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NATIONAL WATER RESOURCES STUDY, MALAYSIA
PERLIS-KEDAH-PULAU PINANG
REGIONAL WATER RESOURCES STUDY
PART 2
BERIS DAM FEASIBILITY STUDY

VOL. 6
ANNEX

I. DESIGN AND COST ESTIMATE

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

NATIONAL WATER RESOURCES STUDY, MALAYSIA

PERLIS - KEDAH - PULAU PINANG

REGIONAL WATER RESOURCES STUDY

PART 2

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ABBREVIATIONS

(1) Organization/Plan

4MP (5MP)	:	Fourth (Fifth) Malaysia Plan
DID (JPT)	:	Drainage and Irrigation Department
EPU	:	Economic Planning Unit
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
IBRD	:	The World Bank
JICA	:	Japan International Cooperation Agency
MADA	:	Muda Agricultural Development Authority
MOH	:	Ministry of Health
MTR	:	Mid-Term Review of 4MP
NEB (LLN)	:	National Electricity Board
NWRS	:	National Water Resources Study
PWA	:	Pulau Pinang Water Authority
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
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation Above Mean Sea Level
Eq.	:	Equation
Fig.	:	Figure
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
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
yd = yard

Area

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

Volume

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

Weight

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

Time

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

Electrical Measures

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

Other Measures

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

Derived Measures

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

Money

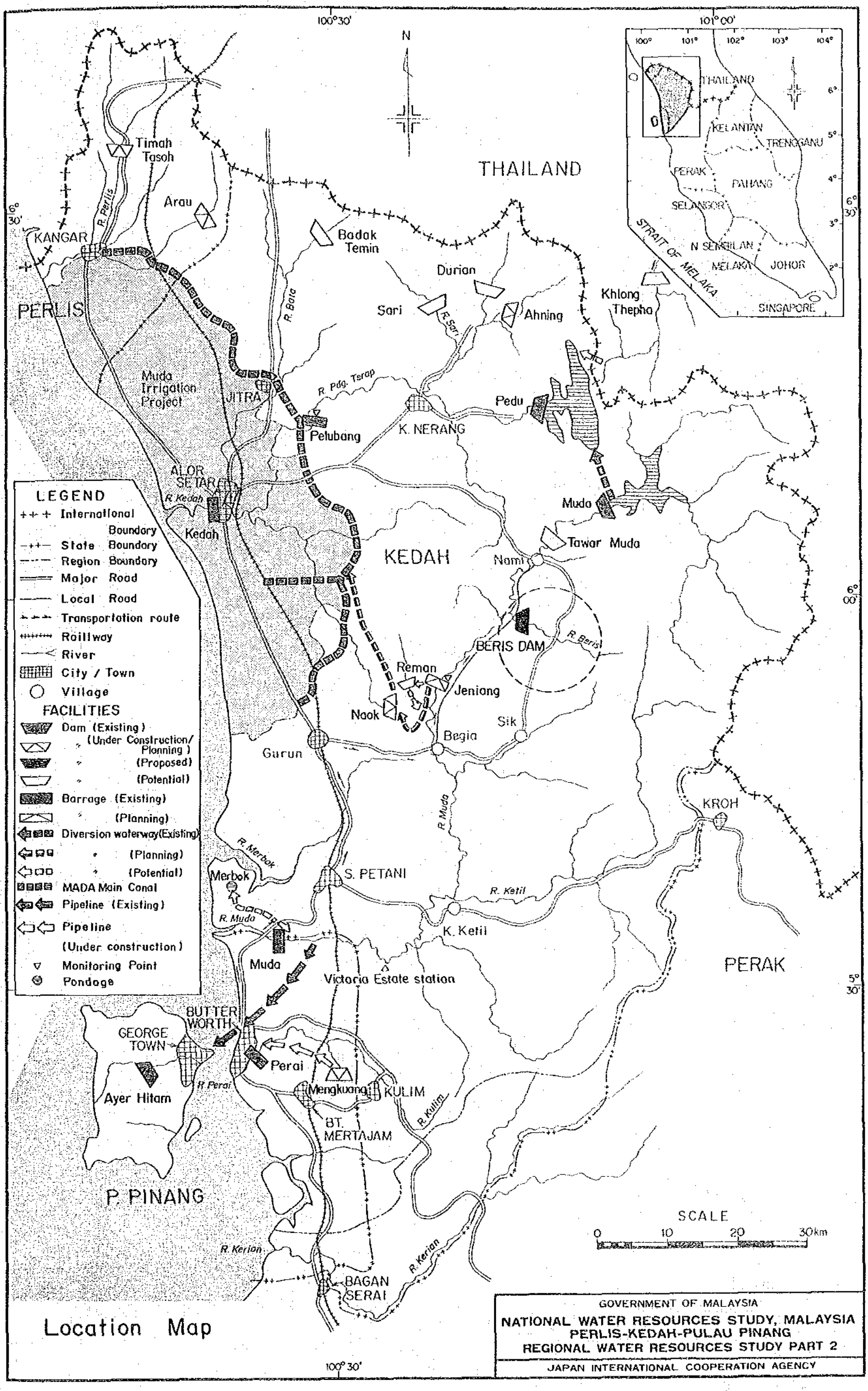
M$ = Malaysian ringgit
US$ = US dollar
¥ = Japanese Yen

CONVERSION FACTORS

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

Exchange Rate
(at the end of 1983)

US$1 = M$2.312
¥100 = M$0.998



Location Map

ANNEX I

DESIGN AND COST ESTIMATE

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1. INTRODUCTION

This Annex deals with the preliminary design and cost estimate carried out for the Beris dam feasibility study to define the scale of the project component and the project cost based on the results of ground survey, geological investigation, construction material survey and further alternative studies made under the feasibility phase. The basic conception of the design, construction schedule and cost estimate considered for the proposed plan are mainly described in this Annex. Further, design drawings and cost estimates of the alternative plans are also shown and described in Chapter 8 of this Annex.

Details of the geological investigation and construction material survey are compiled separately in Annex G "Engineering Geology" and Annex H "Construction Material".

In addition, original topographical maps and river sections obtained by the ground survey are kept under the custody of this study team.

2. DESCRIPTION OF PROPOSED PROJECT FACILITIES

2.1 General

The main component of the proposed Beris Dam Project is of a river diversion tunnel and coffer dams, a concrete gravity type main dam, a rockfill type saddle dam, an overflow type spillway, two river outlet facilities and relocation road. Their location are shown on Plates 1 to 3.

Based on the optimization of reservoir capacity, normal high water level (HWL) is set to be El. 85.0 m at which the reservoir storage capacity is 111.3×10^6 m^3. This capacity entails the construction of 41 m high main dam and 28 m high saddle dam.

The main damsite is located on the Beris river 1.6 km upstream from its confluence with the Muda river. The saddle dam is located at low ridge about 700 m northeast from the main dam.

In the main damsite, the diversion tunnel of 215 m long with 1 to 54 in slope is passed through the right abutment. A concrete type upstream cofferdam and a rockfill type downstream cofferdam are constructed for the construction of main dam.

The concrete gravity type main dam is designed to be 41 m at the maximum height and 150 m in the crest length. The crest elevation is El. 89.0 m. In the middle portion of the dam, non-gated type spillway with 20 m in overflow width is provided. To dissipate high flow velocity through spillway overflow, horizontal type stilling basin is provided.

Considering reliability of river outlet facilities, two lines of river outlet are provided near the left side of spillway and stilling basin. A river outlet is composed of a fixed trash rack, an intake gate, a steel penstock line, a guard valve, a hollow jet valve.

In order to supply river maintenance water to the limited area between the dam and the river confluence with the Muda river, small outlet valve (high pressure slide gate valve) is also provided to ensure the downstream demand of 0.2 m^3/s.

The rockfill type saddle dam is designed to be 28 m at the maximum height and 160 m in the crest length. The dam crest is El. 90.5 m.

In the reservoir area, new road of 11.9 km length is newly constructed between kg. Batu Seketul and kg. S. Batang to replace the existing road from Nami to Sik which is inundated into the reservoir. In accordance with the design standard of the existing road, asphalt penetration macadam pavement with 5.5 m road width is adopted.

The principal features of the proposed Beris Dam Project are summarized in Tables 1 to 3.

2.2 River Diversion Scheme

The catchment area of the Beris river is 116 km^2 at the damsite. The flood runoff record is not reliable at present.

The design flood of river diversion scheme is decided depending on the dam type. In Japan, many concrete dams have been constructed in such catch basin with rapid river flow. The design flood with one or two times per year in overtopping possibility is usually adopted for the diversion scheme in those dams. Herein, a two-year probable flood of 200 m^3/s is adopted as the design flood for the river diversion scheme.

The route of tunnel is selected at the right abutment, since the tunnel length can minimize from topography. Slope of tunnel is decided at 1:54 to meet the riverbed elevation of both tunnel portal.

The horseshoe shape tunnel section of 5.0 m in diameter is determined so that 200 m^3/s design flood can be discharged under free flow condition.

Plug length of 15.0 m is determined from shearing resist against the reservoir water pressure. Pipe cooling by using the natural river water is conducted for the plug concrete and contract grout is made to protect from leakage water through construction joint.

The water level in front of the diversion inlet is calculated to be El. 61.8 m at the design flood. The upstream cofferdam crest is fixed at El. 62.0 m to meet the inlet water level. Considering the possibility of overtopping damage, concrete cofferdam is designed.

While the downstream cofferdam is designed as a random fill, because cofferdam is only 3.5 m high and easily repaired or rebuilt even if washed away.

In the saddle damsite no cofferdam is provided because the foundation elevation is far higher than the flood water level.

2.3 Main Dam

The main damsite is situated on the Beris river 1.6 km upstream of its confluence with the Muda river and this is the only site on Beris River that offers favourable topography and geology for constructing a main dam to impound the large gross storage of about 111.3×10^6 m^3. The riverbed at the damsite has an elevation of about 51.0 m and a width of about 20 m respectively. The both abutments have relatively steep slopes of about 1 in 1.4 to 1 in 1.5.

The geology of the main damsite is described in detail in Annex G "Engineering Geology".

The bedrock of the damsite is alternation of conglomerate and gritty sandstone with subordinate interbeded sandstone, which belong to Triassic Semanggol Formation. The formation strikes about N30°E and dips 20° to 30° NW regularly. There is no injuriously fractured zone due to faulting. Permeability of the foundation rocks is generally, less than 10 Lugeon unit except for surfacial sections. However high Lugeon unit in the rage of 20 to 40 exists partly in river floor foundation deeper than 10 m. The concrete gravity type of main dam is constructed at the above damsite.

