It is hereinafter assumed that both the Beris and Tawar-Muda dams will be implemented in the immediate future.

In conclusion, the Beris dam can be justified in any case, but the Tawar-Muda dam may or may not be justified, depending on the allocation of water between the Kedah river system and the Muda-Perai river system.

6.3.3 Analysis of net water output

Annual water deficit and corresponding net water output of the Jeniang system, Beris dam and Tawar-Muda dam are illustrated for 2000 assuming the hydrological condition between 1961 and 1980 as shown in Fig. 25. If the 3 source projects are implemented, entire water deficit are removed from the Muda-Perai river system but some water deficit takes place in the Kedah river system. The average water deficit remaining in the Kedah river system is about 6% of total water demand in the Kedah river system under High Growth Case and 3% under Low Growth Case.

As the basic information to show the distribution of the responsibility for the implementation of source development project, average water deficit by cause is divided by the source project. In dividing water deficit into that to be supplied by each source facilities, the following assumptions are introduced.

The Jeniang system is constructed to supply water deficit within its net water output in MADA, minor irrigation projects in the main stream and domestic and industrial water supply which are existing and to be developed in the Kedah river system up to 2000.

The Beris dam is constructed to supply most water deficit caused by the increase in domestic and industrial water supply demand in the Muda-Perai river system, all water deficit caused by minor irrigation development in tributaries in both the Kedah and Muda-Perai river system, and a part of remaining water deficit in MADA, minor irrigation projects and domestic and industrial water supply in the Kedah river sytem. The Tawar - Muda dam is constructed to supply all remaining water deficit caused by increase in domestic and industrial water demand in the Muda-Perai river system and a part of water deficit in the MADA area, minor irrigation projects in the Kedah river system.

A proposed share of water deficit by net water output by the Jeniang, Beris and Tawar-Muda, based on the above-mentioned assumptions is summarized in Table 25 (for the same data assuming Alternatives 2 and 3 in Jeniang system's operation, see ANNEX I).

6.3.4 Economic evaluation of individual source project

The economic benefit on an irrigation project by water deficit supply is herein estimated to be the net benefit, or the net production value less the cost of irrigation facilities, assigned in proportion to the ratio of the water deficit supplied to total water demand of the project.

The value of EIRR is calculated to be 12.2% for the Jeniang system, 14.4% for the Beris dam and 11.5% for the Tawar-Muda dam in High Growth Case, and 12.9% for the Jeniang system, 13.5% for the Beris dam and 9.0% for the Tawar-Muda dam in Low Growth Case. All the 3 source projects show appropriately high values of EIRR in both High and Low Growth Cases. The Beris dam showing a high value or EIRR is deficitly justified. The Tawar-Muda dam is also justified, but its economic and physical impacts are smaller than that of the Beris dam.

The estimated average annual net water output, present values of benefit and cost assuming a discoutn rate of 8% and value of EIRR of the 3 projects are summarized in Table 26 for High Growth Case and in Table 27 for Low Growth Case.

6.4 Financial Analysis

The costs of source projects are allocated to purposes which are the causes of water deficit to be met by the source projects.

In the present excercise of cost allocation of the Beris and Tawar-Muda dam, the separable costs-remaining benefits method is applied for the present value of the capital and O&M costs at the beginning of 1982 discounted at a rate of 8%. The results of the calculation for the Beris dam and Table 29 for the Tawar-Muda dam. In all the calculated cases the benefit for each purpose is smaller than the corresponding alternative facilities cost, therefore it is the justifiable expenditure. The ratio of separable cost to the total cost is 52 - 53% in the Beris dam and it is 21 - 23% in the Tawar-Muda dam. Therefore, the allocated cost is more use-oriented for the Beris dam and more benefit oriented for the Tawar-Muda dam.

The percentage distribution of allocated cost of the Beris dam is 22.8% for MADA, 39.6% for minor irrigation, 2.0% for domestic and industrial water supply in the Kedah river system, 15.8% for irrigation, 19.1% for domestic and industrial water supply in the Muda-Perai river system and 0.7% for the river maintenance flow in the Kedah river system in High Growth Case. It is 41.1% for MADA, 43.4% for minor irrigation, nil for domestic and industrial water supply in the Kedah river system and, 11.4% for irrigation and 4.1% for domestic and industrial water supply in the Muda-Perai river system in Low Growth Case.

The same ratio of the Tawar-Muda dam is 38.7% for MADA, 4.6% for minor irrigation, 4.8% for domestic and industrial water supply in the Kedah river system, 1.8% for irrigation and 48.9% for domestic and industrial water supply in the Muda-Perai river system and 1.2% for the river maintenance flow in the Kedah river system in High Growth Case, and 80.4% for MADA, 8.3% for minor irrigation, 0.4% for domestic and industrial water supply in the Kedah river system, 1.4% for irrigation and 9.5% for domestic and industrial water supply in the Muda-Perai river system.

A disbursement schedule by the Malaysia Five Year Development Plan period for public and private expenditure for the water demand and supply balance in the whole Region is prepared as shown in Tables 30 and 31 for High Growth Case and Tables 32 and 33 for the Low Growth Case. In the disbursement schedule, the investment costs of the Timah-Tasoh dam, Arau dam, Ahning dam, Jeniang system, Mengkuang dam, Beris dam and Tawar-Muda dam are included. The separable cost for flood mitigation purpose is excluded from the costs of the Timah-Tasoh and Arau dams. Total cost of the Ahning and Mengkuang dams are allocated for domestic and industrial water supply. The investment cost of the Jeniang system is allocated in proportion to the water deficit to be met. The direct facilities costs include the public investment costs for on-going tertiary development in the MADA area, minor irrigation schemes development, rehabilitation of existing minor irrigation schemes, PWD/PWA and RESP public water supply system development, and private investment costs for water supply system by private enterprises. The investment cost for the river maintenance flow is a part of the source facilities costs.

For the States of Perlis and Kedah the total public development expenditure is estimated to be M$1,313 x 10^6 comprising M$223 x 10^6 for irrigation, M$1,084 x 10^6 for public water supply and M$6 x 10^6 for river maintenance flow in High Growth Case. The allocated investment cost of the Jeniang system, Beris dam and Tawar-Muda dam is M$90 x 10^6, or 7% of the total public development expenditure. The private expenditure for water supply system is estimated to be M$1,316 x 10^6. For Low Growth Case, the public development expenditure is estimated to be M$713 x 10^6 including M$226 x 10^6 for irrigation and M$551 x 10^6 for public water supply. The allocated cost of the 3 source projects is M$66 x 10^6 or 5% of total expenditure. Private investment cost is estimated to be M$264 x 10^6.

For the State of Pulau Pinang, the public development expenditure in High Growth Case is estimated to be M$1,571 x 10^6 including M$1 x 10^6 for irrigation and M$1,570 x 10^6 for public water supply. The allocated cost of the Beris and Tawar-Muda dams is M$58 x 10^6 or 4% of the total public development expenditure. The private expenditure is estimated to be M$1,182 x 10^6. For Low Growth Case, the total public development expenditure is estimated to be M$934 x 10^6 consisting of M$1 x 10^6 for irrigation and M$933 x 10^6 for public water supply. The allocated cost of the two dams is M$12 x 10^6 or 7% of the total public development expenditure. The private expenditure is estimated to be M$642 x 10^6.

The public development expenditure for MADA is estimated to be M$952 x 10^6 consisting of M$838 x 10^6 of tertiary development cost and M$115 x 10^6, or 12% of allocated cost of the Jeniang system, Beris dam and Tawar-Muda dam in High Growth Case and it is M$1,022 x 10^6 in Low Growth Case. The tertiary development cost is equal to that in the High Growth Case and the allocated cost of the 3 source projects is M$185 x 10^6, or 15% of the total expenditure.

6.5 Overall Plan Including Potential Projects

The Beris and Tawar-Muda dams can significantly mitigate the water deficit, but their water output is not enough to meet all the water deficit in a dry year. The remaining water deficit has to be eliminated by saving water use for the time being.

Among the potential source (including the Rui dam), the Reman, Merbok, Khlong Thepha and Rui dam are large in expected water output and their values of construction cost/ net water output are even smaller than that of the Tawar-Muda dam. Plans including some of the potential dams are studied for higher safely in supply.

It is assumed that the on-going Mengkuang dam, Ahning dam and Jeniang system and the proposed Beris dam are implemented under any plan. The Tawar-Muda dam is included only in the plans in which total water output of less costly projects is not sufficient to meet all water deficit in 2000 under the 1977 hydrological condition.

Net water output for 2000 water demand under the 1977 hydrological condition and preliminary value of EIRR are estimated for the Jeniang system, proposed dams and potential dams as shown in Table 34. Power benefit is counted with a unit power value of M$208/kW and M$0.145/kWh in estimating the value of EIRR for the Rui dam. The projects showing the value of EIRR less than 8% are not included in any source development plan.

Some potential projects can be implemented and some cannot be. All possible cases are assumed between two extreme cases; any of the potential projects can be implemented in our extreme case and no potential project can be implemented in the other. The latter case is identical with that described in 6.3.

There are 10 different cases consivable for High Growth Case. The optimum plan for each case is as shown in the upper part of Fig. 26. If the Rui dam is implemented with a net water output of 140 x 10^6 m^3, the Rui dam and Mengkuang dam can meet all water deficit in the Muda-Perai river system, so that the Jeniang system can take all water except for 2 m^3/s of river maintenance flow. Water additionally transferable to the Kedah river system is estimated to be 7 x 10^6 m^3.

Most source projects in any possible plan should be implemented as early as possible, becuase the existing water deficit is already large relative to its future increase. A relative present value of cost of overall plan may be approximately represented by a simple sum of the construction cost of all the projects involved, because the construction period is not much different among the projects. The lower portion of Fig. 26 shows the relationship between the simple sum of construction cost and total net water output for each case, with an indication of total water deficit in 2000 under the 1977 hydrological condition.

Only 3 cases are conceivable for Low Growth Case as shown in Fig. 27.

The plan shown for each case in Figs. 26 and 27 is the optimum one for the case. The selection among the plans solely depends on the potential projects which can be implemented.

It is noteworthy that high supply capacity with low cost can be attained if the Reman dam can be implemented, and furthermore all the water deficit can be met only if the Reman dam is implemented (H1, H2, H3 and L1 in Figs. 26 and 27). The Khlong Thepha and Tawar-Muda dams can be alternative or additional source development to the Beris and Reman dams. If water demand growth high like in High Growth Case, the Merbok storage and Rui dam are justified and very effective.

In conclusion, the Beris dam should be implemented in the immediate future, because of its significant impact in balancing regional water demand and supply and its definite viability from the economic point of view. Apart from the Beris dam, the Reman is probably the best source project. The possibility of the implementation of the Reman dam should be seriously scrutinized, through consultation and coordination among the concerned authorities. Further study should be carried out for the Khlong Thepha dam and Merbok storage at a pre-feasibility level. Mineral potential study should be carried out in order to clarify the possibility of the Rui dam. Some source projects are anyway needed to be implemented in addition to the Beris dam in the immediate future. They should be selected among the Tawar-Muda dam and the potential source projects.

7. FLOOD MITIGATION PLAN

7.1 Flood Mitigation Plan by River Basin

The existing river channels in the Region are generally so small as capable of flood discharge occurring once in only 2 years. The land is often flooded when flood takes place. Innundation in an upstream river stretch is usually compounded by poor discharge capacity in the downstream river channel. Basic countermeasure to flooding is either increase in the discharge capacity in the river channel or reduction in flood discharge. The increase in the discharge capacity is attained by the channel improvement such as straightening the river course and enlarging the river cross section in the problem river stretch and downstream. The reduction in flood discharge is conducted by retarding flood in a reservoir or a retarding basin, or by diverting a part of discharge through a bypass floodway.

The recommended flood mitigation plan is resulted from an alternative study by river basin from the economic point of view assuming a discount rate of 8%.

(1) The Perlis river flood mitigation plan

The predominant problem area in the Perlis river basin is Kangar, where the Temenggang, Korok and Gial rivers flow in and the Perlis river drain.

For High Growth Case, the best plan comprises the channel improvement of 23 km in total length for the lower stretch of the Perlis main stream, Temenggang river, upper stretch of the Gial river and the Arau river, bypass flood-ways of 22 km in total length to the north of Kangar and between the Gial river and the sea, and the Timah-Tasoh dam and Arau dam, as shown in Fig. 28. The design flood is a 50-year flood.

In Low Growth Case, the above-mentioned plan seems to be marginally viable in economic sense, and the construction of the Timah-Tasoh dam only is the best plan.

It is recommended that the Timah-Tasoh dam be developed including the flood control purpose, because it can reduce flood damage along the Korok river and in Kangar significantly. The other measures in the best plan for High Growth Case should be implemented depending on the socio-economic development in the river basin.

(2) The Kedah river flood mitigation plan

The problem areas in the Kedah river basin are located in the river stretches of Kuala Nerang and upstream of the Pelubang barrage.

The recommended plan for both High and Low Growth Cases is the channel improvement of 18 km in total length with a design flood of 10 years in return period for the river stretches containing bottlenecks upstream of Kuala Nerang, the Pelubang barrage and Alor Setar as shown in Fig. 29.

(3) The Muda river flood mitigation plan

The problem area in the Muda river basin is mainly located along the Ketil river, especially at Kuala Ketil.

The recommended plan for both High and Low Growth Cases is the channel improvement of 50 km in total length for the lower stretch of the main stream which has bottleneck, at the confluence of the Muda river and the Ketil river and in an upper stretch of the Ketil river with a design flood of 10 years in return period as shown in Fig. 30.

(4) The Perai river flood mitigation plan

The problem area in the Perai river is Butterworth along the lower stretch of the main stream.

The recommended plan for both High and Low Growth Cases is to provide a retarding basin upstream of the Perai barrage by reforming the existing swamp as shown in Fig. 31.

(5) The Pinang river flood mitigation plan

The problem area in the Pinang river basin is Georgetown, which develops along the Pinang river.

The recommended plan is the channel improvement of 2.4 km in length. This plan is economically unjustified in Low Growth Case, but it is still recommended because it can protect a large population.

7.2 Implementation Program of Flood Mitigation Plan

The construction schedule for High Growth Case is assumed as follows: In the Perlis river, the Timah-Tasoh dam is constructed during 5MP, the channel improvement in the main stream and the Temenggang river, and excavation of the bypass floodway to the north of Kangar are conducted in 6MP and the other works for the Gial and Arau rivers is carried out in 7MP. For the Kedah river, the river improvement is provided in 5MP for the Alor Setar area, in 6MP upstream of the Pelubang barrage and in 7MP in the Kuala Nerang area. For the Muda river, the channel improvement work is carried out for the lower stretch of the main stream in 5MP and 6MP and for the other areas in 7MP. The retarding basin in the Perai river is constructed in 5MP. The channel improvement in the Pinang river is carried out in 7MP.

The construction schedule for Low Growth Case is different from that for High Growth Case in the following points. For the Perlis river, only the Timah-Tasoh dam is constructed. The channel improvement for the Alor Setar area is delayed from 5MP to 6MP.

The investment schedule at 1982 constant price, corresponding to the above-mentioned construction schedule is shown in Table 35.

7.3 Effects of Flood Mitigation Plan

The principal feature of the recommended flood mitigation plan is shown in Table 36 for High Growth Case and in Table 37 for Low Growth Case.

In the plan for High Growth Case, the total investment cost is estimated to be M$138.6 x 10^6. The annual equivalent of flood damage of M$20.49 x 10^6 can be reduced by M$14.15 x 10^6, or 69%, assuming a discount rate of 8%. The value of EIRR ranges between 11.1% for the Muda river and 18.4% for the Perai river. Average annual flooded area of 39 km^2 is reduced by 13.7 km^2, or 35%. Average annual population affected by flood is projected to be 33,500 to the year 2000 under without the project condition. Out of this, 23,300, or 70% are protected.

In Low Growth Case, the total investment cost is M$107.2 x 10^6 at 1982 constant price. Annual equivalent of flood damage of M$11.17 x 10^6 is reduced by M$6.46 x 10^6, or 58%. The value of EIRR ranges between 7.6% for the Pinang river and 12.9% for the Perai river. Average annual flooded area of 39 km^2 is reduced by 11.7 km^2, or 30%. Out of average annual affected population in 2000 of 29,900, 16,000 or 54% are protected.

7.4 Pre-Feasibility Design of Channel Improvement for the Lower Muda River

The major benefitted area of the recommended flood mitigation plan for the Muda river is located in and around Kuala Ketil where 10-year flood discharge is estimated to be 340 m^3/s. The discharge capacity of the lower stretch of the Muda river is 400 m^3/s on an average but it involves several sections capable of only 200 - 320 m^3/s. These facts imply that an increase in discharge capacity at Kuala Ketil if intended will be constrained by poor discharge capacity in the lower Muda river. Even if the discharge capacity at Kuala Ketil is effectively increased, that will result increased flood damage in the lower Muda river. It is, therefore, recommended that the channel improvement be provided for the lower Muda river first.

A design of channel improvement for the lower Muda river at a pre-feasibility level is described hereunder.

7.4.1 Cross section survey

A river cross section survey was carried out for a 33.8 km long river stretch of the Muda river between the Muda barrage and the confluence of the Muda river and the Sedim river in February and March 1983, as one of the undertaking by the Government of Malaysia for the Study. The location of surveyed cross section is indicated in Fig. 32.

7.4.2 Design criteria

The existing river cross section is 100 - 150 m in width and about 5 m in depth for 10 km between the section No. 1, the Muda barrage, and section No. 9, where the longitudinal slope of riverbed is 1/10,000 on an average. It is 60 - 100 m in width and about 7 m in depth for 23.8 km between the section No. 9 and No. 26, where the longitudinal slope of riverbed is 1/5,000 on an average.

There are 6 intakes as shown in Fig. 32. The river is crossed by the Merdeka bridge at the section No. 3 and a railway bridge at section No. 13. There are bunds on both banks distant from the river channel by 100 - 800 m.

The existing river channel seems to be stable showing neither significant erosion nor sedimentation. The overflow crest of the Muda barrage is located at El. -0.9 m which is higher by about 1 m than the riverbed about 1 km upstream. It seems that sedimentation upstream the barrage has little developed, but it is desirable to assume a horizontal sedimentation for the future. For the operation of existing intakes it is desirable that the existing channel cross section is unchanged. No backswamp problem is expected even if a continuous bund is constructed along the river channel, because the existing bunds shut down major runoff which is caused by rainfall behind the bunds. Taking into account these, a composit cross section channel is recommended.

7.4.3 Design

The design flood discharge is 1,100 m^3/s corresponding to 10-year flood. For the stretch between the sections No. 1 and No. 9, the longitudinal slope is set to be level and the standard cross section consists of a low flow channel of 130 m in bottom width and 7 m in the design water depth, and flood water channels of 65 m in bottom width and 3 m in the design water depth on both sides of the low flow channel. The bottom of the flood water channel is generally set at the existing ground level and continuous bunds are constructed on both banks. For the stretch between the stations No. 9 and No. 26. The longitudinal slope is set to be 1/5,000. The low flow channel is 80 m in bottom width and 7 m in design water depth. The flood flow channels of 50 m in standard bottom width and 2.5 m in design water depth with continuous bunds are provided on both sides of the low flow channel.

The proposed plan is shown in Fig. 32, proposed longitudinal profile is illustrated in Fig. 33 and proposed cross sections are shown in Figs. 34 and 35.

7.4.4 Construction Plan

Major work quantities are excavating of 1.7 x 10^6 m^3, embankment of 1.7 x 10^6 m^3, sod facing of 1.2 x 10^6 m^2 and pavement of 270,000 m^2.

The construction work will require 10 years between 1986 and 1995 including 1 year of preparatory work.

Earthwork forms a critical path. Maximum rate of annual earthwork is estimated to be 90,000 m^3/y of under-water excavation 170,000 m^3/y of dry excavation and 300 x 10^3 m^3/y of embankment. Assuming that 6 months between January and June are workable, the following earth moving equipment is required.

2 - backhoe
30 - dump truck
9 - loader
17 - Bulldozer

7.4.5 Construction cost

The construction cost is estimated to be M$27.9 x 10^6 including the costs for construction work of M$16.5 x 10^6, engineering service of M$1.7 x 10^6, compensation of M$6.4 x 10^6 at 1982 constant price as shown in Table 38.

8. WATER POLLUTION ABATEMENT PLAN

8.1 Water Pollution Projection

Man-made pollution in river water is, first of all, detected by organic pollution, which adversely affects domestic and industrial water use, irrigation and other water uses if reaches to a certain level. The organic pollution in water is well represented by the concentration of biochemical oxygen demand (BOD), which is the oxygen used to meet the metabolic needs of aerobic micro-organisms in water rich in organic matter. The self-purification mechanism of a river is largely reduced and the aquatic eco-system is affected if the concentration of BOD exceeds 5 mg/l. Odour occurs when the concentration of BOD in water is greater than 10 mg/l. It is desirable to control the concentration of BOD in the river below 10 mg/l from the viewpoint of environmental quality.

The ordinary water treatment method for the domestic water supply is the sedimentation, filtration and chlorination, if BOD concentration in raw water is not more than 2 mg/l. The ordinary treatment method for the industrial water supply is the sedimentation, if BOD concentration in raw water is not more than 5 mg/l. For BOD concentration in raw water more than the above-mentioned limit but not more than 20 mg/l, pre-treatment is carried out by the rapid sand-filter bed and activated carbon absorption (secondary treatment). For BOD concentration between 20 and 200 mg/l, an aerated lagoon process such as aerated lagoon or maturing pond (primary treatment) is further needed. Major sources of organic pollution in the rivers in the Region are domestic and industrial sewage in urban and rural areas, effluent from rubber factories, palm oil mills and sugar mills and animal husbandry.

A projection of BOD concentration in the rivers assuming the minimum 5-day runoff occurred in 1977 is made to 2000.

The results are described for major rivers hereunder.

(1) The Perlis river

The pollution source in the Perlis river is urban sewage from Kangar, if the sugar mill in the upstream reaches is provided with an effluent treatment system. It is estimated that BOD load discharged from Kangar into the river in 2000 is 6 tons/d for High Growth Case and 2 tons/d for Low Growth Case. The river will be clean in the upper and middle stretches but it will be grossly polluted below Kangar with BOD concentration of more than 80 mg/l in either case by 2000.

(2) The Kedah river

Major pollution sources are Alor Setar, Jitra and 2 rubber factories near Alor Setar. BOD load discharged into the river in 2000 is estimated to be 11 tons/d from urban areas, 1 ton/d each from rubber factories and rural areas for High Growth Case, and 4 tons/d from urban areas and 1 ton/d each from rubber factories and rural areas for Low Growth Case. The tributaries will be clean in upper and middle reaches except that the stretch below Jitra is mildly polluted, but the main stream below Alor Setar will be grossly polluted showing BOD concentration of 37 mg/l in High Growth Case and 28 mg/l in Low Growth Case by 2000.

(3) The Merbok river

Sg. Petani, Tikam Batu and 11 rubber factories are the major pollution sources in the Merbok river, where runoff is small. BOD load discharged into the river in 2000 is estimated to be 6 tons/d from the rubber factories and 14 tons/d from Sg. Petani and Tikam Batu for High Growth Case and 6 tons/d from the rubber factories and 4 tons/d from the towns for Low Growth Case. The entire main stream will be grossly polluted showing BOD concentration of 111 mg/l in High Growth Case and 92 mg/l in Low Growth Case.

(4) The Muda river

There are 12 rubber factories and 1 palm oil mill, which discharge effluent into the Muda river or its tributaries. BOD load discharged into the river in 2000 is estimated to be 2 tons/d from the rubber factories and palm oil mill and 1 ton/d from rural areas for High Growth Case and 2 tons/d from the rubber factories and palm oil mill for Low Growth Case. The Muda river will be entirely clean even in 2000.

(5) The Perai river

Kulim and 10 rubber factories and a rural place of animal husbandry are major pollution sources in the Perai river, while Butterworth, other towns and animal husbandry discharging effluent into the sea, being located near the sea coast. BOD load discharged into the river in 2000 is estimated to be 5 tons/d from the rubber factories, 2 tons/d from Kulim and 2 tons/d from rural areas for High Growth Case, and 5 tons/d from the rubber factories, 1 ton/d from Kulim and 2 tons/d from rural areas for Low Growth Case. The river will be grossly polluted in the vicinity of Kulim, BOD concentration being 25 mg/l in High Growth Case and 17 mg/l in Low Growth Case, and also grossly polluted at the estuary showing BOD concentration of 19 mg/l in High Growth Case and 17 mg/l in Low Growth Case by 2000.

(6) Other rivers

In the Juru river major pollutant source are Bukit Mertajam, a rubber factory and animal husbandry. BOD load in 2000 will be 2 tons/d from Bukit Mertajam and 1 ton/d from rural area in High Growth Case and 1 ton/d each from Bukit Mertajam and rural area in Low Growth Case. BOD concentration in the lower stretch will be high of 35 mg/l in High Growth

Case and 23 mg/l in Low Growth Case, because low river flow is small compared with the pollutant load.

In the Jejawi river major pollutant sources are 2 rubber factories, 2 palm oil mills and animal husbandry. BOD concentration will be less than 5 mg/l even in 2000, BOD load being estimated to be 2 tons/d from rural area for High and Low Growth Cases.

In the rivers in the Pinang island, BOD load in 2000 is estimated to be 7 tons/d from rubber factories, 3 tons/d from urban area and 1 ton/d from rural area in High Growth Case and 7 tons/d from rubber factories and 1 ton/d each from urban area and rural area in Low Growth Case. BOD concentration in each river is not quantified.

8.2 Recommended Water Pollution Abatement Plan

It is assumed that BOD concentration should not be more than 5 mg/l in river stretches where intakes are located and 10 mg/l in other river stretches.

The recommended measures to attain the above-mentioned standard are the improvement of purification facilities in all the rubber factories, palm oil mills and sugar factories, and sewerage development in large towns. There is no significant measures to reduce BOD load from small towns or rural areas. If the standard cannot be attained with all the above-mentioned measures, either augmentation of river flow by operation of storage dams or diversion of urban sewage to the sea through a conduit is recommended.

(1) The Perlis river pollution abatement plan

The lower reaches of the Perlis river will be polluted, because 2 m^3/s of sewage containing a high BOD load from Kangar is discharged in the river where the dry season runoff is only 0.93 m^3/s.

Three alternative measures are proposed for the pollution abatement in the lower reaches of the river. Alternative 1 is to provide a sewerage system to Kangar and to augment the river flow with the Timah-Tasoh dam. Alternative 2 is to provide a sewerage system for Kangar and a conduit of 9 km in length, which conveys sewage into the sea. Alternative 3 is to augment the river flow with the Timah-Tasoh dam with no sewerage development in Kangar.

In Alternative 1, the sewerage development with an investment of M$74 x 10^6 at 1982 constant price can reduce BOD load by 4 tons/d in High Growth Case and that with an investment of M$33 x 10^6 can reduce BOD load by 1 ton/d in Low Growth Case. An augmentation of dry season runoff to 1.5 m^3/s in High Growth Case and 0.4 m^3/s in Low Growth Case is required, if BOD concentration should be 10 mg/l.

In Alternative 2, the sewerage development with an investment of M$80 x 10^6 in High Growth Case or M$39 x 10^6 in Low Growth Case at 1982 constant price can keep the river clean by totally eliminating Kangar sewage from the river.

