社会開発協力部報告書

7

GOVERNMENT OF MALAYSIA

# NATIONAL WATER RESOURCES STUDY, MALAYSIA

## REGIONAL [illegible] NORTH JOHOR

GOVERNMENT OF MALAYSIA

# NATIONAL WATER RESOURCES STUDY, MALAYSIA

# REGIONAL WATER RESOURCES STUDY OF SOUTH JOHOR

## VOL. 1
## MAIN REPORT

DECEMBER 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

NATIONAL WATER RESOURCES STUDY, MALAYSIA

REGIONAL WATER RESOURCES STUDY OF SOUTH JOHOR

## LIST OF VOLUMES

PREFACE

It is with great pleasure that I present this report entitled "REGIONAL WATER RESOURCES STUDY OF SOUTH JOHOR" to the Government of Malaysia.

The report embodies the result of the study which was carried out from July 1984 to December 1985 by a Japanese study team commissioned by the Japan International Cooperation Agency following the request of the Government of Malaysia to the Government of Japan.

The Study team, headed by Mr. Ichiro Kuno of the Nippon Koei Co., Ltd., had a series of discussions on the Project with the officials concerned of the Government of Malaysia, conducted a wide-ranging field survey and has prepared the present report.

I hope that this report will be useful as a basic reference for development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

December, 1985

Keisuke Arita
President
Japan International
Cooperation Agency

JAPAN INTERNATIONAL COOPERATION AGENCY

# NATIONAL WATER RESOURCES STUDY, MALAYSIA
# REGIONAL WATER RESOURCES STUDY OF SOUTH JOHOR

December 1985

Mr. Keisuke Arita
President
Japan International
Cooperation Agency
Tokyo

Dear Sir,

## LETTER OF TRANSMITTAL

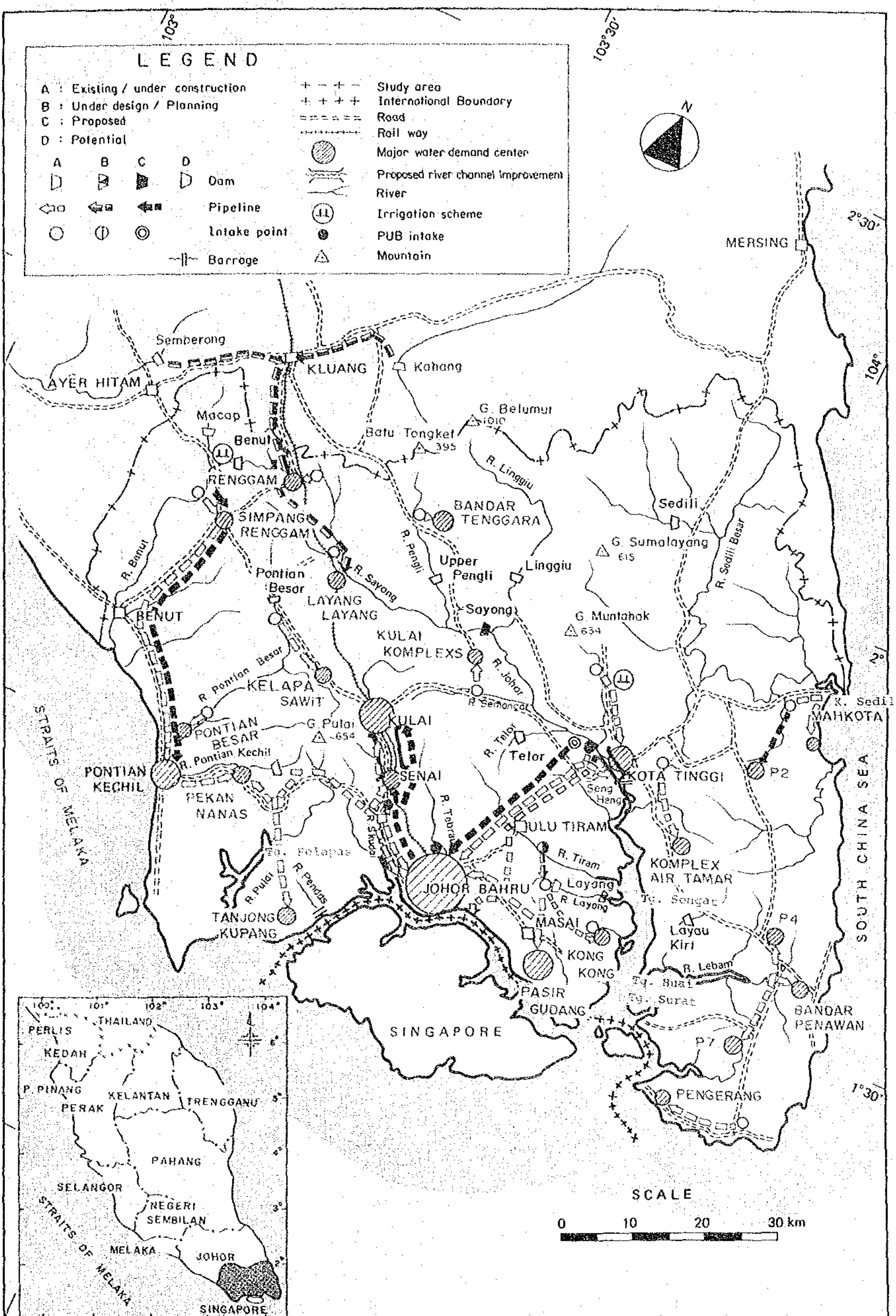
We are pleased to submit to you the Final Report of the National Water Resources Study, Malaysia, Regional Water Resources Study of South Johor, for consideration by the Government of Malaysia in implementing water resources development and management in the specified Region, in line with nation's socio-economic development objective.

The report presents a master plan which is based on a target year of 2005. It is concluded that the proposed Sayong dam on the Johor river and improvement of the downstream river channel should be implemented as soon as possible, in order to meet the anticipated municipal water demands of Johor Bahru, Pasir Gudang and their vicinities, and to mitigate flood hazards at Kota Tinggi.

All members of the Study Team wish to express their appreciation to the personnel of your Agency, the Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction and Embassy to Malaysia as well as to officials and individuals of Malaysia for the advice and assistance extended to the Study Team. The Study Team sincerely hopes that the study results will contribute to the water resources development of Malaysia in particular and to her socio-economic development and well-being in general.

Yours sincerely,

Ichiro Kuno
Team Leader




GOVERNMENT OF MALAYSIA

**NATIONAL WATER RESOURCES STUDY, MALAYSIA**
**SOUTH JOHOR**
**REGIONAL WATER RESOURCES STUDY**

JAPAN INTERNATIONAL COOPERATION AGENCY

# ABBREVIATIONS

(1) Oreganization/Plan

| | | |
|---|---|---|
| 4MP (5MP) | : | Fourth (Fifth) Malaysia Plan |
| DID (JPT) | : | Drainage and Irrigation Department |
| DOA | : | Department of Agriculture |
| DOE | : | Department of Environment |
| EPU | : | Economic Planning Unit |
| FELCRA | : | Federal Land Consolidation and Rehabilitation Authority |
| FELDA | : | Federal Land Development Authority |
| GSD | : | Geological Survey Department |
| JICA | : | Japan International Cooperation Agency |
| KEJORA | : | Lembaga Kemajuan Johor Tenggara |
| MOA | : | Ministry of Agriculture |
| MOH | : | Ministry of Health |
| MTR | : | Mid-Term Review of 4MP |
| NEB | : | National Electricity Board |
| NWRS | : | National Water Resources Study |
| PUB | : | Public Utility Board (Singapore) |
| PWD (JKR) | : | Public Works Department |
| RESP | : | Rural Environmental Sanitation Program |
| RISDA | : | Rubber Industry Smallholders Development Authority |
| WHO | : | World Health Organization |

(2) Others

| | | |
|---|---|---|
| B | : | Benefit |
| BOD | : | Biochemical Oxygen Demand |
| C | : | Cost |
| COD | : | Chemical Oxygen Demand |
| D & I | : | Domestic and Industrial |
| dia. | : | Diameter |
| DRC | : | Dry Rubber Content |
| EIRR | : | Economic Internal Rate of Return |
| EL. | : | Elevation Above Mean Sea Level |
| Eq. | : | Equation |
| FFB | : | Fresh Fruit Bunch |
| Fig. | : | Figure |
| GDP | : | Gross Domestic Project |
| GNP | : | Gross National Product |
| GRP | : | Gross Regional Project |
| HWL | : | Normal High Water Level |
| O & M | : | Operation and Maintenance |
| Q | : | Discharge |
| Ref. | : | Reference |
| SS | : | Suspended Solid |
| VA | : | Value Added |

# ABBREVIATIONS OF MEASUREMENT

**Length**

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

**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

**Weight**

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

**Time**

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

**Other Measures**

% = percent
° = degree
' = minute
" = second
°C = degree in centigrade
$10^3$ = thousand
$10^6$ = million

**Derived Measures**

$m^3/s$ = cubic meter per second
Mgd = million gallon per day
Mld = million litre per day

**Money**

M$ = Malaysian Ringgit
M¢ = Malaysian Cent

# CONVERSION FACTORS

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

Exchange Rate

(1985)

US$1 = M$2.41<br>
¥100 = M$0.980

# SUMMARY

## 1. Study Objective

The Regional Water Resources Study of South Johor (the Study) was carried out based on the Scope of Work, which was agreed on March 2, 1984 between the Government of Malaysia and the Japan International Cooperation Agency (JICA), the official agency responsible for implementation of the technical cooperation programs of the Government of Japan.

The South Johor Region (the Region) is a group of basins of the Sedili Besar, Sedili Kechil, Johor, Skudai, Tebrau, Pulai, Pontian Kechil, Pontian Besar, Benut and some other rivers on the southern tip of Peninsular Malaysia, where significant water stress is expected in the near future.

The objective of the Study is to formulate an integrated water resources development and management plan for the Region to the extent that problems related to water resources can be identified and priority projects can be figured out for consideration by the federal and state governments in making decisions on implementation of water resources development.

The Study was commenced in July 1984 and was completed in December 1985. The Study includes studies on the regional water demand and supply balance system including water pollution abatement planning, pre-feasibility studies of selected dams, updating of flood mitigation plans previously proposed and pre-feasibility design of a channel improvement project for a model river stretch, and studies on legal and institutional arrangement for the regional water resources development and management.

## 2. The South Johor Region

The State of Johor, to which the Region belongs, has an area of 19,140 $km^2$, on which $1.8 \times 10^6$ people live. Gross regional production (GRP) in 1983 was estimated to be M\$$3.5 \times 10^9$ at 1970 constant price. The agriculture sector contributed 32% and manufacturing 22% of GRP in that year.

7,350 $km^2$ of the Region is dominated by tropical monsoon climate but rainfall is rather uniformly distributed over the year. Out of an annual rainfall of $18 \times 10^9$ $m^3$ over the Region, $10 \times 10^9$ $m^3$ is lost to evapotranspiration and deep percolation, and the remaining $8 \times 10^9$ $m^3$ is surface runoff. The groundwater potential is generally poor.

The Region had a population of 800,000 in 1983. Johor Bahru, Pasir Gudang and other towns are located in the Region. Agricultural land of 396,000 ha is cultivated for rubber, oil palm and other crops, forest covers 228,000 ha.

The public water supply system of the Public Works Department (PWD) supplied treated water of 199 Mld to 68% of population in 1983. Under the Rural Environmental Sanitation Program (RESP), 10,000 people are supplied with untreated water in isolated rural areas. FELDA, RISDA and some private enterprises have their own water supply facilities.

Based on the Indenture made in 1961 and Deed made in 1962 between the Government of the State of Johor and Singapore City Council, the Public Utility Board (PUB) of Singapore has abstracted raw water from Gunong Pulai, the Tebrau river, Skudai river and Johor river with its own headworks and pipelines. PUB abstracted 668 Mld of raw water from the rivers in the Region and PWD tapped 121 Mld of treated water from PUB system in 1983.

