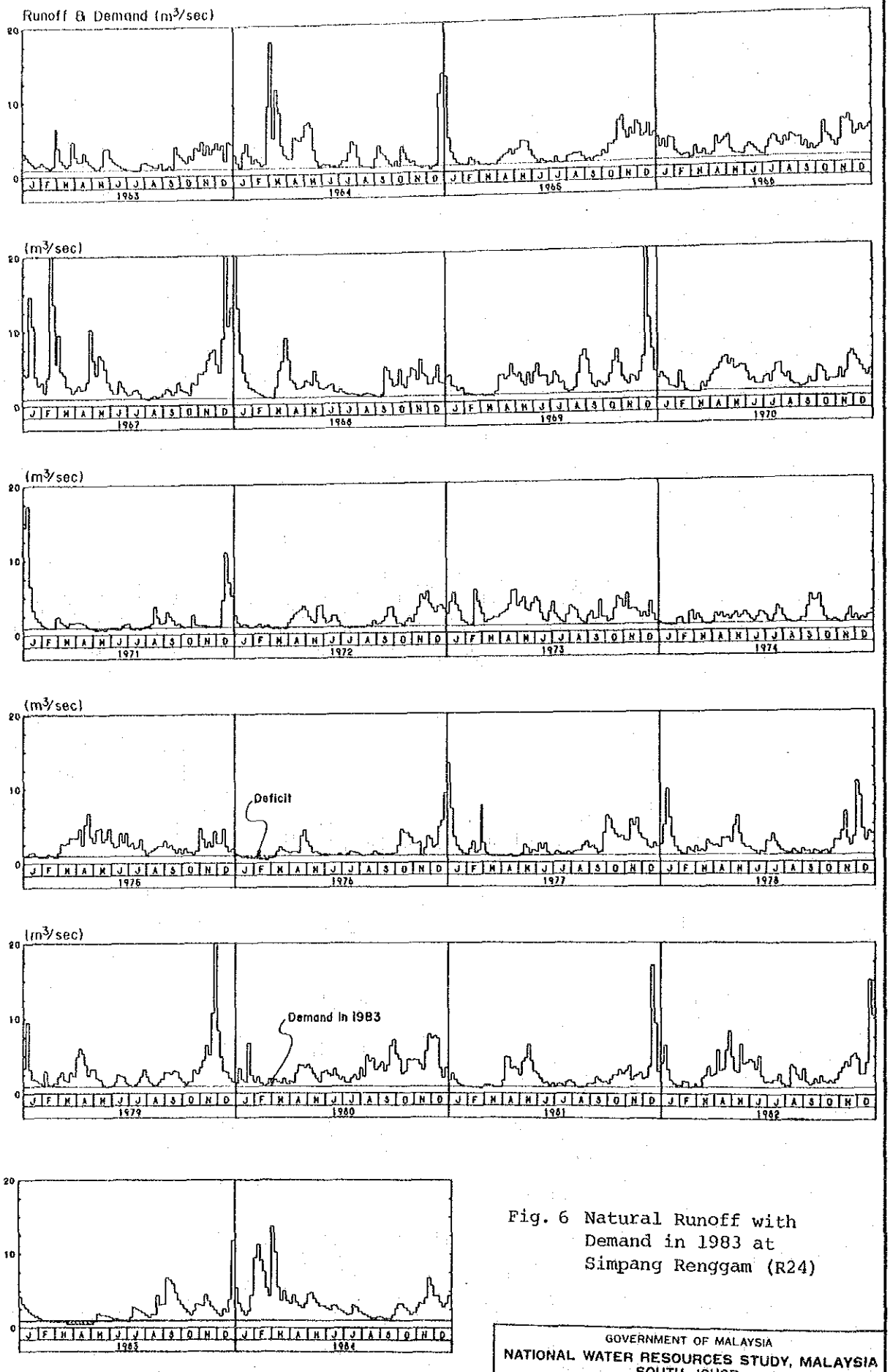

Fig. 6 Natural Runoff with Demand in 1983 at Simpang Renggam (R24)

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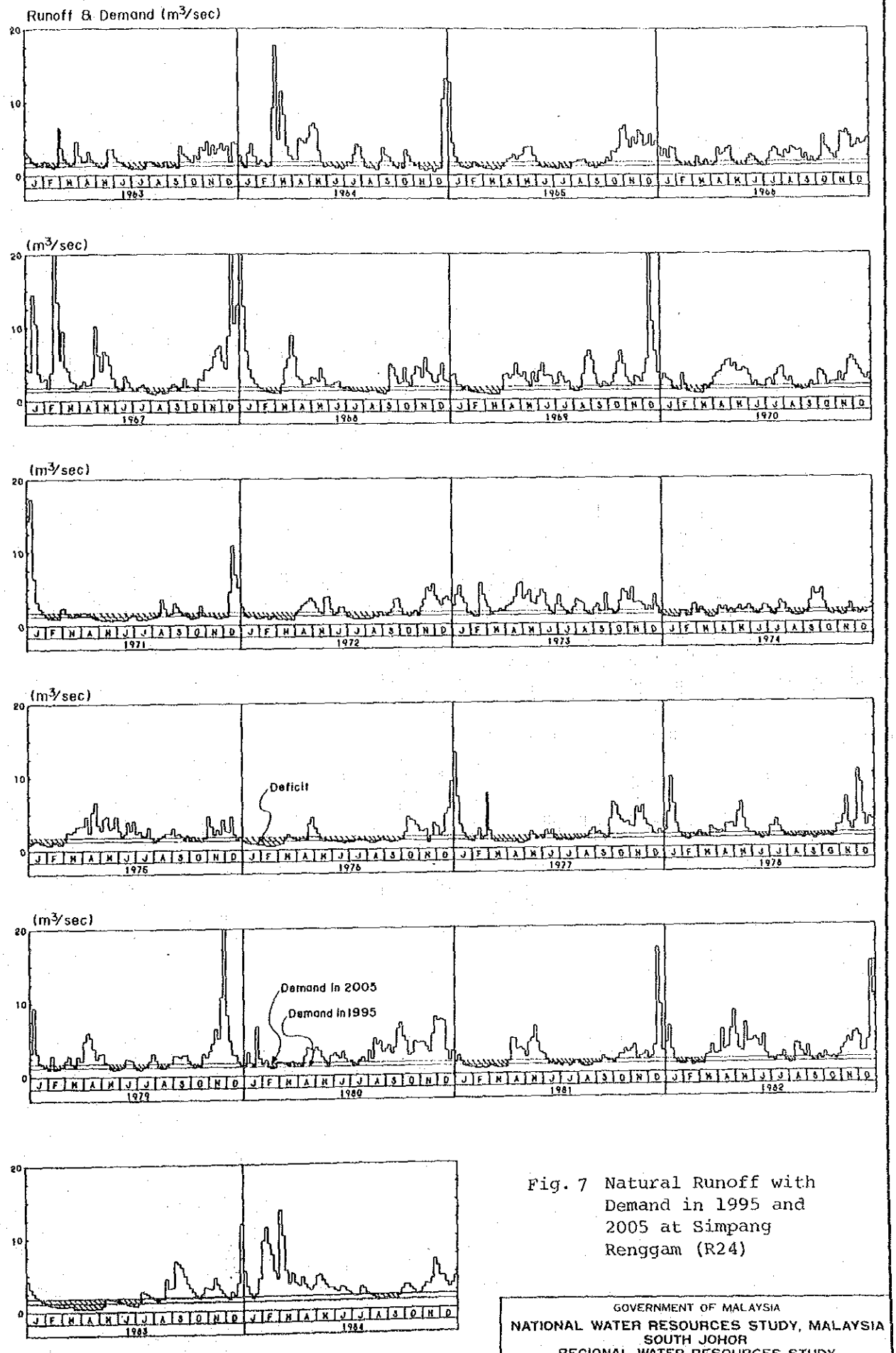

Fig. 7 Natural Runoff with Demand in 1995 and 2005 at Simpang Renggam (R24)

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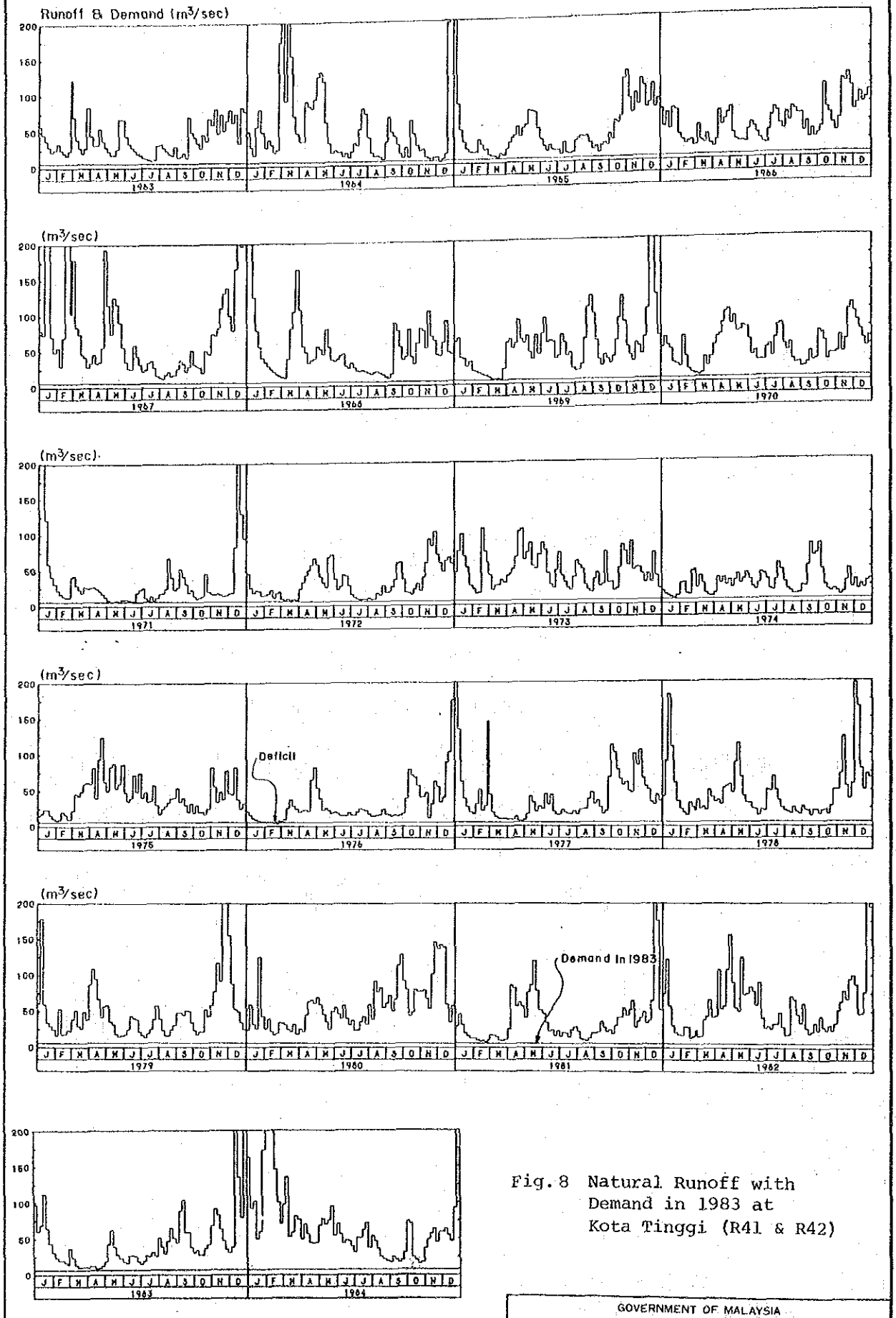

Fig. 8 Natural Runoff with Demand in 1983 at Kota Tinggi (R41 & R42)

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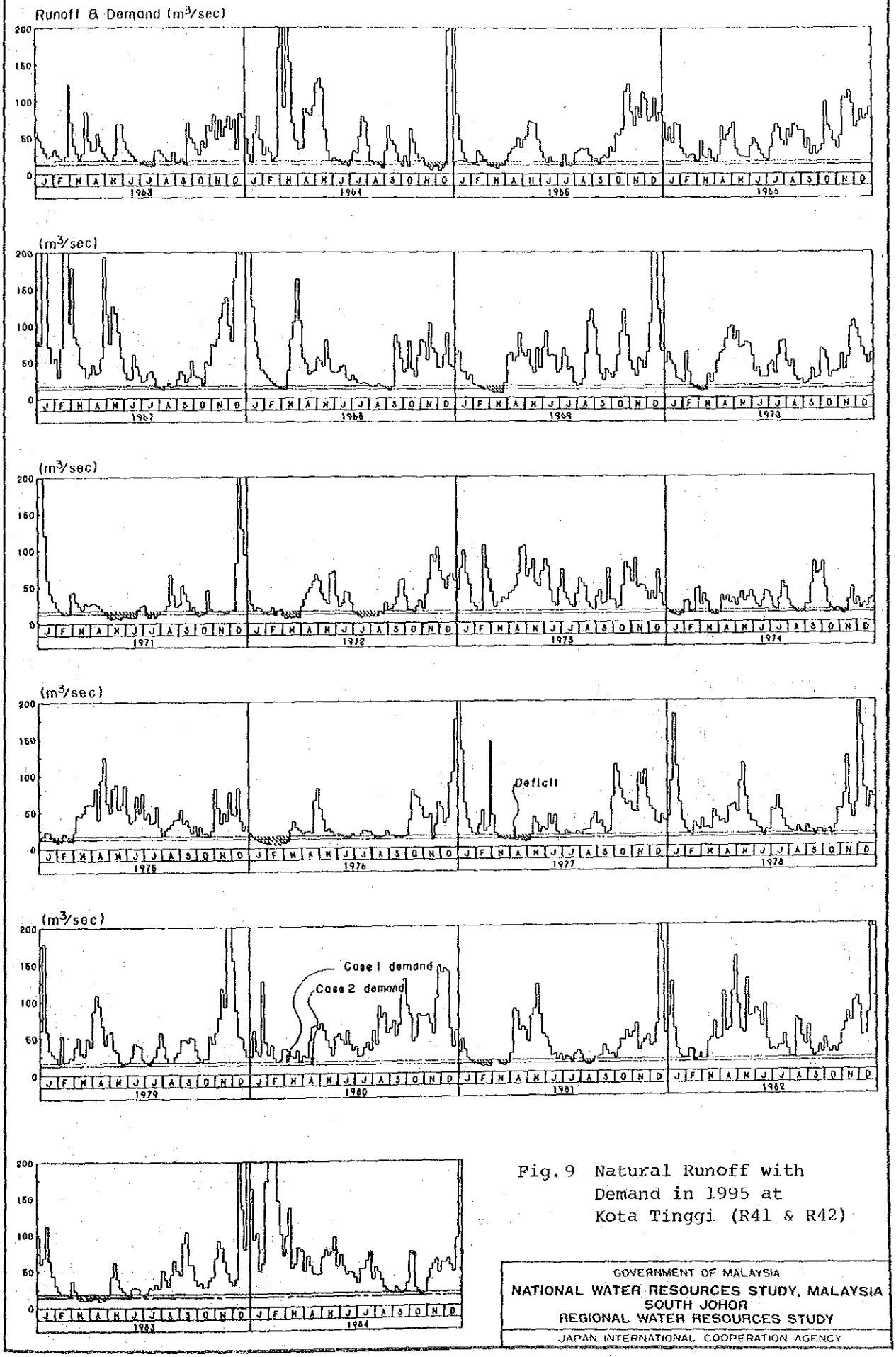

Fig. 9 Natural Runoff with Demand in 1995 at Kota Tinggi (R41 & R42)

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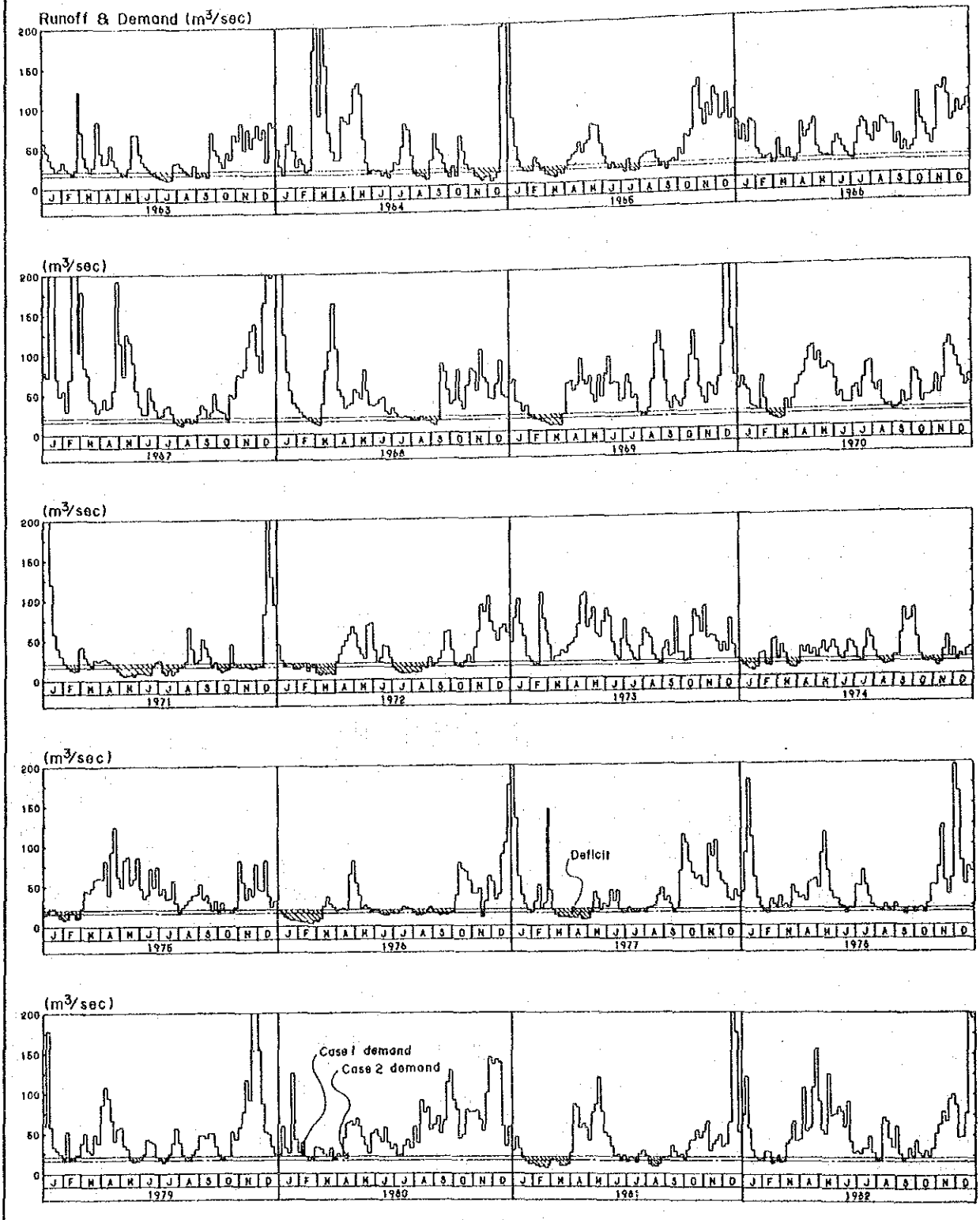

Fig.10 Natural Runoff with Demand in 2005 at Kota Tinggi (R41 & R42)