In Alternative 3, the low river flow should be augmented to 4.8 m^3/s.

Annual outflow required for the Timah-Tasoh dam to maintain BOD concentration in the river less than 10 mg/l under the 1977 hydrological condition is estimated to be 3.4 x 10^6 m^3 in High Growth Case and 0.29 x 10^6 m^3 in Low Growth Case for Alternative 1 and 90.5 x 10^6 m^3 in High Growth Case and 14.2 x 10^6 m^3 in Low Growth Case for Alternative 3. It is probable that the Timah-Tasoh dam can meet the above-mentioned requirement at reasonable cost if Alternative 1 is selected but it cannot afford to deliver such a large volume of water as required by Alternative 3.

Selection between Alternatives 1 and 2 depends on the cost of the Timah-Tasoh dam, which is being studied by a study team. It is herein assumed that Alternative 1 is selected.

It is necessary to provide purification facilities at the sugar mill to keep BOD concentration below 10 mg/l in the upper reaches of the river.

(2) The Kedah river pollution abatement plan

BOD concentration will be high in the lower stretch of the Kedah river, due to sewage discharged from Alor Setar.

Alternative 1 is sewerage development in Alor Setar and augmentation of river flow with a dam. Alternative 2 is sewerage development in Alor Setar and construction of an 8 km long conduit which conveys sewage into the sea, so that the lower stretch of the Perlis river is kept clean.

In Alternative 1, the sewerage development with an investment of M$247 x 10^6 in High Growth Case or M$89 x 10^6 in Low Growth Case can reduce BOD load by 5 tons/d in High Growth Case or 2 tons/d in Low Growth Case. Low flow in the river needs to be increased to 6.2 m^3/s in High Growth Case and 2.3 m^3/s in Low Growth Case.

In Alternative 2, the sewerage development with an investment of M$257 x 10^6 in High Growth Case or M$99 x 10^6 in Low Growth Case can totally eliminate Alor Setar sewage from the river.

Either of the Alternatives seems to be feasible. It is herein assumed that Alternative 1 is taken up.

The improvement of purification facilities in the 2 rubber factories should be conducted.

No measure is recommended for Jitra, because there is no intake downstream of Jitra and BOD concentration is less than 10 mg/l.

(3) The Merbok river pollution abatement plan

The improvement of purification method in all the existing rubber factories is essential for the pollution abatement in the Merbok river. Low river flow in the Merbok river is so small as grossly polluted even by the sewage from Sg. Petani only.

Alternative 1 is the sewerage development for Sg. Petani and augmentation of river flow by diverting water from the Muda river.

Alternative 2 is the sewerage development for Sg. Petani and construction of an 8 km long conduit to bypass sewage from Sg. Petani to the Muda river downstream of the Muda barrage.

Alternative 1 is not applicable, because annual volume of water to be imported from the Muda river is so large as 370×10^6 m^3 in High Growth Case and 130×10^6 m^3 in Low Growth Case, that is greater than the net water output expected from the proposed Beris or Tawar-Muda dam.

Alternative 2 is recommended. Its investment cost is estimated to be M\$162 $\times 10^6$ in High Growth Case and M\$67 $\times$ 10^6 in Low Growth Case.

(4) The Muda river pollution abatement plan

The improvement of purification method in all the rubber factories and the palm oil mill is recommended. By this measure BOD concentration in the whole Muda river system can be kept below 3 mg/l even in High Growth Case.

(5) Perai river pollution abatement plan

The lower reaches of the Perai river is polluted mainly by the effluent from rubber factories, but the Kulim river is polluted by the sewage from Kulim.

The recommended plan includes the improvement of purification method for the rubber factories and sewerage development for Kulim. By these measures, BOD concentration in the Kulim river will be less than 5 mg/l even in High Growth Case.

(6) Pollution abatement plan in other rivers

The improvement of purification method in all the rubber factories and palm oil mills is recommended also for the other rivers.

In the Juru river, a sewerage system is under construction for Bukit Mertajam as a part of the sewerage system of Butterworth. With this system completed, BOD concentration in the river will be less than 10 mg/l.

The Jejawi river does not need any measure for pollution abatement.

Water quality in the rivers in the Pinang island will be improved, though not quantified in terms of BOD concentration, because the improvement in purification method in the rubber factories will reduce total BOD load from 11 tons/d to 4 tons/d in High Growth Case and from 9 tons/d to 2 tons/d in Low Growth Case.

8.3 Implementation Program of Water Pollution Abatement Plan

The recommended targets of water pollution abatement plan by 1990 and 2000 are shown in Table 39 for the improvement of purification method in rubber factories, palm oil mills and a sugar mill, and in Tables 40 and 41 for the sewerage development, including those for Butterworth and Georgetown, which are not effective for water pollution abatement but on-going for the improvement of public health.

The construction cost for the public sewerage development is estimated based on the actual cost of on-going projects and estimated cost in previous studies, divided into public and private expenditure, generally assuming that costs of house connection pipe in the existing town area and the costs of branch sewer and house connection pipe in the new town area are born by private. For the new town development areas in major towns such as Alor Setar and Sg. Petani where there is no public sewerage system, even central collection system and treatment facilities are assumed to be constructed by private developers at their own cost.

The public and private expenditures for the recommended sewerage development plan are estimated by the Malaysia Five Year Development Plan period as shown in Tables 42 and 43 for High Growth Case and in Tables 44 and 45 for Low Growth Case.

The construction cost of purification facilities in rubber factories, palm oil mills and a sugar mill are estimated as shown in Table 46, based on information provided by DOE.

8.4 Effects of Water Pollution Abatement Plan

8.4.1 Environmental effect

Out of 361 km of river stretches studied, 10 km in the Perlis river, 12 km in the Kedah river, 22 km in the Merbok river and 8 km in the Perai river will be polluted with BOD concentration higher than 10 mg/l by 2000 if no water pollution abatement measure will be taken. On the other hand BOD concentration will be less than 10 mg/l in all these river stretches if the recommended water pollution abatement plan is implemented.

8.4.2 Social effect

The recommended public sewerage development, if implemented, will contribute to the improvement of public health by providing service to population of 553,000 by 2000 in High Growth Case and 356,000 in Low Growth Case.

8.4.3 Economic effect

The recommended plan cannot be justified from the point of purely economic view, but it should be implemented because of its importance from the viewpoint of environmental and social objectives.

9. LEGAL AND INSTITUTIONAL ARRANGEMENT

9.1 Distinctive Features of the Region from the Administrative Point of View

The Kedah-Muda-Perai river system forms an undivided water demand and supply balance system spanning the States of Perlis, Kedah and Pulau Pinang, where water is utilized for various purposes. An equitable coordination among water-related agencies and among the States should be maintained for the development and management of water resources in the river system.

A new project which uses water, automatically causes trade-off of water among the new and existing projects, under the condition that water deficit already takes place. The trade-off of water may result a greater loss in existing projects than the benefit which accrues in the new project. An integrated approach should, therefore, always be taken in making the decision on the implementation of water resources project. In principle, an additional water source should be developed, if a new project which takes water is envisaged.

The integrated approach is also required for the source development. The cause of water deficit and the area affected by the water deficit are not always identical each other as demonstrated in Section 4.7. All the existing source facilities and those to be implemented in the Kedah-Muda-Perai river system should be developed and operated to contribute to the multipurpose complex of water uses in the river system but not to limited projects.

Some of the desirable source projects still involve uncertainties. It is necessary to accept certain water deficit for the time being.

The costs of irrigation facilities are high compared with the present water charges collected from beneficiaries. A social problem is expected to be induced, if the principle of beneficiaries to pay the cost is immediately carried out.

9.2 Recommended Principles

Water resources are essential component required for the socio-economic development of Malaysia. That is especially true in the Kedah-Muda-Perai river system, where water deficit already takes place and desired socio-economic development can be attained only if water resources are developed accordingly. Water resources should be developed effectively and they should be managed efficiently consistent with the national socio-economic policy, which is published in the Malaysia Five Year Development Plan. The Federal Government should increase its leadership in water resources development and management in the Region.

Each of the States of Perlis, Kedah and Pulau Pinang should be entitled to a reasonable and equitable share in the beneficial uses of water of the Kedah-Muda-Perai river system. Each of them should convince the water uses and socio-economic needs by others and conduct the avoidance of water pollution and unnecessary waste in utilization of water, within its territory.

The States should collaborate in development and management of source projects and in water rationing in a manner that water resources are equitably allocated among the water users.

9.3 Recommendations on Administration System

9.3.1 Administrative Action Required

Presently the lower stretch of the Muda river is the major source of domestic and industrial water, of which demand will increase rapidly. The irrigation area in the lower 35 km stretch is 13,284 ha in the State of Pulau Pinang and 2,704 ha in the State of Kedah. There are minor irrigation projects of 1,248 ha in tributaries upstream of the stretch. The irrigation area in the State of Kedah expected to be developed in the lower stretch is 1,921 ha and that upstream of the stretch is 3,980 ha. On the other hand, there is no irrigation development plan in the State of Kedah but the existing irrigation area will be reduced by 471 ha.

According to an analysis, the Mengkuang dam can meet most water deficit which affects domestic and industrial water use. Some water deficit must take place in dry period due to increased water demand by irrigation development in the State of Kedah and growth of domestic and industrial water demand in the State of Pulau Pinang, until the Beris and Tawar-Muda dams are implemented. If the Jeniang system only is implemented it should be operated not interfering the downstream water uses. Even after all the 3 source projects are implemented, their operation may adversely affect to the downstream water uses if not properly operated.

The function of the Jeniang system is to supplement water in the southern half of the MADA area. Some water should be diverted from the Pedu dam to the same area even after the Jeniang system is completed. If wasteful water use takes place in the other half of the MADA area or in minor irrigation projects between the Pedu dam and Pelubang barrage, the southern MADA area will receive less water from the Pedu dam and accordingly it will require more water diverted from the Muda-Perai river system through the Jeniang system. The same case may occur, if the Pedu dam cannot supply sufficient water because it has used up storage due to inadequate operation in previous years.

All the source facilities should be operated according to a rule which ensures water to each State at an allocated rate and maximum benefit to all water users. Day-to-day operation of the source facilities should be integratedly controlled.

Hydrological stations should be established and operated at backwater ends and outlet work of each source facility in order to record the inflow and outflow. Key hydrological stations should be established and operated upstream of major demand centers in order to record river discharge for the use in operation of source facilities. The recommended locations of the key hydrological stations are Kangar in the Perlis river, backwater end of the Pelubang barrage in the Kedah river, upstream of the intake for the Pinang Tungal irrigation project in the Muda river and backwater end of the Perai barrage in the Perai river.

A schedule of discharges to be sustained at the backwater end of the Pelubang barrage and Muda barrage and a schedule of maximum rate of water which may be taken at each intake downstream of the Pinang Tungal intake should be agreed upon between the State of Kedah and State of Pulau Pinang.

Within the above-mentioned discharge, each responsible agency should determine and enforce a schedule of maximum rate of water which may be taken at every intake. It is desirable that the maximum rate of water to be taken is determined a little below the normally required rate in order to promote water saving by individual water users.

An extraordinary drought takes place once in 5 years, according to hydrological record between 1961 and 1980. The extraordinary drought should be officially declared and water rationing should be started, if the water level at a key hydrological stations lowers below a predetermined drought water level and outflow from relevant dams cannot be increased according to the operation rule. No priority is probably necessary, because water deficit under the extraordinary drought is not large compared with total water demand, if the Jeniang system, Beris dam and Tawar-Muda dam are implemented.

It is recommended that DID should manage the river maintenance flow, because its function has covered a wide range of river management.

9.3.2 Master agreement on regional water resources development and management

The legislation of the National Water Code has been recommended by NWRS, for the purpose of establishing a coordination system and promoting uniformity of water resources development and management. A draft water resources code is being prepared by the Government. As an interim measure until the code is legislated, it is recommended to make a master agreement on the regional water resources development and management among the Federal Government and the State Government of Perlis, Kedah and Pulau Pinang as outlined below.

(1) A Regional Water Resources Master Plan shall be formulated and authorized by the Federal Government and the Government of the three States. The Plan shall provide for (a) the target envisaged by each State for the development of domestic and industrial water supply, irrigation and river maintenance flow, (b) the target water demand which each State intends to meet, and (c) the outline of water source development projects to be implemented in the Region in immediate future. Water resources development within the Region shall be implemented according to the Plan.

(2) Each State shall properly manage water use in the river stretches within the State at all times. The allocation of water shall be undertaken according to an agreement which shall be made among the three States. All source facilities within the Region shall be integratedly managed according to the operation rules which shall be approved by the three States.

(3) The costs for development and management of water source facilities within the Region shall be equitably allocated according to a rule which shall be agreed by the three States.

(4) The Federal Government shall show the States an arbitration proposal at the request by one of the three States and the States shall duly consider the proposal, if there is a dispute between the States regarding the interpretation of this Agreement or setting up of a subsidiary agreement or rule based on this Agreement.

In order to ensure its effectiveness, the Agreement should be adopted or approved by the Federal Government and the Governments of the three States. It is more desirable that the Agreement shall be established as a Regional Water Policy of the National Land Council or the equivalent.

9.3.3 Regional water resources master plan

The regional water resources master plan as proposed by NWRS should include the statements on the development targets envisaged by each state for public water supply, irrigation and river maintenance flow, the target water demand which each state intends to meet, and water source development projects to be implemented in immediate future. The plan should be revised, if a significant change in the targets is necessary.

The plan should bind the Federal Government and State Governments in controlling water use and developing the source facilities including financing on them, but it may not bind the development of direct facilities such as water supply system and irrigation system. The water source projects should be implemented according to the program set forth in the plan. For this purpose, the Federal Government should provide financial and technical support. The State Government should acquire, reserve or alienate necessary land. Each federal/state agency should finance the cost allocated to it. An executing agency of the implementation should be appointed by all the agencies concerned. Each state government should be responsible for controlling water demand not to exceed over the target provided in the plan.

9.4 Recommendations on Financial System

A cost allocation rule is essential for the multipurpose development. The rule should be established by the Federal Government as a condition of federal grant and loan. Among a number of cost allocation methods having been proposed, there is neither unique correct method nor standardized method, but the separable costs-remaining benefit method is predominantly employed. The allocation method should be selected from the viewpoint that the desired socio-economic goal is best promoted, since cost allocation directly affects the economic and social efficiency of a multipurpose project.

A large investment is required not only for water resources development but for the socio-economic development of Malaysia. It is desirable to conduct the principle of beneficiaries-to-pay in view of capital efficiency and promotion of people's participation in development.

The cost of domestic and industrial water after all the proposed development is completed is estimated to be M\$0.7/m^3 on an average. It corresponds to a unit cost of domestic water supply of M\$0.58/m^3 and that of commercial water supply of M\$1.16/m^3, if a ratio of 1:2 is assumed between the unit costs of the two purposes. The estimated cost of domestic water supply is about 0.7% of private household expenditure and that of commercial water supply is 0.9% of gross value of manufacturing output. These seem to be within the capacity-to-pay of consumers.

The water rate of PWA has been revised from time to time in recent years. It is M\$0.30/m^3 for domestic use and M\$0.40/m^3 for commercial use, according to the tariff applicable in 1983. This rate indicates the present cost of water, because the account of PWA usually shows a reasonable surplus. With new facilities increasingly coming in, the cost of water will increase and will reach the above-mentioned cost in the future. It seems possible for PWA to continue its sound account toward future by revising its tariff from time to time.

The rate of public water supply of M\$0.22/m^3 for domestic use and M\$0.44/m^3 for commercial use has remained unchanged for years in the States of Perlis and Kedah. The water supply account is in deficit in these States. The management and development of water supply system to meet increasing demand cannot be undertaken, unless a sound account is established. It is recommended to include provisions for accounting and auditing procedure in the Water Supply Fund Enactment of these States.

The cost of source facilities for domestic and industrial water supply owned by private enterprise is estimated to be M\$0.05 - 0.08/m^3. The rate of raw water for private water supply system should be established to cover this cost.

The investment of irrigation development is totally made from federal grant with little exceptions. O&M cost of the proposed irrigation facilities is estimated to be M$218/ha for the MADA area and M$170/ha for minor irrigation projects. It is probable that this cost will be also within the capacity-to-pay, because farmers' real income will largely increased by irrigation development. On the other hand, the present irrigation rate is M$20 - 25/ha in the MADA area and M$7 - 15/ha in minor irrigation projects. Immediate rising of water rate is not practical, because the willingness-to-pay is estimated to be low under the existing rate structure. It is recommended that irrigation water rate should be gradually increased and all O&M cost should be covered by water rate collected in the future.

Water resources development project often involves compensation problems in acquiring the land. The Land Acquisition Law provides that a monetary compensation shall be made based on the commercial value of the land in acquiring an alienated land, but there is no other law specifically applicable to non-alienated land or any other properties. Under these circumstances, the compensation problem should be settled based on the Common Law or privately. It is normal that the compensation is made based on the market value of the land to be acquired or the properties which will be lost or damaged. There may be cases that the affected personnel cannot find substitutional means of living because the value of the original land is evaluated to be too low to pay for a substitutional land, or there is no employment opportunity if the original profession is sticked to. It is desirable to make some administrative arrangement such as giving priority for the affected people to enter in a resettlement scheme, arranging a job training course, proving special loan and to conduct other measures.

9.5 Recommendations on Institutional System

It is assumed that the construction will start in 1985 for the Jeniang system and in 1986 for the Beris and Tawar-Muda dams. An implementation program is prepared for the financial arrangement before the construction is started. The implementation program for the multipurpose facilities should be prepared based on a concensus among the concerned agencies. Otherwise confusions and conflicts are expected regarding the costs and uses of facilities. It is necessary to establish the institutional system as recommended by NWRS within 1984.

The recommended institutions are the National Water Resources Committee (NWRC), Federal Water Resources Division (FWRD), State Water Resources Committee (SWRC), State Water Resources Division (SWRD) and Water Resources Development and Management Corporation (WRDMC).

Herein the functions of the recommended institutions are elaborated for the matters to be undertaken for the time being.

FWRD should be established in EPU, consisting of administrative staff and engineering staff. The latter should be seconded from DID, PWD and some other federal agencies. FWRD should prepare a master agreement for the regional water resources development and management and regional water resources master plan for the Region for the approval by NWRC and SWRCs. It should also prepare a rule for cost allocation of multipurpose project, procedure for grant allocation to the river maintenance flow, and WRDMC Act. It is also important for FWRD to prepare various guidelines to maintain uniformity and efficiency of the activities of SWRC and SWRD. FWRD should supervise WRDMC and it should persuade federal and state agencies to entrust the implementation and management of multipurpose projects to WRDMC.

NWRC should be endowed with function of coordinating the activities of SWRCs, which have to negotiate each other on the right and responsibilities in water and related land management and also it should reflect the federal policy in appraising various agreements and rules. In order to ensure these functions, the members of NWRC should be appointed by NDPC.

SWRD should be established in SPU, of which engineering staff should be seconded from DID and PWD/PWA. It should collaborate with FWRD in preparing the master agreement and regional water resources master plan. SWRD should initiate to prepare a comprehensive water resources inventory, schedule of water taken by each intake, water rationing plan, river maintenance flow and water quality standard in rivers. SWRD should supervise the control of intakes and water rationing which are undertaken by DID and PWD/PWA.

The members of SWRC should be appointed by EXCO by the similar reason mentioned for NWRC.

WRDMC should establish a regional headquarters in the Region. It should also establish a communication network for the central control of water source facilities being entrusted by the State Governments. WRDMC should prepare a proposal of operation rules of source facilities, discharge to be ensured at key hydrological stations and drought water levels, for the appraisal by SWRC. The most urgent task of WRDMC is to undertake the implementation of the Jeniang system, Beris dam and Tawar-Muda dam, being entrusted by the Federal and State Governments.

10. PART 2 STUDY

According to the Scope of Work, a feasibility study in Part 2 is carried out in 12 months for a dam project which is selected as a result of Part 1. It is herein recommended that the Beris dam be taken up for Part 2 Study.

The pre-feasibility study in Part 1 was conducted to examine the technical possibility of implementation of the proposed projects and priority ranking, but the objective of the feasibility study in Part 2 is to evaluate the Beris dam project from the technical, economic, financial and social points of view and to prepare an implementation plan for the dam.

The objective of the intended feasibility study is divided into four components; (1) recommendations on water allocation, (2) preliminary design of the Beris dam, (3) evaluation of the Beris dam, and (4) preparation of an implementation program of the Beris dam:

(1) Recommendation on water allocation

The shear of water demand by each source project is important from the social and political points of view, but it is theoretically indeterminate, under the condition that even the total water output by the on-going and recommended source facilities cannot meet all the existing water deficit. Scme alternative plans for water allocation by demand by cource projects will be worked out for the consideration by the Federal and State Governments. Water reaching a demand center is usually a mix of natural flow and output from a source project. Source project should be operated to attain a target discharge at an appropriate point. A monitoring system will be proposed. It will consist of several hydrological station, for each of which discharge schedule is established. An integrated operation plan of the existing and proposed source projects will be presented, based on the hydrological record since 1961.

(2) Preliminary design of the Beris dam

The design, construction planning and cost estimate will be carried out in order to show the technical feasibility and investment requirement of the project.

(3) Evaluation of the Beris dam

The Beris dam project will be evaluated from the economic, financial, social and environmental points of view and the compensation method will be studied, for the consideration by the decision-makers.

(4) Preparation of an implementation program of the Beris dam

Information necessary for the implementation of the Beris dam project will be summarized in an implementation program, including a water allocation among the States, proposed financial arrangement, proposal for the implementation and management agencies, operation rule of source facilities and proposed control of intakes.

TABLES

Table 1 LIST OF DIRECT PARTICIPANTS IN THE STUDY

Colombo Plan Expert

E. Sazawa (MOC)

SPECIAL ABBREVIATIONS

MOC : Ministry of Construction

NK : Nippon Koei Co., Ltd.

CTI : CTI Engineering Co., Ltd.

SSC : System Science Consultants Inc.

OHBA: Ohba Co., Ltd.

Study Team

Team Leader
- I. Kuno (NK)

Deputy Team Leader
- N. Hirose (NK)

Member
- S. Nishioka (NK)
- Y. Matsumoto (NK)
- M. Akagawa (NK)
- M. Mizutani (NK)
- S. Sato (NK)
- S. Ezoe (NK)
- Y. Murakami (NK)
- Y. Watanabe (NK)
- T. Naito (SSC)
- S. Shimura (SSC)
- A. Takato (NK)
- M. Ohuchi (NK)
- T. Nomura (NK)
- Y. Motoki (NK)
- N. Fukuda (NK)
- S. Heishi (CTI)
- M. Otogawa (CTI)
- H. Inujima (SSC)
- H. Suzuki (OHBA)
- T. Shiina (OHBA)
- T. Harada (OHBA)
- H. Nakajima (OHBA)
- Y. Azuma (OHBA)

Counterpart Officers

Chief Counterpart
- Sieh Kok Chi (DID)

Counterpart (Federal Government)
- Lee Choong Min (DOE)
- Foong Kam Chong (MADA)

Counterpart (Perlis State)
- Saffie Bakar (EPU)
- Mohd. Arif b. Abd. Ghani (DID)
- Abu Bakar bin Sudin (DID)
- Teng Jit Seng (PWD)
- Alzahari b. Hj. Hassan (PWD)

Counterpart (Kedah State)
- Abdul Mukthi (EPU)
- Syed Rahman (EPU)
- Liew Chook San (DID)
- Lim C.H. (DID)
- Lim Meow See (PWD)
- Tan Swee Kwong (PWD)
- Chiah (PWD)
- Tan Mohd. Aminuddin Ismail (Forest Department)

Counterpart (Pulau Pinang State)
- Vijayalakshmi (EPU)
- Lee Yow Ching (PWA)
- Lim Weng Yit (DID)
- Oo Gin Kok (DID)

Counterpart (Perak State)
- Abu Hassan Shaari (EPU)
- Joseph Yeoh (DID)
- Lee Daw Hwa (DID)

Table 2 LIST OF MEMBERS OF COMMITTEES ESTABLISHED TO SUPPORT THE STUDY

Advisory Committee

Chairman
- H. Tamamitsu (MOC)

Member
- Y. Itobayashi (MOC)
- S. Ohno (MOC)
- T. Fujii (MOC)
- H. Fujita (MOC)
- J. Yokota (MOC)
- T. Fujisawa (MOC)

Legal and Institutional Advisor
- H. Mori (MOC)

Coordinator
- Y. Okazaki (JICA)
- R. Ono (JICA)

Steering Committee

Chairman
- Ali Abu Hassan (EPU)

Member
- Members of Technical Committee
- Representatives of Federal Departments and State Governments

Secretary
- Rosman bt. Hj. Jentra (EPU)

Technical Committee

Chairman
- Cheong Chup Lim (DID)

Member
- Chan Boon Teik (PWD)
- Rosmah bt. Hj. Jentra (EPU)
- Jamilah bt. Talib (EPU)
- Th'ng Yong Huat (NEB)
- Peter Ho Yueh Chuen (DOE)
- Chiah Bee Peng (AGC)
- Colombo Plan Expert

Secretary
- Sieh Kok Chi (DID)

Table 3 MONTHLY RUNOFF RECORD AT KEY STATIONS (1/2)

Basin: Perlis
Station: Titi Konkerit Baru (6502431 & 6502432) Catchment Area: 150 km^2

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	4	2	1	1	2	5	4	3	4	11	6	14	57
1962	11	2	1	1	15	3	5	7	17	12	6	3	82
1963	2	1	0	0	0	1	1	0	15	14	14	9	57
1964	3	2	1	0	13	2	1	0	1	5	14	6	48
1965	2	1	0	0	1	1	8	7	8	6	10	16	61
1966	7	3	1	1	15	4	3	4	9	19	16	22	103
1967	23	5	2	1	12	14	7	11	15	20	9	8	126
1968	3	2	2	6	1	1	1	6	7	15	7	3	54
1969	5	2	1	12	7	4	3	3	4	18	24	13	94
1970	6	3	2	1	5	4	10	7	12	8	9	12	77
1971	15	3	4	1	3	11	5	3	7	20	11	8	93
1972	5	2	1	7	2	2	1	1	40	11	28	22	122
1973	7	3	2	3	2	4	4	19	6	12	10	19	91
1974	5	2	1	1	2	2	1	1	3	7	8	4	37
1975	21	1	2	1	4	6	2	3	7	7	8	12	73
1976	1	1	1	1	6	3	12	7	26	14	27	4	102
1977	1	1	1	0	1	2	1	7	16	10	2	1	42
1978	1	1	2	2	6	1	4	8	8	8	10	8	58
1979	1	1	1	4	10	4	15	4	5	6	21	4	74
1980	3	3	2	3	3	3	3	16	13	26	11	6	94
Mean	6	2	1	2	6	4	5	6	11	13	13	10	78