Irrigation farming is conducted only in two minor irrigation projects of 255 ha.

3. Future Water Demand

It is estimated that the population in the Region will grow from 860,000 in 1985 to 1,600,000 by 2005 at an average rate of 3.2%. Taking into account the views of officials concerned in PWD and MOH, the target for domestic water supply in 2005 assumes that the service factor will be 99% in the urban area and 100% in the rural area, being 87% by PWD and 13% by RESP. It is further assumed that the additional manufacturing water demand after 1983 will be met by PWD system. With these assumptions, domestic and industrial water demand is estimated to grow from 258 Mld in 1983 to 1,061 Mld by 2005. Herein industrial water demand consists of manufacturing water demand and agro-base industrial water demand.

Irrigation water demand is estimated to increase from 5 x $10^6$ $m^3$ in 1983 to 6.5 x $10^6$ $m^3$ in 1990 onward, assuming some expansion in irrigation areas.

The river maintenance flow in the Johor river is assumed to be 2.4 $m^3/s$ (207 Mld) at the highway bridge of Kota Tinggi, based on the fact that PUB intake in the Johor river was closed for a short time because of high salinity during a low flow on April 21, 1983 but there was no salinity problem during another low flow which occurred on January 2, 1981. For other rivers, the river maintenance flow was assumed to be a daily mean runoff of 99% in probability of exceedance.

PUB will maintain the present abstraction of 397 Mld from Gunong Pulai, Skudai and Tebrau intakes but will expand the intake capacity in the Johor river. It is assumed that water drawn at PUB intake in the Johor river will reach 728 Mld (160 Mgd) by 1990 and it will be kept unchanged up to 2005.

River runoff and water demand plus river maintenance flow were compared at each intake site assuming hydrological conditions of a 22 year period from 1963 to 1984, and assuming that some of the existing water resources development plans envisaged by PWD such as Layang Scheme phases Ia and Ib (182 Mld), Kluang Scheme (90 Mld), and Simpang Renggam

Scheme Stage I and II (25 Mld) would be commissioned as scheduled. Results showed that a water deficit would develop toward 2005 but only to a minor extent. Serious deficits were calculated for PUB intakes in the Skudai and Tebrau rivers and at Kota Tinggi where it was assumed that an intake would be installed by PWD near PUB intake in the Johor river.

At the intake point in the Skudai river a water deficit of 44 Mld (16 x $10^6$ $m^3/y$) is estimated against the projected water demand in 1985. Deficits were generated in 21 years out of 22 years simulation period at the intake point with the average deficit of 16 Mld (6 x $10^6$ $m^3/y$).

The Tebrau river showed the similar results. The average deficit is 44 Mld (16 x $10^6$ $m^3/y$). The simulation generated deficits in all the simulation period of 22 years.

The most significant deficits were projected in the Johor river at the Kota Tinggi intake. The projected deficit in 1985 is 13 Mld (4.8 x $10^6$ $m^3/y$) against the river runoff experienced in 1971. It will increase to 77 Mld (28 x $10^6$ $m^3/y$) in 1995 and 189 Mld (69 x $10^6$ $m^3/y$) in 2005. The occurrence frequencies of deficit are estimated to be 6 years in 1985, 15 years in 1995 and 21 years in 2005 against the simulation period of 22 years.

## 4. Proposed Dams and Barrages

As a result of map studies and reconnaissance, 8 dams and 2 coastal barrages were proposed. The proposed Benut and Pontian Besar dams can be considered for water supply on the west coast, the Sayong, Linggiu, Pengli and Telor dams and Johor estuary barrage will be alternative source facilities in the Johor river system. The Sedili dam can provide a regulated outflow if water demand arises in the vicinity. Layau Kiri dam will be future source of water at the southeastern corner of the Region. The Sungai Pundas barrage may serve the area near Kupang.

Among the proposed dams and barrages, the Sayong, Linggiu, Telor dams and the Johor estuary barrage were considered in the plan formulation for the Johor river. No water resources development plan is proposed for the Skudai and Tebrau rivers, because the water resources of these rivers are under the full and exclusive right and liberty of the City Council of Singapore. Little water deficit is expected in the other rivers up to the target year of 2005.

The Sayong damsite is located on the Sayong river, a tributary of the Johor river. The geology of damsite is fresh tight granite partly weathered. Catchment area is 662 $km^2$. If the reservoir normal high water level (HWL) is set at 18 m, the gross storage capacity will be 179 $\times 10^6$ $m^3$ and the earth embankment volume of the dam will be 808,000 $m^3$. The proposed reservoir area is 4,310 ha at a flood water level of EL. 20.1, including agricultural land of 2,560 ha mainly cultivated for oil palm and 1,750 ha of forest. Houses flooded will be 33 in number. The investment cost is estimated to be M$132 $\times 10^6$ including the construction cost of M$35 $\times 10^6$ and compensation cost of M$55 $\times 10^6$.

The Linggiu damsite is located on the Linggiu river, a tributary of the Johor river. The prevailing rock is Paleozoic sandstone which is fractured and highly permeable due to faults which will need special foundation treatment for the dam. The catchment area is 206 $km^2$. If HWL is set at EL. 34, the gross storage capacity will be 125 $\times 10^6$ $m^3$ and the earth embankment volume of the dam will be 850,000 $m^3$. The reservoir area of 1,900 ha will be mostly forest. The investment cost will be M$132 x $10^6$ but the compensation cost will be insignificant.

The Telor damsite is located on a tributary of the Johor river. The foundation rock is weathered granite. The catchment area is 38 $km^2$. If HWL is set at EL. 28, the gross storage capacity will be 49 x $10^6$ $m^3$ and the earth embankment volume of the dam will be 900,000 $m^3$. The proposed reservoir area of 815 ha comprises agricultural land of 265 ha and forest of 550 ha. The investment cost will be M$65 x $10^6$ including M$29 x $10^6$ of construction cost and M$7 x $10^6$ of compensation.

The Johor estuary barrage site is located near Seng Heng, 3 km downstream of highway bridge of Kota Tinggi. The investment cost is estimated to be M$67 x $10^6$. It is envisaged that the barrage will meet 22 x $10^6$ $m^3$ of water deficit by saving water to repulse sea water. The construction of the barrage will involve the following problems; effects on ecosystem, disturbance to navigation, flood hazards caused by failure in gate operation, a rise in the groundwater table, and pollution of pondage due to sewage of Kota Tinggi.

## 5. Water Demand and Supply Balance Plan

Referring to design criteria adopted for the domestic and industrial projects in Malaysia, the target of the water supply is herein assumed that safe supply should be guaranteed even in the driest period under the hydrological condition of the 22-year period between 1963 and 1984.

In Johor river water deficits of 55 Mld (20 x 106 m3/y) in 1990 and 189 Mld (69 x $10^6$ $m^3/y$) in 2005 were projected against the river runoff in 1971, the least runoff in the dry period in 22 years period. The deficits were caused mainly due to the water demand in Johor Bahru, Senai, Kulai and PUB. In this deficit projection, the water supplements by Layang scheme Ia and Ib were counted. Further, the water tapping by PWD from PUB's water main was assumed to be 110 Mld (40 x $10^6$ $m^3/y$) in this balance simulation.

Among the various combinations of dams and barrages conceivable to supplement the projected deficit, Sayong dam with a high water level of EL. 17.0 was found to incur the least economic cost and was selected as the optimum water resources development plan of the Johor river. Next to Sayong dam, Linggiu dam with a high water level of EL. 34.0 will incur the least economic cost.

The suitable sites for water resources development are limited. On the other hand, water demand will increase year by year beyond the target year of 2005. Accordingly it is considered that a dam construction should take advantage of the suitability of the site up to its maximum as far as it is economically preferable. A dam which was constructed at its optimum scale under the given conditions such as target year should reserve the possibility to enlarge its scale in the future. In this respect, the optimum scales of dams were studied assuming the future water demand beyond 2005 and the price of water.

The present worth of water supply was assumed to be M¢19.0/$m^3$ referring the alternative cost derived on the basis of Layang Scheme Ic. The growth of demand in the period from 2005 to 2010 was assumed to be the same as that in the period from 2000 to 2005. Flood attenuation was evaluated as a benefit as damage reduction.

Sayong dam with a high water level of EL. 18.0 will yield a water supply benefit of M$144.5 x $10^6$ assuming that water demand after 2010 is constant and a flood attenuation benefit of M$4.1 x $10^6$ totaling M$148.6 x $10^6$ for an evaluation period of 50 years. The corresponding economic cost was estimated to be M$82.3 x $10^6$ and the maximum benefit minus cost to be M$66.3 x $10^6$.

Linggiu dam with a high water level of EL. 36.0 would provide the maximum benefit minus cost of M$54.7 x $10^6$ among the various scale development alternatives. In this case the water supply benefit is estimated at M$141.0 x $10^6$ and flood attenuation benefit at M$1.3 x $10^6$. While the economic cost is estimated at M$87.6 x $10^6$ for the development at this scale.

Sayong dam with a high water level of EL. 18.0 and Linggiu dam with a water level of EL. 36.0 were found to be optimum even if the present value of water is assumed to be M¢15.0.

Since Sayong dam with a high water level of EL. 17.0 has sufficient capacity to sustain the water demand up to 2005, heightening the dam by 1.0 m from EL. 17.0 was examined as one of the alternative methods of constructing the dam at the optimum scale. In this case the water demand was fixed to be constant after the target year of 2005 and the water supply benefit of M$126.0 x $10^6$ was obtained. The flood attenuation benefit is estimated to be M$3.9 x $10^6$ which makes a total benefit of M$129.9 x $10^6$. The initial cost is estimated to be M$82.2 x $10^6$ and the heightening cost of M$0.8 x $10^6$ in the year 2006 is equivalent to M$0.1 x $10^6$ in 1986. Consequently the derived benefit minus cost is M$47.6 x $10^6$. Meanwhile Sayong dam with a high water level of EL. 18.0 yields the flood attenuation benefit of M$4.1 x $10^6$. Hence the total benefit is estimated to be M$130.1 x $10^6$ and benefit minus cost to be M$47.8 x $10^6$.

An economic internal rate of return of 13.1% was derived for Sayong dam with a high water level of EL. 18.0 assuming that the unit water value is M¢19.0 and that the water demand after 2005 is constant.

According to the results of a sensitivity analysis, if economic growth stagnates due to depression and the annual growth rate of GDP between 1983 and 2005 is 5%, an economic internal rate of return of 10.6% would be secured by provision of Sayong dam with a high water level of EL. 18.0.

In view of this, it is recommended that Sayong dam with high water level of EL. 18.0 should be constructed as soon as possible to meet the rapidly growing water demand in the Region.

A pump station and a treatment plant (R42) is proposed at Kg. Tai Hong some 2 km upstream from the existing PUB's intake (R41) to abstract water including that released from the proposed dam. The total demand to be loaded on R41 and the newly proposed intake is 1,216 Mld or 444 x $10^6$ $m^3/y$ in 2005. Since the capacity of R41 is 160 Mgd or 728 Mld, a capacity of 488 Mld is required at the new intake, treatment plant and pipelines ultimately.

At the proposed intake site, a rapid-filter type treatment plant will require 50 ha of land. In order to convey the treated water to demand centers 7 sets of pumps with a lifting head capacity of 50 m will be required. The total length of double-lane pipeline (transmission main) will be 28 km with a pipe diameter of 1.6 m. The total financial cost for the intake, treatment plant and pipeline is estimated at M$159 x $10^6$ at 1986 constant price. The cost of the distribution system is estimated to be M$272 x $10^6$. The total investment cost for the whole water supply works including the cost of M$107 x $10^6$ for Soyong dam with a high water level of EL. 18.0 is estimated at M$538 x$10^6$ at 1986 present value of financial cost.

The total supplied water is estimated to be 638 x$10^6$ $m^3$ during the evaluation period of 50 years. Hence the unit water price is estimated at M¢ 84/$m^3$ assuming that the annual OM cost is 1 to 2 % of direct construction cost.