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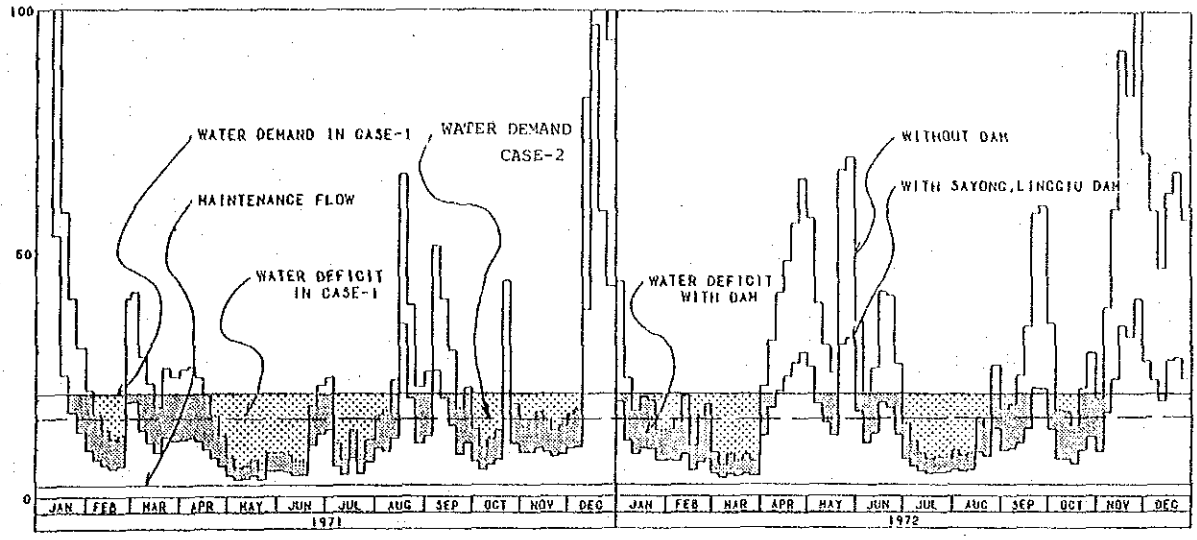
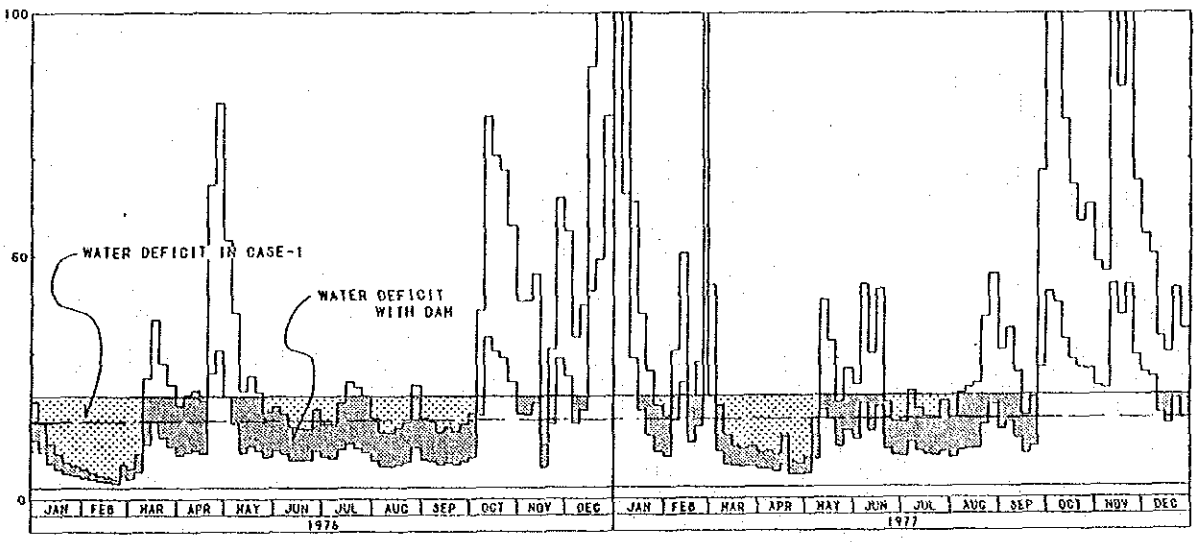
Hydrological condition of 1971-1972



Hydrological condition of 1976-1977



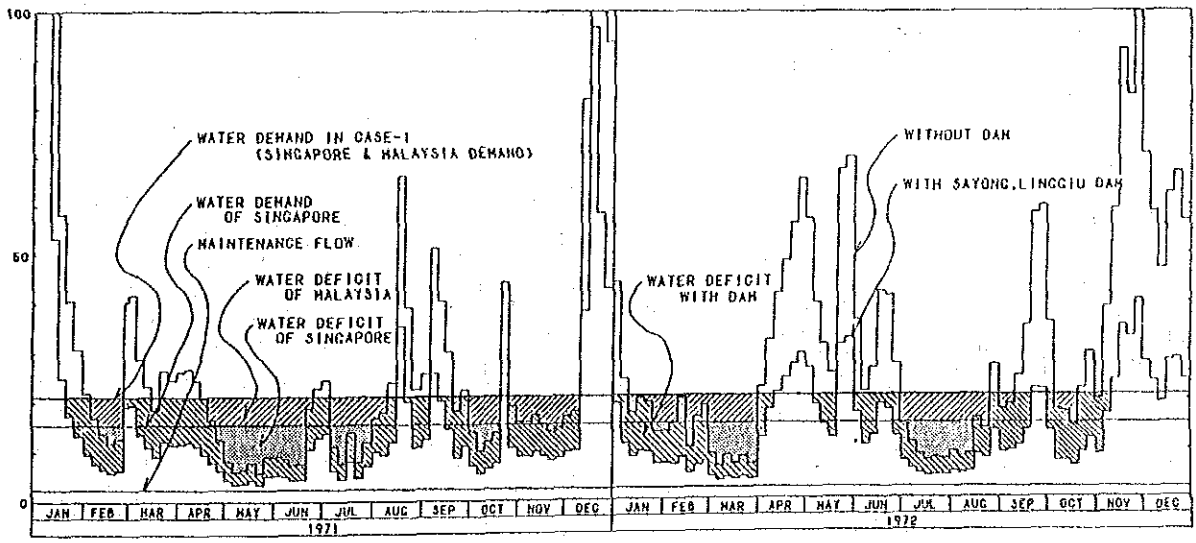


Fig. 11 Water Blance at Kota Tinggi against Water Demand in 2005

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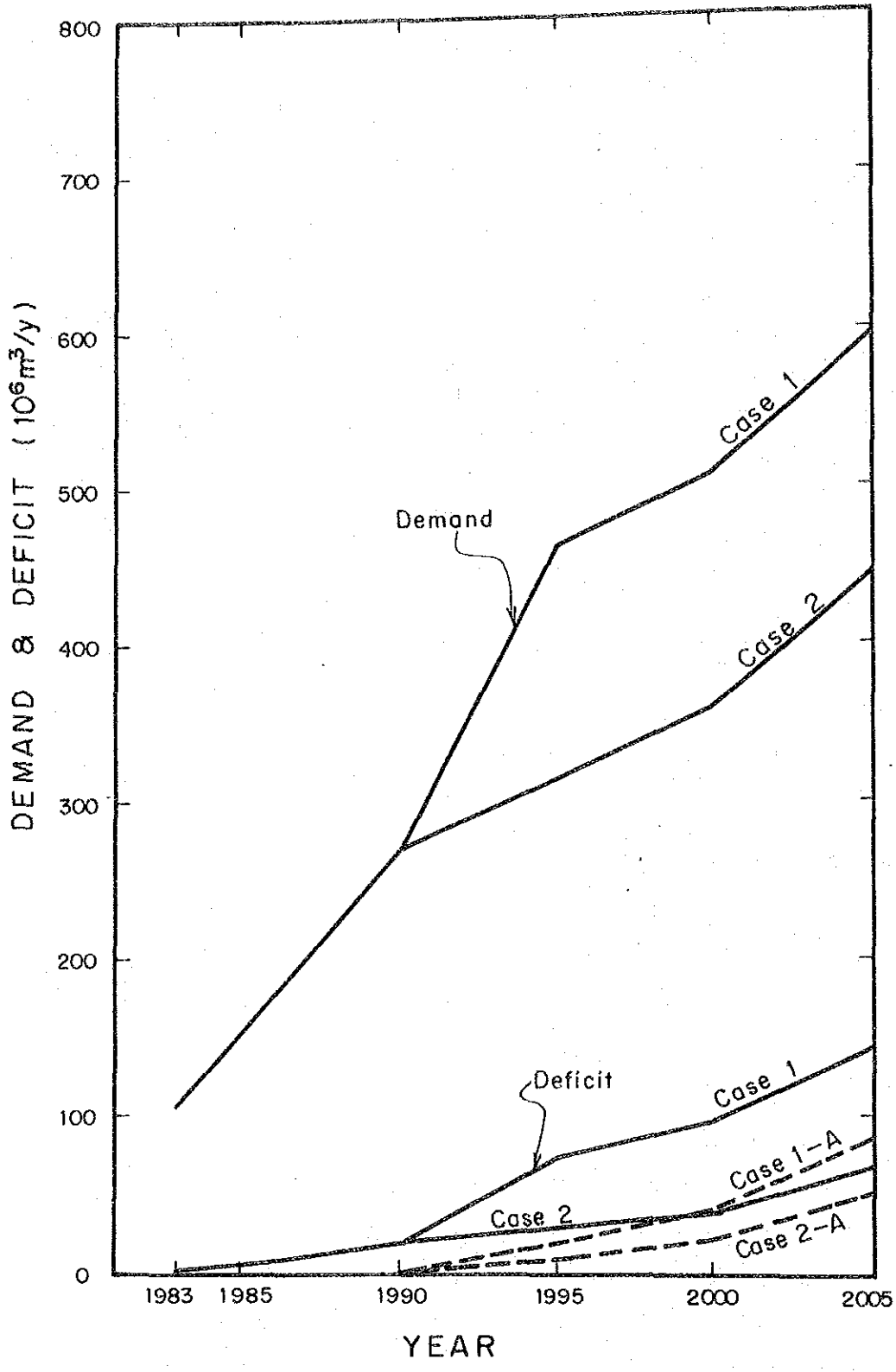

Fig. 12 Water Demand and Deficit at Target Year

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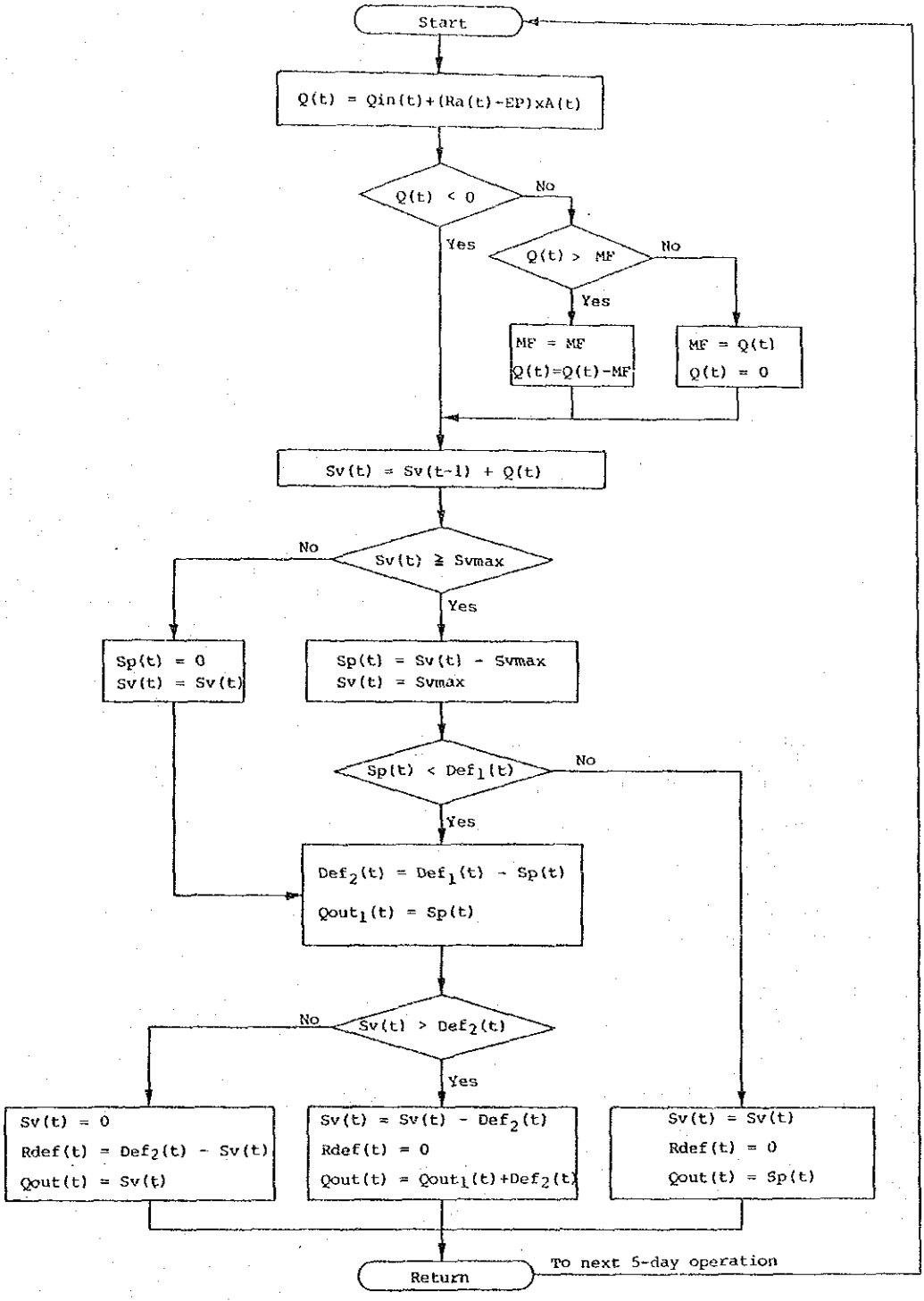

Remarks,
- $Q_{in}(t)$: Inflow volume to reservoir from river channel
- $Ra(t)$: Precipitation falling into reservoir
- $Q(t)$: Total inflow volume to reservoir
- EP : Evaporation
- $A(t)$: Water surface area of reservoir
- MF : Maintenance flow
- Q_{out} : Outflow from dam
- $S_v(t)$: Remaining effective storage volume
- $S_{v\ max}$: Effective storage volume
- $Sp(t)$: Overflow from spillway
- $Def(t)$: Water deficit
- $R_{def}(t)$: Remaining water deficit

Fig. 13 Flow Chart of Reservoir Operation

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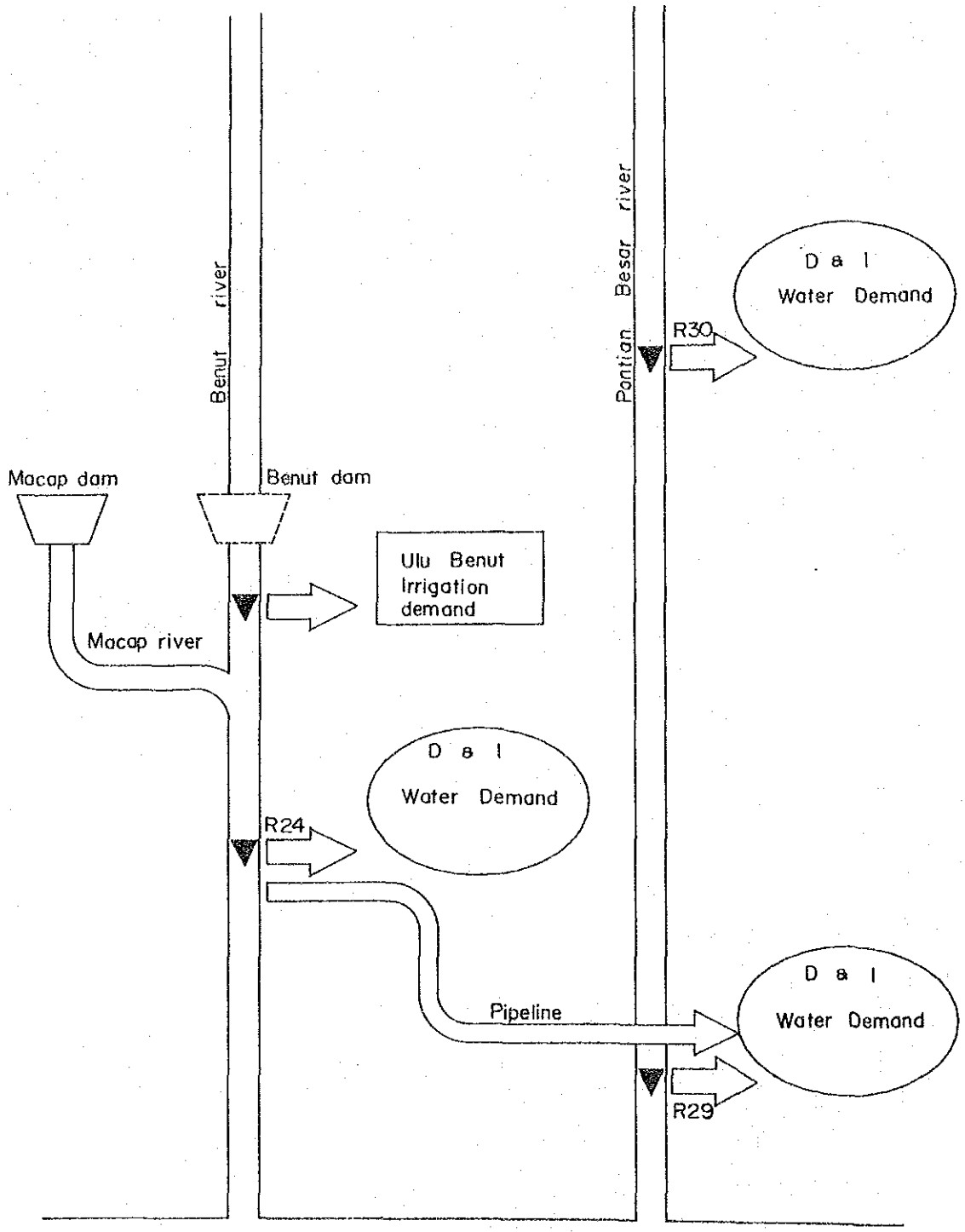

Fig. 14 Schematic Model of Reservoir Operation in Benut River.