Basin: Kedah
Station: Lengkuas (6204421) Catchment Area: 1,270 km^2

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	15	8	17	24	36	21	10	8	20	101	73	48	382
1962	34	7	9	12	60	14	47	34	112	229	76	8	641
1963	7	4	3	2	10	2	5	3	26	128	127	22	337
1964	2	1	2	3	20	11	15	10	69	69	151	27	379
1965	3	2	8	15	19	7	12	55	96	186	209	249	861
1966	37	14	14	13	32	48	14	13	54	193	159	135	724
1967	120	12	12	17	63	57	62	45	66	254	149	97	953
1968	24	11	26	80	31	18	24	31	71	146	93	91	645
1969	46	17	10	7	8	30	36	149	80	121	191	100	795
1970	40	19	11	5	35	25	35	60	79	118	110	100	637
1971	58	38	108	24	13	53	45	88	147	211	170	104	1,059
1972	52	25	22	140	53	21	11	11	345	132	201	149	1,163
1973	62	28	17	55	101	121	41	76	61	179	173	139	1,055
1974	58	29	17	10	142	46	31	50	212	164	86	55	899
1975	45	18	14	9	9	14	23	27	63	107	80	144	553
1976	49	20	10	22	156	44	102	48	151	208	146	84	1,040
1977	39	18	10	5	33	7	4	24	48	147	70	33	438
1978	15	6	3	2	10	46	54	33	129	101	47	49	494
1979	15	6	2	24	47	26	31	32	106	55	116	64	522
1980	25	10	4	4	7	4	9	31	77	214	170	122	677
Mean	37	15	16	24	44	31	31	41	101	153	130	91	713

Table 4 MONTHLY RUNOFF RECORD AT KEY STATIONS (2/2)

Basin: Muda
Station: Jeniang (5806414) Catchment Area: 1,740 km^2

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	71	47	44	67	98	89	63	51	56	175	174	97	1,032
1962	81	32	48	52	129	75	105	107	124	280	125	90	1,247
1963	75	34	24	24	124	84	95	103	180	353	353	176	1,624
1964	60	29	27	32	111	90	130	76	152	156	297	103	1,262
1965	49	27	26	69	129	49	47	110	132	287	299	349	1,572
1966	125	80	62	68	137	141	85	66	126	303	323	264	1,780
1967	357	88	55	51	130	115	114	90	87	221	158	103	1,568
1968	36	22	16	12	14	13	73	158	99	256	166	77	944
1969	81	43	44	125	98	87	89	221	174	392	317	236	1,908
1970	87	50	42	55	176	159	154	91	226	268	293	184	1,783
1971	97	52	68	32	30	93	77	100	282	223	186	159	1,399
1972	84	43	32	33	28	53	52	35	124	220	549	221	1,474
1973	92	51	39	80	75	86	68	248	92	231	190	194	1,446
1974	86	42	33	32	79	45	31	73	146	174	156	109	1,004
1975	101	62	67	68	67	40	99	86	246	223	188	272	1,518
1976	123	64	45	65	199	111	149	103	219	502	422	171	2,173
1977	69	25	15	12	24	45	21	81	131	481	243	55	1,203
1978	24	9	16	45	90	51	131	88	181	221	201	61	1,119
1979	14	8	8	63	68	99	73	79	264	128	303	70	1,176
1980	20	13	26	29	75	95	61	191	272	621	358	223	1,983
Mean	87	41	37	51	94	81	86	108	166	286	265	161	1,461

Basin: Perai
Station: Ara Kuda (5405421) Catchment Area: 129 km^2

Unit: 10^6 m^3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	13	10	14	16	16	8	9	7	7	19	36	32	187
1962	36	13	14	21	24	14	15	13	11	55	27	18	260
1963	15	7	11	8	13	8	7	7	7	26	53	31	192
1964	13	7	6	10	18	8	15	12	52	35	25	12	211
1965	8	4	6	8	9	5	8	11	14	31	35	39	178
1966	16	10	13	18	14	12	12	10	12	24	19	24	184
1967	22	15	13	19	28	16	15	11	12	22	27	18	217
1968	11	6	7	17	17	9	12	13	10	15	21	15	153
1969	13	8	10	9	18	15	10	13	10	32	21	20	178
1970	19	8	7	17	19	11	19	11	24	50	52	29	265
1971	15	13	14	12	10	9	8	15	20	26	13	24	179
1972	13	11	8	19	12	10	7	7	13	31	35	27	192
1973	12	7	10	16	20	16	12	15	11	23	29	30	202
1974	11	11	8	15	15	8	8	8	12	13	14	10	135
1975	15	14	20	24	15	13	12	9	13	11	24	21	190
1976	11	7	10	10	12	8	6	8	21	32	22	16	163
1977	13	8	5	6	9	7	5	7	15	37	23	22	155
1978	10	5	6	10	19	8	6	8	11	21	11	6	119
1979	4	2	2	9	8	8	6	11	26	17	40	17	150
1980	8	5	5	6	7	12	6	23	28	27	32	30	188
Mean	14	9	9	14	15	10	10	11	16	27	28	22	185

Table 5 HYDROLOGICAL BALANCE BY RIVER BASIN

River Basin	Catchment Area (km^2)	Rainfall (10^6 m^3/y)	Evapo-Transportation (10^6 m^3/y)	Surface Runoff (10^6 m^3/y)	Groundwater Recharge (10^6 m^3/y)
Perlis	883	1,690	1,120	470	100
Kedah	3,593	7,680	4,650	2,770	260
Merbok	412	1,040	550	490	0
Muda	4,355	10,240	5,540	4,380	320
Perai	411	1,020	520	450	50
Pulau Pinang	300	800	420	380	0
Julu & Other Southern Rivers	371	870	500	350	20
Total	10,325	23,340	13,300	9,290	750

Table 6 PRINCIPAL FEATURES OF ON-GOING PROJECTS

(1) Dam

Name of Dam	Timah-Tasoh	Arau	Ahning	Mengkuang
River System	Perlis	Perlis	Kedah	Mengkuang
Purpose	Flood control & irrigation	Flood control	Water supply, irrigation & power	Water supply
Reservoir				
Catchment area (km^2)	150	58	120	3.6
Surface area (km^2)	12.2	5.5	9	1.7
Normal HWL (El. m)	27.4	23.6	113	43.3
Active storage capacity (10^6 m^3)	37	25	200	24
Dam				
Type	Earthfill	Earthfill	Concrete-faced Rockfill	Earthfill
Crest length (m)	4,300	900		792
Dam height (m)	10			27
Dam volume (10^3 m^3)			750	

(2) Jeniang Diversion System

	Jeniang	Naok	Remarks
Catchment area (km^2)	667		Diversion Canal
Normal HWL (El. m)	34	30	
Capacity			Capacity 40m3/s
Active storage capacity (10^6 m^3)		27	Length 10 km
Dam type	Concrete Barrage	Earthfill	
Dam volume (10^3 m^3)		2,160	
Dam height (m)			

Table 7 PROJECTED POPULATION BY STATE

	Area (10^3 km^2)	Population (10^3)				
		1980	1982	1985	1990	2000
Perlis	0.80	157	167	175	191	217
Kedah	9.43	1,173	1,205	1,259	1,328	1,398
Pulau Pinang	1.03	970	999	1,066	1,133	1,480
Other States	318.82	11,961	12,634	13,680	15,491	18,962
Malaysia	330.08	14,261	15,000	16,180	18,143	22,057

Table 8 PROJECTED GDP AT 1970 CONSTANT PRICE

Unit: M$$10^9$

	1980	1982	1985	1990	2000
High Growth Case					
Perlis/Kedah	1.4	1.6	2.1	3.2	6.8
Pulau Pinang	2.2	2.4	3.0	4.4	9.1
Other States	21.8	24.5	31.6	47.3	97.2
Malaysia	25.4	28.5	36.7	54.9	113.1
Low Growth Case					
Perlis/Kedah	1.4	1.6	1.9	2.4	3.2
Pulau Pinang	2.2	2.4	2.8	3.4	5.5
Other States	21.8	24.5	29.3	37.5	55.5
Malaysia	25.4	28.5	34.0	43.3	64.2

Table 9 PROJECTED POPULATION AND GDP BY EPU IN JULY 1983

	Perlis	Kedah	Pulau Pinang	Malaysia
Population (10^3)				
1980	148	1,116	955	13,745
1990	173	1,249	1,105	17,409
GDP (M$\$10^9$)				
1980	----- 1.5 -----		2.1	26.2
1990	----- 2.3 -----		4.1	46.9

Remarks; GDP: At 1970 constant price

Table 10 PROJECTED DOMESTIC AND INDUSTRIAL WATER DEMAND BY STATE BY RIVER SYSTEM

Unit: 10^6 m^3/y

	1982			1990			2000		
	Perlis	Kedah	Muda-Perai	Perlis	Kedah	Muda-Perai	Perlis	Kedah	Muda-Perai
High Growth Case									
State of Perlis	10	-	-	16	-	-	39	-	-
State of Kedah	-	27	20	-	60	25	-	145	43
State of P. Pinang	-	-	109	-	-	224	-	-	410
Total	10	27	129	16	60	249	39	145	453
Low Growth Case									
State of Perlis	10	-	-	12	-	-	18	-	-
State of Kedah	-	-	20	-	46	18	-	66	25
State of P. Pinang	-	-	109	-	-	178	-	-	283
Total	10	27	129	12	46	196	18	66	308

Remarks; Merbok river basin is not included.

Table 11 PROJECTED IRRIGATION AREA BY STATE/MADA BY RIVER SYSTEM

Unit: 10^3 ha

	1982			1990			2000		
	Perlis	Kedah	Muda-Perai	Perlis	Kedah	Muda-Perai	Perlis	Kedah	Muda-Perai
MADA	-	95.8	-	-	94.9	-	-	93.0	-
State of Perlis	2.8	0.9	-	0.8	0.9	-	3.6	1.5	-
State of Kedah	-	2.1	5.1	-	6.3	9.3	-	8.4	11.3
State of P. Pinang	-	-	15.1	-	-	14.7	-	-	14.7
Total	2.8	98.8	20.2	2.8	102.1	24.0	3.6	102.9	26.0

Remarks; Areas entered in the lines of states are minor irrigation areas excluding control drainage projects.

Table 12 PROJECTED IRRIGATION WATER DEMAND BY STATE/MADA BY RIVER SYSTEM

Unit: 10^6 m^3/y

	1982			1990			2000		
	Perlis	Kedah	Muda-Perai	Perlis	Kedah	Muda-Perai	Perlis	Kedah	Muda-Perai
MADA	-	1,621	-	-	1,543	-	-	1,485	-
State of Perlis	26	8	-	24	8	-	63	35	-
State of Kedah	-	36	101	-	114	176	-	156	219
State of P. Pinang	-	-	328	-	-	288	-	-	288
Total	26	1,665	429	24	1,665	464	63	1,676	507

Table 13 AVERAGE ANNUAL WATER DEFICIT BY CAUSE BY AFFECTED AREA IN HIGH GROWTH CASE

Unit: 10^6 m^3

Cause of Water Deficit	Affected Area by Water Deficit: Kedah River System: MADA	Main Minor	D&I	Total	Muda-Perai River System: Main Minor	D&I	Total
1982							
Kedah System							
MADA	271			271			
Main minor		1		1			
Tributary minor	5.9		0.1	6			
D&I			5	5			
Total	276.9	1	5.1	283			
Muda-Perai System							
Main minor					3		3
Tributary minor					0.8	0.2	1
D&I						1	1
Total					3.8	1.2	5
1990							
Kedah System							
MADA	280.0	11.0	11.0	302			
Main minor	31.5	1.2	1.3	34			
Tributary minor	10.2	0.4	0.4	11			
D&I				0			
Total	321.7	12.6	12.7	347			
Muda-Perai System							
Main minor					2.3	0.7	3
Tributary minor					4.5	0.5	5
D&I						0	0
Total					6.8	1.2	8
2000							
Kedah System							
MADA	231.8	13.3	24.9	270			
Main minor	43.8	2.5	4.7	51			
Tributary minor	30.0	1.8	3.2	35			
D&I	26.6	1.5	2.9	31			
Total	332.2	19.1	35.7	387			
Muda-Perai System							
Main minor					1.5	1.5	3
Tributary minor					5.0	5.0	10
D&I					13.0	0	13
Total					19.5	6.5	26

Remarks; Supply by Ahning and Mengkuang dams is counted in D&I deficit in 1990 and 2000.

Table 14 AVERAGE ANNUAL WATER DEFICIT BY CAUSE BY AFFECTED AREA IN LOW GROWTH CASE

Unit: 10^6 m^3

Cause of Water Deficit	Affected Area by Water Deficit						
	Kedah River System				Muda-Perai River System		
	MADA	Main Minor	D&I	Total	Main Minor	D&I	Total
1982							
Kedah System							
MADA	271			271			
Main minor		1		1			
Tributary minor	5.9		0.1	6			
D&I			5	5			
Total	276.9	1	5.1	283			
Muda-Perai System							
Main minor					3		3
Tributary minor					0.8	0.2	1
D&I						1	1
Total					3.8	1.2	5
1990							
Kedah System							
MADA	282.0	11.2	8.8	302			
Main minor	25.2	1.0	0.8	27			
Tributary minor	10.3	0.4	0.3	11			
D&I				0			
Total	317.5	12.6	9.9	340			
Muda-Perai System							
Main minor					3		3
Tributary minor					3.0	0	3
D&I						0	
Total					6.0	0	6
2000							
Kedah System							
MADA	244.3	14.0	11.7	270			
Main minor	46.2	2.6	2.2	51			
Tributary minor	31.7	1.8	1.5	35			
D&I	0.8	0.1	0.1	1			
Total	323.0	18.5	15.5	357			
Muda-Perai System							
Main minor					2.0	1.0	3
Tributary minor					4.6	2.4	7
D&I					2.0	0	2
Total					8.6	3.4	12

Remarks; Supply by Ahning and Mengkuang dams is counted in D&I deficit in 1990 and 2000.

Table 15 PRINCIPAL FEATURE OF PROPOSED DAMS AT OPTIMUM SCALE (1/2)

			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	Embankment volume	10^2 m^3	929	-	1,084
2.6	Dam concrete volume	10^3 m^3	67	62	-
3.	Secondary/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
5.	Outlet Facilities				
5.1	Tributary		Badak	Sari	Durian
6.	Power Station				
6.1	Installed capacity	MW	-	-	-
6.2	Energy output	GWh	-	-	-
7.	Investment Cost (at 1982 Price Level)				
7.1	Construction work	M$$10^6$	123.0	52.2	111.5
7.2	Land acquisition	M$$10^6$	26.2	20.3	1.8
	Total	M$$10^6$	149.2	72.5	113.3

Remarks; 1.8 net water output is estimated assuming 1977 hydrological condition and the deficit at 2000 in the Kedah river system.

Table 16 PRINCIPAL FEATURE OF PROPOSED DAMS AT OPTIMUM SCALE (2/2)

			Tawar-Muda	Beris	Rui No. 2	Rui No. 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	14.6	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	214	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	Embankment volume	10^2 m^3	281	-	2,714	2,594
2.6	Dam concrete volume	10^3 m^3	-	58	-	-
3.	Secondary/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
5.	Outlet Facilities					
5.1	Tributary		Muda	Beris	Tiak and Rui	
6.	Power Station					
6.1	Installed capacity	MW	-	-	26 + 0.88	26 + 0.88
6.2	Energy output	GWh	-	-	64 + 4.4	74 + 4.4
7.	Investment Cost (at 1982 Price Level)					
7.1	Construction work	M$$10^6$	103.8	45.2	391.6	398.3
7.2	Land acquisition	M$$10^6$	10.8	29.0	0.4	7.3
	Total	M$$10^6$	114.6	74.2	392.0	405.6

Remarks; 1.8 net water output is estimated assuming 1977 hydrological condition and the deficit at 2000 in the Kedah river system for Tawar-Muda and Beris, and the deficit in the Muda-Perai river system for the Rui 2 and Rui 3.

Table 17 PRESENT LAND USE IN PROPOSED RESERVOIR AREAS (1/2)

Item	Badak Temin	Sari	Durian
1. Reservoir			
1.1 Water level (m)	49	88	78
1.2 Area (km^2)	11.9	3.9	5.7
2. Land Use (ha)			
2.1 Rubber			
RISDA & Smallholder	707	-	-
FELDA	108	-	-
Sub-total	815	-	-
2.2 Sugarcane	-	170	275
2.3 Paddy	-	-	-
2.4 Upland crop	-	-	-
2.5 Residential land/quarter	3	0	-
2.6 Forest	338	207	294
2.7 Mine	34	13	-
2.8 Water/barren	0	0	1
3. No. of Houses	34	3	-
4. Road (km)	1.6	2.0	9.5
5. Others	-	-	-

Table 18 PRESENT LAND USE IN PROPOSED RESERVOIR AREAS (2/2)

Item	Tawar Muda	Beris	Rui 2	Rui 3
1. Reservoir				
1.1 Water level (m)	81	88	246	243
1.2 Area (km^2)	12.2*	15.4*	9.8	12.5*
2. Land Use (ha)				
2.1 Rubber				
RISDA & Smallholder	501	744	10	11
FELCRA	111	-	-	-
Sub-total	612	744	10	11
2.2 Sugarcane	-	-	-	-
2.3 Paddy	14	135	4	4
2.4 Upland crop	5	31	-	-
2.5 Residential land/quarter	11	33	3	3
2.6 Forest	540	591	942	1,083
2.7 Mine	-	-	-	128
2.8 Water/barren	38	6	21	21
3. No. of Houses	33	152	51	56
4. Road (km)	0.4	2.3	-	-
5. Others	-	-	Pong power station	

Remarks; *: Net area in the proposed reservoir area.

Table 19 PRINCIPAL FEATURES OF POTENTIAL DAMS

		Reman	Merbok	Khlong Thepha	Ma
River system		Muda	Merbok	Khlong Thepha	Muda
Reservoir					
Catchment area	km^2	32		173	40
Annual inflow	10^6 m^3			87	38
Normal HWL	El. m	57	8.5	125	75
LWL	El. m	37	0	120	60
Surface area	km^2	18	13	16	4
Active storage capacity	10^6 m^3	240	110	78	35
Regulated outflow	10^6 m^3	175	118	73	30
Dam					
Type		Earthfill	Dyke	Rockfill	Rockfill
Maximum height	m	40	10	50	30
Crest length	m	170	14,400	600	500
Dam volume	10^3 m^3	286,000	10,000	800	700
Transfer Canal					
Discharge capacity	m^3/s	40	20	5	
Length	km	10	5	6	
Construction cost at 1982 price level	M$$10^6$	96	132	90	80

Table 20 ESTIMATED PADDY YIELD AND NET PRODUCTION VALUE

	Main Season		Off Season	
	Yield (Ton/ha)	Net Production Value (M$/ha)	Yield (ton/ha)	Net Production Value (M$/ha)
1. With Insufficient Water				
1.1 MADA				
- Without tertiary development	4.0	1,220	4.2	1,230
1.2 Rainfed	2.1	440	-	-
1.3 Existing minor irrigation	3.4	600	3.5	610
2. With Sufficient Water				
1.1 MADA				
- Transplanting area	4.7	1,900	5.0	1,980
- Direct-seeding area	4.7	1,900	4.8	1,960
- Without tertiary development	4.0	1,220	4.2	1,230
1.2 Minor irrigation				
- New projects	4.2	1,590	4.8	1,880
- Existing since 1982	3.4	600	3.5	610

Remarks; Net production value is projected to 1995 onward at 1982 constant price.

Table 21 TOTAL NET PRODUCTION VALUE IN 2003 ONWARD UNDER WITH AND WITHOUT PROJECT CONDITIONS

Unit: M$$10^6$

	Without Project	With Project	Increment
Kedah River System			
MADA	209.9	359.0	149.1
Minor projects depending on MADA canal/main stream	1.5	11.7	10.2
Minor projects in tributaries	5.6	10.9	5.3
Muda River System			
Minor projects depending on main stream	19.7	26.6	6.9
Minor projects in tributaries	5.4	17.5	12.1

Table 22 DOMESTIC AND INDUSTRIAL WATER SUPPLY BENEFIT BASED ON ALTERNATIVE FACILITIES COST

Alternative Facilities	Annual Equivalent of Cost (M$$10^3$)	For Kedah System Net Water Output (10^6 m^3)	For Kedah System Benefit (M$/$m^3$)	For Muda-Perai System Net Water Output (10^6 m^3)	For Muda-Perai System Benefit (M$/$m^3$)
Beris	7.1	59.3	0.12	25.0	0.28
Tawar-Muda	12.4	33.4	0.37	14.0	0.89
Sari	8.6	16.7	0.51	8.0	1.08
Badak-Temin	15.5	21.5	0.72	10.1	1.54
Durian	12.4	14.6	0.85	7.8	1.59

Remarks; Benefit is not unit value of raw water but unit value of water deficit met for the purpose of domestic and industrial water supply.

Table 23 ECONOMIC INVESTMENT COST, ANNUAL COST AND PRODUCTION FORGONE OF JENIANG SYSTEM AND PROPOSED DAMS

	Investment Cost ($M\$10^6$)	Annual Cost + Production Forgone ($M\$10^3/y$)
Jeniang system	60.13	0.66
Beris dam	43.55	1.00
Tawar-Muda dam	84.31	1.05
Sari dam	51.11	1.10
Durian dam	89.25	1.11
Badak-Temin dam	98.43	1.90
Rui No. 2 dam (High)	261.12	2.60
(Low)	244.10	2.40
Ma dam	64.00	1.30
Khlong Thepha dam	72.00	1.40
Reman dam	65.10	4.75
Merbok scheme	99.77	1.40

Remarks; (1): Values at the optimum scale

(2): In 1982 constant price

Table 24 PRIORITY ORDER OF PROPOSED DAMS

Priority Order	Dam	(1) Investment Cost ($M\$10^6$)	(2) Net Water Output (10^6 m^3)	(3) (1)/(2) ($M\$/m^3$)
1	Beris	74.2	92.3	0.804
2	Tawar-Muda	114.6	40.4	2.84
3	Sari	72.5	22.8	3.18
4	Badak-Temin	149.2	30.3	4.92
5	Durian	113.3	20.5	5.53

Remarks; Net water output is estimated assuming 2,000 water demand in the Kedah river basin under the hydrological condition in 1977. Investment cost and net water output are of the optimum scale.

Table 25 NET WATER OUTPUT OF SOURCE FACILITIES BY CAUSE OF WATER DEFICIT

Unit: 10^6 m^3

	Low Growth Case			High Growth Case		
	Jeniang & Naok	Beris	Tawar-Muda	Jeniang & Naok	Beris	Tawar-Muda
1990						
Kedah System						
MADA	197.4	40.4	28.5	193.2	38.6	27.0
Main minor	17.6	3.6	2.5	21.8	4.4	3.0
Tributary minor	0	11.0	0	0	11.0	0
D&I	0	0	0	0	0	0
Sub-total	215.0	55.0	31.0	215.0	54.0	30.0
Muda-Perai System						
Main minor		1.0	2.0		0	3.0
Tributary minor		3.0	0		5.0	0
D&I		0	0		0	0
Sub-total		4.0	2.0		5.0	3.0
Total	215.0	59.0	33.0	215.0	59.0	33.0
2000						
Kedah System						
MADA	180.2	12.6	25.1	156.0	6.5	16.0
Main minor	34.1	2.4	4.8	29.5	1.2	3.0
Tributary minor	0	35.0	0	0	35.0	0
D&I	0.7	0.0	0.1	17.9	0.8	1.8
Maintenance flow	0	0	0	11.6	0.5	1.2
Sub-total	215.0	50.0	30.0	215.0	44.0	22.0
Muda-Perai System						
Main minor		0	3.0		0.9	2.1
Tributary minor		9.0	0		10.0	0
D&I		0	0		4.1	8.9
Sub-total		9.0	3.0		15.0	11.0
Total	215.0	59.0	33.0	215.0	59.0	33.0

Table 26 RESULTS OF ECONOMIC EVALUATION OF INDIVIDUAL SOURCE PROJECTS IN HIGH GROWTH CASE

		Jeniang System	Beris Dam	Tawar-Muda Dam
Average Annual Net Water Output	(10^6 m^3)	215	59	33
Present Value of Benefit (r = 8%)				
Kedah river system				
MADA	(M10^6)	193.00	19.69	34.63
Main minor	(M10^6)	26.31	2.84	4.01
Tributary minor	(M10^6)	-	24.26	-
D&I	(M10^6)	9.95	1.39	4.26
Sub-total	(M10^6)	229.26	48.18	42.90
Muda-Perai river system				
Main minor	(M10^6)	-	-	-
Tributary minor	(M10^6)	-	3.33	1.43
D&I	(M10^6)	-	23.63	44.48
Sub-total	(M10^6)	-	26.96	45.91
Total	(M10^6)	229.26	75.14	88.81
Present Value of Cost (r = 8%)	(M10^6)	43.14	35.91	57.49
EIRR	(%)	12.2	14.4	11.5

Table 27 RESULTS OF ECONOMIC EVALUATION OF INDIVIDUAL SOURCE PROJECTS IN LOW GROWTH CASE

		Jeniang System	Beris Dam	Tawar-Muda Dam
Average Annual Net Water Output	(10^6 m^3)	215	59	33
Present Value of Benefit (r = 8%)				
Kedah river system				
MADA	(M$$10^6$)	238.09	31.20	51.63
Main minor	(M$$10^6$)	30.72	3.89	5.67
Tributary minor	(M$$10^6$)	-	24.26	-
D&I	(M$$10^6$)	0.39	0	0.24
Sub-total	(M$$10^6$)	269.20	59.35	57.54
Muda-Perai river system				
Main minor	(M$$10^6$)	-	-	-
Tributary minor	(M$$10^6$)	-	3.21	1.12
D&I	(M$$10^6$)	-	6.39	6.02
Sub-total	(M$$10^6$)	-	9.60	7.14
Total	(M$$10^6$)	269.20	68.95	64.68
Present Value of Cost (r = 8%)	(M$$10^6$)	43.14	35.91	57.49
EIRR	(%)	12.9	13.5	9.0

Table 28 JOINT COST ALLOCATION OF BERIS DAM

Unit: M$$10^6$

	Kedah River						Muda River				
				D/I					D/I		
		Irrigation		Water Supply		River	Irrigation		Water Supply		
		Main	Tributary	Pri-		Maint.	Main	Tributary	Pri-		
	MADA	Minor	Minor	vate	Public	Flow	Minor	Minor	vate	Public	Total
High Growth Case (C1-A3-P2)											
1. Benefit	19.69	2.84	24.26	0.49	0.90	0	0.39	9.68	1.86	15.03	
2. Alternative Cost	34.23	33.00	41.47	32.86	32.93	32.93	32.96	34.98	32.93	33.61	
3. Justifiable Expenditure	19.69	2.84	24.26	0.49	0.90	0	0.39	9.68	1.86	15.03	75.14
4. Separable Cost											
- Construction	3.57	0.67	12.43	0.31	0.36	0.36	0.37	5.57	0.38	2.31	26.33
- Capitalized O&M	0.11	0.01	0.38	0.01	0.01	0.01	0.01	0.18	0.01	0.08	0.79
Total	3.68	0.68	12.81	0.32	0.37	0.37	0.38	5.75	0.39	2.39	27.12
Total Allocated Cost											
Construction	11.20	1.70	17.89	0.39	0.62	0.36	0.38	7.44	1.08	8.33	49.38
Capitalized O&M	0.45	0.06	0.62	0.01	0.02	0.01	0.01	0.26	0.04	0.35	1.82
Total	11.65	1.76	18.51	0.40	0.63	0.37	0.38	7.70	1.12	8.68	51.20
(Proportion in %)	22.75	3.43	36.15	0.78	1.24	0.72	0.75	15.05	2.19	16.95	100
Low Growth Case (C2-A3-P2)											
1. Benefit	31.20	3.89	24.26	0	0	0	0.71	5.60	0.26	3.03	
2. Alternative Cost	34.72	33.48	41.47	0	0	0	33.00	34.18	32.73	33.00	
3. Justifiable Expenditure	31.20	3.89	24.26	0	0	0	0.71	5.60	0.26	3.03	68.95
4. Separable Cost											
- Construction	6.70	1.11	12.43	0	0	0	0.67	4.24	0.11	0.36	25.62
- Capitalized O&M	0.21	0.04	0.38	0	0	0	0.01	0.18	0.01	0.01	0.84
Total	6.91	1.15	12.81	0	0	0	0.68	4.42	0.12	0.37	26.46
Total Allocated Cost											
Construction	20.28	2.64	18.83	0	0	0	0.68	4.90	0.19	1.85	49.38
Capitalized O&M	0.77	0.10	0.64	0	0	0	0.01	0.21	0.01	0.07	1.82
Total	21.05	2.74	19.48	0	0	0	0.70	5.11	0.20	1.42	51.20
(Proportion in %)	41.12	5.36	38.04	0	0	0	1.37	9.98	0.39	3.75	100