The crest elevation of the dam is set at El. 89.0 m which allows wave height of 1.1 m above the flood water level (FWL) of El. 87.7 m. The dam height and crest length is 41 m and 150 m respectively.

The cross section of dam is based on a basic triangle of vertical upstream face and a downstream slope of 1:0.8. The effective width of the crest road is 6m in consideration of installation work of spillway bridge girder as well as the access road width. The dam concrete volume for main dam is estimated to be 56 x 10^3.

Main dam concrete is planned to be placed in 1.5 m high lift by using 1.5 m^3 concrete bucket. Cracking in dam concrete structure is undesirable because it affects the watertightness, internal stress and durability. Keen attention should be paid into temperature control for the concrete gravity dam. Seasonal ambient temperature is not so much in tropical area. In other words, concrete placing temperature is simillar to the final stable state temperature.

The temperature differentials can be reduced comparing to the site where is much seasonal temperature variation.

On the other hand, concrete placing interval is estimated to be around 7 days based on the capacities of concrete plant and cable crane. It implies that large part of hydration heat in a placement lift can be dispersed from the top exposed surface before the next lift is placed.

Taking into consideration the above site conditions, the maximum temperature rise is estimated to be in the range of 10°C to 15°C above the concrete placing temperature. It is considered that the temperature change of 15°C is allowable to avoide the crack occurence. Thus it is decided that no artifical cooling is made for the dam concrete.

To decrease the uplift on the dam foundation, 10 m deep foundation drain in spacing of 5.0 m is provided from the foundation gallery. Gallery cavity is decided to be 2.0 m wide and 2.5 m high from the drilling work.

Curtain grouting is conducted from the upstream dam filet in varying depth of 6 to 36 m in order to provide a water tight curtain in the foundation rock. Typical pattern of curtain hole is two lines with interval. Short hole grouting is carried out over the foundation of dam to consolidate the surface of foundation. Typical pattern of grout hole in 3m deep is 5m interval in both ways.

2.4 Spillway

In order to ensure dam safety against flood into reservoir after dam completion, ogee crest overflow spillway is provided in the middle of main dam. The downstream slope of the dam is utilized as the open chuteway. The chuteway terminates in a holizontal apron stilling basin with abrupt rise which functions as energy dissipator for high velocity overflow.

Fixed crest spillway is adopted, as flood control function is only incidental. Accordingly the ogee crest elevation is set at El. 85.0 m corresponding to the normal high water level. Spillway width is selected to be 20 m in compliance with the width of the Beris river. In determining the flood water level (FWL) of the reservoir and the discharge capacity of spillway, a probable maximum flood (PMF) occurring 24 hours after a 100-year probable flood is assumed, referring to a recommendation by US Bureau of Reclamation. The peak discharge of PMF and 100-year probable flood is estimated to be 4,200 m^3/s and 2,500 m^3/s under with reservoir condition respectively. In this case, the maximum reservoir water level is at El. 87.7 m and the maximum outflow is 200 m^3/s. Clearance of training wall and energy dissipator are determined against the discharge of 200 m^3/s.

Spillway training wall height is determined from the overflow depth adding to 2.0 m high allowance which is estimated as an empirical freeboard. Invert elevation of stilling basin is set at El. 45.2 m so as to have conjugate water depth below the tail water level. The length of stilling basin is decided to be 31.0 m on empirical assumption that the jump form in the stilling basin is depending on the Froude number of the discharge entering the basin and conjugate water depth. Top of side wall is decided to be El. 56.0 m which have 3.5 m freeboard estimated from empirical manner.

Spillway bridges of 6 m in effective width and 20 m in clear span are designed as a PC girder considering difficulties of falsework. TL-20 load (1st class bridge in Japanese standard) is adopted for the live load of bridge.

2.5 River Outlet Facilities

The river outlet facilities are provided across the main dam in order to release water from the reservoir to the downstream area at varying rate desired by the downstream water demand. It is one of the most important facilities in the project facilities. If stopping for a long term for a maintenance and/or repair, serious problem would be arised. Accordingly two sets of independent river outlet facilities are provided in this project.

Each set of facilities is capable of discharging 15 m^3/s, which is the maximum release rate of the system, under the low water level (LWL) and comprises an intake structure with the bottom at El. 55.0 m on the upstream face of dam, ø 1.5 m steel penstock embedded in the dam body, guard valve and hollow jet valve of 1.5 m in diameter. In order to supply water to the limited area between the dam and the river confluence with the Muda river, ø 0.6 m valve is branched from the each penstock pipe at a valve house. 0.2 m^3/s discharge is released to the downstream area through this value, when water required in the limited area, but no releasing through the main valve.

A valve house is constructed near the toe of the dam and on a backfill area of the left side wall of the stilling basin. It houses the guard valves and control devices of all valves.

In the intake structure, a fixed trash rack and an intake gate is provided. The intake gate is commonly used for the closure of both penstock pipe by using a monorail crane installed on the dam crest.

Taking into consideration river maintenance flow of 0.2 m^3/s during reservoir impounding, small opening with 0.6 m high and 0.6 m wide is provided at the bottom of intake structure. This opening is closed by concrete stop log when the reservoir water rises up to LWL.

2.6 Saddle Dam

The topography of the saddle damsite, where locates at the low ridge, is relatively flat. Slope of both abutment is 1 in 2.5 in left and 1 in 3.7 in right respectively. Lowest portion of ridge on the dam axis is El. 69.0 m which is the same elevation as LWL.

The bedrocks of the left abutment at the saddle damsite is mainly composed of sandstone and gritty sandstone with subordinate interbedded conglomerate, while the bedrock in the right abutment is alternation of shale and fine grained sandstone. Through the center of the saddle runs a fractured fault zone, probably trending at nearly right angle along the dam axis. Another fault zone is suspected to exist on the right abutment with width of 20 m. The results of permeability test show that the Lugeon unit at the saddle damsite is generally less than 10 except around El. 60 m on the left abutment where 14 to 56 of the Lugeon unit was observed. It is deemed that the high permeability is due to cracky sandstone. On the other hand, permeability of the fractured zone is 10.4 Lugeon unit at maximum.

Taking the above unfavorable dam foundation for the gravity dam into account, rockfill type dam is selected.

The crest elevation of the dam is set at El. 90.5 m which allows 0.9 m of pervious fill and 1.9 m of freeboard including wave run-up height of 0.9 m above FWL of El. 87.7 m. The dam height and crest length is 28.0 m at the maximum and 160 m respectively. Total embankment volume is estimated to be 121.6×10^3 m^3.

Zoning of rockfill dam is considered as below:

(1) Thickness of core is determined so as to have about creep length of 50% against the water pressure at the foundation and top of core width is taken at 3.0 m from the minimum construction space of core embankment.

(2) Double filters between impervious core and outer shell are provided from the criteria of Terzaghi. Filter material is obtained from the processed material which is costly. Thus minimum construction width of 4.0 m in double filter layers by using 8 ton dump track is selected.

(3) Outer shell slope is determined from the result of stability analysis by slip circle method. In the detail design stage, further study should be made on the following points to obtain more economical dam design.

(a) Possibility of collection of natural river sand and gravel for filter material.

(b) Zoning of excavated weathered rock as the transition zone instead of double filter zone.

(c) Flat core zoning to reduce the quarry rock volume.

As for the foundation treatment, curtain and blanket groutings are considered for the core foundation. Fractured zones are assumed in the lowest part and the right abutment. However, permeability of fault zone shows low value. Accordingly slush grouting is recommended to be applied when encountering with fractured zone in accompanied with several faults in the foundation excavation. Further, if required, they are treated with dental concrete with grouting.

Total grouting hole length including slush grouting is estimated at 6.5×10^3 m.

2.7 Relocation of Principal Road

New road of 11.9 km long is constructed for the replacement of the existing road between kg. Batu Seketul and kg. S. Batang.

Basic design of the relocation road and bridge is made for the cost estimation based on 1/10,000 topographic map prepared by this feasibility phase.

The route of the relocation road is selected based on the resettlement plan proposed in Annex K "Land Acquisition Cost and Environmental Studies". 300 m long bridge is crossed over the Beris reservoir. Type of bridge is selected PC girder of 20 m span which is the same size as the spillway bridge taking into consideration the construction facilities of the Project. Maximum height of pier is estimated to be 20 m. PC piles are provided if required for the pier foundation.

Design standard of road is determined to meet the existing road requirement as below:

(1) Road : Asphalt penetration macadam pavement with 5.5 m width.

(2) Bridge : B.S. load criteria and bridge width of 6.5 m.

2.8 Preparatory Works

Prior to the commencement of the main works, following preparatory works are constructed as shown on Plate 3 and their details are described in 6.3 Construction Method.

(1) Access roads

(2) Power and water supply system

(3) Telecommunication system

(4) Temporary buildings

(5) Installation of heavy construction plant and equipment

Further, proposed quarry site for rock and concrete aggregate is located on the ridge of El. 100 m to 150 m between the main and the saddle damsites. Proposed borrow area for soil material is located on the area of El. 60 m to 100 m about 700 m northwest of the saddle dam.

3. OPTIMIZATION OF DAM SCALE

3.1 General

The scale of the Beris dam is optimized by employing the net benefit (B-C) maximization criteria.

For optimization study, four cases of reservoir normal high water level (HWL) are chosen as shown below and the economic cost and benefit were estimated for these different scales of Beris dam.

Case No.	Normal high water level (El. m)	Dam height (m)
1	77	33
2	83	39
3	85	41
4	88	44

It is assumed that all the cases have the same basic layout and type of main and saddle dams, are as shown on Plates 3 to 5 (for the proposed one).

3.2 *Economic Cost of Different Scales of Dam*

The construction cost for different dam heights are estimated in Chapter 8 of this Annex assuming that the unit rates of cost by work items are the same for all the cases. The economic cost (net present value) of each construction cost is calculated in the same manner as adopted in Annex J "Economic Analysis".

3.3 Economic Benefit of Different Scales of Dam

(1) Net water output

The Beris dam is operated as one of source facilities which are integrated in the Kedah-Muda-Perai river system. The net water output is estimated by the integrated operation system developed in Annex F "Study on Operation of Water Resources System", assuming that the Beris dam is implemented in addition to the existing and ongoing project including the Pedu-Muda, Mengkuang and Ahning dams, and Jeniang system.