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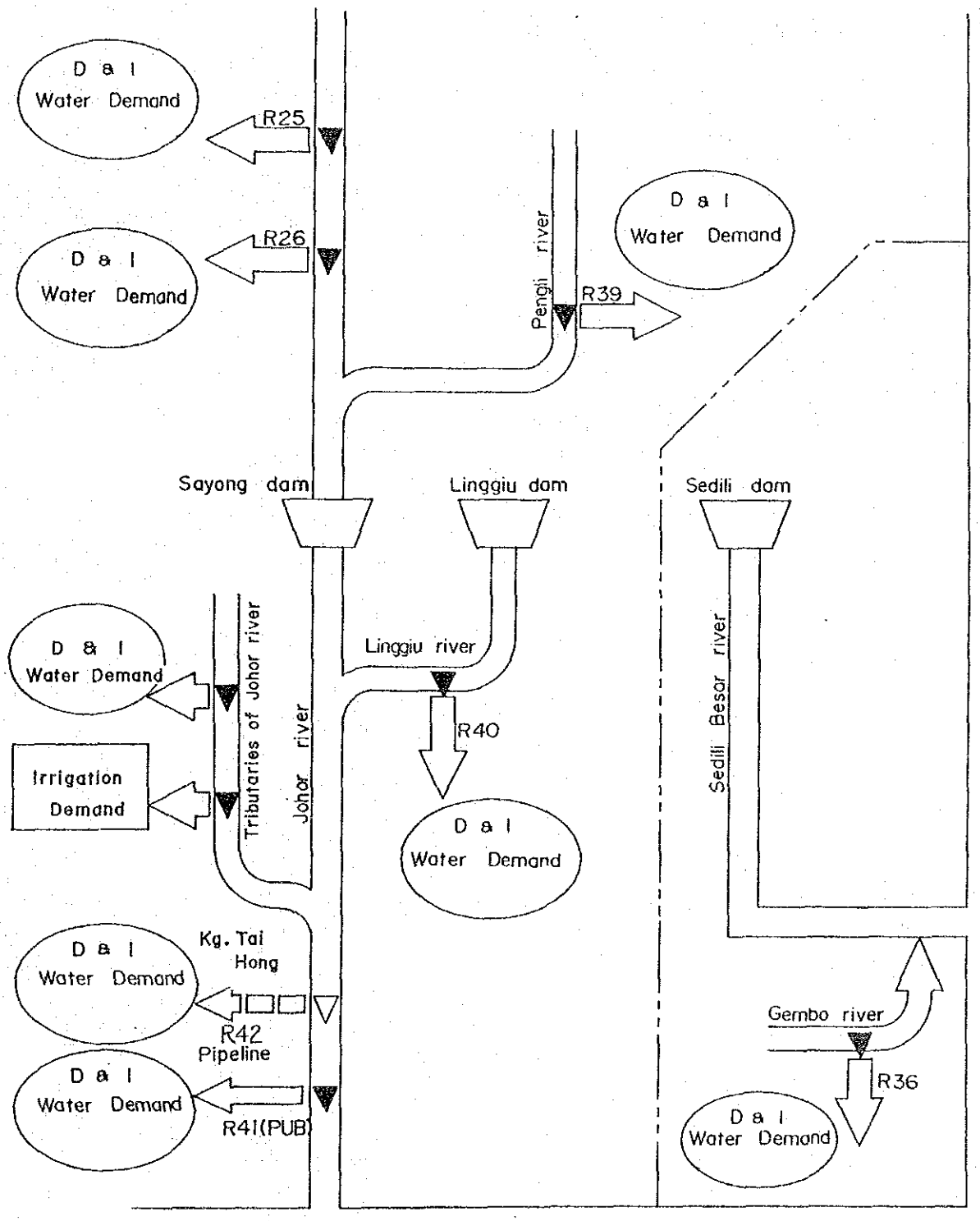

Fig. 15 Schematic Model of Reservoir Operation in Johor River

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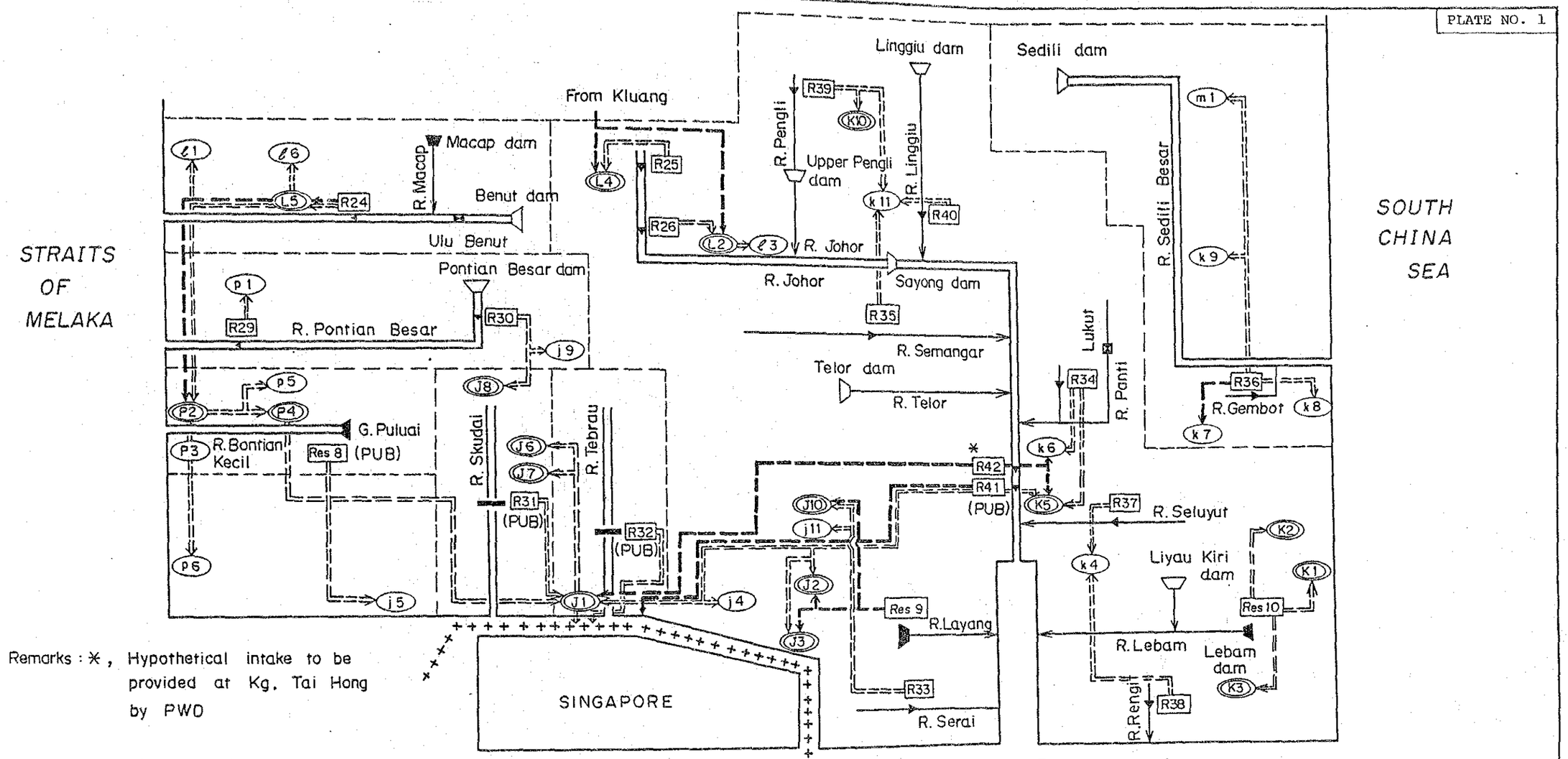
PLATES

PLATE NO. 1



Remarks : ✳, Hypothetical intake to be provided at Kg. Tai Hong by PWD

LEGEND

Main Stream	Dam in Operation
Tributary	Dam Proposed
Existing Pipeline	Barrage for Domestic and Industrial Water
Proposed Pipeline	Intake for Domestic and Industrial Water
Boundary of River Basin	Intake for Irrigation
Demand Center (Town)	No. of Intake for Domestic and Industrial Water
Demand Center (Lural)	

Name of Town and Mukim of Demand center

Name of District

Johor Bahru

- J 1 Johor Bahur
- J 2 Masai
- J 3 Pasir Gudang
- j 4 Johar Bohur Tebrau Pelentong
- j 5 Pulai, Tg. Kupang
- J 6 Kulai
- J 7 Senai
- J 8 Kelapa Sawit
- j 9 Senai Kulai, Sedenak
- J10 Ulu Tiram
- j11 Sg. Tiram

Kota Tinggi

- K 1 Bandar Penawah
- K 2 P4
- K 3 P7
- k 4 Johor Lama, Pantai Timur Pengerang
- K 5 Kota Tinggi
- k 6 Kota Tinggi
- K 7 P2
- k 8 Sedili Kecil
- k 9 Ulu Sg. Sedili Besar, Sedili Kambang
- K10 Bandar Tenggara
- k 11 Ulu Sg. Johor

Pontian

- p 1 Api Api, Benut
- Ayer Baloi
- Sg. Pinaggan
- P 2 Pontian Kecil
- k 3 Pontian, Rimba Terjun
- P 4 Pekan Nanas
- k 5 Jeram Batu
- k 6 Ayer Masin, Serkat Sg. Karang

Kluang & Mersing

- ℓ 1 Ulu Benut, Macap
- L 2 Layang Layang
- ℓ 3 Layang Layang
- L 4 Renggan
- L 5 Simpang Renggam
- ℓ 6 Renggam
- m 1 Mersing

Water Demand and Supply System

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ANNEX K
DESIGN AND COST ESTIMATE OF PROPOSED DEVELOPMENT PLAN

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1. INTRODUCTION

The Annex presents proposed development plan, design of water resources facilities, and a summary of the assumed construction schedule and cost estimate of the proposed facilities.

In the Preliminary Draft Final Report, the results of four case studies revealed the superiority of the Case 1 from economical viewpoints. However both the Federal and the State Governments of Malaysia adopted the Case 2 to establish the regional water resources development master plan to avoid influence of future uncertainty of water abstraction by PUB.

2. PROPOSED DEVELOPMENT PLAN

2.1 General

At the inception stage of the Study, nine dams and two barrages were identified as the water source facilities and four cases of basic water resources development concept were determined by the Steering Committee held on October 12, 1984, for further study. These study cases were due to uncertainty of future water abstraction from the Johor river by PUB. Four study cases are as follows:

Case 1: The abstraction by the PUB will reach 266 x 10^6 m^3/y or 160 Mgd in 1990 and 415 x 10^6 m^3/y or 250 Mgd in 1995. After 1995, the abstraction is kept constant of 250 Mgd up to 2005. The water resources and supply facilities are to meet water demand in both the State and Singapore.

Case 1a: The abstraction amount is the same as that in Case 1. However, water resources facilities are developed only to secure the water supply to the State of Johor but water deficit of Singapore is not looked after.

Case 2: The abstraction by the PUB will reach 160 Mgd in 1990. After 1990, the abstraction is kept constant of 160 Mgd. The water resources and supply facilities are developed to meet the water deficits of both the State and Singapore.

Case 2a: The abstraction by the PUB is the same as that in Case 2. However, water resources and supply facilities are developed only to secure the water supply to the State of Johor but water deficit in Singapore is not looked after.

The location and condition of source facility sites are shown in Fig. 1 and Table 1.

2.2 Proposed Development Plan

2.2.1 Case study

As aforementioned four cases are assumed to establish water supply plan in the Region. The simulation study on water demand and supply system is carried out to find water deficit in the target year 2005. The results revealed that serious water deficit would occur only in the central region that consists of a group of cities and towns such as Johor Bahru, Kulai, Senai, Kota Tinggi and small communities. So the water resources planning has been concentrated on the said region.

2.2.2 Selected case

The case study is resulted in the comparison of economic construction cost for each alternative. Table 2 shows the development alternatives and their economic construction cost with ranking among the options. Selected alternatives in each case are as follows:

Case	Combination of dam	Economic Cost in 1986 ($M\$10^6$)
Case 1	Sayong (HWL 18) + Linggiu (HWL 31)	113.9
Case 2	Sayong (HWL 17)	75.6
Case 1-A	Sayong (HWL 18)	82.3
Case 2-A	Sayong (HWL 16)	69.3

2.2.3 Stage development and enlargement of the dam

As mentioned above Case 2 is selected for the master planning at the said Steering Committee meeting. In the condition of Case 2, the Sayong dam with high water level (HWL) of El. 17 m can sustain water demand by 2005. However the optimum scale of the Sayong dam is found at the scale with high water level of El. 18 m as studies in the ANNEX L. From the view point to develop the dam upto its optimum scale, the stage development of the Sayong dam was studied in estimating the economic construction cost in two stages.

Table 3 shows the cost of additional construction works to enlarge the dam in the future; the year of second stage construction is assumed as 2006, next year of the target year. Estimated economic cost for dam enlargement from the scale with HWL 17 m to the scale with HWL 18 m are; the cost of M$0.81 x 10^6 which will be included in the first stage construction for the base of enlargement, and the cost of M$0.12 x 10^6 for the second stage in 1986 time basis.

Because the cost of the Sayong dam with HWL 18 m is equivalent to the sum of the cost of the scale at HWL 17 m and of additional enlargement cost, it is concluded that the construction of the Sayong dam with HWL 18 m is recommendable and preferable from economic view point.

2.2.4 Recommended plan

As mentioned above, four case studies were carried out and eventually the Case 2 was selected in establishing the regional water resources master plan. Several options, in other words combination of dams are considered to meet the demand in the target year 2005. To evaluate options accurately, least cost criteria is applied on the same time basis at 1986. Also concept of economic cost is applied to each development scheme.

Finally, the development scheme of the Sayong dam with high water level of El. 18 m and water supply facilities with supply capacity of 107 Mgd, which is the required supply capacity in 2005, are recommended. The principal features of the proposed plan are shown in Table 4.

2.3 Major Facilities to be Developed

2.3.1 Dam

To meet water demanD in the Region in 2005, the construction of Sayong dam with high water level of El. 17.0 is required by 1991. However, through the economic comparison of the alternative development scales, eventually the construction of Sayong dam with high water level of El. 18.0 m is recommended in the light of developing its potentiality upto optimum scale. The proposed dam is an earthfill dam of 808,000 m^3 in total embankment volume. It is 31 m in the maximum height and 1,140 m in crest length. The dam crest is set at El. 25.5 m. The principal feature of dam is shown in Table 4.

A concrete spillway section is placed at the left bank of the dam. The spillway is of a free overflow type with orgee crest of 50 m in width. Two lanes of circular diversion conduit are constructed beside the spillway. Both of the conduit are utilized for installing two sets of river outlet having a hollow-jet-valve to regulate outflow.

Principal features of dams selected in case study are shown in Table 5 and plan of Sayong dam is shown in Plate 1.

2.3.2 Intake and water treatment plant

The intake site is selected through reconnaissance survey along the Johor river. Consideration is given to the site whereat a proposed intake could be so located that the intake ports are submerged at all the stages of the river to a sufficient depth. Adding that, several technical viewpoints are considered for the selection. For instance, an intake site in the downstream has advantage over an intake site in the upstream in abstracting discharge from remaining basin. While an intake in the downstream would have problem of water quality such as saline water intrusion in the dry season or high tide periods more frequently than that in the upstream.

Through the site selection, which is a kind of trade-off decision on merits and demerits between a site in the upstream and in the

downstream. Finally, the site at Kg. Tai Hong which is extending on the right bank of Johor river is selected.

Two sets of water intakes are planned. Intake structures consist of a conduit with protective works and coarse screens at the open end and floating gates.

In the proposed development plan, the dimension of each intake is 12 m by 11 m. Each intake has four ports which are of open end of pipes connecting an intake and a low lift pumping station.

A new water treatment plant to treat required amount of water in 2005 will be constructed at Kg. Tai Hong by 1991. Main facilities of the treatment plant are located on the slightly higher place aparting approximately 200 m from the river.

The plant will have capacity of 107 Mgd to treat river water. The type of proposed plant will be of a type of rapid-filter plant of which essential features are chemical coagulation accomplished in flocculation basins, clarification accomplished in settling basins, and filtration. The required area for the plant with the said capacity is about 50 ha.

The basic layout of intakes and treatment facilities are shown in Plate 2.

2.3.3 Pipeline

To convey treated water from the treatment plant to the demand area, new pipeline (transmission main) will be constructed. New pipeline route is proposed to be laid in parallel with existing PUB pipelines at this master planning stage. The pipeline route is selected based on the map with scale of 1:25,000 with due consideration for topographic elevation of the route, accessibility to the route from existing roads and minimizing total length of the pipeline. However the route will necessarily be studied through detailed survey in the future stage. The proposed pipeline route is shown in Fig. 2.

The required new pipeline will be of steel pipe in double-lane with diameter of 1.6 m. The diameter is determined so as to have sufficient capacity to convey required water amount of 107 Mgd (5.63 m^3/s) in 2005. The land space required for a new pipeline is approximately 20 m in width.

3. DESIGN OF DAM

3.1 Reservoir and Damsite Characteristics

3.1.1 Dimension of reservoirs

The topographic maps with the scale of 1:10,000 were made for the selected areas such as Linggiu, Sayong and Sedili Besar river basins by the JICA survey team. The contour interval is 5 m.

The area-capacity curves were made to show the relationship between reservoir surface elevation and reservoir area. The basis for such curves are a topographic map with the scale of 1:10,000 for the said three prospective reservoir areas and a map with scale of 1:25,000 for prospective Benut, Pontian Besar, Upper Pengli, Telor and Layau Kiri reservoir areas. These curves are shown in Fig. 3 through Fig. 5.

3.1.2 Technical and socio-economic problems due to submergence

(1) Sayong reservoir area and damsite

The prospective reservoir area in the Sayong river basin is widely developed, such as rubber plantation, oil palm plantation and also as residential area. For example, 1,782 ha of oil palm area will be submerged if the water level is set at El. 20 m. In the upstream area of the Sayong river basin the town Layang-Layang with a population of 5,000 in 1985 is located, in which housing development is thriving over the low land along the river.

Land acquisition and compensation for houses and private and public facilities are the heaviest burden to the Sayong dam scheme. When the reservoir water level comes to higher than El. 21-22 approximately, an oil palm mill having a capacity of 50 ton/day will have to be relocated.

As topographic map shows, the highest point of left abutment of the damsite is approximately 20 m which is not high enough to sustain a dam

body. Then the spillway structure with a tall gravity wall functioning an artificial abutment is designed to retain the dam body.

(2) Linggiu reservoir area and damsite

The prospective reservoir area is 12.4 km^2 covered with natural forest including the forest reserve area of 126 ha if the water level is set at El. 30.5 m. The land to be submerged by the construction of a dam belongs to the State, which makes it easy to develop a dam scheme in the area from the view point of land acquisition. However, the possible damsite is very limited by the topographic condition. Possible damsite is identified about 15 km upstream of the confluence with the Johor river.

Two or three dam axes can be found at the site, but they exist closely each other within the range of 300 m.

Base rocks in the damsite and reservoir 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 high value ranging between 1×10^{-3} cm/s and 1×10^{-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 in the stage of low water pressure such as 1 or 2 kg/cm^2. This indicates a possibility that after impounding water in the reservoir, high water pressure would cause leakage. Furthermore, ground water 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 the underseepage path which would cause loss of water and finally failure of a dam.

To avoid problems may encounter after implementation of the dam, a concrete diaphragm is designed under the dam body along dam axis because

the foundation is considerably permeable. The depth is determined so that a diaphragm could reach to the level of which Lugeon value is 5 or less than that. Because this Lugeon value is normally accepted as the target level of improvement for foundation treatment by grouting.

The construction cost for the diaphragm shares 47% of the total cost of main construction works at the dam scale with high water level of El. 32 m. This geotechnical problem is the heaviest burden to the Linggiu dam scheme.

The watershed between the Linggiu basin and the Jengli basin does not show clear boundary at the uppermost stream of the Jengli river indicating only low land of jungle of which elevation is in the range from 100 ft to 150 ft by the available maps with scale of 1:25,000 or 1:63,360.

A saddle dam will necessarily be required to retain reservoir water for the Linggiu dam scheme. At the reservoir surface level over El. 36 m (approximately El. 120 ft), the construction of a saddle dam should be considered since permeable river deposits exist along the river course. The construction cost for a saddle dam is included in the estimated cost of dams higher than that with high water level of El. 37 m.

(3) Other reservoir areas and damsites

Concerning other reservoir areas and damsites, technical problems are not found so far. Land acquisition and compensation are the common matters to be cleared. Particularly in the prospective reservoir area of the Pontian Besar dam, a considerable length of national highway will be submerged by the creation of a reservoir. Sedili reservoir area is mostly covered with forest. Except to submerge a part of afforestation area no technical and social problems are found in the proposed Sedili reservoir area.

3.2 Types of Dam and Auxiliary Structures

3.2.1 Dam

Through the field reconnaissance, geologic drilling and construction material survey, it is clarified that technically an earthfill type dam is suitable for each damsite.

The engineering assessment of the earthfill material for the selected damsite such as Sayong, Linggiu, Sedili Besar and Upper Pengli is summarized in ANNEX I. The soils prospected to use for the impervious earthfill at each site are of fine-grained and plastic type as a whole, so the careful design will be required at the future implementation stage.

The field reconnaissance carried out by JICA expert revealed that deposits of the river sand are limited in location and scarce. Borrow area to obtain sand gravel for filter and concrete aggregate materials will have to be found out of vicinity of each damsite. And also quarried rock sources are not found in the vicinity of each damsite. Those are main reason for the decision of a dam type.

The results of core drilling carried out at the selected damsites show the existance the fractured weak foundation rock except Sayong damsite. This is the third reason to propose fill type dam at the damsites in the study area.

The slope of earthfill dam is determined on the basis of a slope stability analysis. Basic property of construction materials are obtained from laboratory tests carried out by Federal DID laboratory in Kuala Lumpur. Tentative design values of embankment materials are shown in Table 6. The typical section of proposed dams are shown in Fig. 6. The location and condition of each damsite are shown in Fig. 1 and Table 1. General layout of each dam are shown in Plate 3 through Plate 6.

3.2.2 Spillway

The catchment area of the eight proposed damsites are ranging from 31 km^2 to 224 km^2 except the one of 662 km^2 at Sayong damsite. This suggests that spillway operation against flood inflow be prompt and reliable. Furthermore, the proposed dams are planned only for water supply purpose. The following fundamental requirements are applied to the spillway design:

(a) Non-gated overflow weir;
(b) Open channel chuteway;
(c) Spillway structures be installed on the firm foundation rock.

3.2.3 River diversion works for dam construction

A diversion conduit system installed in the concrete spillway section and a multistage channel system are compared, and eventually it is concluded that a diversion conduit system is suitable for Linggiu, Sayong and Sedili damsites as width of valley bottom is not so wide to execute multistage diversion method. While concerning five damsites; Benut, Pontian Besar, Upper Pengli, Telor and Layau Kiri, a multistage diversion system is considered to be suitable as the width of valley bottom is more than 500 m.