No serious environmental impact is anticipated from construction of the Sayong dam. The historical graveyards of MAKAM DUA and MAKAM TUJU should be relocated to an appropriate site located above flood water the catchment area be gazetted as forest reserve to keep the impounded water clean and to extend the life of the reservoir through the sediment control as much as possible.

## 6. Flood Mitigation Plan

One of the most extensive floods in the Region occurred in December 1969 submerging an area of 570 $km^2$. The duration of flooding was 5 to 7 days and the average depth of submergence was reported to be 1 to 2 m. Recently, the Region has been frequently hit by floods. Amongst recent floods, those of 1978, 1979, 1981 and 1983 caused considerable damages to the Region.

DID improved the Skudai, Tebrau, Benut, Pontian Besar and Pontian Kechil rivers against 5-year to 20-year flood discharges. Macap dam constructed on the Macap river is a flood control dam contributing flood mitigation to the Benut river.

Generally rivers in the Region have too small a channel section to carry flood discharge. Flood mitigation plans, mainly by means of channel improvement, were worked out for major rivers based on existing data and reconnaissance. Except for the middle reach of the Skudai river and the Johor river near Kota Tinggi, however, the plans were found economically unjustified unless flood damage potential significantly increases.

The stretch of the Johor river near Kota Tinggi was selected as a sample area for a pre-feasibility study of the flood mitigation plan. The major purpose of this plan was accordingly set to protect Kota Tinggi and its suburban area. An essential part of alternative plans was channel improvement of the main river by construction of levees. For the plan by channel improvement alone, 4 alternatives with different dredging depths were compared. The other alternatives included either flood control by a proposed dam or by a bypass floodway. Comparison of alternative plans resulted in the selection of a plan for channel improvement including the construction of levees and the dredging of the main stream, installation of gates at the mouth of the Permandi river, a tributary, and levee construction in the lower stretch of the Tembeyoh river, another tributary. The design flood discharge was set to be 770 $m^3/s$ or the 30-year probable flood. The length of channel improvement would be 6.7 km. The construction cost was estimated to be M\$7.4 x $10^6$.

If this plan is implemented, the average annual flood damage of M$1.1 x $10^6$ will be reduced by 87%. The value of EIRR is estimated to be 8.6%. The population affected by floods of 4,600 will be reduced by 4,100.

## 7. Water Pollution Abatement Plan

There are 8 towns, 30 palm oil mills, 20 rubber factories, 7 pineapple factories and 49 animal husbandry units, which discharge pollution loads into the rivers. The rivers are generally clean, as far as water quality data up to 1983 indicates, but they will be polluted in the future with increases in population and production.

The target for river water pollution abatement is assumed to be that the concentration of biochemical oxygen demand (BOD) should be less than 10 mg/l in all river stretches and that it should be less than 5 mg/l in any river stretch where an intake for domestic industrial water supply is located.

If no measures are taken to reduce pollutant loads at their source, by the above criteria and according to a projection of BOD concentrations in rivers to 2005 and assuming river flow of 99% in probability of exceedance, problematic river stretches will be the Pontian Besar river below Pontian Besar town, the lower stretch of the Skudai river, the Johor river near Layang Layang and Kota Tinggi.

It is recommended that all rubber factories, palm oil mills and pineapple canneries should have purification facilities to reduce BOD concentrations in their effluent to 50 mg/l and that sewerage system should be provided for Pontian Kechil, Kota Tinggi and Bandar Tenggara in addition to those which are included in 4MP for Johor Bahru, Skudai valley and Pasir Gudang Corridor. For the small towns of Renggam and Layang Layang, underground soakaways combined with septic tanks are recommended. With these measures the assumed target can be attained for all river stretches but some river stretches will be a little polluted for very short periods.

The investment required for implementation of the recommended water pollution abatement plan is estimated to be M$853 x $10^6$ including M$755 x $10^6$ for sewerage development and M$98 x $10^6$ for installation of purification systems in rubber factories, palm oil mills and pineapple canneries.

## 8. Legal and Institutional Arrangements

The Government of Malaysia has decided to formulate a water resources development master plan on the basis of a maximum water abstraction from the Johor river by Singapore of 728 Mld or 160 Mgd upto the target year of 2005. The Government may develop the water resources of the Johor river jointly with Singapore.

In conformity with these decisions it is necessary to prepare an agreement with Singapore covering legal and institutional arrangements regarding;

- the method of flow measurement and flow estimation in order to operate the dam to avoid jeoperdizing the rights of Singapore granted in the present Agreement Deed,
- mutual consent to maintain the present situation for water abstraction from the upstream reach of the Johor river and water tapping from the water main of PUB by the State,
- the scale of development,
- the executing organization,
- land use by Singapore,
- allotment of cost or to tariff to sell water to Singapore,
- reservoir operation against floods,
- saving of water use during a drought, and
- establishment of a committee or board as the decision making body.

The Government of Malaysia should undertake the necessary arrangements for project approval and budgetary procedures.

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# 1. INTRODUCTION

## 1.1 Study Objective

The National Water Resources Study, Malaysia (NWRS) was carried out between October 1979 and October 1982 under a technical cooperation program between the Government of Malaysia and the Government of Japan, in order to make recommendations on actions to be taken by the Federal and State Governments for integrated water resources development and management, which is needed to coordinate multifarious activities under conditions of water stress that have occurred increasingly in places where water was previously abundant.

NWRS proposed a National Water Policy by which water resources development and management would support development of all the socio-economic sectors related to water resources and consistent with the national development goal. The Water Resources Development and Use Plan was proposed as a nation-wide water resources development and management program to be implemented up to 2000 in accordance with the National Water Policy. In order to ensure efficient and effective execution of the proposed program, recommendations were made on necessary arrangements in the financial system, by administrative actions, in the institutional framework, by legal provisions and for further studies.

NWRS was organized to formulate a macro framework for water resources development and management from the national viewpoint, and based on an overview of present and future problems rather than dealing with specific projects. The Water Resources Development and Use Plan as presented was, therefore, a notional program to show the direction and extent of water resources development toward 2000. This notional program now has to be developed into firm and medium-term programs at national and regional levels, for implementation of specific projects.

The objective of the Regional Water Resources Study of South Johor (the Study) is to formulate an integrated water resources development and management plan for one of major water stress regions which were identified by NWRS, to the extent that problems related to water resources may be identified and priority projects indicated for the consideration by the federal and state governments in making decisions on implementation of water resources development.

## 1.2 Technical Cooperation

The Government of Malaysia has implemented a series of regional water resources studies for the major water-stress regions, including the Perlis-Kedah-Pulau Pinang Regional Water Resources Study (PKP Study) which was conducted between December 1982 and March 1985 as a technical cooperation project between the Government of Malaysia and Government of Japan.

Based on a request made in November, 1982 by the Government of Malaysia, the scope of Work for the Study was agreed on March 2, 1984 between the Government of Malaysia and the Japan International Cooperation Agency (JICA), the official agency responsible for implementation of the technical cooperation programs of the Government of Japan. The Study was entrusted by JICA to the Study Team which had previously conducted NWRS. The Study Team members and officials of the two Governments who directly participated in the Study were as listed in Table 1.

To guide the Study, the Government of Malaysia established a Steering Committee chaired by Mr. Ali Abu Hassan, the former Director of the Infrastructure and Utility Division, Economic Planning Unit (EPU) of the Prime Minister's Department, who was later succeeded by Dr. Mohamed Noor Bing Harung, the present Director of the same division.

The Steering Committee has been assisted by a Technical Committee chaired by Ir. Cheong Chup Lim, Deputy Director General of the Drainage and Irrigation Department (DID). An Advisory Committee chaired by Mr. Y. Itobayashi, the former Director of the First Construction Department, Water Resources Development Public Corporation, Japan was established by JICA to review the findings by the Study Team.

Chairmanship of the advisory committee was later taken over by Mr. S. Jojima, the present Director of the same Department. The Steering Committee and the Advisory Committee have maintained close liaison by meeting regularly to exchange views on the Study. Furthermore, in order to reflect the views of the State on the Study, a State Coordination Committee chaired by Dr. Shahir Nasir, the then director of the state EPU, was established. The chairman of the State Coordination Committee was later succeeded by Mr. Mohd. Noor, the present director of the state EPU. The members of each Committee are listed in Table 2.

## 1.3 Study Contents

The Study was commenced in July 1984 and was completed in December 1985.

The Study contains:

(1) a study on the regional water demand and supply balance system including water pollution abatement planning;

(2) a pre-feasibility study on selected dams,

(3) an updating of flood mitigation plans proposed by NWRS and the pre-feasibility design of a channel improvement project for the lower stretch of the Johor river, which was selected as a model river stretch, and

(4) a study on the legal and institutional arrangement for the regional water resources development and management.

## 1.4 Final Report

During the Study period, Inception Report, Progress Report, Interim Report, Preliminary Draft Final Report and Draft Final Report were prepared. This Final Report contains the results of the Study including additional studies based on comments on the *Preliminary Draft Final Report, July 1985.* This Final Report comprises eight volumes with a Main Report (Vol. 1) supported by fifteen Annexes from A to O compiled in seven volumes.

## 1.5 Acknowledgement

The contributions to the Study by officials of the Federal and State Governments and by individuals who have provided information and data, participated in discussions, given valuable advice and provided other forms of assistance to the Study are gratefully acknowledged. Heartfelt gratitude is also due to officials of the Ministry of Foreign Affairs, *and the Ministry of Construction of the Government of Japan,* and to the Japanese Embassy to Malaysia, who have given advice and provided various supports in performing the Study.

# 2. BACKGROUND

## 2.1 Topography and Geology

The South Johor region (the Region) of 7,350 $km^2$ covers a group of river basins, which are located on the southern tip of Peninsular Malaysia. It lies between $1^o15'$ and $2^o15'$ north in latitude and between $103^o08'$ and $104^o18'$ east in longitude. The Region faces the South China Sea in the east, Singapore across the Straits of Johor in the south, and Straits of Melaka in the west. The northern boundary consists of the watersheds of the Benut, Johor and Sedili Besar rivers.

The mountains running from northwest to southeast in the northeastern part of the Region are inferred to be a continuation of the Tahan cordillera. They are featured by the peaks of G. Belumut (EL. 1,010 m), Bt. Batu Tangkat (EL. 395 m), Muntahak (EL. 634 m), and hilly areas in the east coast. The southwestern half of the Region is generally flat with low hills. About 94% of the Region is below the EL. 100 m contour. The land slope is mostly less than $6^o$ and 92% of land is less than $2^o$ in slope. The Region includes nine major and other minor river basins. The Sedili Besar and Sedili Kechil rivers run eastward into the South China Sea. The Johor, Skudai and Tebrau rivers flow southward. The Pulai, Pontian Kechil, Pontian Besar and Benut rivers drain swamp forest in the west coast.

Sedimentary rocks and associated Permian volcanics occur in 20% of the Region mostly in the Sedili Besar river basin, in the southeastern part of the Region, and in the Linggiu river basin, a tributary basin of the Johor river. Sedimentary rocks and associated Triassic to Jurassic volcanics tend to lie northwest-southeast to the west of the national railway line. They occupy 8% of the Region. Sedimentary Jurassic to Cretaceous rocks and semiconsolidated Tertiary sediments are found to a minor extent. Intruded Permian to Cretaceous granites occupy 32% of the Region, mainly in the Johor river basin. Unconsolidated terrace deposits, marine coastal deposits and recent Quarternary alluvium cover 38% of the Region. A geological map of the Region is shown in Fig. 1.

## 2.2 Climate

The climate of the Region is dominated by monsoons. The northeast monsoon usually commences in late October or November and ends in March. The southwest monsoon starts in May or June and ceases in September.

