1.2 Needs and Problems

Power demand in Sabah has increased with an average of about 12 per cent of annual growth rate for the past 10 years from 1975 to 1985. In 1984, its peak power demand reached at 120 MW, and energy sold at 503 GWh. Based on the past trend of the power demand increase, future population increase, economic development, etc., the Sabah Electricity Board (SEB) forecasts the power demand for whole Sabah State as 210 MW of peak power and 1,100 GWh of energy consumed in 1990 and 520 MW and 2,700 GWh in 2000. The west coast area in and around the capital city Kota Kinabalu is to be connected by one transmission and distribution line network and estimated the requirement of 130 MW of power demand and 700 GWh of energy consumed in 1990 and 300 MW and 1,600 GWh in 2000.

In the past years SEB supplied electric power to the consumers by installing various size of diesel generators up to 8,000 kW in unit capacity and 15,000 kW class gas turbine generators. However, to cope with the energy policy of the Government of Malaysia by changing fossil fuel to domestic hydro energy, SEB constructed the Tenom Pangi hydroelectric power station having the installed capacity of 66 MW. The Tenom Pangi power station is designed as a run-of-river type plant mainly from its topographical and hydrological reasons, and it naturally needs a backup power plant of about 50 MW.

In order to satisfy sharply increasing power demand in Sabah by utilizing an abundant hydroelectric power potential, SEB decided to contemplate construction of the Sook reservoir by which the power generation of the existing Tenom Pangi power station is to be firmed up and furthermore an additional capacity will be installed.

1.3 Objective of the Study

According to "Scope of Work for Feasibility Study on Tenom Pangi Hydroelectric Power Development Project, Phase III (Sook Reservoir)" agreed upon between the Government of Malaysia and Japan International

Cooperation Agency (JICA) on October 27, 1984, the objective of the Study is summarized as :

> To formulate the optimum development plan and to assess technical, economic and financial feasibility of the Project. In the Study, due consideration shall be given to the inseparable relevant relation with the on-going Tenom Pangi Hydropower Project.

1.4 Scope of the Study

According to "Scope of Work", agreed upon between the Government of Malaysia and JICA, the detailed scope of work is stipulated as shown below :

The study, which consists of the following three (3) stages, will be carried out within a period of 18 months.

1) Preliminary Investigation Stage

2) Detailed Field Investigation Stage

3) Feasibility Design Stage

The detailed scope of work at the respective stages are itemized as follows :

1) Preliminary Investigation Stage

(1) Field investigation into social, financial and economic background and power situation

Investigation and data collection concerning social, financial and economic conditions and the existing power facilities, load forecast, power source development programmes.

(2) Comparative layout studies

Comparative studies of the previous development plans and the alternatives, based upon the existing topographic maps and data.

(3) Site reconnaissance

(a) Site reconnaissance on the project site including alternative sites.

(b) Ground surface surveys on topography and geology of dam sites including reservoir areas, power station sites, switchyard and quarry sites.

(c) Survey on a transportation programme

(d) Siting of hydrological observation stations (Siting of rainfall gauging stations, water level gauging stations and discharge observation stations).

(4) Preliminary field investigation works

(a) Topographic survey

Topographic surveys on the proposed sites for main structures and reservoir area, including alternative sites.

(b) Field geological investigation

Preliminary field geological investigations for comparative study of the alternative sites. Seismic prospecting, drilling works and permeability tests.

(c) Installation of hydrological observation stations

Installation of observation instruments and establishment of system for continuous observation.

(5) Selection of the optimum site and preparation of a detailed field investigation programme

(a) Selection of the sites

Preliminary layout studies of several alternative sites will be conducted. Construction costs of the respective sites will be estimated based on the preliminary layout design, and costs and benefits will be examined. The optimum site of the study will be selected from the alternative sites from the technical, economical, social and environmental view-points.

(b) Preparation of a detailed field investigation programme

The programme of the detailed field investigation works on the selected site will be prepared. The detailed field investigation works will include topographic surveys, seismic prospecting, drilling works and field/laboratory tests.

2) Detailed Field Investigation Stage

Based upon the results of studies at the Preliminary Investigation Stage, the following will be carried out :

(1) Topographic surveys

Ground survey on the proposed sites of dam, spillway, headrace, power station, tailrace, switchyard and quarry, including the installation of survey posts and bench marks.

(2) Seismic prospecting

Seismic prospecting on the proposed sites of dam, spillway, headrace, power station and quarry.

(3) Drilling works

Drilling works and permeability tests on the optimum site of dam, spillway, headrace, power station, tailrace and quarry.

(4) Trench excavation

Geological investigation by trench excavation and collection of soil and/or rock materials on the proposed sites of dam, spillway and quarry.

(5) Test pitting

Collection of investigation materials by test pitting on the proposed sites of concrete aggregates, quarry if necessary and riverbed materials.

(6) Discharge observations

Actual measurement of discharge, sediments at the installed discharge observation stations.

(7) Field/laboratory test

Mechanical tests of fill materials, soil tests, concrete aggregate tests, bedrock mechanical tests and water quality tests.

(8) Power market survey

(a) Review and analysis of the present power system and relevant future programme.

(b) Collection of information on a relevant future programme of industrialization.

(c) Review and analysis of relevant information on growth of power consumption, available forecasts of power demand, characteristics of power consumption pattern, etc.

(9) Investigation and study of the substations and transmission line from the power station to the closest substation proposed.

(10) Study of social and environmental problems.

(11) Hydrometeorological investigation on flood/drought runoff and sediments.

(12) Investigation of access road and transportation.

(13) Investigation of the houses, roads and land to be submerged in the reservoir, and recommendation on compensation thereof.

3) Feasibility Design Stage

Based upon the results of studies at the Detailed Field Investigation Stage, the following will be carried out.

(1) Study and review of an optimum power generating scheme

(a) Study and review of a power generating scheme and study of optimum operation of the power stations for the demand.

(b) Comparative study of the alternative layouts or sites of main permanent structures of the power station.

(c) To ascertain the timing, staging and phasing of the development of the study incorporated with the Sabah

Electricity Board's (SEB) generation and transmission lines expansion plan.

(2) Geological and material survey

(a) Geological survey of damsites including reservoir areas and other main structure site.

(b) Engineering study for the location of quarry sites and borrow area, aimed at the estimation of possible gain.

(3) Feasibility design

The design work will include all of the principal civil works, steel structures, electro-mechanical equipment, temporary construction facilities, transmission line routes, and transmission line structures.

(4) Cost estimation

The cost estimation of the project will be broken down into local and foreign currency costs. The schedule of yearly disbursements will be prepared.

(5) Construction plan for the project will be prepared using time-oriented bar chart.

(6) Economic and financial analyses of the project

Economic analysis will be carried out for power generation. The economic analysis will include computation of the capital cost and operation and maintenance costs, examination and economic analysis of alternative power sources, project analysis from the viewpoint of national economy, cost-benefit analysis, calculation of economic rate of return and sensitivity analysis. Financial analysis will include determination of financial capital costs, cash flow, evaluation of financial internal rate of return.

2. THE PROJECT AREA

2.1 Location, Area and Topography

Malaysia is a federation of 13 states. It extends like an arc and consists of two main parts separated by the South China Sea. They are called by their relative location as West Malaysia on the Malay Peninsula and East Malaysia on the island of Borneo.

Sabah is one of the 13 states of Malaysia. It occupies the northern part of the island of Borneo. The State of Sabah is bounded on the south by Brunei, Sarawak and Kalimantan, the territory of Indonesia. Its coastline of about 1,440 km long is surrounded by the South China Sea on the west to north and by the Sulu and Celebes Seas on the east. Total area of the States of Sabah is 76,115 km^2, which is a little over half of West Malaysia.

The capital city of the State of Sabah is Kota Kinabalu. It is situated on the west coast and is about 1,000 km south of Manila, 1,600 km north-east of Singapore and about 1,900 km south of Hong Kong.

Sabah is a mountainous country of dense tropical rain forests as well as alluvial and swampy coastal plains. It is intersected by numerous rivers and fertile valley plains. There lie central mountain ranges having occasional peaks of 1,000 to 2,000 m high. Above all, the highest range is the Crocker Range. It culminates at Mount Kinabalu having a peak of 4,101 m or 13,455 ft, the highest mountain in Southeast Asia.

Rivers are numerous throughout the country and are of importance for the area, being used often as the means of transportation and communication. Swift streams flow down the slopes of the Crocker Range into the South China Sea. The longest river in the east coast area is the Kinabatangan River. The Padas River is the longest river in the west coast area.

The Padas River basin is the second largest river basin in Sabah after the Kinabatangan River basin. It is situated at the southwestern corner of Sabah. Catchment area of the Padas River is 9,180 km^2, occupying 10.6% of the whole area of the State of Sabah. Total river length is about 195 km along the Padas River and about 175 km along the Pegalan River. It consists of three major sub-basins and two divisions as shown below:

1) Padas sub-basin
2) Pegalan sub-basin
3) Sook sub-basin
4) Tenom gorge section
5) Coastal flood plain

Their principal features are shown in Table 2.1.

Table 2.1 RIVER BASIN AREA

Sub-basin/division	River length (km)	Catchment area (km^2)	Basin width (km)	Percentage of area (%)
1. Padas	120	3,670	55	40
2. Pegalan	100	2,295	40	25
3. Sook	100	1,835	40	20
4. Tenom gorge	40	645	20	7
5. Coastal flood	35	735	35	8
Total	(195)1/	9,180	-	100

1/: Padas + Tenom gorge + Coastal flood plain

The Sook River is one of the largest tributaries of the Pegalan River. It joins with the main stream Pegalan at about 3 km downstream of the town of Keningau. The Sook River drains 1,835 km^2 of the catchment area with its 70 km long river course. River gradient is ranging 1/300 to 1/500.

The proposed Sook damsite is located on the Sook River at about 3 km upstream from the confluence with the Pegalan River. The Sook River breakthrough the tertiary rocky hill has north-northeast and south-southwest trends, and forms a narrow gorge. The catchment area at the proposed Sook damsite is 1,705 km^2. Width of the river floor at the damsite is about 30 m. Bedrocks crop out along the river channel. Overburden on both banks of the gorge is proved to be 10 - 15 m and 60 - 70 m high dam will create effectively a reservoir having gross storage capacity of 400 - 600 x 10^6 m^3.

The existing Tenom Pangi Power project is located on the mainstream Padas River at the upper reach of the Tenom gorge, about 100 air km south of Kota Kinabalu. It consists of an intake weir, about 5 km long headrace tunnel and a 66 MW power station. The catchment area at the weir site is 7,815 km2. The Tenom Gorge forms a series of rapids with an average gradient of about 1/100, and in its first 16 km section about 170 m of water head is available. The Tenom Pangi power station harnesses the head of about 75 m in the uppermost section of the Tenom Gorge.

Location of the State of Sabah and the Padas River basin is as depicted in the location map at the beginning of this report. Vicinity of the proposed Sook damsite and the reservoir area is as shown in Figure 2.1.

2.2 Geology

2.2.1 Regional Geology

The Padas River basin, including tributary basins of the Pegalan, Sook, Dalit and Punti Rivers, is developed in a mountainous zone of the Crocker range, the Trusmadi range and the Witti range, from west to east in order, all of which extend in the north-northeasterly direction, and opens to the coast on South China Sea. Inter-mountain plains of Tenom, Keningau and Sook are located between the Trusmadi range and the Witti range.

Bedrocks of this region consist mainly of Tertiary Eocene to Miocene sediments of the North Borneo Geosyncline, which belong to the Crocker Formation, the Temburong Formation and the Trusmadi Formation. These sedimentary rocks are overlain by Quaternary terrace deposits which form the terrace plains in Tenom, Keningau and Sook. Characteristics of these geological units are as described below:

1) Trusmadi Formation

The Trusmadi Formation is developed to the east of the project area, as shown in Figure 2.2. It consists of conglomerates containing gravels of slightly metamorphosed dark bluish grey mudstone and argillaceous rocks and also of sandstone, siltstone and limestone. Quartzite forms portions of the bed. This formation of Eocene or Lower Eocene sediments is probably an elevated block bordered on the west side by a fault system, which can be discerned in aerial photographs, according to Collenette (1967), but not traceable in the field. The sequential relationship with other strata surrounding the Trusmadi Formation are yet unknown. It is separated from the Crocker Formation by a fault in the east side of Mt. Trusmadi.

2) Crocker Formation

Crocker Formation spreads widely exposed on the ground surface in and around the project area, as shown in Figure 2.2., and is bounded on the east side by the Witti fault and the Kinaya fault. This formation is composed mainly of Eocene to Miocene sedimentary rocks of sandy flysch type, comprising massive and slightly stratified greywacke sandstones, siltstones, veriegated mudstones, shales and infrequently, conglomerates and limestones.

The formation is strongly folded, as is the case in many other parts of Sabah State. The strata dip sharply kin general, while the general strike coincides with the orientation of Crocker mountain range, that trends north or north-northeast. Some strike faults can be traced on aerial photographs.

3) Temburong Formation

The Temburong Formation is developed to the west of the project area as shown in Figure 2.2. The formation consists mainly of very homogeneous flysch-type muddy sedimentary rocks with frequent normal intercalations of slightly calcareous pelagic shales.

Argillaceous rocks characterized by rythmical repetitions of siltstone and shale are developed in this formation, while massive shales form its greater part with lenticular intercalations of limestone in parts.

The age of this formation is probably Oligocene to Upper Miocene, coinciding at least with the upper horizons of the Crocker Formation.

4) Quaternary Deposits

Quaternary terraces, both diluvial and alluvial, are developed in the major inter-mountain plains of Tenom, Keningau and Sook. The terraces are composed of gravels, sand, silt and clay. The river alluvium burying the bottom of valleys and deltaic clayey soils with organic materials are more recent deposits.

2.2.2 General Geology of the Project Area

1) Bedrocks

Geology of the project area is shown in Figure 2.3. Bedrock of this area is composed of sandy sedimentary rocks of Eocene to Miocene Crocker Formation, of which representative feature is the alternation of sandstone and shale. Thin layers of conglomerate are infrequently interbedded. The sandstone is poorly sorted, containing angular detritus, well-cemented and hard. The shale is also well-cemented but strongly foliated along the bedding planes and brittle.

The bedrocks of the Sook damsite and the quarry consist mainly of the sandstones, which, in spite of the hard and massive appearance, are inflicted with open cracks, often sub-vertical. From calcite veins occasionally filling the sub-vertical open cracks, it is deemed that a substantially long time has elapsed since these cracks were formed. Loose rock blocks scattered at the feet of the slopes in the damsite seem to be an evidence of the creep occurred in the superficial zone of the bedrock because of separations by such cracks.

The Sook damsite is located in a topography of relatively high relief, as against the flat or gently undulating terrains upstream and downstream. Yet the surface erosion seems not to be strong enough to strip thick layers of residual soil or products of intensive weathering covering the ground surface, which are thicker in the upper parts of the slopes. Distribution of bedrock outcrops is almost confined in the parts near the river beds of the Sook and the tributaries. Continuous outcrops of fresh hard sandstone are seen on the Sook river banks and riverbed. The river alluvial deposits are thin and minor in the vicinity of the damsite, but they seem to be fairly large in the area of flat terrain upstream and downstream.

The Crocker Formation in the project area shows the general strike of N30°E, roughly coinciding with the orientation of the mountain range extending to this area, and the dip of 25° to 80° east or west. The angle of the dip is more acute in the western parts. There is a limited area in the southwestern part of this region, where the stratification is not conformable with that in other areas, showing the strike of N50° - 80°E and the dip of 11° to 17° southeast. This abnormally of stratification is deemed due to folding and/or faulting.

2) Quaternary Deposits

In the inter-mountain plains of Keningau and Sook, the bedrock mainly consisting of sandstones of the Crocker Formation is covered by Quaternary deposits, which form terraces at four stages in the Sook plain and two stages in the Keningau plain. Saddle dams have to be located on these terrace deposits. The features of the Quaternary deposits are as follows:

(1) Sook plain

- The upper terrace at the elevation of 310 m to 350 m is developed widely in the east of the project area and limitedly in the northern part, as shown in Figure 2.3. The terrace plane is obscured by intensive erosion into a topography of rather sharp undulation. A bed of sandy clay is the dominating member with varied thickness averaging at 5 m. Gravel layers are intercalated in the middle part and at the bottom, with the thickness of several tens centimetres to a meter and several tens of centimetre or less, respecrtively. The component gravels are mainly of quartzite of about 2 cm in diameter.

- The middle terrace at elevation 260 m to 315 m forms a wide flat area, as shown in Figure 2.3. The terrace deposit is more than 60 m thick and divided into four sub-horizontal beds, that is, from under the thin top soil downward in order, the 50 to 60 cm thick silt layer with quarts grains, the 5 m thick silt and clay layer with dense inclusion of siliceous grains, the 20 m thick gravel bed with round gravels of quartzite and sandstone with 2 cm to 5 cm of diameter, and the fine to medium sand and silty clay to the depth of 60 m. The lowest bed of sand and silty clay tends to be finer downward and grey to dark grey coloured, while the other beds in the upper levels are brown. According to the geophysical prospecting by seismic refraction method, these Quaternary beds are as thick as 180 m, burying a large ancient valley dissected in the underlying bedrock, in the middle part of the axis of the saddle dam.

- The lower terrace at elevation 260 m to 280 m covers a fairly wide area of lowland along the Biah River, and consists mainly of loose sand, silt and clay with high contents of siliceous grains and intercalation of a gravel layer with weathered gravels of about 5 cm in diameter. Parts with high proportions of fines show high water contents and are very cohesive.

- Flood plains are developed along the Sook River mainstream and in the vicinities of confluences of the tributaries. Deposits of the flood plains are mostly silt containing round gravels of 5 cm or less sizes.

- Talus deposits of small sizes are seen commonly, while a large one is found near the confluence of the Sook River and the Biah River. The latter is a product of collapse of the middle terrace and an ill-sorted mixture of the fine and coarse components.

(2) Keningau plain

- The upper terrace at elevation 250 m to 290 m is located in the vicinity of the confluence of the Pegalan river and the Sook river and on the west foothills of the mountain range. The deposits are sand, silt and clay containing a large quantity of rounded or sub-rounded gravels of small cobble size and less. The gravels are slightly or moderately weathered.

- The lower terrace at elevation 240 m to 250 m covers a vast area along the Pegalan and the Sook rivers as shown in Figure 2.3. Comparatively fresh round or sub-round gravels of small cobble size are included in loose sand, silt and clay. Parts with high proportions of fines have high water content and are very cohesive.

- Flood plains are distributed along the Sook river, with thick layers of small-cobble-sized gravels interbedded in sandy silt.

- Talus deposits are found on the west foothills of the mountain range running through this region. Sources of the talus deposits are the upper terrace or a terrace at even higher level which has been obscured by erosion and the bedrock sandstone. The deposits are random mixtures of materials from these sources.

2.2.3 Geology of the Reservoir Area

The Sook reservoir to be dammed up will cover an area from the southern margin of Keningau plain to the western flank of the Trusmadi range. The reservoir area is surrounded from northwest, west, south and east by gentle hilly terrains of the Crocker Formation. The bedrock around the reservoir area is thickly weathered. Land slidings are found on the northwestern margin of the reservoir areas, in which the sliding planes seem to be located below and/or through the deteriorated rock zone. Because of the mild slopes, the sliding on reservoir impounding, if occurs, will be of so slow movement that no hazardous effects on the reservoir and the dam structures are envisaged. It should, however, be determined in the stage of detailed design whether these land sliding are to be treated or left as they are.

The north side of the reservoir is bordered by a low watershed which separates the Sook plain from the Keningau plain. A long saddle dyke would be required on the watershed. It is composed of Quaternary Pleistocene deposits, more than 60 m thick, of the middle terrace of the Sook plain. As the interface of the bedrock lies deep under the Quaternary deposit, the saddle dyke will inevitably have to be constructed upon a foundation of the unconsolidated Quaternary deposits. Under-seepage from the reservoir should be controlled by means of extensive blanketing or a special grouting method.

The middle terrace deposits are widely developed in the east to central part of the reservoir area, and the flood plain deposits occupy the remaining western part.