3.3 Design Criteria Applied to Dam

3.3.1 General

Application of a local design criteria is preferable, however no authorized criteria on dams auxiliary structures have been prepared yet in Malaysia. Then the study was conducted mainly based on the criteria under Japanese National Committee on Large Dams. It is modified to some extent taking into the local peculiarity and practices which have been applied to the existing facilities. The British and the USBR standard are also consulted.

3.3.2 Reservoir water level, freeboard and spillway discharge capacity

(1) High water level

The adopted spillway is a non-gated free overflow type with orgee crest. Accordingly the high water level (HWL) corresponds to the orgee crest of a spillway.

(2) Low water level

The low water level (LWL) is so determined that an allowance of 2-4 m is provided for the intake elevation above the elevation which corresponds to the horizontal sedimentation in 100 years. The annual average sediment in the project area is assumed to be 0.25 mm/y.

(3) Freeboard for non-overflow section of main dam

The freeboard which provides the highest crest elevation of non-overflow section of main dam is adopted from the following alternative combination of freeboard and the maximum design water surface.

The Maximum Design Water Surface	Freeboard Requirement
High water level	Hf (1) = hw + he + ha + hi or 3.0 m for fill type
Design flood discharge water level without reservoir retardation effect	Hf (2) = hw + ha + hi or 2.0 m for fill type
PMF water level with reservoir retardation effect	Hf(PMF) = ht

where, hw: Wave height due to wind
he: Wave height due to earthquake
ha: Rise of water level due to unexpected accident in operating spillway gates (0.5 m for a gated type and 0 for a non-gated type)

hi: Addition of allowance for safety according to type and importance of dams (1.0 m for fill dams)

Through the comparative study on alternative combination of freeboard, the crest elevation of the non-overflow section of a dam is determined as the sum of the PMF water level and freeboard by wave height, as this combination gives highest crest elevation.

3.3.3 Design flood discharge

(1) Estimation of flood runoff

The flood discharge at the proposed damsites is generated on the basis of point storm rainfall data recorded in the Study Area. The list of rainfall gauging stations selected for the flood analysis is shown in Table 1 through 3 in ANNEX D.

The direct runoff hydrograph is generated by the storage function model which is so made as to represent hydrological characteristics in the Study Area. By means of the said model, probable floods and PMF are estimated. Table 7 shows the peak discharge of probable floods with recurrence interval of 2 to 10,000 years and the one of PMF at the proposed damsites.

(2) Design flood for river diversion

The river diversion works are required for dam construction to prevent or to minimize damage by flooding before completion. As mentioned in 3.2.3, a diversion conduit system is applied to Sayong, Linggiu and Sedili damsites and a multistage diversion system to other five damsites.

The choice of design flood for river diversion is a trade-off decision between economy and safety.

The diversion conduit or channel discharge capacity is determined so that the 20-year flood runoff can be discharged under free flow conditions in order to divert floods in one dry season without

overtopping the cofferdam with freeboard of 1 m. The hydraulic conditions required for river diversion works are:

(a) the maximum flow area of a circular conduit be 82%, and
(b) the maximum flow velocity be less than 10 m/s.

(3) Design flood for spillway and dam

The peak discharge of 200-year flood is adopted to design spillway and of PMF to determine freeboard and the crest elevation of a dam. Design floods for each dam are shown in Table 7.

The scale of the spillway is determined by analyzing the scale-cost relationship between the width of free overflow portion and the cost of spillway. Selected scale of the spillway for each dam is shown in Table 8.

4. DESIGN OF WATER SUPPLY WORKS

4.1 Intake

Two sets of intakes of which each dimension is 12 m by 11 m are planned on the right bank at Kg. Tai Hong 2 km upstream of Kota Tinggi. The intake should be so located that intake ports are submerged at all the stages of the river to a sufficient depth. The intake structures consist of a concrete conduit with coarse steel bar screens at the open end to avoid entrance of debris and floating gates with boom. Each intake has four ports which are of open end of steel pipes, 1.3 m in diameter, having abstracting capacity of 107 Mgd (5.63 m^3/s) at a flow velocity of 1 m/s.

4.2 Treatment Plant

The water treatment methods for domestic and industrial use are generally: 1) chemical treatment, 2) flocculation, 3) setting, 4) rapid-filtration, and 5) chrolination in Malaysia. Some treatment plants adopt the methods of aeration and pH adjustment. Alum, lime and soda ash are used as coagulant for flocculation. In Malaysia, Drinking Water Stnadards by WHO is adopted to check water quality. The Standards is shown in ANNEX F "WATER QUALITY".

The plant will have capacity of 107 Mgd to treat river water. The type of proposed plant will be of a rapid-filter plant which mainly consists of settling basin, mixing chamber, flocculation basin, sedimentation basin, filter, chlorination pond, clear water reservoir and sludge basin. The layout of the treatment plant is shown in Plate 2.

Following design conditions are considered to make plans for abovementioned major facilities.

Facilities

Mixing chamber	:	Processing time	2 min
Flocculation chamber	:	- do -	20-30 min
Settling tank	:	- do -	3-4 h
Rapid gravity filters	:	filtration velocity	115 m/d

4.3 Pipeline

The proposed pipeline will be of steel pipe in double-lane with diameter of 1.6 m. The diameter of pipes is determined to have delivery capacity of 107 Mgd in 2005 on the basis of cost comparison between single-stage and two-stage construction. The two-stage construction cost gives lower present value at 1986 time basis, than the pipeline layout of double-lane is adopted. Flow velocity ranging from 1.5 m/s to 2 m/s is considered to determine the diameter of pipes. The pipeline route is shown in Fig. 2.

4.4 Pumping Station

The construction of a high lift pumping station is necessary to boost up treated water to demand areas. Total pipeline length of 28 km, total pump head of 50 m and required delivery amount of 5.6 m^3/s are considered to determine the type of pump and its capacity.

The type of pump will be of volute pump. Practices on installing pumps in Malaysia are as follows:

a) Three sets or more numbers of pumps usually are installed to minimize risks at a breakdown.

b) Maximum throat diameter is ranging from 500 mm to 700 mm in light of procurement.

Considering these conditions, seven sets of volute pumps with throat diameter of 600 mm are planned to deliver water of 5.6 m^3/s (107

Mgd). Required space for the pumping station is approximately 25 m by 40 m. It is constructed within the lot of the treatment plant.

5. WORK CONDITIONS FOR COST ESTIMATE

5.1 General

Through the case study, proposed developed plan is to construct Sayong dam with high water level of El. 18.0 m to meet water demand of 178 x 10^6 m^3/y in 2005 considering given conditions in Case 2. The results of comparative study in each case are shown in Table 2.

In the proposed development plan, single development of Sayong dam can sustain water demand in the major urban area in the State such as Johor Bahru, Kulai, Senai and Kota Tinggi by 2005. However beyond the target year of 2005, Linggiu dam scheme will have to be implemented as the second priority scheme after Sayong dam scheme.

While Sedili dam scheme is one of the promising water resources in the Region even it will not play a role in water resources development plan by the target year of 2005. In this light, Sedili dam scheme is studied from various technical view points as well as other two, Sayong and Linggiu dams.

5.2 Construction Time Schedule

It is assumed that the construction works of any proposed dams will be commenced after about 1.5 years of the detailed design and tendering period. The construction period was estimated to be about 3 years for earthfill dams in the Sayong and Sedili except the Linggiu dam. The construction period for the Linggiu dam was planned to be about 4 years due to the works of cast-in-place concrete pile.

Basic assumptions on time scheduling for each dam construction are; Sayong dam will be constructed by 1991 to start commissioning at earliest; Linggiu dam will be constructed as the second priority scheme under given demand condition in Case 1; and schedule for Sedili dam is presented unspecifying the year.

The procedure of each dam is summarized as follows:

Sayong dam

1984-1985	Prefeasibility study
1986	Feasibility study
1987	Detailed design
1988-1989	Tendering and preparatory works
1989-1991	Main construction works

Linggiu dam

1984-1985	Prefeasibility study
1994	Feasibility study
1995	Detailed design
1995-1996	Tendering and preparatory works
1997-2000	Main construction works

Sedili dam

1984-1985	Prefeasibility study
1st-2nd year	Feasibility study
2nd-3rd year	Detailed design
3rd-4th year	Tendering and preparatory works
5th-7th year	Main construction works

Fig. 7 through 9 show the work sequence of earthfill type dams.

5.3 Basic Conditions for Construction Works

The yearly workable days for each work item in the project area are estimated to be 190 days for earth works, 250 days for rock embankment works and 230 days for concrete works on the basis of meteorological data and actual work conditions obtained from on-going dam projects in Malaysia.

Working hours are estimated to be 8 hours a day and 1-shift system is assumed for main construction works except for works of grouting deaphragm wall and cast-in-place concrete pile which require a 2-shift system.

6. COST ESTIMATE

6.1 General

The objective of the study is to estimate the cost of construction works of the proposed water supply facilities such as dam, treatment plant and pipeline. The cost for distribution system is counted only for the purpose of estimating unit water value.

The cost estimate is down in financial costs to prepare the statement of financial requirement. Economic cost is estimated to make clear the economic priority among the dam alternatives.

Following assumptions and conditions are set.

(1) Construction cost is estimated at 1985 constant price level.
(2) The exchange rate of currency is US$1.0=M$2.41=¥246.
(3) All items of construction cost were expressed in terms of the Malaysian Ringgit including both foreign and local currency components.

6.2 Constitution of Construction Cost

The construction cost is composed of the main construction cost, compensation cost, engineering and administration cost and contingency.

The main construction cost consists of costs of preparatory works, main construction works, miscellaneous works and transportation. The compensation costs include land acquisition cost of flooded area, construction yard and land for access roads, and relocation cost of houses, public facilities and roads. For further discussions on the compensation cost, refer to Volume 8, Annex M "LAND USE IN THE PROPOSED RESERVOIR AREAS". The engineering and administration cost covers the costs for detailed design and supervision works. The contingency includes the physical contingency. Costs of the main construction works were estimated on the unit cost basis, while other costs were estimated

on the lump sum basis. Fig. 10 shows the flow chart of construction cost estimate and constitution of construction cost of a dam project in this study.

6.3 Unit Construction Cost

The cost of main construction works is estimated on the unit cost basis, principally. The unit cost of main construction works is divided into the direct and the indirect costs. The direct cost includes labour, material, equipment, miscellaneous and supervision costs while the indirect cost consists of contractor's profit and overhead costs.

(1) Labour cost

All kinds of labours required for the construction are of dam and water supply works available in Malaysia. The daily wage rates of major workers are estimated as shown in Table 9 on the basis of the market research.

(2) Material cost

It is assumed that all kinds of construction materials are also available in Malaysia. Table 10 shows unit prices of major construction materials required for the dam facilities.

(3) Equipment expenses

The costs of construction equipment and spare parts delivered to the port of Johor Bahru is estimated on the basis of market price in Japan plus inland transportation charge, ocean freight charge, insurance and landing cost at the port of Johor Bahru.

The equipment expense per unit an hour comprises of depreciation cost, repairing cost and management cost of equipment.

Table 11 shows the hourly equipment expenses of major construction equipment in which the foreign currency portion includes equipment and

spare parts costs, transportation cost to the port of Johor Bahru and the premium of insurance and the local currency portion includes labour and material cost of repairing and landing cost at the port of Johor Bahru.

(4) Miscellaneous cost

The miscellaneous cost is assumed at 3% of the sum of labour and material costs.

(5) Contractor's supervision cost

The supervision cost is required for contractor's supervision of the construction works. It is assumed at 3% of the sum of labour, material, equipment and miscellaneous costs.

(6) Profit and overhead

Profit and overhead cost of contractor is assumed to be 15% of the direct cost referring to the on-going dam projects in Malaysia.

The cost of the main construction works at various different scales are calculated for Sayong, Linggiu and Sedili dams. Estimated costs are shown in a form of priced BQ in Table 12 through 17.

6.4 Lump Sum Cost

(1) Preparatory works

The cost of preparatory works is assumed at 10% of the main construction works for the dam projects.

(2) Miscellaneous works

The cost of miscellaneous works covers those for unallocated minor works and it is assumed at 10% of the sum of costs of preparatory and main construction works. The cost will, however, not be necessary to be

counted in the detailed design stage when the estimated is supported by detailed survey and investigation.

(3) Transportation cost

Transportation cost is assumed at 2% of the sum of the costs of preparatory, the main construction and miscellaneous works. It covers the inland transportation cost of the construction equipment and plant from Johor Bahru to the proposed damsites.

(4) Engineering and administration

The cost of engineering and administration covers the detailed design and construction supervision costs. Its rate to the cost of main construction works is assumed at 33% in the Sayong and Sedili dam and 27% in the Linggiu dam.

(5) Contingency

The project contingency consists of the physical contingency. The physical contingency is assumed at 30% of the sum of the main construction, compensation and engineering and administration costs for the study of pre-feasibility stage.

6.5 Construction Cost of Proposed Dams

The construction costs of the proposed dams were calculated by applying the unit costs and the lump sum costs, abovementioned. Table 18 to 35 give the total construction costs by major cost items and the disbursement schedule for the Sayong, Linggiu and Sedili dams.

The construction costs for the Benut, Pontian Besar, Upper Pengli, Telor and Layau Kiri dams are tabulated in Table 36 through 40.

6.6 Construction Cost of Water Supply Works

The construction costs of proposed water supply works were calculated by the similar way as in the case of dam cost estimate. The costs for the proposed treatment plant, pumping station and pipeline are estimated in 2 cases; they are single stage development and 2-stage development. The estimated costs are shown in Table 41 through 43.

As shown in the above Tables, the construction cost of single stage development is lower than that of two stage development for a dam and pumping station works. While the cost of 2-stage development for a treatment plant and pipeline works is lower than the cost of single stage development. Lower cost is applied for the cost estimate of proposed plan.

6.7 Unit Water Cost

Unit water cost is estimated in financial cost at 1986 time basis. Unit water cost of the proposed plan is estimated at M¢84/m^3 as shown in Table 44.

TABLES

Table 1 CONDITION OF ALTERNATIVE DAMSITES

SITE CONDITIONS		BENUT	PONTIAL BESAR	LINGGIU	UPPER PENGLI	SAYONG	TELOR	SEDILI	LAYAU KIRI Main	LAYAU KIRI Sub
River System		Benut River	Pontian Besar River	Johor river	Johor River	Johor River	Johor River	Sedili Besar River	Johor River	Johor River
Location of Damsite		1°52'53"N 103°19'44"E	1°44'28"N 103°25'49"E	1°54'27"N 103°41'38"E	1°51'31"N 103°35'34"E	1°48'59"N 103°41'24"E	1°43'00"N 103°47'08"E	2°02'21"N 103°50'42"E	1°35'54"N 104°04'24"E	1°35'30"N 104°06'12"E
Catchment Area		37 Km^2	40 Km^2	206 Km^2	127 Km^2	662 Km^2	38 Km^2	224 Km^2	31 Km^2	
Damsite Topography		Flat and wide valley	Flat and wide valley	Steep left abutment	Flat and wide valley	Gentle slope valley	Gentle slope valley	Rather steep slope on both abutment	Flat and wide valley	
Valley Bottom Width		1.1 Km	1.7 Km	0.4 Km	1.3 Km	0.4 Km	0.6 Km	0.4 Km	1.0 Km	
Geology & Construction Materials	1) Geology	Shale and sandstone of Mesozoic	Shale and sandstone of Mesozoic	Mainly sandstone of Paleozoic, fractured by fault, highly permeable	Semi-consolidated clayey silt of Pleistocene to Pliocene	Flesh tight granite partly weathered	Weathered granite	Phyllite of Paleozoic, moderately weathered	Weathered granite	
	2) Soils	Mostly sandy silt	Silty sand	Clayey to sandy silt	Silty sand	Mainly sandy silt	Sandy silt to silty sand	Sandy silt	Sandy silt to clay	
Scale of Dam and Reservoir										
1) Gross Storage at H.W.L.	(m^3)	20 x 10^6	51 x 10^6	123 x 10^6	130 x 10^6	179 x 10^6	49 x 10^6	85 x 10^6	41 x 10^6	
2) Effective Storage at H.W.L.	(m^3)	18 x 10^6	48 x 10^6	107 x 10^6	120 x 10^6	128 x 10^6	46 x 10^6	61 x 10^6	38 x 10^6	
3) High water Level	(m)	29.0	25.5	34.0	41.0	18.0	28.0	20.0	22.0	
4) Flood Water Level	(m)	31.1	27.3	35.2	43.1	20.1	29.6	21.1	23.8	
5) Dam Height	(m)	30	29	32	33	31	29	32	29	27
6) Crest Length	(m)	2,000	2,400	560	2,200	1,140	2,200	490	1,600	1,100
7) Dam Volume	(m^3)	1.9 x 10^6	3.1 x 10^6	0.9 x 10^6	2.8 x 10^6	0.8 x 10^6	0.9 x 10^6	0.7 x 10^6	1.3 x 10^6	0.6 x 10^6
Land Use in Reservoir Area EL.	(m)	31.1	27.3	35.2	43.1	20.1	29.6	21.1	23.8	
1. Rubber	(ha)	322	675	-	-	203	-	-	-	
2. Oil Palm	(ha)	379	316	-	1,060	1,853	53	-	658	
3. Other Agricultural Land	(ha)	-	38	-	-	502	-	-	-	
4. Residential Land	(ha)	-	-	-	-	-	-	-	48	
5. Factory Area	(ha)	-	64	-	-	-	-	-	-	
6. Forest	(ha)	-	254	2,027	1,850	1,747	1,087	2,140	4	
7. Mine	(ha)	-	-	73	-	-	-	-	-	
Total Area	(ha)	701	1,347	2,100	2,910	4,305	1,140	2,140	710	
8. Houses	(nos)	-	89	-	13	33	-	-	66	
9. Road (main)	(km)	-	8.2	-	3.6	5.0	-	-	7.6	
10. Transmission Line	(km)	-	-	-	-	2.7	-	-	-	
11. Pumping Station	(nos)	-	-	-	1	-	-	-	-	
Investment Cost of Dam (M$ 10^6)										
Total Cost		99	163	132	181	132	65	61	117	
(Compensation)		(13)	(35)	(-)	(35)	(55)	(7)	(-)	(19)	
Special Problems			Submerge highway	Permeable foundation		Land acquistion			Lebam dam is enough	

Table 2 LIST OF ALTERNATIVE DEVELOPMENT PLANS

Case	Present Value/1 of Dam Cost in 1986 ($M\$10^6$)	First Dam				Second Dam				Ranking
		Dam	/2 HWL	/3 S	/4 Year	Dam	HWL	S	/4 Year	
1	132.6	Sayong	17	98	1991	Linggiu	33	89	1995	5
	113.9	Sayong	18	128	"	Linggiu	31	58	2001	1
	122.7	Sayong	21	247	"	-		-	-	2
	158.3	Linggiu	33	89	"	Sayong	18	128	1992	7
	136.6	Linggiu	34	107	"	Sayong	17	98	1995	6
	118.5	Linggiu	35	126	"	Sayong	16	73	1999	3
	122.6	Linggiu	40	253	"	-		-	-	4
2	85.2	Sayong	16	73	"	Telor	24	18	2000	3
	75.6	Sayong	17	98	"	-		-	-	1
	96.6	Linggiu	33	89	"	Telor	24	18	2002	4
	85.0	Linggiu	34	107	"	-		-	-	2
1-A	86.5	Sayong	17	98	"	Telor	22	10	2003	3
	82.3	Sayong	18	128	"	-		-	-	1
	96.0	Linggiu	34	107	"	Telor	22	10	2003	4
	86.3	Linggiu	35	126	"	-		-	-	2
2-A	99.6	Sayong	15	25	"	Linggiu	31	58	2000	5
	69.3	Sayong	16	73	"	-		-	-	1
	95.4	Linggiu	31	58	"	Telor	24	18	2001	4
	82.3	Linggiu	32	73	"	-		-	-	2
	83.5	Linggiu	33	89	"	-		-	-	3

Note: /1: Time basis; 1986, the commencement of service; 1992 and discount rate; 10%

/2: High water level

/3: Active storage

/4: Completion of dam construction

Table 3 COST OF ADDITIONAL CONSTRUCTION WORKS FOR DAM ENLARGEMENT

Unit: $M\$10^6$

1. Additional Cost (C1)

	(1)	(2)	(3) = (1) - (2)
Case	Sayong (HWL 18)	Sayong (HWL 17) + Compensation (HWL 18)	Difference
Economic Cost /1	82.3	81.4	0.9 ... (C1)