Table 29 JOINT COST ALLOCATION OF TAWAR-MUDA DAM

Unit: M$$10^6$

	Kedah River						Muda River				
	Irrigation			D/I Water Supply		River Maint. Flow	Irrigation		D/I Water Supply		
	MADA	Main Minor	Tributary Minor	Pri-vate	Public		Main Minor	Tributary Minor	Pri-vate	Public	Total
High Growth Case (C1-A3-P2)											
1. Benefit	34.63	4.01	0	1.49	2.77	0	1.43	0	4.89	39.59	
2. Alternative Cost	70.71	64.82	0	63.53	63.93	63.93	64.20	0	63.72	66.73	
3. Justifiable Expenditure	34.63	4.01	0	1.49	2.77	0	1.43	0	4.89	39.59	88.81
4. Separable Cost											
- Construction	7.26	1.56	0	0.30	0.86	0.86	1.37	0	0.67	4.19	17.07
- Capitalized O&M	0.36	0.08	0	0.01	0.04	0.04	0.06	0	0.03	0.20	0.82
Total	7.62	1.64	0	0.31	0.90	0.90	1.43	0	0.70	4.39	17.89
Total Allocated Cost											
Construction	28.97	3.47	0	1.25	2.36	0.86	1.37	0	4.04	32.48	74.79
Capitalized O&M	1.45	0.17	0	0.05	0.12	0.04	0.06	0	0.20	1.63	3.73
Total	30.42	3.64	0	1.31	2.48	0.90	1.43	0	4.24	34.11	78.52
(Proportion in %)	38.74	4.64	0	1.66	3.16	1.15	1.82	0	5.40	43.44	100
Low Growth Case (C2-A3-P2)											
1. Benefit	51.63	5.67	0	0.06	0.18	0	1.12	0	0.48	5.54	
2. Alternative Cost	74.13	65.43	0	63.53	63.53	0	64.20	0	9.46	9.49	
3. Justifiable Expenditure	51.63	5.67	0	0.06	0.18	0	1.12	0	0.48	5.54	64.68
4. Separable Cost											
- Construction	11.24	2.62	0	0.05	0.08	0	1.05	0	0.10	0.80	15.94
- Capitalized O&M	0.56	0.13	0	0.00	0.00	0	0.06	0	0.00	0.04	0.77
Total	11.80	2.75	0	0.05	0.08	0	1.11	0	0.10	0.84	16.71
Total Allocated Cost											
Construction	60.11	6.21	0	0.06	0.20	0	1.07	0	0.57	6.57	74.79
Capitalized O&M	3.01	0.31	0	0.00	0.01	0	0.06	0	0.02	0.33	3.73
Total	63.12	6.51	0	0.06	0.21	0	1.12	0	0.59	6.90	78.52
(Proportion in %)	80.39	8.30	0	0.08	0.27	0	1.43	0	0.75	8.78	100

Table 30 DISBURSEMENT SCHEDULE OF PUBLIC AND PRIVATE DEVELOPMENT EXPENDITURE FOR WATER DEMAND AND SUPPLY BALANCE PLAN IN HIGH GROWTH CASE (1/2)

Unit: M$$10^6$

	4MP	5MP	6MP	7MP	Total
I. Perlis/Kedah					
Irrigation (Minor Scheme)					
Direct Facilities	49.90	23.40	31.70	31.70	136.70
Timah Tasoh	0.00	18.60	0.00	0.00	18.60
Arau	0.00	16.00	0.00	0.00	16.00
Jeniang	0.30	9.83	0.00	0.00	10.13
Beris	2.49	38.67	0.00	0.00	41.16
Tawar-Muda	0.47	6.95	0.00	0.00	0.16
Sub-total	53.16	113.45	31.70	31.70	222.75
Public Water Supply					
Direct Facilities	150.70	352.60	375.80	152.80	1,031.90
Ahning	0.00	34.38	0.00	0.00	34.38
Jeniang	0.12	3.88	0.00	0.00	4.00
Beris	0.17	2.52	0.00	0.00	2.69
Tawar-Muda	0.67	9.92	0.00	0.00	10.59
Sub-total	151.66	403.30	375.80	152.80	1,083.56
Private Water Supply					
Direct Facilities	94.20	412.40	556.60	222.50	1,285.70
Ahning	0.00	21.62	0.00	0.00	21.62
Jeniang	0.06	2.08	0.00	0.00	2.14
Beris	0.09	1.31	0.00	0.00	1.40
Tawar-Muda	0.31	4.63	0.00	0.00	4.94
Sub-total	94.66	442.04	556.60	222.50	1,315.80
River Maintenance Flow					
Direct Facilities	0.00	0.00	0.00	0.00	0.00
Jeniang	0.12	3.88	0.00	0.00	4.00
Beris	0.03	0.51	0.00	0.00	0.54
Tawar-Muda	0.08	1.23	0.00	0.00	1.31
Sub-total	0.23	5.62	0.00	0.00	5.85
Sub-total					
Direct Facilities					
Timah Tasoh	0.00	18.60	0.00	0.00	18.60
Arau	0.00	16.00	0.00	0.00	16.00
Ahning	0.00	56.00	0.00	0.00	56.00
Jeniang	0.60	19.67	0.00	0.00	20.27
Beris	2.78	43.01	0.00	0.00	45.79
Tawar-Muda	1.53	22.73	0.00	0.00	24.26
Sub-total	4.91	176.01	0.00	0.00	180.92

Table 31 DISBURSEMENT SCHEDULE OF PUBLIC AND PRIVATE DEVELOPMENT EXPENDITURE FOR WATER DEMAND AND SUPPLY BALANCE PLAN IN HIGH GROWTH CASE (2/2)

Unit: M$10[6]

	4MP	5MP	6MP	7MP	Total
II. MADA					
Irrigation (Major Scheme)					
Direct Facilities	128.70	171.00	268.90	268.90	837.50
Jeniang	1.60	52.11	0.00	0.00	53.72
Beris	1.02	15.80	0.00	0.00	16.82
Tawar-Muda	2.80	41.59	0.00	0.00	44.39
Sub-total	134.13	280.50	268.90	268.90	952.43
III. Pulau Pinang					
Irrigation (Minor Scheme)					
Direct Facilities	0.00	1.30	0.00	0.00	1.30
Public Water Supply					
Direct Facilities	194.40	471.70	549.50	219.30	1,454.90
Mengkuang	62.00	0.00	0.00	0.00	62.00
Jeniang	0.00	0.00	0.00	0.00	0.00
Beris	0.65	10.11	0.00	0.00	10.76
Tawar-Muda	2.70	40.10	0.00	0.00	42.80
Sub-total	259.75	541.91	549.50	219.30	1,570.46
Private Water Supply					
Direct Facilities	180.00	404.40	424.10	169.60	1,178.10
Jeniang	0.00	0.00	0.00	0.00	0.00
Beris	0.03	0.76	0.00	0.00	0.81
Tawar-Muda	0.20	2.96	0.00	0.00	3.61
Sub-total	180.25	408.12	424.10	169.60	1,182.07
River Maintenance Flow	0.00	0.00	0.00	0.00	0.00
Sub-total					
Direct Facilities					
Mengkuang	62.00	0.00	0.00	0.00	62.00
Jeniang	0.00	0.00	0.00	0.00	0.00
Beris	0.70	10.87	0.00	0.00	11.57
Tawar-Muda	2.90	43.06	0.00	0.00	45.96
Sub-total	65.60	53.93	0.00	0.00	119.53
IV. Total of the Region					
Direct Facilities					
Irrigation	178.60	195.70	300.60	300.60	975.50
Public Water Supply	345.10	844.30	925.30	372.10	2,486.80
Private Water Supply	274.20	816.80	980.70	392.10	2,463.80
River Maintenance Flow	0.00	0.00	0.00	0.00	0.00
Timah-Tasoh	0.00	18.60	0.00	0.00	18.60
Arau	0.00	16.00	0.00	0.00	16.00
Ahning	0.00	56.00	0.00	0.00	56.00
Mengkuang	62.00	0.00	0.00	0.00	62.00
Jeniang	2.21	71.78	0.00	0.00	73.99
Beris	4.50	69.68	0.00	0.00	74.18
Tawar-Muda	7.23	107.38	0.00	0.00	114.61
Total	873.84	2,196.24	2,206.60	1,064.80	6,341.48

Table 32 DISBURSEMENT SCHEDULE OF PUBLIC AND PRIVATE DEVELOPMENT EXPENDITURE FOR WATER DEMAND AND SUPPLY BALANCE PLAN IN LOW GROWTH CASE (1/2)

Unit: M$10^6

	4MP	5MP	6MP	7MP	Total
I. Perlis/Kedah					
Irrigation (Minor Scheme)					
Direct Facilities	49.90	23.40	31.70	31.70	136.70
Timah Tasoh	0.00	21.20	0.00	0.00	21.20
Arau	0.00	16.00	0.00	0.00	16.00
Jeniang	0.35	11.41	0.00	0.00	11.76
Beris	2.47	38.17	0.00	0.00	40.64
Tawar-Muda	0.70	10.46	0.00	0.00	0.16
Sub-total	53.42	120.64	31.70	31.70	226.46
Public Water Supply					
Direct Facilities	106.20	184.50	158.30	65.30	514.30
Ahning	0.00	34.38	0.00	0.00	34.38
Jeniang	0.00	0.14	0.00	0.00	0.14
Beris	0.02	0.31	0.00	0.00	0.33
Tawar-Muda	0.09	1.33	0.00	0.00	1.42
Sub-total	106.31	220.66	158.30	65.30	550.57
Private Water Supply					
Direct Facilities	37.00	83.20	87.00	34.80	242.00
Ahning	0.00	21.62	0.00	0.00	21.62
Jeniang	0.00	0.07	0.00	0.00	0.07
Beris	0.00	0.07	0.00	0.00	0.07
Tawar-Muda	0.03	0.34	0.00	0.00	0.37
Sub-total	37.03	105.30	87.00	34.80	264.13
River Maintenance Flow					
Direct Facilities	0.00	0.00	0.00	0.00	0.00
Jeniang	0.00	0.00	0.00	0.00	0.00
Beris	0.00	0.00	0.00	0.00	0.00
Tawar-Muda	0.00	0.00	0.00	0.00	0.00
Sub-total	0.00	0.00	0.00	0.00	0.00
Sub-total					
Direct Facilities					
Timah Tasoh	0.00	21.20	0.00	0.00	21.20
Arau	0.00	16.00	0.00	0.00	16.00
Ahning	0.00	56.00	0.00	0.00	56.00
Jeniang	0.35	11.62	0.00	0.00	11.97
Beris	2.49	38.55	0.00	0.00	41.04
Tawar-Muda	0.82	12.13	0.00	0.00	12.95
Sub-total	3.66	155.50	0.00	0.00	159.16

Table 33 DISBURSEMENT SCHEDULE OF PUBLIC AND PRIVATE DEVELOPMENT EXPENDITURE FOR WATER DEMAND AND SUPPLY BALANCE PLAN IN LOW GROWTH CASE (2/2)

Unit: $M\$10^6$

	4MP	5MP	6MP	7MP	Total
II. MADA					
Irrigation (Major Scheme)					
Direct Facilities	128.70	171.00	268.90	268.90	837.50
Jeniang	1.86	60.15	0.00	0.00	62.01
Beris	1.85	28.62	0.00	0.00	30.47
Tawar-Muda	5.82	86.30	0.00	0.00	92.12
Sub-total	138.23	346.07	268.90	268.90	1,022.10
III. Pulau Pinang					
Irrigation (Minor Scheme)					
Direct Facilities	0.00	0.00	0.00	0.00	0.00
Public Water Supply					
Direct Facilities	115.60	290.80	323.70	129.60	859.70
Mengkuang	62.00	0.00	0.00	0.00	62.00
Jeniang	0.00	0.00	0.00	0.00	0.00
Beris	0.15	2.30	0.00	0.00	2.45
Tawar-Muda	0.57	8.40	0.00	0.00	8.97
Sub-total	178.32	301.50	323.70	129.60	933.12
Private Water Supply					
Direct Facilities	97.00	219.80	231.70	92.70	641.20
Jeniang	0.00	0.00	0.00	0.00	0.00
Beris	0.01	0.20	0.00	0.02	0.21
Tawar-Muda	0.04	0.57	0.00	0.00	0.61
Sub-total	97.05	220.57	231.70	92.70	642.02
River Maintenance Flow	0.00	0.00	0.00	0.00	0.00
Sub-total					
Direct Facilities					
Mengkuang	62.00	0.00	0.00	0.00	62.00
Jeniang	0.00	0.00	0.00	0.00	0.00
Beris	0.16	2.50	0.00	0.00	2.66
Tawar-Muda	0.61	8.97	0.00	0.00	9.58
Sub-total	62.77	11.47	0.00	0.00	74.24
IV. Total of the Region					
Direct Facilities					
Irrigation	178.60	195.70	300.60	300.60	975.50
Public Water Supply	221.80	475.30	482.00	194.90	1,374.00
Private Water Supply	134.00	303.00	318.70	127.50	883.20
River Maintenance Flow	0.00	0.00	0.00	0.00	0.00
Timah-Tasoh	0.00	21.20	0.00	0.00	21.20
Arau	0.00	16.00	0.00	0.00	16.00
Ahning	0.00	56.00	0.00	0.00	56.00
Mengkuang	62.00	0.00	0.00	0.00	62.00
Jeniang	2.21	71.77	0.00	0.00	73.98
Beris	4.50	69.67	0.00	0.00	74.17
Tawar-Muda	7.25	107.40	0.00	0.00	114.65
Total	610.36	1,316.04	1,101.30	623.00	3,650.70

Table 34 NET WATER OUTPUT AND EIRR OF THE JENIANG SYSTEM, PROPOSED DAMS AND POTENTIAL DAMS

	Net Water Output (10^6 m^3)	EIRR (%)
Tawar-Muda	41	11.5 (9.0)
Rui	140 (87)	8.5 (4.9)
Khlong Thepha	73	14.5 (13.9)
Merbok	118 (87)	12.0 (4.1)
Reman	175	19.7 (17.8)
Beris	92	14.4 (13.5)
Jeniang	175 (178)	12.2 (12.9)

Table 35 DISBURSEMENT SCHEDULE FOR IMPLEMENTATION OF FLOOD MITIGATION PLAN IN HIGH GROWTH CASE

Unit: M$$10^6$

	5MP	6MP	7MP
High Growth Case			
Perlis	11.6	20.1	11.3
Kedah	6.9	4.4	3.4
Muda	14.8	16.5	9.1
Perai	5.3		
P. Pinang			38.6
Total	38.6	41.0	62.4
Low Growth Case			
Perlis	11.6		
Kedah		11.3	3.4
Muda	14.8	16.5	9.1
Perai	5.3		
P. Pinang			38.6
Total	31.7	27.8	51.1

Table 36 PRINCIPAL FEATURE OF RECOMMENDED FLOOD MITIGATION PLAN IN HIGH GROWTH CASE

River System		Perlis	Kedah	Muda	Perai	P.Pinang
1. Alternative Code		4.50	1.10	1.10	2.50	1.50
2. Flood Mitigation Measures						
2.1 Channel improvement	(km)	45*	18	50	-	2.4
2.2 Dam	(10^6 m^3)	20	-	-	-	-
2.3 Retarding basin	(10^6 m^3)	-	-	-	20	-
3. Construction Cost						
3.1 Channel improvement	(M10^6)	23.7	9.7	33.0	-	3.7
3.2 Dam	(M10^6)	11.4	-	-	-	-
3.3 Retarding basin	(M10^6)	-	-	-	0.8	-
3.4 Compensation	(M10^6)	7.9	5.0	4.0	4.5	34.9
Total	(M10^6)	43.0	14.7	37.0	5.3	38.6
4. Economic Effect						
4.1 Flood damage without development	(M10^6/y)	5.45	3.24	6.57	1.60	3.63
4.2 Damage reduction	(M10^6/y)	4.20	2.02	3.12	1.54	3.27
4.3 4.2/4.1	(%)	77	62	47	96	90
4.4 Net economic benefit	(M10^6/y)	1.84	1.06	1.38	1.14	0.35
4.5 EIRR	(%)	17.2	14.1	11.1	18.4	12.5
5. Average Annual Flooded Area						
5.1 Without development	(km^2)	8.0	7.5	16.2	6.2	1.1
5.2 Reduction	(km^2)	3.4	1.4	3.2	4.9	0.8
5.3 5.2/5.1	(%)	43	19	20	79	73
6. Average Annual Population Affected (2000)						
6.1 Without project	(10^3)	11.2	3.3	10.3	3.3	5.4
6.2 Reduction	(10^3)	7.8	1.6	6.7	2.6	4.6
6.3 6.2/6.1	(%)	70	48	61	79	85

Remarks; *: Including bypass floodways

Table 37 PRINCIPAL FEATURE OF RECOMMENDED FLOOD MITIGATION PLAN IN LOW GROWTH CASE

River System		Perlis	Kedah	Muda	Perai	P.Pinang
1. Alternative Code		5.50	1.10	1.10	2.50	1.50
2. Flood Mitigation Measures						
2.1 Channel improvement	(km)	-	18	50	-	2.4
2.2 Dam	(10^6 m^3)	15	-	-	-	-
2.3 Retarding basin	(10^6 m^3)	-	-	-	20	-
3. Construction Cost						
3.1 Channel improvement	(M$$10^6$)	-	9.7	33.0	-	3.7
3.2 Dam	(M$$10^6$)	8.8	-	-	-	-
3.3 Retarding basin	(M$$10^6$)	-	-	-	0.8	-
3.4 Compensation	(M$$10^6$)	2.8	5.0	4.0	4.5	34.9
Total	(M$$10^6$)	11.6	14.7	37.0	5.3	38.6
4. Economic Effect						
4.1 Flood damage without development	(M$$10^6$/y)	2.77	1.65	3.70	0.88	2.17
4.2 Damage reduction	(M$$10^6$/y)	0.72	1.05	1.91	0.82	1.96
4.3 4.2/4.1	(%)	26	64	52	93	90
4.4 Net economic benefit	(M$$10^6$/y)	0.08	0.09	0.17	0.42	-0.96
4.5 EIRR	(%)	8.2	9.3	9.3	12.9	7.6
5. Average Annual Flooded Area						
5.1 Without development	(km^2)	8.0	7.5	16.2	6.2	1.1
5.2 Reduction	(km^2)	1.4	1.4	3.2	4.9	0.8
5.3 5.2/5.1	(%)	18	19	20	79	73
6. Average Annual Population Affected (2000)						
6.1 Without development	(10^3)	9.6	3.1	10.0	2.5	4.7
6.2 Reduction	(10^3)	2.8	1.5	6.0	2.0	3.7
6.3 6.2/6.1	(%)	29	48	60	80	79

Table 38 INVESTMENT COST OF RIVER CHANNEL IMPROVEMENT FOR MODEL RIVER STRETCH IN MUDA RIVER BASIN

Work Item		Unit Cost	Volume	Amount
I.	Construction			
	(1) Excavation	M$2.5/m^3	1,740 x 10^3 m^3	M$4,350 x 10^3
	(2) Embankment	M$4.0/m^3	1,650 x 10^3 m^3	6,600 x 10^3
	(3) Sod Facing	M$2.7/m^2	1,210 x 10^3 m^3	3,270 x 10^3
	(4) Levee/Road Pavement	M$8.6/m^2	270 x 10^3 m^3	2,320 x 10^3
	Total			M$16,540 x 10^3
II.	Compensation			
	(1) Rubber/Oil Palm Land	M$29 x 10^3/ha	23 ha	M$670 x 10^3
	(2) Paddy Land	M$43 x 10^3/ha	13 ha	560 x 10^3
	(3) Forest Land	M$5 x 10^3/ha	404 ha	2,020 x 10^3
	Total			M$3,250 x 10^3
III.	Engineering Service (10% of I)			M$1,650 x 10^3
IV.	Physical Contingencies (30% of I, II & III)			M$6,430 x 10^3
	Grand Total			M$27,870 x 10^3

Table 39 RECOMMENDED TREATMENT CAPACITY FOR RUBBER FACTORIES, PALM OIL MILLS AND A SUGAR MILL

Unit: 10^3 m^3/d

Basin No.	Basin Name	Treatment Capacity 1990	Treatment Capacity 2000
2	Perlis	0.05	0.05
3	Kedah	0.60	0.64
4	Merbok	7.60	10.04
5	Muda	1.20	1.28
6	Perai	5.04	9.36
7	P. Pinang	3.25	5.06

Remarks; Operation days per year by industry are as follows:

Rubber factories: 250 days
Palm oil mills : 250 days
Sugar mills : 120 days

Table 40 OUTLINE OF RECOMMENDED PUBLIC SEWERAGE SYSTEM IN HIGH GROWTH CASE

Town	1990 Treatment Capacity (10^3 m^3/d)	1990 Service Factor (%)	1990 Served Population (10^3)	2000 Treatment Capacity (10^3 m^3/d)	2000 Service Factor (%)	2000 Served Population (10^3)
Kangar	16	85	18	63	100	29
Alor Setar	52	85	70	201	100	96
Sg. Petani	34	85	52	130	100	75
Kulim	7	65	25	26	100	50
Butterworth	36	40	33	92	80	66
Georgetown	72	70	207	100	80	237
Total	217	-	405	612	-	553

Remarks; Public sewerage systems in C5 & C8 are not effective for river water pollution abatement.

Table 41 OUTLINE OF RECOMMENDED PUBLIC SEWERAGE SYSTEM IN LOW GROWTH CASE

Town	1990			2000		
	Treatment Capacity (10^3 m^3/d)	Service Factor (%)	Served Population (10^3)	Treatment Capacity (10^3 m^3/d)	Service Factor (%)	Served Population (10^3)
Kangar	2	20	4	15	80	18
Alor Setar	12	30	23	48	80	59
Sg. Petani	8	30	17	32	80	46
Kulim	1	10	4	8	80	30
Butterworth	17	25	19	51	70	44
Georgetown	46	55	149	57	70	159
Total	86	-	216	211	-	356

Remarks; Public sewerage systems in C5 & C8 are not effective for river water pollution abatement.

Table 42 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM IN HIGH GROWTH CASE

Unit: M$$10^6$

Town	4MP	5MP	6MP	7MP	Total
Kangar	10	23	24	17	74
Alor Setar	32	74	83	58	247
Sg. Petani	21	47	51	36	155
Kulim	6	13	14	10	43
Butterworth	24	48	49	35	156
Georgetown	13	26	26	18	83
Total	106	231	247	174	758

Table 43 ESTIMATED PRIVATE DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM, AND IMPROVEMENT OF PURIFICATION SYSTEM IN PRIVATE FACTORIES IN HIGH GROWTH CASE

Unit: M$$10^6$

Town	4MP	5MP	6MP	7MP	Total
Kangar	3	13	19	13	48
Alor Setar	5	26	41	27	99
Sg. Petani	4	20	31	20	75
Kulim	1	5	7	5	18
Butterworth	3	5	5	4	17
Georgetown	6	9	5	4	24
Total	22	78	108	73	281

Table 44 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM IN LOW GROWTH CASE

Unit: M$$10^6$

Town	4MP	5MP	6MP	7MP	Total
Kangar	4	10	11	8	33
Alor Setar	10	26	31	22	89
Sg. Petani	7	18	21	14	60
Kulim	4	8	9	6	27
Butterworth	13	32	37	25	107
Georgetown	2	9	13	9	33
Total	40	103	122	84	349

Table 45 ESTIMATED PRIVATE DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM AND IMPROVEMENT OF PURIFICATION SYSTEM IN PRIVATE FACTORIES IN LOW GROWTH CASE

Unit: M\$$10^6$

Town	4MP	5MP	6MP	7MP	Total
Kangar	1	3	4	3	11
Alor Setar	1	2	3	2	8
Sg. Petani	1	3	4	3	11
Kulim	1	2	2	1	6
Butterworth	1	1	0	0	2
Georgetown	0	0	0	0	0
Total	5	11	13	9	38

Table 46 ESTIMATED PRIVATE DEVELOPMENT EXPENDITURE FOR PURIFICATION SYSTEM IN RUBBER FACTORIES, PALM OIL MILLS AND A SUGAR MILL IN HIGH AND LOW GROWTH CASES

Unit: M\$$10^6$

Name of Basin	4MP	5MP	6MP	7MP	Total
Perlis	0	0.1	0	0	0.1
Kedah	0.5	0.5	0.2	0.1	1.3
Merbok	5.9	7.1	3.4	2.4	18.8
Muda	0.9	1.0	0.3	0.2	2.4
Perai	3.9	6.1	4.6	2.8	17.4
P. Pinang	2.5	3.4	2.1	1.4	9.4
Total	13.7	18.2	10.6	6.9	49.4