2.2.4 Geology of the Sook Damsite

The proposed Sook damsite is located in the hilly zone northwest of the reservoir area, where the Sook River runs northwestward dissecting a narrow gorge with rather steep slopes, that is, approximately 30 degrees on the right bank and 15 to 25 degrees from horizontal on the left bank.

The bedrock is composed mainly of sandstones of the Crocker Formation intercalated with thin shale layers at intervals of one metre to several metres. The bedding strikes N-S to N30°W and dips

35° NE, which plane is nearly parallel with the slope on the left bank.

The bedrock is more or less disturbed down to the depth of more than 50 m below the ground surface, probably due to a plastic flow caused by foldings. Most of the sandstone beds are cracky, and major part of the shale layers are fractured into flaky and clayey conditions. Especially, a 30 m thick zone below the ground surface is badly cracked and pervious. A zone deeper than 30 m is less cracky and relatively water-tight.

Creeping of the bedrock seems to have occurred along the bedding planes on the left bank and on the rather steep slope on the right bank. Sliding planes are discerned within several metres of depth on the left bank, whereas the bedrock is visibly loosened, intensively weathered and highly pervious for a thickness of about 15 m under the same bank.

2.2.5 Fault

It was noticed that a topographic lineation can be traced in the direction from southwest to northeast or from south-southwest to north-northeast, passing through the western part of the reservoir area. The lineation, which could be suspected to indicate a fault line, runs across the saddle dam site and along a part of a slope to border two levels of terrace planes.

The corresponding lineation was later pointed out by the Geological Survey Department of Malaysia through SEB, as a major tectonic lineation on a satellite imagery which is about 7 km in length and has the NE-SW bearing.

If the difference in levels of the terrace planes is due to faulting, the fault could be regarded to be active in the recent geological age. A trench excavation on the slope between the two terrace planes revealed a subsurface of vertical boundary of a gravel bed, which, however, could be interpreted as a side face of a terrace deposit scoured by water flow and subsequently covered by alluvial and/or colluvial deposits. The slope on the difference of the terrace levels meets the said lineation for about one kilometre's length, and deviate westward in the northern part.

The geophysical prospecting on the axis of the saddle dam, across the lineatiuon, detected no substantial disturbances, nor low velocity zones, to suggest any existence of major fault.

The study of seismicity resulted in locating epicentres of the past earthquakes, mostly less than 6 in magnitude, rather sparsely in distance more than 100 km from the damsite. While recorded epicentres crowd in the area from the east coast of Borneo to North Sulawesi, more than 200 km in distance, of which earthquakes can also effect some tremour to the damsite, a major part of Sabah including the project area, Sarawak and Kalimantan have recorded only a few earthquake sources since the year of 1897. No epicentre to be related with the said lineation was found.

Further, the lineation can be traced not longer than 10 km, and does not seem to have such significance as tectonic lineations like seismically active zones do.

Eventually, the studies have failed to prove that the lineation can be interpreted to indicate an active fault. No evidences have been found to consider the fault to be active. The lineation is assumed to be a fault line which was created by the tectonic movement in the past, and its geotechnical implication is only as a passage of underseepage from the reservoir.

As indicated by the result of the geophysical prospecting in the seismic refraction method which detected no significant disturbances, the fault could probably be associated with no serious fractures from geotechnical point of view, if it is significant tectonically. For the saddle damsite, which is traversed by the fault, the more imminent problem will be to cut off underseepage through the foundation of the unconsolidated terrace deposits. If the cut-off is performed by laying an earth blanket to stretch up to several tens of metres inside the reservoir area from the dam axis, it will also effect for cutting off the seepage through the fault line.

It is recommended for geotechnical investigations in the stage of detailed design to make further examination of this fault by the detailed field reconnaissance, the top soil stripping and the deep inclined core drilling.

2.2.6 Seismicity

The design seismic acceleration factor for a pseudo-static method of design against the earthquake risk is proposed to be 0.12 g, based on the maximum probable peak acceleration in a return period of 100 years which has been estimated from earthquake data within 500 km of distance from the dam site during the years from 1897 to 1984.

2.3 Hydrometeorology

2.3.1 Climate

Climate of Sabah is the tropical rain forest climate characterized by constantly moist days throughout the year. The northeast winds begin generally in November and last until March, and the southwest winds prevail from May until August. The rainy season of the west coast of Sabah generally coincides with the time of the southwest wind season, and rainfall of the east coast is abundant during the northeast wind season. However, due to region's insularity this climate is somewhat modified from place to place.

Heavy rainfall occurs in the coastal belt area where it records from 2,000 to 3,000 mm a year. A large inland plain east of the Crocker Range where the Padas River flows down, is sheltered from the southwest winds by the mountain range to the west and from the northeast winds by the mountainous hinterlands between the plain and the east coast, creating one of the driest area of Sabah. Average annual rainfall in this area is between 1,500 mm and 2,000 mm. The monthly rainfall is between 100 mm to 200 mm, and seasonal pattern of rainfall distribution cannot be clearly defined. The areal distribution of mean annual rainfall is as depicted in Figure 2.4.

Sabah is outside the typhoon threaten zone, but torrential rainstorms accompanied by high winds are frequent. Maximum wind velocities recorded during the past 10 years are 23 m/sec at Kota Kinabalu, and 19 m/sec at Sandakan.

Temperatures in Sabah are generally constant throughout the year, ranging from about 29.5°C in the day time to about 22°C during night. Temperature decreases with the altitude, and it falls to about 10°C at night in the higher mountainous area. Relative humidity is usually high.

The Padas basin is characterized by the marine-equatorial climate subject to northeast and southwest winds. Mean daily temperatures are in the range of 30°C on the coastal flood plain falling to 26°C in the other inland areas and less than 20°C in the mountainous areas. Relative humidity is uniformly high throughout the year at around 80%, but is generally lower in the dry season especially in the inland areas.

2.3.2 Rainfall

In the Padas River basin, there are 5 recording type rain gauges located at Apin Apin, Kemabong, Keningau, Sook and Tambunan and 9 non-recording type rain gauges located at Apin Apin, Keningau, Melalap, Sapong Estate, Sunsuron, Tambunan, Tenom, Tulid and Ulu Tomani. During the period of field investigation of this time, sites for the 3 more recording type rain gauges are selected at Tulid, Bonor and Kalampun and for 2 more non-recording type gauges at Bonor and Kalampun in the Sook River basin. Their locations are as shown in Figure 2.5. Available records are as follows:

Recording type gauges (daily records)

Apin Apin	1966 - Present
Kemabong	1965 - Present
Keningau	1968 - Present
Sook	1965 - Present
Tambunan	1966 - Present

Non-recording type gauges (daily records)

Apin Apin	1961 - 1967
Keningau	1918 - 1944, 1950 - Present
Melalap	1952 - Present
Sapong Estate	1924 - 1927, 1930 - 1939, 1952 - Present
Sunsuron	1965 - Present
Tambunan	1918 - 1927, 1930 - 1940, 1950 - 1968
Tenom	1921, 1924 - 1927, 1930 - 1939, 1952 - Present
Tulid	1953 - Present
Ulu Tomani	1964 - Present

Annual mean rainfall of the Padas River basin is 1,856 mm (1960 - 1984). Its monthly fluctuation is small varying from 123 mm to 190 mm, and almost all the months receive rainfall. Annual rainfalls at selected 11 gauges and monthly rainfall for the Padas basin are as shown in Tables 2.2 and 2.3 respectively.

Table 2.2 ANNUAL RAINFALL

(Unit: mm)

Year	Sapong E. 5059002	Kembabong 4959001	Malalap E. 5361001	Keningau 5364001	Tulid 5159001	Tenom 5663001	Tambunan 5460001	Apin Apin 5462003 5163002	Kg. Sook 5261001	Scheme Biah 5261001	Babawan 5164001
1960	1,510	-	1,547	1,523	2,605	1,824	1,824	-	-	-	-
1961	1,496	-	1,424	1,424	1,753	1,514	1,398	1,891	-	-	-
1962	1,896	-	2,020	2,104	1,502	2,025	1,995	3,458	-	-	-
1963	1,640	-	1,549	1,496	1,728	1,549	1,841	2,796	-	-	-
1964	1,671	-	1,640	1,896	1,365	2,108	1,528	2,350	-	-	-
1965	1,700	427*	1,744	1,697	1,764	1,773	1,386	1,578	2,009	-	-
1966	1,621	1,536*	1,330	1,444	2,173*	1,834	-	2,592	1,853	-	-
1967	1,161	1,298*	1,309	1,475	1,920	1,396	-	1,418*	1,422*	1,083	-
1968	1,660	1,704	1,649	1,889	1,911	-	1,778*	1,027*	2,227	2,013	-
1969	1,643	1,145*	1,360	1,480	1,759	1,152	1,321*	1,150*	1,544*	1,454	-
1970	2,024	1,876*	1,718	1,683	1,960*	1,958	1,961*	911*	2,000*	1,431*	2,086*
1971	1,966	1,652*	1,940	-	2,195*	1,959	1,608*	-	1,818*	-	2,323*
1972	1,126	1,270*	1,237	1,280*	1,782*	1,322	1,511	-	1,641*	1,171*	3,343
1973	2,389*	1,365*	1,690	1,532*	1,985*	2,817	1,520*	1,357*	1,113*	1,449*	1,718*
1974	1,920	1,663*	2,052	1,551*	2,707	-	2,200*	1,580	1,200*	1,979	2,133
1975	2,034	1,821	1,719	1,761	2,138	1,803	2,111	1,730	998*	1,628*	2,625
1976	1,540	1,571*	1,296	1,185*	1,507	1,330	1,049*	1,302*	1,771*	1,634*	1,172*
1977	1,611*	1,644*	1,298*	1,740*	2,234	1,371	1,930*	1,203*	1,144*	2,204	1,492
1978	1,095*	321*	-	1,290	2,014	1,128	263*	1,615	1,318*	1,583	1,956
1979	1,718*	1,618*	-	1,843	2,016	1,995	1,840*	2,260	1,369*	1,919	2,511
1980	922*	1,544*	984*	1,518*	2,390	1,486	796*	878*	1,619*	1,368*	2,585
1981	-	1,480*	1,423*	1,872	2,166	-	-	1,633	1,839*	864*	2,391
1982	-	1,305	892	1,130	1,622	-	-	1,180*	1,583*	-	1,580*
1983	-	1,558	1,121	1,463	1,863*	-	-	1,655	1,739*	-	952
1984	-	354*	-	1,660	-	-	-	2,251	-	-	1,262*
Mean 1/	1,630	1,585	1,539	1,638	1,963	1,700	1,702	2,199	2,030	1,842	2,363
Mean 2/	1,635	1,358	1,497	1,581	1,961	1,700	1,498	1,719	1,499	1,549	2,009

Note: Mark * shows lack of data.

1/: Mean over 1960 to 1984 excluding data attached with *

2/: Mean over 1960 to 1984 including data attached with *

Table 2.3 MONTHLY RAINFALL
(1960 - 1984/PADAS BASIN)

(Unit: mm)

Month	Rainfall
Jan	150
Feb	123
Mar	136
Apr	143
May	190
June	151
July	136
Aug	140
Sept	170
Oct	172
Nov	179
Dec	166
Total	1,856

2.3.3 Streamflow

Water level observation and streamflow measurement have been made at 4 places of Tenom Lama on mainstream of the Padas River, Kemabong on the Padas, Ansip on the Pegalan and Biah on the Sook since 1968. Besides, stream gauges are established at Tenom Ferry, Keningau and Sook. The Drainage and Irrigation Department (DID) of the State of Sabah is operating and maintaining these gauges.

The monthly streamflows recorded at Tenom Lama and Biah are as shown in Tables 2.4 and 2.5 respectively. The mean streamflow at Tenom Lama is 210 m3/s, and the one at Biah is 29.4 m^3/s. It corresponds to an annual runoff height of 858 mm and 551 mm respectively. The mean runoff coefficient is about 0.47 for the Padas basin at Tenom Lama and as low as 0.29 for the Sook basin at Biah.

Table 2.4 MONTHLY RUNOFF OF PADAS RIVER AT TENOM LAMA (5159401)

(Unit: m^3/s)

Year	Jan	feb	mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1969	99	79	123	91	153	176	201	117	107	181	226	205	147
1970	278	82	75	224	397	336	177	246	206	282	274	235	234
1971	160	451	249	93	152	111	33	363	212	187	371	218	225
1972	354	226	172	218	229	119	40	79	201	251	198	183	189
1973	28	15	35	212	216	152	167	119	625	218	390	281	205
1974	150	447	200	230	197	197	205	157	226	345	195	206	230
1975	365	95	181	135	290	193	211	136	341	102	202	341	216
1976	473	203	183	171	196	89	94	140	71	174	289	132	185
1977	228	371	298	406	388	354	274	21	55	213	258	480	287
1978	107	61	52	55	195	199	265	61	120	109	315	153	141
1979	55	63	179	84	245	107	321	118	269	374	553	458	236
1980	270	169	93	171	221	212	140	215	67	150	314	422	204
1981	895	233	77	112	108	137	110	140	117	182	405	225	228
1982	158	217	71	160	268	205	85	80	56	154	117	198	147
1983	73	39	11	6	20	61	171	332	326	148	364	439	166
1984	510	356	274	492	443	321	260	123	266	372	187	365	331
Mean	263	194	142	179	232	186	172	159	204	215	291	290	210
Size	16	16	16	16	16	16	16	16	16	16	16	16	12

Table 2.5 MONTHNLY RUNOFF OF SOOK RIVER AT BIAH (5261402)

(Unit: m^3/s)

Year	Jan	feb	mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	10.6	9.1	12.7	28.2	36.3	21.2	16.8	11.7	27.0	34.0	19.0	10.4	19.8
1969	10.2	5.5	8.8	8.9	15.6	25.7	25.3	14.4	11.3	24.2	17.7	28.2	16.3
1970	17.1	6.7	6.7	10.6	64.2	51.1	35.5	37.5	18.8	39.7	32.5	39.7	30.0
1971	11.1	85.0	40.6	10.5	7.4	9.4	2.7	37.2	25.1	12.0	58.9	47.5	29.0
1972	28.4	24.3	28.3	41.2	31.9	23.2	4.0	7.4	17.4	33.7	25.8	41.8	25.6
1973	2.7	0.4	1.1	6.9	14.8	12.5	13.8	12.0	120.0	57.4	74.8	45.0	30.1
1974	28.5	49.0	32.9	10.3	60.7	22.1	34.1	17.9	47.9	44.1	25.7	36.1	34.1
1975	63.1	15.3	15.9	15.3	64.9	43.8	21.2	17.1	44.3	27.4	25.7	39.0	32.8
1976	39.4	32.4	25.4	14.1	28.7	14.4	8.1	9.8	6.6	21.3	38.5	11.7	20.9
1977	21.6	46.0	39.6	28.1	31.0	50.4	58.7	11.5	4.8	20.7	31.1	61.0	33.7
1978	12.8	12.5	4.7	13.2	16.3	23.3	26.6	6.4	6.6	2.7	24.1	15.8	13.8
1979	5.6	4.0	16.0	4.7	17.8	53.9	40.6	11.1	46.3	32.5	79.5	28.0	28.3
1980	33.3	23.7	32.4	35.6	35.7	34.4	11.3	21.3	4.9	8.2	31.7	61.5	27.8
1981	195.0	24.9	4.2	8.9	29.5	21.2	12.7	5.6	10.1	17.2	54.3	30.6	34.5
1982	21.6	9.7	5.7	8.7	39.1	19.0	7.3	8.3	8.1	18.2	22.3	45.4	17.8
1983	7.5	5.0	3.0	1.4	3.3	8.1	22.1	49.0	58.0	15.3	72.5	89.4	27.9
1984	137.9	81.7	54.2	89.3	121.5	156.1	59.8	23.6	48.0	63.6	24.1	67.0	77.2
Mean	38.0	25.6	19.5	19.8	36.4	34.7	23.6	17.8	29.7	27.8	38.7	41.1	29.4
Size	17	17	17	17	17	17	17	17	17	17	17	17	12

It is considered that this low runoff coefficient of the Sook basin is mainly due to its basin topography characterized by the Sook plain locating in the centre of the basin and the continuation of low hills in the other area.

2.3.4 Flood Flow

Flood data of the Sook River are available at Biah stream gauging station for the 17 years from 1968 to 1984. Annual maximum floods at this station are as shown in Table 2.6. The maximum flood of 410 m^3/s is recorded on January 14, 1981.

Table 2.6 ANNUAL MAXIMUM FLOODS OF SOOK RIVER AT BIAH

Year	Date	Peak flow (m^3/sec)
1968	Mar 31	141
1969	Mar 31	115
1970	May 27	124
1971	Feb 13	217
1972	Jun 17	165
1973	Sep 28	296
1974	Sep 26	236
1975	Jan 13	221
1976	Nov 3	161
1967	Mar 1	213
1978	Dec 14	104
1979	Nov 2	198
1980	Dec 4	153
1981	Jan 14	410
1982	Dec 21	139
1983	Nov 14	340
1984	Jan 26	320

Probable floods of the respective return periods at Biah on the Sook River are derived by the Log-Pearson Type III method as shown in

Table 2.7. The recorded maximum flood of 410 m3/s corrsponds to a return period of about 30 years.

Table 2.7 PROBABLE FLOODS OF SOOK RIVER AT BIAH

Return period (yr)	Flood peak flow (m^3/sec)
5	269
10	327
50	468
100	535
200	605

Probable maximum flood (PMF) for the proposed Sook dam is also derived for checking the dam safety against any probable flood. The PMF has a peak flow of 1,940 m3/s and a 10 days' volume of 560 x 10^6 m^3 as depicted in Figure 2.6. This PMF is derived by converting the probable maximum precipitation (PMP) into flood flow using a unitgraph.

The PMP over the Sook River basin is obtained by maximizing the observed storm records in and around the Sook River basin. The PMP has an accumulated depth of 35 mm for duration of 1 hr, 91 mm for 24 hr, and 411 mm for 7 days. The unitgraph is derived based on the recorded hydrograph at Basin on the Sook River. Initial rainfall loss is neglected assuming that the whole basin is saturated by antecedent rainfall while the retention loss is assumed at 1.5 mm/hr.

2.3.5 Sediment Transport

Sampling of suspended sediment had been conducted for about 40 times from 1970 to 1982 at four gauging stations in the Padas River basin and its analysis was made.

According to the results of the analysis, suspended sediment transport at Biah on the Sook River is estimated to be 350 ton/day or 270m^3/day. Thus, assuming ratio of bed load transport to suspended load as 20% and reservoir trap efficiency as 100%, sediment transport to the Sook reservoir is calculated to be $170m^3/km^2/year$, which corresponds to an annual denuded depth of the land of 0.17mm.

2.4 Socio-economy

2.4.1 Area and Population of Sabah

The State of Sabah has a total area of 76,155 km^2. It occupies 22.4 per cent of the total land of Malaysia. Population of Sabah records a faster growth rate than that of whole Malaysia. According to the national population censuses for 1970 and 1980, population growth rate of Sabah State indicates 4.46 per cent per annum while that of whole Malaysia, 2.8 per cent during the period of 10 years from 1970 to 1980. According to Fourth Malaysian Plan (1981 - 1985), it is estimated at 3.5 per cent per annum for Sabah and 2.5 per cent for whole Malaysia for the same period. As for the future population growth rate, Sabah Economic Planning Unit (SEPU) estimates somewhat gradual decrease as shown below.

Year	Population growth rate (%)
1985 - 1990	3.51
1991 - 1995	3.16
1996 - 2000	2.84

Based on the population growth rate of 3.5 per cent per annum for the year 1980 - 1985 and population of 1,011,046 in 1980, population of whole Sabah is estimated to reach at about 1,200,000 in 1985 and at more or less 2,000,000 up to the year of 2000. Area and population for the State of Sabah are as shown in Table 2.8.