2. Construction Cost in Second Stage /2 (C2)

		Cost
1)	Spillway crest	0.34
2)	Concrete pitching	0.02
3)	Extra treatment of dam crest	0.11
4)	Engineering service fee	0.16
5)	Contingency	0.19
	Total	0.84

Construction cost 1986 time basis = 0.84 x 0.148 = 0.12 ... (C2)

3. *Dam Enlargement Cost*

Cost in 1st stage (C3) = C1 x 90% = 0.81

Cost in 2nd stage C2 = 0.12

Remarks; /1: Economic cost 1986 time basis

/2: Executed in 2006

Table 4 PRINCIPAL FEATURES OF PROPOSED DEVELOPMENT PLAN

1.	Dam	
	Location	Sayong Pinang
	High water level 1	El. 18.0 m
	Effective storage	128 x 10^6 m^3
	Crest elevation	El. 25.5 m
	Dam height	31 m
	Embankment volume	808,000 m^3
2.	Treatment Plant	
	Location	Kg. Tai Hong
	Type	Rapid-filter type
	Treatment capacity	107 Mgd
	Area	50 ha
3.	Pumping Station	
	Location	Kg. Tai Hong
	Type of pump	Volute pump
	Total pump head	50 m
	Throat diameter	600 mm
	Number of pump	7 sets
4.	Pipeline	
	Location	Kg. Tai Hong - Johor Bahru
	Number of lane	2 lanes
	Diameter	1.6 m
	Capacity	5.63 m3/s

Table 5 PRIORITY DAM SCHEMES SELECTED IN CASE STUDY

	Case 1		Case 2	Case 1A	Case 2A
Name of Dams	Sayong ,	Linggiu	Sayong	Sayong	Sayong
Reservoir					
High water level	El. 18 m	El. 31 m	El. 17 m	El. 18 m	El. 16 m
Flood water level	El. 20.1 m	El. 32.6 m	El. 19.3 m	El. 20.1 m	El. 18.5 m
Surface area (HWL)	31 km^2	13.3 km^2	27 km^2	31 km^2	23.5 km^2
Effective storage	128 x $10^6 m^3$	58 x $10^6 m^3$	98 x $10^6 m^3$	128 x $10^6 m^3$	73 x $10^6 m^3$
Dead storage	51 x $10^6 m^3$	16.5 x $10^6 m^3$	51 x $10^6 m^3$	51 x $10^6 m^3$	51 x $10^6 m^3$
Dam					
Type of dam	Earthfill	Earthfill	Earthfill	Earthfill	Earthfill
Crest elevation	El. 25.5 m	El. 37.0 m	El. 25.0 m	El. 25.5 m	El. 24.0 m
Crest length	1,140 m	530 m	1,100 m	1,140 m	1,000 m
Dam height	31 m	29 m	30.5 m	31 m	29.5 m
Embankment volume	808,000 m^3	714,000 m^3	774,000 m^3	808,000 m^3	714,000 m^3
Spillway & River Outlet					
Crest length	50 m	30 m	50 m	50 m	50 m
Discharge capacity	300 m^3/sec	130 m^3/sec	340 m^3/sec	300 m^3/sec	390 m^3/s
Type of river outlet	2 sets of steel pipe	2 sets of steel pipe	2 sets of steel pipe	2 sets of steel pipe	2 sets of steel pipe

Table 6 TENTATIVE DESIGN VALUES OF CONSTRUCTION MATERIALS

	Earthfill Material							
	Sayong				Upper			Rock
	(A)	(B)	Sadili	Linggiu	Pengli	Filter	Drain	rip-rap
Specific Gravity Gs	2.67	2.66	2.75	2.66	2.59	2.64	2.60	2.60
Wet Density t (t/m^3)	1.94	1.80	1.74	1.72	1.73	2.00	2.07	1.98
Saturated Density sat (t/m^3)	2.04	1.84	1.92	2.07	2.06	2.24	2.18	2.17
Shear Strength*								
C' (t/m^2)	2	3	4	5	2	0	0	0
ø' (°)	30	28	25	20	30	33	35	40
Cuu (t/m^2)	5	5	6	8	5	-	-	-
øuu (°)	25	25	20	15	25	-	-	-
Permeability k (cm/sec)	$1x10^{-5}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-3}$	$1x10^{-2}$	$1x10^{-1}$

* All the values of shear strength are assumed for preliminary design purposes, not based on the laboratory tests.

Table 7 PROBABLE FLOOD PEAK DISCHARGE OF PROPOSED DAM

Unit: m^3/s

Return Period	Peak Discharge at Damsite							
	Benut	Pontian Besar	Upper Pengli	Sayong	Linggiu	Telor	Layau Kiri	Sedili
2	21	27	67	380	98	29	24	180
5	38	45	109	530	150	49	48	360
10	72	80	159	640	240	67	66	510
20	89	96	221	860	340	88	90	680
50	130	130	360	1,260	500	120	110	930
100	150	150	430	1,450	680	140	130	1,080
200/1	190	190	510	1,840	810	170	160	1,220
500	220	230	690	2,210	1,100	200	180	1,440
1,000	250	250	800	2,720	1,270	230	200	1,600
10,000	380	380	1,320	4,400	2,110	350	290	2,360
PMF/2	420	420	1,340	4,630	2,280	350	360	2,470

Remarks; /1: Design flood for spillway

/2: Design flood for dam safety

Table 8 RELATIONSHIP BETWEEN SCALE OF SPILLWAY AND FLOOD WATER LEVEL

Damsite	H.W.L (m)	Non-gated Overflow Crest Length (m)	F.W.L (m) 200 Yr Flood	F.W.L (m) PMF
Sayong	16.0	50*	18.5	21.6
		75	18.2	21.1
		100	18.0	20.7
	18.0	50*	20.1	22.8
		75	19.9	22.5
		100	19.8	22.2
	19.0	50*	20.9	23.2
		75	20.7	23.0
		100	20.6	22.8
	20.0	50*	21.7	23.7
		75	21.6	23.5
		100	21.5	23.3
Linggiu	27.0	30*	29.1	32.5
		40	28.9	32.1
		50	28.8	31.8
	29.5	30*	31.3	34.2
		40	31.1	34.0
		50	31.0	33.7
	32.0	30*	33.5	36.0
		40	33.4	35.8
		50	33.3	35.6
Sedili	16.0	50*	18.4	20.5
		75	18.2	20.1
		100	17.9	19.8
	18.0	50*	20.0	21.5
		75	19.8	21.2
		100	19.6	20.9
	20.0	50*	21.1	22.9
		75	21.0	22.6
		100	21.0	22.5

Remarks; Asterisk (*) shows selected scale of spillway at each reservoir level.

Table 9 LABOUR WAGE

Unit: M$/d

No.	Category	Wage
1.	Foreman	55
2.	Operator	45
3.	Assistant Operator	30
4.	Driver	35
5.	Mechanic	45
6.	Electrician	45
7.	Concrete Worker	35
8.	Reinforcement Worker	40
9.	Carpenter	45
10.	Powder Operator	45
11.	Driller	35
12.	Boring Worker	35
13.	Grout Worker	35
14.	Common Labour	25

Table 10 UNIT PRICE OF CONSTRUCTION MATERIALS

No.	Material	Unit	Price(M$)
1.	Diesel Oil	lit	0.49
2.	Lubricant	lit	2.49
3.	Gasoline	lit	1.08
4.	Grease	kg	3.95
5.	Dynamite	kg	9.68
6.	Reterder	kg	3.50
7.	Reinforcement Bar	ton	1,070.00
8.	Fine Aggregate	m^3	11.14
9.	Coarse Aggregate	m^3	31.13
10.	Timber	m^3	420.00
11.	Plywood	sheet	38.70
12.	Boring Rod	Nos	110.25

Table 11 HOURLY EXPENSES OF MAJOR EQUIPMENT

No.	Equipment	Capacity	F/C(M$)	L/C(M$)	Total(M$)
1.	Bulldozer w/Ripper	21t	56.26	31.14	87.40
2.	Bulldozer	15t	36.89	20.38	57.27
3.	Back Hoe	1.2m^3	82.95	39.48	122.43
4.	Back Hoe	0.7m^3	43.94	21.45	65.39
5.	Tractor Shovel	1.4m^3	28.43	15.77	44.20
6.	Wheel Loader	3.5m^3	58.78	32.58	91.36
7.	Wheel Loader	2.1m^3	37.92	20.85	58.77
8.	Dump Truck	15t	31.31	15.60	46.91
9.	Dump Truck	11t	21.12	11.12	32.24
10.	Dump Truck	8t	16.33	8.59	24.92
11.	Hydraulic Crane	10t	32.78	17.04	49.82
12.	Tamping Roller	13.5t	24.61	11.99	36.60
13.	Vibratory Roller	3t	12.20	6.55	18.75
14.	Crawler Drill	10m^3/min	24.08	10.23	34.31
15.	Boring Machine	5.5kw	32.06	17.51	49.57*
16.	Grout Pump	7.5kw	26.65	14.39	41.04*
17.	Grout Mixer	600ℓ	44.52	24.05	68.57*
18.	Truck Mixer	3.2m^3	21.59	10.08	31.67
19.	Concrete Pump w/chassis	85m^3/h	74.80	34.05	108.85
20.	Air Compressor	14m^3/min	126.30	57.93	184.23*
21.	Concrete Plant	1m^3x1	109.13	58.15	167.28

Remarks; *; Equipment expense per day

Table 12 PRICED B.Q. OF MAIN CONSTRUCTION WORKS OF SAYONG DAM (1/6)

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	N.H.W.L. 16 m Quantity	N.H.W.L. 16 m Amount	N.H.W.L. 17 m Quantity	N.H.W.L. 17 m Amount	N.H.W.L. 18 m Quantity	N.H.W.L. 18 m Amount
1. Access Road								
Rolling	M	219.25	7,000	1,535	7,000	1,535	7,000	1,535
Sub Total				1,535		1,535		1,535
2. Diversion & River Outlet								
Excavation Common	CU.M	4.19	225,000	943	225,000	943	225,000	943
W. Rock	CU.M	10.36	54,000	559	54,000	559	54,000	559
Rock	CU.M	24.71	40,000	988	40,000	988	40,000	988
Embankment	CU.M	5.85	15,000	88	15,000	88	15,000	88
Mass Concrete	CU.M	161.99	10,500	1,701	10,700	1,733	11,000	1,782
Reinforced Concrete	CU.M	275.12	560	154	570	157	590	162
Plug Concrete	CU.M	183.46	810	149	880	161	950	174
Diversion Gate	L.S			1,100		1,130		1,170
Bulk Head Gate, Hoist & Hoist Tower	L.S			557		578		599
Trashrack	L.S			22		22		22
Steel Pipe	L.S			288		288		288
Release Valve	L.S			1,980		1,980		1,980
Sub Total				8,529		8,627		8,755
3. Spillway								
Excavation Common	CU.M	4.19	132,000	553	121,600	510	111,000	465
W. Rock	CU.M	10.36	22,800	236	16,600	172	14,500	150
Rock	CU.M	24.71	7,800	193	7,800	193	7,800	193
Mass Concrete	CU.M	161.99	15,700	2,543	16,800	2,721	17,800	2,883
Reinforced Concrete	CU.M	275.12	2,100	578	2,150	592	2,200	605
Gabion Mattress	CU.M	97.08	2,800	272	2,800	272	2,800	272
Sub Total				4,375		4,460		4,568
4. Main Dam & Cofferdam								
Excavation Common	CU.M	4.19	568,000	2,380	583,000	2,464	597,000	2,501
W. Rock	CU.M	10.36	12,500	130	14,000	145	15,000	155
Curtain Grout	M	249.63	7,200	1,797	7,700	1,922	8,000	1,997
Blanket Grout	M	184.63	13,100	2,419	13,800	2,548	14,400	2,659
Embankment								
U/S Coffer	CU.M	5.85	104,000	608	107,000	626	109,000	638
D/S Coffer	CU.M	5.85	25,000	146	25,000	146	25,000	146
Earth	CU.M	5.85	545,000	3,188	595,000	3,481	625,000	3,656
Drain	CU.M	25.01	19,000	475	23,000	575	24,000	600
Riprap	CU.M	46.06	21,000	967	24,000	1,105	25,000	1,152
Sod Facing	SQ.M	3.14	17,000	53	19,000	60	20,000	63
Sub Total				12,163		13,072		28,425
Total 1-4				26,602		27,694		28,425
Miscellaneous				2,926		3,046		3,127
Transportation				644		670		688
Grand Total				30,172		31,410		32,240

Table 13 PRICED B.Q. OF MAIN CONSTRUCTION WORKS OF SAYONG DAM (2/6)

Sayong (2)

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	N.H.W.L. 19 m Quantity	N.H.W.L. 19 m Amount	N.H.W.L. 20 m Quantity	N.H.W.L. 20 m Amount	N.H.W.L. 22 m Quantity	N.H.W.L. 22 m Amount
1. Access Road								
Rolling	M	219.25	7,000	1,535	7,000	1,535	7,000	1,535
Sub Total				1,535		1,535		1,535
2. Diversion & River Outlet								
Excavation Common	CU.M	4.19	225,000	943	225,000	943	225,000	943
W. Rock	CU.M	10.36	54,000	559	54,000	559	54,000	559
Rock	CU.M	24.71	40,000	988	40,000	988	40,000	988
Embankment	CU.M	5.85	15,000	88	15,000	88	15,000	88
Mass Concrete	CU.M	161.99	11,500	1,863	12,000	1,944	13,200	2,138
Reinforced Concrete	CU.M	275.12	620	171	640	176	720	198
Plug Concrete	CU.M	183.46	1,030	189	1,100	202	1,250	229
Diversion Gate	L.S			1,210		1,240		1,230
Bulk Head Gate, Hoist & Hoist Tower	L.S			620		641		683
Trashrack	L.S			22		22		22
Steel Pipe	L.S			288		288		288
Release Valve	L.S			1,980		1,980		1,980
Sub Total				8,921		9,071		9,427
3. Spillway								
Excavation Common	CU.M	4.19	106,000	444	101,000	423	97,000	406
W. Rock	CU.M	10.36	14,400	149	14,300	148	14,200	147
Rock	CU.M	24.71	7,800	193	7,800	193	7,800	193
Mass Concrete	CU.M	161.99	19,500	3,159	20,600	3,337	24,200	3,920
Reinforced Concrete	CU.M	275.12	2,400	660	2,500	688	2,800	770
Gabion Mattress	CU.M	97.08	2,800	272	2,800	272	2,800	272
Sub Total				4,877		5,061		5,709
4. Main Dam & Cofferdam								
Excavation Common	CU.M	4.19	609,000	2,552	614,000	2,573	632,000	2,648
W. Rock	CU.M	10.36	21,000	218	22,000	228	28,000	290
Curtain Grout	M	249.63	8,400	2,097	8,800	2,197	9,200	2,297
Blanket Grout	M	184.63	15,000	2,769	15,600	2,880	16,200	2,991
Embankment								
U/S Coffer	CU.M	5.85	110,000	644	111,000	649	112,000	655
D/S Coffer	CU.M	5.85	25,000	146	25,000	146	25,000	146
Earth	CU.M	5.85	690,000	4,037	745,000	4,358	820,000	4,797
Drain	CU.M	25.01	26,000	650	28,000	700	30,000	750
Riprap	CU.M	46.06	27,000	1,244	29,000	1,336	32,000	1,474
Sod Facing	SQ.M	3.14	21,500	68	23,000	72	25,000	79
Sub Total				14,423		15,140		16,127
Total 1-4				29,756		30,806		32,797
Miscellaneous				3,273		3,389		3,608
Transportation				720		746		794
Grand Total				33,749		34,940		37,199

Table 14 PRICED B.Q. OF MAIN CONSTRUCTION WORKS OF LINGGIU DAM (3/6)

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	N.H.W.L. 27 m Quantity	N.H.W.L. 27 m Amount	N.H.W.L. 29.5 m Quantity	N.H.W.L. 29.5 m Amount	N.H.W.L. 32 m Quantity	N.H.W.L. 32 m Amount
1. Access Road								
Rolling	M	219.25	12,000	2,631	12,000	2,631	12,000	2,631
Sub Total				2,631		2,631		2,631
2. Diversion & River Outlet								
Excavation Common	CU.M	4.19	146,000	612	146,000	612	146,000	612
W. Rock	CU.M	10.36	10,000	104	10,000	104	10,000	104
Rock	CU.M	24.71	0	0	0	0	0	0
Embankment	CU.M	5.85	0	0	0	0	0	0
Mass Concrete	CU.M	161.99	10,700	1,733	11,400	1,847	12,600	2,041
Reinforced Concrete	CU.M	275.12	560	154	600	165	670	184
Plug Concrete	CU.M	183.46	810	149	900	165	1,000	183
Diversion Gate	L.S			1,070		1,120		1,170
Bulk Head Gate, Hoist & Hoist Tower	L.S			515		557		613
Trashrack	L.S			22		22		22
Steel Pipe	L.S			264		264		264
Release Valve	L.S			1,890		1,890		1,890
Sub Total				6,513		6,746		7,083
3. Spillway								
Excavation Common	CU.M	4.19	250,000	1,048	225,000	943	204,000	855
W. Rock	CU.M	10.36	216,000	2,238	163,000	1,689	145,000	1,502
Rock	CU.M	24.71	0	0	0	0	0	0
Cast-In-Place Concrete Pile	NOS.	12,049.88	400	4,820	400	4,820	400	4,820
Mass Concrete	CU.M	161.99	10,900	1,766	13,100	2,122	16,100	2,608
Reinforced Concrete	CU.M	275.12	1,600	440	1,700	468	1,900	523
Gabion Mattress	CU.M	97.08	1,600	155	1,600	155	1,600	155
Sub Total				10,467		10,197		10,463
4. Main Dam & Cofferdam								
Excavation Common	CU.M	4.19	469,500	1,967	472,000	1,978	485,000	2,032
W. Rock	CU.M	10.36	28,500	295	28,000	290	30,000	311
Dental Work	L.S			600		600		600
Diaphragm Wall	SQ.M	2,190.22	14,600	31,977	15,000	32,853	15,300	33,510
Blanket Grout	M	184.63	2,200	406	2,500	462	3,000	554
Embankment								
U/S Coffer	CU.M	5.85	109,000	638	109,000	638	106,000	620
D/S Coffer	CU.M	5.85	20,000	117	20,000	117	20,000	117
Earth	CU.M	5.85	475,000	2,779	520,000	3,042	591,000	3,457
Drain	CU.M	25.01	13,000	325	14,500	363	17,000	425
Riprap	CU.M	46.06	13,000	599	14,500	668	17,000	783
Sod Pacing	SQ.M	3.14	11,000	35	12,500	39	14,000	44
Sub Total				39,738		41,050		42,453
Total 1-4				59,349		60,624		62,630
Miscellaneous	L.S			6,528		6,669		6,889
Transportation				1,436		1,467		1,516
Grand Total				67,313		68,760		71,035

Table 15 PRICED B.Q. OF MAIN CONSTRUCTION WORKS OF LINGGIU DAM (4/6)