There are 47 rainfall gauging stations in the Region. Based on the rainfall record between 1963 and 1982 at these stations, an isohyetal map was prepared as shown in Fig. 2. In general, annual rainfall is high on the east coast and is lower towards the west coast. It is 2,900 mm at the northeast corner and 2,100 mm at the northwest corner of the Region. There is a high rainfall area around G. Pulai (EL. 655 m). Average annual rainfall in the Region is estimated to be 2,460 mm. Seasonal variation in rainfall is rather moderate but it is relatively high between October and December and between March and May.

Storm rainfall normally takes place at the height of northeast monsoon, between November and February, especially in December. The maximum one day's rainfall of 363 mm was recorded on Dec. 9, 1954 at gauging station 2435, Ldg Nam Heng near Ulu Tiram (See Fig. 2). One day's rainfall of 80 mm has been observed at least once a year and at every gauging station.

The air temperature is 26°C to 27°C on average with little seasonal variation. Relative humidity is 68% to 74% on average, also with little seasonal variation.

## 2.3 Water Resources

The region of 7,350 km$^2$ is dominated by tropical monsoon climate but rainfall is rather uniformly distributed over the year.

The Federal DID has 6 hydrological stations in the Region. The State DID maintains a hydrological station each on the Skudai river and the Tebrau river. Automatic recording type equipment is installed at all stations. DID conducts discharge measurements once a month.

The Rantau Panjang hydrological station on the Johor river has been recording for the longest period of 22 years in the Region while most stations have only a few years' records. The Federal DID has compiled the water level record of 1963 to 1984 for this station and has stored it in the Hydrologic Data Bank. The catchment area above the gauging station is 1,130 $km^2$. The average annual runoff depth is 1,000 mm against the average annual rainfall depth of 2,400 mm over the 22-year period of record. The minimum runoff depth of 567 mm occurred in 1974 against the basin rainfall of 1,910 mm. The minimum average daily runoff at the station is 2.5 $m^3/s$ recorded on December 10, 1964. The maximum average daily runoff is 642 $m^3/s$ recorded on December 12, 1969. The specific discharge is computed to be 57 $m^3/s/100\ km^2$. The duration curve of average daily runoff is illustrated on Fig. 3 and a monthly runoff record is presented in Table 3.

Groundwater in the Region occurs in both unconsolidated and consolidated aquifers. Unconsolidated aquifers are found in Quaternary sediments of sand and gravels. Along the east and west coast, minor groundwater potential is recognized in the terrestrial deposits. Consolidated acquifers generally have no potential except for cracks and decomposed sandy materials in the fractured zone of sandstones, conglomerate shales, tuffs and granites in limited hilly areas.

In general, the quality of groundwater is good for D&I water uses in both unconfined and confined aquifers, but some alluvial aquifers have been intruded by sea water especially in the western coastal plain. It is estimated that the groundwater development potential in the Region is insignificant.

## 2.4 Socio-economy

The population of Malaysia was 14,811,000 in 1983. Almost 83%, or 12,284,000, lived in Peninsular Malaysia. The urbanization ratio in Peninsular Malaysia increased from 29% in 1970 to 38% by 1980.

The gross domestic product (GDP) of Malaysia was M$38,810 x $10^6$ in 1983 in factor cost at 1970 price level. The contribution of agricultural sector to GDP in the same year was estimated at 23%, while the manufacturing sector contributed 18%. Per capita GDP was M$2,080 in 1983 in factor cost at 1970 price level.

The State of Johor is located in the Southernmost part of Peninsular Malaysia having an area of 19,140 km2. Population of the State was 1,756,000 in 1983.

The gross regional product (GRP) of the State was M$3,523 x $10^6$ and per Capita GRP was M$2,007, which was slightly lower than the national average, in 1983 in factor cost at 1970 price level. The agricultural sector contributed 32% and manufacturing sector 22% to GRP in 1983.

The districts of Johor Bahru, Kota Tinggi and Pontian form a substantial part of the Region. Parts of Kluang and Mersing districts cover the northern edge of the Region. The population of the Region was 719,000 in 1980 and was estimated to be 800,000 or about 46% of population in the State in 1983. The Region is noted as a densely populated industrial area culminated by Johor Bahru, the capital of the State, which was the 5th largest town in Malaysia with population of 256,000 in 1980. In addition to existing towns, there are 10 industrial estates in the Region. The largest one is the Pasir Gudang Industrial Estate located 24 km east of Johor Bahru.

Rubber and oil palms are the dominant crops in the Region. Other noteworthy crops are sugarcane, coconuts, pineapples, bananas, pepper, coffee, paddy, orchards and horticultural crops. Productions in the Region in 1983 was estimated to be 117,000 tons of dry rubber content (DRC) for rubber and 3,345,000 tons of fresh fruit bunch (FFB) for oil palm. Pineapple production in the same year was estimated at 177,000 tons of fresh fruits. These products were primary-processed in factories located in the vicinity of plantations. At present 20 rubber factories, 24 palm oil mills and 5 pineapple canneries are in operation in the Region.

## 2.5 Land Use

The Department of Agriculture prepared a land use map at a scale of 1 to 126,720 which shows the land use of the Region in 1974. The Department prepared another land use map at the same scale based on survey results by means of Land Sat in 1981. The map has not yet been published but was made available to the Study. Various governmental offices and corporations furnished the Study team with maps showing forest reserves, plantations, towns, villages and other land uses.

A land use map of the Region is shown in Fig. 4. Agricultural land of 395,702 ha occupying 54% of the Region comprising 155,223 ha of rubber, 167,967 ha of oil palm, 15,053 ha of coconuts, 14,148 ha of pineapple, 9,155 ha of sugarcane and 34,156 ha of other crop areas. Forest of 228,275 ha (31%) mostly covers the mountainous area in the northeast of the Region. Swamps of 71,791 ha (10%) occupy coastal plains. Non-agricultural lands such as urban estate, mining areas and others are 39,232 ha (5%). Between 1974 and 1981, agricultural land increased by 56,000 ha and non-agricultural land expanded by 30,000 ha. On the other hand, forest cover was reduced by 58,000 ha and swamps decreased by 28,000 ha. In agricultural land, rubber decreased by 27,000 ha. Expansion of agricultural land is largely attributable to the development of oil palm.

## 2.6 Water Use

### 2.6.1 Domestic and industrial water uses

Public water supply in the State of Johor is administered by the Water Supply Division of Public Works Department (PWD) of the State Government. PWD supplies piped-treated water to major towns in urban area and also to minor towns and villages in rural area. The urban water supply system also commands some suburban rural areas nearby. PWD waterworks supplied water of 72.6 x $10^6$ $m^3$, or 199 Mld on average (in terms of source demand) in the Region in 1983. The served population was 545,000, or 68% of the total population of 798,000 in the Region. According to "K1 table" for 1982 by PWD, per capita domestic water use was 242 l/d in the urban area and 140 l/d in the rural area, and unaccounted-for ratio ranges between 20 and 30%. It is estimated that 30 x $10^6$ $m^3$ (82 Mld), or 41% of PWD supply was used for industrial (manufacturing) purposes. The unit cost and average unit rate of water were calculated by the district as shown in Table 4, based on the financial data of PWD. Unit cost of water ranges between M¢ 12/$m^3$ and M¢ 62/$m^3$ and unit water rate is between M¢ 6/$m^3$ and M¢ 30/$m^3$. The cost of M¢ 18/$m^3$ in the Johor Bahru district is low in relation to other districts which reflects the low water change of water tapped from PUB system.

In the interior and isolated rural areas, untreated water supply systems have been developed by the State Government with materials and technical advices from MOH, under the Rural Environmental Sanitation Program. Construction, operation and maintenance of facilities is conducted by beneficiaries themselves. Water users are advised to boil water before drinking. It was estimated that 0.5 x $10^6$ $m^3$ of untreated water was supplied to the served population of 10,000 in the Region in 1983.

FELDA, RISDA and some private enterprises have their own water supply facilities, of which the total supply in 1983 was estimated to be 21.2 x $10^6$ $m^3$ (53 Mld).

The Public Utility Board (PUB) of Singapore has abstracted raw water form Gunong Pulai, the Tebrau river, the Skudai river and Johor river based on agreements between the State of Johor and Singapore City Council. Water abstracted at each intake is treated near the intake and conveyed to Singapore through a pipeline system. Some of the water is tapped from the pipeline system into the PWD water supply system. A record of abstractions by PUB between 1980 and 1983 is shown in Table 5. In 1983 PUB abstracted 244 x $10^6$ $m^3$ (668 Mld) of raw water from the rivers in the Region, and 44 x $10^6$ $m^3$ (121 Mld) of treated water was tapped by PWD.

Agro-base industries such as rubber factories, palm oil mills and pineapple canneries as shown in Fig. 5 are water consumers in the Region, normally taking water from streams in rural areas. Applying assumed unit water demands to the production volumes described in Section 2.4, the average water demand of agro-based industries in 1983 was estimated to be 19 Mld, including 5 Mld for rubber factories, 13 Mld for oil palm mills and 1 Mld for pineapple canneries.

### 2.6.2 Irrigation water uses

The state DID of Johor has operated and maintained two irrigation schemes in the Region.

The 78 ha Lukut scheme is located about 10 km north of Kota Tinggi. The scheme takes water by gravity from the Lalang river, a tributary of the Johor River. Usually only one crop a year is cultivated. The water diverted was estimated to be 1.1 x $10^6$ $m^3$ in 1983.

The 177 ha Ulu Benut scheme is located near Renggam and extends along the Benut river. The scheme diverts water from the Benut river by gravity. Two crops a year are grown. The water diverted was estimated to be 3.9 x $10^6$ $m^3/y$ in 1983.

### 2.6.3 Inland fishery

Freshwater fish ponds have been developed in inland marshy areas, and brackishwater ponds are located in coastal areas. The main products are grass carp and big head carp in the freshwater ponds, while prawns are primary product in the brackish water ponds. In 1984, total area of fish ponds was 379 ha, of which 149 ha was freshwater ponds. The Government make much of inland fishery in 4MP as the Brackishwater Pond Project in western Johor and the Freshwater Pond Project in KEJORA region.

Up to now, no water shortage has been recorded in either brackishwater or freshwater ponds. Ponds are mostly developed in swamps. The increase in water loss attributable to fish pond development in terms of evaporation and percolation is therefore considered to be insignificant.

### 2.6.4 Inland navigation

Inland navigation in the Region is scanty. Passenger boats navigate in the lower reaches of the Johor river, Sedili Besar river and the Pulai river. Navigation routes of the Johor river link Kong Kong with the other side of the river; Tg. Surat Buai and Tg. Sengat. The predominant passengers on this route are people who work in Johor Bahru area coming from Kota Tinggi district. The main purpose of navigation in the Sedili Besar river is to transport school children from rural areas to Kg. Sedili, while local people cross the Pulai river using passenger boats from Tg. Pelepas to work in the fish ponds in the marshy area located in the opposite side of the river. The traffic of transportation is 4 to 6 times per day. The average load is 12 persons, and the average size of boat is 40 feet long and 3 to 4 feet deep.

## 2.7 Water Quality

The National Water Quality Monitoring Program (1978) of the Division of Environment (DOE) requires routine water quality monitoring and surveillance of important river basins. A network of water quality monitoring stations (WQMSs) has been developed at critical locations for more important rivers with respect to sources of public water supplies, river fishery and agricultural irrigation. Monitoring in the Region has been conducted since 1978. The sampling is carried out 2 to 9 times a year at each of 41 WQMSs located in the Benut, Pontian Besar, Pontain Kechil, Skudai, Tebrau, Johor, Sedili Besar rivers. The basic parameters selected to represent the various qualitative aspects of the national waters are pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS) and Ammoniacal Nitrogen ($NH_4$-N).