2.4.2 Area and Population of Padas Basin

The Padas River basin covers basically the administrative districts of Beaufort, Sipitang, Tenom, Keningau, Tambunan and Kuala Penyu. It includes the urban centres of Beaufort, Tenom, Keningau and Tambunan which are some 50 to 150 km far from the capital city of Kota

Kinabalu and can be reached in 1 to 3 hours by car. Population of the basin is about 100,400 in 1980, and its per square kilometer density is 10.9.

Area, population and population density of the Padas basin in 1980 are as shown in Table 2.9.

Table 2.8 AREA AND POPULATION OF SABAH

City and town	Area (km²)	1970	1980
Interior Division	18,298	121,036	151,173
Keningau	3,574	26,341	41,204
Tanom	2,409	23,542	16,353
Beaufort	1,735	31,684	36,403
Sipitang	2,732	10,061	12,076
Kuala Penyu	453	11,681	12,565
Tambunan	1,347	11,956	14,204
Nabawan/Pensiangan	6,048	5,771	8,369
Labuan Division	91	17,189	26,413
West Coast Division	7,589	220,830	309,369
Kota Kinabalu	350	60,746	108,725
Kota belud	1,386	35,935	45,503
Ranau	2,978	22,674	28,047
Tuaran	1,166	40,688	48,374
Penampang	466	26,502	37,998
Papar	1,243	34,285	40,722
Kudat Division	4,623	66,257	82,066
Kudat	-	-	38,392
Pitas	-	-	16,520
Kota Marudu	-	-	27,147
Sandakan Division	28,205	113,791	168,996
Sandakan	2,266	72,828	113,496
Kinabatangan	17,594	14,177	25,434
Labuk/Sugut	8,345	26,786	30,066
Tawau-Division	14,905	114,161	217,695
Tawau	6,164	60,189	113,708
Semporna	1,165	29,290	52,215
Lahad Datu/Kunak	7,576	24,682	51,772
Total	73,711	653,264	955,712
(Whole Malaysia)	329,294	10,439,400	13,745,200

Table 2.9 AREA, POPULATION AND POPULATION DENSITY OF PADAS BASIN (1980) 1/

District	Area (km^2)	Population	Population Density ($person/km^2$)
1. Beaufort	650	13,600	20.9
2. Sipitang	2,150	9,000	4.4
3. Tenom	2,300	25,200	11.0
4. Keningau	2,880	33,200	11.5
5. Tambunan	840	8,900	10.6
6. Kuala Penyu	360	10,000	27.8
Total	9,180	100,400	10.9

2.4.3 Land Use of Padas Basin

The present land use of the Padas River basin, totaling about 920,000 ha, is mainly the hilly forest of about 740,000 ha, and the agricultural land of about 50,000 ha; paddy field, etc. of about 10,000 ha and tree crops field of about 40,000 ha. Moreover, urban and associated area is about 1,000 ha, and the remaining is swamps, miscellaneous land, etc. of about 130,000 ha.

Since 1970, considerable areas of virgin forest have been cleared of trees in commercial logging operations and by shifting cultivations. The main logging centres are now in the southern parts of the basin in the Witti Range and in the southern edge of the

1/ : "REGALAN-PADAS (PADAS BASIN) COMPREHENSIVE REGIONAL DEVELOPMENT PLANNING STUDY" by Engineering Consulting Firms Association, June 1983

Crocker Range east of Sipitang. Proportion of the area for perennial tree crops and annual crops are increasing substantially. Present land use in the basin is as shown in Table 2.10.

Table 2.10 PRESENT LAND USE OF PADAS BASIN 1/

Category	Area (ha)	Percentage (%)
Urban and associated area	700	0.1
Argicultural land	46,000	5.0
- Annual crops area	(10,000)	(1.1)
- Tree Crops area	(36,000)	(3.9)
Hill forest land	739,000	80.5
Swamp and forest incl. swamp	42,000	4.6
Miscellaneous land	90,300	9.8
Total	918,000	100.0

2.4.4 Gross Domestic Product (GDP) and Gross Regional Domestic Product (GRDP)

National economy of Malaysia kept fairly well increase for the recent years though some slow-down of economy is said to be experienced after 1982. It has grown up with about 7.5 per cent per annum increase rate for 10 years from 1975 to 1985. Gross domestic products amounting to M$17,365,000,000 for 1975 is estimated to increase to M$35,869,000,000 in 1985.

1/: "Crop Acreqage of Sabah - 1979" by Jabatan Pertanaian, Sabah, Malaysia

"National Water Resource Study - Malaysia" by JICA, 1982.

"The Land Use of Sabah (1/250,000)" by LRD, UK, 1970 Kota Kinabalu and west coast area.

According to the result of Mid-Term Review of Fourth Malaysian Plan, per capita GDP indicates M$2,119.0 for 1983 and M$2,299.6 for 1985. Annual GDP by industry origin is as shown in Table 2.11.

Table 2.11 ANNUAL GDP BY INDUSTRY ORIGIN (MALAYSIA)

(Unit: 10^6 M$ in 1970 price)

Year	Agriculture, forestry, etc.	Mining and quarrying	Manufac-turing	Construc-tion	Services	GDP
1975	4,804	792	2,850	654	8,265	17,365
1980	6,252	1,171	4,874	1,209	12,719	26,225
1981	6,516	1,148	5,115	1,391	13,922	28,092
1982	6,926	1,220	5,299	1,541	14,567	29,553
1983	6,922	1,398	5,659	1,685	15,778	31,442
1984	7,157	1,638	6,185	1,825	16,822	33,627
1985	7,429	1,718	6,760	1,944	18,018	35,869

Gross regional domestic products of Sabah amounting to M$1,283,000,000 in 1975 is estimated to increase to M$2,563,000,000 for 1985. It has grown up with about 7.2 per cent per annum increase rate for 10 years from 1975 to 1985. This figure is a little smaller than the national average of about 7.5 per cent per annum. According to the Fifth Malaysia Plan, it is estimated to be 5.6 per cent per annum in Sabah for 5 years from 1986 to 1990. Annual GRDP for Sabah by industry origin is as shown in Table 2.12.

Table 2.12 GRDP BY INDUSTRY ORIGIN (SABAH)

(Unit: 10^6 M$ in 1970 price)

Year	Agriculture, forestry, etc.	Mining and quarrying	Manufac-turing	Construc-tion	Services	GRDP
1975	649	28	35	59	512	1,283
1978	847	181	58	78	647	1,811
1980	729	157	61	93	665	1,705
1983	900	224	64	141	848	2,177
1985	1,021	286	74	180	1,002	2,563

2.5 Transportation and Telecommunication

The road network in the Padas basin is dominated by an axial trunk road linking Tambunan and Tomani via Keningau and Tenom. Major stretches of this road are now sealed, but some stretches are still gravel-surfaced. A spur road connects Keningau to Nabawan to the east and to small settlements in the Sook basin. A direct road connects the inland towns of Tenom and Keningau via Tambunan to Penampang near Kota Kinabalu, and via the Keningau - Kimanis road to near Papar south of Kota Kinabalu. A third indirect route to the coast goes via Ranau and Kundasang, to Tamparuli north of Kota Kinabalu. The latter route also links the Padas basin to the east coastal lowlands and Sandakan.

Between Tenom and Beaufort through the Tenom gorge, a single track railway provides an additional mode of transport to the inland areas of the basin. The railway is also connected to Kota Kinabalu via Beaufort and Papar. Keningau is served by a small airstrip from which there are every two days flights to and from Kota Kinabalu.

At and around the proposed Sook damsite and power station site there were no motorable roads. But presently an access road to the Sook damsite has been constructed on the left bank through the forest. The new motorable road is extended for some 3 - 4 km long from the nearby motorable road approaching to the site from the upstream of the Sook River. To the saddle damsites there are two motorable roads.

Principal towns of the basin are served with the telecommunication networks, and an interlocal system linked with the state capital of Kota Kinabalu is operated by means of the wire-telephone and microwave.

2.6 Construction Materials

According to the field reconnaissance, construction materials and concrete aggregates are widely distributred in the project area close to the main structures.

Based on the results of field reconnaissance, the borrow areas and quarry site were selected for the detailed investigation taking into account topographical and geological conditions as well as hauling distance to the main and saddle dam sites. In order to clarify properties and obtainable quantities of materials, materials survey was conducted for these areas and quarry site and laboratory tests were carried out for the samples obtained by the materials survey. Locations of the proposed borrow areas and quarry site are as shown in Figure 2.7.

In the borrow areas and quarry site, excavation of 15 test pits, drilling of 3 boreholes and sampling outcrop at 3 places were carried out to collect samples for the laboratory tests.

The results of materials survey and laboratory tests are summarized as below :

2.6.1 Impervious core Materials for Main Dam

1) The survey area for impervious core materials covers the upstream reaches of the main damsite including the borrow area A and quarry site. A temporary road was constructed on the left river bank to transport the boring machines to the main dam site along the river course. As the result of excavation for construction of the temporary road, materials usable for impervious core were revealed along the road. These materials were also sampled along the temporary road for laboratory tests.

2) The collected materials consist of terrace deposits at borrow area A, highly weathered sandstone and shale including terrace deposits existed on the bed rock at quarry site, and residual soil originated from sandstone at temporary road area.

   The materials in these areas are impervious fine-grained soil. The maximum particle size is 2 to 20 mm and content of under 0.075 mm is more than 60% in grain size distribution. Those are classified into silty clay (CL) or clay (CH) accourding to the Unified Soil Classification System.

3) Materials of borrow area A, which consist of terrace deposits, will be suitable for impervious core materials of main dam because of their properties and availability of sufficient quantities.

On the other hand, materials surrounding quarry site and those obtained along the temporary road are also suitable for impervious core materials, and these areas are more economical compared with borrow area A due to shorter hauling distance.

2.6.2 Embankment Materials for Saddle Dam

1) The borrow area B is located at the most northern part of the reservoir approximately 6 km from the proposed main damsite. The embankment materials for saddle dam are proposed to be obtained from the borrow area B.

The materials of this area are terrace deposits and widly distributed along the saddle dam axis. They are impervious fine-grained soil. The maximum particle size is 2 mm and average content of under 0.075 mm is about 70%. Those belong to silty clay or clay (CL, CH) according to the Unified Soil Classification System.

2) According to the results of materials survey and laboratory tests, the materials of the borrow area B are available for saddle dam embankment and sufficient quantity is obtainable.

3) However, according to the geological survey of saddle dam foundation, thick sand-gravel layer exists beneath the surface impervious layer in the area arround the saddle damsite. Therefore, actual borrow area should be selected outside of the reservoir area not to cause any harmfull effect on impermeability of dam foundation.

4) As the terrace deposits selected for embankment materials are widely distributed around the saddle damsite, it is not difficult to select a new borrow area outside of the reservoir area. However further survey and laboratory tests will be required to finalize selection of borrow area for saddle dam.

2.6.3 Filter Materials

1) The borrow area C is proposed for the source of filter materials and concrete aggregates. It is located on the Pegalan river about 1.5 to 5 km upstream from its confluence with the Sook river.

2) The area is occupied by fluvial deposits. The materials deposited in downstream area are sand-gravel layer for all stratum while the materials in upstream area are composed of fine sand and sand-gravel layer.

   The maximum particle size of the sand-gravel materials is 100 mm and content of sand under 5 mm is approximately 23%. The grading of the materials is relatively coarse. Therefore, some adjustment of grading will be needed for filter materials. There is no problem about quantity of materials.

2.6.4 Rock Materials

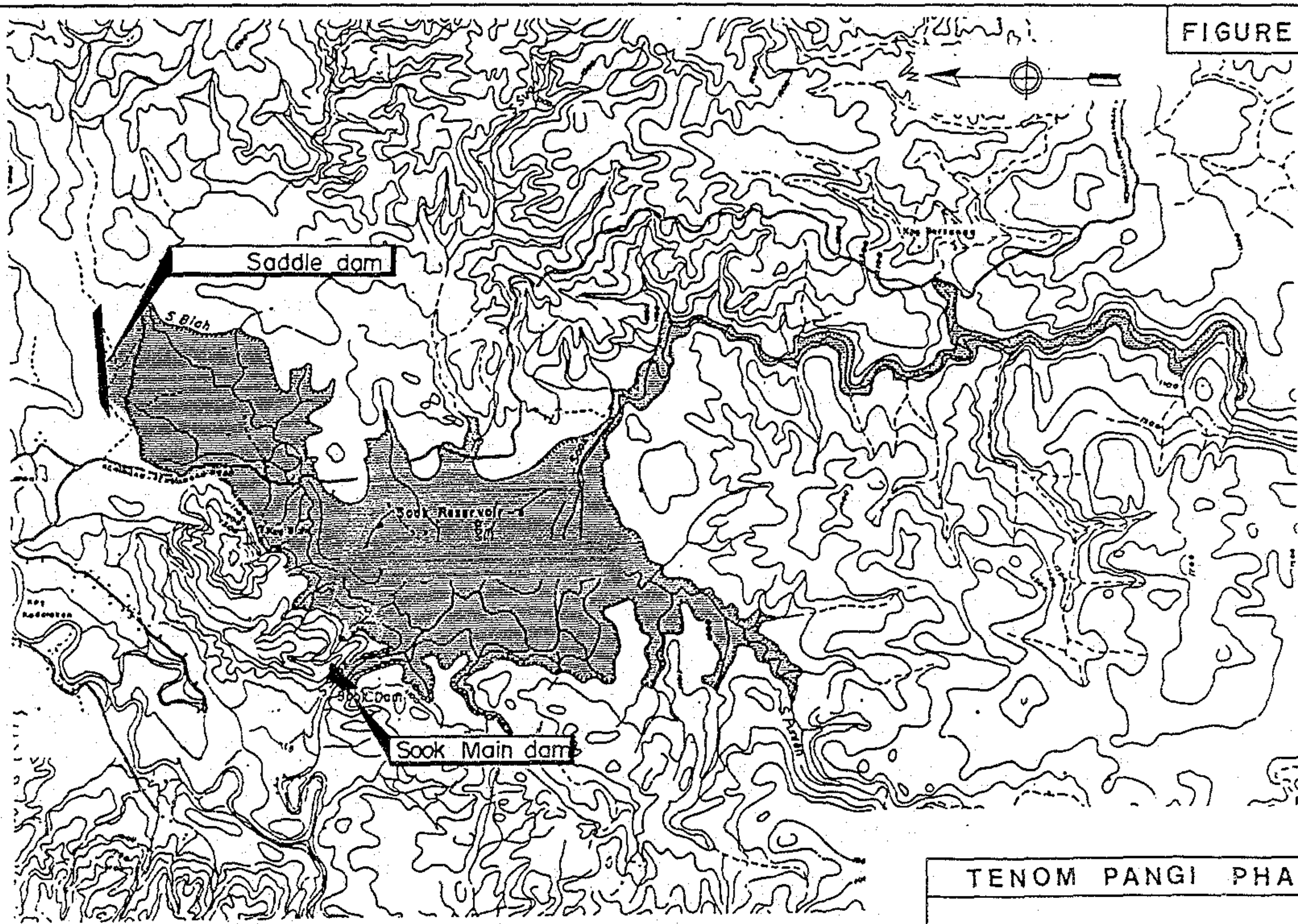
1) The proposed quarry site for the rock material is located approximately 1 to 2 km north of the proposed damsite. The materials in this site consist of shale and sandstone except terrace deposits of thin layer in upper portion, and the main rock is sandstone.

2) According to the results of core drilling, highly weathered layer exists in the bedrock at the quarry site. However, sand rock arround the borehole No. Q85-3 is suitable for rock embankment materials. In order to confirm available quantity of the sand stone, some more additional core drillings are recommendable.

2.6.5 Concrete Aggregates

The materials of borrow area C, which consist of fluvial deposits, are suitable for the concrete aggregates though they contain silt particles. As materials suitable for fine aggregates are not so much contained in the deposits, crushing and sieving facilities will be needed to produce the concrete aggregates. Fresh materials of the quarry site for rockfill materials also can be used for concrete aggregates.

FIGURE NO. : 2. 1



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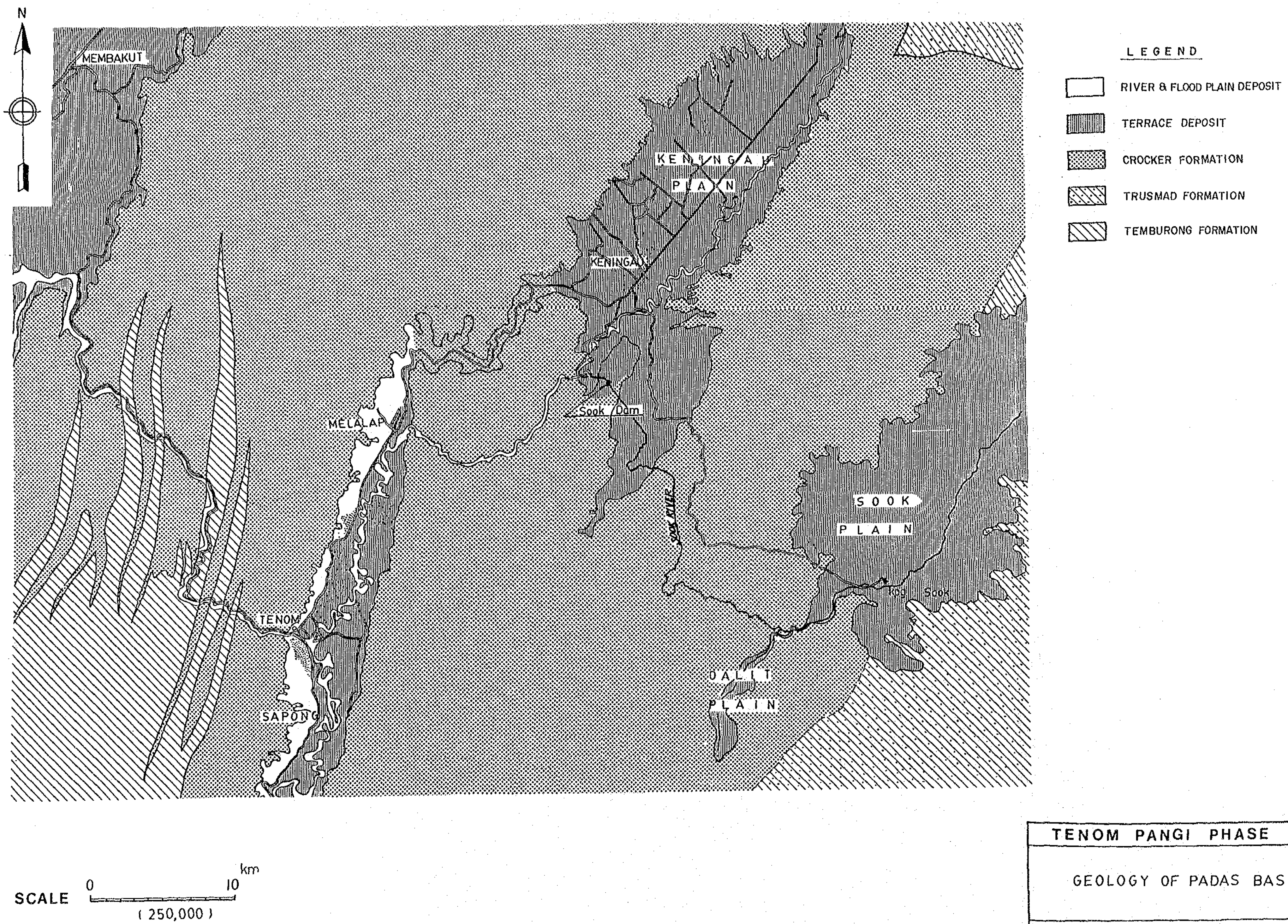
TENOM PANGI PHASE III

