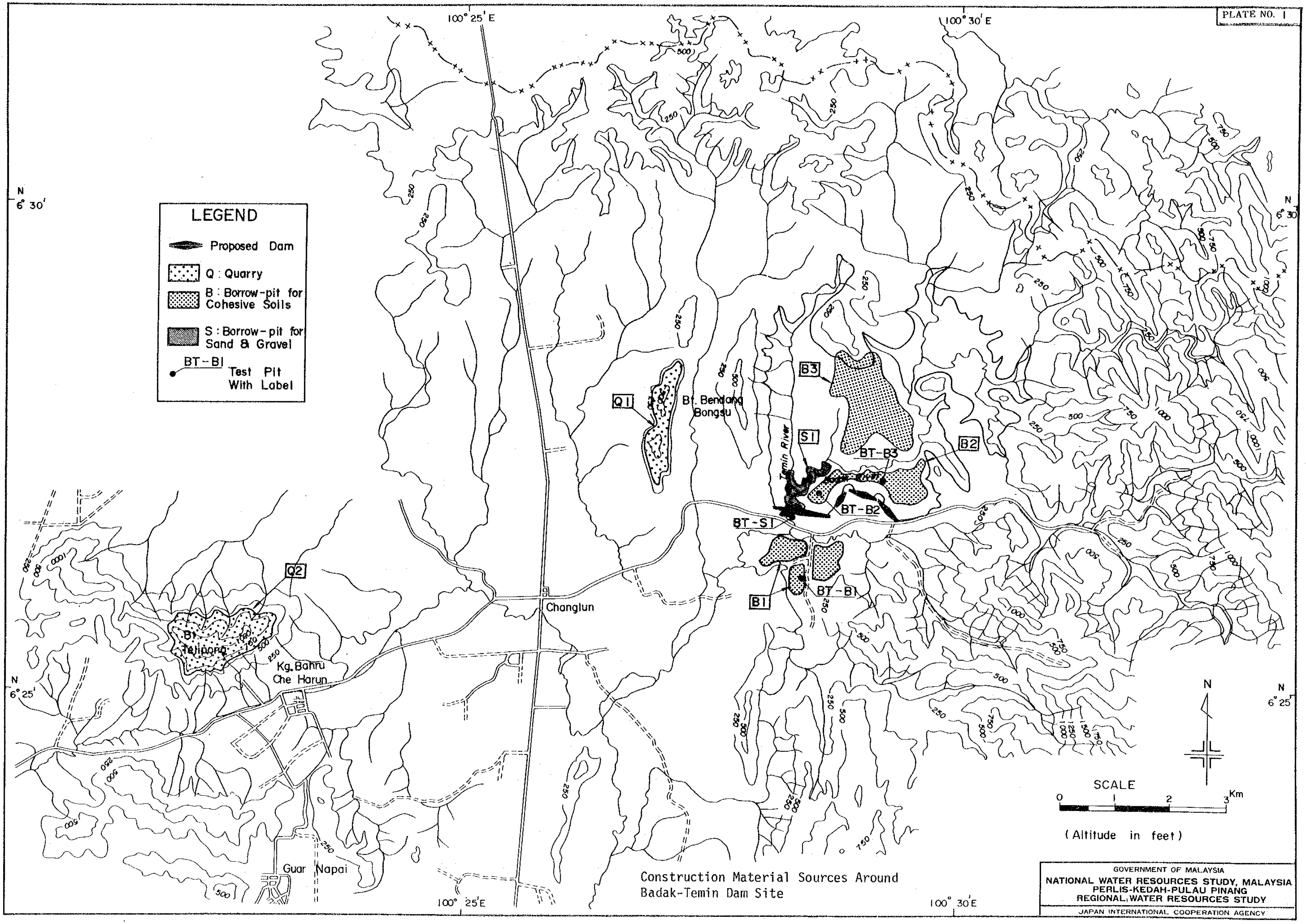
PLATES



Construction Material Sources Around Badak-Temin Dam Site

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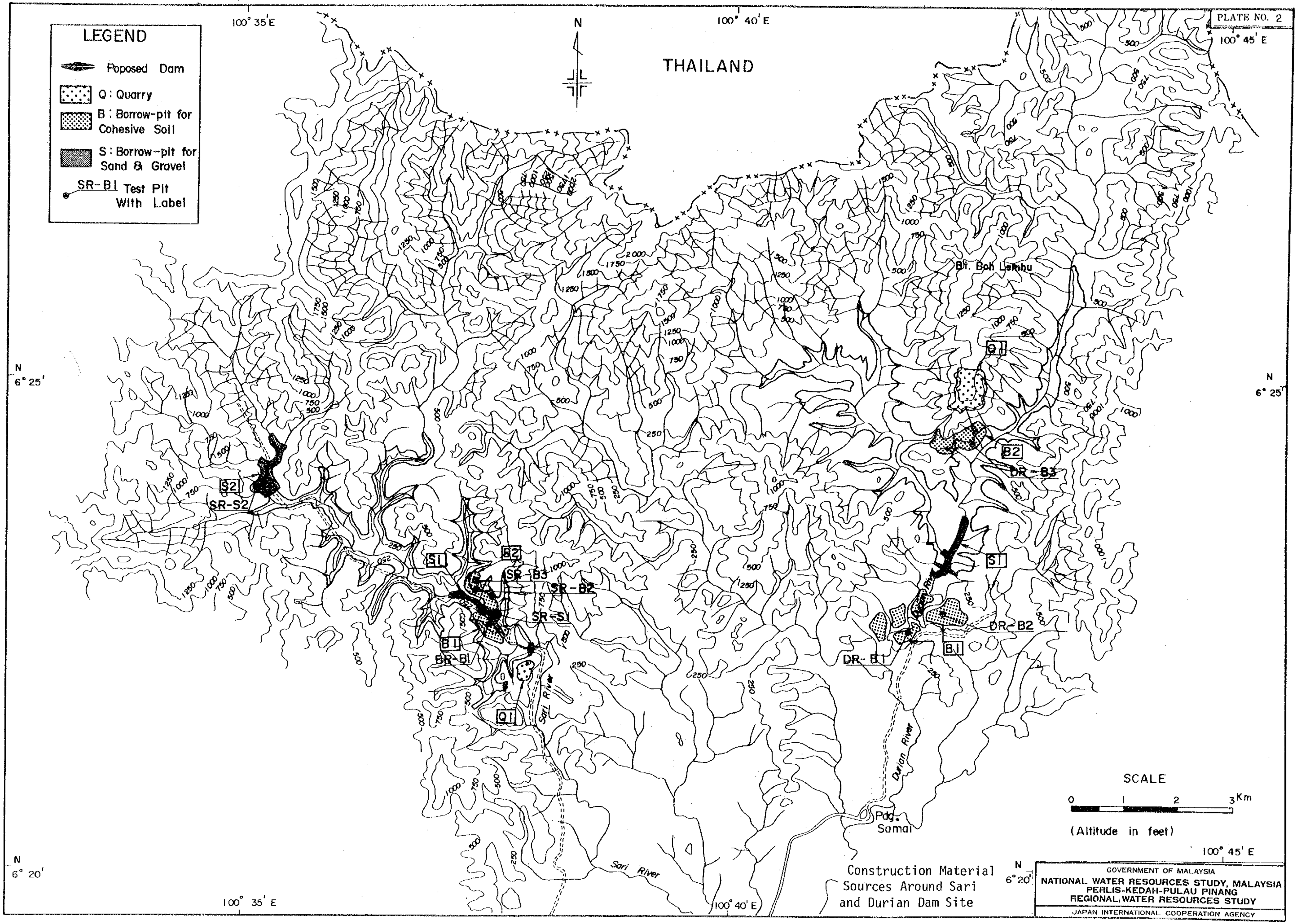

Construction Material Sources Around Sari and Durian Dam Site

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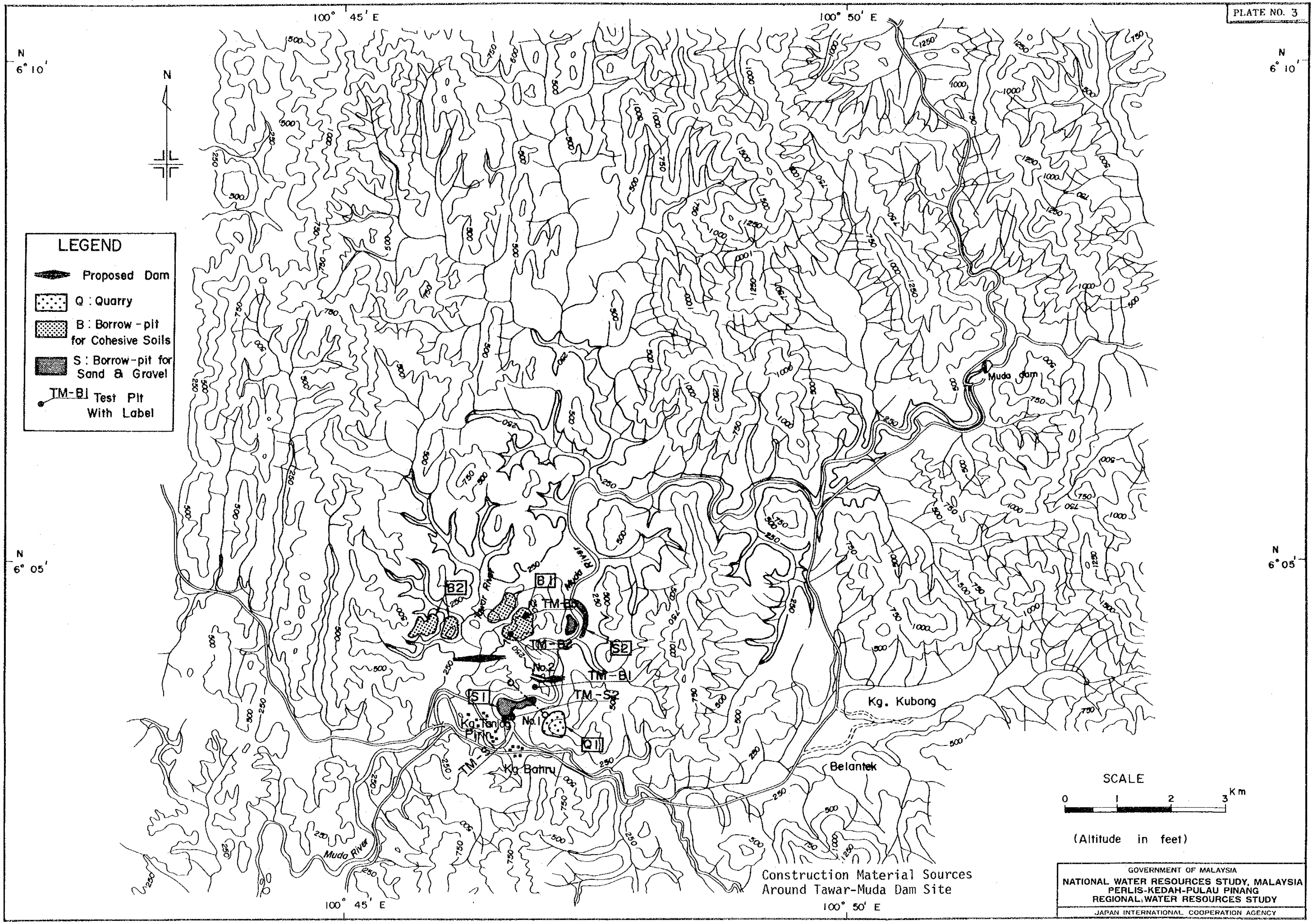
PLATE NO. 3



Construction Material Sources Around Tawar-Muda Dam Site

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Construction Material Sources Around Beris Dam Site

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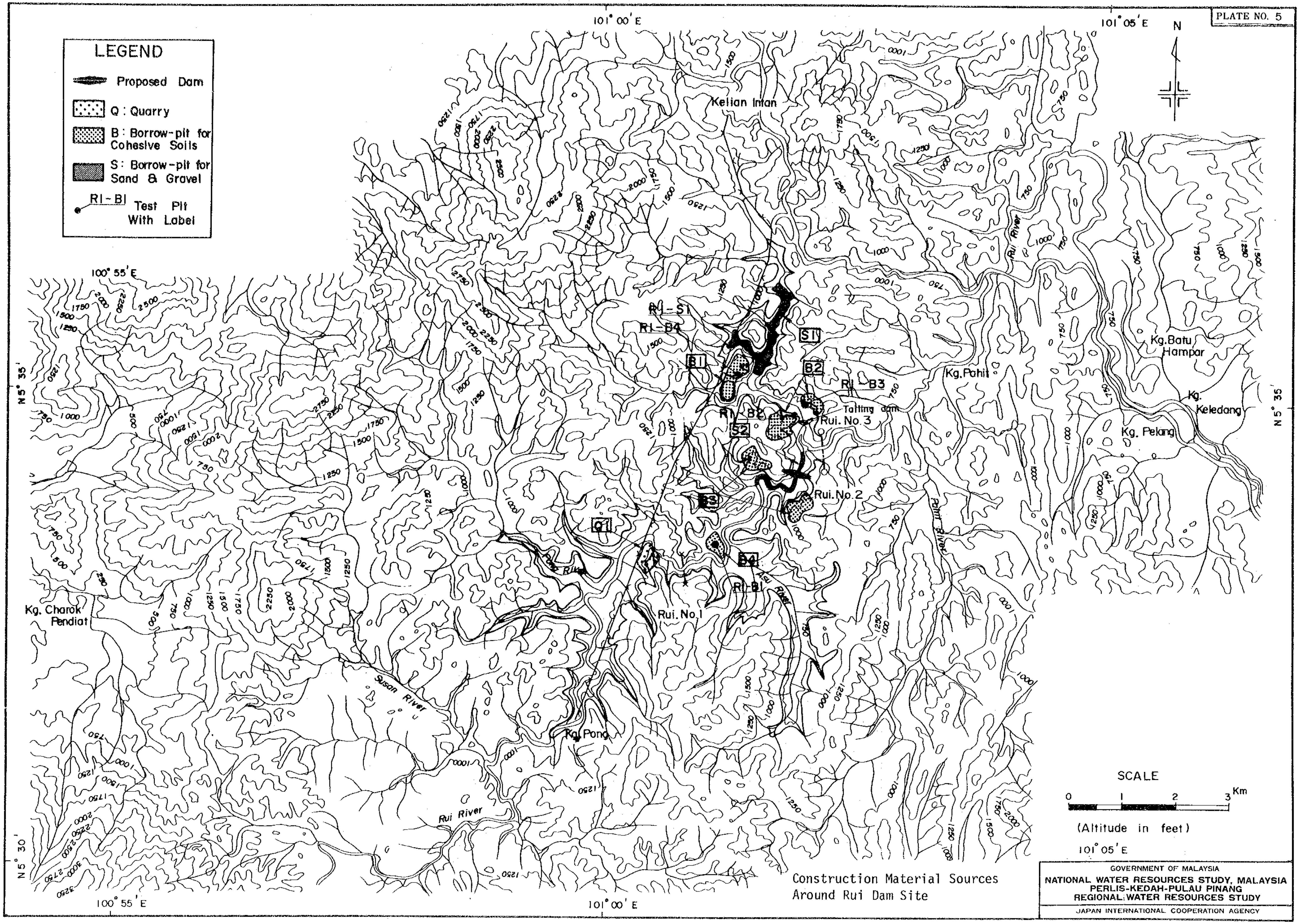

Construction Material Sources Around Rui Dam Site

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ANNEX L

PROPOSED DAM PROJECTS

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1. INTRODUCTION

The objective of the sector of Proposed Dam Projects is at first to investigate the field conditions of the proposed 6 dam project sites and to decide the most viable dam axes, second to prepare the feasibility design of the main dam and auxiliary structures following the least-costly-alternative criteria, and third to prepare the project scale-cost relationship which is required for the optimization of the project scale, the cost benefit analyses and the cost allocation for the sectors involved.

The Study area, the Perlis-Kedah-Pulau Pinang region shown in Fig. 1 includes the Perlis, Kedah, Merbok, Muda and Perai river systems, and the Rui river basins of the Perak river system. The investigation was focused on the proposed 6 dam sites and their alternatives; that is, Badak-Temin, Sari, Durian, Tawar-Muda, Beris and Rui.

The field investigation on the proposed project area was done in association with the topographic, geologic, construction material and land use survey teams in the period from December 13, 1982 to March 31, 1983.

Section 2 summarizes the results of the field investigation including site topography, geology and construction materials. Section 3 describes the dimension of the proposed reservoirs and the technical and social characteristics of the reservoir area. Sections 3, 4 and 5 describe the alternative type of the main dam and the auxiliary structures, the alternative formulation criteria, and the basin transfer facilities, the power stations and the transmission lines respectively. Sections 7 and 8 summarize the project scale-cost relationship, the optimum scale and the proposed features of the main dam and the auxiliary structures.

2. PROPOSED DAM SITES AND ALTERNATIVE DAM AXES

2.1 The Project Area and the Proposed Dam Sites

The project area and the proposed 6 dam sites are shown in Fig. 1. The Badak-Temin, the Sari and the Durian sites are located in the Kedah river basin in the State of Kedah and the Tawar-Muda and Beris sites are located in the Muda river basin in the State of Kedah. The Rui site is in the Rui river basin which is a northern tributary of the Perak river in the State of Perak. These sites are identified on the map of 1:63,360 scale. The site name denotes the name of tributary which a site belongs to. When it involves in two tributaries, two names are combined with hyphen like Badak-Temin. The longitude and the latitude of these sites are approximately set out below.

	Longitude	Latitude
Badak-Temin	100°28'28"E	6°26'50"N
Sari	100°38'10"E	6°22'20"N
Durian	100°42'45"E	6°23'00"N
Tawar-Muda	100°47'00"E	6°03'30"N
Beris	100°44'44"E	5°58'45"N
Rui 1	101°00'50"E	5°34'00"N
Rui 2	101°01'50"E	5°34'50"N
Rui 3	101°01'50"E	5°34'50"N

The site conditions including the proposed dam site, the alternative dam axes, the reservoir area, the alternative construction material sources and the proposed relocation road plan are shown in Plate 1 for the Badak-Temin site, Plate 2 for the Sari and Durian sites, Plate 3 for the Tawar-Muda site, Plate 4 for the Beris site and Plate 5 for the Rui site.

2.2 Alternative Dam Axes

Several alternative dam axes were identified for each site on the Map of 1:63,360 scale and all of these sites were surveyed from topographic and geotechnical aspect. After the site reconnaissance, only one dam axis is selected for the Badak-Temin, Sari and Durian sites respectively. The Tawar-Muda and Beris sites, however have 2 alternative dam axes respectively. The Rui site has 3 alternative dam axes. These alternative dam axes are shown in Plates 1 to 5 respectively.

For the alternative axes a notation system, which gives a younger number from the upper site to the downstream, is adopted; for example, Rui 1 (upmost), Rui 2 (intermediate) and Rui 3 (downstream).

Of the specified alternative dam axes the one which yields the highest investment efficiency is detected in Section 8.

2.3 Topographic Mapping

2.3.1 Scope of topographic survey

A series of the basic map with 1:63,360 scale prepared by the Government of Malaysia is the only available and reliable topographic map in the proposed project area at 1983 stage.

The objective of the topographic survey is to prepare:

(1) The topographic maps in the proposed reservoir area with 1:10,000 scale using the areal photographs made by the Government of Malaysia; which are used for measuring reservoir area and water storage capacity, and

(2) The profiles and plans with 1:1,000 scale at the proposed dam sites; which are used for the preliminary design of dam and auxiliary structures.

2.3.2 Results of topographic mapping

One local bench-mark was installed near the proposed dam sites respectively. The elevation of the local bench-mark and that of the national original bench-marks listed in Table 1 were connected by the grade 3 levelling. The elevation of the local bench-marks is shown in Table 2. The elevation in the reservoir area was measured by the quick levelling. The control survey was done by the traversing method. The horizontal co-ordinates were set for only local co-ordinates; that is, the local co-ordinates and the station of the national triangulation were not connected. The Tawar-Muda site and the Beris site have the common co-ordinates because a common traverse network was used.

The areal triangulation and drafting was done with the accuracy of grade B. The 1:1,000 topographic maps were made by mesh surveying because the local surveyers had no experience of plane table surveying.

Table 3 shows the list of survey work done by the Study Team. The coverage and number of sheets of the topographic maps prepared by the Study Team are listed in Table 4.

2.4 Site Topography and Geology, and Construction Materials

The major items of the topographic and geological conditions of the proposed dam sites are summarized in Table 5 for the Badak-Temin, Sari and Durian sites, Table 6 for the Tawar-Muda and Beris sites and Table 7 for the Rui alternative sites. The thickness of soil layer, depth to the fresh rock and required depth of foundation excavation are summarized in Table 8. The details of the topographic and geological conditions are presented in the Annex, Engineering Geology.

The technical judgement of the proposed quarry-sites and borrow-pits is described in the Annex, Construction Materials.

3. RESERVOIR CHARACTERISTICS

3.1 Dimension of Reservoirs

The topographic maps with the scale of 1:10,000 were made for the prospective reservoir area by the Study Team. The contour interval is 5 m.

The stage-area curves which show the relationship between reservoir water surface elevation and reservoir area and the stage-capacity curves which show the relationship between reservoir water surface elevation and storage capacity are made using the foregoing maps. These curves for the Badak-Temin, Sari, Durian and Tawar-Muda sites are shown in Fig. 2 and those for the Beris 2, Rui 2 and Rui 3 sites are shown in Fig. 3.

3.2 Technical and Social Problems Due to Submergence

3.2.1 Earthquake and landslide

The probability of earthquake due to artificial pondage will be very low, but the earthquake force is taken into account for the design of dam body to keep safety (see Section 5.4).

The maximum rate of daily reservoir drawdown is taken into account in determining the reservoir capacity to avoid diserstrous landslide in the reservoir area.

3.2.2 Socio-economic problems due to submergence

Once a dam is constructed, the land in the prospective reservoir area is submerged, and thus the existing and future land use and social activities will be affected significantly. The anticipated problems are summarized in this section. The details including land acquisition cost are presented in the Annex M, Land Use in Proposed Reservoir Areas.

(1) Badak-Temin site

The proposed reservoir area is mostly occupied by rubber plantations of RISDA and FELDA and is leased to the Abudullar Ghaffer Mining Bhd. in the southeastern end. PWD is constructing a new road across the proposed reservoir area. Northern half and southeastern part of the area is located in a forest reserve. There is a plan to establish the 6th university to the east of the rubber plantation. About 60% of the proposed reservoir area is classified as the probable and possible mining lands according to GSD. The application to prospecting tine ore was approved. There is no village in the reservoir area.

(2) Sari site

The proposed reservoir area is mostly covered by the farm of the Gula Padang Terap Sugarcane Plantation and the Syaricat Pintu Wang Melombong Sendirian Bhd. is mining at the northwest margin of the area. PWD is constructing a road across the area. The proposed reservoir area totally belongs to a forest reserve. FELDA has a plan to develop a rubber plantation in an area which totally occupies the proposed reservoir area. About 60% of the proposed reservoir area is classified as the possible mining land according to GSD. The application to prospecting tine ore was approved. There is no village in the reservoir area.

(3) Durian site

The proposed reservoir area is fully covered by the farm of the Gula Padang Terap Sugarcane Plantation and its eastern part consists a forest reserve. FELDA has a plan to develop the northeastern part of the proposed reservoir area for rubber plantation. Mining potential is very low. There is no village in the reservoir area.

(4) Tawar-Muda site

The proposed reservoir area is cultivated for rubber mini-estates of RISDA in its west and the rest is forest but partly belongs to the rubber plantation of FELCRA. An army camp and a part of Kg. Aur are located within the proposed reservoir area. The area belongs to a forest reserve in its northern part. The Veterinary Department has a plan to develop a cattle grazing land to the northeast of the proposed reservoir area. A small portion of the land duplicate the proposed reservoir. Mining potential is very low. There is no village in the reservoir area.

(5) Beris site

The proposed reservoir area is occupied by forest reserve in its northwestern part and forest largely developed for rubber cultivation by small holders. The Nami-Sik road passes across the southeastern part of the proposed reservoir area, where Kg. Ternas and Kg. Sg. Batang are located. The Kedah Economic Development Authority is planning the Serai Wangi project of citronella in the northern part of the proposed reservoir area and the Forestry Department has a plan to grow teak, partly duplicating the proposed reservoir area. Mining potential is estimated to be low, though a mining prospecting has been applied for the northern part of the proposed reservoir area. Some part of Kg. Sg. Batang (total population 1,200) and Kg. Ternas (total population 300) will be submerged.