The net water output of the Beris dam slightly differs with Alternatives of operation rule of the Jeniang weir described in Annex F. The resulting net water output is summarized in the following table for 2000 demand.

Dam Height Case	High Water Level (El. m)	Net Water Output ($\times 10^6$ m^3)
1	77	32
2	83	52
3	85	66
4	87	67 - 68

(2) Economic benefit

In Annex J "Economic Analysis", the economic benefit of the Beris dam is calculated for the dam of 41 m in height which corresponds to the HWL of El. 85 m, based on the net water output in 1990 and 2000 for the above three Alternatives. The economic benefit of the Beris dam differs with Alternatives, because the proportion of the net water output distributed to water users in the integrated river system depends on the operation rules of the Jeniang weir and the value of water differs with the water users. Thus the unit value of net water output is calculated for these three Alternatives. The unit water values for different discount rates of 8% and 12% are given as the economic benefits devided by the net water output for HWL 85.0 m as shown below.

Discount rate	Unit Water Value (M\$/m^3) Alternative 1	Alternative 2	Alternative 3
8%	1.25**	1.26	1.31*
12%	0.59**	0.60	0.60*

Remarks; *: Highest estimate

**: Lowest estimate

The above unit water present values of the highest and lowest estimates are applied for economic benefit calculations of all the dam scales.

The economic benefit for all the dam scales were estimated as the unit water present values multiplied by the corresponding net water outputs as shown in Tables 4 and 5.

3.4 Optimization

Tables 4 and 5 show the economic benefit less cost calculation for the highest and the lowest unit water value for the discount rates of 8% and 12% of the above.

The resulted net present value of (B-C) curve is illustrated on Fig. 1 for discount rates of 8% and 12% in which the shadowed area indicates that the net present value of (B-C) of the Beris dam lies within the area depending on Alternatives. The curves show that the dam for HWL of El. 85 m gives the highest net present value of (B-C) for the discount rates of both 8% and 12%. Thus the optimum dam scale was determined to be that for the HWL of El. 85 m and this choice is not affected by the change in Alternatives.

4. STUDY ON THE TYPE OF DAM

4.1 Main Dam

Taking into consideration the topography, geology and obtainable embankment materials, concrete gravity and rockfill are conceivable as the appropriate dam type.

Both layouts are shown on Plates 4, 6 and 7. The costs of both Cases including the saddle dam and auxiliary structures are estimated in Tables 21, 22, 35, 36 and 37 and summarized as follows.

Case No.	HWL (El. m)	Dam Type: Main Dam	Dam Type: Saddle Dam	Investment Cost (M$ 10^3)
3	85.0	Concrete gravity	Rockfill	96,590 (29,900)*
5	85.0	Rockfill	Rockfill	107,700 (37,500)*

Remark; *: Direct cost which is defined in Clause 7.2 of this Annex.

The concrete gravity type is inexpensive by about 12% than the rockfill type at the proposed Beris damsite.

4.2 Saddle Dam

Taking into account comparatively poor foundation and obtainable embankment material, zoned rockfill dam having center core is only considered.

5. STUDY ON SMALL HYDROPOWER DEVELOPMENT

A small scale hydropower development is conceivable for the Beris dam project by utilizing potential of the water stored in the reservoir. The possible power output of the power station was examined for the proposed scale and design of the Beris dam, assuming that the power station is operated for the outflow discharge released to meet the downstream water demand.

Figure 2 shows the duration curve of power output based on the 23-year hydrological condition. According to the figure, the power generation is available about a half of the period and the duration of power output is rapidly decreased if the installation capacity is smaller than 3,000 kW. Thus the economic viability of the power generation scheme is examined for the installation capacity of 3,000 kW as follows.

The annual energy output of the power station is calculated to be 4.05 GWh on an average as shown in Table 6. The annual economic benefit is estimated at M$590 x 10^3 assuming the energy value of M$0.145/kWh, which is given in Part 1 Study (Ref. I 9).

The construction cost of the Beris dam project with the 3,000 kW power station and 17.4 km of 33 kV transmission line is estimated in Tables 38 to 40. The annual cost is estimated at M$450 x 10^3 for operation, maintenance and replacement costs.

The net present value of incremental (B-C) in case of the power station being added is calculated for discount rates of 8% and 12% as shown below.

(Unit: M$ 10^6)

Discount rate	Increment		
	Cost (C)	Benefit (B)	(B-C)
8%	7.99	4.15	-3.84
12%	5.67	2.21	-3.46

Thus, small hydropower development is abandoned.

6. CONSTRUCTION PLAN AND SCHEDULE OF PROPOSED PROJECT FACILITIES

6.1 General

The objective of this chapter is to provide the basic idea of the construction plan and schedule necessary for construction cost estimate.

In this sense, conventional and prevailing method and sequence of the works is herein studied for the major permanent structures as required for the project in accordance with the proposed plan which is describe! in Chapter 2.

The study of construction method, sequence and period described herein is based on the following basic construction plan of the project.

(1) Executive body

The project will be implemented by the government or government agency which is assisted by employing the consulting engineers.

(2) Mode of construction

The construction works will be carried out by contractor through international competitive tendering in accordance with the guidelines of the government and financial sources.

(3) Financial source

As for the financial prospect, the foreign currency component and a part of the local currency component if necessary will have the assistance of foreign loan.
Besides, the local currency component will be covered by the national budget.

6.2 Construction Schedule

Pre-construction activities which are the detail design including preparation of tender documents and the selection of contractor including pre-qualification of contractor is essential before the commencement of construction works.

According to the precedent pre-construction program, it is realistic to assume that one year is required for detail design and further one year for selecting the contractor respectively.

On condition that the detail design starts from September 1985 and the pre-qualification is carried out in parallel with the detail design at the final stage of detail design, it is assumed that the construction works will be commenced in June 1987.

In order to start the supply of irrigation water in the beginning of January 1991, the project construction will be completed by the end of 1989, taking into consideration a period of reservoir impounding for one year.

Consequently, the construction period for the project is scheduled to extend over three and a half years including tendering and contractual events after completion of detail design. First one year out of total period will be spent for the tendering and contractual events and the remaining two and a half years for the main construction.

The construction schedule for the major work items is shown on Fig. 3.

6.3 Construction Method

6.3.1 Basic condition and data

The proposed construction method, sequence of works and basic plan of utilizing the construction facilities, plants and equipment are studied for implementation of the respective structures of the proposed plan. In these studies, the following basic conditions, data and assumption are taken into consideration.

(1) Construction timetable

The commencement of the construction works after contractual events is set at the beginning of June 1987. The project is planned to be completed by the end of 1989, considering the start of supply of irrigation water in the beginning of January 1991. Consequently, the construction period extends over 31 months.

(2) Working day and hour for construction

The available working day and hour for construction works are estimated on the basis of the following conditions for the purposes of construction planning and workable day is assumed as shown in Table 7.

(a) Sundays and national holidays are principally excluded from working day.

(b) As to the weather constraint, rainfall is considered for the earth moving works and dam concrete works. According to the monthly rainy day shown in Table 7 which is a consolidated data from the rainfall record obtained in Ampang Pedu from 1971 to 1981, the seasonal distinction can be observed as rainy season during May to November. Then, earth moving works and dam concrete works will be much restricted during the rainy season. Therefore, the following conditions are taken into account:

(i) In case of daily rainfall being less than 3 mm, all outdoor works are carried out.

(ii) In case of daily rainfall being 3 to 10 mm, core embankment is stopped during rainfall, but can be carried out in a half day. However, other outdoor works are fully perform in this case.

(iii) In case of daily rainfall being 10 to 30 mm, embankment and concrete placement are stopped, but rock embankment can be carried out in a half day. In case of daily rainfall being over 30 mm, all outdoor works are stopped, and moreover core and filter embankment are stopped up to next day.

(c) For daily working hour and shift, one shift per one day and 7 hours a shift are principally applied except tunnel works which is carried out by two shift operation so as to divert the river by the end of dry season in 1988.

(3) Selection of construction method and equipment

To achieve an efficient and qualified construction, the mechanized system of construction will be essentially employed for the project. The conventional method and type of equipment will be principally applied, giving consideration to the local condition.

(4) Hourly production rate of construction equipment

Hourly production rate of construction equipment is estimated from the site conditions adding to the following volume change factor of material.

		Loose/Bank	Embankment/Bank
(a)	Earth or soil	1.30	0.9
(b)	Sand and gravel	1.18	1.05
(c)	Weathered rock	1.40	1.13
(d)	Rock	1.65	1.30

Source of embankment material and aggregate with hauling distance is planned as shown in Fig. 4 and hourly production rate for major equipment is shown in Table 8.

6.3.2 Preparatory works and construction facilities

The construction facilities for the dam consist of access roads, power and water supply system, telecommunication system, temporary buildings and heavy construction plants such as cable crane, batching plant and crushing plant. A layout of these construction facilities is shown on Plate 3.

The construction facilities for relocation road are arranged separately to the site of the relocation road because the site is about 30 km far from the damsite. Those construction facilities are described in (9) of this section.

(1) Access road

The damsite is located about 1.6 km southeast from Kg. Kuala Beris where a local road from Kg. Begia to Nami is passing. All weather roads (access roads) are necessary from the local road to the main structures for construction and part of access road is remained permanently for operation and maintenance after completion.

The access roads are about 5 km long, of which about 1.3 km (Quarry site to Saddle dam, Saddle dam to Diversion tunnel inlet and Stock pile to Stilling basin) is constructed with a width of 4 m and the others are with a width of 7 m. A bridge (reinforced concrete type) is constructed to cross the Beris river at about 150 m downstream of the outlet of the diversion tunnel for an access to the stilling basin and the valve house located on the left bank of the Beris river.

In addition, existing bridge crossing the Beris river near Kg. Kuala Beris is replaced considering traffic of heavy equipment for construction use.

(2) Power supply system

The maximum power demand during construction is estimated to be 720 kW assuming a diversity factor 0.8 as shown in Table 9. The electric power is generated by diesel generators installed in 2 places considering layout of construction facilities and its power demand. Two diesel power generators of 300 kVA each is installed on the right abutment near the crushing plant. The other two diesel power generators of 75 kVA each is provided for the supply to offices, camps, a repair shop and others for living facilities near the camps.

(3) Water supply system

The water demand for construction and camp use is 4.0 m^3/min as estimated in Table 10. The water supply facilities proposed at the site are composed of three independent systems considering layout of construction facilities and its demand; (1) system for the heavy construction plants, the quarry site and the saddle dam embankment, (2) system for the construction's camp, offices and shop area and (3) system for borrow area. All water sources for these systems are the Beris river.