FIGURES

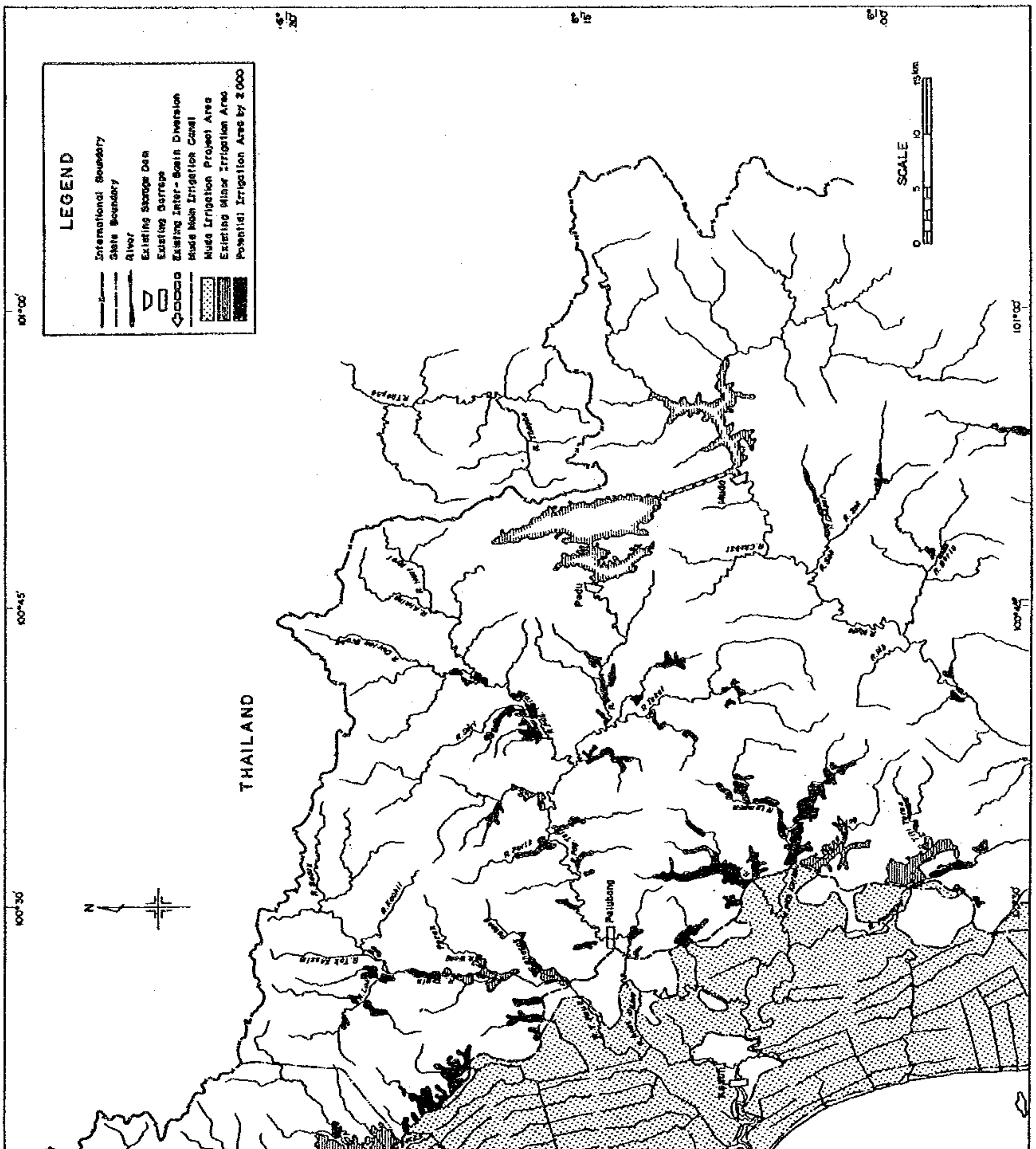

Fig. 1 Location of Irrigation Area (1/2)

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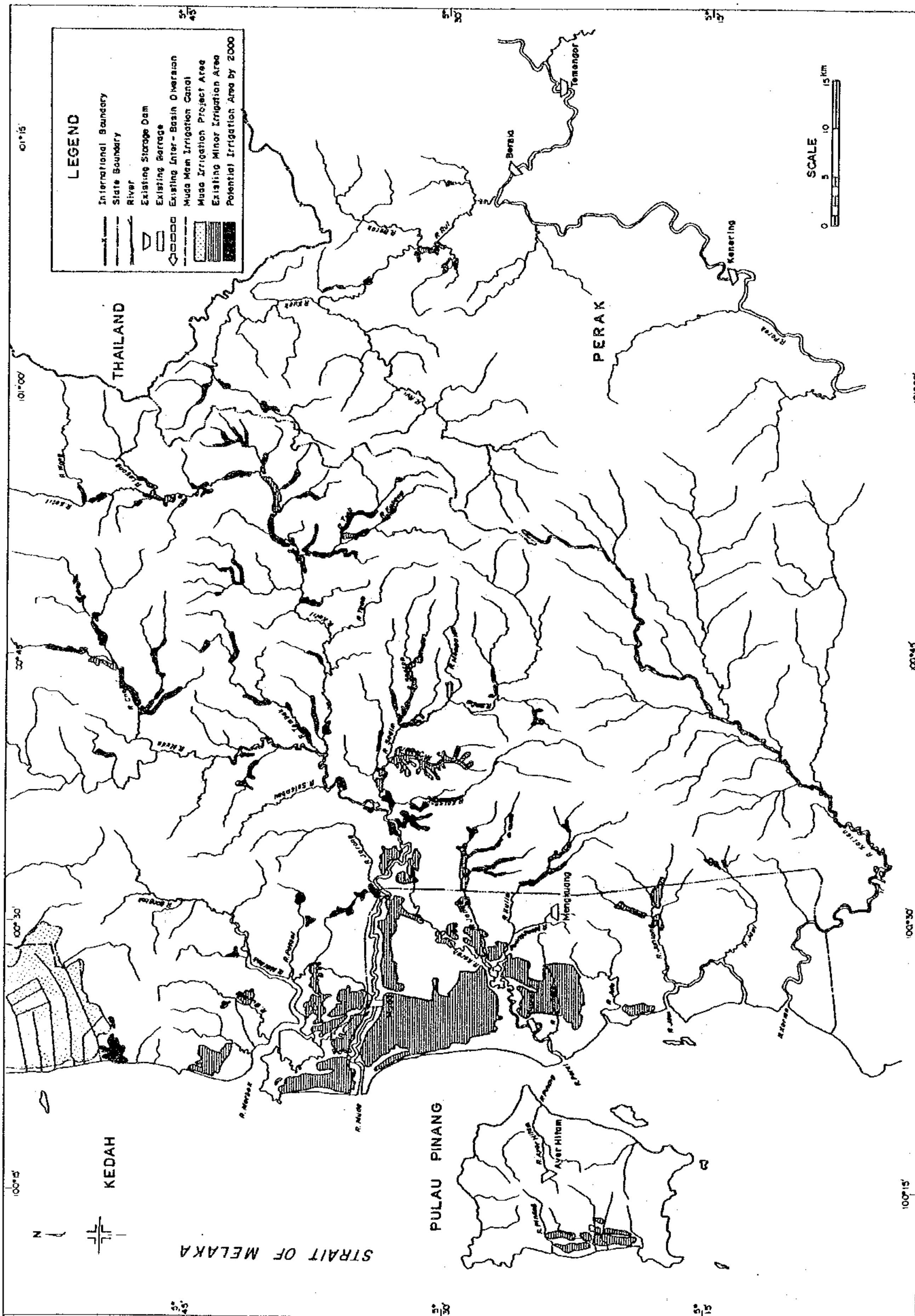

Fig. 2 Location of Irrigation Area (2/2)

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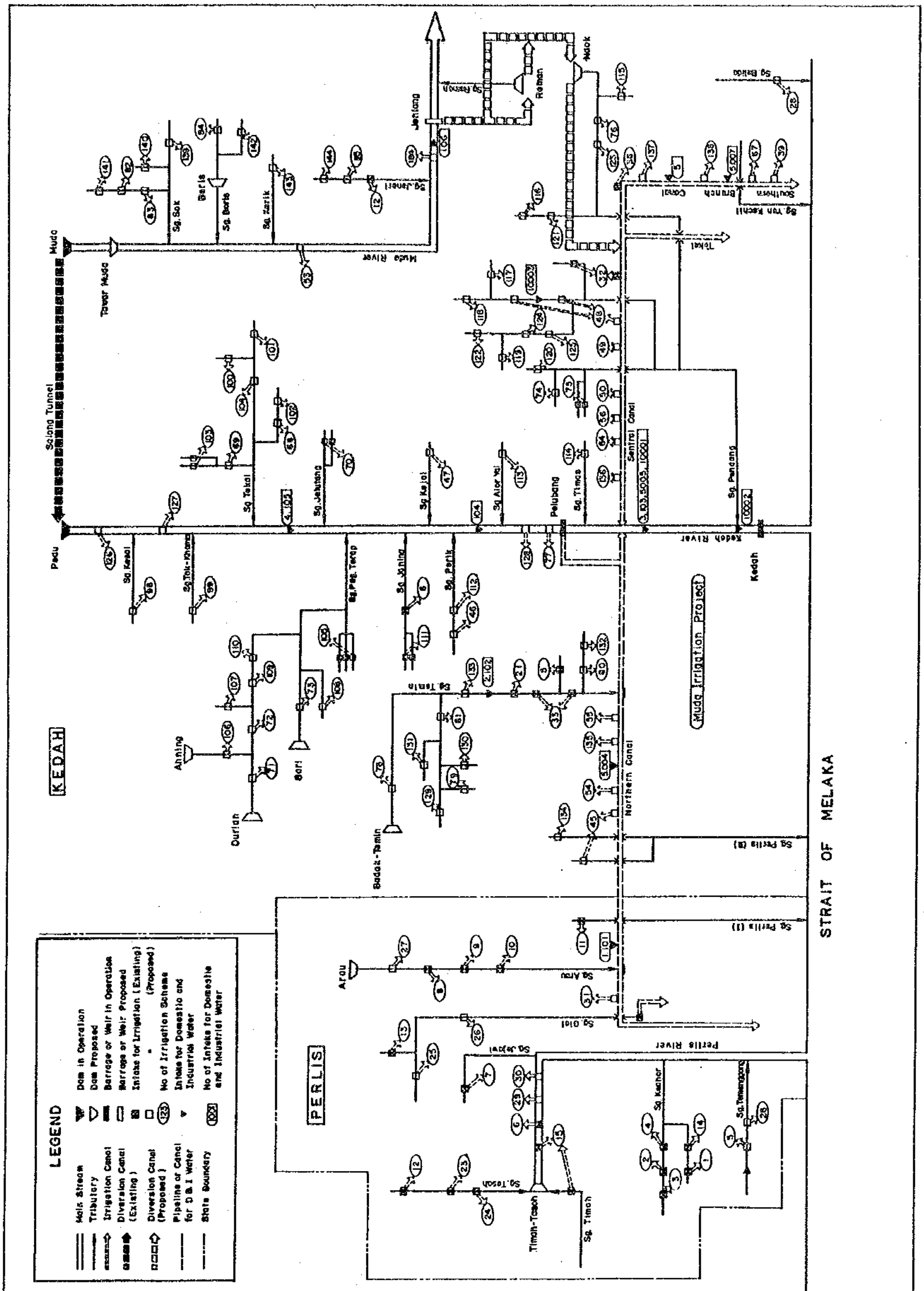

Fig. 3 Water Demand and Supply System Diagram (1/2)

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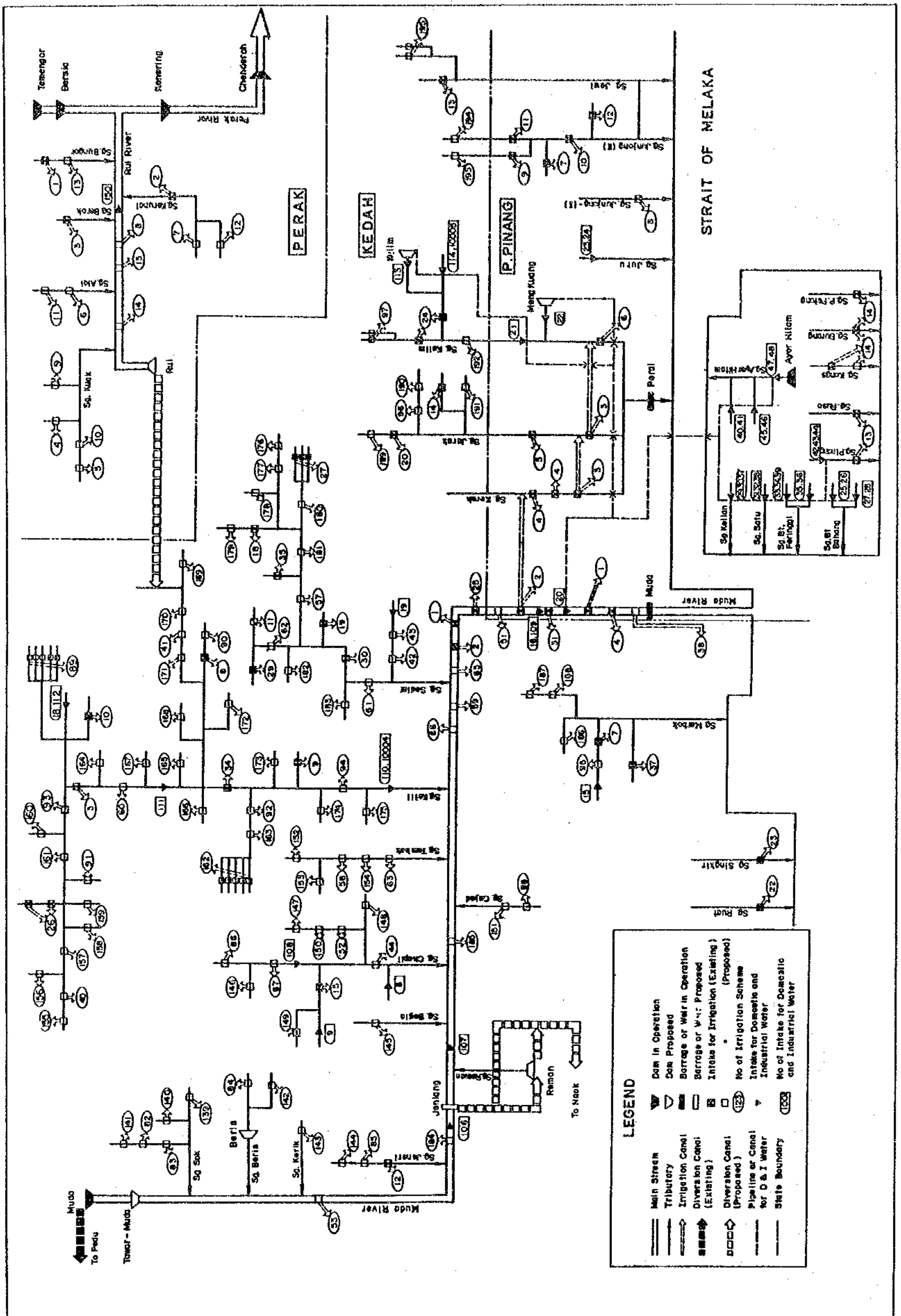

Fig. 4 Water Demand and Supply System Diagram (2/2)

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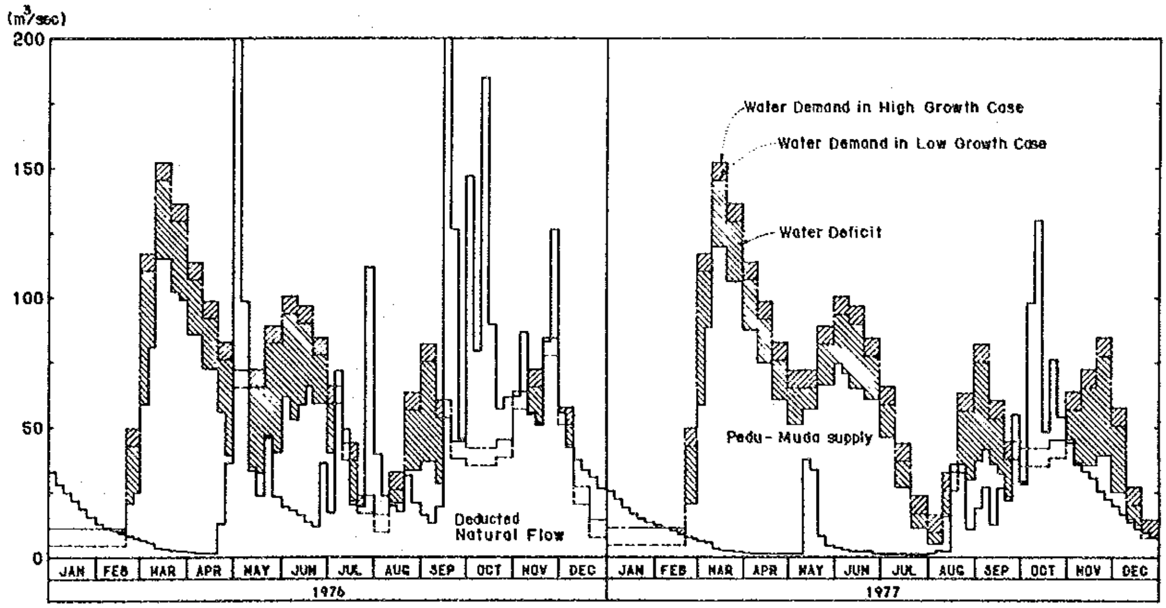
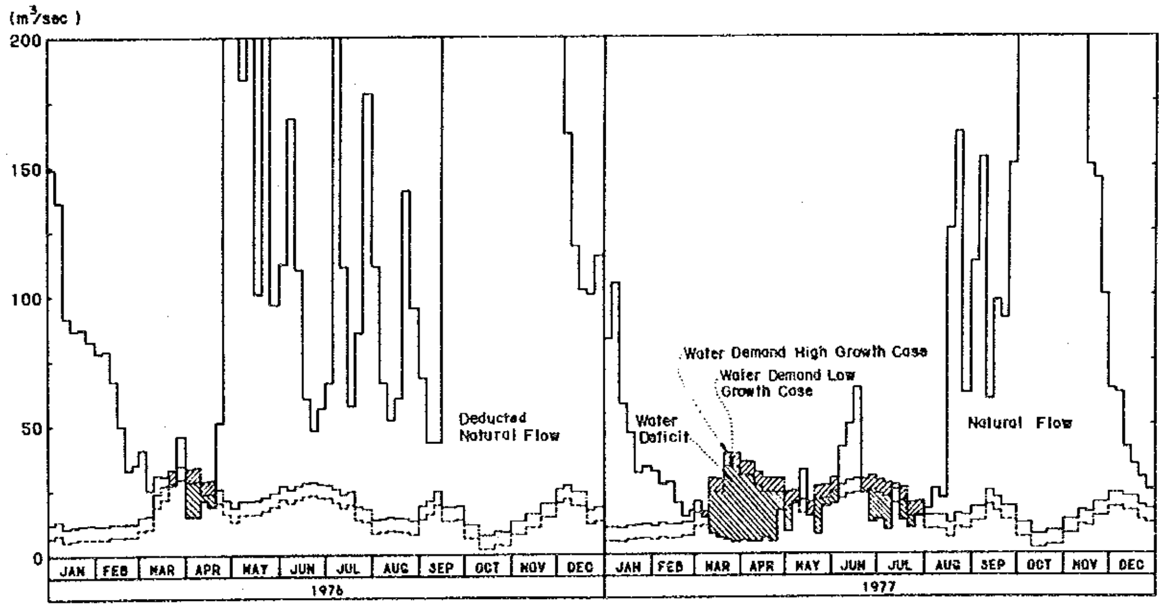
Kedah River System



Muda-Perai River System



Remarks : Water demand in the Muda- Perai river sytem deducted by the Ayar Hitam supply

Fig. 5 Illustration of Water Deficit

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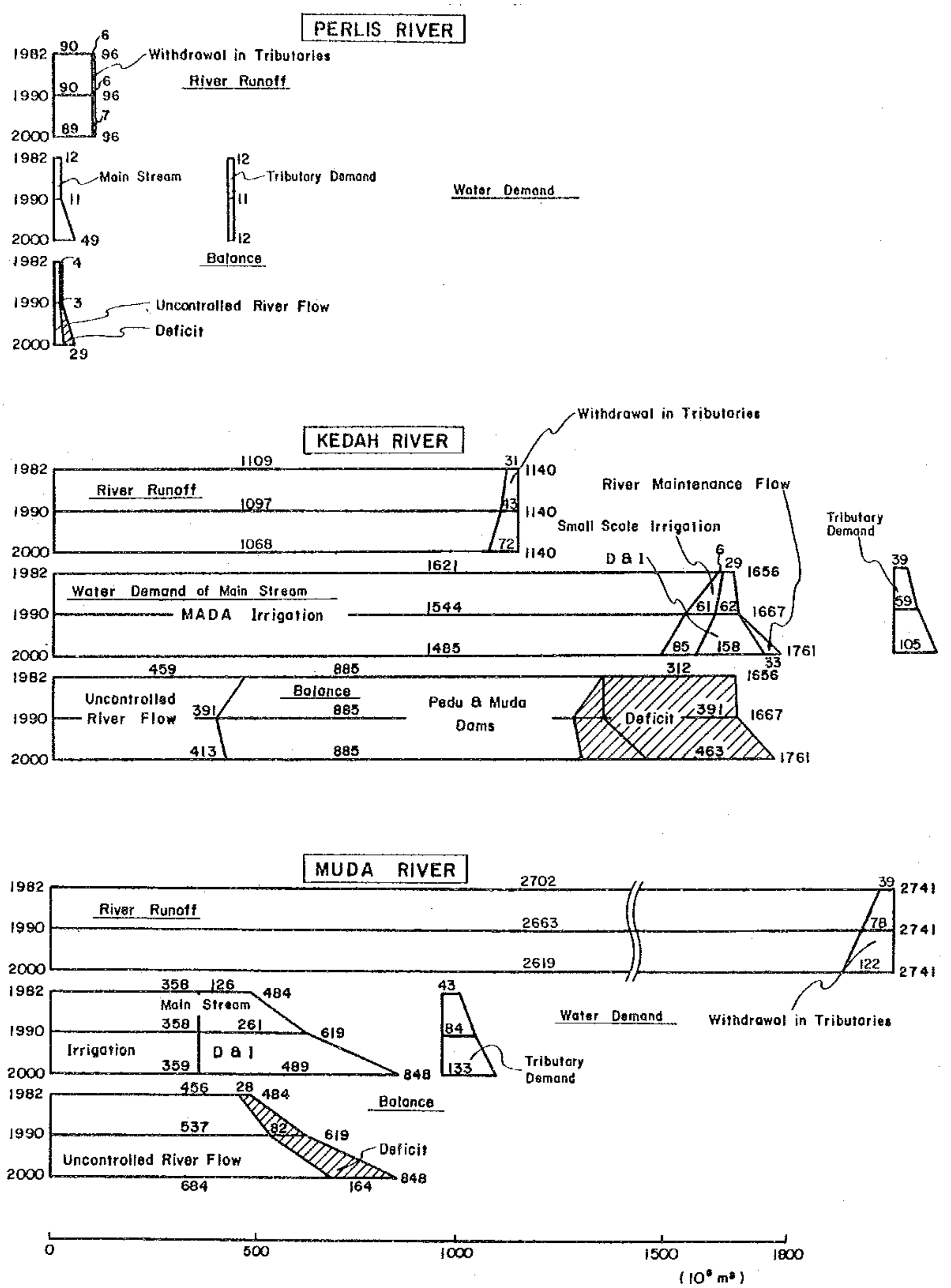

Fig. 6 River Runoff and Water Demand Balance by River Basin in High Growth Case Under 1977 Hydrological Condition

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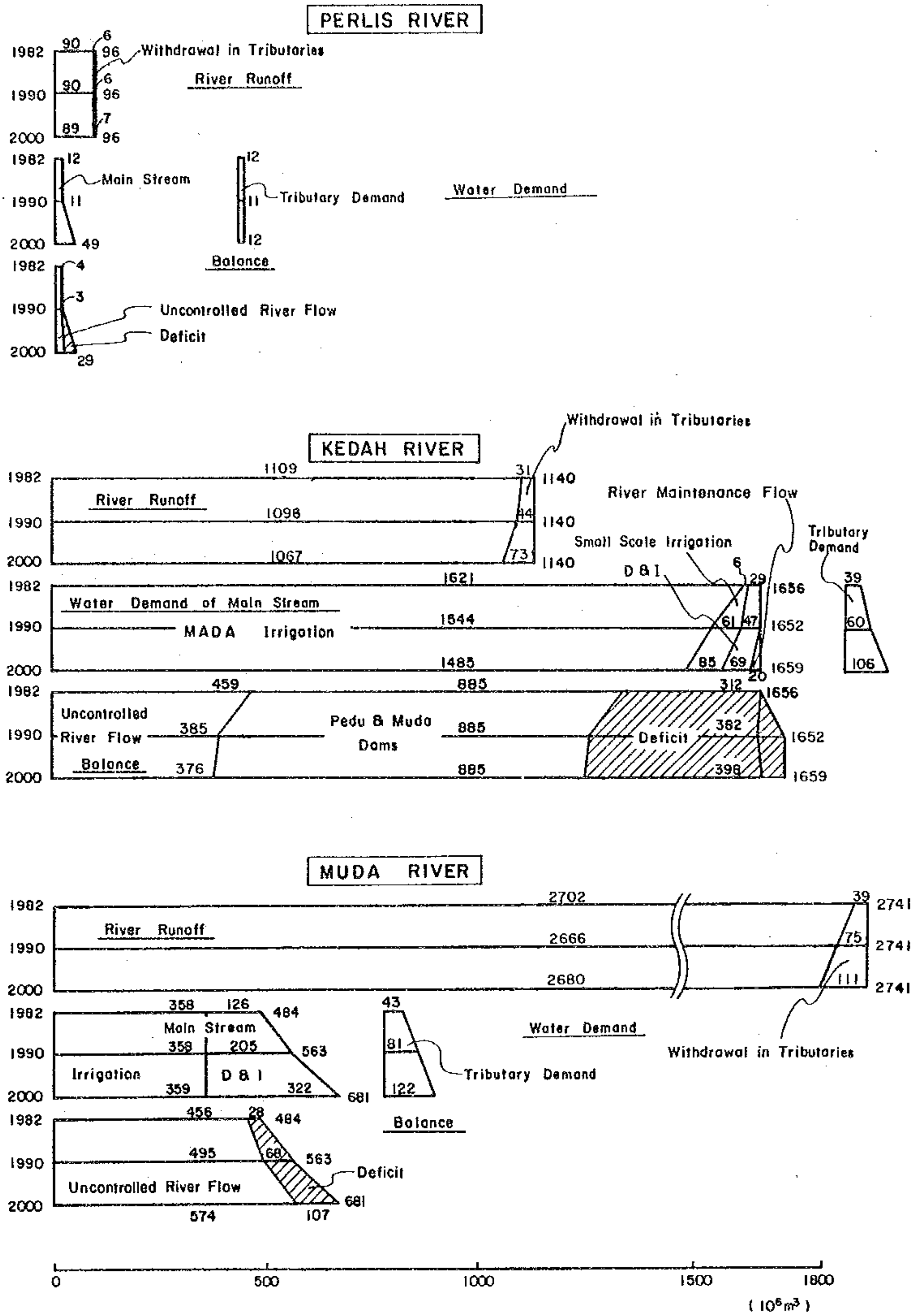

Fig. 7 River Runoff and Water Demand Balance by River Basin in Low Growth Case Under 1977 Hydrological Condition

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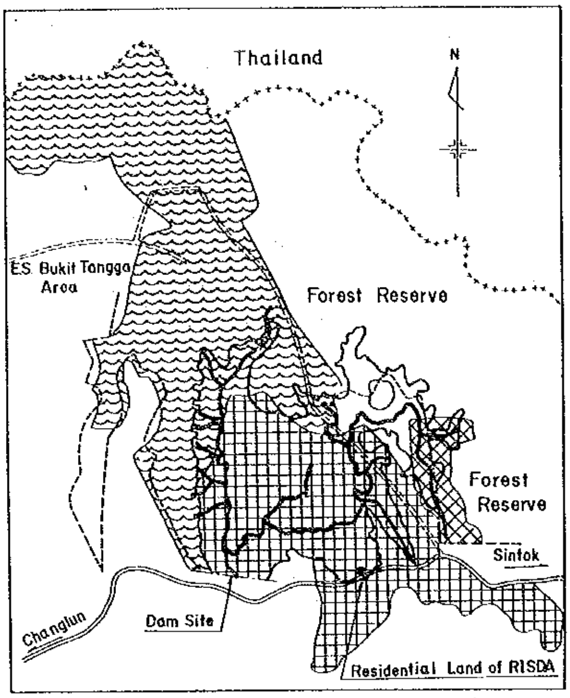
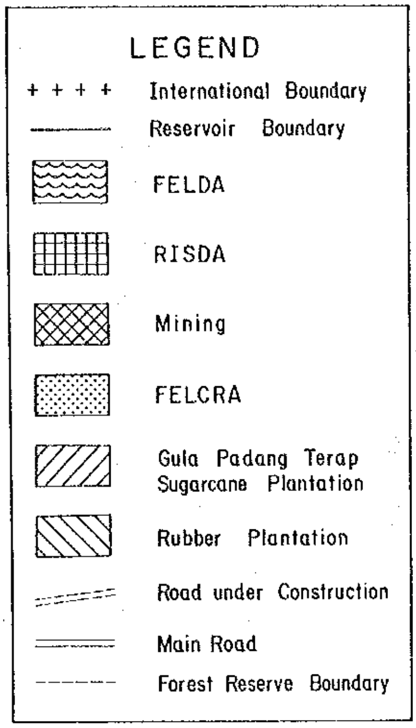
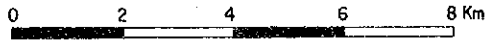