(6) Rui 2 site

The proposed reservoir area is mostly covered by jungle, where there are Kg. Pong and Kg. Asu. The Rahman Hydraulic Tin Bhd. is operating the Tanah Aitam Mill to the northeast of the area. It has the Pong power station of 2 MW, a hydroelectric power station in the southwest of the proposed reservoir area. Tin mining potential is high in the vicinity of the Tanah Hitam Mill and southwestern part of the proposed reservoir area. The Rahman Hydraulic Tin Bhd. is considering to strengthen the Pong power station. GSD expressed in June 1983 that there is a possibility of uranium in the proposed reservoir area, but neither content nor volume is known. The tributary joining to the Rui river between the Rui 2 and Rui 3 dam site is utilized as the tailing area of the Tanah Hitam Mill, and it will be mostly flooded if the Rui 3 dam is constructed. The Kg. Asu and Kg. Pong will be submerged.

3.2.3 Relocation road plan and land acquisition cost

The construction of the Badak-Temin, Sari, Tawar-Muda and Beris dams affects the main roads to some extend. Table 9 summarize the estimated quantities of the submerged main roads and the construction cost of the relocation roads by project site. The assumed unit construction cost is shown in Table 10. The routes of the relocation road plan are shown in Plate 1 for the Badak-Temin area, Plate 2 for the Sari area, Plate 3 for the Tawar-Muda area and Plate 4 for the Beris area.

4. TYPES OF MAIN DAM AND AUXILIARY STRUCTURES

4.1 Main Dam and Subordinate Dams

The results of topographic and geologic investigations clarified that concrete types can be technically possible only at Sari and Beris 2 sites and only fill types can be constructed for the other sites.

Only a concrete gravity dam is adopted for the alternative study because the mechanical property of foundation rock is not available at this stage. As for fill types, a homogeneous earthfill type, concrete and asphalt facing types, and central earth or asphalt core rockfill types are compared in the screening process. The central earth core rockfill dam is adopted for the alternative study because:

(a) earthfill core materials in and around the dam sites have sensitive soil mechanical properties and is merginal for a homogeneous earthfill type (see Annex, Construction Materials); and

(b) facing types are costly.

4.2 Spillway and Energy Dissipator

4.2.1 Spillway

The catchment area of the 6 proposed dam site is very small from 60 to 260 km^2. This suggests that spillway operation against flood inflow be prompt and highly reliable. The following fundamental requirements, therefore are applied to the spillway design:

(a) Non-gated overflow weir;

(b) Open channel chuteway; that is, tunnel chuteway be avoided; and

(c) All the spillway structures be installed on the abutment foundation rock for fill type dams.

4.2.2 Energy dissipator

A stilling basin type, a roller bucket type and a flip bucket (or ski jump) type are studied as alternative energy dissipators. The stilling basin type is adopted for all the site except the Badak-Temin site though the flip type is estimated less economical. The principal reason is that there are villages or residential area in the downstream stretch of the proposed dam sites, and thus the riverbed scoring due to insufficient energy dissipation might cause adverse effects.

The roller bucket type is adopted for the Badak-Temin site because of cost saving. However, the data regarding the river water flow and depth at the site is not sufficient and thus it is subject to the further study.

4.3 River Diversion Works for Dam Construction

A tunnel river diversion system driven through the abutments and a multistage channel system are compared, and eventually the tunnel system is adopted for all the sites except the Badak-Temin site. The multistage system is adopted for the Badak-Temin site because the valley width between abutments (some 1.2 km) is wide enough.

Two lines of tunnels are provided at least for rockfill dams in order to use one tunnel for the river outlet facilities, while the river outlet facilities are installed in dam body in cases of a concrete dam and a multistage channel system. A circular cross section is adopted for diversion tunnels.

4.4 Intake and River Outlet Facilities

A jet flow gate, a hollow jet value and a Howell Banger value were considered for use at outlet facilities to release water for irrigation, domestic and industrial water demand in the downstream area. The hollow jet value is adopted because of its highest reliability.

Two units are installed for the Badak-Temin, Sari, Durian, Tawar-Muda and Beris dams. One unit, of which capacity can be made smaller, is for the emergency operation. In case of the Rui dam each one unit is installed for the Rui river side and the Tiak river side because it is operated only when power is not generated. The value chamber is installed at the end of a diversion tunnel for a rockfill dam and in a dam body for a concrete dam.

Each unit has a guard valve provided for the use of maintenance. The intake structures are equipped with a sluice gate for emergency repair.

5. ALTERNATIVE FORMULATION CRITERIA

5.1 Design Criteria Applied to Dam and Auxiliary Structures

Application of a local design criteria is preferable but no authorized criteria on dams and auxiliary structures have been prepared yet in Malaysia. The study, therefore established a design criteria based on the criteria under Japanese National Committee on Large Dams (Ref. 1). It is modified to some extent taking into the local peculiarity and the practises which have been applied to the existing facilities. The British and the USBR standard are also consulted.

The types and optimum scale of dams and auxiliary structures are determined on the basis of the least-costly alternative criteria taking into account the technical feasibility and safety against uncertainties.

5.2 Reservoir Water Level, Freeboard and Spillway Discharge Capacity

The definition of the reservoir water level and freeboard which is applied to the study is shown in Fig. 4.

5.2.1 Normal high water level and low water level

(1) Normal high water level

The spillway with a non-gated overflow weir being adopted (see Section 4.2), the normal high water level (NHWL El.) corresponds to the crest elevation of a spillway overflow weir.

For optimizing reservoir storage capacity, alternative normal high water levels are selected at least 3 - 4 different elevations between the low water level (LWL) and the maximum scale for each proposed dam site. The minimum requirement of normal high water level should be slightly higher than LWL because of the minimum active storage requirement for compensating the shutdown of the catchment. Table 11 shows the range of the alternative combination of NHWL El, LWL El, and active storage capacity.

(2) Low water level

The low water level shown in Table 15 is determined on the basis of the following two principles:

(a) An allowance of 3 - 5 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; and

(b) The maximum rate of daily reservoir drawdown be kept within 1.0 m/d (30 m/month) in order to prevent from diserstrous landslide in the reservoir area.

5.2.2 Freeboard and spillway discharge capacity

The freeboard above the maximum design water surface is determined considering extraordinary flood discharge, wave due to wind and earthquake, rise of water surface level caused by unexpected accident in operating the spillway gate, operation method of the reservoirs and type and importance of dams. The safety against the probable maximum flood (PMF) is also examined.

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

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

The Maximum Design Water Surface	Freeboard Requirement	
Normal high water level	Hf (1)	= hw + he + ha + hi or 3.0 m for fill type and 2.0 m for concrete type
Design flood discharge water level without reservoir retardation effect	Hf (2)	= hw + ha + hi or 2.0 m for fill type and 1.0 m for concrete type
RMF water level with reservoir retardation effect	Hf (PMF)	= 1.5 m for fill type and 1.0 m for concrete type

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 and 0 for concrete dams)

The wave height due to wind and earthquake is shown in Table 12. Table 13 shows the numerated values of freeboard above the maximum design water surface level.

(2) The dam crest elevation

The crest elevation of the non-overflow section of a main dam, which corresponds to the crest elevation of the impervious core of a fill dam, is the sum of the maximum design water level and the freeboard. Additional height for a road on a fill dam crest or a clearance for the beam height of a bridge above a spillway weir of a concrete dam, which is assumed to be 1.0 m, is required above the non-overflow section.

The dam crest elevation of the non-overflow section, eventually is the sum of the maximum design surface water level, the freeboard and the additional height (1.0 m). Table 14 shows the maximum water level, crest elevation of the impervious core and the dam crest elevation of non-overflow section for each dam site.

5.3 Design Flood Discharge

5.3.1 Estimation of flood runoff

The flood runoff at the proposed dam sites is generated using the point storm rainfall data (1 - 24 hours) at Alor Setar and Jeniang stations. The direct runoff hydrograph is generated by the dimensionless hydrograph method described in the U.S. Bureau of Reclamation Manual (Ref. 3) and Hydrological Procedure No. 11 (Ref. 4).

Table 15 shows the peak discharge of the maximum probable flood with recurrence interval of 2 - 10,000 years at the proposed dam sites.

The probable maximum flood (PMF) is estimated by analysing the design flood envelope curves presented in Ref. 2 because no reliable data is available. Fig. 5 shows the envelope for the specific peak discharge of PMF adopted for the project area. The part of less than 200 km^2 in drainage area is applied to the 5 dam sites in the State of Kedah. The part of larger than 200 km^2, which corresponds to the specific discharge of 7.0 $m^3/s/km^2$ is applied to the Rui 2 and Rui 3 sites.

The further details are presented in the Annex, Meteorology and Hydrology.

5.3.2 Design flood for river diversion

The flood runoff record being not reliable, the design flood discharge, which usually depends on the type of cofferdam, a concrete or a fill, is not distinguished by the type.

The tunnel or channel discharge capacity is determined so that the 20-year flood runoff can be discharged under free flow conditions in order to divert the probable flood runoff in one dry season without overtopping the cofferdam under construction. The requirement of hydraulic conditions is:

(a) the maximum flow area of a circular tunnel be 82%; and

(b) the maximum flow velocity be less than 10 m/s; 6 - 7 m/s be preferable.

The height of the main cofferdam is determined so that the 50-year flood peak runoff can be discharged with freeboard of 1 m. The reservoir retardation effect is not taken into account. The design peak discharges for the proposed sites are shown in Table 16.

5.3.3 Design flood for spillway and energy dissipator

The same design flood discharge is applied to both concrete and fill types at this stage, since uncertainties are involved in the flood runoff records.

The 120% peak discharge of 200-year flood and the peak discharge of 1,000-year flood are compared with, and the larger value, the 1,000-year flood is adopted as the design flood discharge for the case without reservoir retardation effect (storage function). The probable maximum flood (PMF) shown in Table 16 is adopted as the design flood discharge for the case with reservoir retardation effect. The Creager's C-value are also presented in Table 16 for comparison.

The foregoing two cases of spillway discharge are studied under the freeboard criteria described in Section 5.2.2, and the case which results in the larger discharge capacity of spillway overflow weir and chuteway is adopted. As is shown in Table 17 the spillway capacity of the rock-fill type of the Badak-Temin, Sari, Durian, Tawar-Muda, Beris and the concrete type of the Beris is governed by the 1,000-year flood, and that of the concrete type of the Sari and the rockfill type of the Rui 2 and Rui 3 is governed by the PMF.

The 1,000-year flood discharge is adopted as the design capacity for the energy dissipator taking the following uncertainties into account. Not only the 100-year flood runoff seems to be rather small but also the river flow conditions at and around dam sites are unknown.

5.4 Loading Condition

The following two items with regard to loading condition are determined taking the local peculiarity of Malaysia into account:

(a) Coefficient of earthquake, $k = 0.1$ for the probable earthquake due to artificial pondage; and

(b) The minimum factor of safety for the stability analysis of fill dam is 1.5 under the condition of normal high water level without earthquake force and 1.2 with earthquake force.

6. RUI BASIN TRANSFER FACILITIES, POWER STATIONS AND TRANSMISSION LINE

6.1 Rui Basin Transfer Facilities

The Rui water transfer tunnel, which aims to release water from the Rui reservoir to the Muda river, is constructed from the intake at the confluence of the Rui river and the Pong river in the proposed reservoir area to the outlet at a tributary of the Tiak river near Kg. Charok Pendiat. The tunnel length is about 9 km. The tunnel diameter is 3.5 m which is the minimum size requirement for constructing a long tunnel. The route of the basin transfer tunnel is shown in Plate 15. The rock formation is shell of 3 - 4 km in the Rui reservoir portion and intruded granite around the outlet portion. It is probable that the tunnel route intersects not only a few structural faults and many subordinate faults but also the zones of hydrothermal alternation or deterioration in the shell bed.

6.2 Tiak Power Station and Rui Mini-Hydropower Station

The Tiak power station is constructed at the outlet of the Rui basin transfer tunnel, at the foot of a hill slope of intruded granite, 500 m north of Kg. Charok Pediant. A surge tank is constructed near the downstream end of the transfer tunnel. A penstock with 2.5 m diameter and 220 m length connects the end of the tunnel to the Tiak power station. The installed capacity is 26 MW. The average annual energy output are estimated to be 64 GWh for the Rui 2 and 74 GWh for the Rui 3. One unit of outlet valve is provided for the power station for the use in non-power generating period.

The Rui mini-hydropower station is constructed at the outlet of a diversion tunnel to generate the power by the use of the river maintenance water release of 1.4 m^3/s to the Rui downstream stretch. The installed capacity is 880 kW and the normal annual energy output is estimated to be 4.4 GWh.

The principal features of the basin transfer and power generation facilities of Rui 2 and Rui 3 dams are presented in Table 18.

6.3 Transmission Line System

The Tiak hydropower station and the Rui mini-hydropower station are constructed for compensating NEB and Rahman Hydraulic Tin Company (RHT) for power loss at Bersia, Chenderoh and Pong power stations. The Tiak hydropower station and the Rui mini-hydropower station, therefore should be connected with the nearest switching station (Bersia power station or Sg. Petani substation) in the NEB transmission line network and RHT at Kelian Intan. On the other hand if the transmission line connected with the NEB switching station is constructed before the main civil works of the Rui dam, the power required for dam construction can be supplied from NEB instead of installing a temporary generating equipment.

Four alternative transmission line systems described in Table 19 are studied and the alternative-4 is recommended as the best system. That is, the 132 kV transmission line is constructed from Sg. Petani substation to the Tiak power station. The length is about 70 km. From the Tiak power station to RHT and the Rui dam site the power is steped down and transmitted with 11 kV transmission line. One set of 12,000 kVA main transformer is required. The distribution line is 6.6 kV. The route of the proposed transmission line system is shown in Fig. 1.

6.4 Power Compensation Survey

If the Rui dam and water transfer tunnel is constructed, not only the Pong power station and its transmission line is submerged but also the energy output from the Kenering and Chenderoh power stations is affected by the reduction of outflow from the Rui river.

The power compensation survey therefore was done by the Study. The main features of the power plants and transmission line systems of the Pong, Kenering, Chenderoh and Temengor hydropower plants are shown in Table 20. The power generation records of the Chenderoh and Pong hydropower stations are described in Table 21.

The energy loss and the compensation method for these power plants are precisely described in the Annex, Land Use in Proposed Reservoir Area.

7. PROJECT SCALE-COST RELATIONSHIP

7.1 Works Quantities, Project Cost and Construction Schedule

The unit prices, works quantities, costs of main construction works, construction schedule, annual disbursement schedule and the cost estimation criteria are presented in the Annex, Cost Estimation of Proposed Dam Projects.

7.2 Project Scale-Cost Relationship and Optimum Scale

The project scale-cost relationships in terms of project financial cost and reservoir normal high water level (NHWL) are presented in Table 22 and Figs. 6 - 8. The financial project cost is composed of engineering and administration cost, compensation cost and physical contingency at 1982 constant price level. The economic cost in Figs. 6 - 8 excludes compensation cost.

The minimum scale is governed by the low water level plus storage requirement for water release for shutdown. The maximum scale of the Badak-Temin, Durian, Tawar-Muda and Beris dam sites are limited by the topographic constraint.

The optimum development scale is determined in the Annex, Regional Water Demand and Supply Balance System. Table 23 shows the optimum development scale in terms of NHWL, the project financial cost, the annual net water output and the investment efficiency. The net water output is the regulated outflow (yield) excluding shutdown of the catchment under the 1977 hydrological condition. The investment efficiency is the ratio of the total project cost to the 1977 net water output.

8. PROPOSED FEATURES OF MAIN DAM AND AUXILIARY STRUCTURES

The principal features of the proposed dam and the auxiliary structures are presented with the optimum scale in Table 24 for the Badak-Temin, Sari and Durian dams and Table 25 for the Tawar-Muda, Beris, Rui 2 and Rui 3 dams. The plan, the maximum section and the upstream view of the main structures are shown in Plate 6 for the Badak-Temin dam, Plate 7 for the Sari dam, Plate 8 for the Durian dam, Plates 9 and 10 for the Tawar-Muda dam, Plate 11 and 12 for the Beris dam, Plate 13 for the Rui 2 dam and Plate 14 for the Rui 3 dam. The Rui water transfer facilities are shown in Plate 15. The construction schedule is presented in the Annex, Cost Estimate of Proposed Dam Projects.

8.1 The Badak-Temin Dam

The annual inflow from the catchment area of 112 km^2 is estimated to be 58 x 10^6 m^3. The active storage capacity of the reservoir of 58 x 10^6 m^3 with a drawdown of 8.5 m can regulate 30 x 10^6 m^3 of water if the normal HWL is set at El. 45 m.

The Badak-Temin dam is a combination of a rockfill dam of 929,000 m^3 and a concrete gravity dam 67,000 m^3. It is 29 m in the maximum height and 1,075 m in crest length as shown in Plate 6. The dam crest is set at El. 50 m. The concrete spillway section is placed at the middle of the dam. It is a free overflow spillway of 54.0 m in effective width. A river outlet having 2 units of 1.2 m dia. outlet values is installed in the concrete section. In view of wide valley bottom, a multiple stage diversion method is envisaged for the construction of dam. Three saddle dams are constructed with total volume of 462,000 m^3.

The total investment cost is estimated to be M$149.2 x 10^6 including M$123.0 x 10^6 of cost for construction works and M$26.2 x 10^6 of land acquisition cost including physical contingency at 1982 constant price level.

8.2 The Sari Dam

The annual inflow from the catchment area of 61 km^2 is estimated to be 32 x 10^6 m^3. The active storage capacity of the reservoir of 56 x 10^6 m^3 with a drawdown of 22 m can regulate 23 x 10^6 m^3 of water if the normal HWL is assumed at El. 91 m.

The Sari dam is a concrete gravity dam of 47 m in maximum height and 170 m in crest length as shown in Plate 7. The dam volume is 62,000 m^3. The crest is set at El. 95 m. A free overflow spillway of 71 m in effective width is located at the central section of the dam. A river outlet having 2 units of 1 m dia. outlet valves is installed in the spillway section. A diversion tunnel of 5.9 m in diameter and 173 m in length is located in the right abutment for the purpose of construction. A 270 m long saddle dam is constructed with embankment volume of 30,000 m^3 at 1 km to the southwest of the main dam.

The total investment cost is estimated to be M\$72.5 x 10^6, including M\$52.2 x 10^6 of cost for construction works and M\$20.3 x 10^6 of land acquisition cost including physical contingency at 1982 constant price level.

8.3 The Durian Dam

The annual inflow from the catchment area of 74 km^2 is estimated to be 38 x 10^6 m^3. The active storage capacity of 41 x 10^6 m^3 with a drawdown of 14 m can regulate 21 x 10^6 m^3 of water, if the normal HWL is set at El. 74 m.

The Durian dam is a rockfill dam of 39 m in maximum height and 903 m in crest length as shown in Plate 8. The crest is set at El. 79 m. The embankment volume is 1,084,000 m^3. A free overflow spillway of 48 m in effective width is located in the concrete gravity section on the left abutment. Two lines of 4.7 m dia. diversion tunnels are excavated in the isolated hill. One of the tunnel is utilized for installing the river outlet having 2 units of 1 m dia. outlet valves.

The total investment cost is estimated to be M\$113.3 x 10^6 including M\$111.5 x 10^6 of the cost for construction works and M\$1.8 x 10^6 of land acquisition cost including physical contingency at 1982 constant price level.

8.4 The Tawar-Muda Dam

The annual inflow from the catchment area of 129 km^2 between the Muda dam and the Tawar-Muda dam site is estimated to be 123 x 10^6 m^3. The active storage capacity of the reservoir of 54 x 10^6 m^3 with a drawdown of 11.5 m can regulate 41 x 10^6 m^3 of water, if the normal HWL is set at El. 77 m.

The Tawar-Muda main dam is a rockfill dam of 34 m in maximum height and 338 m in crest length as shown in Plate 9. The crest is set at El. 82 m. The embankment volume is 281,000 m^3. A free overflow spillway of 75 m in effective width is located in the concrete gravity section on the left abutment. Two lines of 5.4 m dia. diversion tunnels are excavated in the right abutment. One of the 2 tunnels is utilized to install a river outlet having 2 units of 1.5 m dia. outlet valves. Three saddle dams are constructed with total embankment volume of 43,000 m^3.

The secondary dam is a rockfill dam of 31 m in height and 1,040 m in crest length as shown in Plate 10. The crest is set at El. 82 m. The embankment volume is 870,000 m^3. A division tunnel of 3 m diameter is excavated in the left abutment.

The total investment cost is estimated to be M\$114.6 x 10^6 including M\$103.8 x 10^6 of the cost of construction works and M\$10.8 x 10^6 of land acquisition cost including physical contingency at 1982 constant price level.

8.5 The Beris Dam

The annual inflow from the catchment area of 116 km^2 is estimated to be 110 x 10^6 m^3. The active storage capacity of the reservoir of 101 x 10^6 m^3 with a drawdown of 16 m can regulate 92 x 10^6 m^3 of water, if the normal HWL is set at El. 85 m.

The Beris dam is a concrete gravity dam of 42 m in height and 145 m in crest length as shown in Plates 11 and 12. The crest is set at El. 89 m. The concrete volume is 58,000 m^3. Free overflow spillway of 72 m in effective width is placed and a river outlet having 2 units of 1.5 m dia. outlet valves is installed in the central section of the dam. A diversion tunnel of 5.6 m diameter is excavated in the left abutment. A saddle dam of 150 m crest length is constructed with embankment volume of 104,000 m^3, 0.5 km to the south of the main dam.

The total investment cost is estimated to be M$74.2 x 10^6 including M$45.2 x 10^6 of the cost of construction works and M$29.0 x 10^6 of land acquisition cost including physical contingency at 1982 constant price level.

8.6 The Rui 2 Dam

The annual inflow from the catchment area of 278 km^2 is estimated to be 250 x 10^6 m^3. The active storage capacity of 245 x 10^6 m^3 with a drawdown of 42.5 m can regulate 241 x 10^6 m^3 of water if the normal HWL is set at El. 245 m. If 44 x 10^6 m^3 of water should be released downstream as the river maintenance flow, water available for basin transfer is 197 x 10^6 m^3.

The Rui 2 dam is a rockfill dam of 77 m in maximum height and 460 m in crest length as shown in Plate 13. The crest is set at El. 251 m. Embankment volume is 2,714,000 m^3. A side channel spillway of 117 m in the effective overflow crest length is located on the right abutment. Two lines of 6.6 m dia. diversive tunnels are excavated in the left abutment. One of them is utilized for the installation of a 880 kW power station (the Rui power station) and outlet facilities having a 1.2 m dia. outlet valve. Annual energy output of the power station is estimated to be 4.4 GWh.

The investment cost for the construction of the Rui 2 dam and the Rui power station (excluding the basin transfer facilities) is estimated to be M$224.3 x 10^6 including M$223.9 x 10^6 of the cost for construction works and M$0.4 x 10^6 of land acquisition cost including physical contingency at 1982 constant price level.

The Upstream Rui 2, which is located at 500 m upstream from the Rui 2 site, is studied as an alternative site to the Rui 2 dam (see Plate 5). The project cost is estimated about 85% of that of the Rui 2 dam. The topographic and geologic information is not available at this stage, and thus the Rui 2 site is proposed. The Upstream Rui 2 site is subject to the further study.

A new power supply network connecting the proposed Rui and Tiak power stations with NEB system can supply power to the Tanah Hitam Mill and Kelian Intan township, in place of the Pong power station.

8.7 The Rui 3 Dam

The annual inflow from the catchment area of 305 km^2 is estimated to be 273 x 10^6 m^3. The active storage capacity of 383 x 10^6 m^3 with drawdown of 48.5 m can regulate 269 x 10^6 m^3 of water. Water available for basin transfer is 225 x 10^6 m^3, if the river maintenance flow downstream is 44 x 10^6 m^3.

The Rui 3 dam is a rockfill dam of 85 m in maximum height and 300 m in crest length as shown in Plate 14. The crest is set at El. 256 m. Embankment volume is 2,594,000 m^3. A side channel spillway of 126 m in the effective overflow crest length is located on the left abutment. Two lines of 6.9 m dia. diversion tunnels are excavated in the left abutment. One of them is utilized for the installation of an 880 kW power station (The Rui power station) and a 1.2 m dia. outlet valve. Annual energy output of the power station is estimated to be 4.4 GWh.