The supply system (1) of the above comprises a pumping house (5 ton/min) and a main head tank of 100 m^3. The water used at the quarry and saddle dam sites is transported by 6 m^3 water tank lorries. As for the supply to offices and quarter areas, the water is treated by purification system before being delivered to each building.

(4) Telecommunication system

An internal telephone service with 30 circuits is to be set up to connect all camps, offices and working areas as shown in Table 11. It is proposed that a radio telephone set be installed for communication system between the site office and the government office in Alor Setar.

(5) Temporary buildings

As shown in Table 15, it is assumed that the Contractor's employees are 300 personnel at the maximum during the construction and the accommodation of 3.0×10^3 m^2 in total is built in the camp area of 6.7×10^3 m^2 as estimated in Table 12.

(6) Cable crane

Dam concrete volume of 55.2×10^3 m^3 in total is scheduled to be placed for 19 months considering the time of the river diversion and diversion closure. The estimated workable day is 330 days, so average concrete placement per day is: 55,200/330 = 170 m^3/d.

It is assumed that operation hour per day (7 h) of cable crane is 70% for concrete placement and 30% for miscellaneous works. The operation hour for concrete placement is: 7 x 0.7 ≑ 5 hr. Assuming that a cycle time of concrete placement is 2.5 minutes, backet capacity is: 170 ÷ 5 ÷ 60/2.5 = 1.4 m^3. Thus a 1.5 m^3 concrete bucket is adopted. Considering the site condition of both abutment, a 4.5 ton rail-rope-type cable crane is selected.

(7) Batching plant

Total concrete volume for the construction is about 62.0×10^3 m^3. According to the construction schedule, the peak requirement is estimated to be 3.6×10^3 m^3/month in the concrete works for the main dam and stilling basin. Assuming the operation efficiency to be 0.85, monthly operation day to be 20 days and daily operation hour to be 7 hours, the required hourly production capacity of the plant is:

$$\frac{3{,}600}{20 \times 7 \times 0.85} = 30 \text{ m}^3/\text{h}$$

A batching plant (0.75 m^3 Mixer x 2) with capacity of 30 m^3/hr is installed on the right abutment of the main dam.

(8) Crushing plant

The crushing plant products concrete aggregate of 127.9×10^3 ton and filter material of 42.1×10^3 ton. The peak requirement of crushed stone is estimated to be 11.0×10^3 ton/month. Assuming that operation hour, day and efficiency are 7 hours, 24 days and 0.80 respectively and the production loss is 20 percents, the required plant capacity is:

$$\frac{11,000 \times 1.20}{24 \times 7 \times 0.80} = 100 \text{ ton/h}$$

A crushing plant with capacity of 100 ton/h is installed near the batching plant on the right abutment.

(9) Construction facilities for relocation road

Following considerations are given to a plan of construction facilities for relocation road because the construction site is about 30 km far from the Beris dam site.

(1) The engineers and contractor's stuff are transported daily to the site from main dam office but labours are accommodated in the camps.

(2) Aggregate for concrete and asphalt are produced near the relocation road.

(3) Construction equipment and materials except for aggregate are transported from the Beris dam site.

(4) Telecommunication system is provided to communicate to the Beris dam site.

In compliance with the above, it is proposed that a minimum construction facilities such as a 30 ton/h portable crushing plant, a 10 m^3/h portable concrete mixing plant, 3 number of 75 kVA generator for power supply and labour's camp (floor area of 300 m^2), repair shop, and a radio telephone set be newly installed in the construction site.

6.3.3 River diversion works

(1) Divertion tunnel

Tunnel works are commenced from open excavation of both portal areas on the right abutment in the beginning of August 1987. The construction period for open excavation is one month. The excavation volume of 1.0×10^3 m^3 is carried out at average output of 50 m^3/d. A combination of 11 ton bulldozer, 0.7 m^3 backhoe and light equipment such as leg drills and pick hammers for blasting is used for the excavation.

Diversion tunnel is a 215 m long, horse shoe shaped concrete lined tunnel of 5.0 m inside diameter. The tunnel works are carried out by 2 shifts because they are in a critical pass for the river diversion. The tunnel is driven from the outlet portal toward the inlet portal side for 2 months from the beginning of September 1987. Average excavation progress rate of the tunnel heading is, therefore, 4.4 m/d. It is proposed that the tunnel be excavated by the full face method with two-boom drill jumbos.

The excavated materials are hauled to the stock yard by a combination of a 0.4 m^3 rocker shovel and 6 ton dump truck and used as aggregate materials for concrete or filter materials for saddle dam.

H-shaped steel supports are installed at 1.2 m or 1.5 m intervals up to 20 m from both the inlet and outlet sides of the diversion tunnel considering rock conditions. Additional steel support may be required for bad geological condition encountering in actual excavation.

Immidiately after tunnel excavation, concrete lining is carried out from the outlet portal toward the inlet portal side for 2 months from the beginning of November 1987. Invert lining goes ahead 2 pannels and then arch lining is carried out concurrently by a 10 m long sliding form and concrete pump. The lining progress rate is:

Invert lining : 5 m/d

Arch lining : 5 m/d

Finally, backfill grout and curtain grout are done by 5.5 kW boring machines and 11 kW grout pump for a month. The diversion tunnel is completed in the end of January 1988.

(2) Coffer dam

Upstream primary cofferdam is constructed by earth embankment for river diversion in the beginning of February 1988. The embankment volume of 1,000 m^3 for the cofferdam is obtained from the both banks and is embanked by 15 ton bulldozers and 5 ton vibrating rollers.

After river diversion, excavation of the upstream and downstream cofferdams is commenced in February 1988 after completion of the above primary cofferdam. The excavation is carried out for one month by a combination of 15 ton bulldozer, 21 ton bulldozers with a ripper and light blasting equipment with average output of 150 m^3/d. The excavated materials are disposed to the spoil bank by using 1.4 m^3 dozer shovel and 15 ton dump trucks.

Concrete of 1.2×10^3 m^3 for upstream secondary cofferdam is commenced in the beginning of March 1988 and completed in the end of March 1988. The concrete is placed at average volume of 70 m^3/d with 1.5 m lift by a rail-rope-type cable crane of 4.5 ton in the same manner as main dam described in (3) of 6.3.4 Main dam and stilling basin works.

The embankment volume of 1.0×10^3 m^3 for the downstream secondary coffer dam is obtained from the both banks and embanked by a same equipment and construction method of the upstream primary cofferdam.

(3) Diversion tunnel closure

Prior to closure of the diversion tunnel, the saddle dam embankment and intake structure of river outlet is completed. The diversion tunnel is closed by a diversion gate (roller gate, 5.0 m wide x 5.0 m high) in the beginning of November, 1989. Installation of the gate is carried out by 20 ton truck crane and winch machine.

After closing the roller gate, the diversion tunnel is plugged with concrete. Cooling of the plug is done by circulating natural river water through cooling pipes embedded in the plug concrete. The contact grouting is finally carried out to seal the joint between the tunnel lining and plug concrete segments. The plug works are done for 2 months from the beginning of November 1989 and completed in the end of 1989.

Major equipment of the plug works is a combination of 3.2 m^3 agitator trucks and concrete pump for plug concrete and 11 kW grout pump and 200 l x 2 grout mixer for contact grout.

6.3.4 Main dam and stilling basin works

(1) Foundation excavation

The foundation excavation is started at the both abutment walls before the river diversion. The riverbed portion is carried out concurrently with the construction of cofferdam after river diversion. The excavation of 37.7×10^3 m^3 in total is commenced in the beginning of January 1988 and completed in the end of June 1988. An average output of 300 m^3/d is carried out by a combination of 11 ton and 15 ton bulldozers, 21 ton bulldozers with a ripper and light equipment such as leg drills and pick hammers for blasting.

Excavated materials are disposed to the spoil bank by using a 1.4 m^3 dozer shovel, a 2.1 m^3 wheel loader, 8 ton and 15 ton dump trucks, while a half of excavated rocks are hauled to the stock yard so as to use as rock embankment of the saddle dam.

(2) Foundation treatment

The bedrock of the gravity dam is treated by consolidation grouting and curtain grouting to attain the required strength and watertightness.

The consolidation grouting is commenced on the riverbed in the beginning of April 1988 and carried out toward the abutments before covering rock surface with concrete. The curtain grout is carried out through upstream filet after the rock foundation is covered with concrete. Total grouting length of 5.52×10^3 m for consolidation and curtain grout is carried out for 5 months with an average progress of 50 m/d.

Holes for the injection of grout materials are drilled by 10 m^3/min crawler drills and 5.5 kW boring machines. Cement grout is mixed at two central plants of 600 l x 2 mixer located on the both abutments and derived to 200 l x 2 grout mixers installed at the each work sites. The mixer grout materials are injected by 11 kW grout pumps.

(3) Concrete placement

The body of the gravity dam is divided into 10 blocks by transversal construction joints and the dam concrete is placed by a 4.5 ton rail-rope-type cable crane with the maximum placing capacity of 200 m^3/d. The block exceeding 200 m^3 in one lift is carried out by 0.75 m lift and under 200 m^3 by 1.5 m lift. Formworks for the dam concrete using sliding metal forms are provided for 1.5 m lift. The same sliding metal form is also used for half lift by two times concrete placing. The operating range of the cable crane covers the main dam, upstream secondary cofferdam and part of spillway.

The concrete placement is commenced in the beginning of May 1988 with average output of 170 m^3/d. Dam concrete volume of 55.2×10^3 m^3 in total is scheduled to be placed for 19 months and the concrete placement is completed in the end of November 1989.

The concrete for the stilling basin is placed by a combination of 3.2 m^3 agitator trucks and a 10 ton truck crane with a 1 m^3 bucket concurrently with dam concrete. Total concrete volume of 2.7×10^3 m^3 is placed for 4 months from the beginning of July 1988.

Temperature control is necessary for mass concrete. Natural cooling method without any artifical cooling is considered by taking a lift interval of 5 days at least.

6.3.5 River outlet works

In accordance with concrete placing schedule, steel pipe of 1.5 m in diameter and around 50 m x 2 lines in length is installed in positions by the above-mentioned 4.5 ton cable crane, then embedded into dam concrete. After the dam and valve house are completed, one fixed roller gate (1.5 m wide x 1.5 m high), one fixed trash rack (7 m wide x 3 m high), two hollow jet valves (ø1,500 mm), two guard valves (ø1,500 mm) and two hollow jet valves (ø600 mm) are installed in positions, respectively by 4.5 ton cable crane or 15 ton truck crane. The installation period is one month.