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	N.H.W.L. 33 m Quantity	N.H.W.L. 33 m Amount	N.H.W.L. 34 m Quantity	N.H.W.L. 34 m Amount	N.H.W.L. 35 m Quantity	N.H.W.L. 35 m Amount
1. Access Road								
Rolling	M	219.25	12,000	2,631	12,000	2,631	12,000	2,631
Sub Total				2,631		2,631		2,631
2. Diversion & River Outlet								
Excavation Common	CU.M	4.19	146,000	612	146,000	612	146,000	612
W. Rock	CU.M	10.36	10,000	104	10,000	104	10,000	104
Rock	CU.M	24.71	0	0	0	0	0	0
Embankment	CU.M	5.85	0	0	0	0	0	0
Mass Concrete	CU.M	161.99	13,400	2,171	14,300	2,316	15,500	2,511
Reinforced Concrete	CU.M	275.12	680	187	720	198	780	215
Plug Concrete	CU.M	183.46	1,000	183	1,050	193	1,100	202
Diversion Gate	L.S			1,180		1,190		1,200
Bulk Head Gate, Hoist & Hoist Tower	L.S			635		658		680
Trashrack	L.S			22		22		22
Steel Pipe	L.S			264		264		264
Release Valve	L.S			1,890		1,890		1,890
Sub Total				7,248		7,447		7,700
3. Spillway								
Excavation Common	CU.M	4.19	199,000	834	195,000	817	191,000	800
W. Rock	CU.M	10.36	137,000	1,419	139,000	1,440	142,000	1,471
Rock	CU.M	24.71	0	0	0	0	0	0
Cast-In-Place Concrete Pile	NOS.	12,049.88	400	4,820	400	4,820	400	4,820
Mass Concrete	CU.M	161.99	17,300	2,802	18,500	2,997	19,700	3,191
Reinforced Concrete	CU.M	275.12	1,900	523	1,950	536	2,000	550
Gabion Mattress	CU.M	97.08	1,600	155	1,600	155	1,600	155
Sub Total				10,553		10,765		10,967
4. Main Dam & Cofferdam								
Excavation Common	CU.M	4.19	495,000	2,074	507,000	2,124	515,000	2,158
W. Rock	CU.M	10.36	30,700	318	31,300	324	31,600	327
Dental Work	L.S			600		600		600
Diaphragm Wall	SQ.M	2,190.22	15,400	33,729	15,500	33,948	15,600	34,167
Blanket Grout	M	184.63	3,300	609	3,600	665	3,700	683
Embankment								
U/S Coffer	CU.M	5.85	105,000	614	104,000	608	103,000	603
D/S Coffer	CU.M	5.85	20,000	117	20,000	117	20,000	117
Earth	CU.M	5.85	634,000	3,709	686,000	4,013	715,000	4,183
Drain	CU.M	25.01	18,000	450	20,000	500	21,000	525
Riprap	CU.M	46.06	19,500	898	21,000	967	22,000	1,013
Sod Facing	SQ.M	3.14	15,000	47	16,500	52	17,000	53
Sub Total				43,165		43,918		44,429
Total 1-4				63,597		64,761		65,747
Miscellaneous	L.S			6,996		7,124		7,232
Transportation				1,539		1,567		1,591
Grand Total				72,132		73,452		74,570

Table 16 PRICED B.Q. OF MAIN CONSTRUCTION WORKS OF LINGGIU DAM (5/6)

Unit: NS 10^3

Description	Unit	Unit Price (NS)	N.H.W.L. 98 m Quantity	N.H.W.L. 98 m Amount	N.H.W.L. 40 m Quantity	N.H.W.L. 40 m Amount
1. Access Road						
Rolling	M	219.25	12,000	2,631	12,000	2,631
Mountainous	M	343.97	9,500	3,268	9,500	3,268
Sub Total				5,899		5,899
2. Diversion & River Outlet						
Excavation Common	CU.M	4.19	146,000	612	146,000	612
W. Rock	CU.M	10.36	10,000	104	10,000	104
Rock	CU.M	24.71	0	0	0	0
Embankment	CU.M	5.85	0	0	0	0
Mass Concrete	CU.M	161.99	19,500	3,159	23,700	3,839
Reinforced Concrete	CU.M	275.12	1,000	275	1,250	344
Plug Concrete	CU.M	183.46	1,200	220	1,350	248
Diversion Gate	L.S			1,270		1,330
Bulk Head Gate, Hoist & Hoist Tower	L.S			770		837
Trashrack	L.S			22		22
Steel Pipe	L.S			264		264
Release Valve	L.S			1,890		1,890
Sub Total				8,585		9,490
3. Spillway						
Excavation Common	CU.M	4.19	182,000	763	173,000	725
W. Rock	CU.M	10.36	135,000	1,399	130,000	1,347
Rock	CU.M	24.71	0	0	0	0
Cast-in-Place Concrete Pile	NOS.	12,049.88	400	4,820	400	4,820
Mass Concrete	CU.M	161.99	21,500	3,483	23,800	3,855
Reinforced Concrete	CU.M	275.12	2,200	605	2,500	688
Gabion Mattress	CU.M	97.08	1,600	155	1,600	155
Sub Total				11,225		11,590
4. Main Dam & Cofferdam						
Excavation Common	CU.M	4.19	575,000	2,409	634,000	2,656
W. Rock	CU.M	10.36	32,400	336	33,000	342
Dental Work	L.S			600		600
Diaphragm Wall	SQ.M	2,190.22	15,700	34,386	15,900	34,824
Blanket Grout	M	184.63	3,900	720	4,000	739
Embankment						
U/S Coffer	CU.M	5.85	103,000	603	105,000	614
D/S Coffer	CU.M	5.85	20,000	117	20,000	117
Earth	CU.M	5.85	892,000	5,218	1,068,000	6,248
Drain	CU.M	25.01	23,500	588	26,500	663
Riprap	CU.M	46.06	25,000	1,152	28,000	1,290
Sod Facing	SQ.M	3.14	20,000	63	24,000	75
Sub Total				46,191		48,168
4. Saddle Dam						
Excavation Common	CU.M	4.19	287,000	1,203	383,000	1,605
W. Rock	CU.M	10.36	78,000	808	80,000	829
Curtain Grout	M	249.63	30,000	7,489	35,000	8,737
Blanket Grout	M	184.63	6,000	1,108	8,000	1,477
Embankment						
Earth	CU.M	5.85	475,000	2,779	580,000	3,393
Drain	CU.M	25.01	13,500	338	21,000	525
Riprap	CU.M	46.06	14,600	672	22,000	1,013
Sod Facing	SQ.M	3.14	12,500	39	17,000	53
Sub Total				14,435		17,633
Total 1-5				86,335		92,776
Miscellaneous	L.S			9,497		10,206
Transportation				2,089		2,245
Grand Total				97,921		105,230

Table 17 PRICED B.Q. OF MAIN CONSTRUCTION WORKS OF SEDILI DAM (6/6)

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	N.H.W.L. 18 m Quantity	N.H.W.L. 18 m Amount	N.H.W.L. 20 m Quantity	N.H.W.L. 20 m Amount	N.H.W.L. 22 m Quantity	N.H.W.L. 22 m Amount
1. Access Road								
Rolling	M	219.25	9,000	1,973	9,000	1,973	9,000	1,973
Sub Total				1,973		1,973		1,973
2. Diversion & River Outlet								
Excavation Common	CU.M	4.19	133,000	557	133,000	557	133,000	557
W. Rock	CU.M	10.36	131,000	1,357	131,000	1,357	131,000	1,357
Rock	CU.M	24.71	16,000	395	16,000	395	16,000	395
Embankment	CU.M	5.85	43,000	252	43,000	252	43,000	252
Mass Concrete	CU.M	161.99	12,200	1,976	12,900	2,090	13,800	2,235
Reinforced Concrete	CU.M	275.12	650	179	680	187	730	201
Plug Concrete	CU.M	183.46	1,200	220	1,300	238	1,400	257
Diversion Gate	L.S			1,380		1,430		1,480
Bulk Head Gate, Hoist & Hoist Tower	L.S			462		504		546
Trashrack	L.S			22		22		22
Steel Pipe	L.S			120		120		120
Release Valve	L.S			700		700		700
Sub Total				7,621		7,853		8,122
3. Spillway								
Excavation Common	CU.M	4.19	188,000	788	165,000	691	139,000	582
W. Rock	CU.M	10.36	327,000	3,388	278,000	2,880	250,000	2,590
Rock	CU.M	24.71	20,000	494	7,000	420	14,000	346
Mass Concrete	CU.M	161.99	9,700	1,571	11,800	1,911	14,000	2,268
Reinforced Concrete	CU.M	275.12	1,900	523	2,000	550	2,100	578
Gabion Mattress	CU.M	97.08	3,000	291	3,000	291	3,000	291
Sub Total				7,055		6,744		6,655
4. Main Dam & Cofferdam								
Excavation Common	CU.M	4.19	453,000	1,898	465,500	1,950	495,000	2,074
W. Rock	CU.M	10.36	36,000	373	36,000	373	36,500	378
Curtain Grout	M	249.63	16,400	4,094	16,900	4,219	17,300	4,319
Blanket Grout	M	184.63	4,200	775	4,300	794	4,400	812
Embankment								
U/S Coffer	CU.M	5.85	117,000	684	117,000	684	117,000	684
D/S Coffer	CU.M	5.85	27,000	158	27,000	158	27,000	158
Earth	CU.M	5.85	448,000	2,621	495,000	2,896	565,000	3,305
Drain	CU.M	25.01	12,000	300	14,500	363	17,500	438
Riprap	CU.M	46.06	12,000	553	14,000	645	17,500	806
Sod Facing	SQ.M	3.14	9,500	30	11,000	35	15,000	47
Sub Total				11,486		12,116		13,022
Total 1-4				28,135		28,687		29,773
Miscellaneous				3,095		3,156		3,275
Transportation				681		694		721
Grand Total				31,911		32,537		33,769

Table 18 ANNUAL DISBURSEMENT SCHEDULE (1/18)

Name of Dam: Sayong Dam Type: Earthfill Scheme: H.W.L. 16 m

Unit: M$ 10^6

Item	Amount	1987	1988	1989	1990	1991
1. Preparatory Works	2.66		2.66			
2. Main Construction Works	30.17		6.28	7.78	10.11	6.00
3. Engineering & Administration	10.84	3.25	2.17	2.17	2.17	1.08
4. Compensation	42.10	16.84	12.63	12.63		
5. Physical Contingency	25.73	6.03	7.12	6.77	3.68	2.13
Total	111.50	26.12	30.86	29.35	15.96	9.21

Table 19 ANNUAL DISBURSEMENT SCHEDULE (2/18)

Name of Dam: Sayong Dam Type: Earthfill Scheme: H.W.L. 17 m

Unit: M$ 10^6

Item	Amount	1987	1988	1989	1990	1991
1. Preparatory Works	2.77		2.77			
2. Main Construction Works	31.41		6.54	7.89	10.56	6.42
3. Engineering & Administration	11.28	3.38	2.26	2.26	2.26	1.12
4. Compensation	48.00	19.20	14.40	14.40		
5. Physical Contingency	28.04	6.78	7.79	7.36	3.85	2.26
Total	121.50	29.36	33.76	31.91	16.67	9.80

Table 20 ANNUAL DISBURSEMENT SCHEDULE (3/18)

Name of Dam: Sayong Dam Type: Earthfill Scheme: H.W.L. 18 m

Unit: M$ 10^6

Item	Amount	1987	1988	1989	1990	1991
1. Preparatory Works	2.84		2.84			
2. Main Construction Works	32.24		6.72	7.99	10.90	6.63
3. Engineering & Administration	11.58	3.47	2.32	2.32	2.32	1.15
4. Compensation	54.90	21.96	16.47	16.47		
5. Physical Contingency	30.47	7.63	8.51	8.03	3.97	2.33
Total	132.03	33.06	36.86	34.81	17.19	10.11

Table 21 ANNUAL DISBURSEMENT SCHEDULE (4/18)

Name of Dam: Sayong Dam Type: Earthfill Scheme: H.W.L. 19 m

Unit: M$ 10^6

Item	Amount	1987	1988	1989	1990	1991
1. Preparatory Works	2.98		2.98			
2. Main Construction Works	33.75		7.04	8.22	11.51	6.98
3. Engineering & Administration	12.12	3.64	2.42	2.42	2.42	1.22
4. Compensation	65.20	26.08	19.56	19.56		
5. Physical Contingency	34.21	8.81	9.58	9.03	4.27	2.52
Total	148.26	38.53	41.58	39.23	18.20	10.72

Table 22 ANNUAL DISBURSEMENT SCHEDULE (5/18)

Name of Dam: Sayong Dam Type: Earthfill Scheme: H.W.L. 20 m

Unit: M$ 10^6

Item	Amount	1987	1988	1989	1990	1991
1. Preparatory Works	3.08		3.08			
2. Main Construction Works	34.94		7.29	8.39	12.02	7.24
3. Engineering & Administration	12.55	3.78	2.51	2.51	2.51	1.24
4. Compensation	78.00	31.20	23.40	23.40		
5. Physical Contingency	38.57	10.22	10.84	10.22	4.60	2.69
Total	167.14	45.20	47.12	44.52	19.13	11.17

Table 23 ANNUAL DISBURSEMENT SCHEDULE (6/18)

Name of Dam: Sayong Dam Type: Earthfill Scheme: H.W.L. 22 m

Unit: M$ 10^6

Item	Amount	1987	1988	1989	1990	1991
1. Preparatory Works	3.28		3.28			
2. Main Construction Works	37.20		7.78	8.73	12.91	7.78
3. Engineering & Administration	13.36	4.00	2.67	2.67	2.67	1.35
4. Compensation	104.70	41.88	31.41	31.41		
5. Physical Contingency	47.56	13.23	13.47	12.70	5.15	3.01
Total	206.10	59.11	58.61	55.51	20.73	12.14

Table 24 ANNUAL DISBURSEMENT SCHEDULE (7/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 27 m

Unit: M$ 10^6

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	5.94		5.94				
2. Main Construction Works	67.31		14.70	4.75	7.62	22.96	17.28
3. Engineering & Administration	19.78	5.94	3.96	2.97	2.97	2.97	0.97
4. Compensation	-						
5. Physical Contingency	27.91	1.78	3.78	2.32	3.18	7.78	5.47
Total	120.94	7.72	31.98	10.04	13.77	33.71	23.72

Table 25 ANNUAL DISBURSEMENT SCHEDULE (8/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 29.5 m

Unit: M$ 10^6

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	6.06		6.06				
2. Main Construction Works	68.76		14.99	4.56	7.42	23.70	18.09
3. Engineering & Administration	20.20	6.06	4.04	3.03	3.03	3.03	1.01
4. Compensation	-						
5. Physical Contingency	28.51	1.82	7.53	2.28	3.13	8.02	5.73
Total	123.53	7.88	32.62	9.87	13.58	34.75	24.83

Table 26 ANNUAL DISBURSEMENT SCHEDULE (9/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 32 m

Unit: M$ 106

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	6.26		6.26				
2. Main Construction Works	71.04		15.45	4.52	7.52	24.45	19.10
3. Engineering & Administration	20.87	6.26	4.17	3.13	3.13	3.13	1.05
4. Compensation	-						
5. Physical Contingency	29.45	1.88	7.77	2.30	3.20	8.28	6.02
Total	127.62	8.14	33.65	9.95	13.85	35.86	26.17

Table 27 ANNUAL DISBURSEMENT SCHEDULE (10/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 33 m

Unit: M$ 106

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	6.36		6.36				
2. Main Construction Works	72.13		15.68	4.52	7.59	24.77	19.57
3. Engineering & Administration	21.19	6.36	4.24	3.18	3.18	3.18	1.05
4. Compensation	-						
5. Physical Contingency	29.91	1.91	7.88	2.31	3.23	8.38	6.20
Total	129.59	8.27	34.16	10.01	14.00	36.33	26.82

Table 28 ANNUAL DISBURSEMENT SCHEDULE (11/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 34 m

Unit: M$ 10^6

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	6.48		6.48				
2. Main Construction Works	73.45		15.95	4.55	7.74	25.11	20.10
3. Engineering & Administration	21.58	6.48	4.32	3.24	3.24	3.24	1.06
4. Compensation	-						
5. Physical Contingency	30.45	1.95	8.02	2.34	3.29	8.50	6.35
Total	131.96	8.43	34.77	10.13	14.27	36.85	27.51

Table 29 ANNUAL DISBURSEMENT SCHEDULE (12/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 35 m

Unit: M$ 10^6

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	6.58		6.58				
2. Main Construction Works	74.57		16.18	4.58	7.91	25.42	20.48
3. Engineering & Administration	21.91	6.57	4.38	3.29	3.29	3.29	1.09
4. Compensation	-						
5. Physical Contingency	30.92	1.98	8.14	2.36	3.36	8.61	6.47
Total	133.98	8.55	35.28	10.23	14.56	37.32	28.04

Table 30 ANNUAL DISBURSEMENT SCHEDULE (13/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 38 m

Unit: M$ 10^6

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	8.63		8.63				
2. Main Construction Works	97.92		21.25	6.01	10.39	33.38	26.89
3. Engineering & Administration	28.77	8.63	5.75	4.32	4.32	4.32	1.43
4. Compensation	-						
5. Physical Contingency	40.60	2.60	10.69	3.10	4.41	11.31	8.49
Total	175.92	11.23	46.32	13.43	19.12	49.01	36.81

Table 31 ANNUAL DISBURSEMENT SCHEDULE (14/18)

Name of Dam: Linggiu Dam Type: Earthfill Scheme: H.W.L. 40 m

Unit: M$ 10^6

Item	Amount	1995	1996	1997	1998	1999	2000
1. Preparatory Works	9.27		9.27				
2. Main Construction Works	105.23		24.21	7.54	12.96	34.26	26.26
3. Engineering & Administration	30.92	9.28	6.19	4.64	4.64	4.64	1.53
4. Compensation	-						
5. Physical Contingency	43.63	2.79	11.91	3.66	5.28	11.67	8.32
Total	189.05	12.07	51.58	15.84	22.88	50.57	36.11

Table 32 ANNUAL DISBURSEMENT SCHEDULE (15/18)

Name of Dam: Sedili Dam Type: Earthfill Scheme: H.W.L. 16 m

Unit: M$ 10^6

Item	Amount	1st Year	2nd Year	3rd Year	4th Year	5th Year
1. Preparatory Works	2.8			2.81		
2. Main Construction Works	31.8		7.48	8.74	10.01	5.58
3. Engineering & Administration	11.42	3.43	2.29	2.29	2.29	1.12
4. Compensation	-					
5. Physical Contingency	13.81	1.03	3.77	3.31	3.69	2.01
Total	59.85	4.46	16.35	14.34	15.99	8.71

Table 33 ANNUAL DISBURSEMENT SCHEDULE (16/18)

Name of Dam: Sedili Dam Type: Earthfill Scheme: H.W.L. 18 m

Unit: M$ 10^6

Item	Amount	1st Year	2nd Year	3rd Year	4th Year	5th Year
1. Preparatory Works	2.81		2.81			
2. Main Construction Works	31.91		7.50	8.68	9.65	6.08
3. Engineering & Administration	11.46	3.44	2.29	2.29	2.29	1.15
4. Compensation	-					
5. Physical Contingency	13.86	1.03	3.78	3.29	3.58	2.18
Total	60.04	4.47	16.38	14.26	15.52	9.41

Table 34 ANNUAL DISBURSEMENT SCHEDULE (17/18)

Name of Dam: Sedili Dam Type: Earthfill Scheme: H.W.L. 20 m

Unit: M$ 10^6

Item	Amount	1st Year	2nd Year	3rd Year	4th Year	5th Year
1. Preparatory Works	2.87		2.87			
2. Main Construction Works	32.53		7.63	8.72	9.54	6.64
3. Engineering & Administration	11.68	3.51	2.34	2.34	2.34	1.15
4. Compensation	-					
5. Physical Contingency	14.13	1.05	3.85	3.32	3.56	2.35
Total	61.21	4.56	16.69	14.38	15.44	10.14

Table 35 ANNUAL DISBURSEMENT SCHEDULE (18/18)

Name of Dam: Sedili Dam Type: Earthfill Scheme: H.W.L. 22 m

Unit: M$ 106

Item	Amount	1st Year	2nd Year	3rd Year	4th Year	5th Year
1. Preparatory Works	2.98		2.98			
2. Main Construction Works	33.77		7.89	8.85	9.64	7.39
3. Engineering & Administration	12.13	3.64	2.43	2.43	2.43	1.20
4. Compensation	-					
5. Physical Contingency	14.66	1.09	3.99	3.38	3.62	2.58
Total	63.54	4.73	17.29	14.66	15.69	11.17

Table 36 COST ESTIMATE OF DAM CONSTRUCTION WORKS (BENUT)