The investment cost for the construction of the Rui 3 dam and the Rui power station (excluding basin transfer facilities) is estimated to be M$237.9 x 10^6 including M$230.6 x 10^6 of the cost for construction works and M$7.3 x 10^6 of land acquisition cost including physical contingency at 1982 constant price level.

8.8 The Basin Transfer Tunnel and Tiak Power Station

The 9 km long basin transfer tunnel with 3.5 m diameter is constructed between the confluence of the Rui river and the Pong river and a tributary of the Tiak river near Kg. Charok Rendiat as shown in Plate 15. The Tiak power station is located at the foot of a hill slope, 300 m to the north of Kg. Charok Pediant.

The investment cost for the construction of the basin transfer facilities and Tiak power station is estimated to be M$167.7 x 10^6 including the cost for construction works of M$129.0 x 10^6 and physical contingency of M$38.7 x 10^6 at 1982 constant price level. The principal features of the power stations are described in Section 6.2.

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4. HYDROLOGICAL PROCEDURE NO. 11, DEISGN FLOOD HYDROGRAPH ESTIMATION FOR RURAL CATCHMENTS IN PENINSULAR MALAYSIA, 1976, Ministry of Agriculture, Malaysia

TABLES

Table 1 NATIONAL ORIGINAL BENCH-MARKS USED FOR TOPOGRAPHIC MAPPING

Name of Bench-Mark	Location	Elevation (m)	Destination of Levelling Traverse
BP22	Near the National Boundary to Thailand	89.155	Badak-Temin
MR44	Kuala Nerang	19.123	Sari and Durian
MR33	Guar Cempedak	4.999	Tawar-Muda and Beris
MR144	Kelian Intan	155.610	Rui

Table 2 LOCAL BENCH-MARKS INSTALLED AT DAM SITES

Dam Site	Elevation of Local Bench-Mark (m)
Badak-Temin	38.540
Sari	54.456
Durian	47.840
Tawar-Muda	62.327
Beris	43.951
Rui	247.800

Table 3   SURVEY WORK DONE BY THE STUDY TEAM

Survey Items	Unit	Badak-Temin Site	Sari Site	Durian Site	Tawar-Muda Site	Beris Site	Rui Site	Total
Control Survey	km	11	7	13	20	37	20	108
Grade 3 Levelling	km	15	5	10	11	77	7	135
Local Bench-Mark	point	1	1	1	1	1	1	6
Quick Levelling	km	22	20	15	16	22	41	136
Site Reconnaissance	km^2	19	9	15	20	20	17	100
1/1,000 Topographic Mapping	ha	20	40	50	30	30	100	270
Profile Survey	km	1.2	-	-	2.1	0.9	0.8	5.0
Areal Triangulation	model	8	3	9	6	15	9	50
1/10,000 Map Drafting	km^2	19	9	15	20	20	17	100

Table 4   TOPOGRAPHIC MAPS PREPARED BY THE STUDY TEAM

	Profile (1/1,000)		Plan at Dam Site (1/1,000)		Plan in the Reservoir Area (1/10,000)		
	No. of Traverse Dam Axes	Sheet	Coverage (ha)	Sheet	Coverage (km^2)	Contour Coverage (El. m)	Sheet
Badak-Temin	2	1	20	1	19	Max. 50	1
Sari	2	0	40	2	9	Max. 95	1
Durian	2	0	50	2	15	Max. 80	1
Tawar-Muda	7	3	30	2	20	Max. 80	2
Beris	4	2	30	2	20	Max. 85	1
Rui	6	2	100	4	17	Max. 265	2
Total	23	8	270	13	100	Max. 245	8

Table 5 CONDITIONS OF BADAK-TEMIN, SARI AND DURIAN DAM SITES

Site Conditions	Badak-Temin	Sari	Durian
River System	Kedah river	Kedah river	Kedah river
Latitude and Longitude	6°26'50" N 100°28'28" E	6°22'20" N 100°38'10" E	6°23'00" N 100°42'45" E
Catchment Area	112 km^2	61 km^2	74 km^2
Site Topography	Flat and wide valley (1.2 km) between low ridges	V-shaped valley (0.3 km)	Flat valley (0.8 km) between gentle ridges
Foundation Geology	Sandstone (thick) on right bank and shale on left bank, Devonian-Triassic, Fractures on left bank	Sandstone with shales, hard, Triassic/ Jurassic	Sandstone and shale, moderately hard, Triassic/ Jurassic, Fractures in the riverbed
Alternative Dam Type	Fill types only	Fill types or concrete gravity	Fill types only

Table 6 CONDITIONS OF TAWAR-MUDA AND BERIS DAM SITES

Site Conditions	Tawar-Muda 1 (Upstream)	Tawar-Muda 2 (Downstream)	Beris 1 (Upstream)	Beris 2 (Downstream)
River System	Muda river	Muda river	Muda river	Muda river
Latitude and Longitude	6°03'30" N 100°47'00" E	6°03'30" N 100°47'00" E	5°58'45" N 100°44'44" E	5°58'45" N 100°44'44" E
Catchment Area	129 km^2	130 km^2	114 km^2	116 km^2
Site Topography	Gentle V-shaped valley (0.9 km)	Gentle V-shaped valley (0.8 km)	Gentle V-shaped valley (0.6 km)	V-shaped valley (0.3 km)
Foundation Geology	Sandstone and shale, Triassic	Shale with sand-stone, moderately hard, Triassic, some fractures on the left bank	Sandstone and shale, Triassic, fractured zone runs	Grit, breccia, and sandstone, hard, Triassic fractured zone through the saddle dam site
Alternative Dam Type	Fill types only	Fill types only	Fill types only	Fill types or concrete gravity

Table 7 CONDITIONS OF RUI DAM SITES

Site Conditions	Rui 1 (Upstream)	Rui 2 (Middle)	Rui 3 (Downstream)
River System	Perak river	Perak river	Perak river
Latitude and Longitude	5°34'00" N 101°00'50" E	5°34'50" N 101°01'50" E	5°34'50" N 101°02'50" E
Catchment Area	259 km^2	278 km^2	305 km^2
Site Topography	V-shaped valley (0.5 km) having thin left abutment	Gentle V-shaped valley (0.7 km)	Gentle V-shaped valley (0.8 km)
Foundation Geology	Slaty shale and limestone, hard, Silurian, deep fractures	Slaty shale and limestone, hard, Silurian, deeply weathered	Slaty shale, hard, Silurian, deeply weathered
Alternative Dam Type	Fill types only	Fill types only	Fill types only

Table 8 TOPSOIL, FRESH ROCK AND FOUNDATION EXCAVATION

Dam Site	Thickness of Topsoil			Depth to Fresh Rock			Requirement of Foundation Excavation		
	Left Bank	Center	Right Bank	Left Bank	Center	Right Bank	Left Bank	Center	Right Bank
Badak-Temin	6 m	6 m	3 m	(10 m ±	6 - 12 m)	10 m ±	Fill dam 9 m	 6-12 m	 6.5 m
Durian	4 m	7 m	2 m		10 - 11 m		Fill dam 4 m	 11 m	 8.5 m
Sari	Very thin, less than 1 m			4.5 m	1 m	4.5 m	Fill dam 5 m Concrete dam 12.5m	 3 m 3 m	 3 m 10 m
Tawar-Muda 1 (Upstream)	Approximately 5 m			Similar to the No. 2 Site			Fill dam Similar to the No. 2 Site		
Tawar-Muda 2 (Downstream)	8 m	5 m	1 m	15 m	7 m	22.4m	Fill dam 13 m	 5 m	 12 m
Beris 1 (Upstream)	2 m	3 m	3.5 m	-	-	5 m	Fill dam 3.7 m	 3.0 m	 4.5 m
Beris 2 (Downstream)	2.8 m	1.1 m	2.1 m	4.6 m	1.1 m	2.7 m	Fill dam 4.6 m Concrete dam 6.5 m	 1.1 m 3.8 m	 2.1 m 6.0 m
Rui 1	2 m	3 m	1 m		More than 40 m		Not recommended as alternative because of deep fractures		
Rui 2	16 m	5 m	5 m	Deeply weathered and softened 29 m	 7 m	 25 m	Fill dam 24 m	 7 m	 10 m
Fui 3	15 m	5 m	5 m	30 m	7 m	12 m	Fill dam 20 m	 7 m	 10 m

Table 9 ESTIMATED QUANTITIES AND CONSTRUCTION COST OF RELOCATION ROAD PLAN

	Reservoir Water Level (El. m)	Submerged Main Road	Relocated Road Plan
Badak-Temin	50	Rural road Class-02, double lane base, pavement single lane, 2 sites, total length 1.6 km	Relocation road 7.5 km; M$11.3 x 10^6
	40	Ditto, 1 site 1.2 km	Relocation road 3.0 km; M$4.5 x 10^6
Sari	90	The same road as that of Badak-Temin 5.6 km	Relocation road 9.5 km; M$14.3 x 10^6
	70	Ditto, 4.0 km	Relocation road 8.9 km; M$13.4 x 10^6
Durian		-	-
Tawar-Muda	81	Main road; Rural road Class-02, single lane, rolling; 3 sites, total length 1.4 km	Relocation road, rolling 2.5 km; M$1.8 x 10^6
	71	Ditto, 4 sites, total length 0.7 km	No road relocation Bridge, 0.1 km; M$0.54 x 10^6
Beris	87	Main road; Rural road Class-02, single lane, rolling; 5 sites, total length 2.1 km	Relocation road (rolling) 7.5 km; M$3.9 x 10^6 Bridge, 0.5 km; M$3.9 x 10^6
	70	Ditto, 2 sites, total length 0.3 km	No road relocation Bridge, 0.3 km; M$1.6 x 10^6
Rui		-	-

Table 10 ASSUMED UNIT CONSTRUCTION COST FOR RELOCATION ROAD PLAN

(1) Relocation Road

Rural road Class-02 including pavement

	Single Lane	Double Lane
Base Pavement	30 feet = 9.2 m 18 feet = 5.5 m	60 feet = 18.3 m 36 feet = 11.0 m
Flat	M$400 - 500 x 10^3/km	-
Rolling	M$500 - 600 x 10^3/km	-
Mountainous	M$700 - 1,000 x 10^3/km	M$1,500,000/km -
Pavement only	M$130,000/km	M$260,000/km

(2) Bridge

Reinforced concrete, simple girder bridge, single lane, width = 6.5 m (5.5 m pavement + 1.0 m curving)
Span 20 - 30 m

Low pier ($h \leq 10$ m)	M$5,400,000/km
Medium high pier (h = 10 - 15 m)	M$6,200,000/km
High pier (h = 15 - 20 m)	M$7,800,000/km

Remarks; Financial cost at end 1982 price level

Table 11 NORMAL HIGH WATER LEVEL, LOW WATER LEVEL AND ACTIVE STORAGE CAPACITY

		Minimum Scale		Medium Scales				Maximum Scale	
Dam Site and Type of Dam	Sediment (10^6 m^3)	LWL (El. m)	Dead Storage (10^6 m^3)	NHWL (El. m)	Active Storage (10^6 m^3)	NHWL (El. m)	Active Storage (10^6 m^3)	NHWL (El. m)	Active Storage (10^6 m^3)
Badak-Temin									
Rockfill	3.0	36.5	12.3	-	-	40.0	18.0	45.0	58.0
Sari									
Rockfill	2.0	69.0	5.9	-	-	-	-	91.0	56.0
Concrete	2.0	69.0	5.9	-	-	80.0	17.7	91.0	56.0
Durian									
Rockfill	2.0	60.0	6.4	-	-	69.0	21.1	74.0	40.5
Tawar-Muda									
Rockfill	3.0	65.5	7.5	72.0	19.5	75.0	37.2	77.0	53.5
Beris 2									
Rockfill	3.0	69.0	9.0	-	-	82.0	66.0	-	-
Concrete	3.0	69.0	9.0	77.0	30.5	82.0	66.0	85.0	100.5
Rui 2									
Rockfill	7.0	202.5	19.0	231.0	129.0	236.0	165.0	245.0	244.5
Rui 3									
Rockfill	8.0	201.5	23.0	228.0	139.0	233.0	181.0	250.0	383.0

Remarks; LWL Low water level
NHWL Normal High Water Level

Table 12 WAVE HEIGHT DUE TO WIND AND EARTHQUAKE

Dam Site	Type of Dam	Wave Height Due to Wind: 10 Min. Average Wind Speed (m/s)	Fetch (m)	(1) Wave Height hw (m)	Wave Height Due to Earthquake: Depth of Reservoir Water Ho (m)	(2) Wave Height he (m)
Badak-Temin	Rockfill	20	4,200	0.8	19.2	0.22
Sari	Rockfill	20	3,000	0.6	33.3	0.29
	Concrete	20	3,000	0.9	33.3	0.29
Durian	Rockfill	20	2,800	0.6	28.5	0.27
Tawar-Muda	Rockfill	20	2,700	0.6	20.5	0.23
Beris 2	Rockfill	20	1,900	0.5	31.5	0.28
	Concrete	20	1,900	0.7	31.5	0.28
Rui 2	Rockfill	20	2,400	0.6	54.3	0.37
Rui 3	Rockfill	20	2,900	0.6	54.3	0.36

Remarks; (1) Wave uprush including wave height obtained by combining the S.M.B. Method with Saville Method (Ref. 1).

(2) Horizontal seismic coefficient = 0.1
Period of seismic wave = 1 sec.
(See the formula in Ref. 1)

Table 13 FREEBOARD ABOVE MAXIMUM DESIGN WATER SURFACE LEVEL

Unit: meters

Dam Site and Type of Dam	hw	he	ha	hi	Freeboard for 1,000 Year Flood Hf (1)	Freeboard for 1,000 Year Flood Hf (2)	Freeboard for PMF Hf (PMF)
Badak-Temin Rockfill	0.8	0.2	0	1.0	2.0 < 3.0	1.8 < 2.0	1.8 > 1.5
Sari: Rockfill	0.6	0.3	0	1.0	1.9 < 3.0	1.6 < 2.0	2.0 > 1.5
Sari: Concrete	0.9	0.3	0	0	1.2 < 2.0	0.9 < 1.0	1.0 = 1.0
Durian Rockfill	0.6	0.3	0	1.0	1.9 < 3.0	1.6 < 2.0	1.9 > 1.5
Tawar-Muda Rockfill	0.6	0.2	0	1.0	1.8 < 3.0	1.6 < 2.0	1.7 > 1.5
Beris 2: Rockfill	0.5	0.3	0	1.0	1.8 < 3.0	1.5 < 2.0	2.3 > 1.5
Beris 2: Concrete	0.7	0.3	0	0	1.0 < 2.0	0.7 < 1.0	1.3 > 1.0
Rui 2 Rockfill	0.6	0.4	0	1.0	2.0 < 3.0	1.6 < 2.0	1.5 = 1.5
Rui 3 Rockfill	0.6	0.4	0	1.0	2.0 < 3.0	1.6 < 2.0	1.5 = 1.5

Remarks;
- 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
- hi: Addition of allowance according to type and importance of dams
- Hf (1) = hw + he + ha + hi
- Hf (2) = hw + ha + hi

Table 14 MAXIMUM WATER LEVEL, CREST ELEVATION OF IMPERVIOUS CORE AND DAM CREST ELEVATION

Dam Site and Type of Dam	Normal High Water Level: Medium Scales (El. m)		Normal High Water Level: Maximum Scale (El. m)	Maximum Water Level NHWL (m)	(1) Crest El. of Impervious Core Above NHWL (m)	(2) Additional Height (m)	(3) Dam Crest El. Above NHWL (m)
Badak-Temin						for road	
Rockfill	-	40.0	45.0	+2.0	+4.0	+1.0	+5.0
Sari						for road	
Rockfill	-	-	91.0	+2.0	+4.0	+1.0	+5.0
						for bridge	
Concrete	-	80.0	91.0	+2.0	+3.0	+1.0	+4.0
Durian						for road	
Rockfill	-	69.0	74.0	+2.0	+4.0	+1.0	+5.0
Tawar-Muda						for road	
Rockfill	72.0	75.0	77.0	+2.0	+4.0	+1.0	+5.0
Beris 2						for road	
Rockfill	-	82.0	-	+2.0	+4.0	+1.0	+5.0
						for bridge	
Concrete	77.0	82.0	85.0	+2.0	+3.0	+1.0	+4.0
Rui 2						for road	
Rockfill	231.0	236.0	245.0	+3.0	+5.0	+1.0	+6.0
Rui 3						for road	
Rockfill	228.0	233.0	250.0	+3.0	+5.0	+1.0	+6.0

Remarks;

(1) If no road or bridge is provided this elevation corresponds to the dam crest elevation of non-overflow section. The apex of the basic triangle for stability analysis of a concrete gravity dam be on this elevation.

(2) Additional space for a road on a fill dam crest or a bridge above a spillway weir of a concrete dam.

(3) The stability analysis of a fill dam be done for this crest elevation.

Table 15 PEAK DISCHARGE OF MAXIMUM PROBABLE FLOOD AT PROPOSED DAM SITES

Unit: m^3/s

Dam Site	Flood Peak Discharge by Return Period in Years								
	2	5	10	20	50	100	200	1,000	10,000
Badak-Temin	78	112	136	160	192	218	243	304	395
Sari	63	90	110	130	157	177	199	249	325
Durian	68	97	119	140	169	192	215	269	351
Tawar-Muda	88	136	171	207	255	293	331	423	561
Beris	86	132	166	200	247	283	320	409	543
Rui 2	134	205	257	310	382	437	495	632	837
Rui 3	149	228	286	345	425	487	550	703	931

Remarks; The peak discharges include the base flow component of 3 m^3/s for Badak-Temin, 2 m^3/s for Sari and Durian, 4 m^3/s for Tawar-Muda and Beris, 8 m^3/s for Rui 2 and 9 m^3/s for Rui 3.

Table 16 DESIGN FLOOD DISCHARGE AND C-VALUE OF CREAGER CURVE

Dam Site	Design Flood Discharge						
	River Diversion		Spillway				
			1.2 x 200	1,000 Year		PMF	
	20 Year (m^3/s)	50 Year (m^3/s)	Year (m^3/s)	Discharge (m^3/s)	C-Value	Discharge (m^3/s)	C-Value
Badak-Temin	160	192	292	310	7.3	830	20
Sari	130	157	239	250	8.6	570	20
Durian	140	169	258	270	8.3	650	20
Tawar-Muda	207	255	397	430	9.1	910	20
Beris 2	200	247	384	410	9.5	850	20
Rui 2	310	382	594	640	8.7	1,950	28
Rui 3	345	425	660	710	9.5	2,140	29

Remarks; $q = C \cdot A \, (A^{-0.05} - 1)$

where, q $m^3/s/km^2$
A Catchment area in km^2
C Coefficient in catchment area

Table 17 WIDTH OF SPILLWAY OVERFLOW WEIR AND MAXIMUM WATER LEVEL

Dam Site and Type of Dam	(1) 1/1,000 Design Flood Discharge			(2) PMF Design Flood Discharge		
	Spillway Capacity (m^3/s)	Overflow Depth (m)	Overflow Width (m)	Spillway Capacity (m^3/s)	Max. Overflow Depth (m)	Overflow Width (m)
Badak-Temin						
Rockfill	310	2.0*	54*	402	2.4	54
Sari						
Rockfill		2.0*	44*	333	2.4	44
Concrete	250	2.0	44	402	2.0*	71*
Durian						
Rockfill	270	2.0*	48*	359	2.4	48
Tawar-Muda						
Rockfill	430	2.0*	75*	474	2.2	75
Beris 2						
Rockfill		2.0*	72*	269	1.5	72
Concrete	410	2.0*	72*	269	1.5	72
Rui 2						
Rockfill	640	3.0	61	1,529	3.5*	117*
Rui 3						
Rockfill	710	3.0	68	1,643	3.5*	126*

Remarks; (1) The spillway discharge capacity is equal to the peak discharge of the 1,000 year design flood.

(2) The spillway discharge capacity against PMF taking the reservoir retardation effect into account. The spillway discharge capacity corresponds to the maximum overflow depth provided that the overflow weir crest elevation is 45 m for Badak-Temin, 85 m for Sari, 74 m for Durian, 77 m for Tawar-Muda, 85 m for Beris 2, 241 m for Rui 2 and 238 m for Rui 3.

* The spillway capacity adopted.

Table 18 PRINCIPAL FEATURES OF BASIN TRANSFER AND POWER GENERATION FACILITIES OF RUI 2 AND RUI 3 DAMS

Description	Rui 2	Rui 3
1. Basin Transfer Tunnel and Tiak Power Station		
Headrace (transfer tunnel)	3.5m dia. x 9.0km	3.5m dia. x 9.0km
Penstock	1 x 2.5m dia. x 220m	1 x 2.5m dia. x 220m
Optimum normal HWL El. m	245.0	250.0
LWL El. m	202.5	201.5
Tail water level El. m	76.0	76.0
Maximum gross water head, m	169.0	174.0
Installed Capacity, MW	26	26
Annual energy output*, GWh	64	73
River Outlet	1 x 1.2m dia.	1 x 1.2m dia.
2. Rui Mini-Hydropower Station		
Penstock	1 x 1.2m dia. x 410m	1 x 1.2m dia. x 270m
Tail water level El. m	178	176
Maximum gross water head, m	67	74
Installed capacity, MW	0.88	0.88
Annual energy output, GWh	4.4	4.4
River Outlet	1 x 1.2m dia.	1 x 1.2m dia.

Remarks; Water yield is assumed to be the 90% of the annual average inflow in 20 years excluding the compensation discharge of 1.4 m^3/s at the site, that is, 5.74 m^3/s for Rui 2 and 6.39 m^3/s for Rui 3.

Table 19 ALTERNATIVE TRANSMISSION LINE SYSTEMS

Alternative	Power for Dam Construction	Transmission Line System
Alt - 1	Diesel power station for temporary use · DG 1,000 kW 4 sets including one spare · MTR 5,000 kVA 1 set	· 132 kV T/L is constructed for the use after construction from Sg. Petani S/S to Tiak P/S. · From Tiak P/S to RHT and Rui P/S step down to 11 kV · MTR 12,000 kVA 1 set · Distribution line 6.6 kV
Alt - 2	· The 275 kV T/L is constructed before the main works, and the power from Bersia P/S is used.	· 275 kV T/L (50 km) from Bersia P/S to Tiak P/S · From Tiak P/S to RHT and Rui P/S step down to 11 kV · MTR 12,000 kVA 1 set · Distribution line 6.6 kV
Alt - 3	· The 132 kV T/L is constructed before the main works, and the power from Bersia P/S is used.	· 132 kV T/L (50 km) from Bersia P/S to Tiak P/S · From Tiak P/S to RHT and Rui P/S step down to 11 kV · Extension of switchgear at Bersia P/S and stepdown transformer from 275 kV to 132 kV · MTR 12,000 kVA 1 set · Distribution line 6.6 kV
Alt - 4	· The 132 kV T/L is constructed before the main works, and the power from Sg. Petani P/S is used.	· 132 kV T/L (70 km) from Sg. Petani S/S to Tiak P/S · From Tiak P/S to RHT and Rui P/S step down to 11 kV distribution line · MTR 12,000 kVA 1 set · Distribution line 6.6 kV

Remarks; DG = Diesel generator
T/L = Transmission line
MTR = Main transformer
P/S = Power station
S/S = Substation
RHT = Rahman Hydraulic Tin Company

Table 20 MAIN FEATURES OF POWER PLANTS IN OPERATION AND UNDER CONSTRUCTION

Name of Power Station	Unit	Pong	Kenering	Chenderoh	Temengor
Installed capacity	MW	2	120	44.5	348
Unit & capacity	MWxNo.	0.5x3	40x3	11.5x3 & 10x1	87x4
Annual energy Production (average)	GWh	14.5 (estimated)	456	205	908
Reservoir					
Catchment area	km^2	-	5,540	6,653	3,420
Total storage	10^6 m^3	-	352	200	6,050
Active storage	10^6 m^3	-	70	66	1,270
Water Turbine					
Net head	m	about 63.6	34.8	18.3	101
Max. discharge	m^3/s	-	138.9	240.5	-
Rated discharge	m^3/s	-	134.6	233.2	-
Generator					
Rated capacity	kVA	625	49,000	12,750 & 12,500	85 MW
Rated voltage	kV	0.44	11.0	6.6	-
Rated power factor	%	80	90	90	-
Transformer					
Capacity	kVA	625	50,000	14,000	-
No. of bank		4	3	4	4
Voltage ratio	kV	0.44/11	11/275	6.6/66	-
Transmission Line					
Voltage	kV	11	275	66	275
No. of circuit		1	1	2	2
Conducted size	sq. mm	-	300	80	-
Year of Completion		1924	Scheduled Feb. 1984	1930(3sets) 1981(1 set)	1978( ) 1979( )
Owner		RHT	NEB,	NEB took over from PRH on Oct. 1983	NEB

Remarks; RHT = Rahman Hydraulic Tin Company
NEB = National Electricity Board
PRH = Perak River Hydroelectric Power Co., Ltd.