6.3.6 Saddle dam works

(1) Foundation excavation

The foundation excavation is scheduled to commence after completing the excavation of the main dam, so all excavating equipment are available. Common excavation of 27.8×10^3 m^3 is carried out by 11 ton and 15 ton bulldozers with a ripper by the average rate of 500 m^3/d. Excavating period is 4 months. Both excavated materials are hauled to the spoil bank by a combination of 2.1 m^3 wheel loader and 15 ton dump trucks.

(2) Foundation treatment

The bedrock of the saddle dam is treated by ordinary blanket grouting method and also by ordinary curtain grouting method. The construction method and equipment are the same as those executed in the main dam. All of the construction equipment and labours are also diverted from the main damsite.

(3) Core embankment

Core material of 22.3 x 10^3 m^3 is borrowed from the borrow area located about 700 m northwest of the saddle dam.

The core embankment is commenced in the beginning of November 1988 at an average embanking rate of 150 m^3/d. The construction period is 9 months.

Stripping and excavation at the borrow area are made by 15 ton bulldozers. The excavated materials mainly originated from sandstone are loaded on 8 ton dump trucks by a 1.4 m^3 dozer shovel. At the damsite, the core materials are spread by a 11 ton bulldozer and compacted by a tamping roller in 20 cm layers by 8 passes. Adjacent area on the bottom and abutment rock are compacted by a light compactor such as 80 kg tampers or rammers.

(4) Filter and transition embankment

The required quantities of filter and transition for the saddle dam are 18.6 x 10^3 m^3 in total. Both the materials which are obtained from the quarry site located at 300 m southwest of the saddle dam are processed by the crushing plant of 100 ton/h. Screened aggregate for filter material is stockpiled near the crushing plant.

The filter embankment is commenced concurrently with other embankment materials in the beginning of November 1988 at an average embanking rate of 110 m^3/d. The construction period is 9 months.

The filter material is hauled to the saddle damsite by 8 ton dump truck, spread and compacted by a 11 ton bulldozer and a 7 ton vibrating roller in 30 cm layers by 6 passes.

(5) Rock embankment

The rock material is 80.7 x 10^3 m^3 in total, of which 8.1 x 10^3 m^3 is obtained from the stocked rock at the stock pile and 72.6 x 10^3 m^3 is quarried from quarry site. A bench cut with snake holes in 5 m high is adopted for quarry rock blasting.

The rock embankment is commenced in the beginning of November 1988 at an average embanking rate of 370 m^3/d. The construction period is 10 months.

At the quarry site, the blast hole is drilled by 10 m^3/min crawler drills and blasted material is loaded by 2.1 m^3 wheel loader into 15 ton dump trucks for haulage to the saddle dam. The rock material is spread and compacted by 21 ton bulldozer in 60 cm layers by 8 passes.

6.3.7 Relocation road works

Overall length of the relocation road with 5.5 m width is 11.9 km, of which 7.0 km is in a rolling area, 3.0 km in a mountainous area and 1.9 km in a flat area. A precasted and prestressed concrete girder type bridge (length: 300 m, width: 6.5 m single lane) is also constructed at tributary of the reservoir.

The construction of relocation road is started from a rolling area in the beginning of 1989 and construction period is 12 months. The progress of the construction is estimated at 2 km/month in the rolling area, 0.5 km/month in the mountainous area and 0.8 km/month in the flat area. The construction of the bridge is carried out concurrently with the road work and the construction period is 12 months.

The construction of this relocation road is carried out by a combination of excavation equipment such as 15 ton and 11 ton bulldozers, a 0.7 m^3 backhoe, a 2.1 m^3 wheel loader, 15 ton and 8 ton dump trucks and light blasting equipment and a combination of road equipment such as 8 ton macadam rollers, 8 ton tire roller, motor grader with 3.7 m blade and 1,000 l asphalt distributor.

6.3.8 Construction equipment, materials and labour force

The major construction equipment proposed for the construction and its number are estimated and summarized in Table 13. The required construction material and labour force are shown in Tables 14 and 15 respectively.

7. CONSTRUCTION COST ESTIMATE OF PROPOSED PROJECT FACILITIES

7.1 General

The construction cost is estimated for the proposed project facilities on the basis of the construction plan and schedule described in Chapter 6 of this Annex, and the following assumption and conditions.

(1) The cost is estimated at the end of 1983 price level.

(2) The cost is calculated in terms of the Malaysian Ringgit including both foreign and local currency portions.

(3) The exchange rate of currency is US$1.0 = M$2.312 = ¥231.6.

(4) Price escalation rate is assumed to be 5% per annum for both foreign and local currency portions.

(5) The project will be implemented by the Government or government agency with employment of engineering consultants and the construction works will be carried out by the contract system though international competitive tenders.

7.2 Constitution of Construction Cost

The construction cost consists of the direct cost, the indirect cost and the contingency. The direct cost is estimated based on the work items and quantities derived from the proposed design. This includes material cost, labour cost, equipment cost and contractor's indirect cost such as overhead, administration cost, profit, taxes and other incidentals.

The indirect cost includes the compensation cost, and engineering services and government administration cost.

The contingency costs also includes the physical one computed by direct and indirect cost of the above and prise escalation.

On the other hand, the estimated cost is divided into foreign and local currencies component according to their sources as follows:

(1) Foreign currency portion

(a) Depreciation and spare parts of construction equipment cost

(b) Manufacturing cost for gates and valves

(c) Ocean freight charge and insurance for the above two items, and

(d) Cost of engineering services for foreign consultants

(2) The local currency portion

(a) Cost of repair and operation for construction equipment

(b) Labour cost

(c) Material cost

(d) Inland transportation cost for steel pipes, equipment and materials to the site

(e) Installation cost for gates and valves

(f) Compensation cost, and

(g) Cost of engineering services for local consultants

7.3 Construction Cost Estimate

In Malaysia, keen competition among contractors during the present recession period (1982-end-to-date) has lowered the construction price so much as they are not indicative of general trend. The construction cost of the proposed project facilities is estimated based on normal market price. Sources of collected information for construction cost estimates are as follows:

(1) Cost indices by the Department of Statistics, Malaysia

(2) Ongoing and completed dam projects in Malaysia

(3) Both foreign and local manufacturers, suppliers and agents

7.3.1 Direct Costs

Direct cost is estimated on the unit price basis. The unit price consists of costs of labour wages, material costs and equipment costs including contractor's indirect cost. The following assumption is taken into each cost item and then unit price is summed up. Unit price adopted for the cost estimate is shown in Table 16.

(1) Labour wages

All kinds of labours required for the construction are available in Malaysia. The daily wages are estimated as shown in Table 17 on the basis of data from ongoing project in Malaysia. This wages include living allowance, leaves, bonus, medicare and others according to the government standard.

All construction works except tunnel work are scheduled to be carried out by 1 shift, while the tunnel work are done by 2 shifts. Late night allowance is 50%.

(2) Material costs

All kinds of materials for the construction are procured from the Malaysian market. Table 18 shows the unit prices of major construction materials in which inland transportation cost from the port of Pinang to the site is included.

As for the materials producted in and then imported from foreign countries, these materials are also covered by local currency portion because the contractor can procure them by local currency.

(3) Equipment costs

Costs of major construction plants, equipment and their spare parts consist of their price in Japan, ocean freight, insurance, landing cost at the port of Pinang and inland transportation charge. Their unit prices are estimated by total of the hourly depreciation cost, hourly maintenance and repair cost, and hourly consumable goods cost in Table 19.

(4) Supply, delivery and installation costs of steel pipes, gates and valves

The steel pipes, gates and valves are scheduled to be imported. These cost estimates are on the basis of Japanese price levels in principle. Further, the supply, delivery and installation costs includes the design, materials, manufacturing, painting, test, packing ocean freight, insurance premium, landing cost at Pinang port, inland transportation and installation at the site.

The cost of steel pipes, gates and valves is divided into the foreign currency portion and local currency portion, and its division ratio is 92% and 8% respectively.

(5) Contractor's indirect cost

In the estimation of various units prices, indirect costs such as site expense, overhead, profit and tax of contractors are considered and they are added in the unit price.

The indirect cost is assumed to be 20% of the total costs of (1) to (4) of the above.

7.3.2 Indirect costs

(1) Compensation costs

Compensation cost consists of those of land aquisition and resettlement. The cost is estimated to be M$25,700,000 in Annex K "Land Acquisition Cost and Environmental Studies".

(2) Engineering services and government administration costs

Engineering services and government administration for design and construction supervision is estimated to be M$8,400,000.

7.3.3 Contingency

Contingency consists of physical contingency and price escalation contingency. The physical contingency for the direct and indirect cost is assumed to be 20% of them. The price escalation for the direct cost, indirect cost and physical contingency is also assumed to be 5% per annum.

7.4 Summary of Construction Cost

The construction cost for the implementation of project is estimated at M$96,590,000 in total, consisting of M$20,450,000 for foreign currency portion and M$76,140,000 for local currency portion.

The construction cost is summarized in Table 20 and the breakdown of the construction cost is detailed in Tables 21 and 22.

7.5 Disbursement Schedule

The project is recommended to be executed over 52 months (21 months for detailed design and contracting works, and another 31 months for construction works including preparatory works). The disbursement schedule of the construction cost for the civil works is prepared according to the construction schedule on the assumption of an advance payment of M$5,000,000 in maximum. For the metalworks, 10% of steel pipes, gates and valves cost is paid at signing the contract, 80% at the time of shipment and 10% at the time of installation completion.

The disbursement schedule is shown in Table 23.

7.6 Operation and Maintenance Cost

Operation and maintenance cost (O & M costs) for the project includes the following items:

(1) Operating personnel

(2) Administration and maintenance of administration office, civil structures and mechanical equipment

(3) Miscellaneous

The annual operation and maintenance cost is shown in Table 24.

8. PRELIMINARY DESIGN AND CONSTRUCTION COST ESTIMATE OF ALTERNATIVES

Preliminary design and construction cost estimate for the following cases of the Beris dam and Tawar - Muda dam are made for the plan formulation of the Beris dam described in Chapters 3 to 5 of this Annex, and for economic evaluation in Annex J "Economic Analysis".