Benut

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	H.W.L. 25 m Quantity	H.W.L. 25 m Amount	H.W.L. 27 m Quantity	H.W.L. 27 m Amount	H.W.L. 29 m Quantity	H.W.L. 29 m Amount
1. Preparatory Works				3,415		3,643		3,869
2. Main Construction Works								
2.1 Access Road								
Rolling	M	219.25	4,700	1,030	4,700	1,030	4,700	1,030
Mountainous	M	343.97	0	0	0	0	0	0
Sub Total				1,030		1,030		1,030
2.2 Diversion & River Outlet								
Excavation	CU.M	8.25	98,000	809	98,000	809	98,000	809
Embankment	CU.M	5.85	25,000	146	25,000	146	25,000	146
Concrete	CU.M	167.65	3,100	520	3,200	536	3,300	553
Metal Works	L.S			853		982		1,095
Sub Total				2,327		2,473		2,603
2.3 Spillway								
Excavation	CU.M	8.68	399,000	3,463	354,000	3,073	318,000	2,760
Concrete	CU.M	178.39	11,300	2,016	11,500	2,051	11,700	2,087
Sub Total				5,479		5,124		4,847
2.4 Main Dam & Cofferdam								
Excavation	CU.M	4.63	620,000	2,871	702,000	3,250	784,000	3,630
Curtain Grout	M	249.63	35,500	8,862	36,400	9,087	37,400	9,336
Blanket Grout	M	184.63	18,500	3,416	19,500	3,600	20,400	3,766
Embankment								
Coffer	CU.M	5.85	325,000	1,901	325,000	1,901	325,000	1,901
Earth	CU.M	5.85	1,040,00	6,084	1,252,000	7,324	1,464,000	8,564
Drain	CU.M	25.01	37,500	938	46,000	1,175	54,000	1,351
Riprap	CU.M	46.06	25,500	1,175	30,000	1,382	34,000	1,566
Sod Facing	SQ.M	3.14	22,000	69	26,000	82	30,500	96
Sub Total				25,315		27,801		30,211
Total 2.1 - 2.4				34,152		36,429		38,691
Miscellaneous	L.S			3,757		4,007		4,256
Transportation				826		882		936
Total of 2				38,735		41,318		43,884
3. Engineering & Administration				13,488		14,388		15,281
4. Compensation				7,200		9,900		13,300
5. Physical Contingency				18,852		20,775		22,900
Grand Total				81,690		90,024		99,234

Table 37 COST ESTIMATE OF DAM CONSTRUCTION WORKS (PONTIAN BESAR)

Pontian Besar

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	H.W.L. 10 m Quantity	H.W.L. 10 m Amount	H.W.L. 22 m Quantity	H.W.L. 22 m Amount	H.W.L. 25.5 m Quantity	H.W.L. 25.5 m Amount
1. Preparatory Works				4,152		4,951		5,711
2. Main Construction Works								
2.1 Access Road								
Rolling	M	219.25	3,200	702	3,200	702	3,200	702
Mountainous	M	343.97	0	0	0	0	0	0
Sub Total				702		702		702
2.2 Diversion & River Outlet								
Excavation	CU.M	8.25	112,000	924	112,000	924	112,000	924
Embankment	CU.M	5.85	40,000	234	40,000	234	40,000	234
Concrete	CU.M	167.65	3,600	604	4,100	687	4,400	738
Metal Works	L.S			878		1,290		1,600
Sub Total				2,640		3,135		3,496
2.3 Spillway								
Excavation	CU.M	8.68	259,000	2,248	200,000	1,736	165,000	1,432
Concrete	CU.M	178.39	8,900	1,588	9,400	1,677	9,700	1,730
Sub Total				3,836		3,413		3,163
2.4 Main Dam & Cofferdam								
Excavation	CU.M	4.63	536,000	2,482	757,000	3,505	967,000	4,477
Curtain Grout	M	249.63	57,100	14,254	60,900	15,202	64,000	15,976
Blanket Grout	M	184.63	25,200	4,653	27,400	5,059	30,000	5,539
Embankment								
Coffer	CU.M	5.85	500,000	2,925	500,000	2,925	500,000	2,925
Earth	CU.M	5.85	1,122,000	6,564	1,744,000	10,202	2,385,000	13,952
Drain	CU.M	25.01	29,000	725	45,000	1,125	62,000	1,551
Riprap	CU.M	46.06	32,000	1,474	49,000	2,257	60,000	2,764
Sod Facing	SQ.M	3.14	31,000	97	45,000	141	55,500	174
Sub Total				33,173		40,417		47,358
2.5 Saddle Dam								
Excavation	CU.M	4.63	24,000	111	48,000	222	60,000	278
Curtain Grout	M	249.63	1,900	474	2,400	599	2,800	699
Blanket Grout	M	184.63	800	148	1,100	203	1,400	258
Embankment								
Earth	CU.M	5.85	37,000	216	70,000	410	92,000	538
Drain	CU.M	25.01	1,100	28	3,000	75	5,700	143
Riprap	CU.M	46.06	3,800	175	6,700	309	9,700	447
Sod Facing	SQ.M	3.14	4,300	14	7,400	23	10,500	33
Sub Total				1,166		1,841		2,396
Total 2.1 ~ 2.5				41,516		49,508		57,114
Miscellaneous	L.S			4,567		5,446		6,283
Transportation				1,005		1,198		1,382
Total of 2				47,087		56,152		64,778
3. Engineering & Administration				14,347		17,109		19,737
4. Compensation				17,400		25,500		35,000
5. Physical Contingency				24,896		31,113		37,568
Grand Total				107,882		134,825		162,795

Table 38 COST ESTIMATE OF DAM CONSTRUCTION WORKS (UPPER PENGLI)

Upper Pengli

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	H.W.L. 33 m Quantity	H.W.L. 33 m Amount	H.W.L. 37 m Quantity	H.W.L. 37 m Amount	H.W.L. 41 m Quantity	H.W.L. 41 m Amount
1. Preparatory Works				4,748		5,997		6,757
2. Main Construction Works								
2.1 Access Road								
Rolling	M	219.25	5,100	1,118	5,100	1,118	5,100	1,118
Mountainous	M	343.97	0	0	0	0	0	0
Sub Total				1,118		1,118		1,118
2.2 Diversion & River Outlet								
Excavation	CU.M	8.25	223,000	1,840	223,000	1,840	223,000	1,840
Embankment	CU.M	5.85	30,000	176	30,000	176	30,000	176
Concrete	CU.M	167.65	8,800	1,475	9,700	1,626	10,300	1,727
Metal Works	L.S			1,350		2,277		2,829
Sub Total				4,841		5,918		6,571
2.3 Spillway								
Excavation	CU.M	8.68	169,000	1,467	136,000	1,180	127,000	1,102
Concrete	CU.M	178.39	10,100	1,802	10,600	1,891	11,000	1,962
Sub Total				3,269		3,071		3,065
2.4 Main Dam & Cofferdam								
Excavation	CU.M	4.63	450,000	2,084	673,000	3,116	781,000	3,616
Curtain Grout	M	249.63	36,400	9,087	42,000	10,484	46,000	11,483
Blanket Grout	M	184.63	15,700	2,899	18,000	3,323	20,300	3,748
Embankment								
Coffer	CU.M	5.85	439,000	2,568	439,000	2,568	439,000	2,568
Earth	CU.M	5.85	726,000	4,247	1,033,000	6,043	1,111,000	6,499
Drain	CU.M	25.01	20,000	500	29,500	738	36,000	900
Riprap	CU.M	46.06	19,000	875	28,500	1,313	36,000	1,658
Sod Facing	SQ.M	3.14	17,000	53	27,500	86	35,000	110
Sub Total				22,313		27,672		30,583
2.5 Saddle Dam								
Excavation	CU.M	4.63	329,000	1,523	650,000	3,010	710,000	3,287
Curtain Grout	M	249.63	29,000	7,239	34,000	8,487	40,000	9,985
Blanket Grout	M	184.63	12,500	2,308	16,000	2,954	20,000	3,693
Embankment								
Earth	CU.M	5.85	577,000	3,375	930,000	5,441	1,065,000	6,347
Drain	CU.M	25.01	17,000	425	20,500	513	22,000	550
Riprap	CU.M	46.06	21,500	990	36,000	1,658	40,000	2,211
Sod Facing	SQ.M	3.14	25,000	79	40,000	126	51,000	160
Sub Total				15,940		22,188		26,234
Total 2.1 ~ 2.5				47,480		59,968		67,570
Miscellaneous	L.S			5,223		6,596		7,433
Transportation				1,149		1,451		1,635
Total of 2				53,852		68,016		76,638
3. Engineering & Administration				14,650		18,503		20,849
4. Compensation				9,000		18,700		35,300
5. Physical Contingency				24,675		33,365		41,863
Grand Total				106,925		144,581		181,407

Table 39 COST ESTIMATE OF DAM CONSTRUCTION WORKS (TELOR)

Telor

Unit: M$ 103

Description	Unit	Unit Price (M$)	H.W.L. 22 m Quantity	H.W.L. 22 m Amount	H.W.L. 25 m Quantity	H.W.L. 25 m Amount	H.W.L. 28 m Quantity	H.W.L. 28 m Amount
1. Preparatory Works				2,174		2,378		2,548
2. Main Construction Works								
2.1 Access Road								
Rolling	M	219.25	1,900	417	1,900	417	1,900	417
Mountainous	M	343.97	1,300	447	1,300	447	1,300	447
Sub Total				864		864		864
2.2 Diversion & River Outlet								
Excavation	CU.M	8.25	114,000	941	114,000	941	114,000	941
Embankment	CU.M	5.85	55,000	322	55,000	322	55,000	322
Concrete	CU.M	167.65	4,500	754	4,700	788	5,000	838
Metal Works	L.S			983		1,267		1,669
Sub Total				3,000		3,317		3,770
2.3 Spillway								
Excavation	CU.M	8.68	216,000	1,875	186,000	1,614	158,000	1,371
Concrete	CU.M	178.39	9,500	1,695	9,800	1,748	10,000	1,784
Sub Total				3,570		3,363		3,155
2.4 Main Dam & Cofferdam								
Excavation	CU.M	4.63	318,000	1,472	342,000	1,583	353,000	1,634
Curtain Grout	M	249.63	16,500	4,119	18,000	4,493	19,500	4,868
Blanket Grout	M	184.63	20,500	3,785	22,500	4,154	23,500	4,339
Embankment								
Coffer	CU.M	5.85	260,000	1,521	260,000	1,521	260,000	1,521
Earth	CU.M	5.85	352,000	2,059	485,000	2,837	598,000	3,498
Drain	CU.M	25.01	10,000	250	13,000	325	16,000	400
Riprap	CU.M	46.06	22,500	1,036	27,000	1,244	29,000	1,336
Sod Facing	SQ.M	3.14	20,000	63	25,500	80	30,500	96
Sub Total				14,306		16,238		17,692
Total 2.1 ~ 2.4				21,739		23,782		25,481
Miscellaneous	L.S			2,391		2,616		2,803
Transportation				526		576		617
Total of 2				24,656		26,973		28,900
3. Engineering & Administration				9,927		10,860		11,636
4. Compensation				1,900		3,900		6,700
5. Physical Contingency				11,597		13,233		14,935
Grand Total				50,254		57,344		64,719

Tahle 40 COST ESTIMATE OF DAM CONSTRUCTION WORKS (LAYAU KIRI)

Layau Kiri

Unit: M$ 10^3

Description	Unit	Unit Price (M$)	H.W.L. 14 m Quantity	H.W.L. 14 m Amount	H.W.L. 18 m Quantity	H.W.L. 18 m Amount	H.W.L. 22 m Quantity	H.W.L. 22 m Amount
1. Preparatory Works				3,248		3,747		4,326
2. Main Construction Works								
2.1 Access Road								
Rolling	M	219.25	0	0	0	0	0	0
Mountainous	M	343.97	4,500	1,548	4,500	1,548	4,500	1,548
Sub Total				1,548		1,548		1,548
2.2 Diversion & River Outlet								
Excavation	CU.M	8.25	105,000	866	105,000	866	105,000	866
Embankment	CU.M	5.85	25,000	146	25,000	146	25,000	146
Concrete	CU.M	167.65	2,900	486	3,300	553	3,500	587
Metal Works	L.S			772		1,111		1,349
Sub Total				2,271		2,677		2,948
2.3 Spillway								
Excavation	CU.M	8.68	355,000	3,081	258,000	2,239	235,000	2,040
Concrete	CU.M	178.39	7,300	1,302	8,000	1,427	8,300	1,481
Sub Total				4,384		3,667		3,520
2.4 Main Dam & Cofferdam								
Excavation	CU.M	4.63	237,000	1,097	284,000	1,315	306,000	1,417
Curtain Grout	M	249.63	27,900	6,965	30,200	7,539	33,000	8,238
Blanket Grout	M	184.63	15,300	2,825	17,500	3,231	19,800	3,656
Embankment								
Coffer	CU.M	5.85	340,000	1,989	340,000	1,989	340,000	1,989
Earth	CU.M	5.85	381,000	2,229	675,000	3,949	950,000	5,558
Drain	CU.M	25.01	11,000	275	18,800	470	24,000	600
Riprap	CU.M	46.06	10,000	461	18,700	861	25,000	1,152
Sod Facing	SQ.M	3.14	10,000	31	15,500	49	21,000	66
Sub Total				15,872		19,403		22,674
2.5 Sub Dam								
Excavation	CU.M	4.63	186,000	861	256,000	1,185	314,000	1,454
Curtain Grout	M	249.63	10,300	2,571	11,300	2,821	15,200	3,794
Blanket Grout	M	184.63	9,900	1,828	10,300	1,902	12,400	2,289
Embankment								
Coffer	CU.M	5.85	92,000	538	92,000	538	92,000	538
Earth	CU.M	5.85	295,000	1,726	434,000	2,539	520,000	3,042
Drain	CU.M	25.01	7,000	175	13,300	333	18,800	470
Riprap	CU.M	46.06	6,000	276	9,200	424	11,600	534
Sod Facing	SQ.M	3.14	5,000	16	7,800	24	9,900	31
Connecting Channel								
Excavation	CU.M	8.25	50,000	413	50,000	413	50,000	413
Sub Total				8,404		10,178		12,566
Total 2.1 - 2.5				32,478		37,472		43,257
Miscellaneous	L.S			3,573		4,122		4,758
Transportation				786		907		1,047
Total of 2				36,836		42,501		49,062
3. Engineering & Administration				13,228		15,262		17,618
4. Compensation				13,500		15,700		19,800
5. Physical Contingency				20,044		23,163		27,242
Grand Total				86,856		100,373		118,047

Table 41 CONSTRUCTION COST OF TREATMENT PLANT

Unit: M$10^6

Item	Case A Single Stage Development (107 Mgd)	Case B 2-Stage Development 1st Stage (50 Mgd)	Case B 2-Stage Development 2nd Stage (57 Mgd)	Total
1. Preparatory work & main const. works	113	54	63	
2. Engineering service & administration	11.3	5.4	6.3	
3. Land acquisition	0.8	0.8	-	
4. Contingency	37.5	18.1	20.8	
Total/1	162.6	78.3	90.1	
Present value/2	118.6	57.1	33.7	90.8

Notes; /1: Financial cost in 1985 price level

/2: Present value of financial cost; 1986 time basis

Table 42 CONSTRUCTION COST OF PUMPING STATION

Unit: M$10^6

Item	Case A Single Stage Development (5.6 m3/s)	Case B 2-Stage Development 1st Stage (2.63 m^3/s)	Case B 2-Stage Development 2nd Stage (3.0 m3/s)	Total
1. Preparatory work & main const. works	21.5	16.5	17.5	
2. Engineering service & administration	2.2	1.7	1.8	
3. Land acquisition	-	-	-	
4. Contingency	7.1	5.5	5.8	
Total/1	30.8	23.7	25.1	
Present value/2	21.5	18.0	9.0	27.0

Notes; /1: Financial cost in 1985 price level

/2: Present value of financial cost; 1986 time basis

Table 43 CONSTRUCTION COST OF PIPELINE

Unit: M$10^6

Item	Case A Single Stage Development (107 Mgd)	Case B 2-Stage Development 1st Stage (50 Mgd)	Case B 2-Stage Development 2nd Stage (57 Mgd)	Total
1. Preparatory work & main const. works	48	28	31.4	
2. Engineering service & administration	4.8	2.8	3.1	
3. Land acquisition	0.9	0.9	-	
4. Contingency	16.1	9.5	10.4	
Total/1	69.8	41.2	44.9	
Present value/2	50.8	28.6	17.4	46.0

Notes; /1: Financial cost in 1985 price level

/2: Present value of financial cost; 1986 time basis

Table 44 COST OF WATER RESOURCES FACILITIES FOR PROPOSED DEVELOPMENT PLAN AND UNIT WATER COST

1. Total Cost

Unit: M$10^6

Item	Cost	Remarks
1. Dam	107	Sayong: HWL 18 m Single stage development
2. Treatment Plant	91	2-stage development
3. Pumping Station	22	Single stage development
4. Pipeline	46	2-stage development
5. Distribution System	272	Multi stage development
Total	538/1	

2. Unit Water Cost

$$\text{Unit water cost} = \frac{M\$538 \times 10^6}{638 \times 10^6 m^3/2} = M¢84/m^3$$