Fig. 8 Present Land Use Map in the Proposed Badak-Temin Reservoir Area





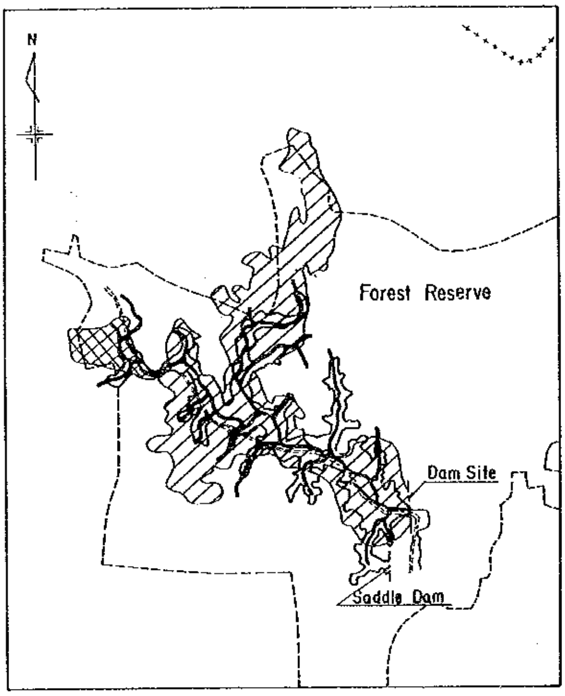


Fig. 9 Present Land Use Map in the Proposed Sari Reservoir Area

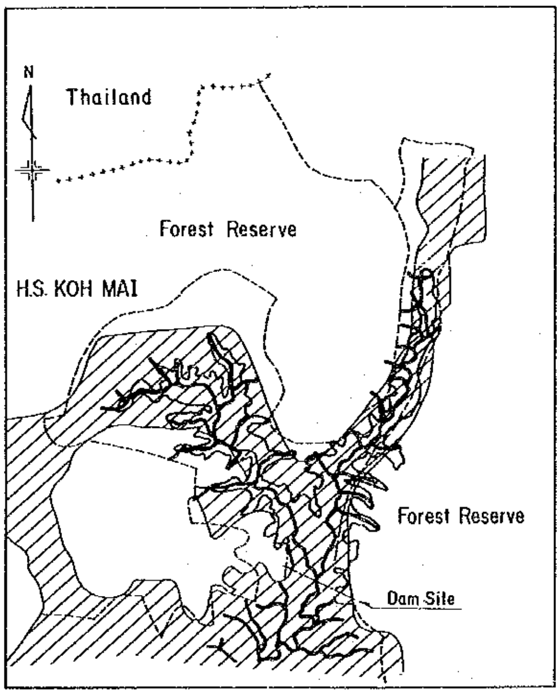


Fig. 10 Present Land Use Map in the Proposed Durian Reservoir Area

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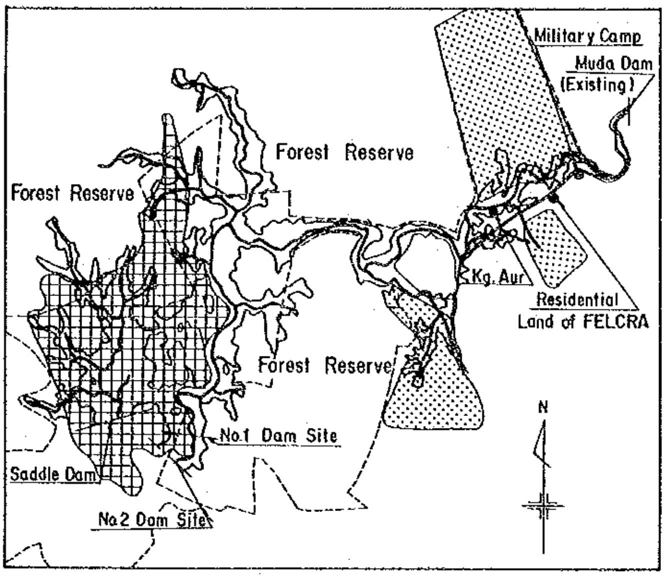

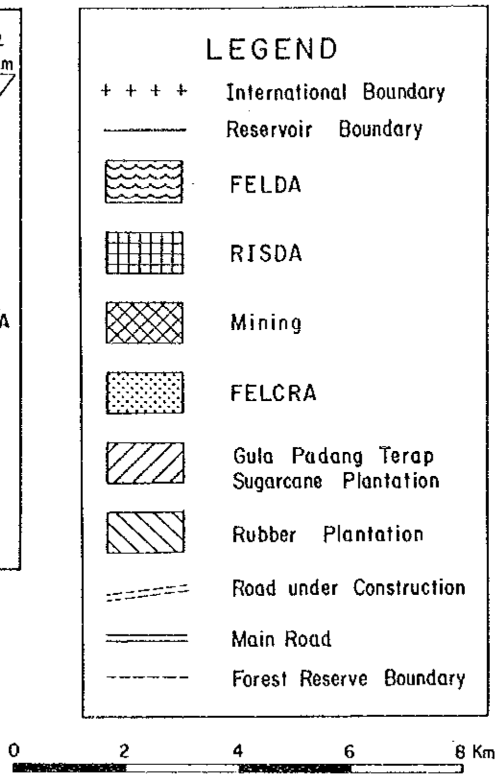

Fig. 11 Present Land Use Map in the Proposed Tawar-Muda Reservoir Area

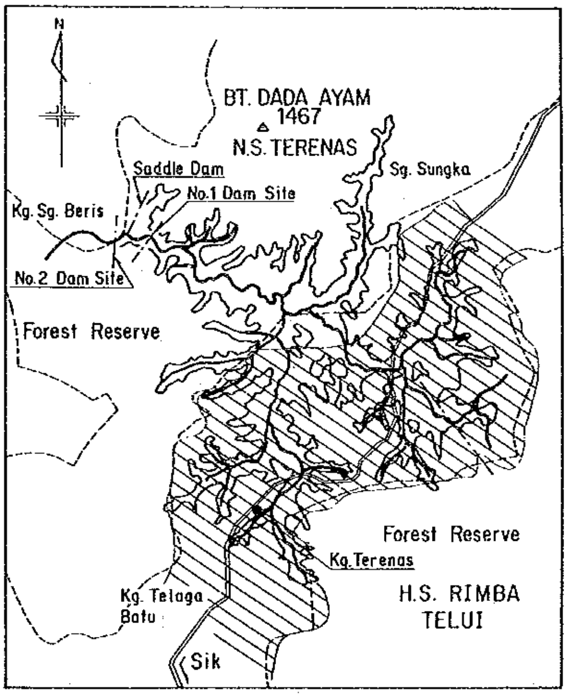

Fig. 12 Present Land Use Map in the Proposed Beris Reservoir Area

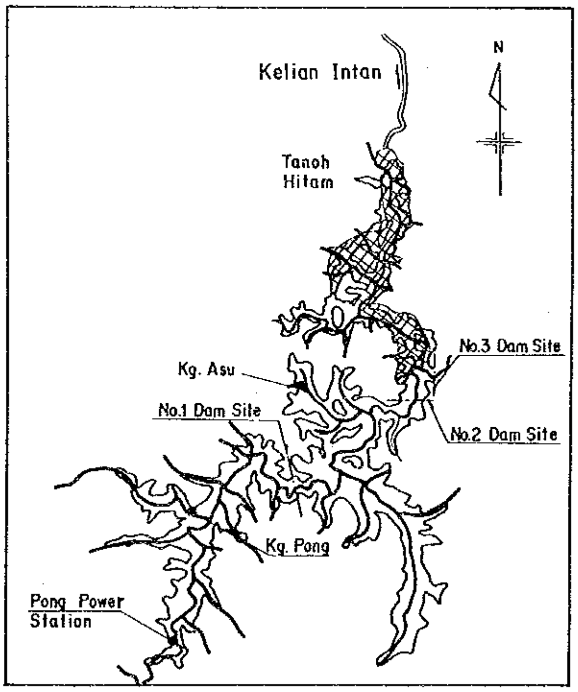

Fig. 13 Present Land Use Map in the Proposed Rui Reservoir Area

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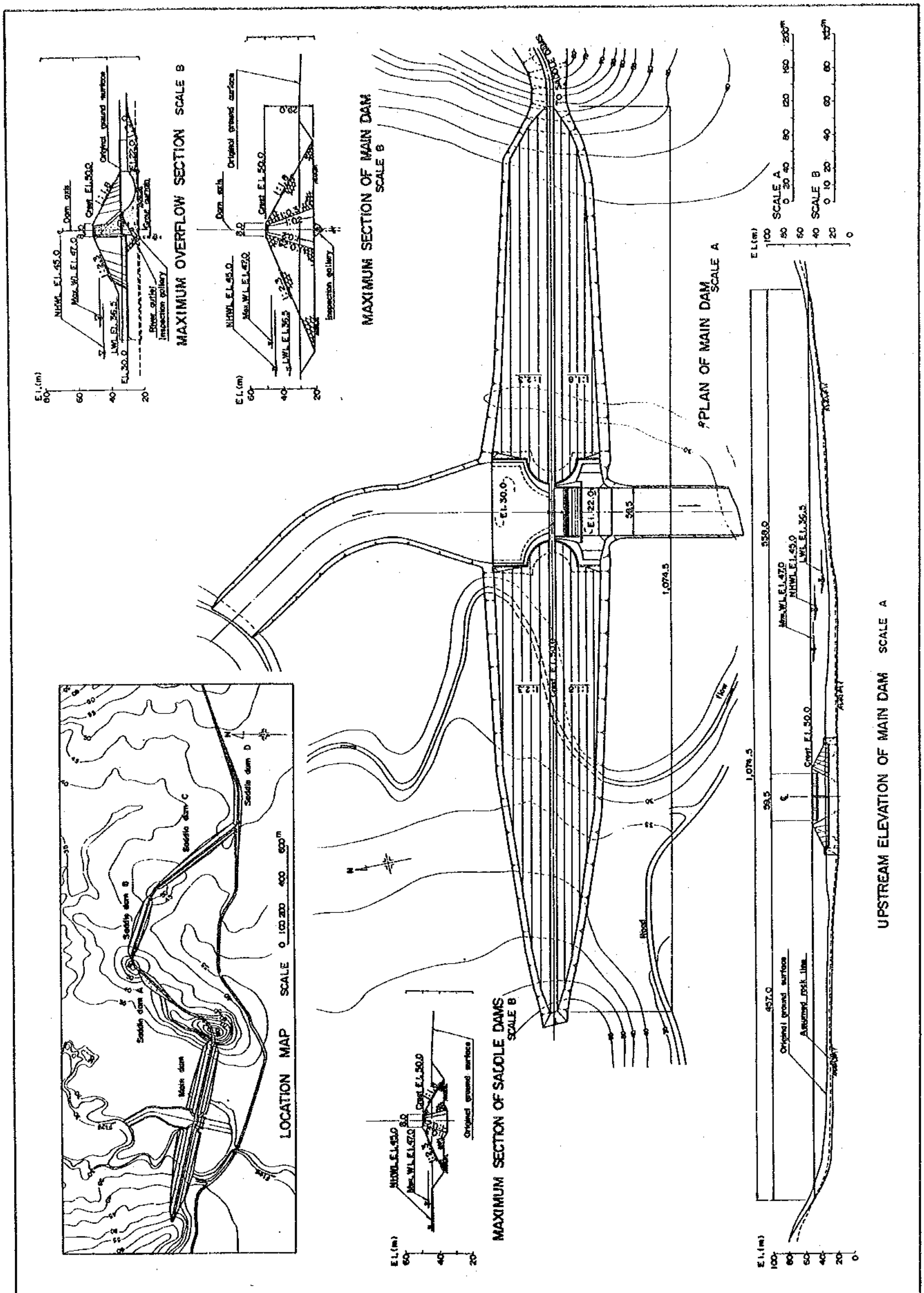

Fig. 14 Plan, Elevation, Profile and Section of Badak-Temin Dam

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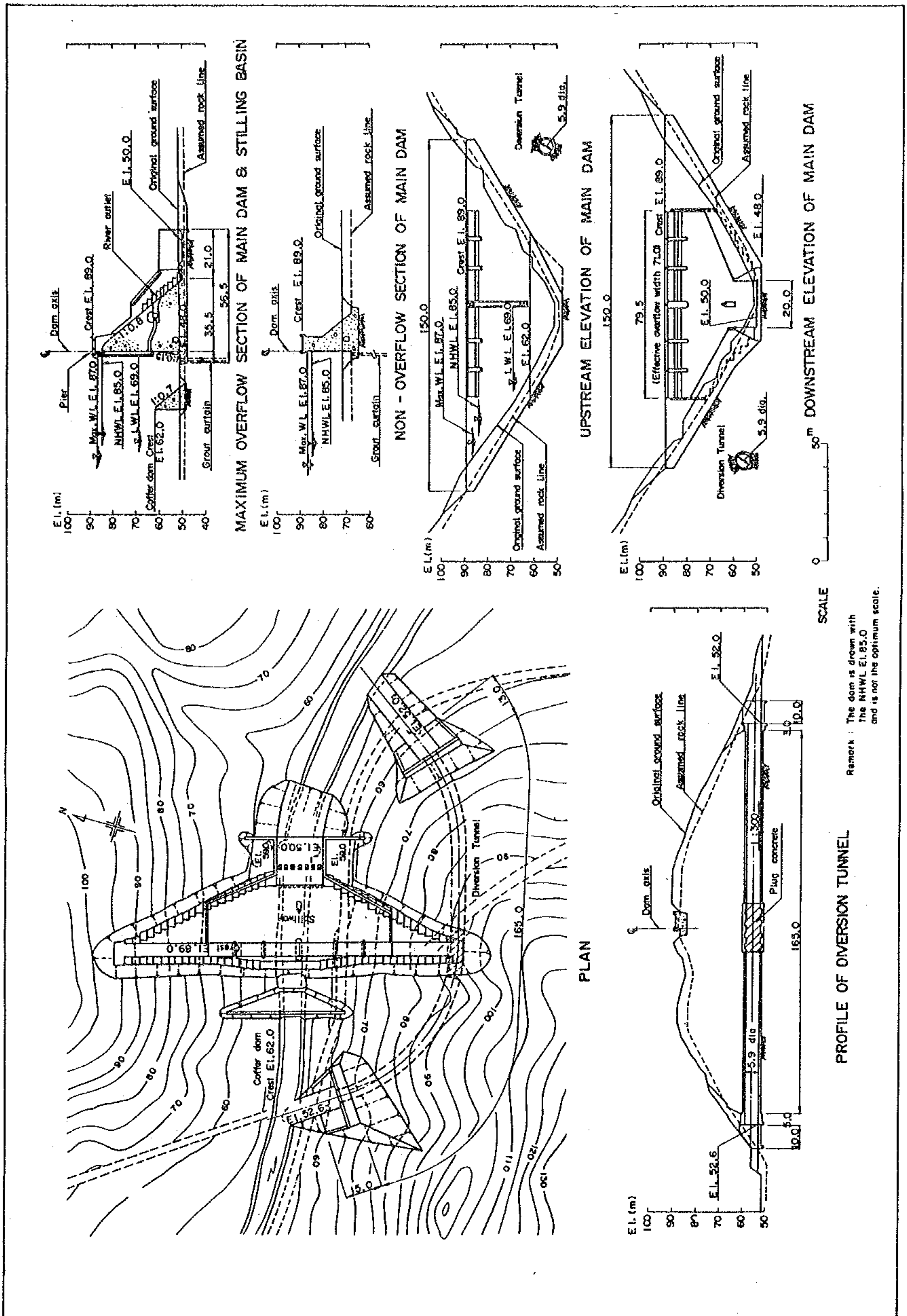

Fig. 15 Plan, Elevation, Profile and Section of Sari Dam

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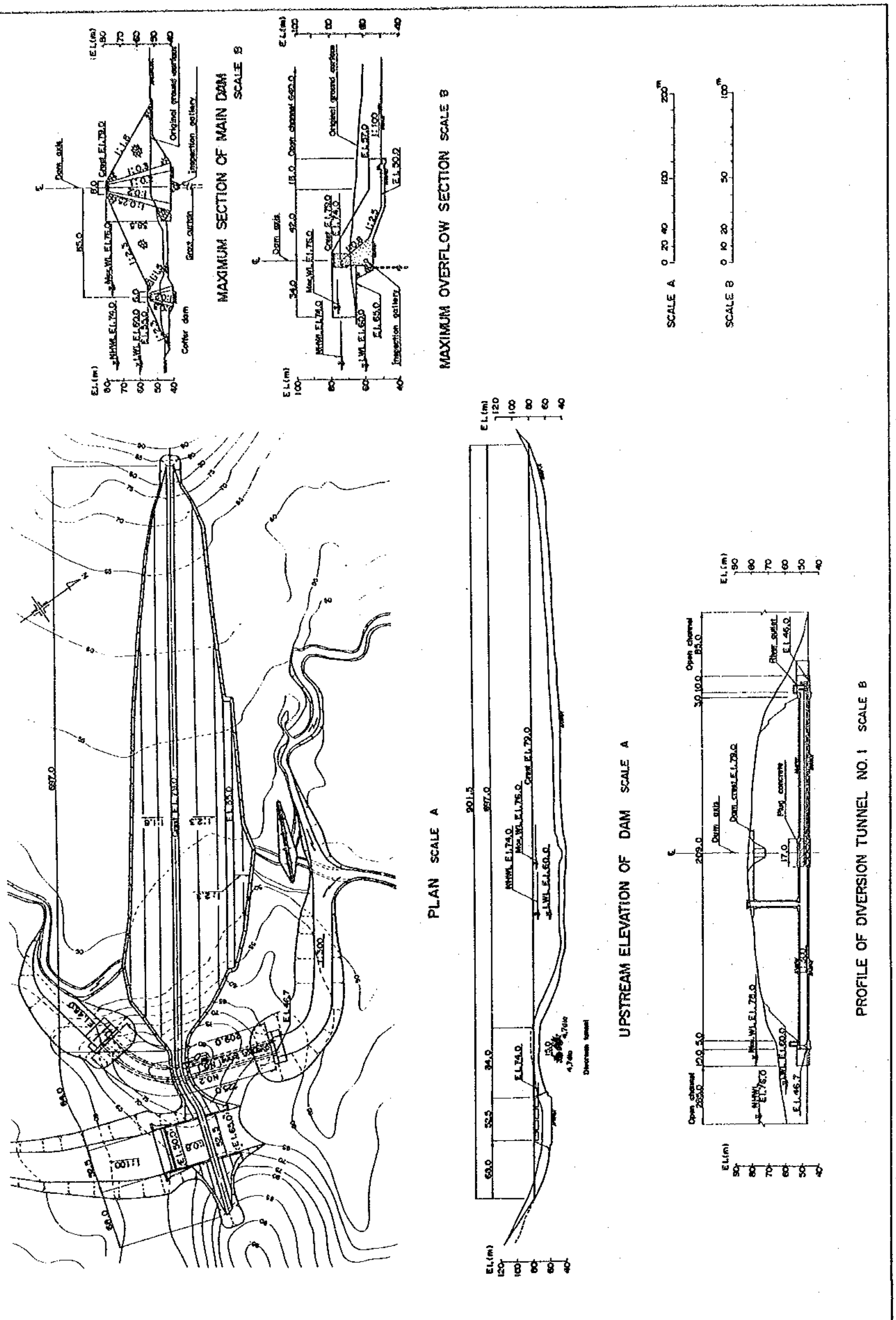

Fig. 16 Plan, Elevation, Profile and Section of Durian Dam

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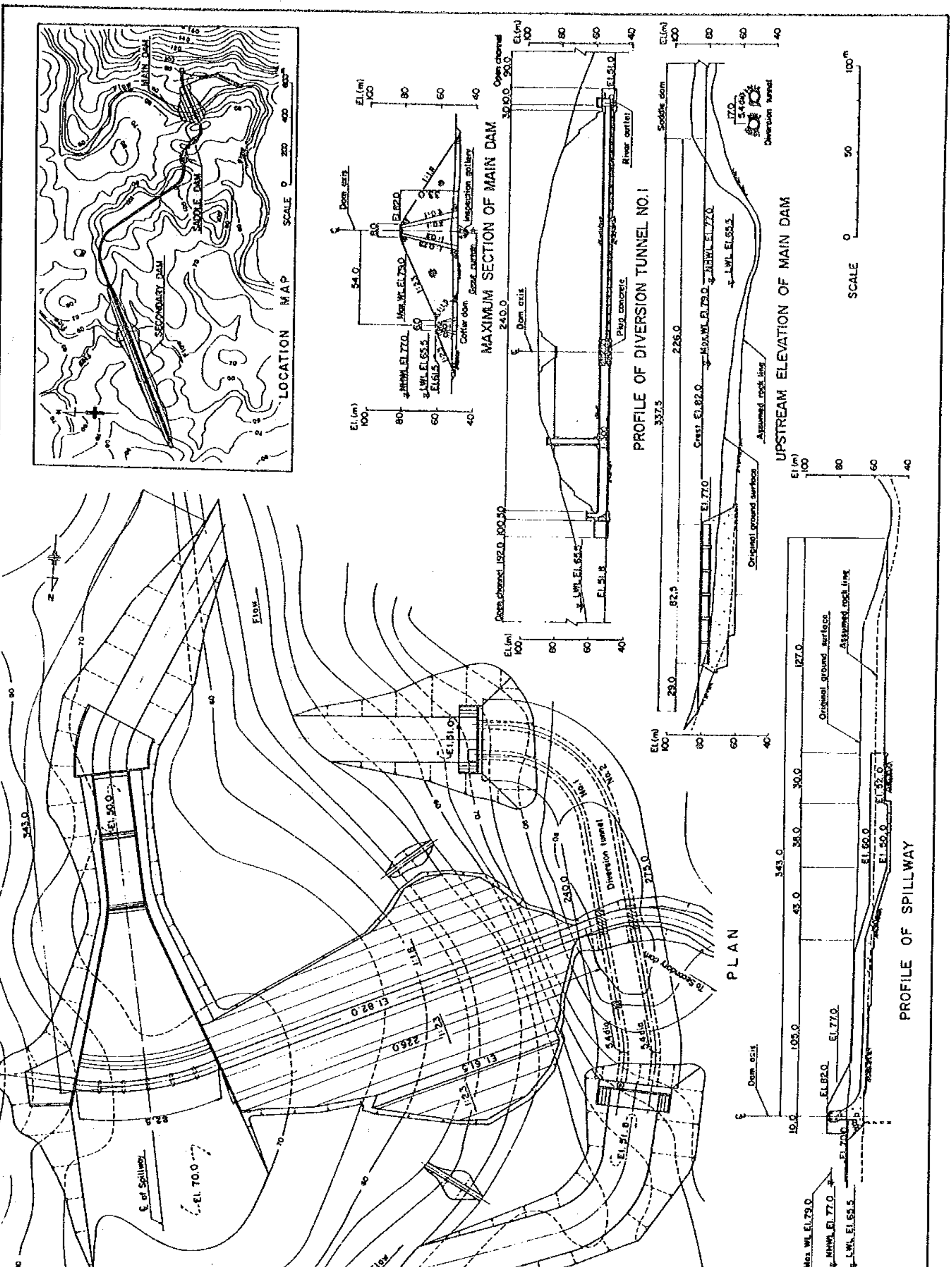

Fig. 17 Plan, Elevation, Profile and Section of Tawar-Muda Dam (1/2)

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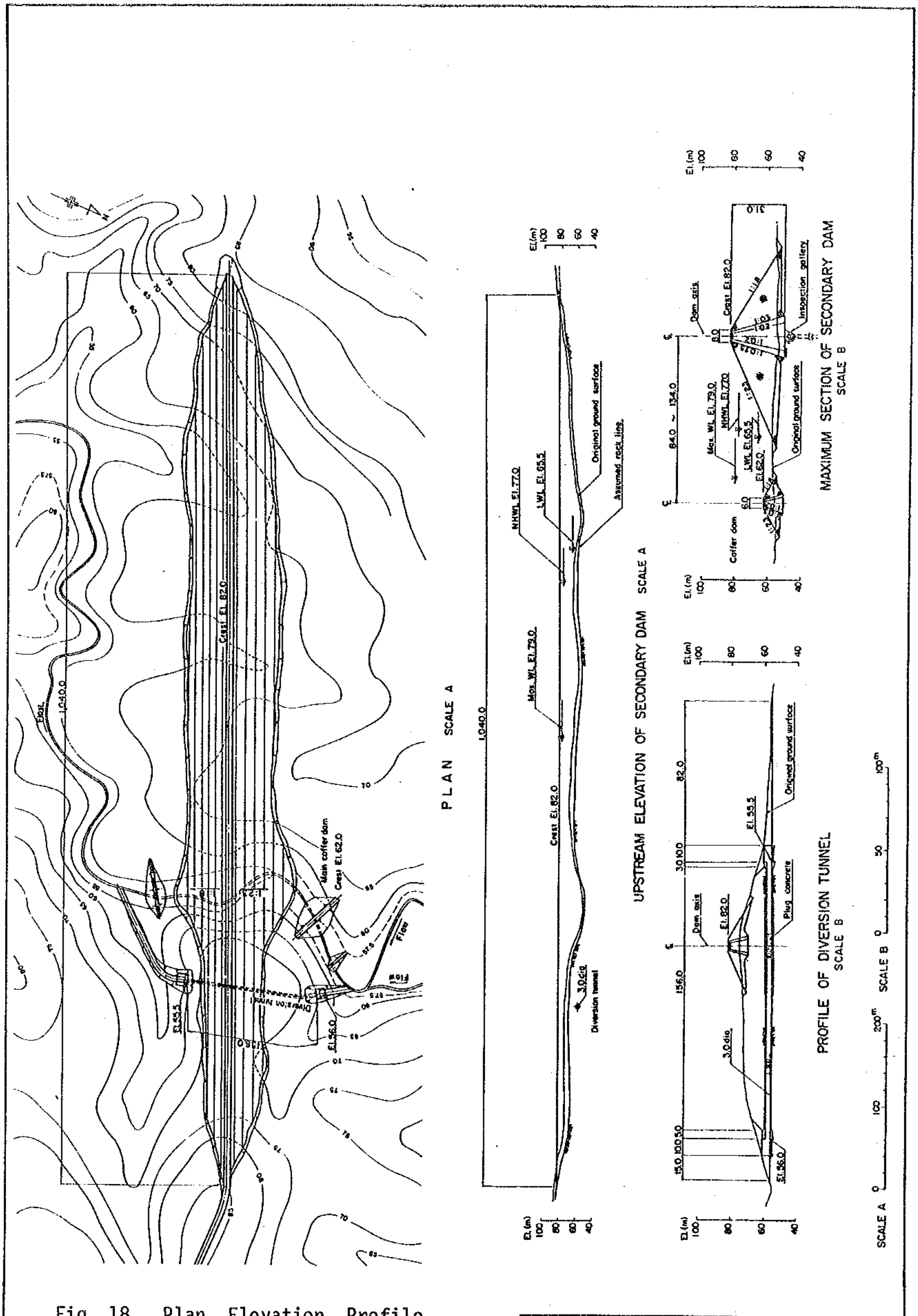