VICINITY MAP

SEB / JICA

FIGURE NO. 2.2

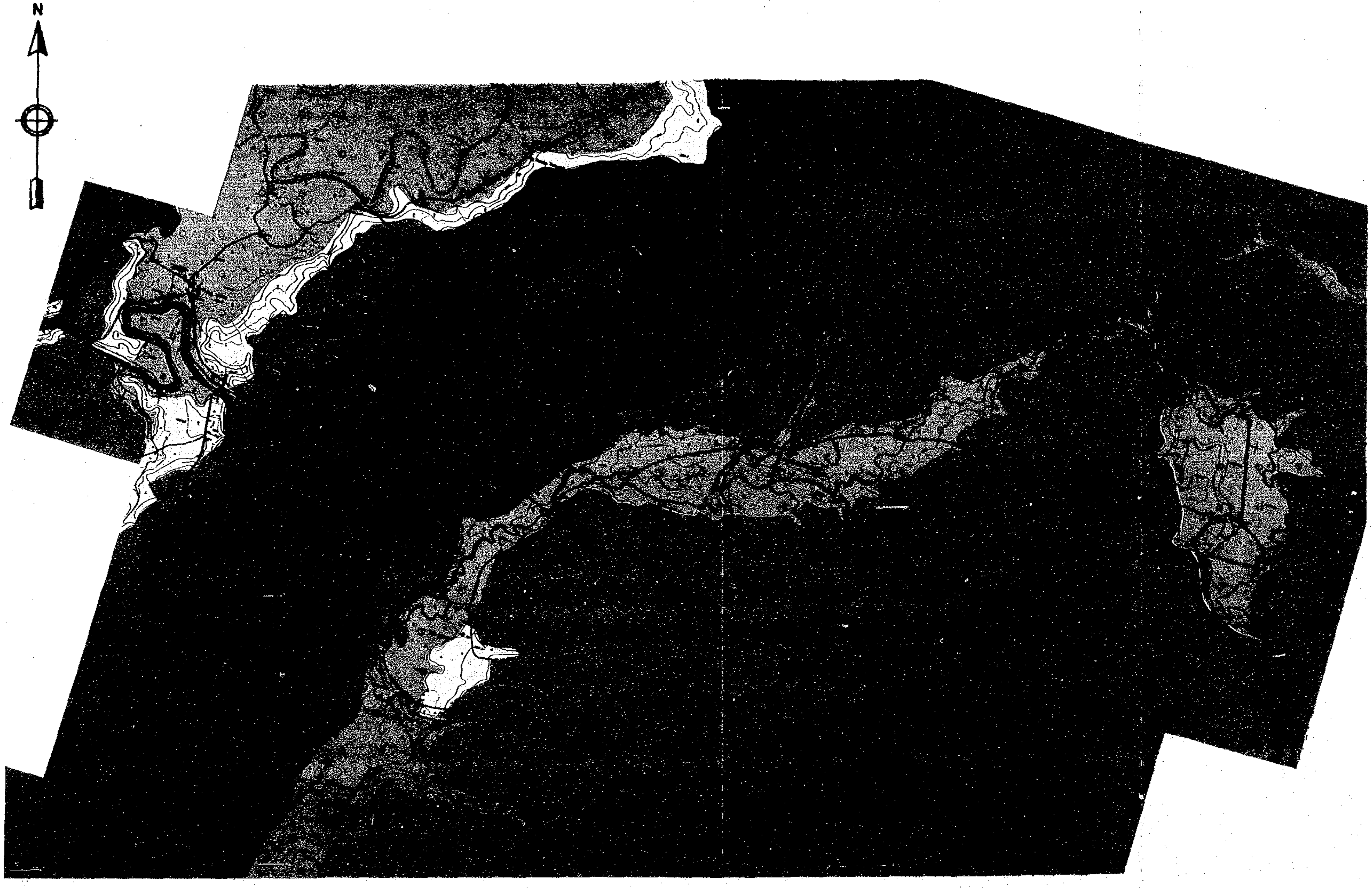


TENOM PANGI PHASE III

GEOLOGY OF PADAS BASIN

SEB / JICA

FIGURE NO. 2.3



SCALE 0 1 1.5 km
(1:30,000)

LEGEND

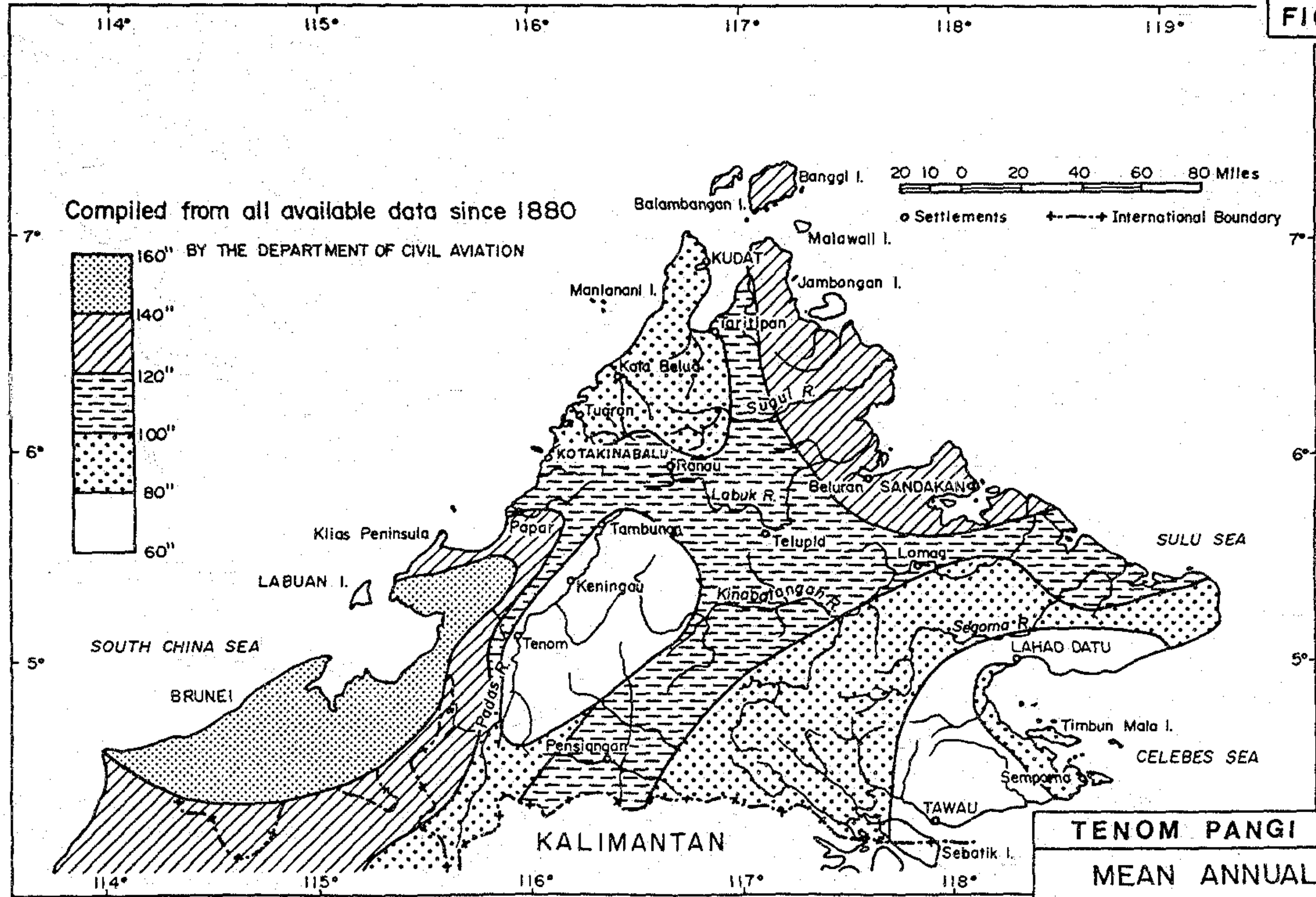
- FLOOD PLAIN (HOLOCENE)
- LOWER TERRACE PLAIN (PLEISTOCENE)
- MIDDLE TERRACE PLAIN (PLEISTOCENE)
- HIGHER TERRACE PLAIN (PLEISTOCENE)
- BEDROCK (CROCKER FORMATION OF EOCENE TO MIOCENE)

TENOM PANGI PHASE III

GEOLOGICAL PLAN OF PROJECT SITE

SEB / JICA

FIGURE NO. : 2.4

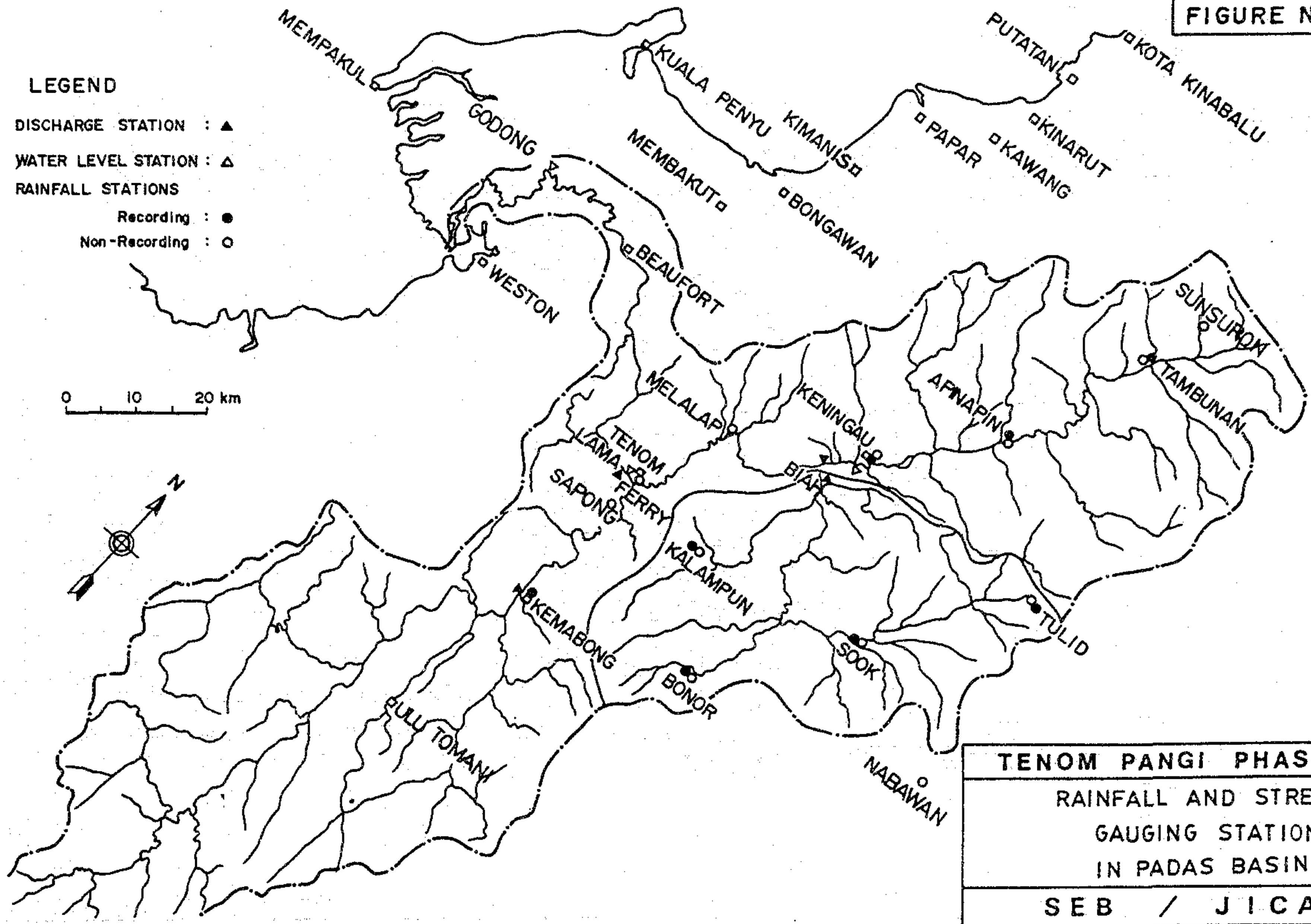


TENOM PANGI PHASE III

MEAN ANNUAL RAINFALL
IN
SABAH

SEB / JICA

FIGURE NO. : 2.5

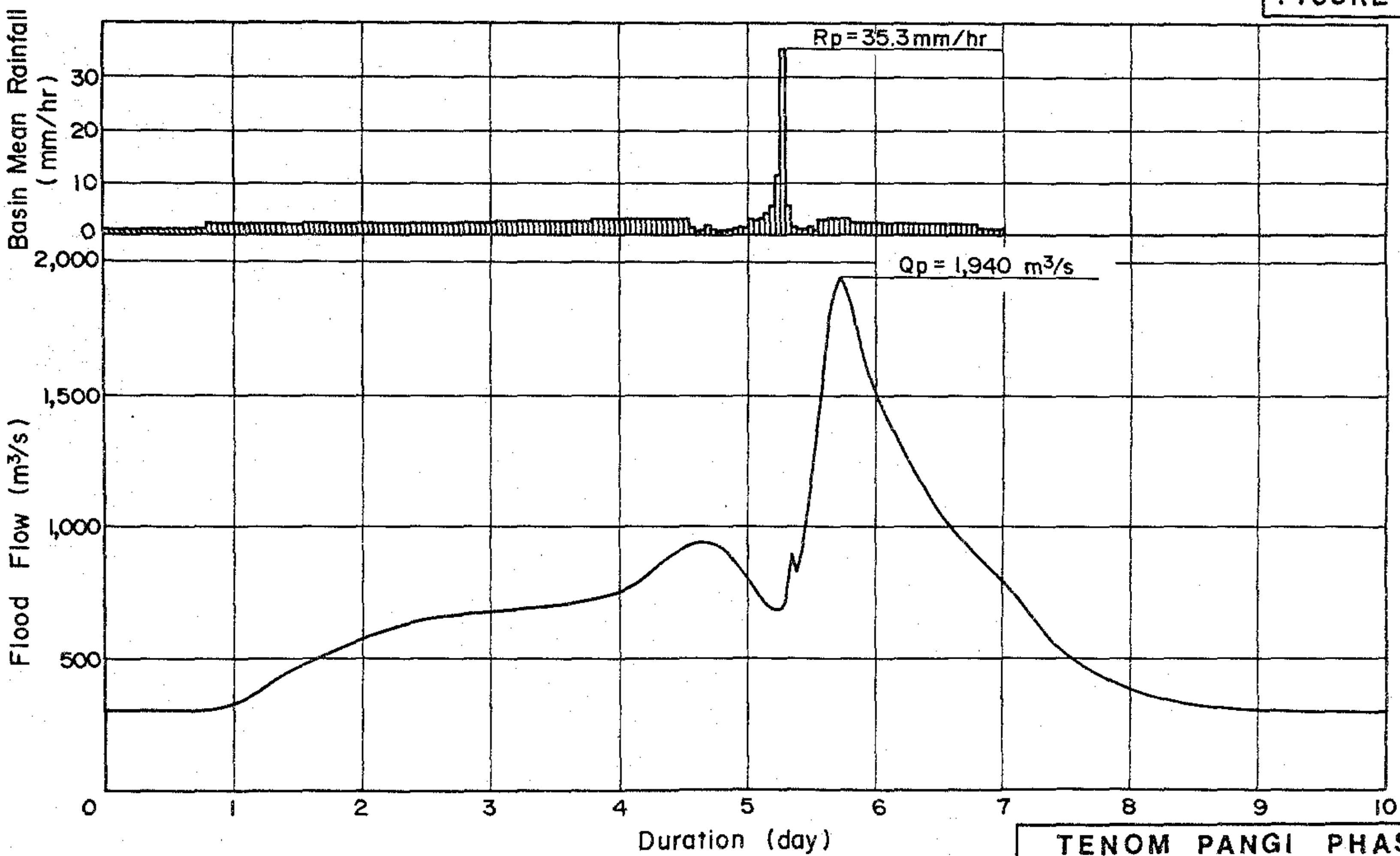


TENOM PANGI PHASE III

RAINFALL AND STREAM GAUGING STATION IN PADAS BASIN

SEB / JICA

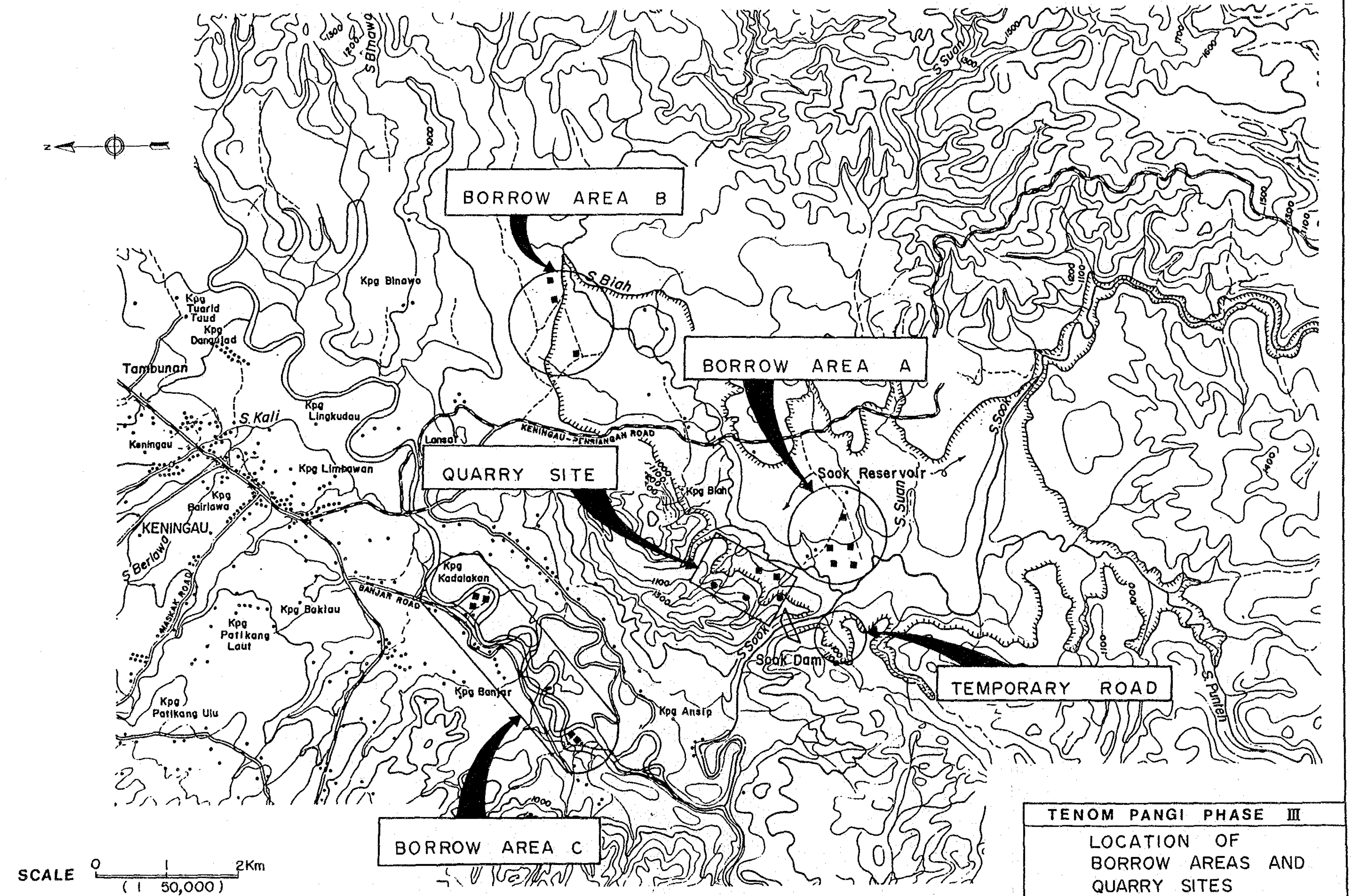
FIGURE NO. : 2.6



SCALE

Note : Rloss = 1.5 mm/hr
10 day flood volume
= $560 \times 10^6 m^3$

TENOM PANGI PHASE III
PROBABLE MAXIMUM FLOOD OF SOOK DAM
SEB / JICA



TENOM PANGI PHASE Ⅲ

LOCATION OF BORROW AREAS AND QUARRY SITES

SEB / JICA

3. POWER MARKET STUDY

3.1 Present Situation of Power Supply System

3.1.1 SEB Organization

The public electric power supply to the whole of Sabah has been undertaken by Lembaga Letrik Sabah (LLS), Sabah Electricity Board (SEB). SEB was established on January 1, 1957 as a separate entity of the State Government of Sabah under the Electricity Board Ordinance in 1956, taking over responsibility of the Department of the Public Works for generation and supply of electricity for the public. The then title of the Board was the North Borneo Electricity Board, and it was altered to the present one, Sabah Electricity Board, in 1963. SEB looks after all phases of electric power supply business covering generation, transmission, distribution and consumer services. At present, SEB's operation is made in three separate regions; Central Division for the metropolitan area of Kota Kinabalu including Kudat and Kota Belud, Western Division for the west coast load centers including Labuan and the towns of the interior residencies such as Beaufort, Tenom and Keningau, the Eastern Division for the east coast towns such as Sandakan, Tawau,Lahad Datu, etc. In this report the Central and West Divisions which can be easily interconnected with a transmission system is called as the west coast area and the East Division as the east coast area.