(1) Beris dam

Case No.	High Water Level (El. m)	Main Dam	Saddle Dam	River Outlet
1	77.0	Concrete gravity	Rockfill	Valve house constructed
2	83.0	Concrete gravity	Rockfill	Valve house constructed
3	85.0	Concrete gravity	Rockfill	Valve house constructed
4	88.0	Concrete gravity	Rockfill	Valve house constructed
5	85.0	Rockfill	Rockfill	Valve house constructed
6	85.0	Concrete gravity	Rockfill	Powerhouse & Valve house constructed

Case 3 is a proposed plan as shown on Plates 3 to 5 and the construction cost is shown in Tables 21 and 22.

(2) Tawar - Muda dam

Normal high water level	:	El. 77.0
Main dam	:	Rockfill
Saddle dams (2 nos.)	:	Rockfill
River outlet	:	Valve house constructed

The construction cost estimates of all cases are based on the following assumptions.

(1) The unit costs were estimated by work items for the proposed plan of the Beris dam. These unit costs were principally applied to the alternative scales of the Beris dam and the Tawar - Muda dam. For the Tawar - Muda dam, the unit costs were reduced by M$10 for open concrete and backfill grouting works and by M$12 for filter embankment because sand and gravel materials are available at the Tawar - Muda damsite.

(2) Work quantities of all cases of the Beris dam is roughly estimated based on Plates 3 to 8, while those of Tawar - Muda dam is derived from Tables 12 to 14 of Annex M for Part 1 Study (Ref. I 14).

The construction costs of all cases are shown in Tables 25 to 43.

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TABLES

Table 1 PRINCIPAL FEATURE OF THE PROJECT (1/3)

(1) Location: About 1.6 km upstream of the confluence of the Muda river and the Beris river

(2) Reservoir:

Catchment area	:	116 km^2
Average annual inflow	:	109.4×10^6 m^3
Gross storage capacity	:	111.3×10^6 m^3
Effective storage capacity	:	102.4×10^6 m^3
Reservoir surface area	:	16 km^2 at FWL
Maximum water level (FWL)	:	El. 87.7 m
HWL	:	El. 85.0 m
LWL	:	El. 69.0 m
Top of horizontal sediment	:	El. 65.5 m
Design flood (peak inflow)	:	4.2×10^3 m^3/s*

(3) Main dam:

(a) Dam

Type	:	Concrete gravity dam
Dam maximum height	:	41 m
Crest elevation	:	El. 89.0 m
Crest length	:	150 m
Crest width	:	6.0 m
Upstream slope	:	Perpendicular
Downstream slope	:	1 in 0.8
Concrete volume	:	57.9×10^3 m^3**

(b) Spillway

Type	:	Ungated overflow weir crest spillway having open channel chute way (20.0 m effective width)
Apex elevation of overflow weir	:	El. 85.0 m
Capacity (regulated outflow)	:	200 m^3/sec at FWL 87.7 m
Stilling basin	:	Horizontal apron stilling basin with abrupt rise (20.0 m width)

Remarks; *: Occurred by probable maximum flood (PMF)

**: Including stilling basin concrete (2.7×10^3 m^3)

Table 2 PRINCIPAL FEATURE OF THE PROJECT (2/3)

(c) Diversion tunnel

Type	:	Concrete lined tunnel diversion
Section	:	Standard horseshoe section of 5.0 m in diameter
Overall length	:	215 m
Design discharge (2-year probable flood)	:	200 m^3/s
Diversion gate	:	One roller gate (5.0 m wide x 5.0 m high)

(d) Upstream secondary cofferdam

Type	:	Concrete gravity dam
Dam maximum height	:	10 m
Crest elevation	:	El. 62.0 m
Crest length	:	60 m
Crest width	:	1 m
Upstream slope	:	perpendicular
Downstream slope	:	1 in 0.7
Concrete volume	:	1.2×10^3 m^3

(4) Outlet facilities:

Type	:	Steel lined penstock embedded in dam concrete
Nos.	:	Two lines
Diameter	:	1.5 m
Length	:	About 50 m x 2 lines
Trash rack	:	One fixed trash rack (7 m wide x 3 m high)
Emergency gate	:	One fixed roller gate (1.5 m wide x 1.5 m high)
Valve	:	Two hollow jet valves (ø1,500), two high pressure slide gate valves (ø600) and guard valves (ø1,500)
Capacity of valves	:	15 m^3/s for one hollow jet valve and one guard valve 3 m^3/s for one high pressure slide gate valve
Valve house	:	On-ground type (6 m long x 6.5 m wide x 4.5 m high)

Table 3 PRINCIPAL FEATURE OF THE PROJECT (3/3)

(5) Saddle dam:

Type	:	Zoning type rockfill dam having center core
Dam maximum height	:	28 m
Crest elevation	:	El. 90.5 m
Crest length	:	160 m
Crest width	:	8.0 m
Upstream slope	:	1 in 2.3
Downstream slope	:	1 in 1.8
Embankment volume	:	121.6 x 10^3 m^3

(6) Relocation road:

(a) Road	:	Asphalt penetration macadam surface pavement road (length : 11.9 km width : 5.5 m single lane)
(b) Bridge	:	Precasted and prestressed concrete girder (PC girder) bridge (l = 300 m in total (20 m x 15 span), 6.5 m single lane)
(c) Low voltage power line (440 V)	:	Length : 12.2 km

Table 4 RELATION BETWEEN PROJECT SCALE AND NET PRESENT VALUE OF (B-C) (DISCOUNT RATE; 8%)

Item	Case No. 1	2	3	4
1. Normal high water level (El.m)	77.0	83.0	85.0	88.0
2. Economic cost (C)				
Construction cost (M$ 10^6)	65.8	87.9	96.6	111.8
Economic cost (net present value) (M$ 10^6)	25.4	33.9	37.3	43.2
3. Economic benefit (B)				
Net water output (10^6 m^3)	32	52	66	67 - 68
Unit benefit (M$/$m^3$)				
High*	1.31	1.31	1.31	1.31
Low**	1.25	1.25	1.25	1.25
Economic benefit (net present value) (M$ 10^6)				
High*	41.9	68.1	86.5	89.1
Low**	40.0	65.0	82.5	83.8
4. (B-C) (net present value) (M$ 10^6)				
High*	16.5	34.2	49.2	45.9
Low**	14.6	31.1	45.2	40.6

Remarks; *: Based on the highest estimate of unit water present value

**: Based on the lowest estimate of unit water present value

Table 5 RELATION BETWEEN PROJECT SCALE AND NET PRESENT VALUE OF (B-C) (DISCOUNT RATE; 12%)

Item	Case No. 1	2	3	4
1. Normal high water level (El.m)	77.0	83.0	85.0	88.0
2. Economic cost (C)				
Construction cost (M$ 10^6)	65.8	87.9	96.6	111.8
Economic cost (net present value) (M$ 10^6)	20.3	26.6	29.2	34.0
3. Economic benefit (B)				
Net water output (10^6 m^3)	32	52	66	67 - 68
Unit benefit (M$/$m^3$)				
High*	0.60	0.60	0.60	0.60
Low**	0.59	0.59	0.59	0.59
Economic benefit (net present value) (M$ 10^6)				
High*	19.2	31.2	39.6	40.8
Low**	18.9	30.7	38.9	39.5
4. (B-C) (net present value) (M$ 10^6)				
High*	-1.1	4.6	10.4	6.8
Low**	-1.4	4.1	9.7	5.5

Remarks; *: Based on the highest estimate of unit water present value

** Based on the lowest estimate of unit water present value

Table 6 ANNUAL AVERAGE POWER OUTPUT

*** HYDRO-POWER ***

*** BERIS P/STATION(P/MAX=3000 KW) ... T/Y 2000,QJ=2.5(CMS) (DEC.22)

UNIT : GWH

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1961	0.	0.58	2.22	0.33	0.33	0.	0.	0.	0.	0.	0.	0.14	3.60
1962	0.	0.86	0.33	0.	0.	0.	0.	0.	0.	0.	0.	0.95	2.15
1963	0.	1.17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.07	1.24
1964	0.66	1.01	2.18	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.85
1965	0.38	0.96	1.04	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.38
1966	0.	0.22	2.23	1.80	0.06	0.36	1.68	0.	0.	0.	0.	0.	6.35
1967	0.18	0.34	2.23	1.61	0.	1.08	0.	1.03	0.	0.	0.	0.	6.48
1968	0.	1.01	2.20	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.21
1969	0.	0.62	1.75	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.37
1970	0.	0.58	2.23	2.13	0.18	0.77	0.12	0.36	0.	0.	0.	0.	6.36
1971	0.17	0.64	1.51	2.16	0.99	0.	0.	0.	0.	0.	0.	0.	5.47
1972	0.	0.73	2.23	0.67	0.	0.	0.	0.	0.	0.	0.	0.	3.63
1973	0.	0.58	2.23	1.18	0.	0.43	0.67	0.	0.	0.	0.	0.	5.09
1974	0.	0.71	2.23	1.05	0.	0.	0.	0.	0.	0.	0.	0.	3.99
1975	0.	0.58	1.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.98
1976	0.	0.65	2.23	1.04	0.	0.78	1.02	0.	0.	0.	0.11	0.79	6.62
1977	0.27	0.96	2.23	1.41	0.	0.	0.	0.	0.	0.	0.	0.40	5.27
1978	0.02	2.01	0.68	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.72
1979	0.15	1.69	0.68	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.52
1980	0.01	1.09	1.05	0.	0.	0.	0.	0.	0.	0.	0.62	1.09	3.87
1981	0.21	1.00	2.23	1.77	0.	0.94	1.03	0.	0.	0.	0.	0.40	7.59
1982	0.	0.	0.	0.	0.	0.21	0.54	0.89	0.	0.	0.	0.04	1.67
1983	0.09	0.94	2.23	1.41	0.	0.	0.	0.	0.	0.	0.	0.	4.67
MEAN	0.09	0.82	1.62	0.72	0.07	0.20	0.22	0.10	0.	0.	0.03	0.17	4.05

The power outputs are calculated on the basis of water outputs of the Beris dam for 2000 demand assuming that Alternative 3, Kedah priority, is applied for the operation rule of the Jeniang Weir described in Annex F.