Table 21 POWER GENERATION RECORDS OF CHENDEROH AND PONG HYDROPOWER STATIONS

Chenderoh Power Station

	Fiscal Year							
	1975	1976	1977	1978	1979	1980	1981	1982
Annual energy generated (GWh)	194.70	165.51	81.39*	64.94*	118.97	156.34	185.91	165.14
Station use per annum (GWh)	1.14	1.13	1.21	1.21	1.32	1.32	1.29	1.19

*: The inflow was limited due to impounding the Temengor reservoir.

Pong Power Station

	Dry Season	Rainy Season
Actual average power output per unit (kW)	280 - 320	about 450
Annual energy estimated	14.5 GWh	

*: Assuming the dry season of 90 days (2.6 GWh) and the rainy season of 275 days (11.9 GWh).

Table 22 PROJECT SCALE-COST RELATIONSHIP

Dam and Scale		Alternative Scale 1	2	3	4	Optimum Scale
Badak-Temin Rockfill/ Concrete	NHWL El.	37.0 m	40.0 m	45.0 m	-	45.0 m
	Crest El.	42.0 m	45.0 m	50.0 m	-	50.0 m
	Project cost M10^6	80.0	105.8	149.2	-	149.2
Sari Concrete Gravity	NHWL El.	70.0 m	80.0 m	85.0 m	91.0 m	91.0 m
	Crest El.	74.0 m	84.0 m	89.0 m	95.0 m	95.0 m
	Project cost M10^6	53.1	57.5	63.5	72.5	72.5
Durian Rockfill	NHWL El.	61.0 m	69.0 m	74.0 m	-	74.0 m
	Crest El.	66.0 m	74.0 m	79.0 m	-	79.0 m
	Project cost M10^6	63.7	94.5	113.3	-	113.3
Tawar-Muda Rockfill	NHWL El.	66.0 m	72.0 m	75.0 m	77.0 m	77.0 m
	Crest El.	71.0 m	77.0 m	80.0 m	82.0 m	82.0 m
	Project cost M10^6	72.7	91.1	104.3	114.6	114.6
Beris Concrete Gravity	NHWL El.	69.0 m	77.0 m	82.0 m	85.0 m	85.0 m
	Crest El.	73.0 m	81.0 m	86.0 m	89.0 m	89.0 m
	Project cost M10^6	37.2	50.2	64.6	74.2	74.2
Rui 2 Rockfill	NHWL El.	203.0 m	231.0 m	236.0 m	241.0 m	245.0 m
	Crest El.	209.0 m	237.0 m	242.0 m	247.0 m	251.0 m
	Project cost M10^6	266.8	324.4	345.2	368.1	392.4
Rui 3 Rockfill	NHWL El.	203.0 m	228.0 m	233.0 m	238.0 m	250.0 m
	Crest El.	209.0 m	234.0 m	239.0 m	244.0 m	256.0 m
	Project cost M10^6	274.0	313.9	328.6	345.0	406.3
Upstream Rui 2 Rockfill	NHWL El.	-	-	-	241.0 m	-
	Crest El.	-	-	-	247.0 m	-
	Project cost M10^6	-	-	-	316.3	-

Remarks; (1) The total project cost including engineering and administration, compensation cost and contingency is financial cost at 1982 constant price level.

(2) Upstream Rui 2 dam is a alternative to Rui 2 dam.

Table 23 INVESTMENT EFFICIENCY AT OPTIMUM SCALE BY DAM

Dam	Optimum Scale NHWL (El. m)	(1) Total Project Cost (10^6M$)	(2) Annual Net Water Output (10^6M$)	(3) Investment Efficiency (M$/$m^3$)
Badak-Temin	45	149.2	30.3	4.92
Sari	91	72.5	22.8	3.18
Durian	74	113.3	20.5	5.53
Tawar-Muda	77	114.6	40.4	2.84
Beris	85	74.2	92.3	0.804
Rui 2	245	392.0 (324.0)	214.0	1.83 (1.51)
Rui 3	250	405.6* (336.7)	268.8	1.51* (1.25)

Remarks; (1) Project financial cost at 1982 constant price

(2) 1977 Net water output

(3) Investment efficiency (M$/$m^3$) = Investment cost/ 1977 Net water output

* : including the cost of power station

( ): excluding the cost of power station

Table 24 PRINCIPAL FEATURES OF PROPOSED DAM WITH OPTIMUM SCALE (1/2)

	Unit	Badak-Temin	Sari	Durian
1. Reservoir				
1.1 Catchment area	km^2	112	61	74
1.2 Annual inflow	10^6 m^3	58	32	38
1.3 Maximum WL	El. m	47	93	76
1.4 Normal HWL	El. m	45	91	74
1.5 LWL	El. m	36.5	69	60
1.6 Surface area	km^2	9.4	4.5	4.6
1.7 Active storage capacity	10^6 m^3	58	56	41
1.8 Net water output (1977)	10^6 m^3	30	23	21
2. Main Dam				
2.1 Crest elevation	El. m	50	95	79
2.2 Maximum height	m	29	47	39
2.3 Crest length	m	1,075	170	903
2.4 Type		Rockfill & concrete	Concrete gravity	Rockfill
2.5 Dam embankment volume	10^3 m^3	929	-	1,084
2.6 Dam concrete volume	10^3 m^3	67	62	-
3. Subordinate and Saddle Dams				
3.1 Number		3	1	-
3.2 Total crest length	m	2,106	270	-
3.3 Embankment volume	10^3 m^3	462	30	-
4. Spillway				
4.1 Discharge capacity	m^3/s	310	402	270
4.2 Overflow crest length	m	54	71	48
5. River Outlet Facilities				
5.1 Tributary		Badak	Sari	Durian
5.2 Discharge capacity	m^3/s			
6. River Diversion Facilities for Construction				
6.1 Tunnel No. x diameter (m) x length (m)		Multi-stage channel diversion	1x5.9x173	2x4.7x217
7. Power Station				
7.1 Installed capacity	MW	-	-	-
7.2 Energy output	GWh	-	-	-
8. Basin Transfer Tunnel				
8.1 Diameter (m) x length (m)		-	-	-
8.2 Discharge capacity	m^3/s	-	-	-
9. Investment Cost (at 1982 Price Level)				
9.1 Construction work	M$$10^6$	94.6	40.2	85.7
9.2 Land acquisition	M$$10^6$	20.1	15.6	1.4
9.3 Physical contingency	M$$10^6$	34.4	16.7	26.2
Total	M$$10^6$	149.2	72.5	113.3

Table 25 PRINCIPAL FEATURES OF PROPOSED DAM WITH OPTIMUM SCALE (2/2)

	Unit	Tawar-Muda	Beris	Rui 2	Rui 3
1. Reservoir					
1.1 Catchment area	km^2	129	116	278	305
1.2 Annual inflow	10^6 m^3	123	110	250	273
1.3 Maximum WL	El. m	79	87	248	253
1.4 Normal HWL	El. m	77	85	245	250
1.5 LWL	El. m	65.5	69	202.5	201.5
1.6 Surface area	km^2	9.1	12.6	9.7	16.0
1.7 Active storage capacity	10^6 m^3	54	101	245	383
1.8 Net water output (1977)	10^6 m^3	41	92	241	269
2. Main Dam					
2.1 Crest elevation	El. m	82	89	251	256
2.2 Maximum height	m	34	42	77	85
2.3 Crest length	m	338	145	460	300
2.4 Type		Rockfill	Concrete gravity	Rockfill	Rockfill
2.5 Dam embankment volume	10^3 m^3	281	-	2,714	2,594
2.6 Dam concrete volume	10^3 m^3	-	58	-	-
3. Subordinate and Saddle Dams					
3.1 Number		3	1	-	-
3.2 Total crest length	m	1,520	150	-	-
3.3 Embankment volume	10^3 m^3	913	104	-	-
4. Spillway					
4.1 Discharge capacity	m^3/s	430	410	1,530	1,640
4.2 Overflow crest length	m	75	72	117	126
5. River Outlet Facilities					
5.1 Tributary		Muda	Beris	Tiak and Rui	
5.2 Discharge capacity	m^3/s				
6. River Diversion Facilities for Construction					
6.1 Tunnel No. x diameter x length (m)		2x5.4x248	1x5.6x202	2x6.6x513	2x6.9x383
7. Power Station					
7.1 Installed capacity	MW	-	-	26 + 0.88	26 + 0.88
7.2 Energy output	GWh	-	-	64 + 4.4	74 + 4.4
8. Basin Transfer Tunnel					
8.1 Diameter (m) x length (m)		-	-	3.5x9,000	
8.2 Discharge capacity	m^3/s	-	-	30	
9. Investment Cost (at 1982 Price Level)					
9.1 Construction works	M\$$10^6$	79.8	34.8	301.2	306.4
9.2 Land acquisition	M\$$10^6$	8.3	22.3	0.3	5.6
9.3 Physical contingency	M\$$10^6$	26.5	17.1	90.5	93.6
Total	M\$$10^6$	114.6	74.2	392.0*	405.6*

Remarks; * including the cost of the basin transfer facilities

FIGURES

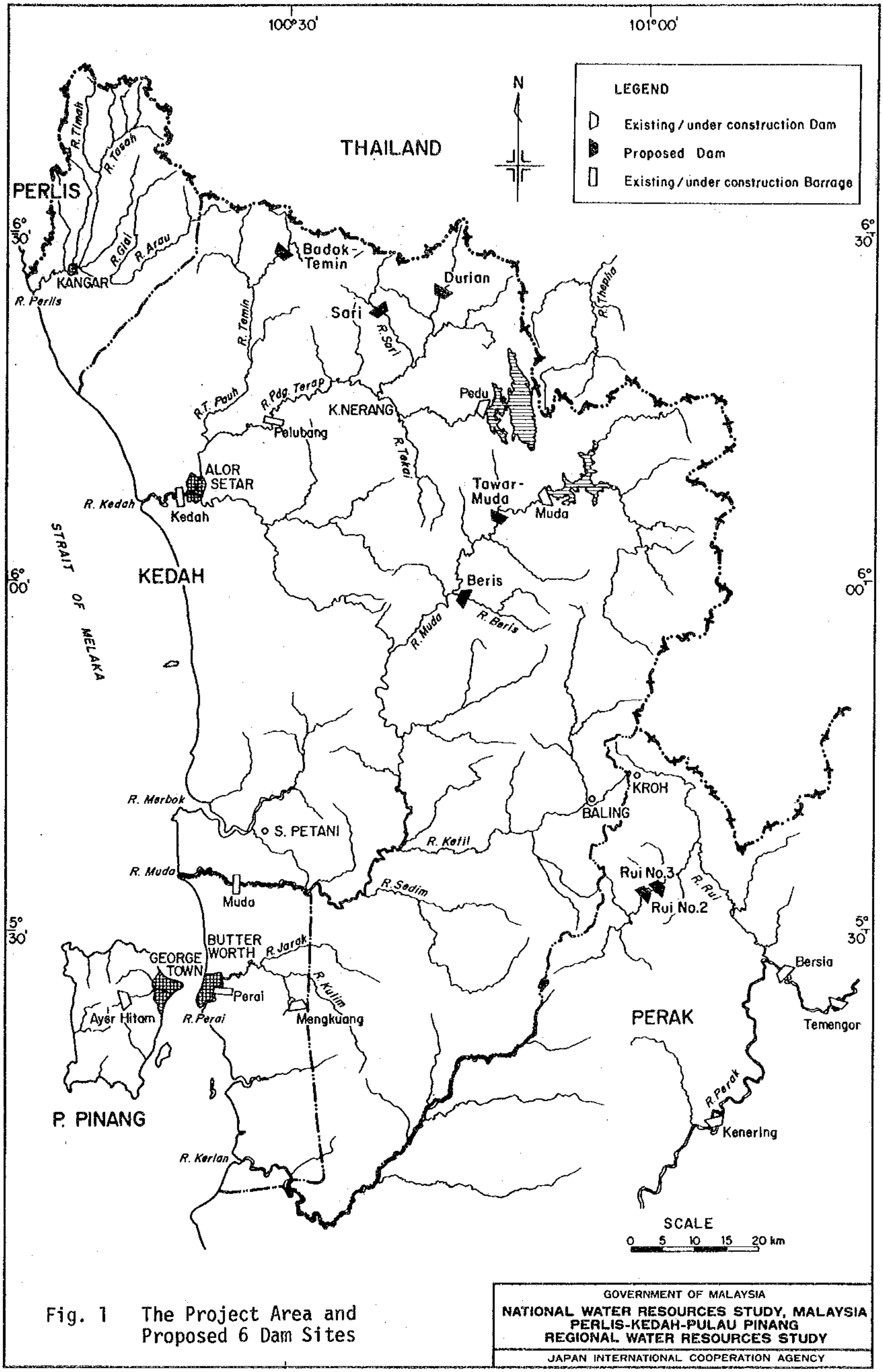
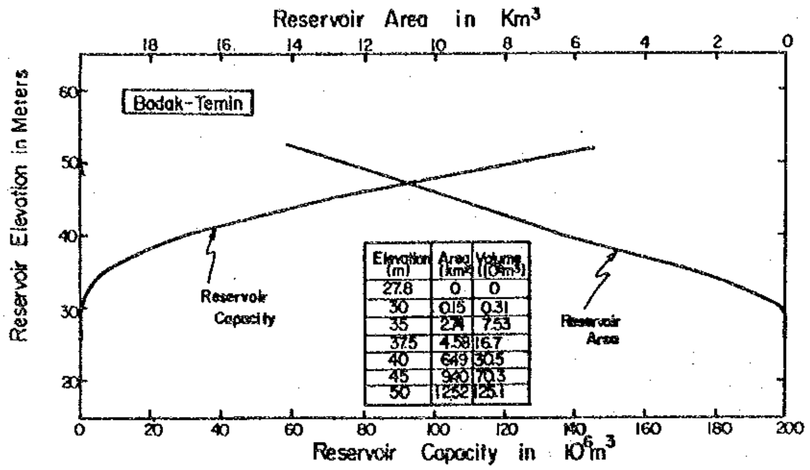
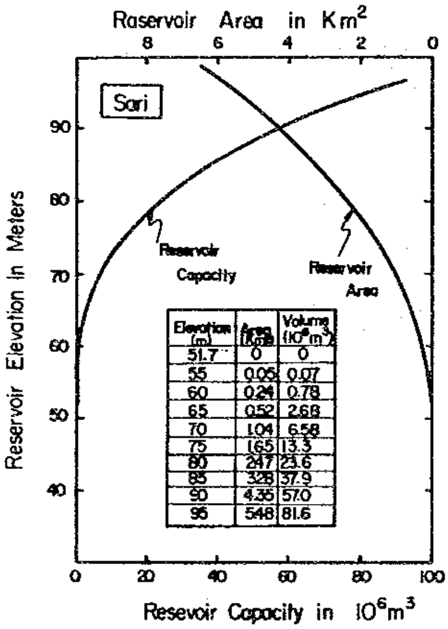


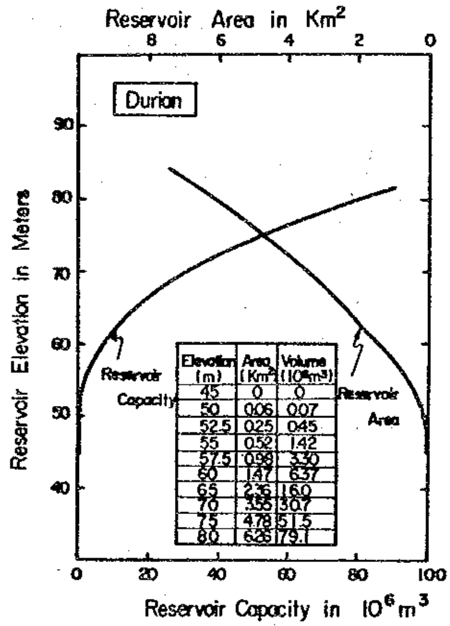
Fig. 1 The Project Area and Proposed 6 Dam Sites



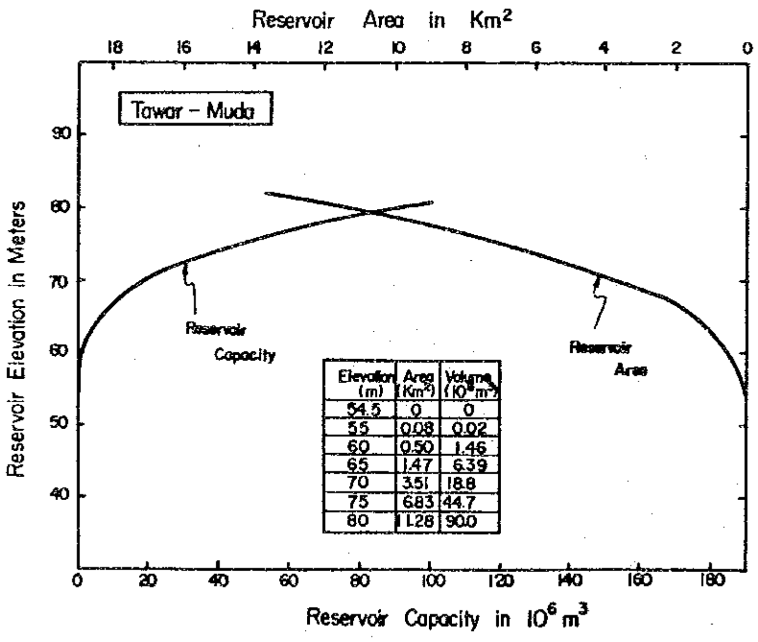
Elevation (m)	Area (km²)	Volume (10⁶m³)
27.8	0	0
30	0.15	0.31
35	2.74	7.53
37.5	4.58	16.7
40	6.49	30.5
45	9.40	70.3
50	12.52	125.1



Elevation (m)	Area (Km²)	Volume (10⁶m³)
51.7	0	0
55	0.05	0.07
60	0.24	0.78
65	0.52	2.68
70	1.04	6.58
75	1.65	13.3
80	2.47	23.6
85	3.28	37.9
90	4.35	57.0
95	5.48	81.6



Elevation (m)	Area (Km²)	Volume (10⁶m³)
45	0	0
50	0.06	0.07
52.5	0.25	0.45
55	0.52	1.42
57.5	0.98	3.30
60	1.47	6.37
65	2.36	16.0
70	3.55	30.7
75	4.78	51.5
80	6.26	79.1



Elevation (m)	Area (Km²)	Volume (10⁶m³)
54.5	0	0
55	0.08	0.02
60	0.50	1.46
65	1.47	6.39
70	3.51	18.8
75	6.83	44.7
80	11.28	90.0

Fig. 2 Area - Storage Curves of Proposed Dams (1/2)

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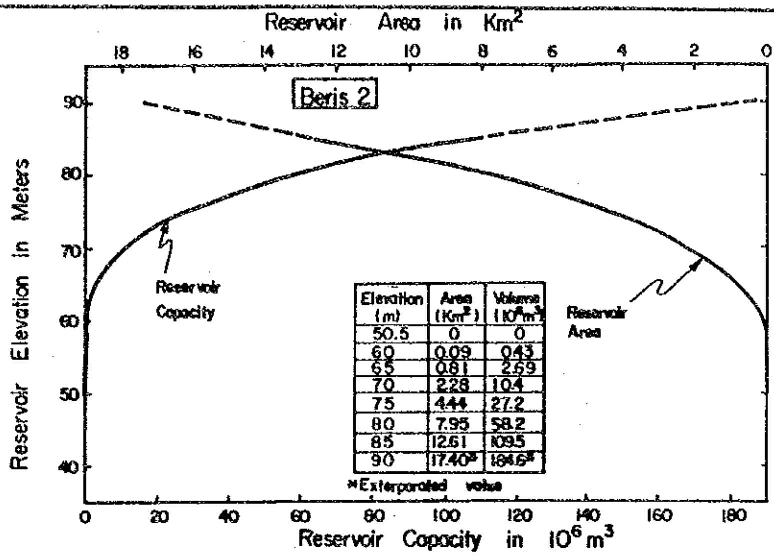
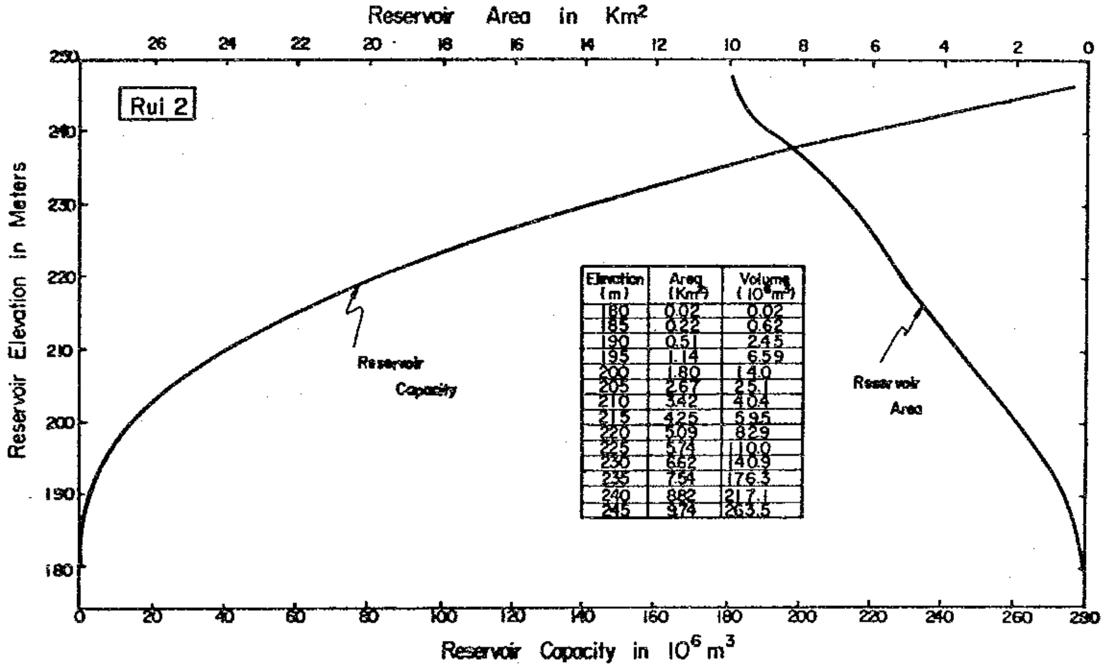
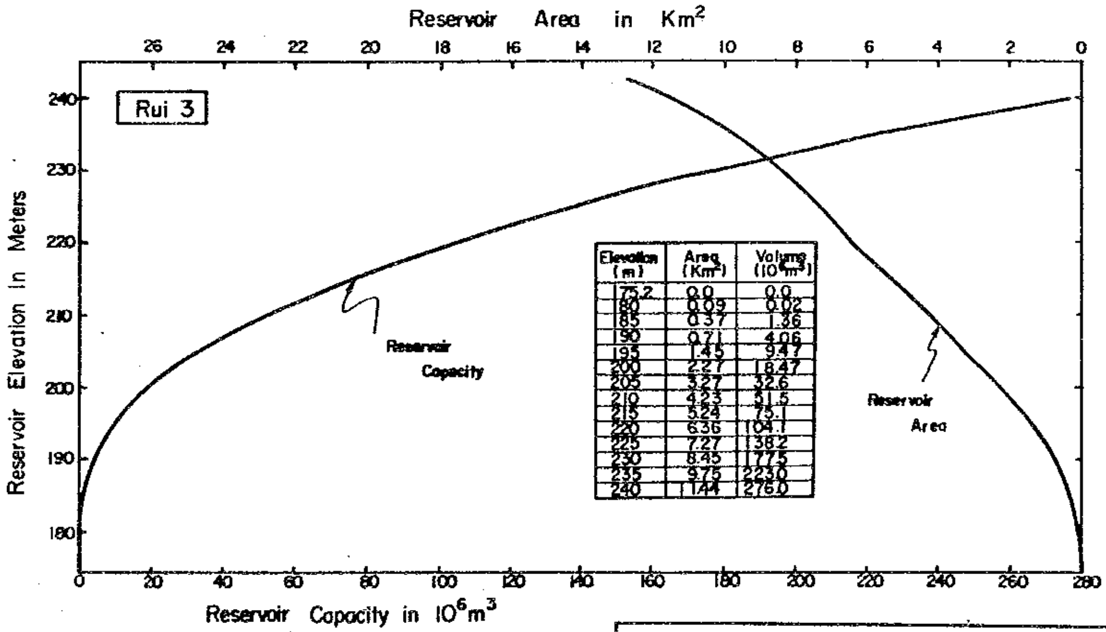