SEB was managed as an electricity supplying body of the State Government of Sabah, but it has been taken over under the management of the Federal Government since January 1, 1984.

A simplified organization chart of SEB as of October 1985 is as depicted in Figure 3.1.

3.1.2 Generating Facilities

Before commissioning of the Tenom Pangi power project, with a 132 kV transmission line, each load centre of SEB has been supplied independently by the Diesel power units or gas turbine units. At present, after starting operation of the Tenom Pangi power station since middle of 1984, a part of the Kota Kinabalu network and the towns of Tenom and Beaufort are interconnected with 132 kV, 66 kV and 11 kV transmission lines and are supplied from the Tenom Pangi power station. The old generating sets are still retained for backups and stand-by units.

Incluling Kota Kinabalu, Beaufort and Tenom power stations, SEB now possesses seven major stations, nine minor stations, several rural stations, one major hydro station and some mini hydro stations. Total installed capacity as of 1985 is 312.5 MW. Location of these power stations is as shown in Figure 3.2. Projected figures of the operating statistics for these power stations for the year 1985 are as summarized in Table 3.1, and the historical statistics are as shown in Table 3.2.

3.1.3 Transmission Line System

At present SEB operates a 132 kV double circuit transmission line with ACSR conductors of 350 mm^2 (Bison) connected between the Tenom Pangi power station and the Penampang substation in the suburb of Kota Kinabalu to send power generated at the Tenom Pangi power station to Kota Kinabalu. A tap-off substation was constructed near Beaufort to supply power to the neighbouring areas from the 132 kV transmission line. Power supply to the town of Tenom is being made from the 11 kV side of the Tenom Pangi power station.

For the purpose of interconnection between the old Kota Kinabalu power system and the Tenom Pangi power system and for reinforcement of the power system in and around Kota Kinabalu, two 66/11 kV substations, the one within the premises of the old Tanjung Aru power station and the other in Inanam, were constructed and 66 kV transmission lines from the Penampang substation to these two substations were constructed. Interconnections for Kota Kinabalu - Tuaran and Kota Kinabalu - Papar are by 22 kV transmission lines.

Other SEB power stations are operated without interconnection among each other.

In the Kota Kitabalu area, 11 kV distribution systems are operated, and for house service the 415/240 V, three-phase, four-wire system is employed.

3.1.4 Power Tariffs and Sales

The power tariff system of SEB applicable throughout Sabah is classified into 9 categories, Tariffs A to I. Tariffs D and H are further classified into D1, D2, and H1, H2. Basic rate, minimum charge and usage charge for each category, effective as of the end of 1985, are as summarized in Table 3.3.

Table 3.1 OPERATING STATISTICS (SEB, 1985 PROJECTED)

Name of Station	Energy generated (GWh)	Energy sold (GWh)	Installed Capacity (kW)	Nos. of Consumers	Remarks
Major Stations	(446.4)	(534.1)	(227,720)	(97,864)	
1. Kota Kinabalu	118.8	275.1	94,470	45,470	
2. Labuan	56.9	48.8	28,350	7,183	
3. Sandakan	130.5	98.7	41,700	18,947	
4. Tawau	96.1	74.0	40,800	14,594	
5. Lahad Datu	18.5	15.9	10,400	4,053	
6. Kudat	10.9	9.9	5,500	2,870	
7. Keningau	14.7	11.7	6,500	4,747	
Minor or Rural Station	(32.8)	(37.7)	(18,820)	(21,005)	
8. Semporna	6.4	3.7	2,849	1,797	
9. Kota Belud	7.2	5.4	3,291	3,073	
10. Ranau	3.2	2.9	1,245	1,644	
11. Beaufort	-	7.5	-	3,232	
12. Tenom	0.2	5.6	2,200	2,175	
13. Beluran	1.0	0.7	650	391	
14. Sipitang	3.9	3.0	1,300	1,291	
15. Kunak	1.5	1.3	300	400	
16. Kota Marudu	1.9	1.4	1,000	856	
17. Rurals	7.5	6.2	5,985	6,146	
Hydro			(66,000)		
18. Tenom Pangi	257.0	-	66,000	-	
Sabah Gas					
19. Power Receiving	5.8	-	-	-	
Total	742.0	571.8	312,540	118,869	

Table 3.2 STATION STATISTICS (SEB)

Particulars	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985 1/
1. Energy generated (GWh)	226.8	251.9	297.1	359.1	413.5	473.8	533.1	601.4	649.1	742.0 3/
2. Energy sold (GWh)	192.1	215.1	250.0	294.4	341.7	384.9	430.2	484.9	502.3	571.8
3. Growth rate (%)	7.0	12.0	16.2	17.8	16.1	12.6	11.8	12.7	3.6	13.8
4. Installed capacity (MW)	80.1	94.7	123.4	129.7	138.7	157.6	213.4	216.7	308.9	312.5
5. Nos. of town served 2/	12	12	12	12	12	12	12	12	16	16
6. Nos. of consumers	51,115	54,756	60,222	65,804	73,624	81,284	90,346	97,095	109,048	118,869
7. Loss and station use (%)	15.3	14.6	15.9	18.0	17.4	18.8	19.3	19.4	22.6	22.9

1/ : Estimated figures.
2/ : Major and minor stations
3/ : Including power receiving from Sabah Gas Industries

Table 3.3 (1) POWER TARIFF BY CATEGORY (SEB)

Category	Rate
A - Flat Rate Lighting, Fans, heating and office apparatus (Office, Halls, Clinics, Museums, Libraries, Community/Sport Centres)	35 ¢ per unit Minimum charge $10.00 per month
B - Cinemas (Abolished and merged with Commercial Tariff)	
C - Charitable Organizations, Hospitals, Mosques, Temples, Schools and Government Hostels	100 units @25 ¢ per unit 400 units @17 ¢ per unit Balance @15 ¢ per unit Minimum charge $10.00 per month
D - <u>Industrial</u>	
D1 - Light Industry below 500 hp or 370 kW	2,000 units @20 ¢ per unit 13,000 units @17 ¢ per unit Balance @15 ¢ per unit Minimum charge $2.00 per every hp or 0.75 kW of connected load but not less than $10.00
D2 - Heavy Industry for load connected above 500 hp or 370 kW (Maximum Demand Power Tariff)	(i) For each kW of maximum demand per month $10.00 (ii) For all unit - 12 ¢ per unit. M.C. $2.00 per every hp or 0.75 kW of connected load but not less than $1,000. (iii) For supplies taken at high voltage or extra high voltage the units recorded will be reduced by 2% for billing purposes (iv) This type of industrial consumers is required to provide a space on their premises for installation of substations

Table 3.3 (2) POWER TARIFF BY CATEGORY (SEB)

Category	Rate
E - Domestic and Household	40 units @25 ¢ per unit 160 units @17 ¢ per unit Balance @15 ¢ per unit Minimum charge $5.00 per month
F - Commercial (Restaurants, Shophouses, Cinemas, Markets Funfairs, Clubs and Associations)	100 units @30 ¢ per unit 900 units @17 ¢ per unit Balance @15 ¢ per unit Minimum charge $10.00 per month
G - Air-conditioning (only applies to center plants)	Flat rate @20 ¢ per unit Minimum charge $5.00 per month
H - <u>Public Lighting</u>	
H1 - Street Lighting	From dusk to dawn, 12 hours basis, 100 watt or pro-rate per month - $5.40 per month or 15 ¢ per unit. Initial charge for use of SEB poles for mounting of light fittings per pole (payable once only) $25.00. The six hour basis of dusk to midnight is abolished.
H2 - Temporary Festivals/Decoration Staircases, Elevators and Playgrounds	Flat rate: 17 ¢ per unit Minimum charge $10.00 per month
I- Armed Forces	500 units @35 ¢ per unit Balance @20 ¢ per unit Minimum charge $10.00 per month

In addition to the above charges, meter rental charges, security deposits and fuel oil variation charge will be charged to the consumers as summarized below:

<u>Meter Rentals</u> :	Single Phase	:	50 cts per month
	Three Phase	:	$1.00 per month

<u>Consumers Security Deposits</u> : Equivalent to 2 months consumption

<u>Fuel Oil Variation Charge</u>

This Clause shall apply to all tariffs, with the exception of Tariff A and up to the 1st 200 units of Tariff E.

For every dollar, or pro rata for every part of a dollar, increase or decrease in the average cost to the Board of the fuel consumed at the five major generating stations above $258 per ton or below $252 per ton, the consumer shall pay an increased or decreased charge of 0.040 cents per unit during the month concerned.

In the event of fuel having a calorific value either more or less than 18500 BTU per lb. the price per ton will be adjusted by simple inverse proportion to that value, provided that if the calorific value is more than 18200 BTU and less than 18800 BTU no adjustment in the price per ton shall be made. The term "fuel" in this agreement includes coal and oil and any substance other than water (Hydro power) which from time to time may be utilized by the Board as a source of energy for generating electricity.

For the year 1985 SEB estimated to sell the electricity with an average selling price of 28.99 M cents per unit inclusive of the fuel oil variation charge of 14 M cents per unit sold. Table 3.4 shows the estimated sales of electricity by each category of tariff and the average selling price per unit.

Table 3.4 SALES BY TARIFF (1985 ESTIMATE)

Tariff	Energy sold (10^3 kWh)	Total sales (10^3 M $)	Average price (M¢)
A	37,028	12,960	35.00
C	16,675	5,021	30.11
D	175,693	53,867	30.66
E	215,893	48,944	22.67
F	71,076	23,228	32.68
G	92,063	31,302	34.00
H	12,998	3,996	30.74
I	12,617	4,479	35.50
Total	634,034	183,797	28.99

3.2 Study Area

At present, power generated at the Tenom Pangi Power Station is delivered mainly to Kota Kinabalu, Beaufort and Tenom; the former two with a 132 kV transmission line between the Tenom Pangi power station and the Penampang substation in the suburb of Kota Kinabalu, and the latter one with an 11 kV line between the Tenom Pangi power station and Tenom town. The Beaufort substation was constructed for the power supply to Beaufort town and its vicinity and for possible future interconnection with Labuan island.

During the period of the Fifth Malaysian plan (1986 - 1990), the existing 132 kV transmission line network is planned to be extended to utilize hydro power of the Tenom Pangi Project, Phases I and II with 66 MW installation, and bulk power supply from a gas-fired combined cycle plant owned by the Sabah Gas Industries in Labuan. The extension plan of 132 kV transmission line network will cover all the west coast towns. In addition to the current power supply areas, Keningau, Labuan, Kota Belud and Kudat and their vicinity areas will be interconnected by the 132 kV transmission lines. Construction of 33 kV transmission lines is also planned to connect Beaufort and neighbouring towns including Sipitang.

Under the Liwagu hydroelectric power project, a 132 kV interconnection will be established for supply of the generated power of this power station to the both of Kota Kinabalu and Sandakan. The distance between Kota Kinabalu and Sandakan is about 320 km. As the power transmission capacity of a 132 kV line is limited, the final interconnection between these two load centers is planned to be made with a 275 kV line. The 275 kV line is required to send power from either of one coast to the other. The distance between Sandakan and Tawau, which will exceed Sandakan in the peak demand within this century, is about 180 km. Since, the major load centers in Sabah are separated each other with large distance, it is not suitable to send large power to one end to the furthest end. Each major load center shall be operated with power sources for its own supply and the interconnecting transmission lines will function to supplement among each other and to minimize installations of backup and standby sources.

Under such situations, the study area of the power market for the proposed Tenom Pangi Power Project, Phases I, II and III is assumed to include only the west coast towns as listed below:

1. Kota Kinabalu
2. Labuan
3. Kudat
4. Kota Belud
5. Beaufort(including Sipitang and other small load centers)
6. Tenom
7. Keningau

Brief description of each load centre is as shown below:

1) Kota Kinabalu

Kota Kinabalu is the capital of the State of Sabah with a population of about 200,000. There are a lot of inflow migrants to this city looking for employment opportunities. This city is surrounded by hinterland areas covered mainly with natural forest. People in these areas grow paddy rice, vegetables and fruits, and practise plantation farms, shifting cultivations, etc. The Kota Kinabalu supply area includes Tuaran and Tamparuli to the north and Penampang and Papar to the south.

Kota Kinabalu is the centre of the political and commercial activities. There are an international airport and sea port facilities as main entry points from abroad. Volume of cargoes passing through these ports is the largest in Sabah except Labuan. Kota Kinabalu is booming in construction activities of large buildings for offices and shops, governmental organizations, industrial complexes, shopping complexes, housing estates, etc. Thus, future prosperity of Kota Kinabalu as a whole can be expected.

2) Labuan

Labuan is a port town located off the south-western corner of Sabah. From the beginning of 1984 Labuan has become the Federal territory. However, the island is close to the Sabah territory and it is planned to interconnect the power system in Labuan island with that of Sabah main land through 132 kV submarine cables.

Business and commercial activities are concentrated in Labuan town, but its surrounding housing estate is expanding toward the north in order to provide accommodation for increasing population.

The Labuan port is a free port and busy in import and export from Sabah. Oil and natural gas industries are based in Labuan in order to utilize production in the island. For utilization of natural gas, Sabah Gas Industries (SGI) was established in the Ranca Ranca industrial complex. Large scale industries such as a shipyard, a hot briquetted iron plant, a methanol plant, a wood-based industry, a flour mill, etc. have already been established or planned in this area. There are also small scale industrial complexes around the town area.

3) Kudat

Kudat is located at the northern-most corner of Sabah facing to Marudu Bay to the east. Economy of this area depends on agricultural activities such as coconuts, palm oil and rubber plantations in the flat lands, timber production in the interior areas and fishing along the coastal areas.

Kudat town is about 200 km far from Kota Kinabalu. There are some commercial and light industrial activities in the town, and port facilities are available. Also, there is some possibility for expansion of fishing activities.

4) Kota Belud

Kota Belud is located on the West Coast Highway connecting Kota Kinabalu and Kudat. Another road is connecting Ranau with a port facility of Kota Belud for transport of copper ore from Mamut mine.

Major economic activity is agriculture. Though there are some commercial activities in the town, no major industries have yet been established.

There is a plan to construct an aquaculture farm for raising shrimps. This project plans to ultimately consume 10 MW of power. For feeding such a big load, a 132 kV transmission line from Kota Kinabalu is required to be constructed.

5) Beaufort

Beaufort is located at about 100 km south of Kota Kinabalu, and is connected with the West Coast Highway. The completion of the Papar-Beaufort section of Highway improved the communication condition between these two towns. This also improved the position of Beaufort as an intermediate town on the highway to Sipitang and further to Sarawak to the south and Labuan to the west.

Beaufort District is one of the coastal districts of the Interior Residency. The main economic activity is agriculture, consisting mainly of rubber and oil palm plantations. Commercial activities are centered in Beaufort town, in which commercial complexes, housing estates and light industrial complexes are under construction. A plastic industry and a palm oil mill have started operation, and the waterworks extension is under planning.

In the Beaufort area, population is well distributed in wide areas and there are numbers of small diesel stations for supply to local towns. They are planned to be connected with the Beaufort system with two 33 kV feeders which will be completed by 1987. The Bongawan feeder will supply power to Membakut, Bongawan, Gadong, Pimping, Palu Palu, Binsulok and Kuala Penyu while the Sipitang feeder will supply to Weston, Sipitang and Sindumin.

6) Tenom

Tenom is connected to Keningau to the north by the Interior Highway and Beaufort to the northwest by the single truck railway along the Padas river gorge.

Agriculture is the main activities of the surrounding area. There are plantations for rubber, cocoa and coffee, and farms for vegetables, fruits, etc. A rubber crumb factory and cocoa bean drying plants are operating in the area. Commercial activities are centered in Tenom town.

7) Keningau

Keningau is the central town of the Interior Residency, and is connected by public roads with Kota Kinabalu and Ranau through Tambunan to the northeast, and with Tenom to the southwest. The town is well arranged as the centre of the district for political and commercial activities.

This town was booming in forest industries from 1970s to the beginning of 1980s but slow down recently due to decrease of forest reserves in the surrounding areas. It was understood that some of the forest related activities have been shut down and retrechment of labours from forest industries was rather serious.

3.3 Present Situation of Power Market in Study Area

The historical power demand data of each load centre for the period 1974 through 1984 were collected from the SEB Annual Reports up to 1980 and SEB's Accounts and Finance Department for the rest of the period. The collected data are (i) number of consumers, (ii) sold energy for each category, (iii) generated energy and (iv) peak demand. The consumption categories are also classified into four sections; domestic, commercial, industrial and army. The collected data are shown in Tables 3.5 to 3.11.

Findings of the available data and the result of analysis are shown below:

1) The electrification ratio of the domestic demand in each load centre as of 1984 is given below:

	(%)
Kota Kinabalu	57.0
Labuan	67.8
Kudat	21.2
Kota Belud	22.8
Beaufort	27.3
Tenom	28.9
Keningau	33.4

In rural areas houses are scattered widely, and it seems difficult to raise the electrification ratio substantially from the present figures.

2) The annual growth rate of sold energy of each load centre is calculated by consumption categories as given below:

	1974/84 (%)	1974/80 (%)	1980/84 (%)	1982/84 (%)
Kota Kinabalu				
Domestic	13.4	15.0	11.2	5.8
Commercial	12.6	15.2	9.5	7.7
Industrial	8.7	10.4	6.1	4.7
Army	9.8	13.0	5.9	10.1
Average	12.3	14.4	9.3	6.3
Labuan				
Domestic	19.1	21.6	16.7	14.1
Commercial	16.5	17.8	15.5	14.8

	1974/84 (%)	1974/80 (%)	1980/84 (%)	1982/84 (%)
Industrial	20.3	34.5	7.6	3.3
Army	4.1	-2.9	9.9	3.9
Average	16.4	20.8	12.2	9.0
Kudat				
Domestic	11.9	10.4	14.2	9.2
Commercial	8.2	13.3	2.2	-1.3
Industrial	15.5	18.0	11.8	19.8
Army	--	--	--	--
Average	12.4	14.5	9.4	9.1
Kota Belud				
Domestic	18.4	13.4	20.7	15.7
Commercial	19.5	15.3	24.9	45.9
Industrial	13.3	7.1	23.2	20.7
Army	16.7	12.7	23.0	25.4
Average	16.7	12.7	23.0	25.4
Beaufort				
Domestic	19.2	23.0	13.8	12.7
Commercial	18.7	25.1	12.6	13.0
Industrial	15.4	13.0	19.2	33.2
Army	--	--	--	--
Average	16.8	18.4	14.4	16.4
Tenom				
Domestic	22.4	22.6	22.0	12.0
Commercial	15.4	19.5	9.5	10.0
Industrial	29.2	41.8	8.2	4.0
Army	--	--	--	--
Average	21.0	26.8	12.84	8.6

	1974/84 (%)	1974/80 (%)	1980/84 (%)	1982/84 (%)
Keningau				
Domestic	20.6	19.8	21.8	16.1
Commercial	22.0	27.0	16.1	9.8
Industriall	12.6	12.5	12.8	3.2
Army	--	--	--	--
Average	19.6	20.4	18.4	12.3

Except Kota Belud in which an extensive rural electrification programme has been completed recently, it is a general tendency that the power demand growth rate has declined gradually after 1980. As seen above growth rate has decreased in the orders of 1974/80, 1980/84 and 1982/84. The recent increase rates of energy demand for 1983 to 1984 are given below:

	(%)
Kota Kinabalu	4.2
Labuan	6.4
Kudat	7.8
Kota Belud	22.8
Beaufort	5.1
Tenom	3.2
Keningau	5.3

All the rates except for Kota Belud are below 10 per cent. The very high rate of Kota Belud seems to have derived from the recent connection of a rural center of Tenghilan station.