So far the records of monitoring indicate that rivers in the Region are generally clean except for some stretches of the Skudai, Tebrau and Johor rivers. In a few km of the Skudai river, a few kilometers below Kulai town, the BOD concentration of 5-6 mg/l and $NH_4$-N concentration were sometimes found to be higher than 1 mg/l. These observations indicated that the river stretch was mildly polluted with domestic waste from Kulai and organic effluent from rubber factories and palm oil mills. BOD concentration of 5-10 mg/l was observed in 1982 and $NH_4$-N concentration increased in the middle stretch of the Tebrau river. The presumed sources of pollution are a rubber factory and a palm oil mill. In the Johor river system, high concentrations of $NH_4$-N were sometimes recorded downstream of Layang Layang town in the Sayong river and a little downstream of the confluence of the Sayong river and Pengli river. BOD also seemed to increase. It is assumed that the former stretch is polluted by domestic waste of Layang Layang and effluent from a palm oil mill and the latter stretch is affected by the effluent from a palm oil mill. It seems that high SS concentration is caused by town development.

## 2.8 Existing and On-Going Source Facilities for Water Supply

Existing source facilities of PWD and PUB in the Region are tabulated in Tables 6 and 7, and their locations are shown in Fig. 6.

PWD has 15 waterworks within the Region. Waterworks normally consist of an intake for direct pumping from a river and a treatment plant immediately downstream, but the Layang Scheme (Layang dam) and Lebam dam have regulating reservoirs.

The Layang Scheme was formulated to develop water resources on the right bank of the drowned valley of the Johor river for water supply to Johor Bahru, Pasir Gudang, FELDA-Kong Kong, Masai and Plentong. Phase Ia of the Scheme completed in 1985 consists of the Layang dam with a storage capacity of 45 x $10^6$ $m^3$ and a treatment plant with a capacity of 105 Mld (23 Mgd). Kong Kong intake R33 was superseded by Phase Ia. Phase Ib is under construction in order to increase the supply capacity of the scheme to 182 Mld (40 Mgd) by 1986. Under Phase Ib, a coastal dike will be constructed to create a storage of 15 x $10^6$ $m^3$ at the estuary of the Layang river. In order to make more water available, two pumping and conveyance systems will be constructed, one will lift water from the estuary storage and the other will transfer water from a tributary. Furthermore, the capacity of treatment plant will be increased by 77 Mld (23 Mgd).

The Kluang Scheme is under construction to develp 90 Mld (20 Mgd) of water for meeting water demand in Kluang district by 1995. A treatment plant of 80 Mld will be constructed to make use of water in the existing Semberong dam for water supply, and also 10 Mld of groundwater will be developed on the flood plain of the Kahang river. The objective area of the Kluang Scheme involves the northwestern part of the Region. The Scheme will supply 0.3 Mld to Sayong, 4.1 Mld to Renggam and 3.0 Mld to Layang Layang by 1987.

In the Simpang Renggam Scheme Stage I, a treatment plant with a capacity of 25 Mld will be constructed in the upstream reach of the Benut river by 1990, in order to utilize regulated outflow from the Macap dam for the water supply in Simpang Renggam, Pontian Kechil and Pekan Nanas.

In Gunong Pulai, PUB has 3 dams, one in the Pontian Kechil river and the other two in the Pulai river. An intake barrage and a pumping station of PUB are operated each in the Skudai river and Tebrau river. Total output of these headworks is about 400 Mld. No expansion of these headworks is conceivable, because their water abstraction seems to have reached full capacity with regard to potential water resources.

A pumping station of PUB is operated in the Johor river 2 km upstream of Kota Tinggi. Raw water pumped directly from the river is treated immediately downstream and it is conveyed to Singapore through a pipeline system of PUB. The capacity of the headworks was 82 Mld (30 Mgd) when it was constructed in 1977, and it was expanded to 164 Mld (60 Mgd) in 1982. The treatment plant capacity will be extended to 410 Mld (90 Mgd) and the capacity of the pipeline system will be increased to 546 Mld (120 Mgd) by the end of 1985 when the present construction work will be completed. Furthermore, PUB completed the design to expand the capacity of the facilities to 728 Mld (160 Mgd) with a target year of 1990, with the consent of the Government of the State of Johor.

All water supply facilities of RESP in the Region are simple wells except for a direct intake from a river and a rain water collection system. The location of RESP water supply facilities is shown in Fig. 7.

## 2.9 Existing Institutions and Laws Related to Water Management

### (1) Institutions

The Federal Constitution provides for distribution of legislative and executive power between the Federal Government and State Governments. Water and rivers are generally regarded as State matters similarly to land.

Inland water is regarded as State property according to the Waters Enactment. The Land and Mines Department of the State is responsible for land and water administration.

The State DID is an engineering agency, which is in charge of river conservancy. DID offers technical assistance to other agencies for engineering aspects of the river management. DID also undertakes drainage schemes, irrigation schemes and flood mitigation projects as an execution agency. The State PWD is another engineering agency and is responsible for the domestic and industrial water supply within the State.

The Federal DOE is responsible for the control of effluent discharge from factories. The Local Council and District offices also have powers to control water polluting activities.

The Local Authorities are responsible for implementation of sewerage and urban drainage projects.

The Forest Department is responsible for management of forests.

The State EPU is responsible for coordination of every development project within the State. The State Development Office has duties to coordinate implementation of Federal and State projects including evaluation of development projects. The Federal EPU is responsible for the coordination of Federally financed projects.

There are some land and regional development authorities within the State. These agencies and their subsidiaries undertake various socio-economic development projects including domestic and industrial water supply within new town areas and industrial estates. Water supply schemes involved in these projects are undertaken by the State PWD.

(2) Laws

The demarcation of responsibilities between the Federal and State is provided in the Federal Constitution.

A river which is wholly within one State comes under State legislative and executive power. The Waters Enactment and River Constructions Enactment are the state laws which provide for the use of river water and river area. As for the river use for mining purpose, the Mining Enactment, a state law, is enforced. All these laws require permission from the State Authority for diversion of river water or for land use along the river.

The National Land Codes, Land Conservation Act and Forest Enactment are the laws providing for the use of land.

There are laws to control water pollution. The Environmental Quality Act, a Federal law, and the Waters Enactment both limit the effluent discharge into the river. The Mining Enactment provides the control of outflow out of silt from a mining area. The Local Government Act has a provision to control water pollution within the local authority area.

The Water Supply Enactment and Irrigation Areas Ordinance are laws mainly providing procedures to be followed by end users and responsible agencies.

PUB withdraws water from certain rivers in the State of Johor for water supply in Singapore, in accordance with the Indenture made in 1961 and Deed made in 1962 between the Government of the State of Johor and the City Council of Singapore. Singapore was a British colony until it merged with Malaysia in 1963. The Constitution and Malaysia (Singapore Amendment) Act enforced in 1965 when Singapore left Malaysia provides as follows:

> The Government of Singapore shall guarantee that the Public Utilities Board of Singapore shall on and after Singapore Day abide by the terms and conditions of the Water Agreements dated 1st September, 1961, and 29th September, 1962, entered into between the City Council of Singapore and the Government of the State of Johor.
>
> The Government of Malaysia shall guarantee that the Government of the State of Johor will on and after Singapore Day also abide by the terms and conditions of the said two Water Agreements.

Both of these agreements grant the City Council certain rights to use of water and land within the State of Johor for the purpose of water supply in Singapore.

The Indenture provides that "the Government of State of Johor grants the City Council the full and exclusive right and liberty to draw off take impound and use all the water which may from time to time be or be brought or stopped or found in on or under the stipulated land, which includes dams in Gunong Pulai and the full and exclusive right and liberty to take impound and use all water from the Tebrau River and Skudai River respectively with some conditions. The required land is alienated to the City Council for a period of 50 years at an annual rental charge of M$5/acre (M$12.5/ha). The City Council shall supply to the Government a daily quantity of water not exceeding 12% of water supplied to Singapore at the request of the Government. Subject to review after 25 years from the date of the agreement, water rates are stipulated as follows:

(1) Water drawn from Johor and delivered to Singapore: M¢ 3/1,000 gal (M¢ 0.66/$m^3$)

(2) Pure water supplied by City Council to the Government: M¢ 50/1,000 gal (M¢ 11.0/m3) "

The Deed provides that "the Government grants unto the City Council the full and exclusive right and liberty to draw off take impound and use the water from the Johor River up to a maximum of 250 million gallons per day (1,138 Mld) with some conditions."

"The required land is alienated to the City Council for a period of 99 years at an applicable rate of rent. The City Council shall supply to the Government a daily quantity of water not exceeding 2% of water supplied to Singapore, at the request by the Government." Subject to review after 25 years from the date of the agreement, the same water rates as above-mentioned for the Indenture are stipulated.

# 3. FUTURE WATER DEMAND AND ASSOCIATED PROBLEMS

## 3.1 Socio-Economic Projection

Socio-economic figures of the Region were projected up to the target year of 2005. The Mid-Term Review (MTR) of Fourth Malaysian Plan (4MP) and Population Censuses for 1970 and 1980 were used in the projection.

The population of Malaysia by state in 1980, 1983 and 1985 is given in MTR, and total populations projected for 1990, 1995, 2000 and 2005 were provided by EPU Regional Section in October 1984 for the use by the Study Team. Populations by state for 1990, 1995, 2000 and 2005 were estimated by a ratio method on the basis of population by state for 1970 in 4MP and that for 1980 and 1985 in MTR. Populations in each town and district rural in each state in future years was estimated by a ratio method on the basis of 1970 and 1980 census populations. These were further adjusted taking into account the urbanization ratio. The projected population by town and district rural is summarized in Tables 8 and 9. The population within the Region in 1985 is estimated to be 860,000 or 47% of the state population of 1,834,000. Out of this, the urban population in Johor Bahru district is 389,000, being 85% of urban population of 459,000. The average growth rate of the regional population is expected to be 3.2% between 1985 and 2005. The population in the Region in 2005 will be 1,600,000, or 59% of the state population, consisting of an urban population of 1,315,000 and a rural population of 285,000. The urban population in Johor Bahru district will be 1,030,000.

Economic data up to 2005 were assumed as summarized in Table 10. Their background is explained hereunder.

GDP of Malaysia in 1980, 1983 and 1985 are given in MTR at 1970 constant prices. Based on these data the average growth rate between 1980 and 1985 was estimated to be 6.8%. The annual growth rate of GDP in the future was assumed to be 7.0% for 1985-1990, 7.0% for 1990-1995, 6.5% for 1995-2000 and 6.0% for 2000-2005. It is estimated that GDP at

1970 constant price will grow from M$30,810 x $10^6$ in 1983 to M$35,250 x $10^6$ by 1985, M$49,450 x $10^6$ by 1990, M$69,360 x $10^6$ by 1995, M$95,020 x $10^6$ by 2000 and M$127,160 x $10^6$ by 2005.

A functional relationship was assumed between GDP per capita and GRP per capita of each state based on the data obtained from 4MP for 1971 and MTR for 1980 and 1985 in order to estimate a preliminary value of GRP per capita of the state in future years. The final value of GRP per capita was calculated by adjusting the sum for all the states by the products of state population and the preliminary value of GRP of the same state to the projected GDP. It is estimated that GRP of the State of Johor at 1970 constant prices will grow from M$3,520 x $10^6$ in 1983 to M$3,980 x $10^6$ by 1985, M$5,500 x $10^6$ by 1990, M$7,740 x $10^6$ by 1995, M$10,580 x $10^6$ by 2000 and M$14,170 x $10^6$ by 2005. GRP per capita of the State of Johor will grow from M$2,010 in 1983 to M$2,170 by 1985, M$2,690 by 1990, M$3,430 by 1995, M$4,250 by 2000 and M$5,190 by 2005.

The ratio of the incremental share of the manufacturing sector in GDP to the incremental GDP per capita was calculated assuming a share of manufacturing sector in GDP of 18% for 1985 as given in MTR and 33% for 2005 by reference to examples in industrialized countries. A preliminary value of share of the manufacturing sector in GRP of each state for an arbitrary year was calculated assuming a linear relationship with the same value of the above-mentioned ratio between GRP per capita and the share of the manufacturing sector in GRP, where the share of the manufacturing sector in GRP in 1985 was as given in MTR. Preliminary values were adjusted to the share of the manufacturing sector in the GDP by being averaged with weight of GRP. The obtained share of the manufacturing sector in GRP in the State of Johor was 22.1% for 1983, 22.3% for 1985, 25.2% for 1990, 29.0% for 1995, 34.6% for 2000 and 38.3% for 2005. Accordingly, the value added of the manufacturing sector in the State of Johor was calculated to be M$780 x $10^6$ for 1983, M$910 x $10^6$ for 1985, M$1,390 x $10^6$ for 1990, M$2,240 x $10^6$ for 1995, M$3,660 x $10^6$ for 2000 and M$5,420 x $10^6$ for 2005.