Fig. 18 Plan, Elevation, Profile and Section of Tawar-Muda Dam (2/2)

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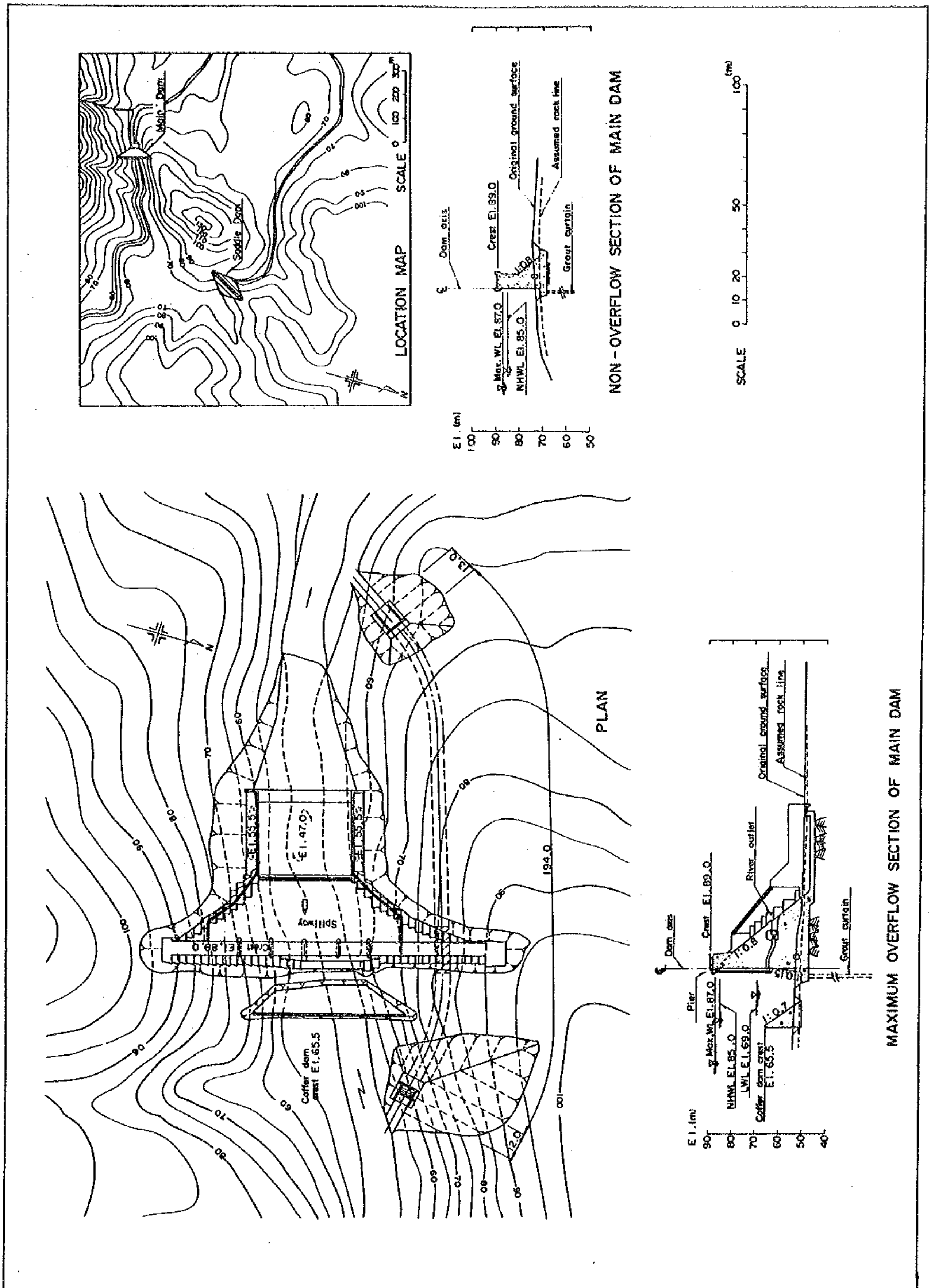

Fig. 19 Plan, Elevation, Profile and Section of Beris Dam (1/2)

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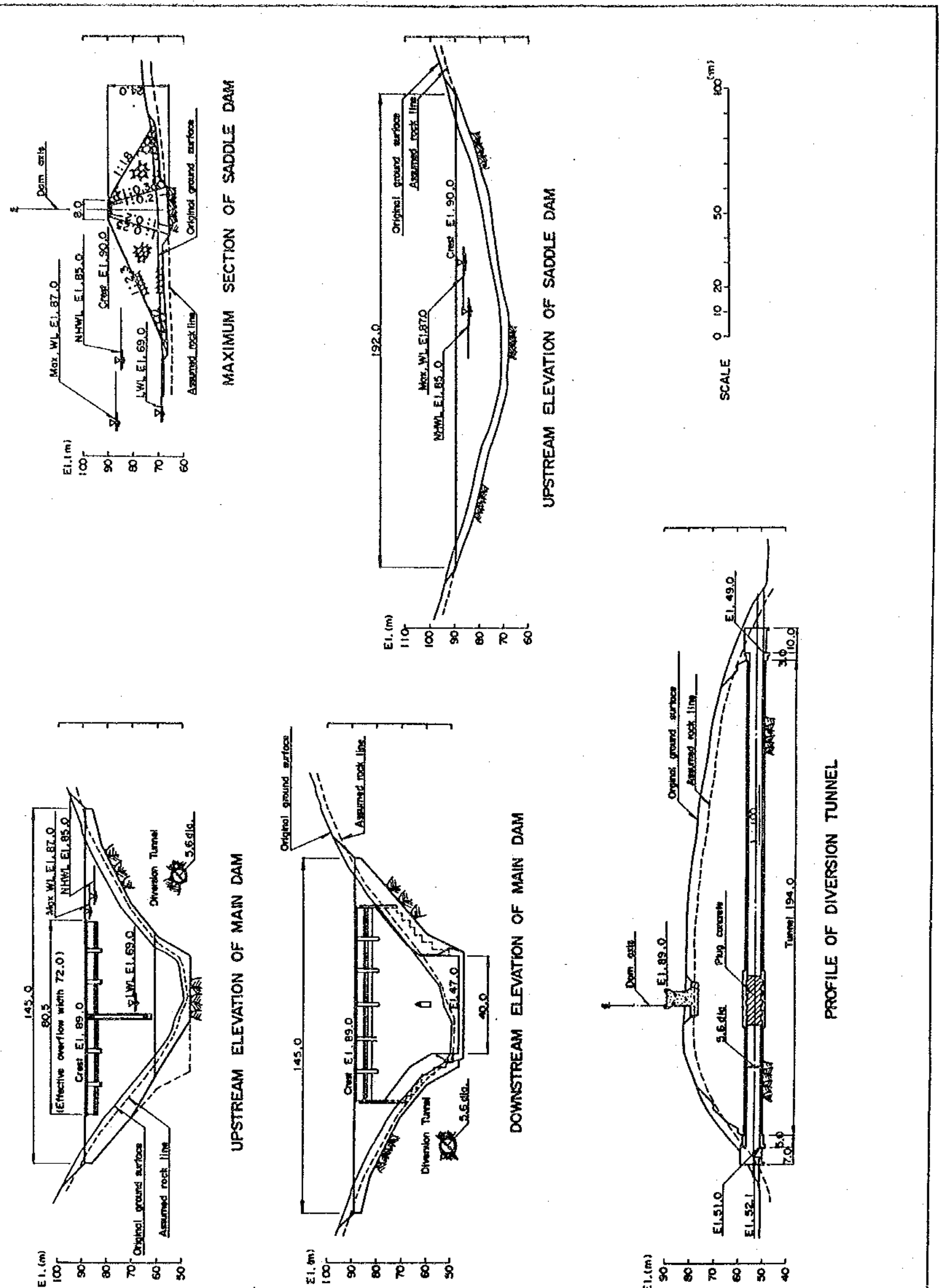

Fig. 20 Plan, Elevation, Profile and Section of Beris Dam (2/2)

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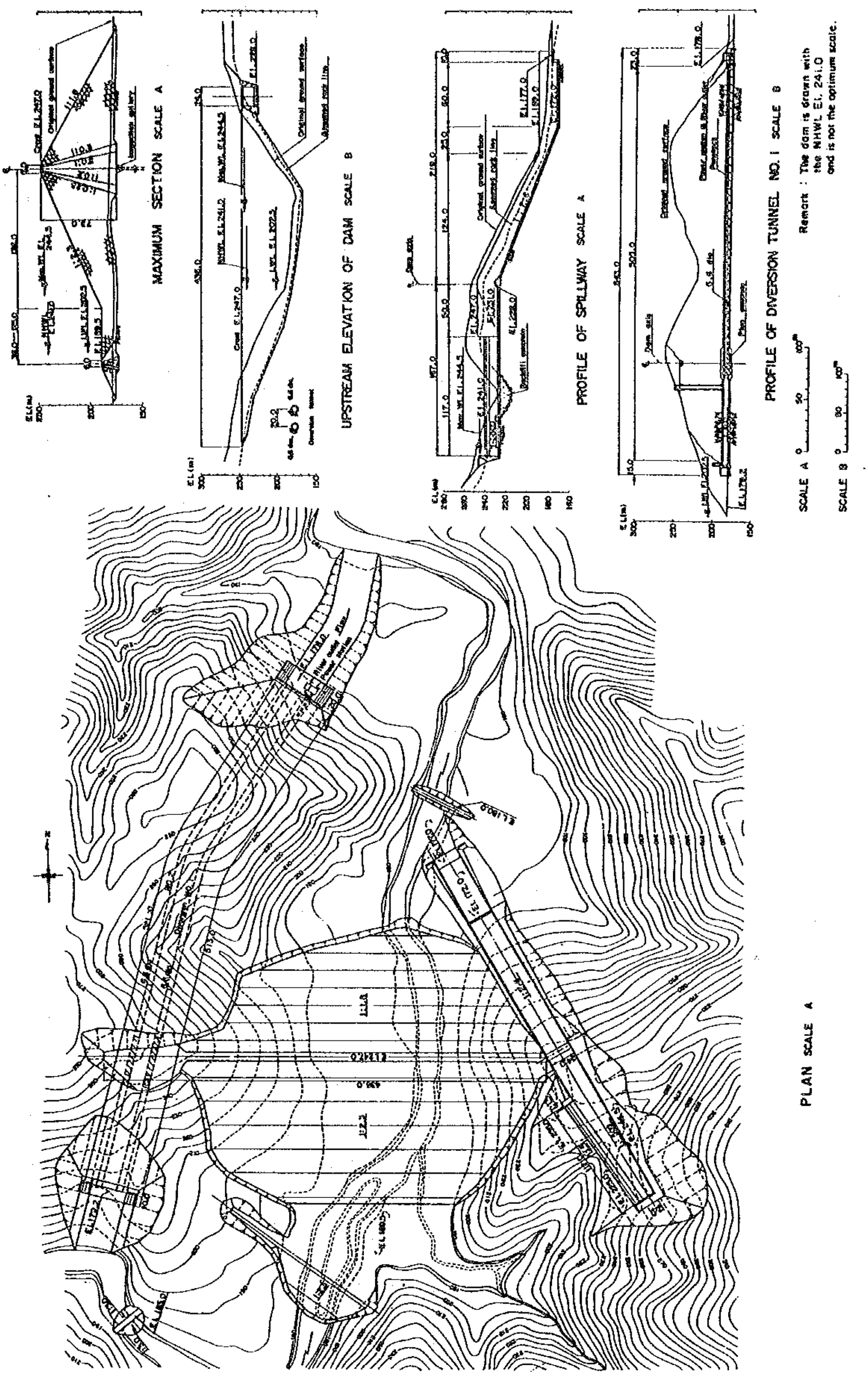

Fig. 21 Plan, Elevation, Profile and Section of Rui 2 Dam

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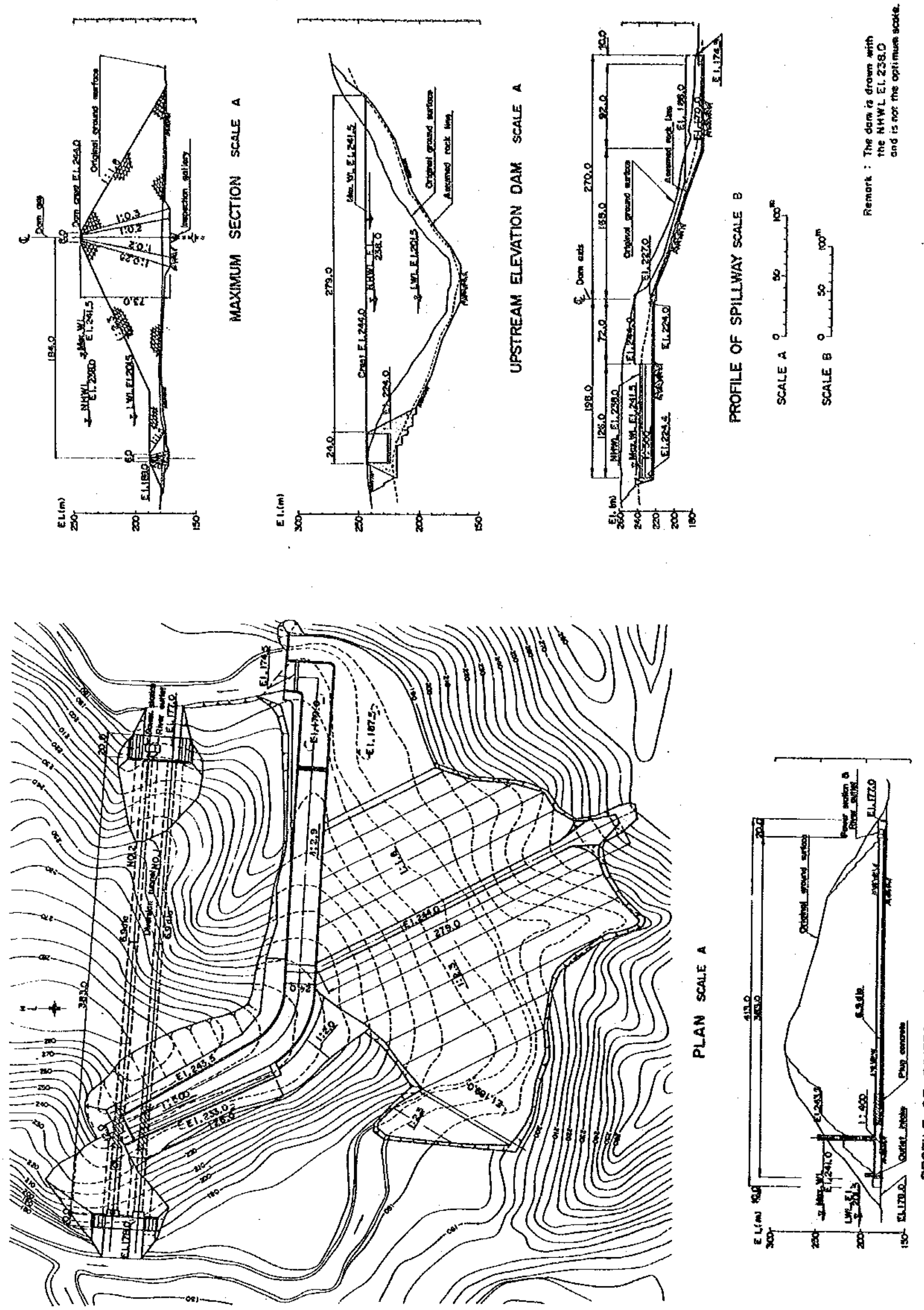

Fig. 22 Plan, Elevation, Profile and Section of Rui 3 Dam

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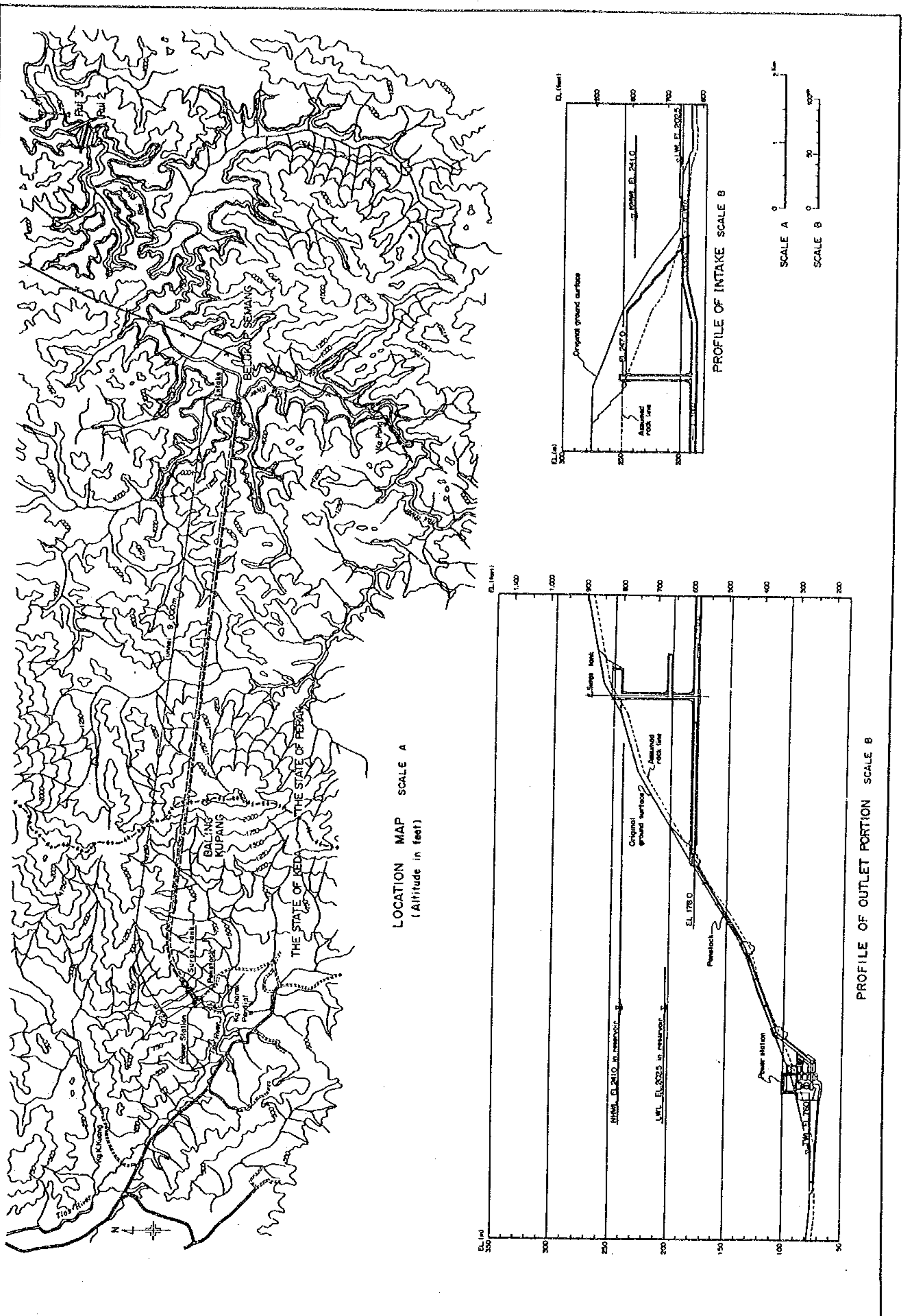

Fig. 23 Rui Basin Transfer Facilities

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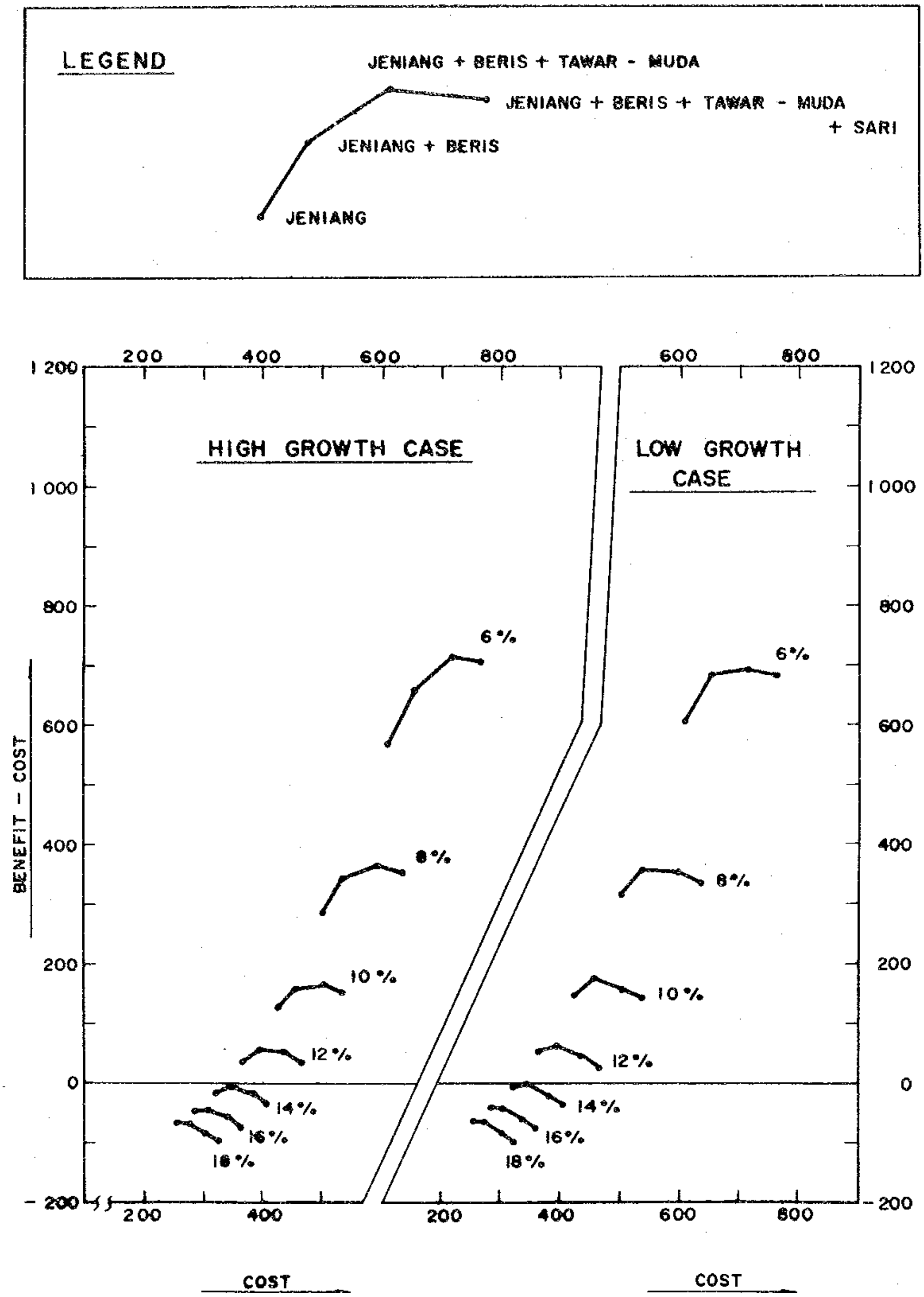

Fig. 24 Present Value of B-C of Overall Water Demand and Supply Balance Plan Involving Varying Combination of Source Projects

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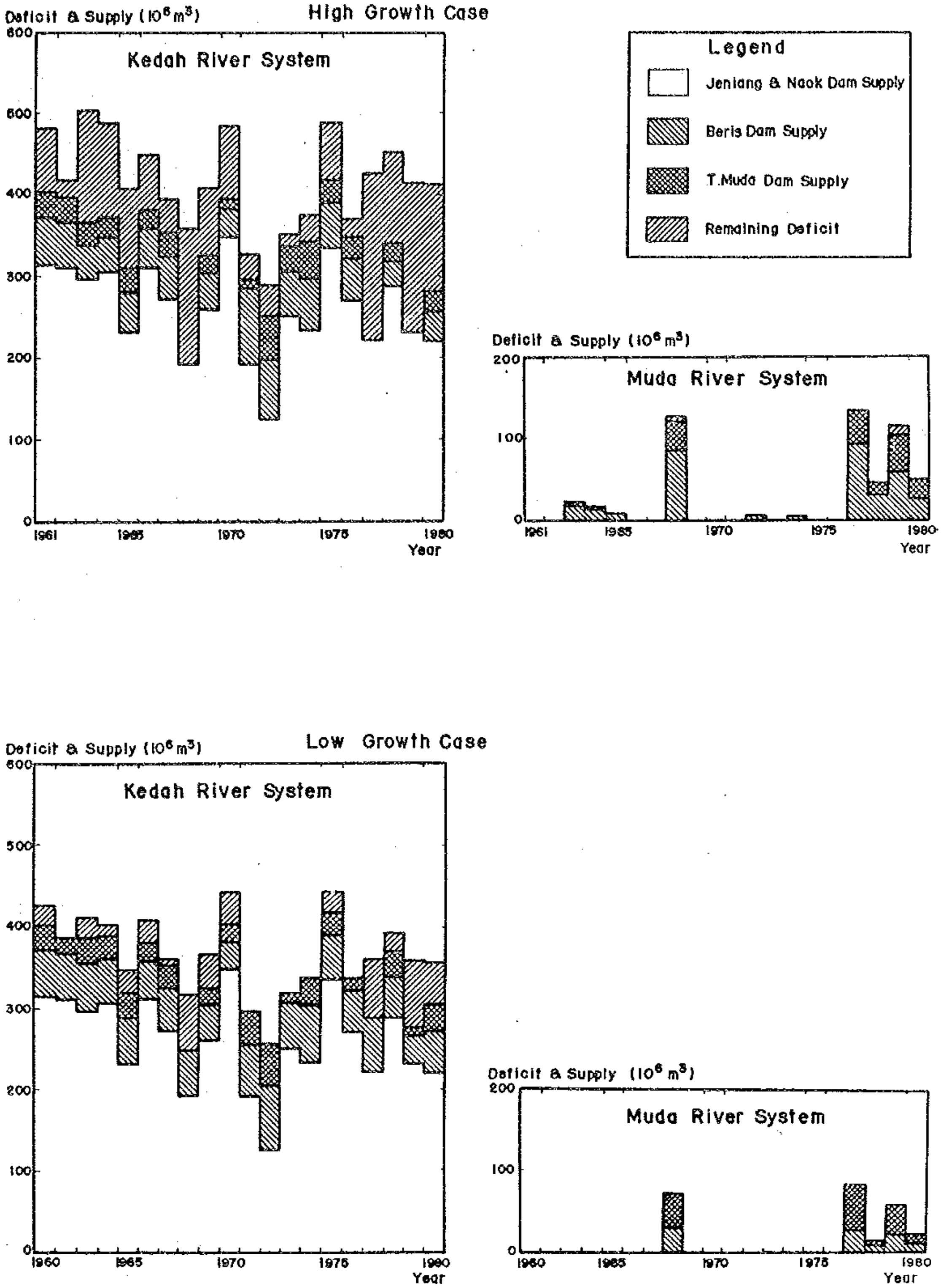