Elevation (m)	Area (Km²)	Volume (10⁶m³)
50.5	0	0
60	0.09	0.43
65	0.81	2.69
70	2.28	10.4
75	4.44	27.2
80	7.95	58.2
85	12.61	109.5
90	17.40*	184.6*

*Exterporated value



Elevation (m)	Area (Km²)	Volume (10⁶m³)
180	0.02	0.02
185	0.22	0.62
190	0.51	2.45
195	1.14	6.59
200	1.80	14.0
205	2.67	25.1
210	3.42	40.4
215	4.25	59.5
220	5.09	82.9
225	5.74	110.0
230	6.62	140.9
235	7.54	176.3
240	8.82	217.1
245	9.74	263.5



Elevation (m)	Area (Km²)	Volume (10⁶m³)
175.2	0.0	0.0
180	0.09	0.02
185	0.37	1.36
190	0.71	4.06
195	1.45	9.47
200	2.27	18.47
205	3.27	32.6
210	4.23	51.5
215	5.24	75.1
220	6.36	104.1
225	7.27	138.2
230	8.45	177.5
235	9.75	223.0
240	11.44	276.0

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

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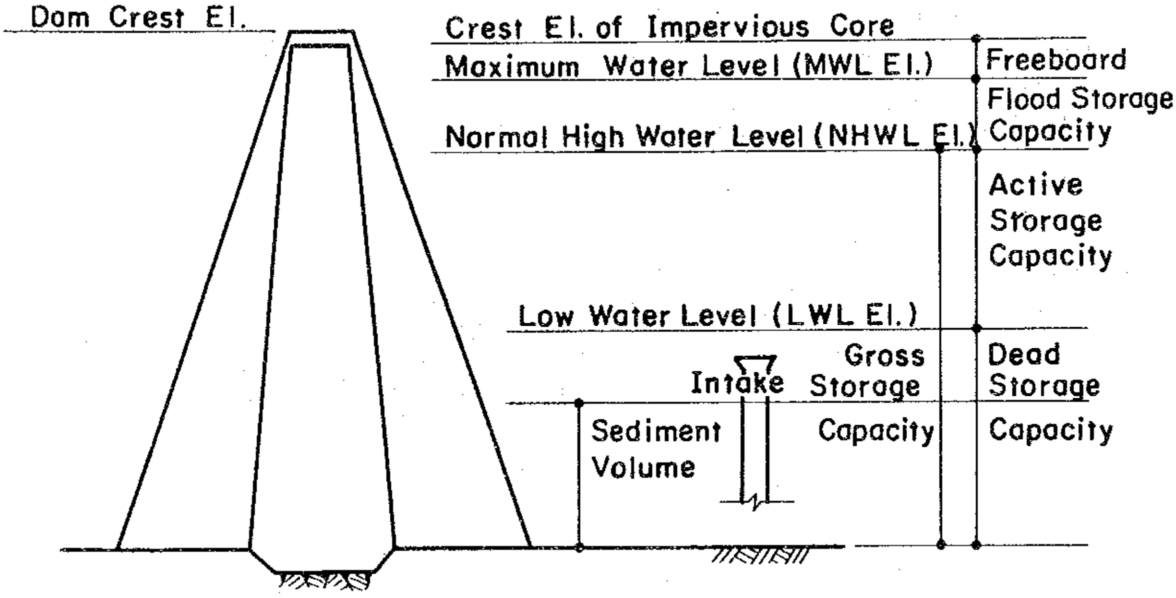

Fig. 4 Definition of Reservoir Water Level and Storage Capacity

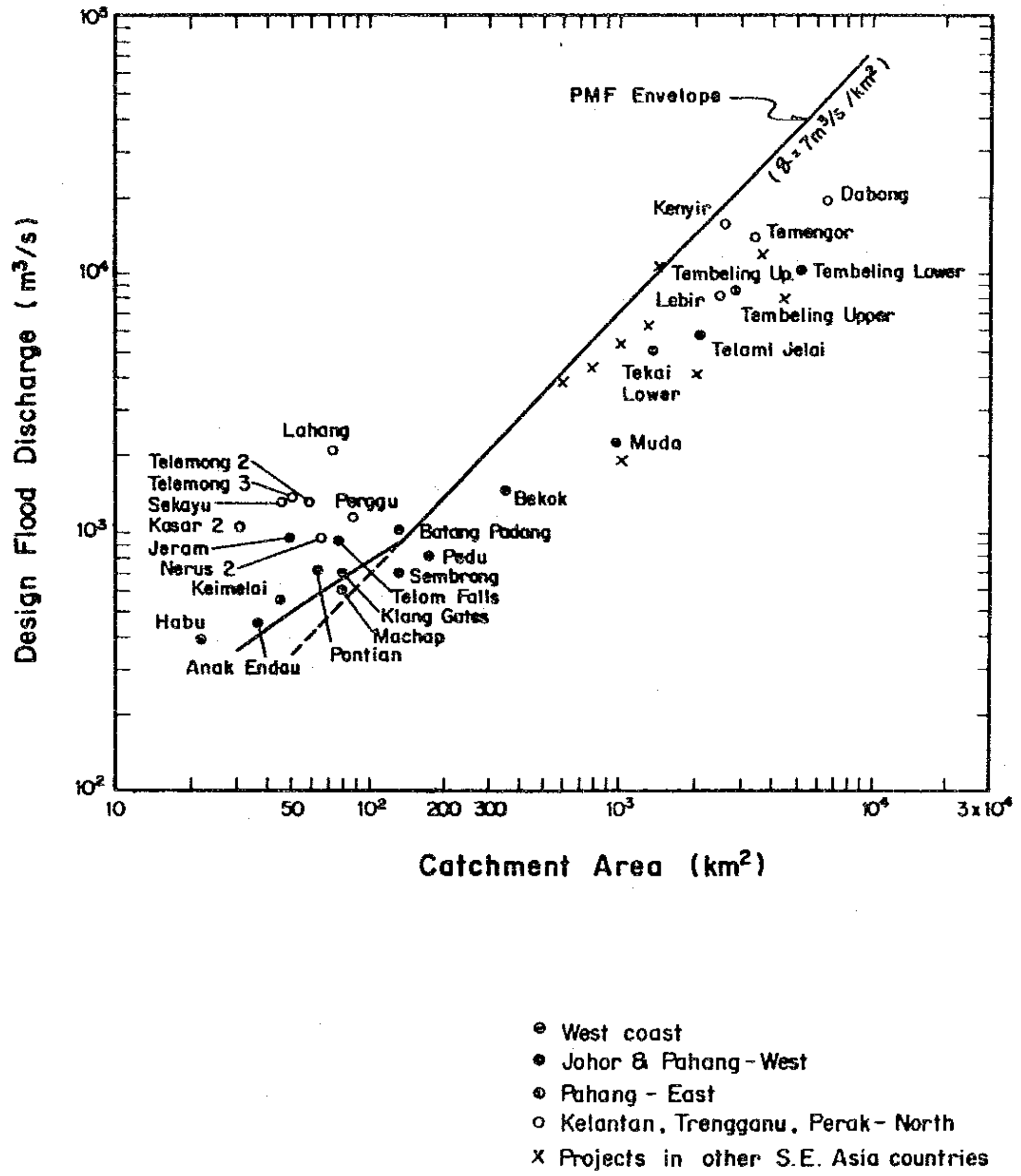

Fig. 5 Probable Maximum Flood Envelope

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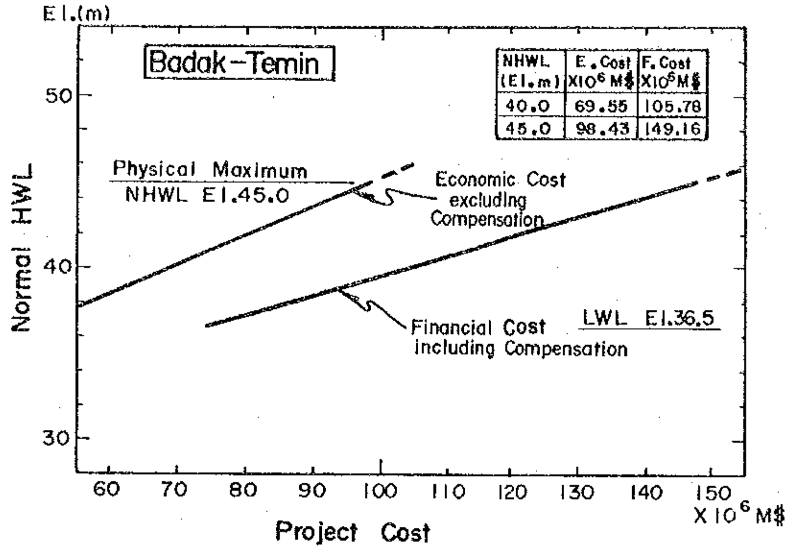
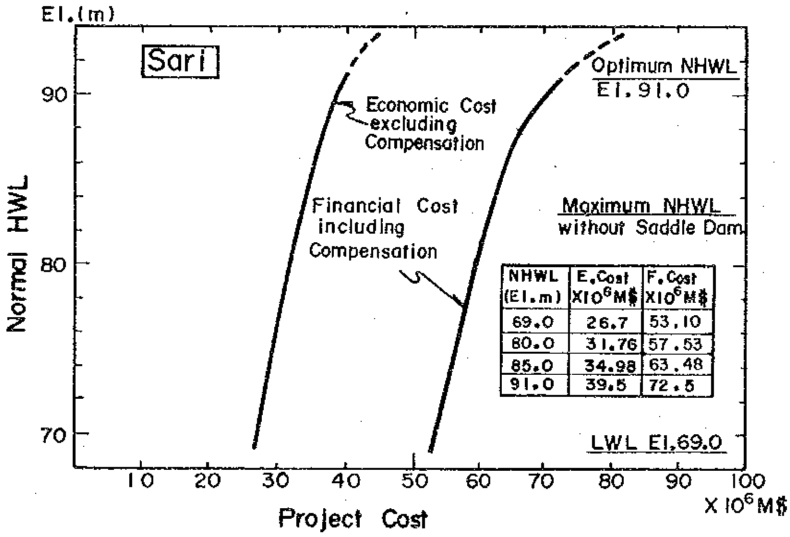
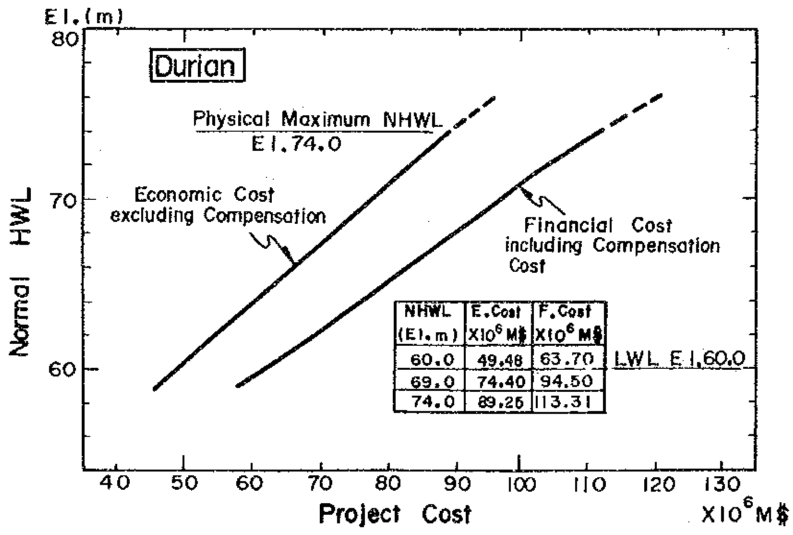


NHWL (El.m)	E.Cost X10⁶M$	F.Cost X10⁶M$
40.0	69.55	105.78
45.0	98.43	149.16



NHWL (El.m)	E.Cost X10⁶M$	F.Cost X10⁶M$
69.0	26.7	53.10
80.0	31.76	57.53
85.0	34.98	63.48
91.0	39.5	72.5



NHWL (El.m)	E.Cost X10⁶M$	F.Cost X10⁶M$
60.0	49.48	63.70
69.0	74.40	94.50
74.0	89.25	113.31

Fig. 6 Scale - Cost Curves of Proposed Dams (1/3)

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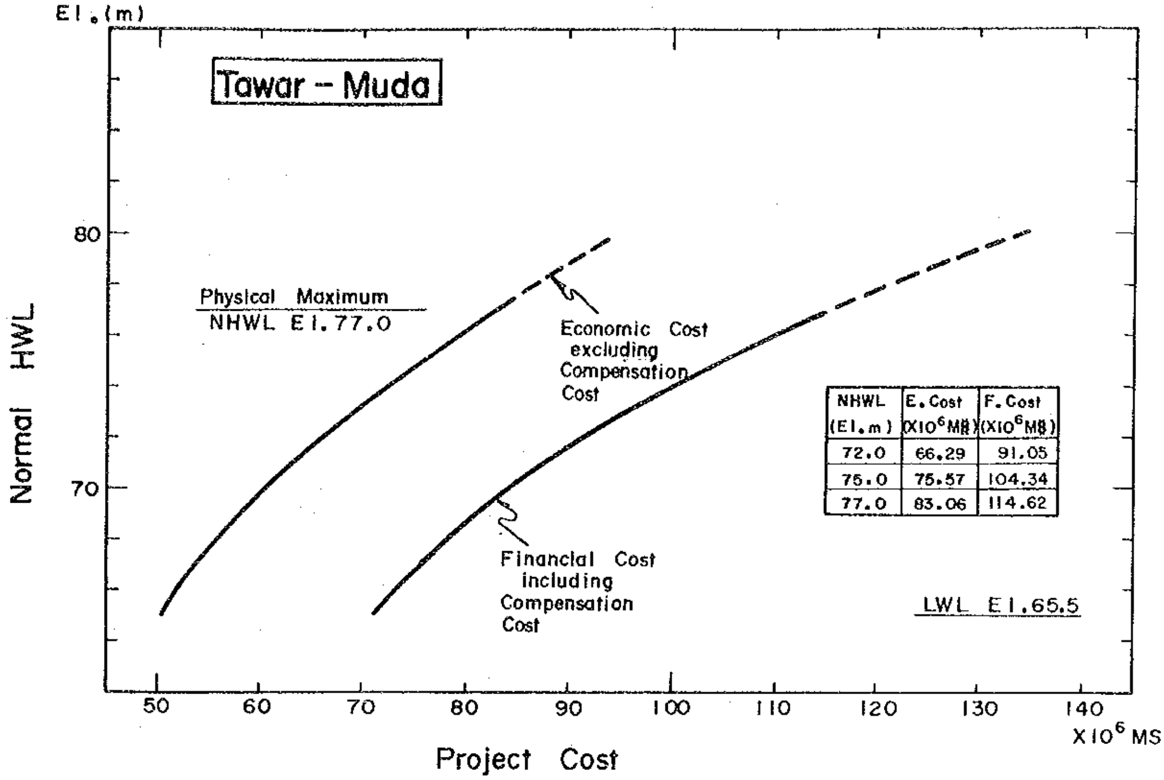
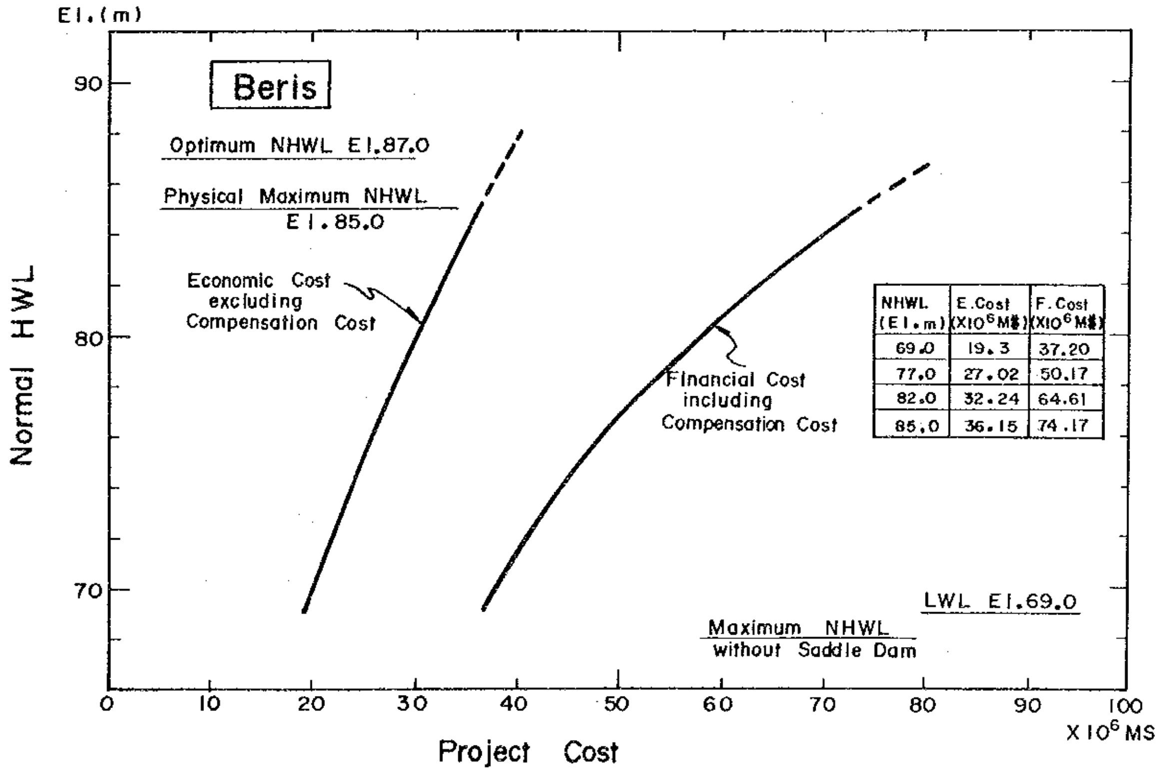


NHWL (El.m)	E.Cost ($X10^6$ M$)	F.Cost ($X10^6$ M$)
72.0	66.29	91.05
75.0	75.57	104.34
77.0	83.06	114.62



NHWL (El.m)	E.Cost ($X10^6$ M$)	F.Cost ($X10^6$ M$)
69.0	19.3	37.20
77.0	27.02	50.17
82.0	32.24	64.61
85.0	36.15	74.17

Fig. 7 Scale - Cost Curves of Proposed Dams (2/3)

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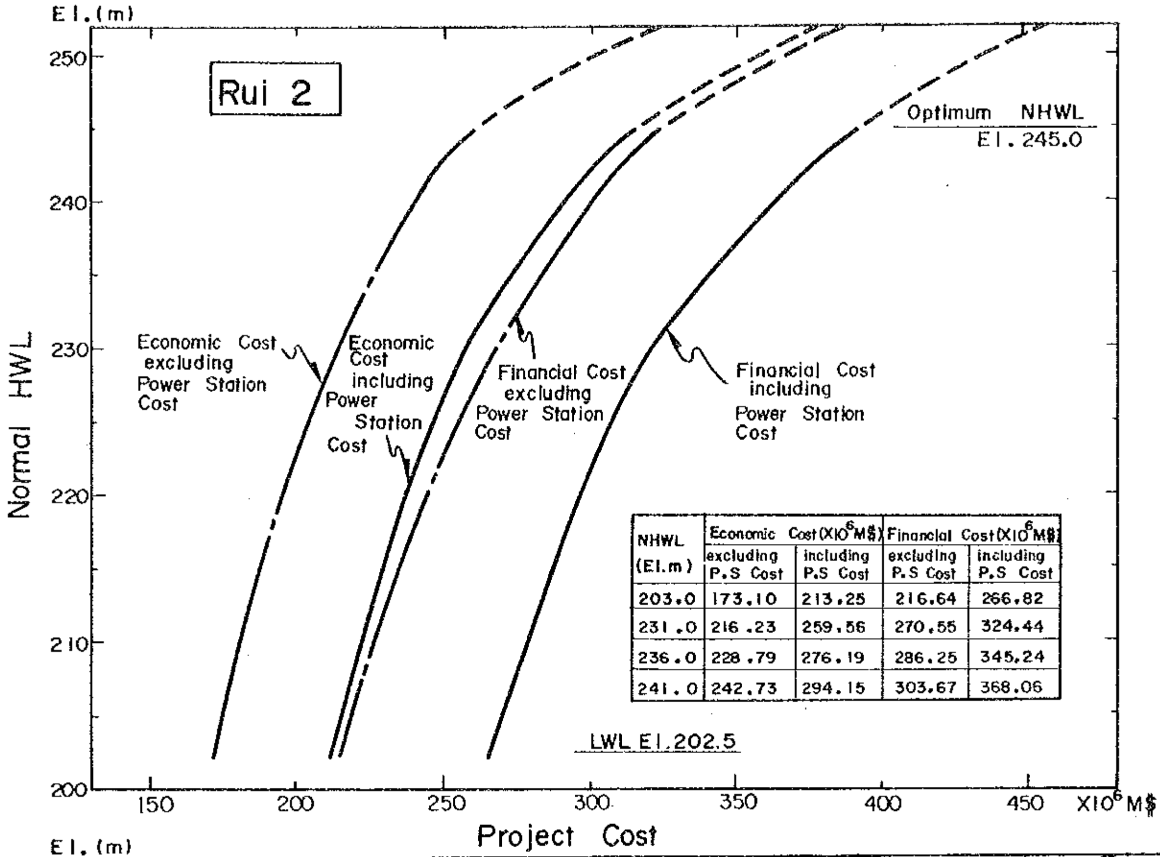
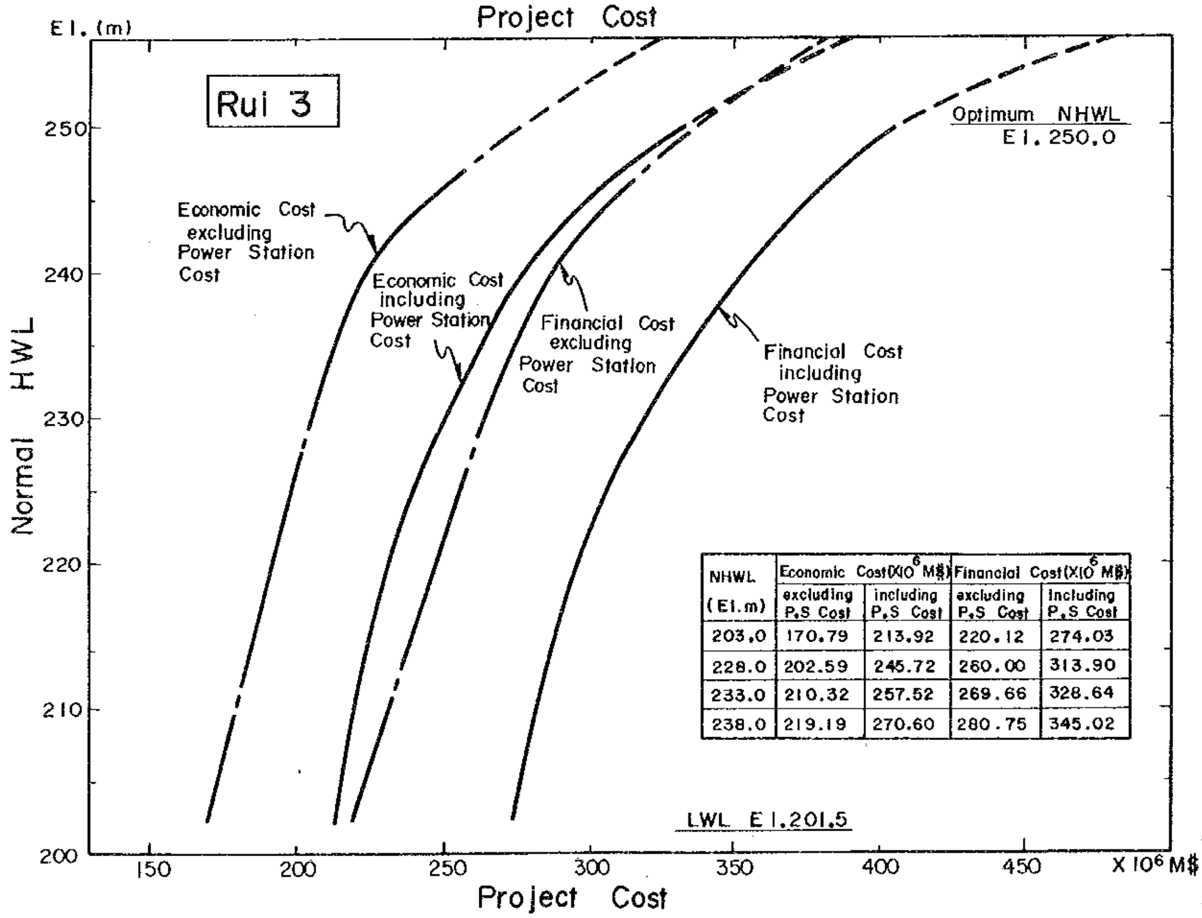