Table 7 ESTIMATION OF WORKABLE DAYS

Unit: day

Month	Rainy days*				Total Rainy days	Sunday & National Holidays	Workable days				
	(1) less than 3 mm	(2) 3-10mm	(3) 10-30mm	(4) more than 30 mm			Core	Filter	Rock	Concrete	Tunnel
Jan.	1.9	1.4	0.4	0.2	3.9	6	23	24	25	24	25
Feb.	1.9	1.0	1.1	0.7	4.7	6	19	19	21	20	22
Mar.	2.7	1.5	2.3	0.9	7.4	4	22	23	25	24	27
Apr.	5.3	2.8	4.3	2.4	13.3	4	15	17	21	19	26
May	6.1	5.2	4.9	1.8	18.0	8	12	14	19	16	23
Jun.	5.9	4.2	3.9	1.4	15.4	5	16	18	22	20	25
Jul.	6.3	3.9	4.0	2.0	16.2	7	14	16	20	18	24
Aug.	6.7	5.6	3.5	2.1	17.9	5	15	18	22	20	26
Sep.	4.8	6.2	6.0	2.7	19.7	6	9	13	18	15	24
Oct.	6.1	6.4	6.9	2.1	22.5	6	11	14	19	16	25
Nov.	7.5	5.0	4.9	2.5	19.9	5	13	15	20	18	25
Dec.	5.4	3.1	1.7	0.8	11.0	6	20	22	23	22	25
Total							189	213	255	233	297

Remarks; (1) The calculation formula of workable days is as follows:

Core: Monthly days - (2) x 1/2 - (3) x 1.0 - (4) x 2.0 - Holidays

Filter: Monthly days - (3) x 1.0 - (4) x 2.0 - Holidays

Rock: Monthly days - (3) x 1/2 - (4) x 1.0 - Holidays

Concrete: Monthly days - ((3) + (4)) x 1.0 - Holidays

Tunnel: Monthly days - Holidays

(2) * : Average monthly rainy days (1971 - 1981) of Ampang Pedu (ST. No. 6207032).

Table 8 HOURLY PRODUCTION RATE OF CONSTRUCTION EQUIPMENT

Unit: m^3/h

No.	Equipment	Capacity	Common	Sand & Gravel	Rock	Concrete
1	Bulldozer w/R	21 ton	-	-	42	-
2	Bulldozer (Dozing)	15 ton	91	89	105	-
3	Bulldozer (Spreading)	15 ton	152	158	200	-
4	Bulldozer (Compacting)	15 ton	92	101	100	-
5	Bulldozer (Dozing)	11 ton	69	76	91	-
6	Bulldozer (Spreading)	11 ton	135	141	177	-
7	Dozer Shovel	1.4 m^3	57	59	33	-
8	Wheel Loader	2.1 m^3	100	103	58	-
9	Dump Truck (ℓ = 1,000 m)	15 ton	35	36	25	-
10	Dump Truck (ℓ = 750 m)	15 ton	44	42	27	-
11	Dump Truck (ℓ = 500 m)	15 ton	52	51	35	-
12	Dump Truck (ℓ = 1,000 m)	8 ton	23	21	15	-
13	Dump Truck (ℓ = 750 m)	8 ton	26	25	18	-
14	Dump Truck (ℓ = 500 m)	8 ton	30	30	21	-
15	Back Hoe	0.7 m^3	57	59	38	-
16	Rocker Shovel	0.4 m^3	-	-	36	-
17	Vibration Roller	7 ton	70	72	-	-
18	Tamping Roller	4 ton	40	-	-	-
19	Macadam Roller	8 ton	43	48	-	-
20	Truck Mixer (ℓ = 1,000 m)	3.2 m^3	-	-	-	9.0
21	Truck Mixer (ℓ = 500 m)	3.2 m^3	-	-	-	12.0
22	Concrete Bucket by Truck crane	1.0 m^3	-	-	-	12.0
23	Concrete Bucket by Truck crane	1.5 m^3	-	-	-	18.0

Table 9 INSTALLED POWER CAPACITY FOR CONSTRUCTION

Unit: kW

No.	Description	Installed Power Capacity
1.	Quarter, Offices, Camps	50
2.	Crushing Plant	400
3.	Concrete Mixing Plant	35
4.	Cable Crane	200
5.	Grout works	40
6.	Repair Shop, Motor Pool	30
7.	Water Supply	85
8.	Miscellaneous	60
	Total	900

Remark; Peak power demand: 900 kW x 0.80 = 720 kW

Table 10 WATER DEMAND FOR CONSTRUCTION

Unit: m^3/min

No.	Description	Living Use	Construction Use
1.	Office, Camp	0.50	
2.	Crushing Plant	-	1.30
3.	Concrete	-	0.10
4.	Repair Shop & Motor Pool	-	0.10
5.	Grout Work	-	0.50
6.	Quarry Site	-	0.20
7.	Borrow Area	-	0.80
8.	Fill Dam (Embankment)	-	0.50
	Total	0.50	3.50

Table 11 REQUIRED EXCHANGE CIRCUIT OF TELECOMMUNICATION

No.	Description	Number
1.	Contractor's office	4
2.	Contractor's camp	3
3.	Engineer's office	4
4.	Engineer's camp	3
5.	Warehouse and repair shop	2
6.	Labour camp	2
7.	Quarry site	1
8.	Borrow pit	1
9.	Batcher plant and crushing plant	2
10.	Cable crane operator room	1
11.	Damsite for the main dam	2
12.	Damsite for the saddle dam	1
13.	Clinic and laboratory	2
14.	Spare	2
	Total	30

Table 12 BUILDING FLOOR AND LAND AREA FOR CONSTRUCTION FACILITIES

Unit: m^2

No.	Description	Floor Area	Land Area
1.	Engineer's Office	100	200
2.	Contractor's Office	250	500
3.	Engineer's Camps	300	1,000
4.	Contractor's Camps	300	1,000
5.	Labour's Camps	1,350	2,500
6.	Repair Shop	100	500
7.	Warehouse	150	300
8.	Garage	150	200
9.	Cement Store House	300	500
	Total	3,000	6,700

Table 13 MAJOR CONSTRUCTION PLANT AND EQUIPMENT REQUIRED FOR CONSTRUCTION

Unit: NOS

No.	Equipment	Capacity	Required number
1.	Bulldozer with ripper	21 ton	2
2.	Bulldozer	15 ton	3
3.	Bulldozer	11 ton	2
4.	Dozer Shovel	1.4 m^3	3
5.	Wheel Loader	2.1 m^3	2
6.	Dump Truck	15 ton	6
7.	Dump Truck	8 ton	5
8.	Truck Crane	15 ton	1
9.	Truck Crane	20 ton	1
10.	Agitator Car	3.2 m^3	2
11.	Vibrator Roller	7 ton	1
12.	Tamping Roller	4 ton	1
13.	Macadam Roller	8 ton	1
14.	Tire Roller	8 ton	1
15.	Asphalt Distributor	1,000 l	1
16.	Back Hoe	0.7 m^3	1
17.	Motor grader	3.8 m	1
18.	Crawler Drill	10 m^3/min	2
19.	Boring Machine	5.5 kW	6
20.	Grout Mixer	600 l x 2	2
21.	Grout Mixer	200 l x 2	6
22.	Grout Pump	7.5 kW	6
23.	Leg Hammer	2.7 m^3/min	10
24.	Two Booms Drill Jumbo (Hydraulic)	10 kg·m x 2	2
25.	Rocker Shovel	0.4 m^3	1
26.	Air Compressor	10 m^3/min	3
27.	Air Compressor	5 m^3/min	4
28.	Generator	300 kVA	2
29.	Generator	75 kVA	5
30.	Cable Crane	4.5 ton	1
31.	Crushing Plant	100 ton/h	1
32.	Portable Crushing Plant	30 ton/h	1
33.	Concrete Mixing Plant	0.75 m^3 x 2	1
34.	Portable Concrete Mixing Plant	10 m^3/h	1
35.	Water Tank Lorry	6 m^3	2

Table 14 CONSTRUCTION MATERIALS REQUIRED FOR CONSTRUCTION

No.	Item	Unit	Quantity
1.	Diesel oil	l	1,200,000
2.	Lubricant	l	19,000
3.	Gasoline	l	200,000
4.	Grease	kg	1,800
5.	Dynamite	kg	51,000
6.	Cement	ton	17,500
7.	Reinforcement bar	ton	900
8.	H-shaped steel	ton	40
9.	ANFO	kg	57,000
10.	Electirc power	kWh	2,300,000
11.	Retarder	kg	44,000
12.	Diamond bit	carat	2,250
13.	Cross bit	nos.	1,200
14.	Detonator	nos.	70,000
15.	Timber	ton	700

Table 15 LABOUR FORCE ENGAGEMENT REQUIRED FOR CONSTRUCTION

Unit: Average Persons/month

Item	1987	1988	1989
1. Contractor's Staff			
Engineer	5	7	7
Accountant	2	2	2
Clerical stuff	4	5	5
Typist	2	2	2
Total	13	16	16
2. Labour			
Foremen	7.6	17.8	17.3
Mechanic	3.7	3.4	3.0
Electrician	5.3	3.4	2.3
Operator	9.7	37.4	28.5
Concrete worker	7.6	17.0	16.8
Reinforcement worker	-	8.5	11.3
Carpenter	7.6	8.5	7.5
Driller	9.7	19.6	12.0
Power operator	3.0	10.2	5.3
Grout worker	-	17.0	26.7
Rigger	11.3	2.6	7.5
Driver	15.3	22.8	20.5
Maid	3	3	3
Guardsmen	5	5	5
Common labour	55.6	97.8	84.0
Total	144.4	274.0	250.7

Table 16 ADOPTED UNIT COST

Unit: M$

Description	Unit	Unit Cost F.C.	L.C.	Total
Excavation				
- Common	m^3	1.5	3.5	5.0
- Weathered rock	m^3	3.0	6.0	9.0
- Rock	m^3	3.3	16.7	20.0
- Tunnel	m^3	15	75	90.0
Concrete				
- Dam	m^3	21.5	82.5	104
- Open	m^3	21.3	95.7	117
- Tunnel	m^3	23	103	126
Form work				
- Dam	m^2	3.5	32.5	36
- Open	m^2	-	24	24
- Tunnel	m^2	43.7	8.3	52
Reinforcement bar	ton	15	1,415	1,430
Embankment fill				
- Core	m^3	3.5	6.5	10
- Filter	m^3	15	22	37
- Rock	m^3	5	12	17
Grouting				
- Backfill grout	m	15	155	170
- Blanket, slush and consolidation grout	m	12	92	104
- Curtain grout	m	16	111	127
Drilling				
- Blanket and slush grout	m	8	27	35
- Consolidation grout	m	8	78	86
- Curtain grout	m	11	132	143
Metal works				
- Diversion gate	ton	11,900	1,100	13,000
- Trash rack	ton	8,200	800	9,000
- Emergency gate	ton	13,800	1,200	15,000
- Steel pipe sheel	ton	7,300	700	8,000
- Release valve	set	276,000	24,000	300,000
Others				
- Relocation road	km	78,000	312,000	390,000
- Power line	km	7,500	7,500	15,000

Remarks; (1) F.C. : Foreign currency portion
(2) L.C. : Local currency portion
(3) Release valve of one set consists of one hollow jet valve (ø1,500), one high pressure slide gate valve (ø600) and one guard valve (ø1,500).