Fig. 25 Illustration of Water Deficit and Supply Balance by Jeniang System, Beris and Tawar-Muda Dams

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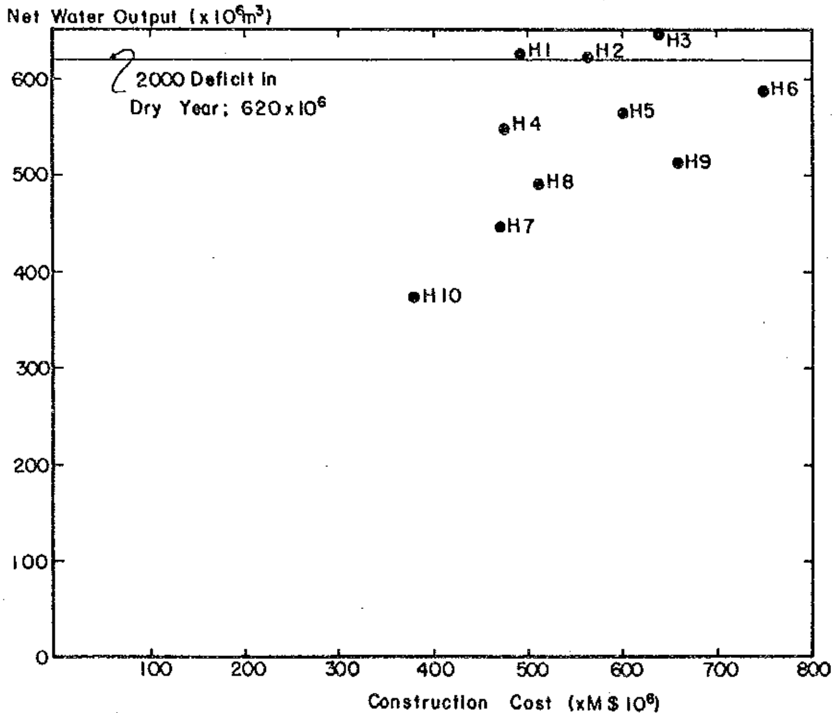
	Net Water Output ($10^6 m^3$)	Construction Cost (M$ 10^6)	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
Tawar-Muda	41	115	Unnecessary	Compatible	Unnecessary	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Rui	140	280	Unnecessary	Unnecessary	For Muda-Perai River	Suspended	Unnecessary	For Muda-Perai River	Suspended	Unnecessary	For Muda-Perai River	Suspended
Khlong Thepa	73	90	Unnecessary	For Kedah River	Suspended	Suspended	For Kedah River	For Kedah River	For Kedah River	Suspended	Suspended	Suspended
Merbok	118	132	For Muda-Perai River	Suspended	Suspended	Suspended	For Muda-Perai River	Suspended	Suspended	For Muda-Perai River	Suspended	Suspended
Reman	175	96	Compatible	Compatible	Compatible	Compatible	Suspended	Suspended	Suspended	Suspended	Suspended	Suspended
Beris	92	73	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
Jeniang	175	72	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River
Ahning	42	56	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River	For Kedah River
Mengkuang	24	62	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River	For Muda-Perai River
Water Output (Kedah) ($10^6 m^3$)			217	290	217	217	290	290	290	217	217	217
Water Output (Muda-Perai) ($10^6 m^3$)			142	24	157	24	142	157	24	142	157	24
Water Output (Compatible) ($10^6 m^3$)			267	308	274	308	133	140	133	133	140	133
Total Water Output ($10^6 m^3$)			626	622	648	549	565	587	447	492	514	374
Total Construction Cost (M$ 10^6)			491	564	639	474	600	748	468	510	658	378
Case			H1	H2	H3	H4	H5	H6	H7	H8	H9	H10



LEGEND

- Suspended
- For Kedah River
- For Muda-Perai River
- Compatible
- Unnecessary

Remarks; Power facilities cost is excluded from construction cost of the Rui dam

Fig. 26 Overall Water Demand and Supply Balance Plan with Potential Projects Included for High Growth Case

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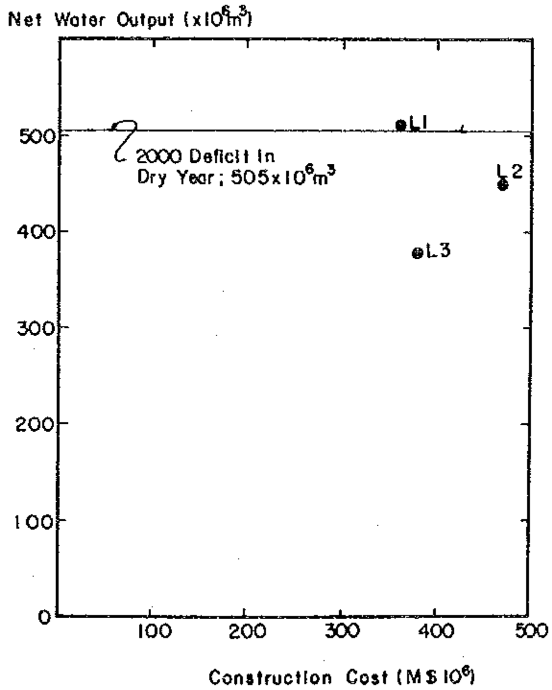
	Net Water Output ($10^6 m^3$)	Construction Cost (M$ 10^6)			
Tawar - Muda	41	115			
Khlong Thepha	73	90			
Reman	175	96			
Beris	92	73			
Jeniang	178	72			
Ahning	42	56			
Mengkuang	24	62			
Water Output	Kedah ($10^6 m^3$)		220	293	220
Water Output	Muda-Perai ($10^6 m^3$)		24	24	24
Water Output	Compatible ($10^6 m^3$)		267	133	133
Total Water Ouput ($10^6 m^3$)			511	450	377
Total Coustruction Cost (M$ 10^6)			359	468	378
Case			L1	L2	L3



LEGEND

- Suspended
- For Kedah River
- For Muda-Perai River
- Compatible
- Unnecessary

Remarks; Power facilities cost is excluded from construction cost of the Rui dam.

Fig. 27. Overall Water Demand and Supply Balance Plan with Potential Projects Included for Low Growth Case

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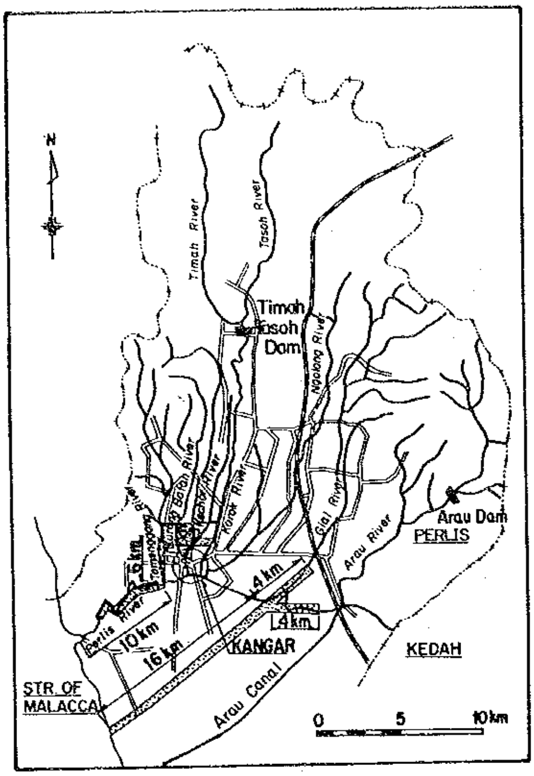


Fig. 28 Recommended Flood Mitigation Plan for the Perlis River Basin

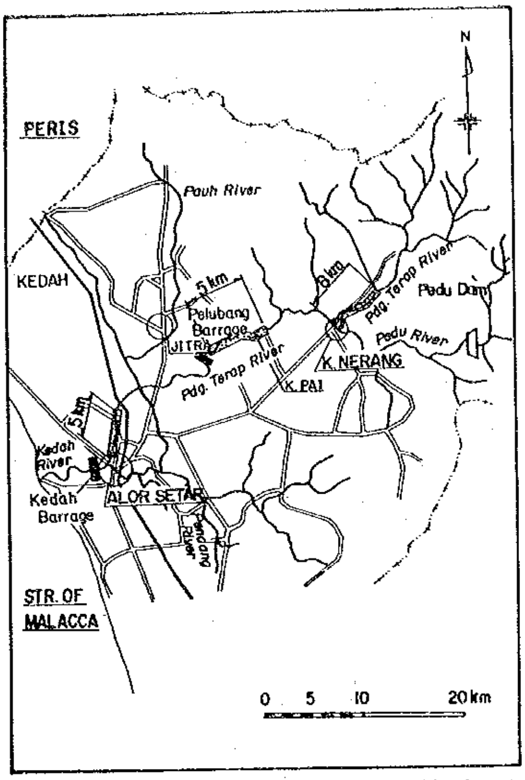


Fig. 29 Recommended Flood Mitigation Plan for the Kedah River Basin

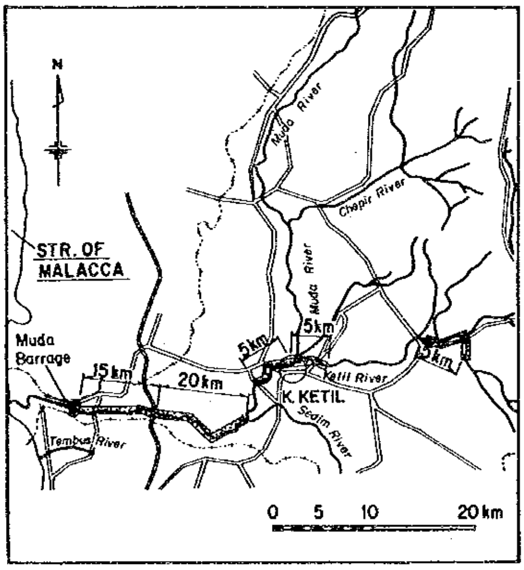
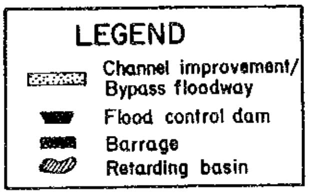


Fig. 30 Recommended Flood Mitigation Plan for the Muda River Basin



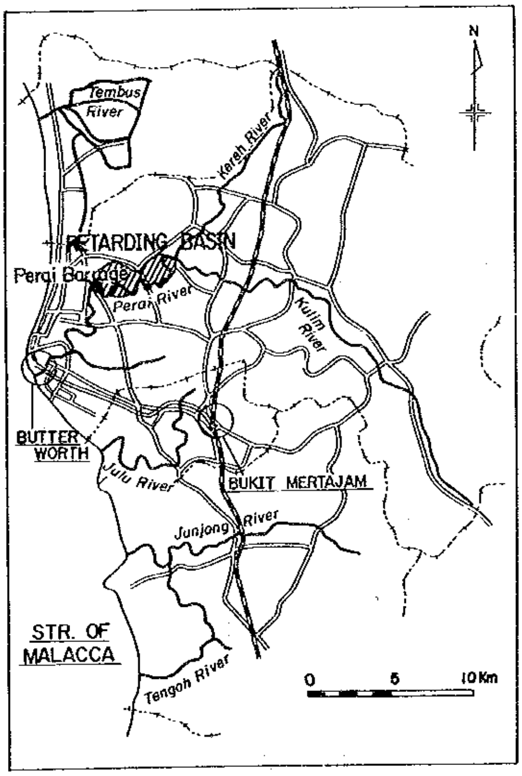


Fig. 31 Recommended Flood Mitigation Plan for the Perai River Basin

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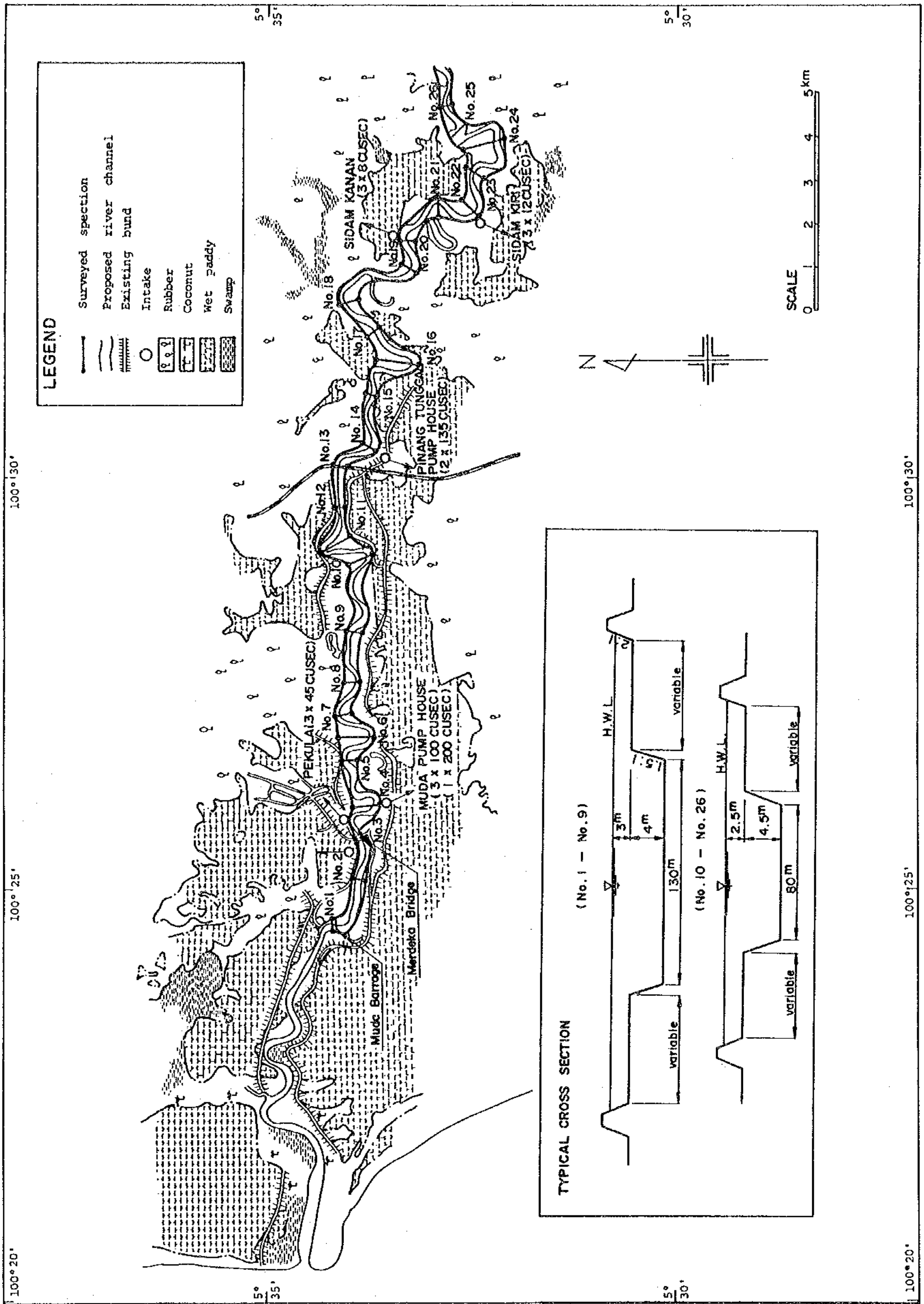

Fig. 32 Plan of River Channel Improvement for Model Stretch of Muda River

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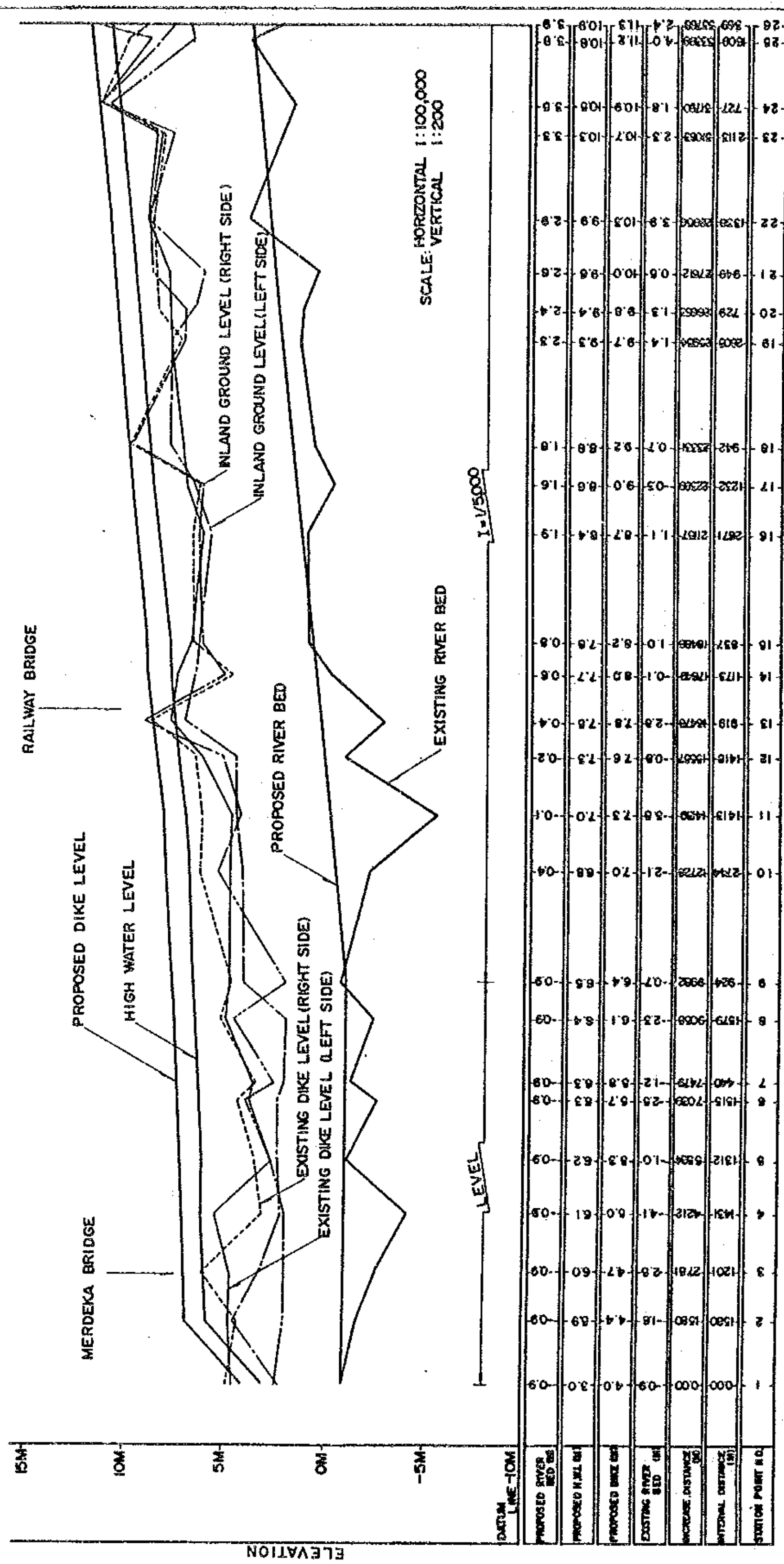

Fig. 33 Proposed Longitudinal Profile for Model River Stretch of Muda River

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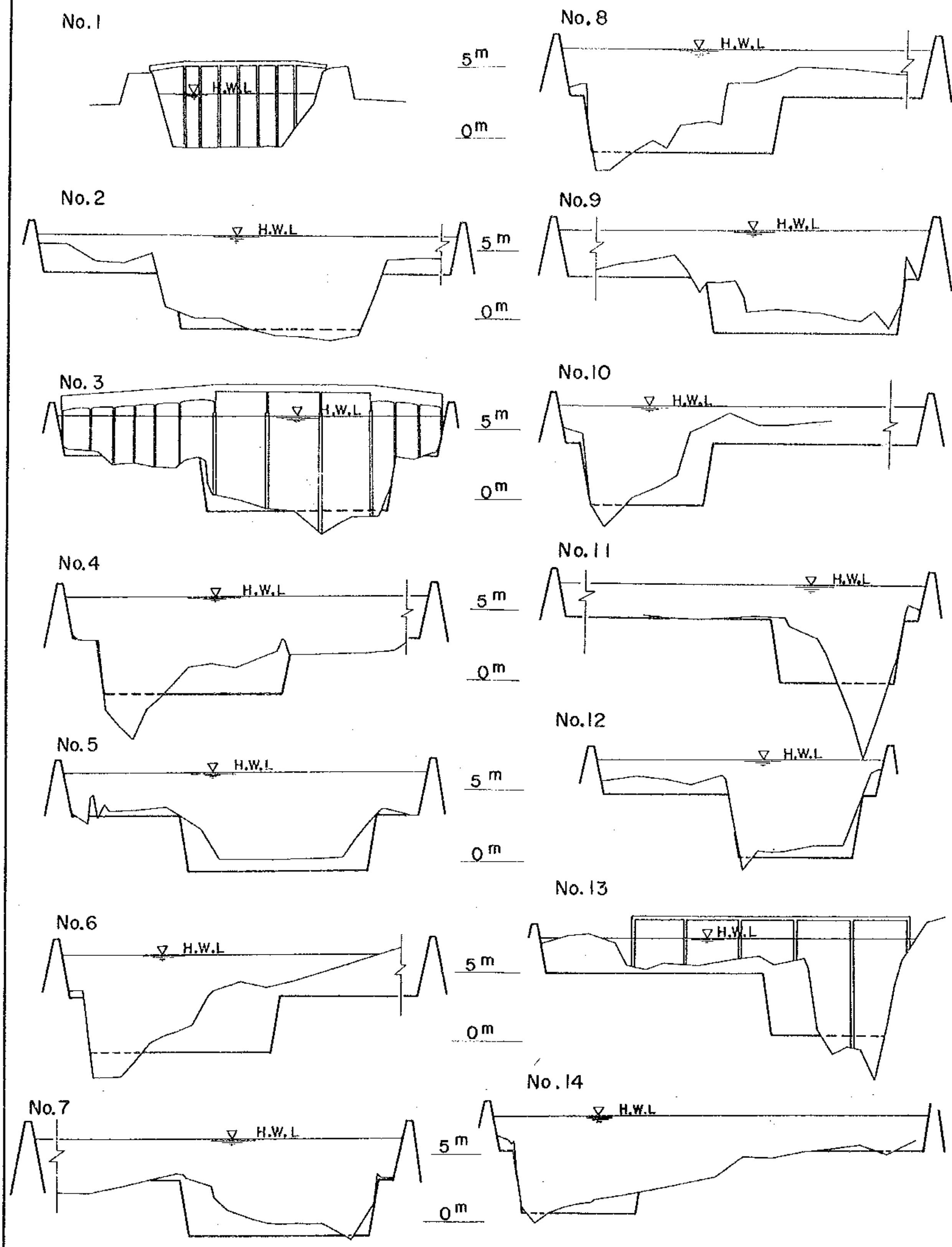

SCALE : VERTICAL 1/400

HORIZONTAL 1/4000

Fig. 34 Proposed Cross Section for Model River Stretch of Muda River (1/2)

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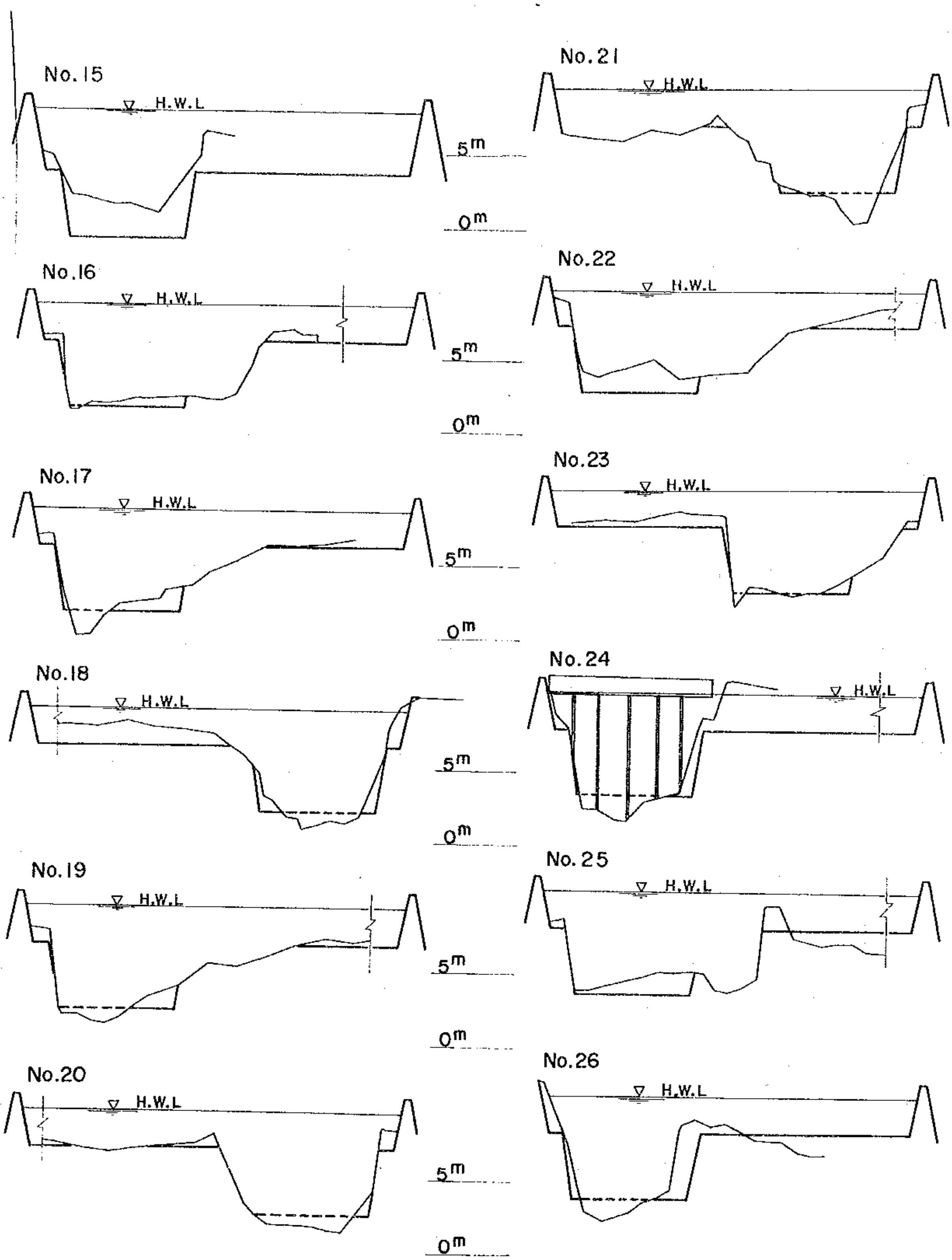

SCALE : VERTICAL 1/400

HORIZONTAL 1/4000

Fig. 35 Proposed Cross Section for Model River Stretch of Muda River (2/2)

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