Note; /1: Present value of financial cost; 1986 time basis

/2: Total amount of supply water for 50 years

FIGURES

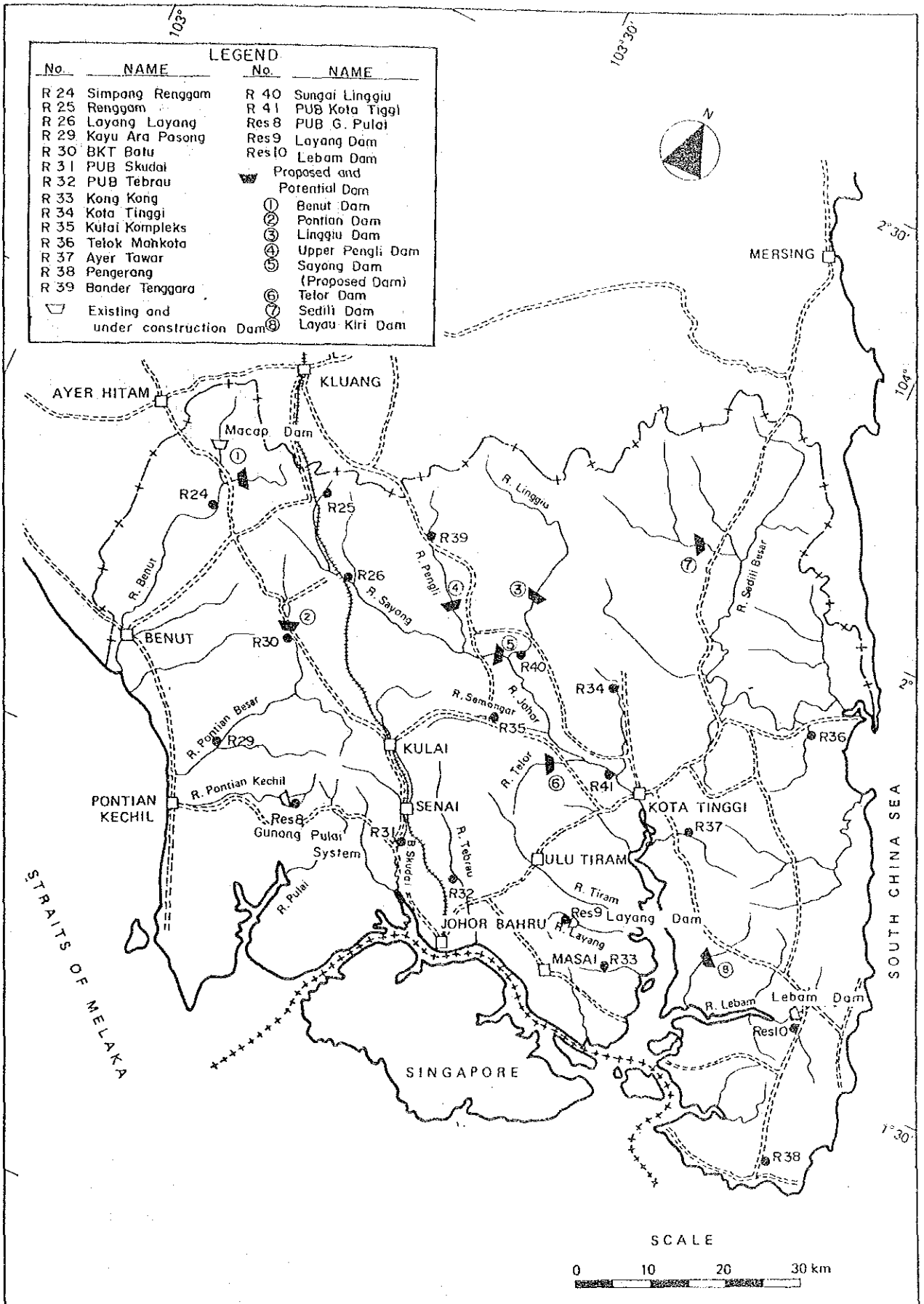

Fig. 1 Location Map of Existing Water Supply Facilities and Proposed Damsites

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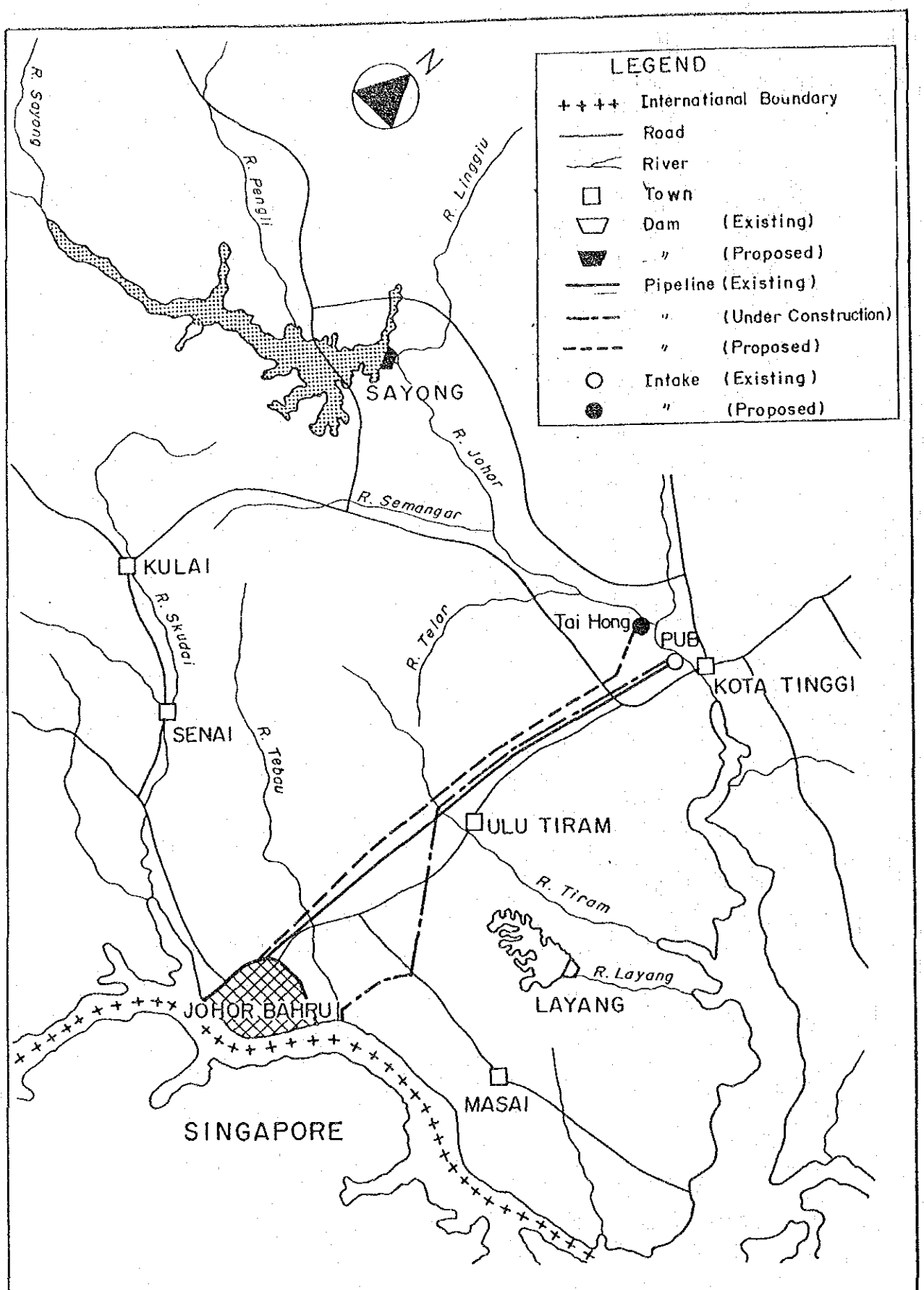
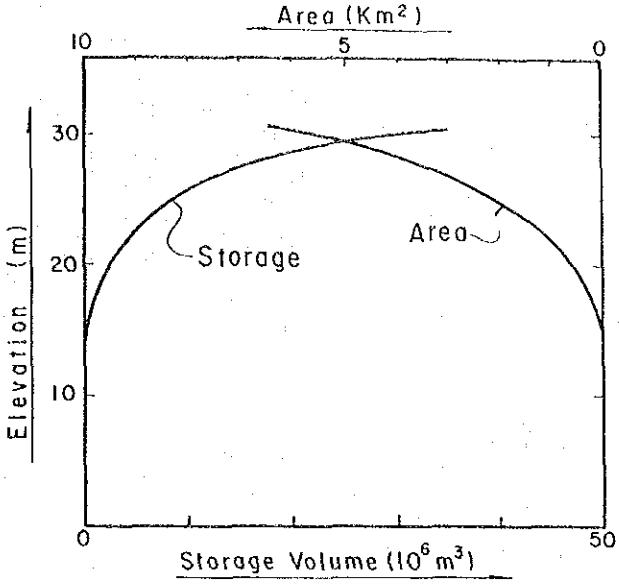
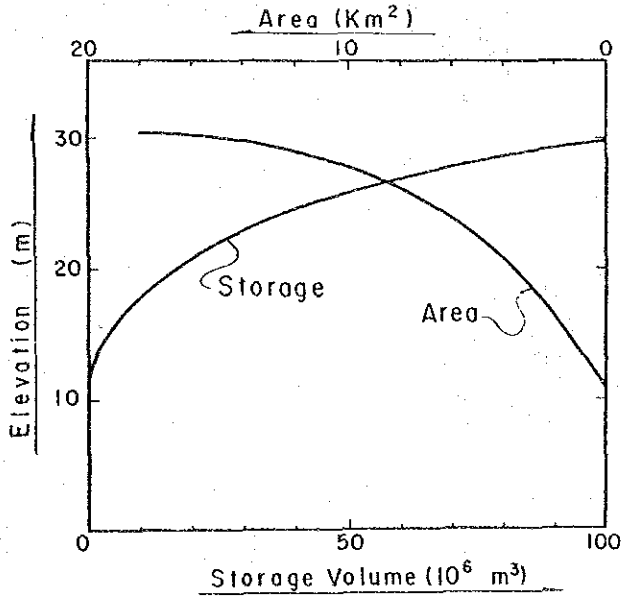


Fig.2 Layout of Pipeline



Benut

EL. (m)	Area (km^2)	Storage (10^6-m^3)
13.7	0	0
15.2	0.01	0.01
22.9	1.2	4.7
30.5	6.2	32.7



Pontian Besar

EL. (m)	Area (km^2)	Storage (10^6-m^3)
10.7	0	0
15.2	1.6	3.7
22.9	5.2	29.8
30.5	17.2	114.9

Fig. 3 Area - Storage Curves of Proposed Dams (1/3)

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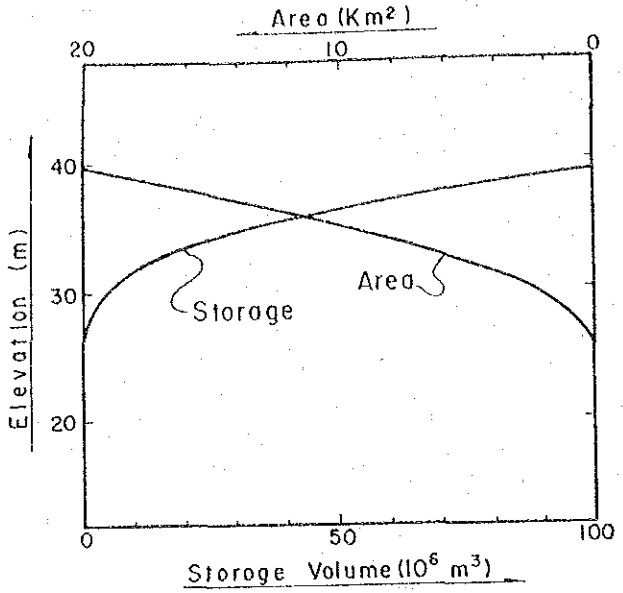
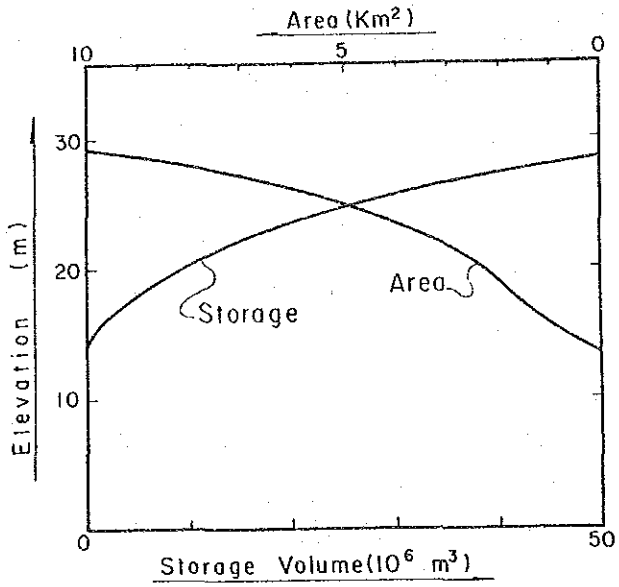


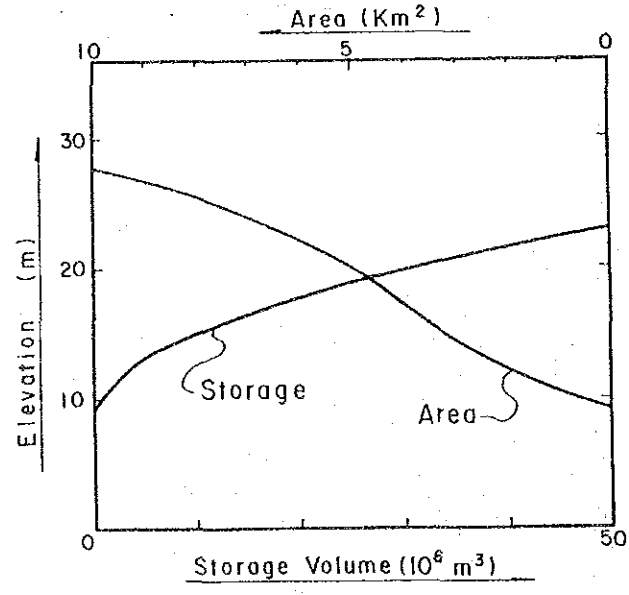
Upper Pengli

EL. (m)	Area (km^2)	Storage (10^6-m^3)
25.9	0	0
30.5	2.4	5.5
38.1	15.8	74.8
45.7	35.1	268.4



Telor

EL. (m)	Area (km^2)	Storage (10^6-m^3)
13.7	0	0
15.2	0.8	0.6
22.9	3.6	17.5
30.5	12.1	77.0



Layau Kiri

EL. (m)	Area (km^2)	Storage (10^6-m^3)
9.1	0	0
15.2	3.4	10.5
22.9	6.3	47.9
30.5	13.5	123.0

Fig. 4 Area-Storage Curves of Proposed Dams (2/3)

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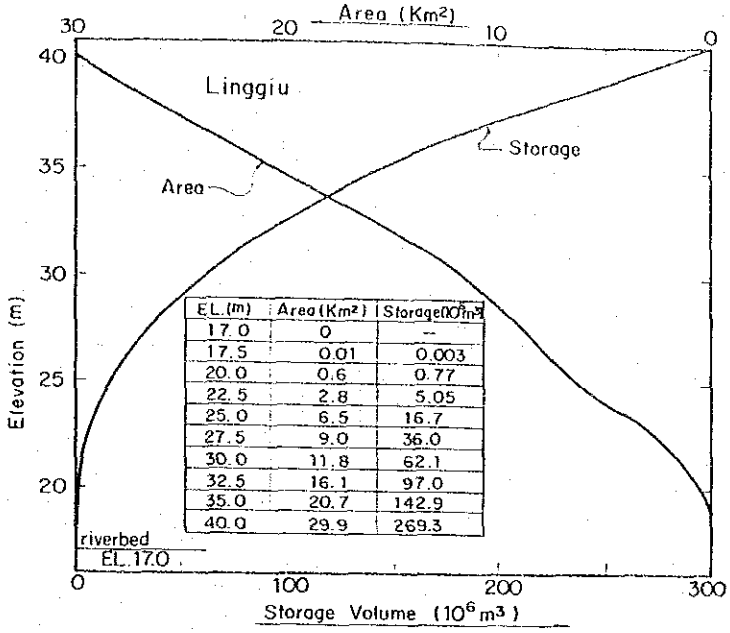
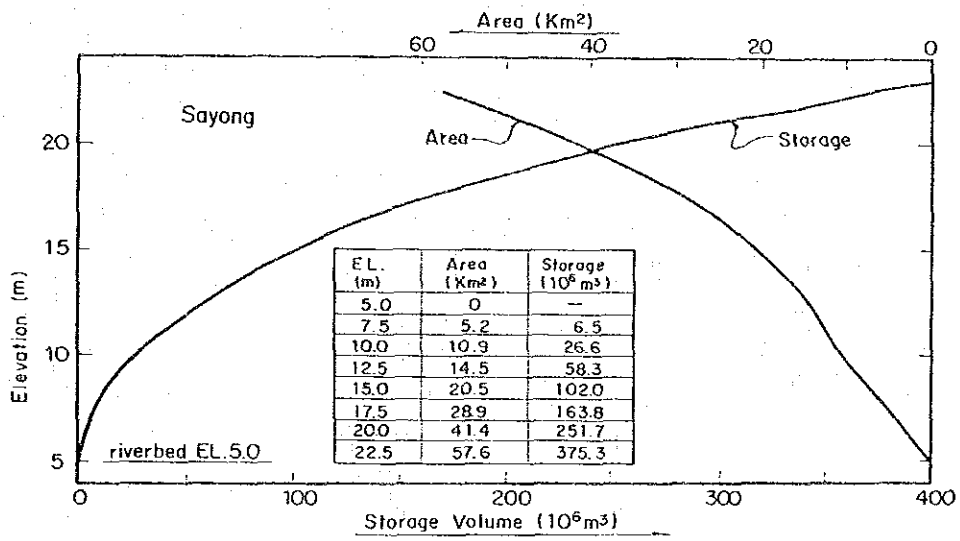
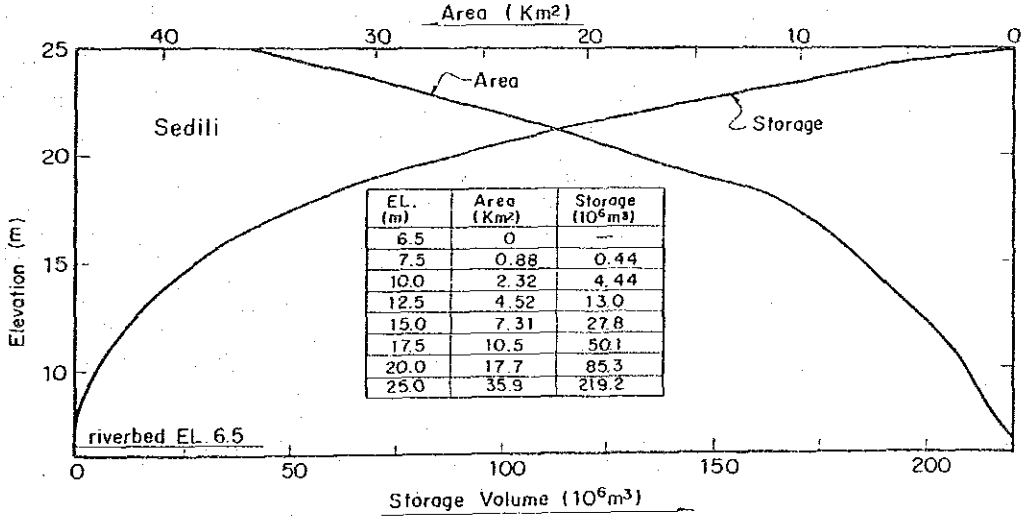


EL.(m)	Area(Km²)	Storage(10⁶m³)
17.0	0	--
17.5	0.01	0.003
20.0	0.6	0.77
22.5	2.8	5.05
25.0	6.5	16.7
27.5	9.0	36.0
30.0	11.8	62.1
32.5	16.1	97.0
35.0	20.7	142.9
40.0	29.9	269.3



EL. (m)	Area (Km²)	Storage (10⁶m³)
5.0	0	--
7.5	5.2	6.5
10.0	10.9	26.6
12.5	14.5	58.3
15.0	20.5	102.0
17.5	28.9	163.8
20.0	41.4	251.7
22.5	57.6	375.3



EL. (m)	Area (Km²)	Storage (10⁶m³)
6.5	0	--
7.5	0.88	0.44
10.0	2.32	4.44
12.5	4.52	13.0
15.0	7.31	27.8
17.5	10.5	50.1
20.0	17.7	85.3
25.0	35.9	219.2

Fig.5 Area - Storage Curves of Proposed Dams (3/3)

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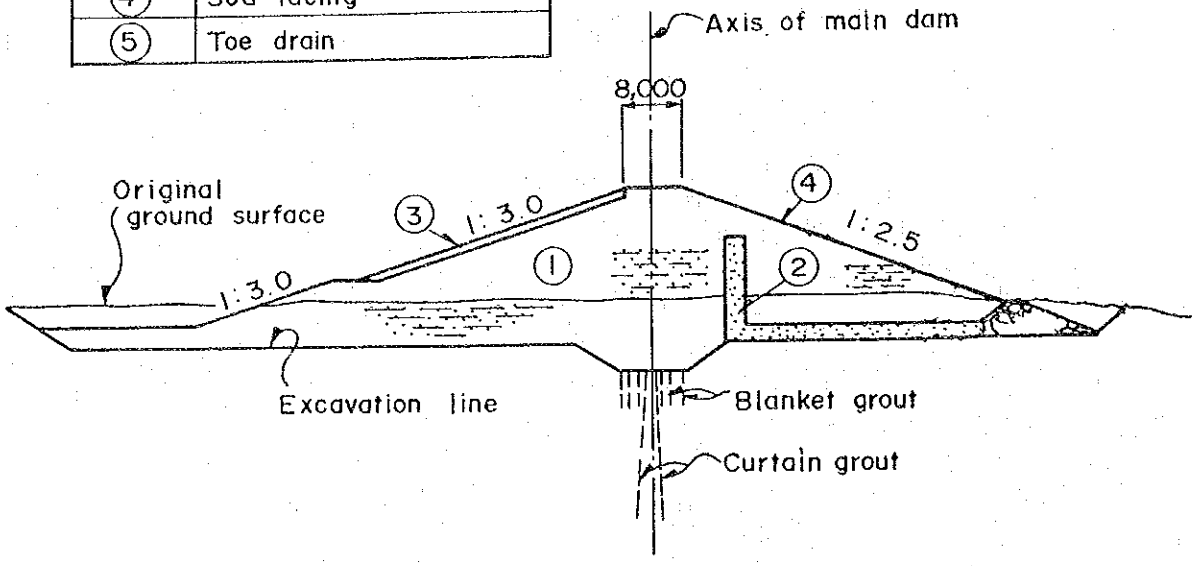
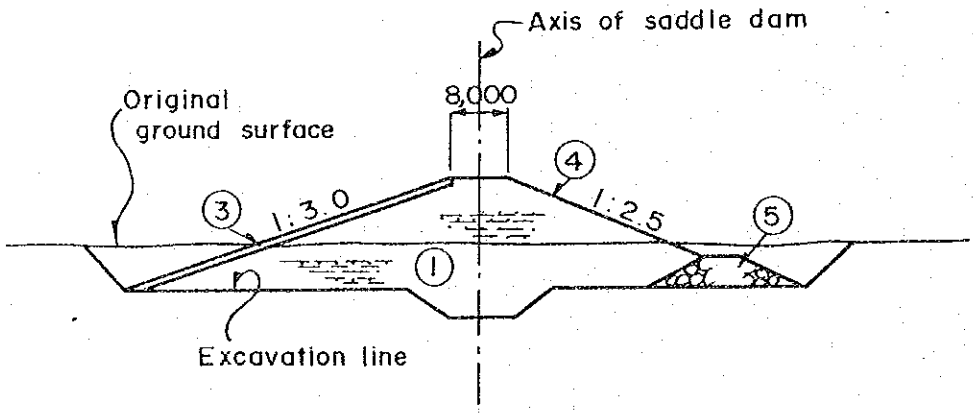
Zone	Material
①	Earthfill material
②	Interceptor drain
③	Riprap
④	Sod facing
⑤	Toe drain



TYPICAL SECTION OF MAIN DAM



TYPICAL SECTION OF SADDLE DAM

Fig. 6 Typical Section of Dams

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