NHWL (El.m)	Economic Cost (X10^6 M$)		Financial Cost (X10^6 M$)	
	excluding P.S Cost	including P.S Cost	excluding P.S Cost	including P.S Cost
203.0	173.10	213.25	216.64	266.82
231.0	216.23	259.56	270.55	324.44
236.0	228.79	276.19	286.25	345.24
241.0	242.73	294.15	303.67	368.06



NHWL (El.m)	Economic Cost (X10^6 M$)		Financial Cost (X10^6 M$)	
	excluding P.S Cost	including P.S Cost	excluding P.S Cost	including P.S Cost
203.0	170.79	213.92	220.12	274.03
228.0	202.59	245.72	260.00	313.90
233.0	210.32	257.52	269.66	328.64
238.0	219.19	270.60	280.75	345.02

Fig. 8 Scale - Cost Curves of Proposed Dams (3/3)

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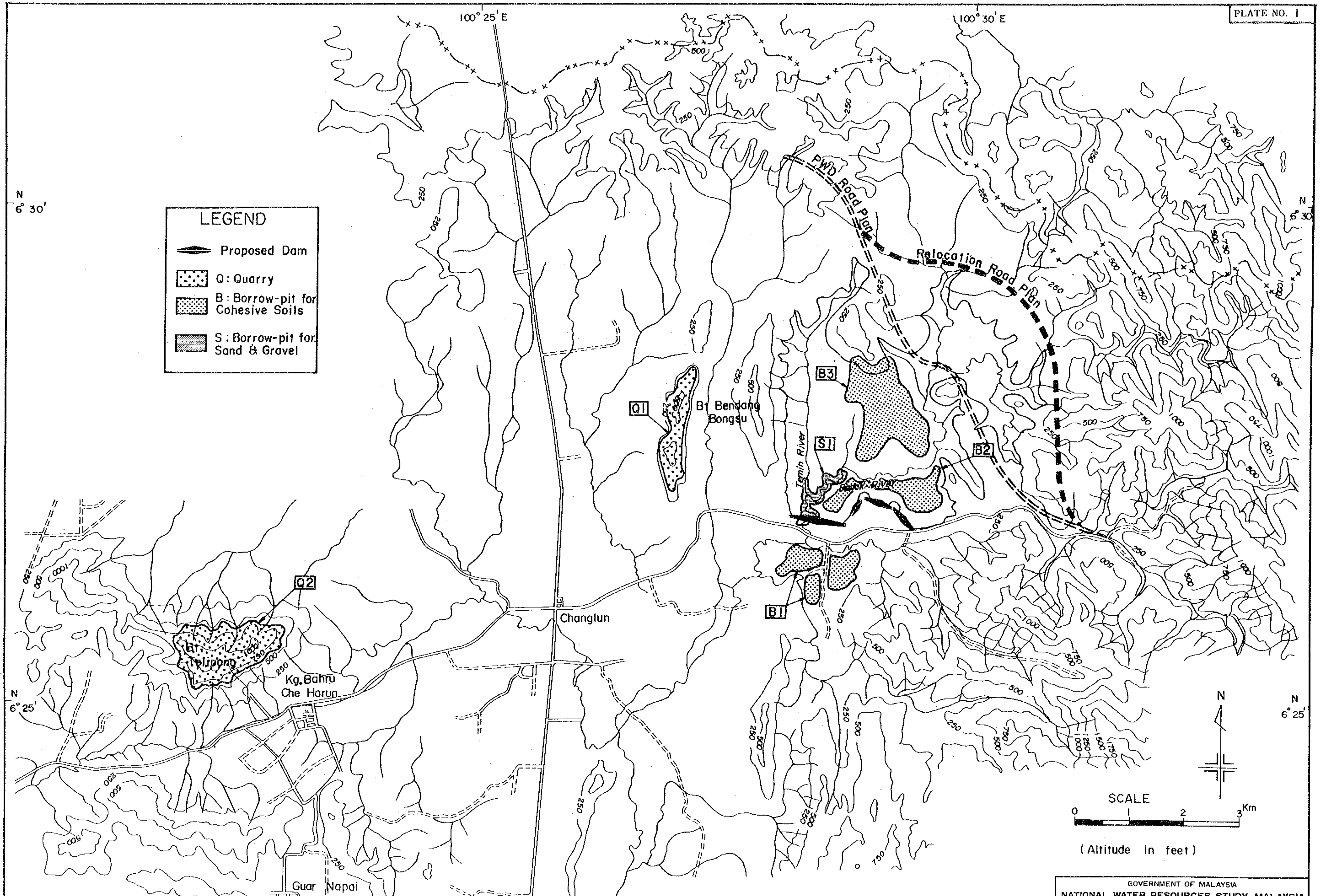
PLATES



The Badak-Temin Dam Project Area

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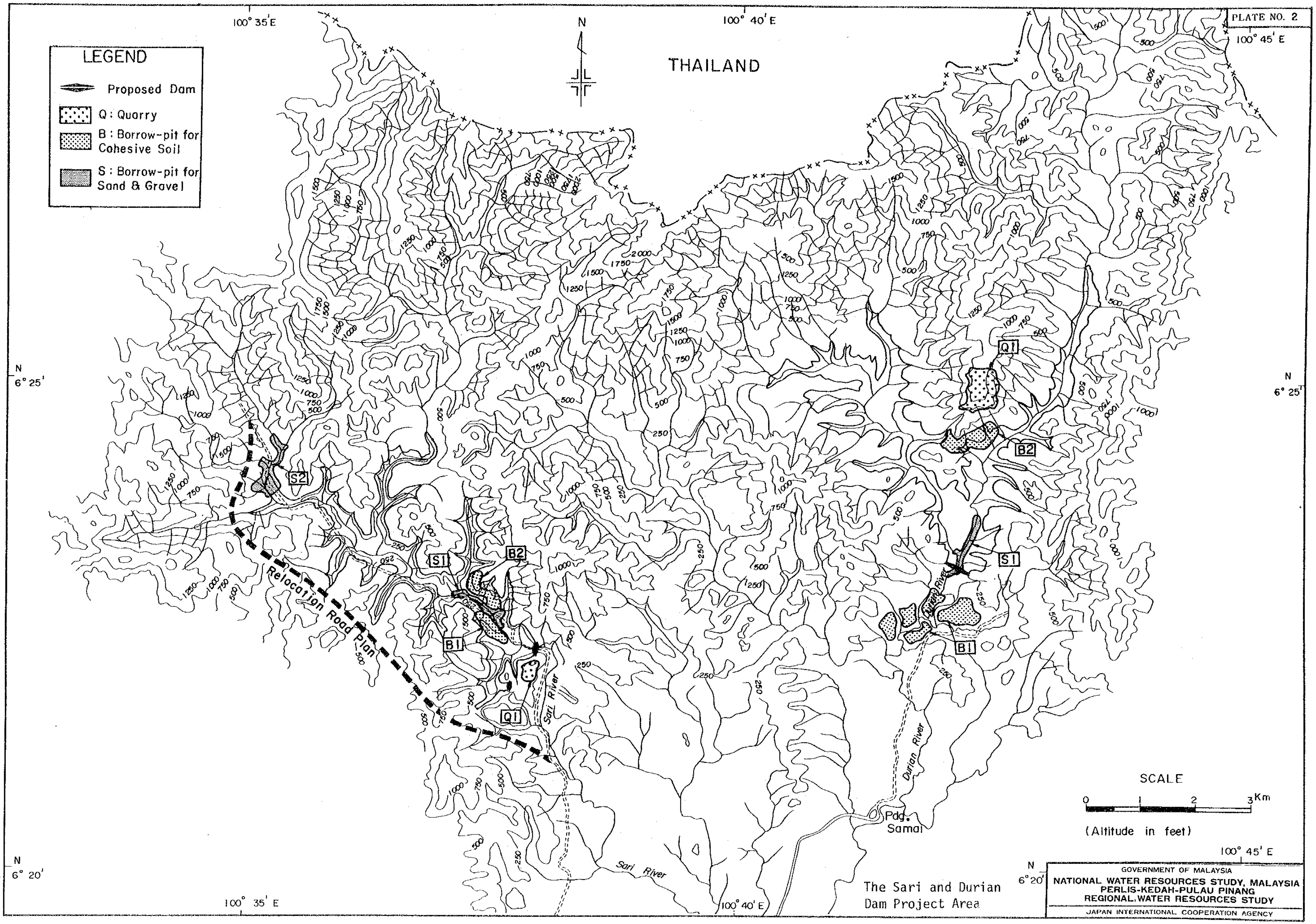

The Sari and Durian Dam Project Area

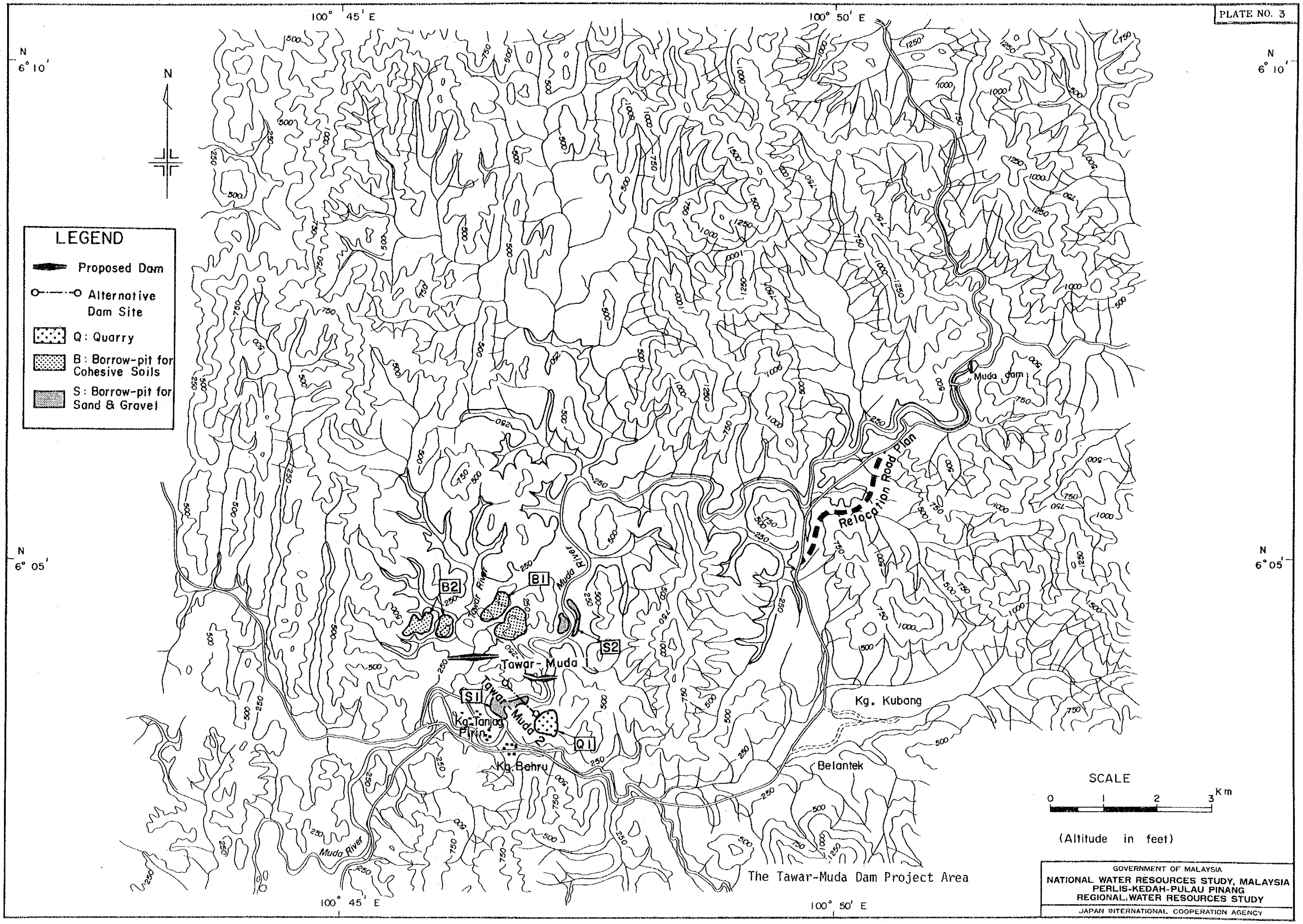
PLATE NO. 3
100° 45' E
100° 50' E
N 6° 10'
N 6° 05'
N
LEGEND
Proposed Dam
Alternative Dam Site
Q : Quarry
B : Borrow-pit for Cohesive Soils
S : Borrow-pit for Sand & Gravel
Muda dam
Relocation Road Plan
Tawar River
Muda River
B1
B2
S1
S2
Q1
Tawar-Muda 1
Tawar-Muda 2
Kg. Tanjag Pirin
Kg. Bahru
Kg. Kubang
Belantek
SCALE
0 1 2 3 Km
(Altitude in feet)
The Tawar-Muda Dam Project Area
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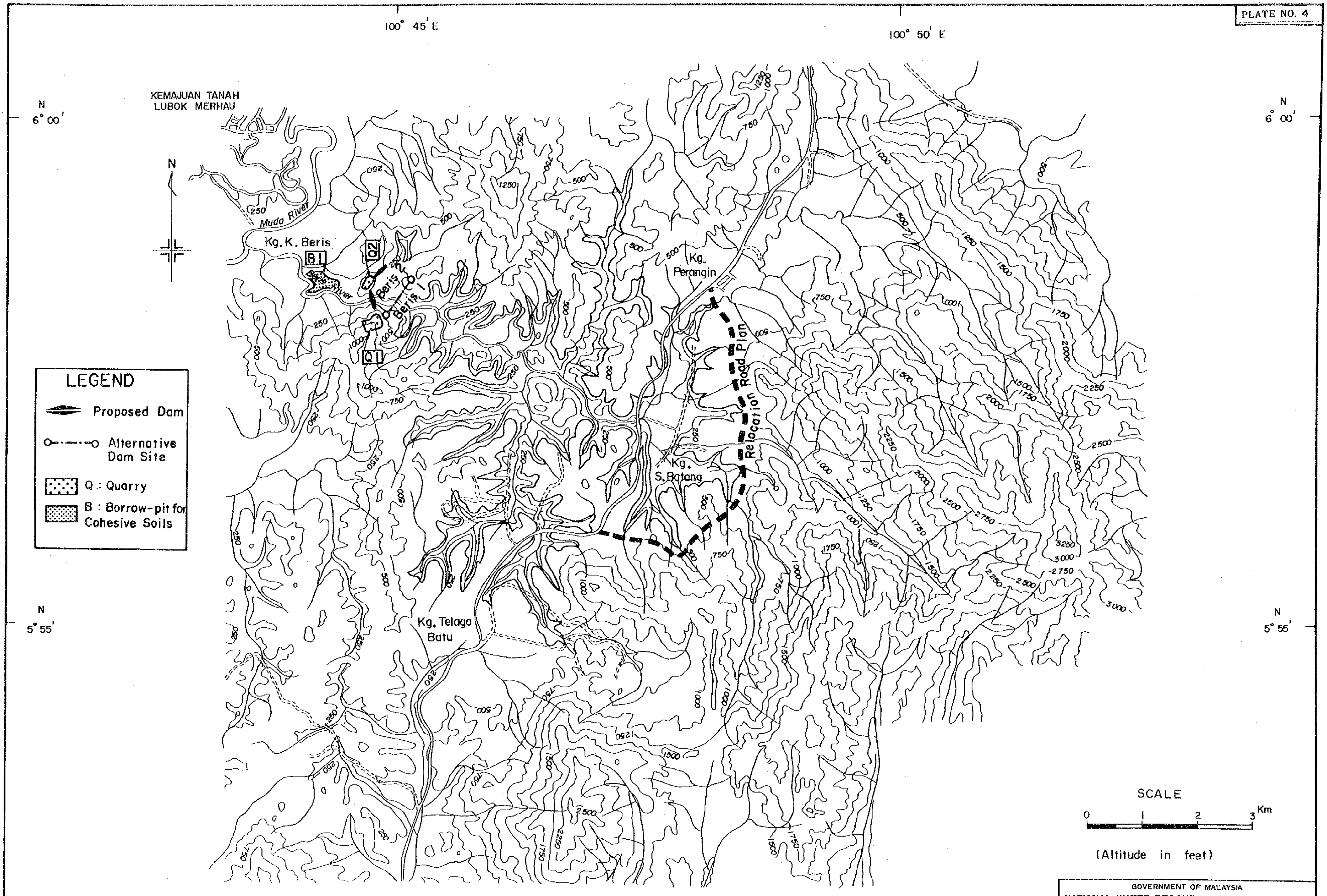

The Beris Dam Project Area

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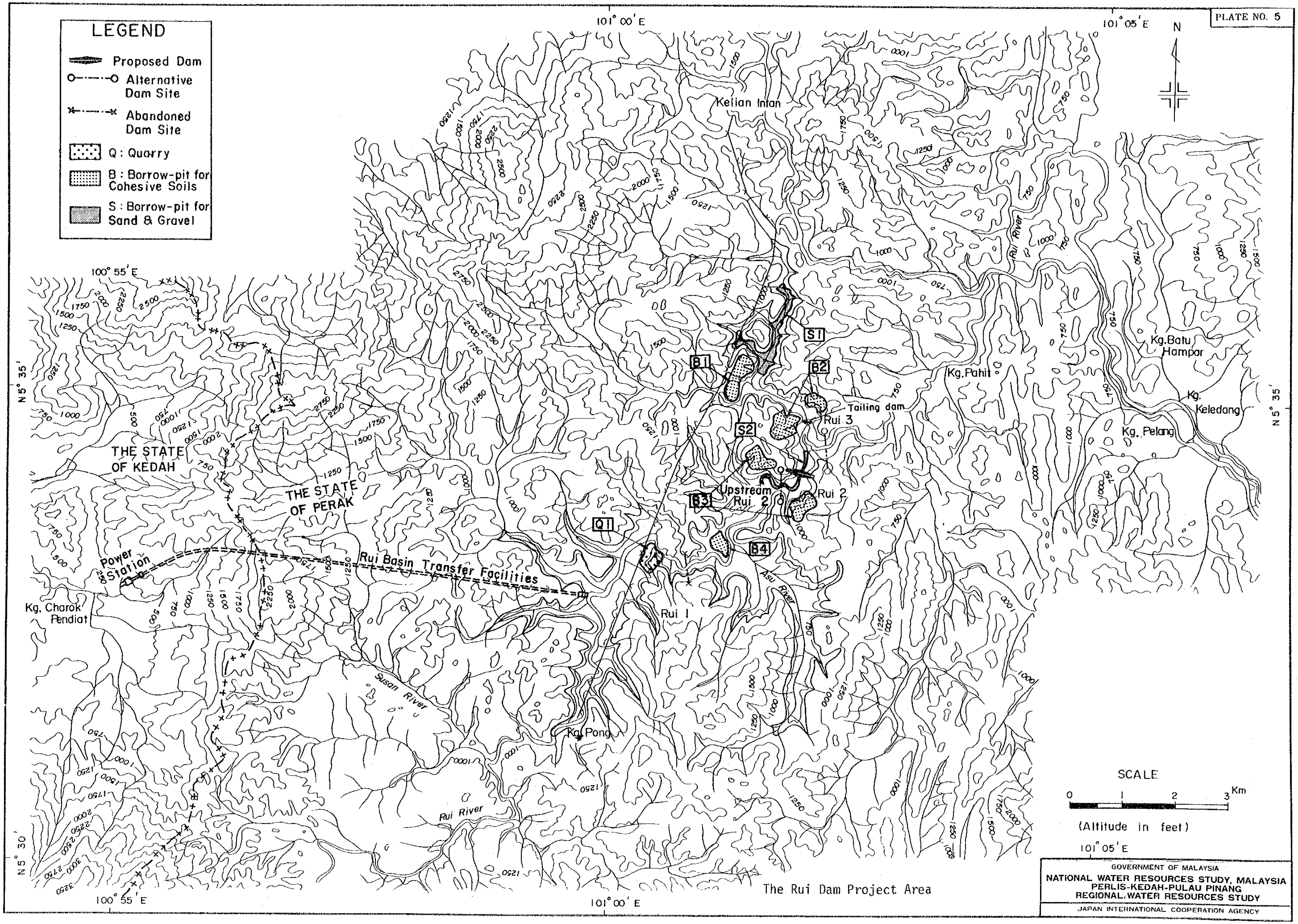

The Rui Dam Project Area

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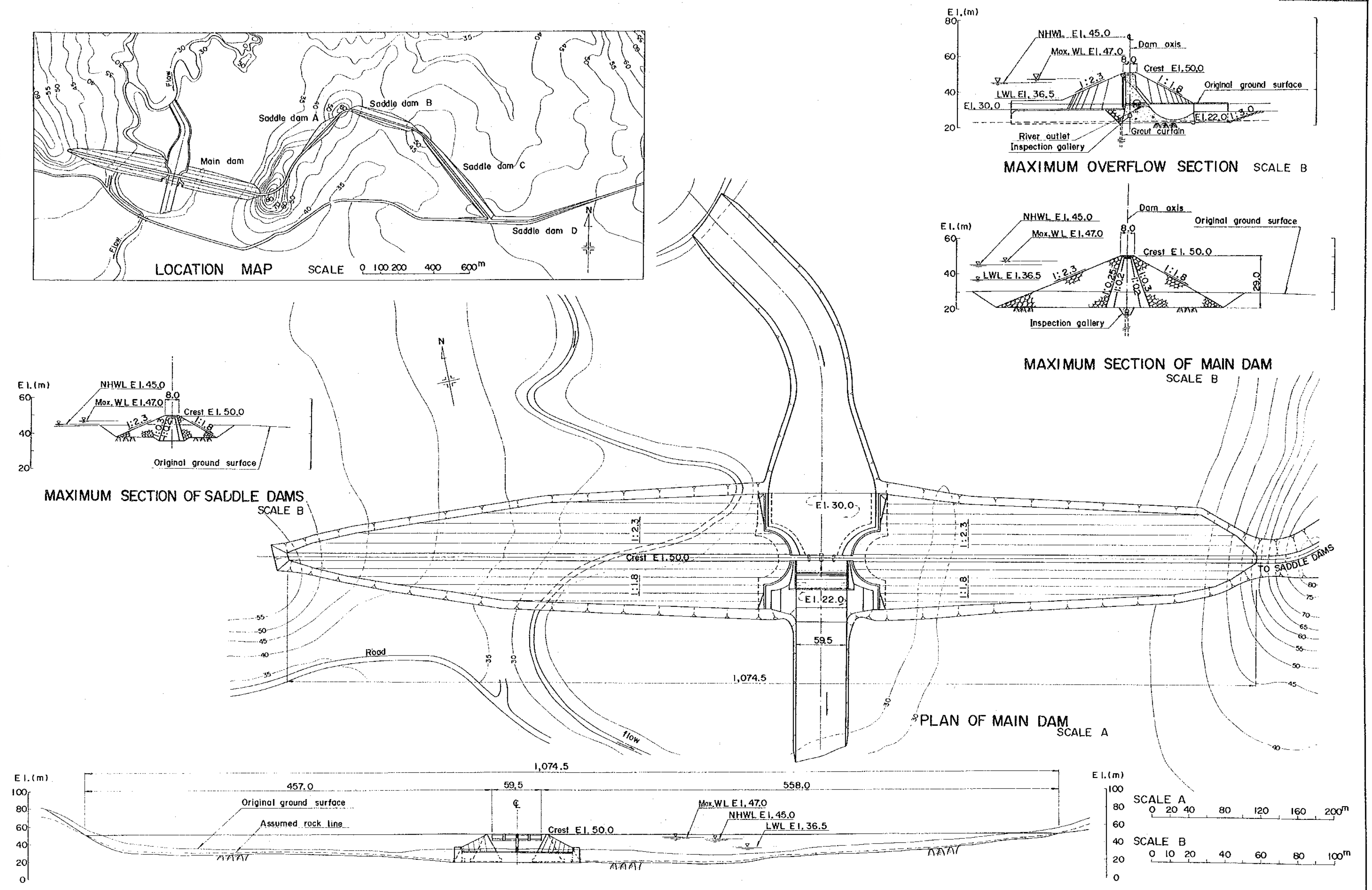