Connection of new consumers has been the largest factor for increasing power demand. Activities for rural electrification have been sluggish during the recent few years. However, based on a new economic policy of the current government, progress of rural electrification as basic infrastructure is expected to be promoted even in the coming future.

Table 3.5 HISTORICAL POWER DEMAND (1974 - 1984)
(KOTA KINABALU POWER STATION)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984 1/
1. Number of consumers											
a) Domestic	12,205	13,416	17,073	17,000	18,685	20,328	22,633	23,562	26,398	26,709	29,838
b) Commercial		3,075	2,972	3,879	3,950	4,436	5,208	5,796	6,242	6,636	9,095
c) Industrial	842	804	768	800	913	1,033	1,178	1,516	1,570	1,659	2,552
d) Army		2	2	14	19	40	15	47	16	16	16
Total	15,868	17,297	20,815	21,693	23,567	25,837	29,034	30,921	34,226	35,020	41,501
2. Sold energy (MWh)											
a) Domestic	23,816	28,382	30,375	33,441	39,313	44,967	54,995	58,848	75,069	81,404	83,973
b) Commercial		29,133	32,036	32,496	42,990	47,773	58,993	68,254	73,070	80,575	84,683
c) Industrial	20,308	20,184	22,233	26,919	31,292	33,999	36,779	40,853	42,548	44,524	46,597
d) Army		1,290	1,509	1,866	2,435	2,161	2,382	2,506	2,476	2,986	3,000
Total	68,282	78,989	86,153	94,722	116,030	128,900	153,149	170,461	193,163	209,489	218,253
3. Generated energy (MWh)	80,082	93,229	99,643	109,051	136,559	160,771	185,568	212,671	240,652	272,660	159,700 2/
4. Peak demand (MW)	15.90	18.05	18.90	22.40	27.25	32.30	35.30	42.30	46.30	54.10	55.90
5. Annual load factor (%)	57.50	58.96	60.18	55.57	57.21	56.82	60.01	57.39	59.33	57.53	58.05

1/ : Estimated figures

2/ : Decrease was caused by power receiving from Tenom Pangi Power Station

Table 3.6 HISTORICAL POWER DEMAND (1974 - 1984)
(LABUAN POWER STATION)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984 1/
1. Number of consumers											
a) Domestic	1,291	1,675	1,986	2,241	2,648	2,864	3,128	3,516	3,894	4,517	5,077
b) Commercial		421	415	440	486	516	573	651	798	902	909
c) Industrial	90	79	85	101	90	116	132	145	150	166	171
d) Army		159	175	246	394	389	390	389	488	535	603
Total	1,950	2,334	2,661	3,028	3,618	3,885	4,223	4,701	5,330	6,120	6,760
2. Sold energy (MWh)											
a) Domestic	2,864	3,759	4,408	5,005	6,101	7,616	8,832	11,129	12,678	14,937	16,516
b) Commercial		2,787	2,922	2,960	3,677	5,360	5,625	7,279	8,111	10,722	11,020
c) Industrial	2,811	3,418	3,621	4,728	6,247	12,392	14,051	16,215	16,163	16,791	17,874
d) Army		2,423	2,509	2,790	3,243	2,160	3,133	3,085	3,407	3,466	3,465
Total	10,686	12,387	13,460	15,483	19,268	27,528	31,641	37,708	40,359	45,916	48,875
3. Generated energy (MWh)	12,371	14,198	15,456	17,861	22,857	31,039	36,040	44,345	50,300	60,045	63,136
4. Peak demand (MW) 2/	2.36	2.83	2.96	3.39	3.45	5.47	6.70	8.30	9.00	10.70	14.30
5. Annual load factor (%)	59.8	57.3	59.61	60.14	75.63	64.78	61.41	60.99	63.80	64.06	50.40

1/: Estimated figure.

2/: Including temporary supply to SGI, about 2.5 MW.

Table 3.7 HISTORICAL POWER DEMAND (1974 - 1984)
(KUDAT POWER STATION)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1. Number of consumers											
a) Domestic	882	922	948	1,023	1,088	1,138	1,253	1,444	1,577	1,791	2,088
b) Commercial	287	282	271	293	307	333	350	359	398	421	489
c) Industrial	66	61	66	59	60	60	62	64	59	69	75
d) Army	1	1	1	1	1	1	1	1	1	1	1
Total	1,236	1,266	1,286	1,376	1,456	1,532	1,666	1,868	2,035	2,282	2,653
2. Sold energy (MWh)											
a) Domestic	1,103	1,410	1,359	1,426	1,531	1,790	1,997	2,403	2,849	3,195	3,395
b) Commercial		1,219	1,350	1,370	1,455	1,666	2,273	2,297	2,541	2,341	2,475
c) Industrial	763	887	996	1,196	1,386	1,610	2,064	2,341	2,246	2,897	3,221
d) Army		17	14	14	16	17	16	14	13	14	15
Total	2,825	3,533	3,719	4,006	4,388	5,083	6,350	7,055	7,649	8,446	9,106
3. Generated energy (MWh)	3,252	3,912	4,229	4,469	5,200	6,216	7,410	7,972	9,190	10,535	11,867
4. Peak demand (MW)	0.78	0.857	0.845	0.863	0.999	1.190	1.405	1.525	1.650	1.960	2.350
5. Annual load factor (%)	47.60	52.11	57.13	59.11	59.42	59.63	60.21	59.68	63.58	61.36	57.65

Table 3.8 HISTORICAL POWER DEMAND (1974 - 1984)
(KOTA BELUD POWER STATION)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1. Number of consumers											
a) Domestic	452	555	608	639	787	888	1,048	1,449	1,881	2,147	2,235
b) Commercial		132	131	133	118	137	141	158	186	195	262
c) Industrial	17	34	36	40	40	48	54	57	61	64	79
d) Army		1	1	1	1	1	1	1	1	3	3
Total	583	722	776	813	946	1,074	1,244	1,665	2,129	2,409	2,579
2. Sold energy (MWh)											
a) Domestic	377	472	547	581	679	804	963	1,159	1,528	1,844	2,044
b) Commercial		356	404	465	492	575	726	739	831	1,120	1,768
c) Industrial	357	401	404	360	343	480	539	546	851	1,154	1,240
d) Army		20	16	12	15	19	18	31	53	66	83
Total	1,095	1,249	1,371	1,418	1,529	1,878	2,246	2,475	3,263	4,184	5,135
3. Generated energy (MWh)	1,309	1,643	1,686	1,814	2,197	2,594	2,941	3,099	4,326	5,488	6,167
4. Peak demand (MW)	0.35	0.38	0.41	0.43	0.515	0.577	0.605	0.723	1.028	1.256	1.330
5. Annual load factor (%)	42.69	49.36	46.94	48.15	48.70	51.32	55.49	48.93	48.04	49.88	52.93

Table 3.9 HISTORICAL POWER DEMAND (1974 - 1984)
(BEAUFORT POWER STATION)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1. Number of consumers											
a) Domestic	442	459	500	526	667	809	1,065	1,164	1,310	1,967	2,016
b) Commercial		170	168	184	187	210	252	273	301	333	373
c) Industrial	44	51	51	53	63	72	87	86	101	115	115
d) Army		2	2	2	2	2	2	2	2	2	2
Total	657	682	721	765	919	1,093	1,406	1,525	1,714	2,417	2,506
2. Sold energy (MWh)											
a) Domestic	445	516	537	612	870	1,234	1,540	1,712	2,037	2,512	2,586
b) Commercial			504	572	665	896	1,235	1,279	1,551	1,732	1,982
c) Industrial	301	342	352	432	537	671	628	617	714	1,306	1,266
d) Army			4	4	4	4	2	1	2	1	1
Total	1,236	1,377	1,397	1,620	2,076	2,805	3,405	3,609	4,304	5,551	5,835
3. Generated energy (MWh)	1,525	1,671	1,704	1,974	2,510	3,157	3,895	4,497	5,097	6,449	3,497
4. Peak demand (MW)	0.35	0.38	0.378	0.44	0.535	0.628	0.745	0.891	1.12	1.288	1.300
5. Annual load factor (%)	49.74	50.20	51.40	51.21	53.56	57.39	59.68	57.68	51.95	57.16	-

Table 3.10 HISTORICAL POWER DEMAND (1974 - 1984)
(TENOM POWER STATION)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1. Number of consumers											
a) Domestic	282	292	305	374	461	572	871	1,145	1,303	1,485	1,506
b) Commercial	152	157	157	161	158	169	207	249	263	282	286
c) Industrial	39	38	39	44	47	48	59	76	84	84	87
d) Army	-	-	-	-	-	-	-	-	-	-	-
Total	473	487	501	579	666	789	1,137	1,476	1,650	1,851	1,879
2. Sold energy (MWh)											
a) Domestic	246	285	312	327	383	528	836	1,155	1,472	1,825	1,852
b) Commercial	338	362	519	742	509	716	985	1,048	1,170	1,380	1,415
c) Industrial	153	147	150	163	620	677	1,243	1,361	1,573	1,609	1,702
d) Army	-	-	-	-	-	-	-	-	-	-	-
Total	737	794	981	1,232	1,512	1,921	3,064	3,564	4,215	4,814	4,969
3. Generated energy (MWh)	889	981	1,196	1,494	1,764	2,221	4,167	4,147	4,855	5,569	6,395
4. Peak demand (MW)	0.23	0.23	0.315	0.345	0.373	0.47	0.895	1.00	1.122	1.278	1.32
5. Annual load factor (%)	44.12	44.79	43.34	49.43	53.99	53.94	53.15	47.34	49.40	49.74	55.30

Table 3.11 HISTORICAL POWER DEMAND (1974 - 1984)
(KENINGAU POWER STATION)

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1. Number of consumers											
a) Domestic	838	885	944	1,085	1,060	1,325	1,636	2,274	2,484	3,007	3,185
b) Commercial	189	208	200	219	403	262	313	372	459	572	598
c) Industrial	59	63	62	65	66	69	74	85	107	118	122
d) Army	1	1	1	1	1	1	1	1	1	1	1
Total	1,087	1,157	1,207	1,370	1,530	1,657	2,024	2,732	3,051	3,698	3,906
2. Sold energy (MWh)											
a) Domestic	666	783	931	1,091	1,271	1,556	1,969	2,552	3,211	3,877	4,331
b) Commercial		697	792	897	1,128	1,298	2,300	2,461	3,472	4,087	4,186
c) Industrial	304	317	316	299	362	462	615	699	933	983	994
d) Army		14	24	32	45	35	22	8	19	200	119
Total	1,611	1,811	2,063	2,319	2,806	3,351	4,906	5,720	7,635	9,147	9,630
3. Generated energy (MWh)	1,841	2,104	2,343	2,716	3,219	3,901	5,291	6,768	9,479	10,944	11,209
4. Peak demand (MW)	0.46	0.50	0.655	0.65	0.725	0.89	1.155	1.700	1.919	2.315	2.410
5. Annual load factor (%)	45.69	48.04	40.83	47.70	50.68	50.04	52.29	45.45	45.42	53.97	53.09

3) Irregular increase of per consumer domestic consumption in the small scale load centers is in many cases caused by connection of new consumers. Usually, energy consumption of newly connected consumers is much smaller than that of the other consumers which have been using electricity for long time. Thus, the new connection of many rural houses is a factor pulling down the per consumers domestic consumption.

4) Per consumer domestic consumption in Kota Kinabalu and Labuan is high. It is said that the consumption level of the two load centers has already reached to the developed countries' level. It seems that such a high level is supported by domestic use of air conditioners. Use of energy-saving type apparatus for air conditioners, refrigerators, etc., which has already begun prevailing in Malaysia, will be a factor to suppress the growth of average annual consumption by domestic consumers. This tendency is noticed for the recent growth of Kota Kinabalu and Labuan.

5) Use of air conditioners in other load centers is not much.

6) The ratio of the commercial demand to the residential demand is generally high in large cities, which is a tendency common to other countries. This ratio seems to be approaching to about 1.0 in Kota Kinabalu and Keningau and to about 0.7 in the other centers.

In local centers the ratio was initially high, and has gone down to a certain value. Formerly, power distribution was confined in town areas where many shops were in operation. However, progress of rural electrification seems to have caused connection of many domestic loads and not so many commercial loads. Thus, the ratio is considered to have decreased. The expected progress of the third sector service industries mainly in city areas will be a factor to increase share of the commercial demand.

7) In developed countries, annual load factor is in the range of 60 to 65 per cent. The load factor was about 60 per cent in Kota Kinabalu, Labuan and Kudat and 50 per cent in other load centers.

8) The daily load curves of Kota Kinabalu and Labuan are of day time peak pattern and those for the other load centers are of evening peak pattern. The daily load curve of Kudat has recently turned from the day peak pattern to the evening peak one.

The day peak pattern seems to have caused by use of air conditioners in the offices and shops and industrial loads during the day time in Kota Kinabalu and Labuan. The dominant amount of domestic demand causes the evening peak pattern of power consumption.

9) In Kota Kinabalu, during the period of 1983 to 1984 in spite of large increase in the number of consumers of domestic, commercial and industrial categories, the increase in power demand of each category was minimal. This was caused by the fact that during this period many of industrial complexes, shopping complexes and housing estates were completed and power supply lines were connected, but many of them had not been occupied and power was not consumed.

Similar examples were observed in other load centers, such as Labuan, Keningau, Kudat, Tenom and Beaufort.

10) In Sabah, industries are mainly of small scale or of cottage nature. Based on the government economic policy, energy intensive heavy industries have not been planned in Sabah. From such circumstance, the demand increase rate of the industrial demand is generally lower than that of the total demand.

11) Growth of the army demand has been irregular as the demand of this category is influenced by the army's policy for defence activity, and has not indicated a fixed trend.

3.4 Power Demand Forecast of West Coast Area

3.4.1 General

Power demand of each of the seven load centers was forecasted based on the data of SEB up to 1984. Different approaches were applied for two periods, one up to 1995 and other beyond 1995, as mentioned below:

1) For the period up to 1995, the power demand of each of four categories, domestic, commercial, industrial and army, was forecasted based on the analysis of the past trend and estimation of the related factors which will affect the power demand. In case factors can not be fixed, such are estimated with certain ranges. The high estimation is obtained by applying high side factors and the low side estimation by low side factors.

2) For the period beyond 1995 up to 2010, the power demand was forecasted macroscopically for the aggregate demand of each load center based mainly on the estimation of economic indices.

3) The high estimate is basically used for deciding the necessary capacity of power supply system and the low estimate which provides an conservative side benefits of the project is used for economic analysis. The weighted average of the high and low estimates is taken as the most likely estimate.

3.4.2 Forecast of Domestic Demand

1) Population and Number of Households

The past data for population and numbers of households were obtained from the census for 1970 and 1980 and from the estimation in the Master Plan Study.

2) Electrification Ratio and Number of Consumers

For the last year of the demand forecast (1995), the target values of electrification ratio of the load centers were estimated for high and low sides.

The number of domestic consumers as of 1995 was calculated by multiplying the number of households by the assumed electrification ratios. For the intermediate years between 1984 and 1995, the number of domestic consumers were first obtained assuming that number of consumers will increase at a same rate and then the electrification ratios were calculated by dividing the number of consumers with the number of households.

The electrification ratios as of 1984 and assumed for 1995 are given below:

Household Electrification Ratios (%)

		Assumed for 1995	
	1984	High	Low
Kota Kinabalu	57.0	85	75
Labuan	67.8	85	75
Kudat	24.0	40	30
Kota Belud	22.8	45	35
Beaufort	27.3	50	40
Tenom	28.9	50	40
Keningau	33.4	55	45

3) Unit Energy Consumption of Domestic Demand

The unit energy consumption was assumed for two cases, one for the consumers connected already as of 1984 and the other for new consumers connected in future. The unit consumption values both for the year 1995 and of newly connected consumers were assumed referring to the actual trend and data of other countries as given below:

Unit Energy Consumption per Consumer (kWh)

	Actual in 1984	Assumed for 1995 High	Assumed for 1995 Low	New connection
Kota Kinabalu	2,814	4,000	3,500	2,000
Labuan	3,253	4,000	3,500	2,000
Kudat	1,626	2,100	1,800	1,200
Kota Belud	915	1,500	1,200	800
Beaufort	1,283	1,800	1,500	1,000
Tenom	1,230	1,800	1,500	1,000
Keningau	1,360	2,100	1,800	1,200

For the intermediate period between 1984 and 1995, the unit energy consumption was assumed to increase with the constant amount. This amount was also applied to newly connected consumers.

4) Domestic Energy Demand

From the above, the domestic energy demand of each load center for each year was calculated by the following formula:

$$Ei = N_{i-1} \times (UC_{i-1} + r) + (N_i - N_{i-1}) \times Q$$

Where,

Ei	=	Domestic energy demand of the year, i
Ni	=	Number of households of the year, i
N_{i-1}	=	Number of households of the year, i-1
UC_{i-1}	=	Unit domestic consumption of the year, i-1
r	=	Increase of the unit domestic consumption in one year
Q	=	Unit domestic consumption of the newly connected consumers

3.4.3 Forecast of Commercial Demand

The energy demand of the commercial category was calculated by multiplying the domestic demand by the ratio of the commercial demand to the domestic demand.

The target values of the ratio were assumed for the year 1995, and then the value of the ratios is assumed to change linearly between 1984 and 1995. The ratios as of 1984 and assumed for 1995, high and low values, are given below:

Ratio of Commercial Demand to Domestic Demand

	1984	Assumed for 1995 High	Assumed for 1995 Low
Kota Kinabalu	1.011	1.1	0.9
Labuan	0.667	0.8	0.7
Kudat	0.729	0.8	0.7
Kota Belud	0.865	0.8	0.7
Beaufort	0.766	0.8	0.7
Tenom	0.764	0.8	0.7
Keningau	0.967	1.0	0.9

3.4.4 Forecast of Industrial Demand

Usually the growth of the industrial power demand is related to the growth of industrial activities or GRDP. Based on the forecasted growth of GRDP being 6 to 6.5 per cent per annum and the recent trend for the growth of energy sold to industrial consumers the growth rate of each load center is assumed as given below:

Growth Rates of Industrial Demand (%)

	High	Low
Kota Kinabalu	8	6
Labuan	8	6
Kudat	12	10
Kota Belud	12	10
Beaufort	12	10
Tenom	8	6
Keningau	10	8

3.4.5 Army Demand

The past trend is rather irregular and it is impossible to forecast the army demand precisely since this demand is largely influenced by deployment of army forces which is affected by the national defence program.

In this report, the army demand of each load center is assumed to increase at a rate of 5 per cent per annum.

3.4.6 Loss and Station Use

The present rate of exceeding 20 per cent in the most of load centers is assumed to be improved to 15 per cent in 1995 with future improvement of distribution systems. The rate is assumed to decrease linearly.

3.4.7 Coming Large Consumers

The list of coming large consumers which are under construction or planned to be executed are shown in Tables 3.12 to 3.18 for each load center. For the recent few years, the construction works have been in boom and many buildings and facilities have been constructed. But, number of on-going projects have been much decreased in the recent years. In the list there are some large scale buildings in Kota Kinabalu such as the EPF building, MUIS building, etc. Also there are some large scale industries such as the cement factory in Sepangar Bay, etc. Each of these projects is estimated to consume more than 2 MW when operated fully. But, actually, it will take some time before consuming full load power. The past growth trend represents the average growth of power demand which included connection of large scale consumers. In Kota Kinabalu, many building projects were completed and connected to the SEB system between 1983 and 1984, but the growth of power consumption was minimal. This means many new buildings have not yet been fully occupied after completion. Similarly, though large buildings may be completed, in the initial stage available spaces will not be fully occupied.