Table 17 LABOUR WAGE

Unit: M$/d

No.	Category	Wage
1.	Foreman	60
2.	Operator	50
3.	Assistant Operator	30
4.	Driver	16
5.	Mechanic	40
6.	Electrician	40
7.	Concrete Worker	25
8.	Reinforcement Worker	35
9.	Carpenter	35
10.	Power Operator	50
11.	Driller	40
12.	Boring Worker	35
13.	Grout Worker	30
14.	Common Labour	20

Table 18 UNIT PRICE OF CONSTRUCTION MATERIALS*

Unit: M$

No.	Material	Unit	Price (M$)
1.	Diesel oil	lit	0.604
2.	Lubricant	lit	2.45
3.	Gasoline	lit	1.08
4.	Grease	kg	3.88
5.	Dynamite	kg	12.36
6.	Cement	kg	0.180
7.	Retarder	kg	2.70
8.	Reinforcement Bar	ton	847
9.	Timber (Plank Square Log)	ton	398
10.	H-shaped Steel, 125 x 125	kg	1.23
11.	Boring Rod	nos.	108

Remark; *: Including inland transportation cost from the port of Pinang to site.

Table 19 HOURLY EXPENSES OF MAJOR EQUIPMENT

Unit: M$

No.	Equipment	Capacity	Hourly Expense F.C.	L.C.	Total
1.	Bulldozer w/R	21 ton	51.98	28.05	80.03
2.	Bulldozer	15 ton	30.60	16.23	46.83
3.	Bulldozer	11 ton	25.10	13.80	38.90
4.	Dozer Shovel	1.4 m^3	20.97	11.49	32.46
5.	Wheel Loader	2.1 m^3	32.39	17.80	50.19
6.	Dump Truck	15 ton	25.77	14.58	40.35
7.	Dump Truck	8 ton	13.94	7.69	21.63
8.	Truck Crane	10 ton	22.40	13.41	35.81
9.	Truck Crane	20 ton	36.03	21.57	57.60
10.	Agitator Truck	3.2 m^3	16.83	7.38	24.21
11.	Vibrator Roller	7 ton	24.21	12.82	37.03
12.	Tamping Roller	4 ton	7.17	2.50	9.67
13.	Macadam Roller	8 ton	12.72	7.58	20.30
14.	Tire Roller	8 ton	12.54	7.43	19.97
15.	Asphalt Distributor	1,000 l	15.29	8.16	23.45
16.	Back Hoe	0.7 m^3	35.24	16.93	52.17
17.	Motor Grader	3.8 m	29.74	16.34	46.08
18.	Crawler Drill	10 m^3/min	21.48	8.55	30.03
19.	Boring Machine	5.5 kW	25.17 (d)	13.07 (d)	38.24 (d)
20.	Grout Mixer	600 l x 2	21.54 (d)	11.48 (d)	33.02 (d)
21.	Grout Mixer	200 l x 2	12.13 (d)	6.33 (d)	18.46 (d)
22.	Grout Pump	7.5 kW	22.65 (d)	12.14 (d)	34.79 (d)
23.	Leg Hammer	2.7 m^3/min	7.68 (d)	1.54 (d)	9.22 (d)
24.	Two Booms Drill Jumbo	10 kg·m x 2	117.07	53.87	170.94
25.	Rocker Shovel	0.4 m^3	51.59	26.26	77.85
26.	Air Compressor	10 m^3/min	59.56 (d)	26.47 (d)	86.03 (d)
27.	Air Compressor	5 m^3/min	35.36 (d)	15.70 (d)	51.06 (d)
28.	Generator	300 kVA	146.04 (d)	58.15 (d)	204.19 (d)
29.	Generator	75 kVA	34.21 (d)	13.98 (d)	48.19 (d)
30.	Cable Crane	4.5 ton	136.63	87.90	224.53
31.	Crushing Plant	100 ton/h	195.25	117.91	313.16
32.	Portable Crushing Plant	30 ton/h	31.40	16.64	48.04
33.	Concrete Mixing Plant	0.75 m^3 x 2	66.32	43.87	110.19
34.	Portable Mixing Plant	10 m^3/h	19.96	10.90	30.86
35.	Water Tank Lorry	6 m^3	8.22	4.55	12.77

Remarks; (1) (d): Equipment expenses per day
(2) F.C.: Foreign currency portion
(3) L.C.: Local currency portion

Table 20 SUMMARY OF CONSTRUCTION COST

Unit: M$10^3

	Item	Foreign Component	Local Component	Total
1.	River Diversion Works	790	1,360	2,150
2.	Main Dam	1,800	8,200	10,000
3.	Stilling Basin	90	620	710
4.	River Outlet	1,200	200	1,400
5.	Saddle Dam	1,100	3,270	4,370
6.	Relocation Road	1,520	5,710	7,230
7.	Preparatory Works	1,000	3,040	4,040
8.	Compensation	-	25,700	25,700
9.	Engineering Services and Government Administration (Design and Supervision)	5,900	2,500	8,400
10.	Contingencies			
	Physical contingencies	2,680	10,120	12,800
	Price escalation	4,370	15,420	19,790
	Sub-total	7,050	25,540	32,590
	Grand Total	20,450	76,140	96,590

Remark; At 1983 price level

Table 21 DETAILED CONSTRUCTION COST ESTIMATES (1/2)

Description	Unit	Quantity	Foreign Currency Unit Cost (M$)	Foreign Currency Amount (M$10^3)	Local Currency Unit Cost (M$)	Local Currency Amount (M$10^3)	Total Unit Cost (M$)	Total Amount (M$10^3)
1. River Diversion Work								
Excavation, common	m^3	200	1.5	0.3	3.5	0.7	5	1
Excavation, weathered rock	m^3	200	3	0.6	6	1.2	9	1.8
Excavation, rock	m^3	600	3.3	2	16.7	10	20	12
Excavation, tunnel	m^3	7,300	15	110	75	548	90	657
Conctete in open	m^3	320	25	8	215	69	240	77
Concrete in tunnel	m^3	2,100	75	158	195	410	270	567
Backfill grouting	m	220	15	3	155	34	170	37
Curtain and consolidation grouting	m	470	25	12	225	106	250	118
Diversion gate	ton	35	11,900	417	1,100	39	13,000	455
Care of river	L.S.			6		24		30
Miscellaneous	L.S.			73.1		118.1		194.2
Sub-total				790		1,360		2,150
2. Main Dam*								
Excavation, common	m^3	7,100	1.5	11	3.5	25	5	36
Excavation, weathered rock	m^3	13,300	3	40	6	80	9	120
Excavation, rock	m^3	10,100	3.3	33	16.7	169	20	202
Concrete in dam	m^3	56,400	25	1,410	105	5,922	130	7,332
Curtain and consolidation grouting	m	5,520	25	138	225	1,242	250	1,380
Measuring apparatus	L.S.			80		20		100
Miscellaneous	L.S.			88		742		830
Sub-total				1,800		8,200		10,000
3. Stilling Basin								
Excavation, common	m^3	300	1.5	0.5	3.5	1	5	1.5
Excavation, weathered rock	m^3	1,400	3	4	6	8	9	13
Excavation, rock	m^3	5,500	3.5	19	16.5	91	20	110
Concrete in open	m^3	2,700	20	54	170	459	190	513
Miscellaneous	L.S.			12.5		61		72.5
Sub-total				90		620		710
4. River Outlet								
Concrete in open	m^3	400	25	10	215	86	240	96
Trash rack	ton	7	8,200	57	800	6	9,000	63
Emergency gate	ton	15	13,800	207	1,200	18	15,000	225
Steel pipe shell	ton	36	7,300	263	700	25	8,000	288
Release valve**	set	2	276,000	552	24,000	48	300,000	600
Miscellaneous	L.S.			111		17		128
Sub-total				1,200		200		1,400

Remarks; (1) At 1983 price level.

(2) *: Including secondary cofferdam of 1.2×10^3 m^3.

(3) **: Consisting of one hollow jet valve (ø1500), one high pressure slide valve (ø600) and guard valve (ø1500) for one set.

Table 22 DETAILED CONSTRUCTION COST ESTIMATES (2/2)

	Description	Unit	Quantity	Foreign Currency Unit Cost (M$)	Foreign Currency Amount (M$10³)	Local Currency Unit Cost (M$)	Local Currency Amount (M$10³)	Total Unit Cost (M$)	Total Amount (M$10³)
5.	Saddle Dam								
	Excavation, common	m^3	27,800	1.5	42	3.5	97	5	139
	Excavation, weathered rock	m^3	12,600	3	38	6	76	9	113
	Excavation, rock	m^3	500	3.5	2	16.5	8	20	10
	Embankment, core	m^3	22,300	3.5	78	6.5	145	10	223
	Embankment, filter	m^3	18,600	15	279	22	409	37	688
	Embankment, rock	m^3	80,700	5	404	12	968	17	1,372
	Curtain grouting	m	4,250	25	106	225	956	250	1,063
	Blanket grouting	m	1,500	20	30	120	180	140	210
	Slush grouting	m	1,070	20	21	120	128	140	150
	Measuring apparatus	L.S.			60		20		80
	Miscellaneous	L.S.			40		238		322
	Sub-total				1,100		3,270		4,370
6.	Relocation Road								
	Road	km	11.9	78,000	928	312,000	3,713	390,000	4,641
	Bridges (1 No.)	m	300	1,200	360	4,600	1,380	5,800	1,740
	Power line	km	12.2	7,500	92	7,500	92	15,000	183
	Miscellaneous	L.S.			140		525		666
	Sub-total				1,520		5,710		7,230
7.	Preparatory Works	L.S.			1,000		3,040		4,040
8.	Compensation	L.S.					25,700		25,700
9.	Engineering and Government Administration (Design and Supervision)	L.S.			5,900		2,500		8,400
	Sub-total 1 to 9				13,400		50,600		64,000
10.	Contingencies								
	Physical contingencies	L.S.			2,680		10,120		12,800
	Price escalation	L.S.			4,370		15,420		19,790
	Grand Total				20,450		76,140		96,590