Plan, Elevation, Profile and Section of Badak-Temin Dam

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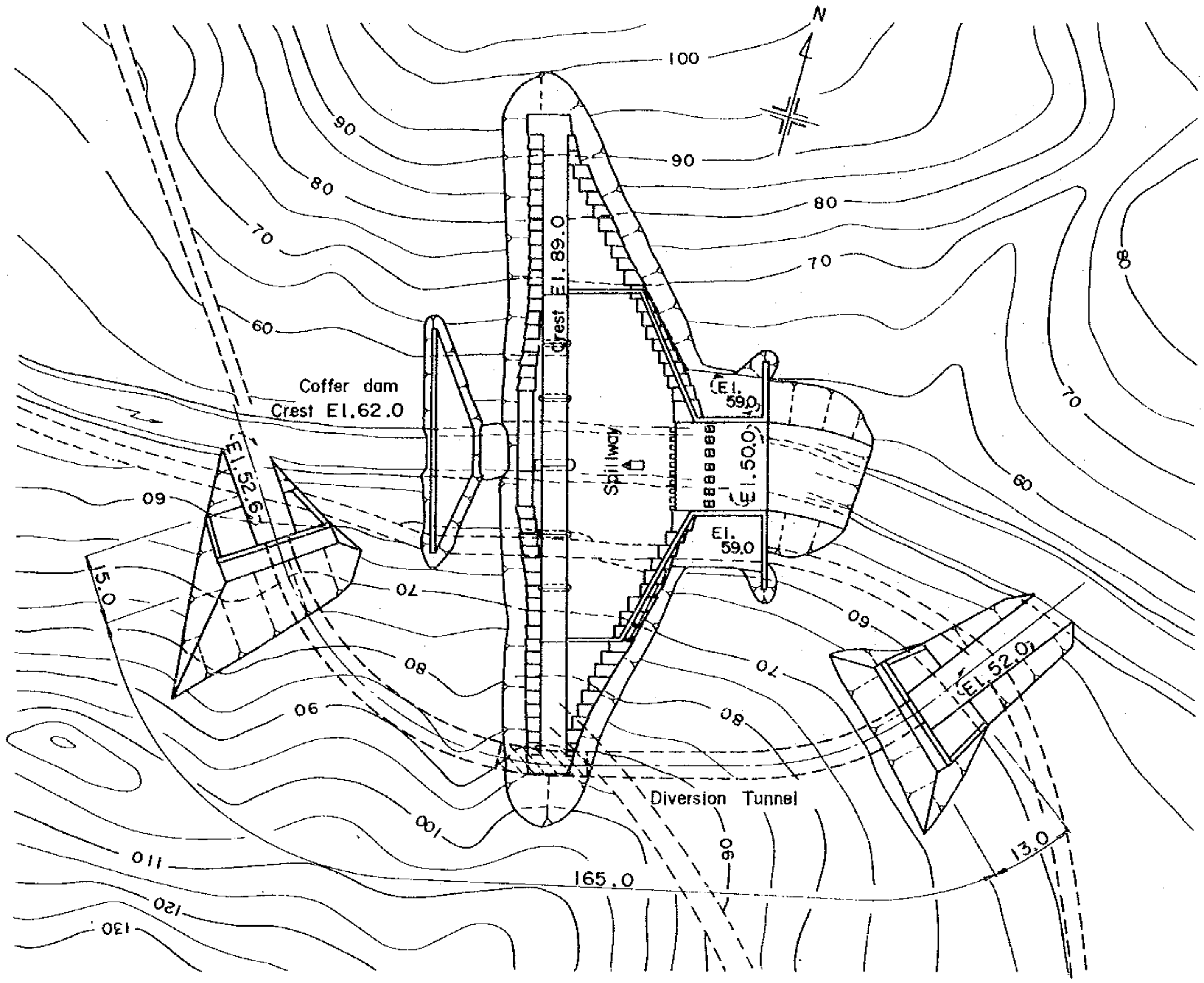
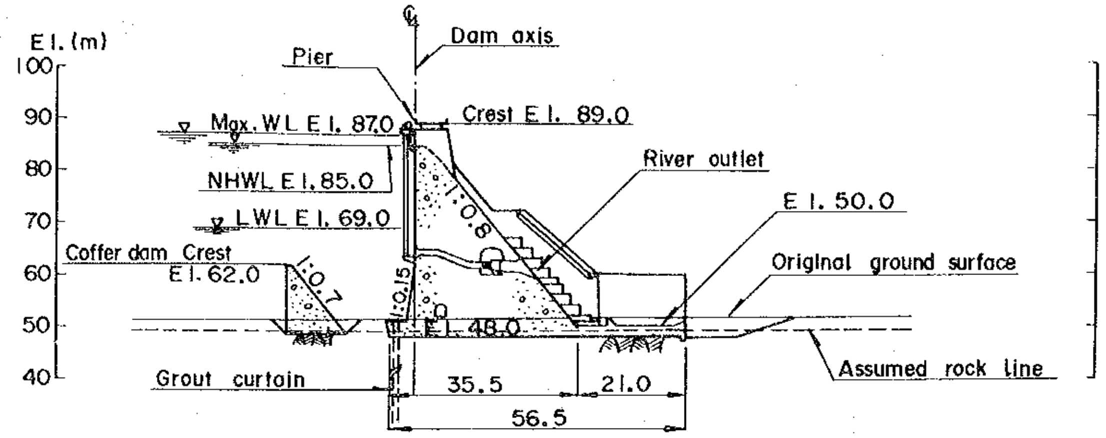
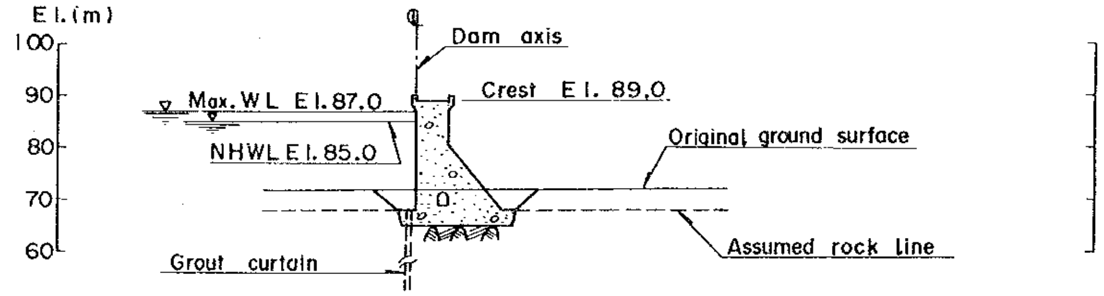
PLATE NO. 7



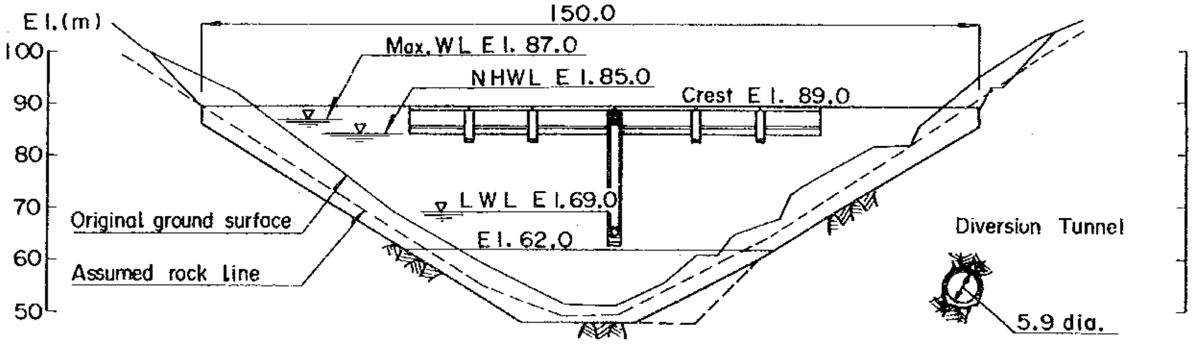
PLAN



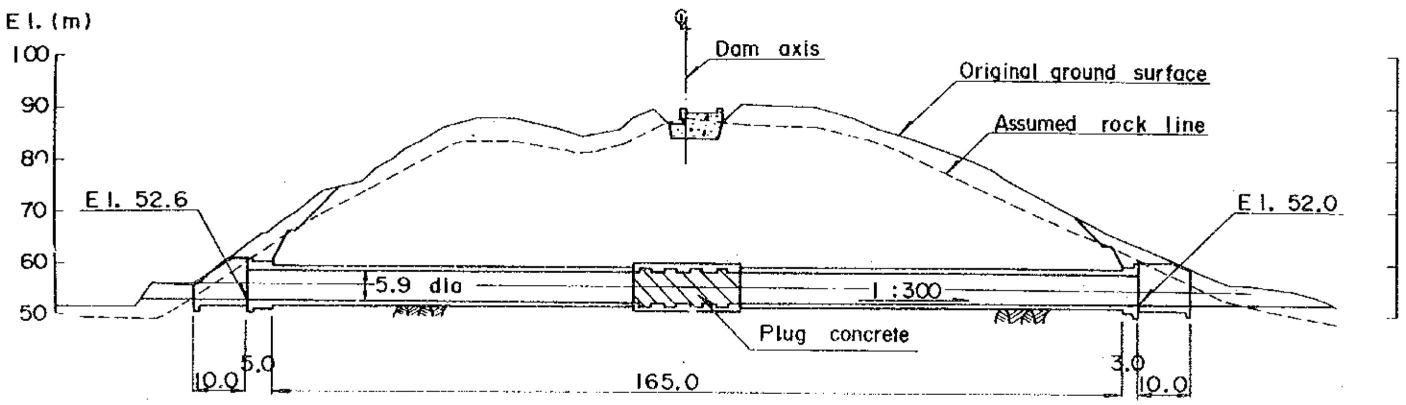
MAXIMUM OVERFLOW SECTION OF MAIN DAM & STILLING BASIN



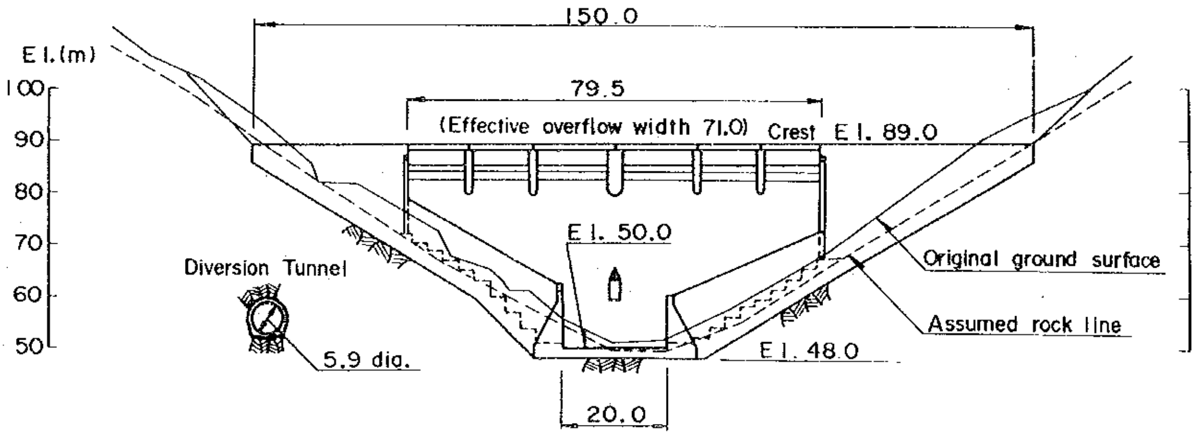
NON - OVERFLOW SECTION OF MAIN DAM



UPSTREAM ELEVATION OF MAIN DAM



PROFILE OF DIVERSION TUNNEL



DOWNSTREAM ELEVATION OF MAIN DAM

SCALE 0 50m

Remark : The dam is drawn with the NHWL El.85.0 and is not the optimum scale.

Plan, Elevation, Profile and Section of Sari Dam

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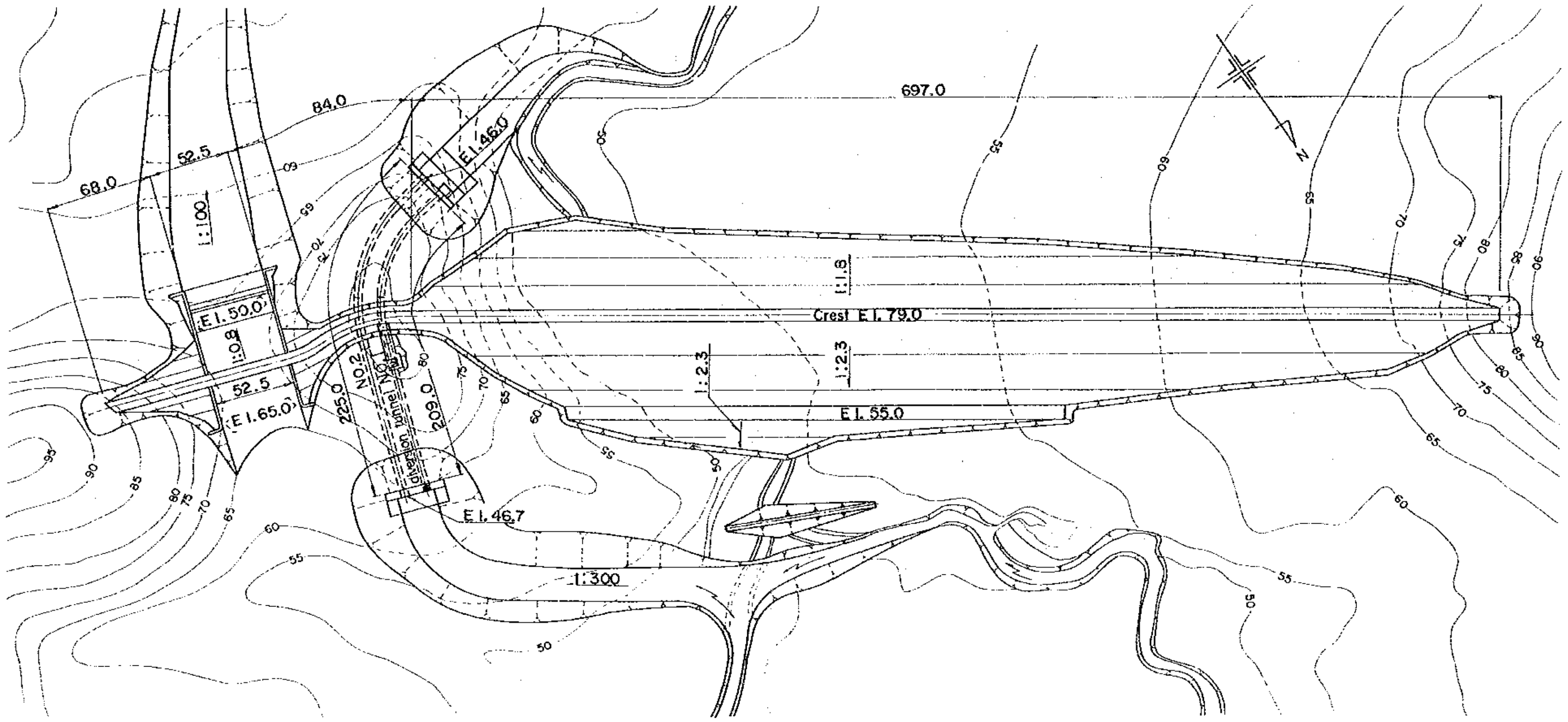
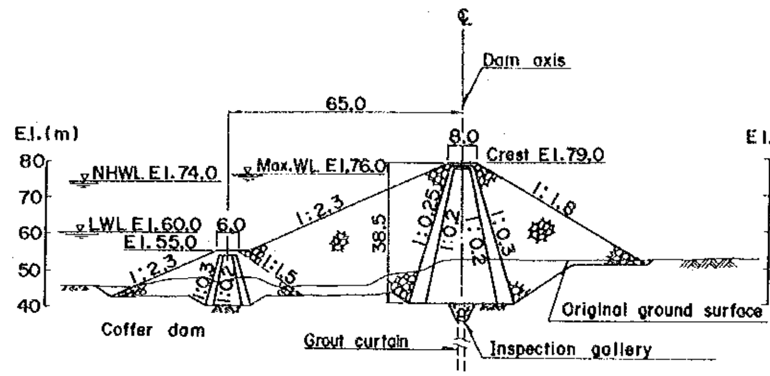
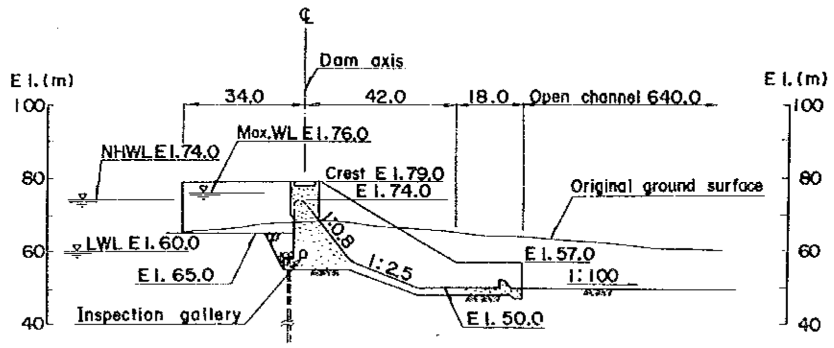
PLATE NO. 8



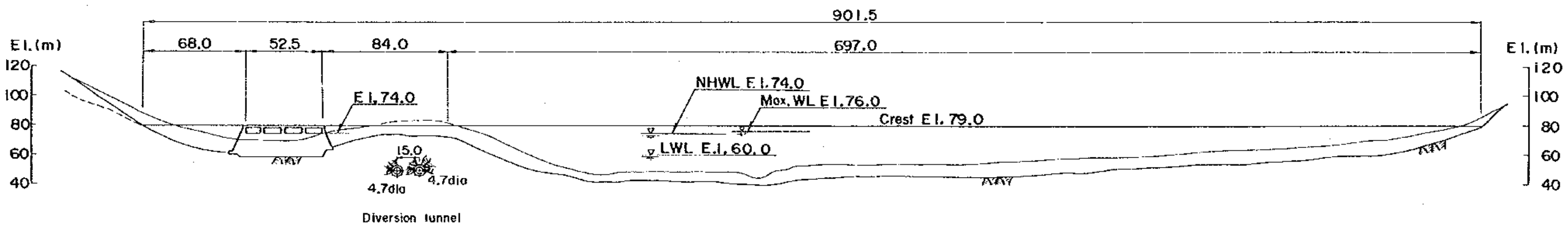
PLAN SCALE A



MAXIMUM SECTION OF MAIN DAM
SCALE B



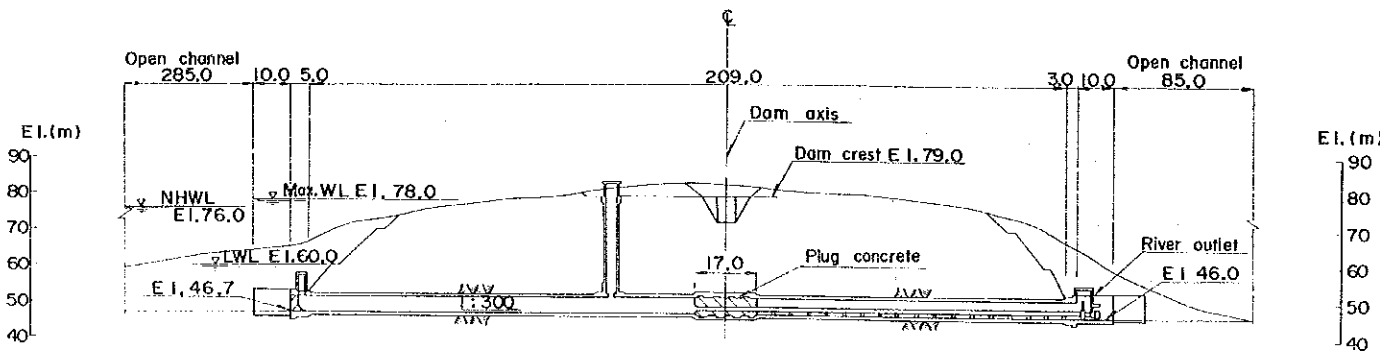
MAXIMUM OVERFLOW SECTION SCALE B



UPSTREAM ELEVATION OF DAM SCALE A

SCALE A 0 20 40 100 200m

SCALE B 0 10 20 50 100m



PROFILE OF DIVERSION TUNNEL NO. I SCALE B

Plan, Elevation, Profile and Section of Durian Dam

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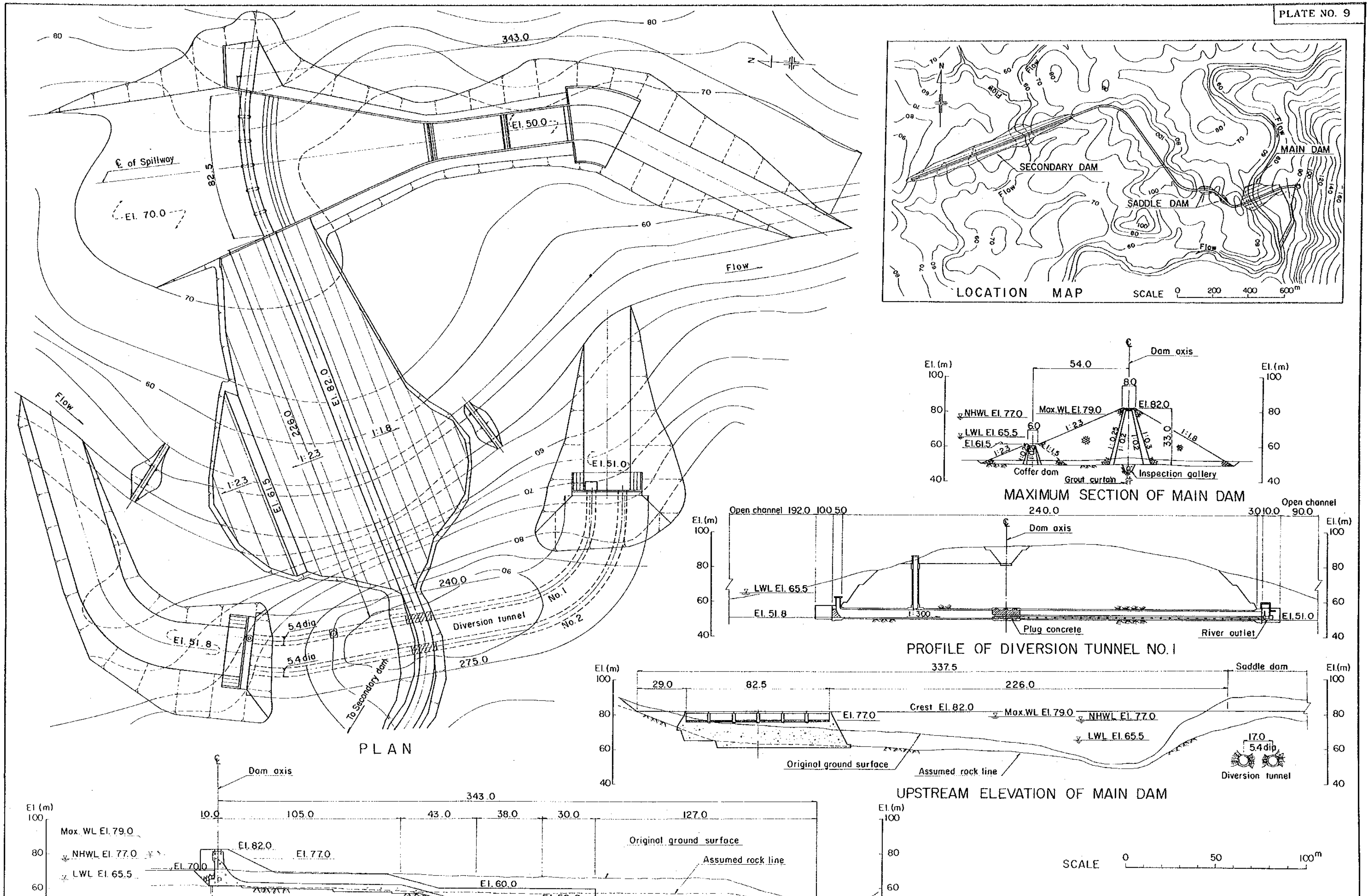