The manufacturing sector was classified into 11 commodity groups and the value added of manufacturing output in Peninsular Malaysia by state by commodity group was estimated on the basis of the results of the Industrial Census of 1974 and 1978. The gross value of manufacturing output in Peninsular Malaysia by state by commodity group was obtained by applying an assumed value added ratio to the above-mentioned estimation. The gross value of manufacturing output in the State of Johor was estimated to be M$2,710 x $10^6$ for 1983, M$3,170 x $10^6$ for 1985, M$4,350 x $10^6$ for 1990, M$7,830 x $10^6$ for 1995, M$12,670 x $10^6$ for 2000 and M$18,590 x $10^6$ for 2005.

### 3.2 Domestic and Industrial Water Demand Projection

Taking into account the views of officials concerned of PWD and MOH, the target for domestic water supply was provisionally set for 2005 as follows: The service factor will be 99% in urban area and 100% in rural area comprising 87% by PWD and the remaining 13% by RESP.

With respect to industrial manufacturing water supply, PWD supplied 82 Mld out of the total water demand of 131 Mld in 1983, i.e., the balance of 49 Mld was privately supplied. It is assumed that all additional manufacturing water demand after 1983 will be supplied by PWD and the private supply of 49 Mld will remain as it is.

The domestic water demand in the Region in future years was estimated to be 152 Mld for 1985, 213 Mld for 1990, 304 Mld for 1995, 395 Mld for 2000 and 514 Mld for 2005 in terms of source demand, assuming per capita daily use which varies with population size and type of supply system.

Industrial water demand consists of manufactural water demand and agro-base industrial water demand. These were estimated separately and then added up.

The total manufacturing water demand in the State of Johor was estimated from the projected gross value of manufacturing output by commodity group, where unit water demand per value was assumed for each commodity group. Before dividing the water demand into towns, manufacturing water demand in the industrial estate of Pasir Gudang was projected to be 19 Mld for 1985, 25 Mld for 1990, 33 Mld for 1995 and 42 Mld for 2000 onward, based on information in SEDC Pasir Gudang Development: Master Plan for Infrastructure Services, 1981. Manufacturing water demand in the whole State reduced by that in Pasir Gudang was allotted to towns in proportion to their population. The estimated manufacturing water demand within the Region was 139 Mld for 1985, 192 Mld for 1990, 271 Mld for 1995, 336 Mld for 2000 and 523 Mld for 2005.

There are on-going agricultural development projects of three different categories; KEJORA of 11,800 ha, FELDA projects of 3,300 ha and the Western Johor Agricultural Development Project of 6,000 ha. Taking into account these projects, production of rubber, oil palm and pineapple was projected. Rubber production will decrease from 117,000 tons of DRC in 1983 to 100,000 tons of DRC by 2005. Oil palm production will increase from 3,345,000 tons of FFB in 1983 to 4,280,000 tons of FFB by 2005. Pineapple production will increase from 177,000 tons of fresh fruit in 1983 to 491,000 tons of fresh fruit by 2005. Presently, there are 20 rubber factories, 30 palm oil mills and 7 pineapple canneries. With the increase in crop productions, the capacity of processing facilities will be extended. Three palm oil mills with total processing capacity of 500,000 tons of FFB per year will be constructed under FELDA by 1990. Moreover three palm oil mills with total capacity of 440,000 tons and 2 pineapple canneries with total processing capacity of 150,000 tons of fresh fruit per year will be constructed under the Western Johor Agricultural Development Project by 2000. The locations of these factories were assumed to be adjacent to the envisioned plantations.

Agro-base industrial water demand in the Region is projected to be 21 Mld for 1985, 22 Mld for 1990, 23 Mld for 1995, 24 Mld for 2000 and 24 Mld for 2005, assuming unit water demand per production volume by crop.

Projected domestic and industrial water demand by district is summarized in Tables 11 and 12. Domestic and industrial water demand in the Region is estimated to be 258 Mld for 1983, 311 Mld for 1985, 427 Mld for 1990, 598 Mld for 1995, 755 Mld for 2000 and 1,061 Mld for

2005. Change in water demand by type of supply system between 1983 and 2005 will be from 199 Mld to 1,003 Mld for PWD, from 1.4 Mld to 3.0 Mld for RESP from 58 Mld to 56 Mld for private systems (Ref. ANNEX B).

### 3.3 Irrigation Water Demand

Due to economic disadvantage, farmers' interest in cultivating paddy is far lower than in cultivating oil palm or rubber. In addition, suitable land for paddy cultivation is limited in the Region. In this Study, no increase is assumed in the area of irrigated paddy except for extension of existing minor irrigation schemes as being planned by DID.

The Lukut scheme of 78 ha in 1984 was assumed to be increased to 104 ha by 1990. A map study revealed that economical water source development for this scheme (Lalang river) would be difficult. One crop per year system was, therefore, assumed. Water demand was estimated to be 1.1 x $10^6$ $m^3$ for 1983 and 1.5 x $10^6$ $m^3$ for 1990 onward.

The Ulu Benut Scheme of 177 ha in 1984 was assumed to be increased to 227 ha by 1990, according to a plan proposed by the state DID. As there is an ample water source for paddy irrigation in this scheme, complete double cropping of paddy can be practiced. Water demand was estimated to be 3.9 x $10^6$ $m^3$ for 1983 and 5.0 x $10^6$ $m^3$ for 1990 onward.

### 3.4 River Maintenance Flow

No special problem due to drought has been recorded in the Region, except that PUB intake in the Johor river was shut down for a short time on April 21, 1983 because high salinity was observed at a monitoring station at a highway bridge a little downstream of the intake due to ingress of sea water. It is estimated that runoff immediately upstream of the intake at that time was 4.1 $m^3/s$ and withdrawal at the intake was 60 Mgd or 3.2 $m^3/s$. Runoff at the highway bridge was thus estimated to be 0.9 $m^3/s$ (78 Mld). The intake did not suffer from low flow on January 2, 1981. Runoff immediately upstream of the intake on that occasion was estimated to have been 5.6 $m^3/s$. Assuming that 60 Mgd or 3.2 $m^3/s$ was being pumped, runoff at the highway bridge is estimated to have been 2.4 $m^3/s$ (207 Mld). Based on these facts, a river maintenance flow of 2.4 $m^3/s$ or 207 Mld is assumed at the highway bridge of the Johor river.

A daily mean discharge of 99% in probability of exceedance is assumed as the river maintenance flow of the other rivers, because a simulation study showed that this discharge would be enough to keep rivers clean, if a water pollution abatement plan is implemented as recommended in Chapter 7.

### 3.5 Water Abstraction by PUB

The present water abstraction by Singapore is deemed to have reached full scale with regard to the water resources potential at Gunong Pulai, Skudai and Tebrau intake sites. It is presumed that no future extension of intake facilities is conceivable for these intake sites. Singapore will continue to abstract water at more or less present level depending on hydrological conditions. Accordingly, future abstraction at these intakes is assumed to be 397 Mld which is equal to the abstraction at these intakes in 1983. PUB is however expanding the intake in the Johor river.

It is assumed that water drawn at PUB intake on the Johor river will reach 728 Mld (160 Mgd) by 1990 and thereafter will remain unchanged up to 2005. This assumption was employed to facilitate planning and was based on a decision made in the Steering Committee meeting of 1985. It involves neither commitment by the Government nor projection of Singapore's water demand, which is out of the scope of the Study.

## 3.6 Water Demand and Supply Balance

### 3.6.1 Hydrological data analysis

Hydrological records in the Region were available for Rantau Panjang (Johor river), Rancangan Tanah Jengeli (Linggiu river), Jambatan Johor Tenggarah (Sayong river), Pengli "A" (Pengli river), Saleng (Skudai river) and BT2 JL Ayer Hitam/Yong Peng (Semberong river). The records are more or less interrupted and some are short in duration. An attempt was made to extrapolate and interpolate the record based on rainfall records by means of a Tank Model method, and daily runoff records were prepared for the 22 year period from 1963 to 1984 for four hydrological stations of Rantau Panjang, Ran Tanah Jengeli, Jambatan Johor Tenggarah and Saleng. The daily runoff records were converted into 5-day runoff records for the convenience of the water demand and supply balance study.

It was possible to prepare the runoff records at arbitrary locations by transposing the runoff record of an appropriate hydrological station, out of the above-mentioned four, based on data in Table 13. In the table, catchment area, average basin annual rainfall, average annual runoff and name of an appropriate hydrological station for transposition are shown for each of 16 intakes and 8 proposed dam sites. Fig. 8 shows daily runoff hydrograph for 22 years from 1963 to 1984 at Kota Tinggi (R41 & R42) on the Johor river, which is the most important site for the water demand and supply balance plan.

### 3.6.2 Water demand by intake

The correlation between demand centers and intakes is indicated in Tables 11 and 12 (for key to intake sites see Fig. 6). Furthermore, the relationship between the river systems, intakes and demand centers is illustrated in Plate 1.

Assumed domestic and industrial water demand including abstraction by PUB for the future years is summarized by intake as shown in Table 14. In preparing this table the following assumptions were made:

(1) PUB intakes Res 8 (Gunong Pulai), R31 (Skudai) and R32 (Tebrau) will continue to draw off the same volume of water as was drawn off in 1983.

(2) A new PWD intake, R42, will be constructed by 1990 near Kg. Tai Hong a little upstream of PUB's intake R41 for supply to Johor Bahru.

(3) PWD taps 5.8 Mld of water from the system of Res 8 (G. Pulai, PUB) and 104 Mld of water from the system of R41 (Johor, PUB), except for 115 Mld in 1983.

### 3.6.3 Water deficit

The water demand and supply balance was analysed at each intake for future years. Natural runoff at intake, and storage supplement/basin transfer by existing and on-going projects, constitute the supply. Demand includes domestic and industrial water demand, irrigation water demand and river maintenance flow. The analysis resulted in computed water deficits at each intake as summarized in Table 15. The estimated water deficit is generally small, but R31 Skudai, R32 Tebrau and R41 Johor + R42 Kg. Tai Hong show significant deficits. The water deficit at Kota Tinggi (R41 & R42) is illustrated in Fig. 9 as a balance between the supply and demand in 2005, assuming the hydrological conditions of the 22-year period from 1963 to 1984.

According to the results of simulation, water deficit was computed in six years out of the simulation period of 22 years at Kota Tinggi in 1985. The frequency increases to 15 years in 1995 and 21 years in 2005. The estimated mean deficit of $22.7 \times 10^6$ $m^3/y$ is concentrated in low flow period and it will affect significantly the socio-economic activities in Johor Bahru, Senai, Kulai and other adjacent urbanized areas. In order to remedy the situation, a water resources development work must be implemented urgently in the Johor river.

# 4. PROPOSED AND POTENTIAL DAMS AND BARRAGES

## 4.1 Basic Concepts

A site reconnaissance was carried out at each damsite which was identified on the 1/63,360 map. Land use and compensation studies were also conducted at the damsites and the proposed reservoir areas. After the initial studies mentioned above, nine dams were selected as possible water source facilities in the Region. In this selection, the topography of a damsite and use of land to be submerged by the proposed reservoir were taken into account. The locations of sites were also considered from the viewpoint of conveyance of water to the demand centers.