Table 3.12 (1) LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (KOTA KINABALU POWER STATION)

	Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1985				
1.	Condominium Development Lot 015402589 Mile 3 1/2 Tuaran Road	2,000	3 x 3,000	
2.	Hotel Accommodation on Block 36 Lot 17 Kampong Air	160	200	
3.	Workshop/Store Complex on CF 213127112, 213122813, 215313081, 21312314 Putatan Road	272	350	
4.	Proposed Development on NT 6567, 21312628 and 21311975 Mile 6 1/2 Tambunan Highway	255	300	
5.	Development on Kapayan Ridge Phase 5 Kapayan, K.K.	831	2 x 500	
6.	Country View Lucky Heights Condominium Block, "Seraya" Jaswin	356.6	500	
7.	Industrial Development on Lot 9276 Mile 6 1/2 Tuaran Road	200	300	
8.	Light Industries on Lot 88 SEDCO Industrial Estate Phase C Mile 5 1/2 off Tuaran Road	486	750	
9.	Industrial Development on CL 015392275 Mile 5 1/2 off Tuaran Road	166.22	250	
10.	Industrial Building on Lot 15377572 Mile 5 1/2 off Tuaran Road	200	300	
11.	1-story housing development 6 units shophouses on lot 6548 Mile 5 1/2 off Tuaran Road	767	1,000	

Table 3.12 (2) LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (KOTA KINABALU POWER STATION)

	Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1985				
12.	13 units Light Industrial Buildings, Lot 15347572 Mile 5 1/2 off Tuaran Road	200	500	
13.	Industrial Development on Lot 2306 Kg. Nountun	300	500	
14.	Housing Development B.O.C. on Lot 28783, 12317 Likas Tuaran Road	300	500	
15.	Development on Lot 12555, 109863, 10988 Mile 5 1/2 Tuaran Road	388.95	500	
16.	4-story Shophouses on Lot 1231 Putatan	275.3	800	
17.	Shophouses at Papar	359.2	500	
18.	Housing Development on Lot 7757 and 7759 Tuaran Road	216	350	
19.	Kota Kinabalu High School at Penampang Kapayan Ridge Scheme	500	750	
20.	Double Shophouses cum Office on Lot 1388 at Putatan	110	300	

Table 3.12 (3) LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (KOTA KINABALU POWER STATION)

	Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1986				
1.	Waikiki Condominium Tanjung Aru	1,120	2,000	
2.	Cement Factory Sepangar Bay	4,000	-	HT supply
3.	MUIS Headquarters	2,000	4 x 750 2 x 1,000	
4.	Multi-story Car Park/ Commercial Complex (Next to Wisma Sabah)	1,200	2 x 800	
5.	Medical Centre Likas Bay	1,400	2 x 1,000	
6.	Kings Fisher Park	4,000		
7.	5-story Flat on Lot 111663 and Lot 15956 Mile 1 1/2 Tuaran Road	150	200	
8.	Housing on CL 015343496 Kolum Road	490	750	
9.	Sports Complex, Japanese Restaurant, Seafood Restaurant and Disco, Tanjung Aru Beach Hotel	500	750	
10.	Development on Lot 7610 Swamp Road, Sihungsung Villa Phase 2	1,112	2 x 750	
11.	18 units 2-story Shophouses Lok Kawi by LPPB	105	500	
12.	Housing Development on NT 4986 Inanam	233	300	
13.	18 units 2-story Shophouses at Lok Kawi Housing Estate, Lok Kawi	500	750	

Table 3.12 (4) LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (KOTA KINABALU POWER STATION)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1987			
1. Multi-story Car Park (in front of Central Market)	6,000	–	
2. 2-story Gallery Showroom Development CL 9173 off Mile 7 Tuaran Road	400	500	
3. Shopping Complex at Kapayan Ridge, Kapayan	500	750	
4. SEDCO Light Industrial Lok Kawi Estate Lok Kawi			

Table 3.13 LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (LABUAN POWER STATION, 1985)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1. Ceramic Factory in Ranca Ranca	1,000	-	HT supply
Detail not available			
1. Asian Supply Base in Ranca Ranca	450	-	Under construction
2. ICI's Production Plant in Ranca Ranca	-	-	Planning stage

Others

Several housing developments, industrial complexes and shophouse complexes are under construction. However, whether they are occupied following their completion is very obscure.

Table 3.14 LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (KUDAT POWER STATION, 1985 - 1988)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1985			
1. Rural Electrification Mile 6 to 11	120	4 x 100	
2. Taman Golden Hill	120	200	
3. Taman Kudat	50	100	
4. Kudat Tyre Retread Factory	250	500	
1986			
1. New Hotel Marudu	500	750	
2. Taman Wiseland Phase-1, 99 units including pumphouse	150	-	
Phase-2			1987
Phase-3			1988
3. Taman Tanjung Kapar	120	300	
4. Kajong Light Industries	50	-	
5. Shin Villa	40	100	
6. Rural Electrification Kg. Humjak/Kg. Lojong	80	200	
1987			
1. Skuati New Shophouses	120	300	
1988			
1. Vocational School	160	300	

Table 3.15 LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (KOTA BELUD POWER STATION)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
Large Project			
1. Aquaculture Farm			
- Pilot farm	480	-	HT in 1985
- Phase I	4,000	-	1988
- Phase II	6,000	-	1991
1985			
1. Rural Electrification one Kampong	-	-	
1986			
1. SMK School	377	500	
2. Rural Electrification Kg. Menungoi	-	-	

Table 3.16 (1) LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (BEAUFORT POWER STATION)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1985			
1. Sabah Associated Plastic Industry at Kg. Klias Kecil	300	500	
2. Beaufort Jaya Commercial and Industrial Complex at Beaufort South	200	500	
3. Municipal Office	150	300	
4. Kg. Klias Kecil	30	50	
5. Kg. Membakut	300	-	Interconnection
6. Taman Kinaemas	-	-	8 shops 105 houses
7. Beaufort Sindumin	100	200	
8. Housing			Not clear
1986			
1. Gadong SMK 2 story school	86	-	
2. Rural Electrification	100	-	
- Kg. Salogun			
- Kg. Rumat			
- Mile 60			

Table 3.16 (2) LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (BEAUFORT POWER STATION)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
Housing Developments now Going-on			
1. Low Cost Housing-LPPB			
Phase II	-	-	92 houses
Phase III	-	-	34 houses
2. Taman Padas	-	-	4 shop-houses
Phase I	-	-	45 residences
3. Housing Development on L 12878	240	-	12 semidetached houses
4. Housing Development on L 175314084	120	-	200 various houses
5. Housing Development on L 850, Phase I	-	-	12 Semidetached houses
Under Planning			
1. Extension of water works	1,000	-	Ht supply

Table 3.17 LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (TENOM POWER STATION)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1985			
1. S.R.K. Market	30	50	
2. Kilang Papan Mile 1 1/2 Jalan Sapong	60	-	
3. Kampong Melalap	200-300	-	600 units
4. Melalap Estate, Phase 3	60	-	
1987			
1. New Mosque, Tenom	80	-	

Table 3.18 LIST OF PROJECTS REQUIRING ELECTRICITY SUPPLY (KENINGAU POWER STATION)

Projects	Expected maximum demand (kW)	Transformer capacity (kVA)	Remarks
1985 - 1986			
1. Mosque	150	200	
2. Rural Electrification Projects	100	-	190 houses
Planning			
1. Mara Technical College	1,0CO	-	No details

Under these conditions, the power demand is assumed to grow according to the general trend of the power demand except for Kota Belud. For Kota Belud where the aquaculture project is underway, the aquaculture load of 4.5 MW in 1990 and 7 MW after 1995 is added to the total demand.

3.4.8 Rural Demand in Beaufort Area

For rural centers around Beaufort, which will be interconnected with 33 kV lines, the 1985 peak demand is estimated based on obtained information as given below:

Weston	150 kW
Sipitang	800 kW
Bongawan	200 kW
Membakut	400 kW
Kuala Penyu	230 kW
Others 1/	130 kW
Total	1,910 kW

The above peak demand is assumed to grow at 12 per cent per annum for the high forecast and 10 per cent for the low forecast.

3.4.9 Forecast Beyond 1995

For the period beyond 1995 up to 2010 the total power demand is assumed to grow in proportion to GRDP level taking into account the following factors.

1) By 1995, Sabah's power consumption mode will become matured level as in developed countries.

1/: Gadong, Pimping, Kg. Palu Palu and Binsulok.

2) The growth rate of per capita power consumption in the developed countries is minimal; a few per cent per year.

3) There will be a lot of Kampongs still to be electrified.

4) A tendency to use energy-saving home appliances for air conditioners, refrigerators, etc. will take place in Sabah.

The increase rate was assumed based on the GRDP growth rate of 6 per cent per annum as given below:

Annual Growth Rate After 1995 (% /yr)

	High Estimate	Low Estimate
1996 - 2000	9.92	7.06
2001 - 2005	8	5.65
2006 - 2010	6	4.25

3.4.10 System Peak Demand

The power demand forecast for each load center for the year 1985 to 1995 is as shown in Tables 3.19 to 3.25. The interconnected system peak demand from 1985 to 2010 is tabulated in Table 3.26 and shown in Figure 3.3.

In adding the evening peak demands to obtain the system peak which occurs day time, the factor of 0.8 is multiplied to the Keningau and Kudat demands and 0.7 to Tenom, Beaufort town and rural and Kota Belud demands. The initial system comprising Kota Kinabalu, Tenom and Beaufort is assumed to be interconnected as shown in the five-year plan, 1986 - 90, as given below:

1986 ---- Beaufort Rural
1987 ---- Keningau
1989 ---- Kota Belud
1990 ---- Labuan and Kudat

Table 3.19 DEMAND FORECAST (1985 - 1995) FOR KOTA KINABALU

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
High estimate	(Actual)											
1. Domestic Demand												
Population (x1,000)	286.6	298.5	311	323.8	337.3	351.3	365.95	381.2	397	413.5	430.8	448.7
No. of household	52,336	54,536	56,843	59,212	61,709	64,309	67,012	69,837	72,766	75,832	79,027	82,357
No. of consumers	29,838	32,243	34,842	37,650	40,685	43,964	47,507	51,336	55,474	59,945	64,777	69,998
Elec. ratio (%)	57	59.1	61.3	63.6	65.9	68.4	70.9	73.5	76.2	79	82	85
Domestic demand (MWh)	83,973	91,997	102,894	114,950	128,281	143,014	159,289	177,259	197,090	218,967	243,090	269,679
Unit consumption (kWh)	2,814	2,853	2,953	3,053	3,153	3,253	3,353	3,453	3,553	3,653	3,753	3,853
2. Commercial demand												
Ratio to R.D. (%)	101	101.87	102.69	103.5	104.31	105.12	105.94	106.75	107.56	108.37	109.19	110
Commercial demand (MWh)	84,863	92,972	104,821	118,037	132,769	149,180	167,451	187,782	210,392	235,525	263,448	294,455
3. Industrial demand (MWh)	46,597	50,325	54,351	58,699	63,395	68,466	73,944	79,859	86,248	93,148	100,599	108,647
4. Army demand (MWh)	3,000	3,150	3,308	3,473	3,647	3,829	4,020	4,221	4,432	4,654	4,887	5,131
5. Total power demand (GWh)	218.3	238.4	265.4	295.2	328.1	364.5	404.7	449.1	498.2	552.3	612	677.8
6. Loss & station use (%)	23.2	22.5	21.7	21	20.2	19.5	18.7	18	17.2	16.5	15.7	15
7. Required energy (GWh)	284.3	307.6	339	373.7	411.2	452.8	497.8	547.7	601.7	661.4	726	797.5
8. Annual load factor	58.05	58	58	58	58	58	58	58	58	58	58	58
9. Peak demand (MW)	55.9	60.5	66.7	73.6	80.9	89.1	98	107.8	118.4	130.2	142.9	157

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Low estimate	(Actual)											
1. Domestic demand												
Population (x1,000)	286.6	298.5	311	323.8	337.3	351.3	365.95	381.2	397	413.5	430.8	448.7
No. of household	52,336	54,536	56,843	59,212	61,709	64,309	67,012	69,837	72,766	75,832	79,027	82,357
No. of consumers	29,838	31,878	34,058	36,387	38,875	41,533	44,374	47,408	50,650	54,113	57,813	61,766
Elec. ratio (%)	57	58.6	60.3	61.9	63.5	65.2	66.8	68.5	70.1	71.7	73.4	75
Domestic demand (MWh)	83,973	89,907	98,044	106,873	116,452	126,840	138,106	150,318	163,555	177,900	193,441	210,276
Unit consumption (kWh)	2,814	2,820	2,879	2,937	2,996	3,054	3,112	3,171	3,229	3,288	3,346	3,404
2. Commercial demand (MWh)												
Ratio to R.D. (%)	101.1	100.1	99	98	97	96	95	94	93	92	91	90
Commercial demand (MWh)	84,863	89,997	97,063	104,736	112,958	121,767	131,200	141,299	152,106	163,668	176,031	189,248
3. Industrial demand (MWh)	46,597	49,393	52,356	55,498	58,828	62,357	66,099	70,065	74,269	78,725	83,448	88,455
4. Army demand (MWh)	3,000	3,150	3,308	3,473	3,647	3,829	4,020	4,221	4,432	4,654	4,887	5,131
5. Total power demand (GWh)	218.3	232.4	250.8	270.6	291.9	314.8	339.4	365.9	394.4	424.9	457.8	493.1
6. Loss & station use (%)	23.2	22.5	21.7	21	20.2	19.5	18.7	18	17.2	16.5	15.7	15
7. Required energy (GWh)	284.3	299.9	320.3	342.5	365.8	391.1	417.5	446.2	476.3	508.9	543.1	580.1
8. Annual load factor (%)	58.05	58	58	58	58	58	58	58	58	58	58	58
9. Peak demand (MW)	55.9	59	63	67.4	72	77	82.2	87.8	93.7	100.2	106.9	114.2

Table 3.20 DEMAND FORECAST (1985 - 1995) FOR LABUAN

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
<u>High estimate</u>	(Actual)											
1. Domestic Demand												
Population (x1,000)	37.7	41.2	44.3	47.7	51.3	55.2	59.5	62.1	64.9	67.8	70.8	74
No. of household	7,490	8,370	9,120	9,950	10,850	11,820	12,899	13,620	14,390	15,200	16,060	16,970
No. of consumers	5,077	5,583	6,138	6,750	7,422	8,161	8,974	9,867	10,850	11,930	13,118	14,425
Elec. ratio (%)	67.8	66.7	67.3	67.8	68.4	69	69.6	72.4	75.4	78.5	81.7	85
Domestic demand (MWh)	16,516	17,871	20,030	22,441	25,134	28,141	31,498	35,244	39,423	44,086	49,286	55,084
Unit consumption (kWh)	3,253	3,201	3,263	3,325	3,387	3,448	3,510	3,572	3,634	3,695	3,757	3,819
2. Commercial demand												
Ratio to R.D. (%)	66.7	67.9	69.1	70.3	71.5	72.7	73.9	75.1	76.4	77.6	78.8	80
Commercial demand (MWh)	11,020	12,135	13,841	15,776	17,971	20,459	23,277	26,468	30,119	34,210	38,837	44,067
3. Industrial demand (MWh)	17,874	19,304	20,848	22,516	24,317	26,263	28,364	30,633	33,084	35,730	38,589	41,676
4. Army demand (MWh)	3,465	3,638	3,820	4,011	4,212	4,422	4,643	4,876	5,119	5,375	5,644	5,926
5. Total power demand (MWh)	48,875	52,948	58,539	64,745	71,635	79,285	87,782	97,220	107,745	119,402	132,356	146,754
6. Loss & station use (%)	25.3	24.4	23.4	22.5	21.6	20.6	19.7	18.7	17.8	16.9	15.9	15
7. Required energy (MWh)	65,428	70,037	76,422	83,542	91,371	99,855	109,317	119,582	131,077	143,684	157,379	172,651
8. Annual load factor	64	64	64	64	64	64	64	64	64	64	64	64
9. Peak demand (MW)	11.67	12.49	13.63	14.9	16.3	17.81	19.5	21.33	23.38	25.63	28.07	30.8

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
<u>Low estimate</u>	(Actual)											
1. Domestic demand												
Population (x1,000)	37.7	41.2	44.3	47.7	51.3	55.2	59.5	62.1	64.9	67.8	70.8	74
No. of household	7,490	8,370	9,120	9,950	10,850	11,820	12,890	13,620	14,390	15,200	16,060	16,970
No. of consumers	5,077	5,519	6,000	6,523	7,092	7,710	8,381	9,112	9,906	10,769	11,787	12,727
Elec. ratio (%)	67.8	65.9	65.8	65.6	65.4	65.2	65	66.9	68.8	70.8	72.9	75
Domestic demand (MWh)	16.516	17,515	19,165	20,970	22,944	25,103	27,464	30,046	32,869	35,956	39,331	43,022
Unit consumption (kWh)	3,253	3,173	3,194	3,215	3,235	3,256	3,277	3,297	3,318	3,339	3,360	3,380
2. Commercial demand (MWh)												
Ratio to R.D. (%)	66.7	67	67.3	67.6	67.9	68.2	68.5	68.8	69.1	69.4	69.7	70
Commercial demand (MWh)	11,020	11,735	12,898	14,176	15,579	17,120	18,813	20,671	22,712	24,953	27,414	30,115
3. Industrial demand (MWh)	17,874	18,946	20,083	21,288	22,566	23,919	25,355	26,876	28,488	30,198	32,010	33,930
4. Army demand (MWh)	3,465	3,638	3,820	4,011	4,212	4,422	4,643	4,876	5,119	5,375	5,644	5,926
5. Total power demand (MWh)	48,875	51,834	55,966	60,445	65,300	70,565	76,275	82,468	89,189	96,482	104,399	112,994
6. Loss & station use (%)	25.3	24.4	23.4	22.5	21.6	20.6	19.7	18.7	17.8	16.9	15.9	15
7. Required energy (MWh)	65,428	68,563	73,063	77,994	83,291	88,873	94,987	101,437	108,502	116,104	124,136	132,934
8. Annual load factor (%)	64	64	64	64	64	64	64	64	64	64	64	64
9. Peak demand (MW)	11.67	12.23	13.03	13.91	14.86	15.85	16.94	18.09	19.35	20.71	22.14	23.71

Table 3.21 DEMAND FORECAST (1985 - 1995) FOR KUDAT

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
High estimate	(Actual)											
1. Domestic Demand												
Population (x1,000)	46.2	47.4	48.6	49.8	51	52.3	53.6	54.9	56.3	57.7	59.1	60.6
No. of household	8,700	8,900	9,300	9,600	9,800	10,100	10,300	10,800	11,000	11,300	11,600	11,900
No. of consumers	2,088	2,250	2,425	2,614	2,818	3,037	3,273	3,528	3,802	4,098	4,416	4,760
Elec. ratio (%)	24	25.3	26.1	27.2	28.8	30.1	31.8	32.7	34.6	36.3	38.1	40
Domestic demand (MWh)	3,395	3,680	4,063	4,484	4,945	5,451	6,006	6,615	7,281	8,012	8,811	9,687
Unit consumption (kWh)	1,626	1,635	1,675	1,715	1,755	1,795	1,835	1,875	1,915	1,955	1,995	2,035
2. Commercial demand												
Ratio to R.D. (%)	72.9	73.5	74.2	74.8	75.5	76.1	76.8	77.4	78.1	78.7	79.4	80
Commercial demand (MWh)	2,475	2,705	3,015	3,354	3,734	4,149	4,613	5,120	5,687	6,305	6,996	7,750
3. Industrial demand (MWh)	3,221	3,608	4,040	4,525	5,068	5,677	6,358	7,121	6,975	8,932	10,004	11,204
4. Army demand (MWh)	15	16	17	17	18	19	20	21	22	23	24	26
5. Total power demand (MWh)	9,106	10,008	11,135	12,380	13,766	15,296	16,997	18,876	20,965	23,272	25,836	28,667
6. Loss & station use (%)	23.3	22.5	21.8	21	20.3	19.5	18.8	18	17.3	16.5	15.8	15
7. Required energy (MWh)	11,867	12,914	14,239	15,671	17,272	19,001	20,932	23,020	25,351	27,871	30,684	33,726
8. Annual load factor	57.65	60	60	60	60	60	60	60	60	60	60	60
9. Peak demand (MW)	2.25	2.46	2.71	2.98	3.29	3.62	3.98	4.38	4.82	5.3	5.84	6.42