Plan, Elevation, Profile and Section of Tawar-Muda Dam (1/2)

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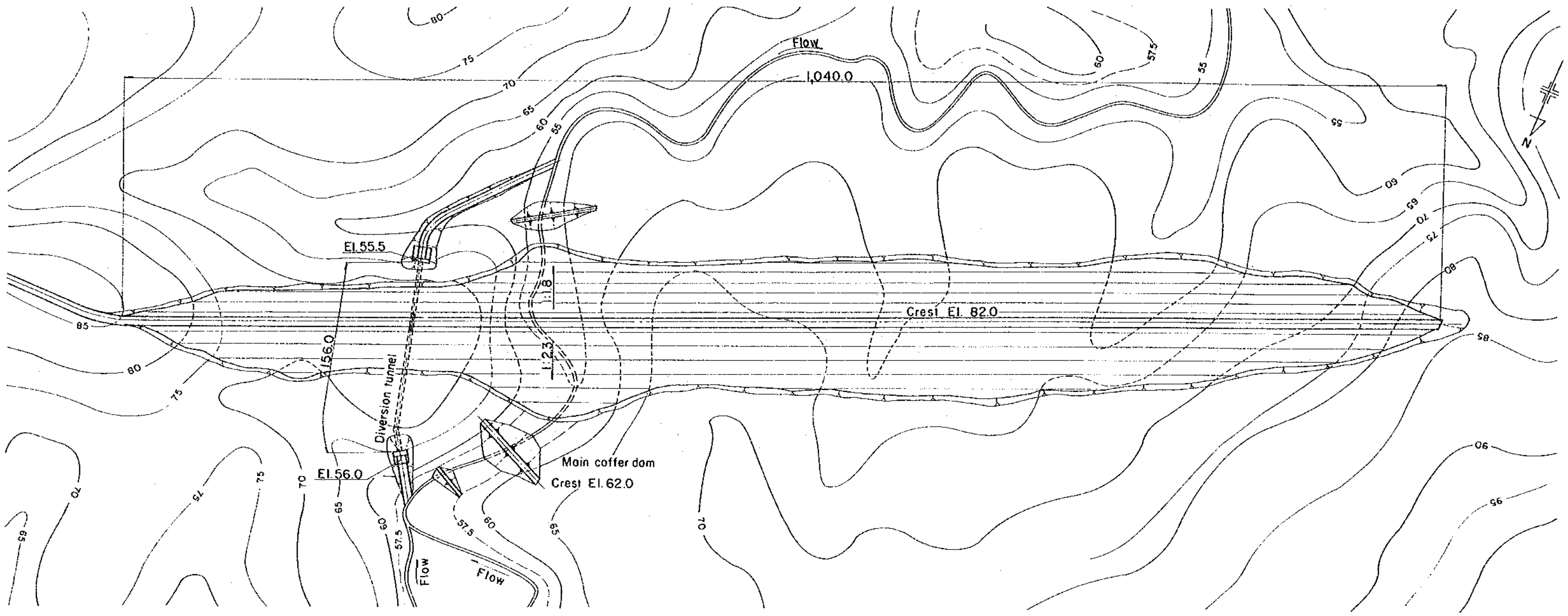
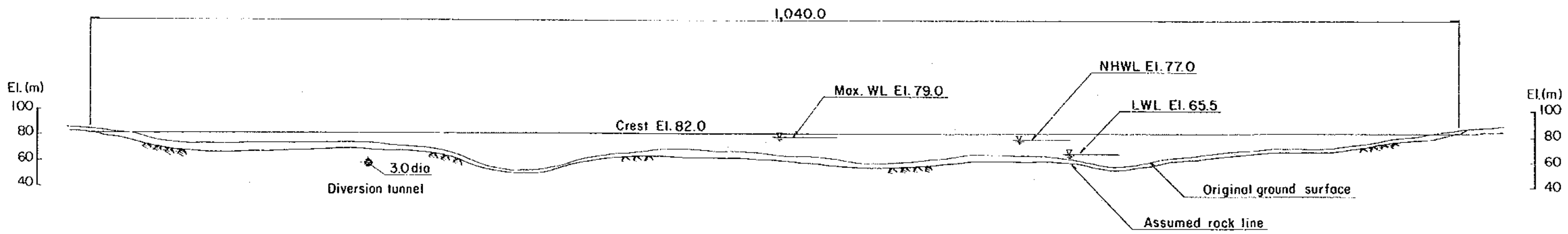
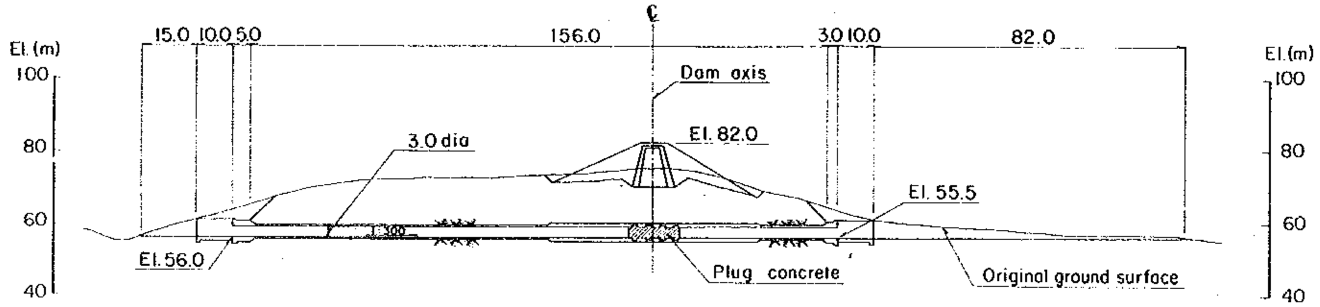
PLATE NO. 10



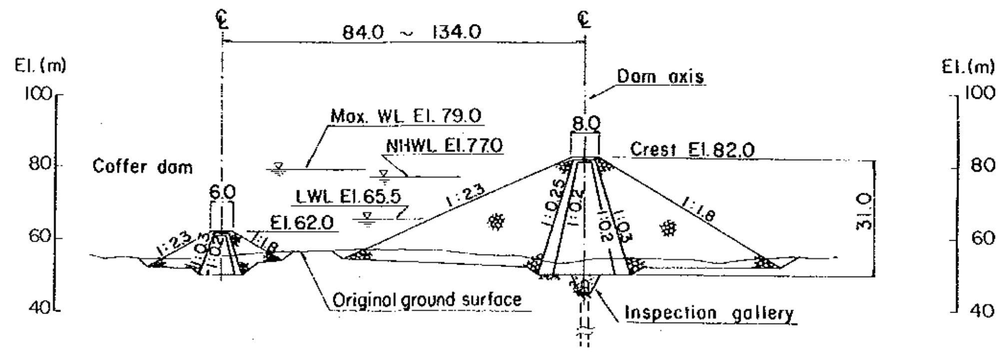
PLAN SCALE A



UPSTREAM ELEVATION OF SECONDARY DAM SCALE A



PROFILE OF DIVERSION TUNNEL
SCALE B



MAXIMUM SECTION OF SECONDARY DAM
SCALE B

SCALE A 0 100 200m SCALE B 0 50 100m

Plan, Elevation, Profile and Section of Tawar-Muda Dam (2/2)

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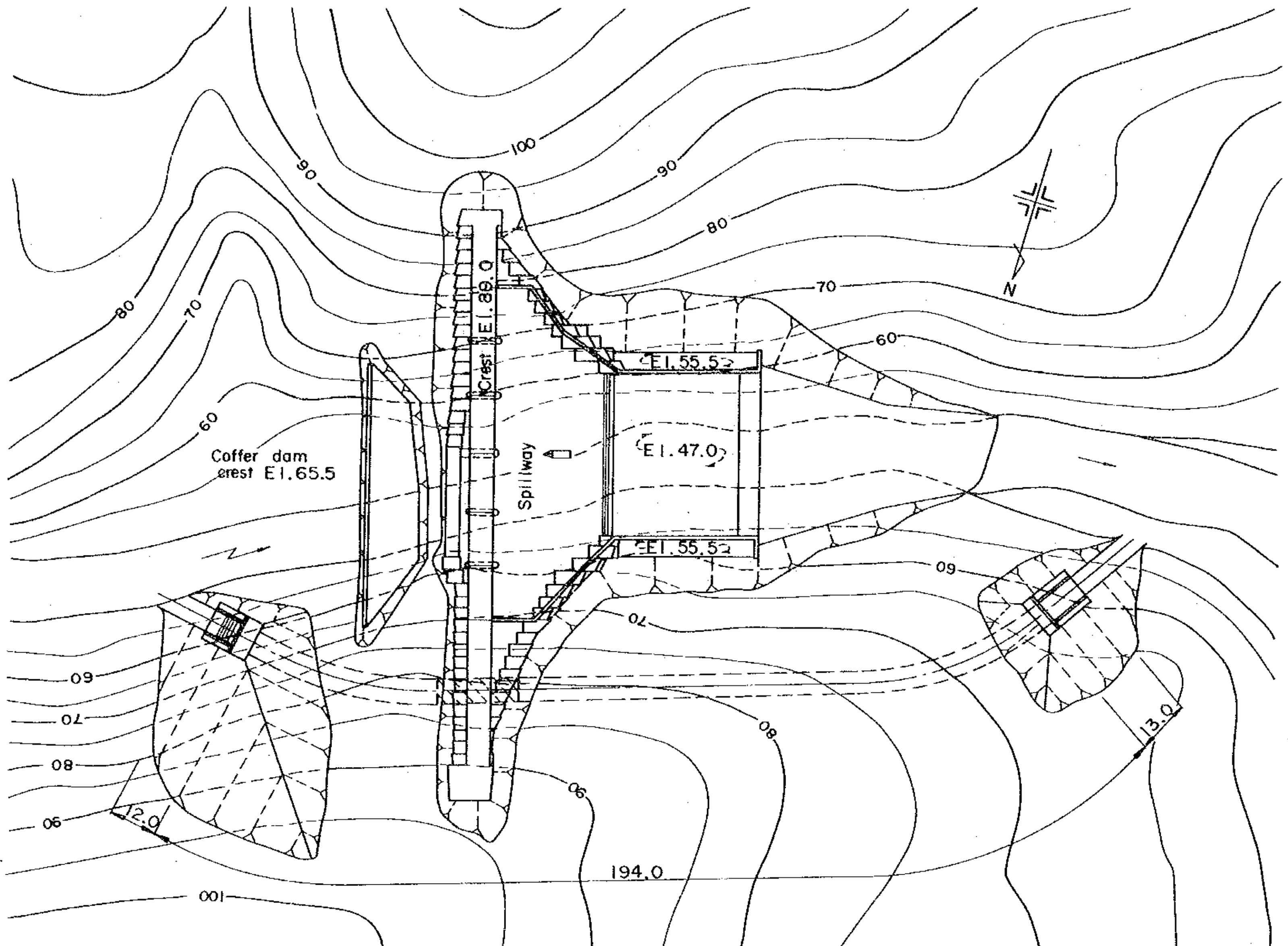
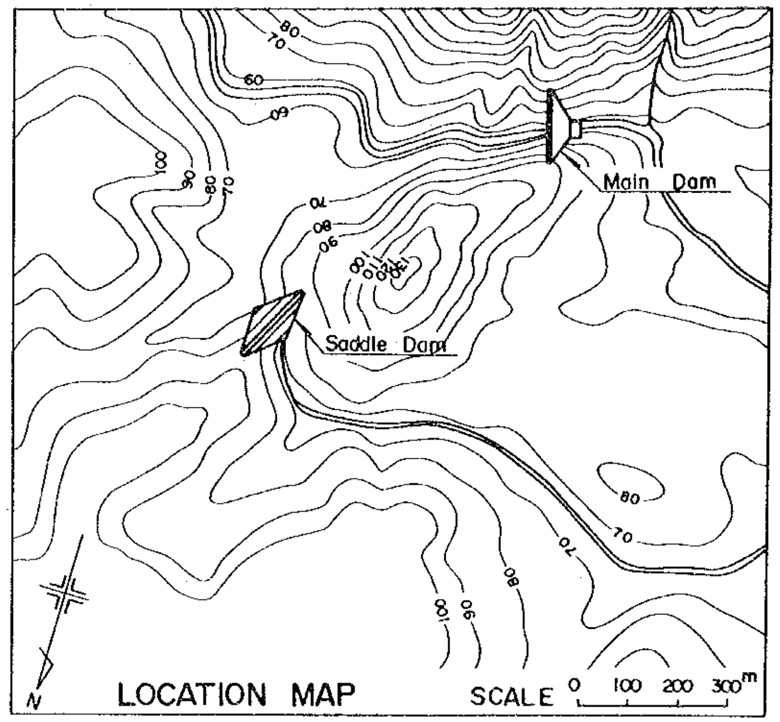
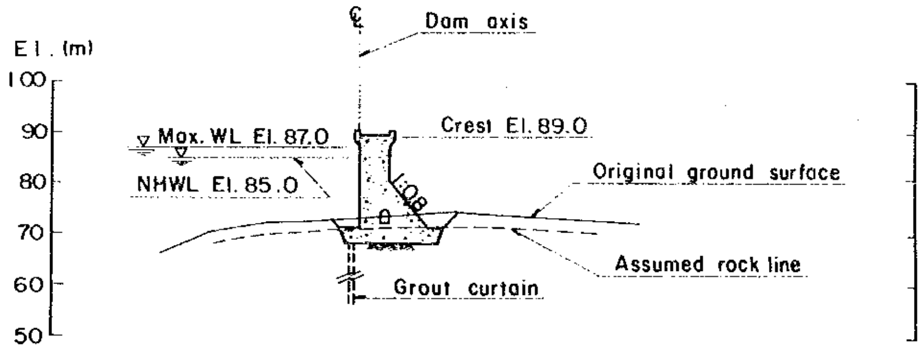


PLAN

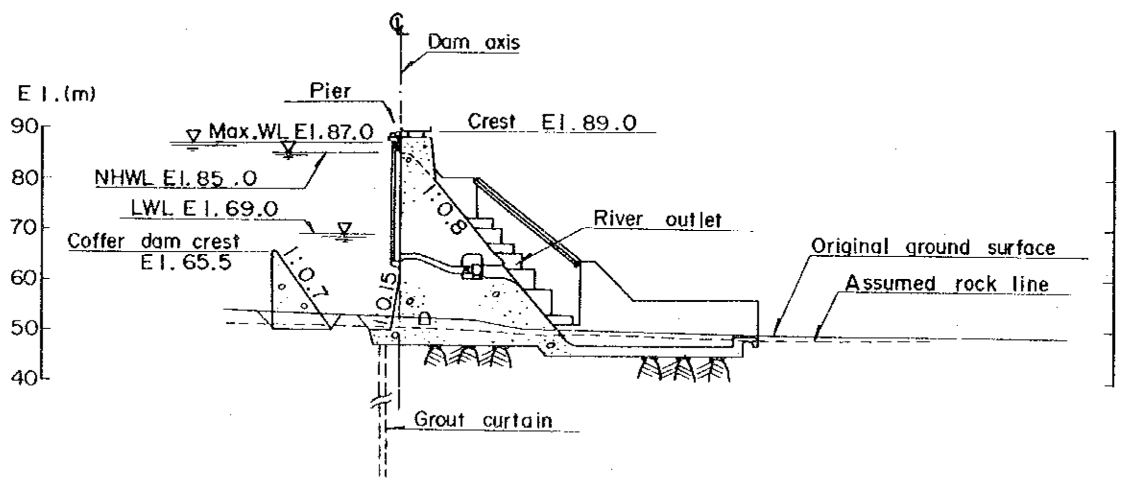


LOCATION MAP



NON-OVERFLOW SECTION OF MAIN DAM

SCALE 0 10 20 50 100(m)



MAXIMUM OVERFLOW SECTION OF MAIN DAM

Plan, Elevation, Profile and Section of Beris Dam (1/2)

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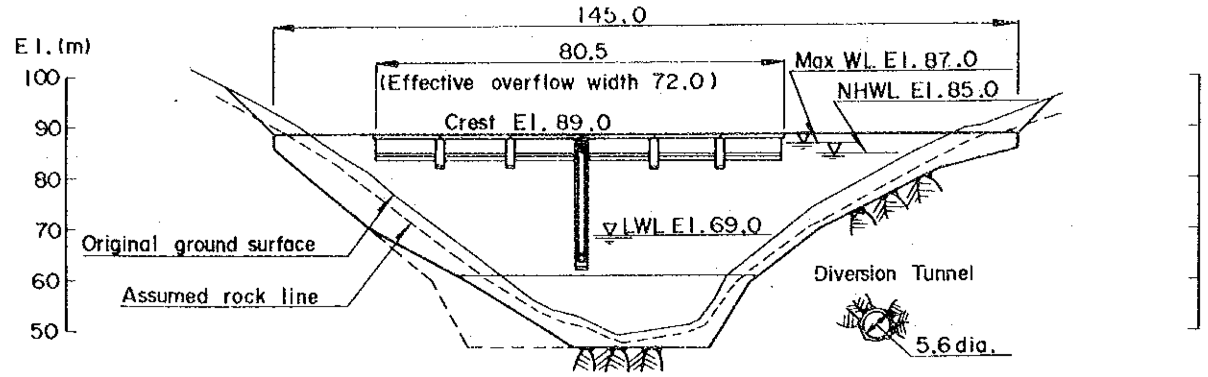
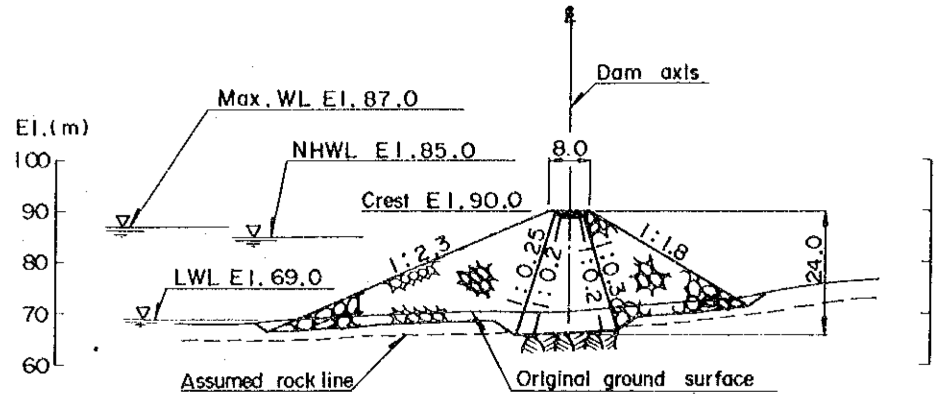
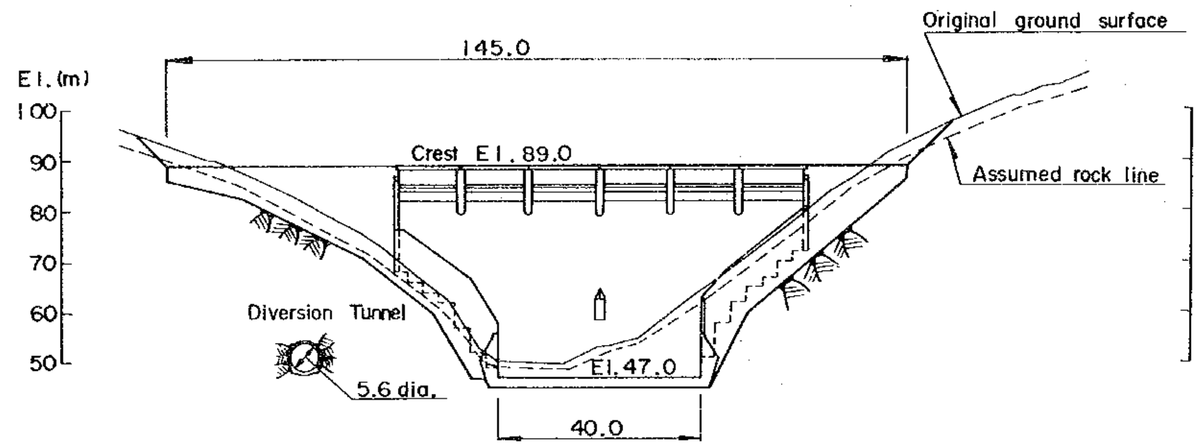
PLATE NO. 12



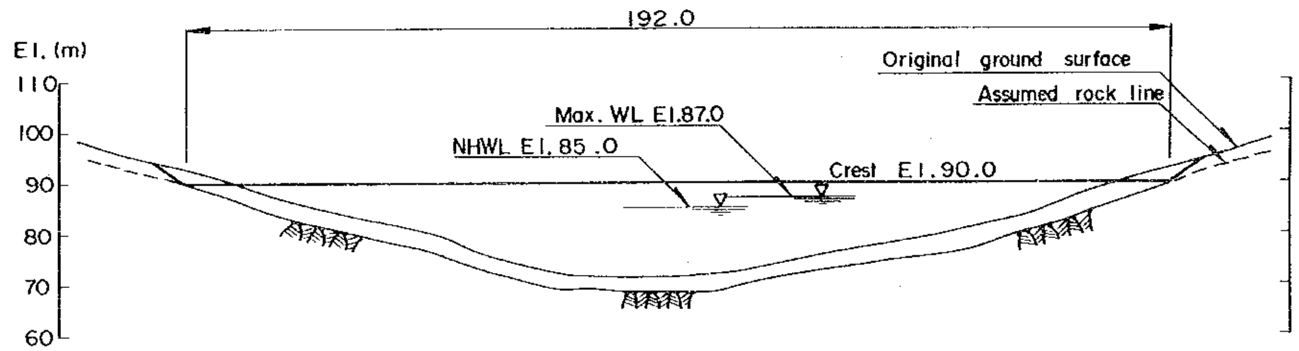
UPSTREAM ELEVATION OF MAIN DAM



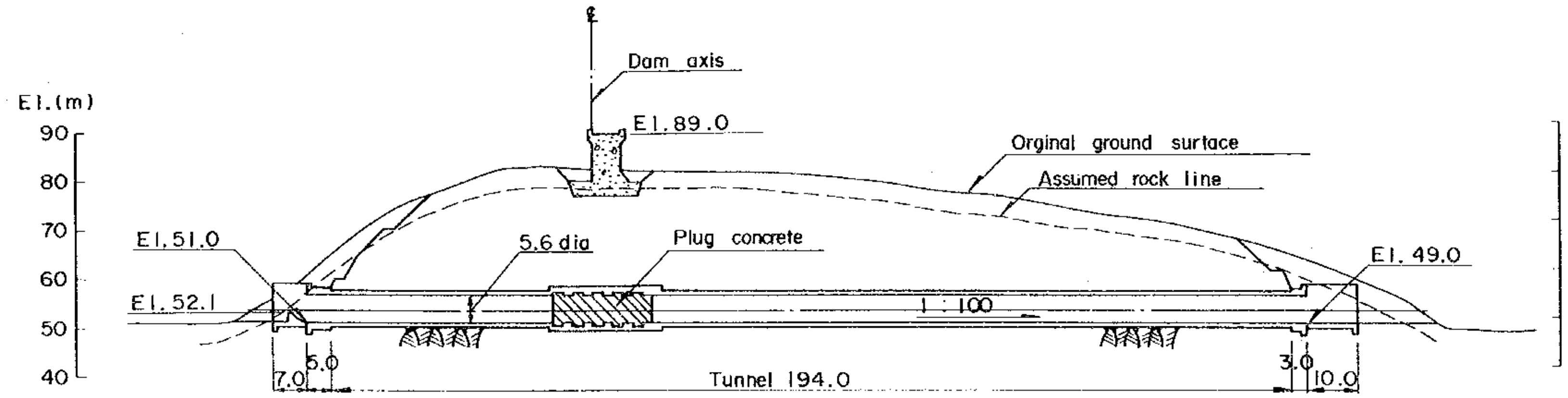
MAXIMUM SECTION OF SADDLE DAM



DOWNSTREAM ELEVATION OF MAIN DAM



UPSTREAM ELEVATION OF SADDLE DAM



PROFILE OF DIVERSION TUNNEL

SCALE 0 10 20 50 100 (m)

Plan, Elevation, Profile and Section of Beris Dam (2/2)

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