Sizing, design and cost estimates for the proposed Linggiu, Sayong and Sedili dams of higher priority were conducted at a pre-feasibility level. This study was carried out on the basis of various data such as the estimated runoff at the damsites in the period between 1963 and 1984, the estimated flood hydrographs, projected water demand up to the year 2005, 1/10,000 maps for the reservoir areas, 1/2,000 maps for the damsites, results of geological drilling at the damsites, the results of geotechnical surveys and tests, and results of land use surveys in the reservoir areas. For the remaining five damsites, the study was conducted at more preliminary level based on the results of field reconnaissance, 1/25,000 maps for damsites and reservoir area, 1/126,720 land use maps and 1/63,360 geological maps.

A damsite was identified on the Tebrau river but it was abandoned and is not discussed further, because it was discovered that the State Government would not consider the dam construction as land development schemes had been committed covering the proposed dam and reservoir sites.

At every proposed damsite, an earthfill dam is assumed mainly because of the poor availability of rock materials and the geological conditions for dam foundations. Features of damsite geology and construction materials at each damsite are described in detail in

ANNEX H and I. The unit price of construction was estimated on the basis of the actual costs of current dam projects in and around the Region. Land acquisition costs were evaluated by the Valuation Department of the State for each site. The assessed cost for oil palm plantations varies from M$16,000/ha to M$19,800/ha according to plantation, rubber plantations varies from M$12,500/ha to M$15,000/ha, and residential land from M$18,000/ha to M$80,000/ha. The costs obtained are presented in ANNEXES K and M. Preliminary features of possible source facilities are summarized in Table 16 and are described hereunder. The location of each damsite is shown in Fig. 6.

## 4.2 Benut Dam and Reservoir

The proposed Benut damsite is located on the Benut River 4 km upstream from Kg. Ulu Benut. The reservoir area extends over the northern part of the road that links Renggam with Simpang Renggam. The dam will contribute to the water supply in the Pontian district and a part of Kluang district.

The topography of the proposed reservoir area is gently undulating between EL. 15 m and EL. 60 m. The reservoir surface area is 7.0 $km^2$ comprising rubber plantation of 322 ha, oil palm of 379 ha and others if the water surface is set at EL. 31.1 m. There are three oil palm estates around the proposed reservoir area with total population of 1,359, but they will not be affected even if the Benut dam is implemented. Present land use is shown in Plate 2 and Table 17.

The reservoir area is underlain mainly by Triassic granite, whereas geology at the dam axis comprises sedimentary rocks such as shale, sandstone and others of Triassic age. A geologic map of the vicinity area of the damsite is shown in ANNEX H. According to the results of brief surface exploration, the soil to be used for the embankment is clayey silt and is abundant in the vicinity of damsite. The average annual inflow from the catchment area of 37 $km^2$ is estimated to be 33 x $10^6$ $m^3$. The effective storage capacity of the reservoir would be 18 x $10^6$ $m^3$ if the normal HWL is set at EL. 29.0 m.

At a conceivable maximum scale, the high water level of the reservoir would be at EL. 29.0 m with the gross storage capacity of 20 x $10^6$ $m^3$, a crest length of 2,000 m and an embankment volume of 1.9 x $10^6$ $m^3$ respectively. A plan of dam is shown in Plate 3.

The total investment cost of dam at the maximum scale is estimated to be M$99 x $10^6$: M$48 x $10^6$ for the cost of construction work and M$13 x $10^6$ for land acquisitions cost at 1985 price levels.

## 4.3 Pontian Besar Dam and Reservoir

The proposed Pontian Besar damsite is located on the Pontian Besar river 2.5 km northwest of Kg. Bukit Batu. The dam axis crosses the national highway going from Kulai to Ayer Hitam. The dam will contribute to the water supply in the Pontian district.

The reservoir surface area would be 13.5 $km^2$ comprising 316 ha of oil palm, 675 ha of rubber, 356 ha of forest and others if the water surface is set at EL. 27.3 m. Present land use is shown in Plate 4 and Table 18. In this case, 89 houses would have to be removed.

Base rocks at the damsite and reservoir area are formed of sedimentary rocks such as shale and sandstone and others of Triassic age. A geological map of the vicinity the proposed damsite is given in ANNEX H. Judging from the results of a field survey, silt-type soil material appears to be insufficient in quantity for an embankment.

This damsite has less priority than the Benut damsite due to foreseeable difficulties in land acquisition.

The average annual inflow from the catchment area of 40 $km^2$ is estimated to be 48 x $10^6$ $m^3$. The effective storage capacity of the reservoir would be 48 x $10^6$ $m^3$ if the normal HWL is set at EL. 25.5 m.

At the conceivable maximum scale, the high water level of the reservoir would be EL. 25.5 m with a gross storage capacity of 51 x $10^6$ $m^3$, a crest length of 2,700 m and an embankment volume of 3.1 x $10^6$ $m^3$. Plan of dam is shown in Plate 3.

The total investment cost of dam at the maximum scale is estimated at M$163 x $10^6$ including M$70 x $10^6$ for the cost of construction and M$35 x $10^6$ for land acquisition costs at 1985 price levels.

## 4.4 Linggiu Dam and Reservoir

The proposed Linggiu damsite is located on the Linggiu river 15 km upstream of the confluence of the Linggiu river and the Johor river. The dam will contribute to the water supply of Johor Bahru and Kota Tinggi districts. The width of low flow channel is 30 m and the width of valley bottom is about 50 m. The abutments at the damsite dip 29° on the left bank and 15° on the right bank.

The reservoir surface area would be 21.0 $km^2$ if the water surface is set at EL. 35.2 m. It is covered with natural forest of which 1,300 ha is forest reserve, and there is a tin mine area of 73 ha. The lease of the mine area is due to expire by 1986. The forest area of 4,828 ha in and around the proposed reservoir area is leased to Sindra, which is a subsidiary of KEJORA, for the period from 1975 to 1990. Sindra plans to end logging in the present leased area by 1989. Since whole area to be submerged is State land, no compensation costs including land acquisition costs are estimated. Only the economic value of forest needs to be considered. Present and future land use plans are shown in Plates 5 and 6 and Table 19.

Base rocks in the damsite and reservoir areas consist mainly of phyroclastics and lava, which belong to upper Permian age. Geology of the damsite consists of rhyolitic tuff and tuffaceous sandstone. The depth of river deposits is 10 m and the depth of overburden is about 10 m in the right abutment and 15 m in the left abutment. According to the results of core boring investigation which was carried out from November 1984 to January 1985, foundation rock at the proposed damsite shows rather high permeability. Permeability of intact rock at the damsite shows values ranging between 1 x $10^{-3}$ cm/s and 1 x $10^{-4}$ cm/s. The results of water pressure test in drill hole LG-3 on the right bank show that the foundation rock at the damsite has high permeability even at the stage of low water pressure such as 1 or 2 $kg/cm^2$ at a depth of 15 m from the original ground surface. This indicates the possibility that high water pressure would cause leakage after impounding of the reservoir. Furthermore, the groundwater level is 20 meters below the ground surface in drill hole LG-1 of the left bank and 13 meters in drill hole LG-3 in the right bank. This indicates the existence of an underseepage path which could cause a considerable loss of water and possibly failure of the dam. A geological map of the vicinity of the proposed damsite is given in Plate 7. A geological profile along the proposed dam axis is shown in Plate 8.

The average annual inflow from the catchment area of 206 $km^2$ is estimated to be 221 x $10^6$ $m^3$. An effective storage capacity of the reservoir of 107 x $10^6$ $m^3$ could supply 82 x $10^6$ $m^3$ of water if the normal HWL is set at EL. 34 m. In this case the embankment volume would be 0.85 x $10^6$ $m^3$ in total. It would be 32 m in the maximum height and 560 m in crest length as shown in Plate 9. The dam crest would be set at EL. 38 m. A concrete spillway section would be placed on the left bank. It would have a free overflow spillway with ogee crest of 30 m in length. Two lanes of circular diversion conduit would be constructed beside the spillway. These conduits would be used to provide two sets of river outlet, each having a hollow-jet-valve to regulate outflow.

A concrete diaphragm will be required under the dam body and along dam axis due to permeability of the foundation. The fractured zone, caused by faults, will have to be plugged with concrete. The spillway structure will be supported by a cast-in-place concrete pile system, because the foundation seems to be fractured and weathered to a great depth.

The investment cost for the Linggiu dam is estimated at M$ 132 x $10^6$ at 1985 price levels. No compensation costs such as land acquisition costs are included, since the whole area to be submerged is state owned land.

## 4.5 Upper Pengli Dam and Reservoir

The proposed Upper Pengli damsite is located on the Pengli river 10 km upstream from the confluence of the Pengli river and the Sayong river. The width of the low flow channel is about 10 m at the damsite. The abutments at the damsite slope at $12^{o}$ on the right abutment and $7^{o}$ on the left abutment. The dam will contribute to the water supply of Johor Bahru and Kota Tinggi districts as well as Singapore.

If the reservoir water level is set at EL. 43.1 m, the reservoir surface area will be 29.1 $km^2$ where the area of 1,850 ha is covered by forest and the oil palm plantation area of 1,060 ha. Present and future land use plans are shown in Plates 10, 11 and Table 20.

The site is underlain by semi-consolidated sand and sandy clay of Pleistocene to Pliocene age in both abutments of the damsite, but on the right bank of the reservoir area the geology is predominantly granite of Triassic age. A geological map was prepared for the vicinity of the proposed damsite and is given in ANNEX H.

Impervious earthfill material for the Upper Pengli dam can be obtained immediately downstream of the proposed damsite on the right bank. Soils occurring in the test pits were of silty sand and showing moderate plasticity. This material could be used for embankment works without special handling operations.

The average annual inflow from the 127 $km^2$ catchment was estimated to be 120 x $10^6$ $m^3$. The effective storage capacity of the reservoir would be 120 x $10^6$ $m^3$ if the normal HWL is EL. 41 m. A plan of dam is shown in Plate 3.

The dam would be an earthfill dam 33 m high, 2,200 m in crest length, and 2.8 x $10^6$ $m^3$ in total embankment volume.

The total investment cost for the Upper Pengli dam at the maximum scale is estimated at M$181 x $10^6$ comprising M$83 x $10^6$ for the costs of construction work, and M$35 x $10^6$ for land acquisition costs at 1985 price levels.

## 4.6 Sayong Dam and Reservoir

The proposed Sayong damsite is located on the Sayong river 0.5 km upstream from the confluence of the Sayong river with the Linggiu river. The width of the low flow channel is about 20 m, while the width of the valley bottom is 200 m. The dam will contribute to the water supply system in Johor Bahru and Kota Tinggi districts as well as Singapore.

If the reservoir water level is set at EL. 20.1 m, the reservoir surface area will be 43.0 $km^2$ which would submerge a rubber plantation of 203 ha and an oil palm area of 1,853 ha. Present and future land use plans are shown in Plates 12, 13 and Table 21.

The geology in the proposed damsite and reservoir area consists mainly of granite overlain by sand and sandy clay of Pleistocene age and sandstone of Mesozoic age. According to the results of a field reconnaissance survey and GSD geological map, there are no faults in the vicinity of the damsite. Boring results showed that there is fresh foundation rock of granite in the left abutment while heavily weathered granite was found at the right abutment. A geological map of the vicinity of the proposed damsite is given in Plate 14. A geological profile along the proposed dam axis is shown in Plate 15.

Impervious earthfill material can be obtained from the residual soil underlain by the weathered granite. Residual soil occurs uniformly over a vast area on both banks with a minimum thickness of 5 m. The results of test pit surveys at the damsite attested to the soils being silty sand and gravel or sandy silt. These soils are suitable for an earthfill embankment.

The 662 $km^2$ catchment area is by far the largest among the proposed damsites and the average annual inflow is estimated to be 567 x $10^6$ $m^3$. An effective storage capacity of the reservoir of 128 x $10^6$ $m^3$ can supply 107 x $10^6$ $m^3/y$ of water if the normal HWL is set at EL. 18 m.

The dam would be an earthfill dam 31 m high and 1,140 m in crest length of 0.81 x $10^6$ $m^3$ in total embankment volume as shown in Plate 16. The dam crest is set at EL. 25.5 m.

A concrete spillway section would be provided on the left bank of the dam. The spillway would be of a free overflow type with ogee crest of 50 m in length.

Two lanes of circular diversion conduit would be constructed beside the spillway. These conduits would be used to provide two sets of river outlet each having a hollow-jet-valve to regulate outflow to meet fluctuating demand.

The reservoir would submerge a wide area, which has already been developed as agricultural land or urban land by FELDA, FELCRA and private enterprises.

The total investment cost for dam is estimated at M$132 x $10^6$ including M$35 x $10^6$ of the cost for main construction works and M$55 x $10^6$ of land acquisition cost at 1985 price levels.

## 4.7 Telor Dam and Reservoir

The proposed Telor damsite is located on the Telor River 6 km upstream from the confluence of the Telor river and Johor River. The width of low flow channel is 5 m. The dam is proposed for supply of water to Johor Bahru and Kota Tinggi districts.

The 11.4 $km^2$ reservoir surface area would flood 50 ha of oil palm area and 1,087 ha of forest if the reservoir surface is set at EL. 29.6 m. Present land use is shown in Plate 17 and Table 22. In the reservoir area there are no public works and no future regional development scheme to compensate.

The geology in the proposed reservoir area is mainly of granite of Triassic age and of alluvium along the river course. No subsurface investigation has been carried out. A geological map of the vicinity of the proposed damsite is given in ANNEX H. Soils suitable for earthfill dam construction are abundant in and around the proposed damsite.

The annual inflow from the 38 $km^2$ catchment area is estimated to be 43 x $10^6$ m3. The effective storage capacity of the reservoir would be 46 x $10^6$ $m^3$ for a normal HWL of EL. 28 m. A plan of the dam is shown in Plate 18.

The dam would be earthfill dam 29 m high and 2,200 m in crest length of 0.9 x $10^6$ $m^3$ in total embankment volume.

The total investment cost of dam at the maximum scale is estimated at M$65 x $10^6$ comprising M$31 x $10^6$ for the costs of construction works and M$7 x $10^6$ for land acquisition costs at 1985 price levels.

## 4.8 Sedili Dam and Reservoir

The proposed Sedili damsite is located on the Sedili Besar River at 3 km upstream from the bridge over the river on the national highway linking Kota Tinggi and Mersin. The width of the low flow channel is 30 m at the dam axis. The abutment at the damsite slopes $13^{o}$ on the right abutment and $16^{o}$ on the left abutment.

Dam is proposed to meet the future water demand of Johor Bahru and Kota Tinggi districts by means of a trans basin diversion.

The reservoir surface area will be 21.4 $km^2$, where almost all the area is covered with forest including planted forest if the water surface is set at EL. 21.1 m. Present land use is shown in Plates 19, 20 and Table 23.

The geology in the reservoir area is mainly of phyllite, sedimentary rocks, acidic to intermediate pyroclastics and lava of Permian age, granite of Triassic and other younger deposits. A few faults striking N-S and NW-SE run through the area. The permeability of the clayey zone accompanied by the faults is judged to be insignificant. A geological map of the vicinity of the damsite is given in Plate 21. A geological profile along the proposed dam axis is shown in Plate 22.

Impervious earthfill material for the Sedili dam can be obtained from the residual soil and heavily weathered phyllite, which occur around the damsite. Abundant reserves of the earthfill material could be expected. Laboratory soil test results show that the in-situ moisture content is higher than the optimum content of 20% by 5 to 15 points. The material occurring at the damsite can be considered to be suitable as the impervious material for an earthfill dam after drying.

The average annual inflow from the 224 $km^2$ catchment area is estimated to be 278 x $10^6$ $m^3$. The effective storage capacity of the reservoir of 61 x $10^6$ $m^3$ could supply 46 x $10^6$ $m^3$ of water if the normal HWL is set at EL. 20 m.

The dam would be an earthfill dam 32 m high and 485 m in crest length of 0.67 x $10^6$ $m^3$ in total embankment volume as shown in Plate 23. The dam crest is set at EL. 25 m.

A concrete spillway section is proposed on the left bank of the dam. The spillway would be of a free overflow type with an ogee crest 50 m in length. Two lanes of circular diversion conduit would be constructed beside the spillway. These conduits would be used to provide two sets of river outlet each having a hollow-jet-valve to regulate outflow to meet fluctuating demand.

The total investment cost for dam is estimated at M$61 x $10^6$. Since whole area to be submerged belongs to the State, no land acquisition costs have been included in this case.

## 4.9 Layau Kiri Dam and Reservoir

The Layau Kiri proposed damsite is located on the Layau Kiri river 10 km upstream of the confluence of the Layau Kiri river and the Lebam river. The width of low flow channel is 5 m at the dam axis. The width of the valley bottom is 800 m. The dam is proposed to supply water to Kota Tinggi district.

The proposed reservoir area is almost all covered with oil palm plantation managed by FELDA. At a water level of EL. 23.8 m, the reservoir surface area becomes 7.1 $km^2$. Present land use is shown in Plate 24 and Table 24.

The geology of the damsite and reservoir area is wholly of granite of Triassic age and subordinate alluvium along the river course. A saddle dam is necessary on the Semenchu river as well as a main dam on the Layau Kiri river. The abutment of the main damsite have moderately gentle slopes covered with thick overburden. It is inferred that excavation for foundations of an earthfill dam will be much as 10 m deep. A geological map of the vicinity of the damsite is given in ANNEX H.

From a brief surface exploration it would appear that there would be ample soil for use as earthfill.

The average annual inflow from the 31 $km^2$ catchment area is estimated to be 37 x $10^6$ $m^3$. The effective storage capacity of the reservoir would be 37.5 x $10^6$ $m^3$ if the normal HWL is set at EL. 22 m.

For HWL at EL. 22 m, embankment volumes would be 1.3 x $10^6$ $m^3$ for the main dam and 0.64 x $10^6$ $m^3$ for the sub dam. A plan of dam is shown on Plate 18.

The total investment cost of the dam at the maximum scale is estimated at M$117 x $10^6$ comprising M$53 x $10^6$ for the costs of construction works and M$19 x $10^6$ for land acquisition cost at 1985 price levels.

## 4.10 Other Alternative Sources Development Plan

To create a reservoir by constructing a dam is an effective way to meet water deficit. An estuary barrage is a useful alternative structure to impound water to meet the required water demand.

The Layang Scheme Phase Ic has been planned to develop 33.2 x $10^6 m^3/y$ (20 Mgd) to supply Johor Bahru, Masai and Pasir Gudang by 1990. According to the report entitled "Johor Bahru New Water Supply Scheme" prepared for PWD, an estuary reservoir with a storage capacity of 45 x $10^6$ $m^3$ could be created by constructing a 7 km long coastal barrage, which would impound water from the Layang, Penderam and Serai rivers. In the report, the estimated construction cost of Scheme Ic would be M$38,790,000 at mid 1983 prices levels. It is anticipated that there would be some problems to be solved such as water pollution, desalination and inland drainage before the scheme could be implemented.

The Study Team made a map study and a field reconnaissance to find a possible estuary barrage site. Apart from the coastal area where the Layang Scheme Ic is planned, possible sites are found along the coastline of Johor Straits to the southeast of Johor Bahru. The most promising site for an estuary barrage is located near Kg. Pendas Laut at the mouth of the Pendas river which has catchment area of 20 km2 at that point. The Pendas river basin has been developed for rubber and oil palm plantations, however the riverbottom which would be submerged is mostly covered with mangrove trees. Topographically this site is suitable for an estuary barrage, because there are existing roads are located on either side of the river mouth as if they form natural dikes. Embankment material for coastal dikes can be obtained near the site. Although the area of Pendas river basin is small as compared with other alternative schemes, an estuary barrage at this site could create a reservoir with a gross storage of 15 x $10^6$ m3 at an investment cost of M$71 x $10^6$ comprising M$48 x $10^6$ for the costs of construction works and M$7 x $10^6$ for land acquisition costs. This reservoir could be used to meet the small local demand on west coast. There would be some problems to be solved such as water pollution and desalination as in the case of the Layang Scheme Phase Ic.

On the Johor river it would be possible to construct a barrage and an intake near Seng Heng, some 3 km downstream of the highway bridge in Kota Tinggi town. It would enable water to be used which otherwise could not be abstracted. The runoff from upstream of R41 often exceeds the intake capacity of R41 and the excess water is wasted. The proposed intake at Seng Heng would abstract part of that excess water. It also will abstract the runoff from the remaining catchment area of 90 $km^2$ between R41 and Seng Heng. The barrage is expected to lessen the necessary river maintenance flow from 2.6 $m^3/s$ to 1.2 $m^3/s$ at the barrage site. The saving of 1.4 $m^3/s$ (121 Mld) could be abstracted and used. Among these abstraction enabled by the provision of a barrage and an intake, only the saving of the river maintenance flow might be considered as the contribution of the barrage because the barrage will create no storage since it would not be allowed to raise the water level in the upstream reach. A reservoir operation study showed that this saving would be equivalent to the deficit supply of 22 x $10^6$ $m^3/y$.

Kota Tinggi town is the center of Kota Tinggi district and is expected to be one of the most rapidly developing towns in the Region. The town has been flooded from time to time and a flood mitigation plan is herein recommended Study adopting a 30-year flood as the design discharge for the urgent works. The flood mitigation work will be up-graded with the development of the objective area and it was assumed that the barrage should be planned not to worsen the present flood situation in Kota Tinggi town against 100-year flood or the discharge of 970 $m^3/s$ during or after the construction.

The barrage is proposed on a bend to the south of the existing river channel. An open cut channel with width of 124 m would shortcut the bend and divert water from the existing channel to the barrage and outlet to the existing channel again. Control gates and a double leafs regulation gate would be provided together with hoist. The existing river channel would be plugged by a dam of 700 m in length. The dam would be connected with the left abutment of the barrage.

The total investment cost of the barrage was estimated at M$67 x $10^6$ including the direct costs of M$37 x $10^6$.

The provision of a barrage would cause some complicated problems. Such as those are summarized below:

(1) Since the barrage would close the estuary, adverse effect on ecosystem would be expected especially on fish fauna.
(2) Navigation in the Johor river would be disturbed.
(3) Failure in gate operation of barrage would cause an increase in the flood hazard in Kota Tinggi.
(4) The groundwater table in the upstream reach may be elevated. Thereby drainage condition would be worsened.
(5) The discharge capacities of tributaries in the upstream reach will be reduced.
(6) The sewerage outlet of Kota Tinggi town would have to be located downstream from the barrage.

# 5. WATER DEMAND AND SUPPLY BALANCE PLAN

## 5.1 Concept of Plan Formulation

The Rivers in the Region, except for the Johor river, Tebraw river and Skudai river, are expected to be able to satisfy the water demand loaded on them up to 2005 with minor failures even under the driest hydrological condition experienced in 1971. All the water in the Skudai and Tebrau rivers are granted to Singapore by the existing Indenture deverlopment was studied. Consequently no water resources development plan was considered in this Study except for the Johor river.

A water demand and supply balance study revealed that a considerable water shortage will take place in the Johor river and the augmentation of river runoff by construction of dams and reservoirs or estuary barrages will be necessary.

Risk of safe supply is a factor in balancing water demand and supply. Water can be supplied to a wide area, if a large risk is accepted, but there is a limit to which the risk can be endured by the water users.

A water demand and supply balance plan should be based on a target of safe supply, which is expressed by some parameters representing the risk of safe supply. Referring to design criteria for domestic and industrial water supply projects in Malaysia, it is assumed that the target should be that the safe supply should be guaranteed even in the driest period under hydrological conditions of the 22-year period between 1963 and 1984.

Since the State of Johor and SCC are bound by the Deed with regard to the water usage of the Johor river, the stipulations of the agreement have been observed in this planning. Accordingly, though the SCC's maximum abstraction is set at 728 Mld or 160 Mgd up to 2005, SCC are entitled to abstract up to 250 Mgd after 2005. However water