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Low estimate	(Actual)											
1. Domestic demand												
Population (x1,000)	46.2	47.4	48.6	49.8	51	52.3	53.6	54.9	56.3	57.7	59.1	60.6
No. of household	8,700	8,900	9,300	9,600	9,800	10,100	10,500	10,800	11,000	11,300	11,600	11,900
No. of consumers	2,088	2,192	2,302	2,417	2,538	2,664	2,798	2,937	3,084	3,238	3,400	3,570
Elec. ratio (%)	24	24.6	24.8	25.2	25.9	26.4	26.6	27.2	28	28.7	29.3	30
Domestic demand (MWh)	3,395	3,553	3,765	3,990	4,228	4,479	4,745	5,026	5,324	5,638	5,971	6,323
Unit consumption (kWh)	1,626	1,621	1,636	1,651	1,666	1,681	1,696	1,711	1,726	1,741	1,756	1,771
2. Commercial demand (MWh)												
Ratio to R.D. (%)	72.9	72.6	72.4	72.1	71.8	71.6	71.3	71.1	70.8	70.5	70.3	70
Commercial demand (MWh)	2,475	2,500	2,726	2,877	3,035	3,207	3,383	3,574	3,769	3,975	4,198	4,426
3. Industrial demand (MWh)	3,221	3,543	3,897	4,287	4,716	5,187	5,706	6,277	6,904	7,595	8,354	9,190
4. Army demand (MWh)	15	16	17	17	18	19	20	21	22	23	24	26
5. Total power demand (MWh)	9,106	9,692	10,406	11,171	11,997	12,892	13,854	14,898	16,019	17,232	18,548	19,965
6. Loss & station use (%)	23.3	22.5	21.8	21	20.3	19.5	18.8	18	17.3	16.5	15.8	15
7. Required energy (MWh)	11,867	12,506	13,306	14,141	15,053	16,015	17,062	18,168	19,371	20,637	22,028	23,489
8. Annual load factor (%)	57.65	60	60	60	60	60	60	60	60	60	60	60
9. Peak demand (MW)	2.25	2.38	2.53	2.69	2.86	3.05	3.25	3.46	3.69	3.93	4.19	4.47

Table 3.22 DEMAND FORECAST (1985 - 1995) FOR KOTA BELUD

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
<u>High estimate</u>	(Actual)											
1. Domestic Demand												
Population (x1,000)	51.6	52.9	54.2	55.5	56.9	58.4	59.8	61	62.2	63.4	64.7	66
No. of household	9,790	10,060	10,320	10,590	10,880	11,190	11,480	11,730	11,980	12,240	12,510	12,790
No. of consumers	2,235	2,436	2,654	2,893	3,152	3,436	3,744	4,080	4,447	4,846	5,281	5,755
Elec. ratio (%)	22.8	24.2	25.7	27.3	29	30.7	32.6	34.8	37.1	39.6	42.2	45
Domestic demand (MWh)	2,044	2,324	2,663	3,043	3,470	3,949	4,487	5,089	5,763	6,517	7,360	8,302
Unit consumption (kWh)	915	954	1,003	1,052	1,101	1,150	1,198	1,247	1,296	1,345	1,394	1,443
2. Commercial demand												
Ratio to R.D. (%)	86.5	85.9	85.3	84.7	84.1	83.5	83	82.4	81.8	81.2	80.6	80
Commercial demand (MWh)	1,768	1,997	2,271	2,577	2,918	3,298	3,724	4,193	4,714	5,292	5,932	6,641
3. Industrial demand (MWh)	1,240	1,389	1,555	1,742	1,951	2,185	2,448	2,741	3,070	3,439	3,851	4,313
4. Army demand (MWh)	83	87	92	96	101	106	111	117	123	129	135	142
5. Total power demand (MWh)	5,135	5,797	6,581	7,459	8,441	9,539	10,770	12,140	13,670	15,376	17,278	19,398
6. Loss & station use (%)	23.8	23	22.2	21.4	20.6	19.8	19	18.2	17.4	16.6	15.8	15
7. Required energy (MWh)	6,739	7,529	8,459	9,489	10,631	11,893	13,296	14,841	16,549	18,437	20,521	22,822
8. Annual load factor	57.84	50	50	50	50	50	50	50	50	50	50	50
9. Peak demand (MW)	1.33	1.92	2.15	2.41	2.7	3.03	3.38	3.78	4.21	4.69	5.22	5.81

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
<u>Low estimate</u>	(Actual)											
1. Domestic demand												
Population (x1,000)	51.6	52.9	54.2	55.5	56.9	58.4	59.8	61	62.2	63.4	64.7	66
No. of household	9,790	10,060	10,320	10,590	10,880	11,190	11,480	11,730	11,980	12,240	12,510	12,790
No. of consumers	2,235	2,381	2,536	2,701	2,877	3,065	3,264	3,477	3,704	3,945	4,202	4,476
Elec. ratio (%)	22.8	23.7	24.6	25.5	26.4	27.4	28.4	29.6	30.9	32.2	33.6	35
Domestic demand (MWh)	2,044	2,219	2,426	2,650	2,892	3,155	3,440	3,749	4,084	4,446	4,838	5,262
Unit consumption (kWh)	915	932	957	981	1,005	1,030	1,054	1,078	1,102	1,127	1,151	1,175
2. Commercial demand (MWh)												
Ratio to R.D. (%)	86.5	85	83.5	82	80.5	79	77.5	76	74.5	73	71.5	70
Commercial demand (MWh)	1,768	1,887	2,026	2,173	2,328	2,493	2,666	2,849	3,042	3,245	3,459	3,683
3. Industrial demand (MWh)	1,240	1,364	1,500	1,650	1,815	1,997	2,197	2,416	2,658	2,924	3,216	3,538
4. Army demand (MWh)	83	87	92	96	101	106	111	117	123	129	135	142
5. Total power demand (MWh)	5,135	5,557	6,043	6,569	7,137	7,751	8,414	9,132	9,906	10,744	11,648	12,625
6. Loss & station use (%)	23.8	23	22.2	21.4	20.6	19.8	19	18.2	17.4	16.6	15.8	15
7. Required energy (MWh)	6,739	7,217	7,768	8,357	8,988	9,664	10,388	11,163	11,993	12,882	13,834	14,853
8. Annual load factor (%)	57.84	50	50	50	50	50	50	50	50	50	50	50
9. Peak demand (MW)	1.33	1.84	1.98	2.13	2.29	2.46	2.64	2.84	3.05	3.28	3.52	3.78

Table 3.23 DEMAND FORECAST (1985 - 1995) FOR BEAUFORT

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
<u>High estimate</u>	(Actual)											
1. Domestic Demand												
Population (x1,000)	40.2	41	41.8	42.6	43.5	44.4	45.3	46.2	47.1	48	49	50
No. of household	7,380	7,530	7,840	8,000	8,160	8,320	8,490	8,840	9,020	9,270	9,520	9,780
No. of consumers	2,016	2,185	2,368	2,567	2,782	3,016	3,269	3,543	3,840	4,162	4,511	4,890
Elec. ratio (%)	27.3	29	30.2	32.1	34.1	36.2	38.5	40.1	42.6	44.9	47.4	50
Domestic demand (MWh)	2,586	2,850	3,192	3,571	3,991	4,457	4,973	5,543	6,175	6,873	7,645	8,499
Unit consumption (kWh)	1,283	1,304	1,348	1,391	1,435	1,478	1,521	1,565	1,608	1,651	1,695	1,738
2. Commercial demand												
Ratio to R.D. (%)	76.6	76.9	77.2	77.5	77.8	78.1	78.5	78.8	79.1	79.4	79.7	80
Commercial demand (MWh)	1,982	2,192	2,464	2,768	3,105	3,481	3,904	4,368	4,884	5,457	6,093	6,799
3. Industrial demand (MWh)	1,266	1,418	1,588	1,779	1,992	2,231	2,499	2,799	3,135	3,511	3,932	4,404
4. Army demand (MWh)	1	3	3	3	3	3	3	3	3	3	3	3
5. Total power demand (MWh)	5,835	6,463	7,248	8,121	9,092	10,172	11,378	12,713	14,197	15,844	17,674	19,705
6. Loss & station use (%)	13.9	14	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15
7. Required energy (MWh)	6,777	7,515	8,437	9,465	10,609	11,883	13,308	14,887	16,643	18,597	20,768	23,182
8. Annual load factor	59.51	58	58	58	58	58	58	58	58	58	58	58
9. Peak demand (MW)	1.3	1.48	1.66	1.86	2.09	2.34	2.62	2.93	3.28	3.66	4.09	4.56

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
<u>Low estimate</u>	(Actual)											
1. Domestic demand												
Population (x1,000)	40.2	41	41.8	42.6	43.5	44.4	45.3	46.2	47.1	48	49	50
No. of household	7,380	7,530	7,840	8,000	8,160	8,320	8,490	8,840	9,020	9,270	9,520	9,780
No. of consumers	2,016	2,141	2,274	2,415	2,565	2,725	2,894	3,074	3,265	3,467	3,683	3,912
Elec. ratio (%)	27.3	28.4	29	30.2	31.4	32.8	34.1	34.8	36.2	37.4	38.7	40
Domestic demand (MWh)	2,586	2,751	2,965	3,193	3,439	3,704	3,987	4,292	4,619	4,970	5,347	5,752
Unit consumption (kWh)	1,283	1,285	1,304	1,322	1,341	1,359	1,378	1,396	1,415	1,433	1,452	1,470
2. Commercial demand (MWh)												
Ratio to R.D. (%)	76.6	76	75.4	74.8	74.2	73.6	73	72.4	71.8	71.2	70.6	70
Commercial demand (MWh)	1,982	2,091	2,235	2,389	2,552	2,726	2,911	3,107	3,316	3,539	3,775	4,026
3. Industrial demand (MWh)	1,266	1,393	1,532	1,685	1,854	2,039	2,243	2,467	2,714	2,985	3,284	3,612
4. Army demand (MWh)	1	3	3	3	3	3	3	3	3	3	3	3
5. Total power demand (MWh)	5,835	6,238	6,735	7,270	7,848	8,471	9,144	9,869	10,652	11,497	12,409	13,393
6. Loss & station use (%)	13.9	14	14.1	14.2	14.3	14.4	14.5	14.6	14.7	14.8	14.9	15
7. Required energy (MWh)	6,777	7,254	7,840	8,473	9,157	9,896	10,694	11,556	12,488	13,494	14,582	15,757
8. Annual load factor (%)	59.51	58	58	58	58	58	58	58	58	58	58	58
9. Peak demand (MW)	1.3	1.43	1.54	1.67	1.8	1.95	2.1	2.27	2.46	2.66	2.87	3.1

Table 3.24 DEMAND FORECAST (1985 - 1995) FOR TENOM

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
High estimate	(Actual)											
1. Domestic Demand												
Population (x1,000)	28.3	28.7	29	29.4	29.8	30.2	30.6	31	31.4	31.8	32.3	32.7
No. of household	5,210	5,280	5,480	5,550	5,630	5,700	5,770	5,960	6,040	6,120	6,250	6,290
No. of consumers	1,506	1,610	1,722	1,841	1,968	2,105	2,250	2,406	2,573	2,751	2,941	3,145
Elec. ratio (%)	28.9	30.5	31.4	33.2	35	36.9	39	40.4	42.6	44.9	47.1	50
Domestic demand (MWh)	1,852	2,035	2,259	2,504	2,773	3,067	3,389	3,740	4,123	4,542	4,999	5,497
Unit consumption (kWh)	1,230	1,264	1,312	1,360	1,409	1,457	1,506	1,554	1,603	1,651	1,700	1,748
2. Commercial demand												
Ratio to R.D. (%)	76.4	76.7	77.1	77.4	77.7	78	78.4	78.7	79	79.3	79.7	80
Commercial demand (MWh)	1,415	1,561	1,742	1,938	2,155	2,392	2,657	2,943	3,257	3,602	3,984	4,398
3. Industrial demand (MWh)	1,702	1,838	1,985	2,144	2,316	2,501	2,701	2,917	3,150	3,402	3,674	3,968
4. Army demand (MWh)	0	0	0	0	0	0	0	0	0	0	0	0
5. Total power demand (MWh)	4,969	5,434	5,986	6,586	7,244	7,960	8,747	9,600	10,530	11,546	12,657	13,863
6. Loss & station use (%)	22.3	21.6	21	20.3	19.6	19	18.3	17.7	17	16.3	15.7	15
7. Required energy (MWh)	6,395	6,931	7,577	8,263	9,010	9,827	10,706	11,665	12,687	13,795	15,014	16,309
8. Annual load factor	55.3	50	50	50	50	50	50	50	50	50	50	50
9. Peak demand (MW)	1.32	1.58	1.73	1.89	2.06	2.24	2.44	2.66	2.90	3.15	3.43	3.72

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Low estimate	(Actual)											
1. Domestic demand												
Population (x1,000)	28.3	28.7	29	29.4	29.8	30.2	30.6	31	31.4	31.8	32.3	32.7
No. of household	5,210	5,280	5,480	5,550	5,630	5,700	5,770	5,960	6,040	6,120	6,250	6,290
No. of consumers	1,506	1,578	1,653	1,732	1,815	1,902	1,992	2,088	2,187	2,292	2,401	2,516
Elec. ratio (%)	28.9	29.9	30.2	31.2	32.2	33.4	34.5	35	36.2	37.4	38.4	40
Domestic demand (MWh)	1,852	1,961	2,094	2,234	2,383	2,541	2,709	2,888	3,077	3,277	3,490	3,715
Unit consumption (kWh)	1,230	1,243	1,266	1,290	1,313	1,336	1,360	1,383	1,407	1,430	1,453	1,477
2. Commercial demand (MWh)												
Ratio to R.D. (%)	76.4	75.8	75.2	74.7	74.1	73.5	72.9	72.3	71.7	71.2	70.6	70
Commercial demand (MWh)	1,415	1,486	1,574	1,669	1,766	1,868	1,975	2,088	2,206	2,333	2,464	2,601
3. Industrial demand (MWh)	1,702	1,804	1,912	2,027	2,149	2,278	2,414	2,559	2,713	2,875	3,048	3,231
4. Army demand (MWh)	0	0	0	0	0	0	0	0	0	0	0	0
5. Total power demand (MWh)	4,969	5,251	5,580	5,930	6,298	6,687	7,098	7,535	7,996	8,485	9,002	9,547
6. Loss & station use (%)	22.3	21.6	21	20.3	19.6	19	18.3	17.7	17	16.3	15.7	15
7. Required energy (MWh)	6,395	6,698	7,064	7,440	7,833	8,256	8,688	9,156	9,634	10,137	10,679	11,232
8. Annual load factor (%)	55.3	50	50	50	50	50	50	50	50	50	50	50
9. Peak demand (MW)	1.32	1.53	1.61	1.7	1.79	1.88	1.98	2.09	2.2	2.31	2.44	2.56

Table 3.25 DEMAND FORECAST (1985 - 1995) FOR KENINGAU

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
High estimate	(Actual)											
1. Domestic Demand												
Population (×1,000)	52.85	55.49	57.99	60.6	63.32	66.17	69.15	71.92	74.79	77.78	80.89	84.13
No. of household	9,550	10,030	10,740	11,220	11,730	12,250	12,810	13,570	14,110	14,670	15,260	15,870
No. of consumers	3,185	3,428	3,689	3,970	4,272	4,597	4,948	5,324	5,730	6,166	6,636	7,142
Elec. ratio (%)	33.4	35.4	37.3	39.3	41.3	43.2	45.2	47.1	49.1	51.1	53	55
Domestic demand (MWh)	4,331	4,837	5,436	6,099	6,830	7,638	8,529	9,512	10,595	11,787	13,100	14,545
Unit consumption (kWh)	1,360	1,411	1,474	1,536	1,599	1,661	1,724	1,786	1,849	1,912	1,974	2,037
2. Commercial demand												
Ratio to R.D. (%)	96.7	97	97.3	97.6	97.9	98.2	98.5	98.8	99.1	99.4	99.7	100
Commercial demand (MWh)	4,186	4,692	5,289	5,952	6,687	7,500	8,401	9,398	10,499	11,717	13,061	14,545
3. Industrial demand (MWh)	994	1,093	1,203	1,323	1,455	1,601	1,761	1,937	2,131	2,344	2,578	2,836
4. Army demand (MWh)	119	125	131	138	145	152	159	167	176	185	194	204
5. Total power demand (MWh)	9,630	10,747	12,060	13,511	15,117	16,891	18,851	21,014	23,400	26,032	28,933	32,129
6. Loss & station use (%)	16.4	16.3	16.1	16	15.9	15.8	15.6	15.5	15.4	15.3	15.1	15
7. Required energy (MWh)	11,519	12,840	14,374	16,085	17,975	20,061	22,335	24,869	27,660	30,735	34,079	37,798
8. Annual load factor	54.6	53	53	53	53	53	53	53	53	53	53	53
9. Peak demand (MW)	2.41	2.77	3.1	3.46	3.87	4.32	4.81	5.36	5.96	6.62	7.34	8.14

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Low estimate	(Actual)											
1. Domestic demand												
Population (×1,000)	52.85	55.49	57.99	60.6	63.32	66.17	69.15	71.92	74.79	77.78	80.89	84.13
No. of household	9,550	10,030	10,740	11,220	11,730	12,250	12,810	13,570	14,110	14,670	15,260	15,870
No. of consumers	3,185	3,428	3,689	3,970	4,272	4,597	4,948	5,324	5,730	6,166	6,636	7,142
Elec. ratio (%)	33.4	34.2	34.3	35.4	36.4	37.5	38.6	39.2	40.6	42	43.5	45
Domestic demand (MWh)	4,331	4,750	5,249	5,796	6,397	7,055	7,776	8,566	9,432	10,379	11,417	12,552
Unit consumption (kWh)	1,360	1,386	1,423	1,460	1,497	1,535	1,572	1,609	1,646	1,683	1,720	1,758
2. Commercial demand (MWh)												
Ratio to R.D. (%)	96.7	96.1	95.5	94.9	94.3	93.7	93	92.4	91.8	91.2	90.6	90
Commercial demand (MWh)	4,186	4,565	5,013	5,501	6,032	6,610	7,232	7,915	8,658	9,466	10,343	11,297
3. Industrial demand (MWh)	994	1,074	1,159	1,252	1,352	1,461	1,577	1,704	1,840	1,987	2,146	2,318
4. Army demand (MWh)	119	125	131	138	145	152	159	167	176	185	194	204
5. Total power demand (MWh)	9,630	10,513	11,552	12,687	13,926	15,278	16,745	18,353	29,105	22,017	24,100	26,369
6. Loss & station use (%)	16.4	16.3	16.1	16	15.9	15.8	15.6	15.5	15.4	15.3	15.1	15
7. Required energy (MWh)	11,519	12,561	13,769	15,104	16,559	18,144	19,840	21,719	23,766	25,994	28,386	31,023
8. Annual load factor (%)	54.6	53	53	53	53	53	53	53	53	53	53	53
9. Peak demand (MW)	2.41	2.71	2.97	3.25	3.57	3.91	4.27	4.68	5.12	5.6	6.11	6.68

Table 3.26 FORECAST OF INTERCONNECTED SYSTEM PEAK DEMAND (SEB WEST COAST AREA)

(Unit: MW)

Demand Centers	1985	1986	1987	1988	1989	1990	1991	1992	1995	2000	2005	2010
(High Estimate)												
1. Kota Kinabalu	60.5	66.7	73.6	80.9	89.1	98.0	107.8	118.4	157.0			
2. Tenom	1.1	1.2	1.3	1.4	1.6	1.7	1.9	2.0	2.6			
3. Beaufort	1.0(2.4)	1.1(2.6)	2.9	3.3	3.6	4.1	4.5	5.0	7.0			
4. Keningau	(2.2)	(2.5)	(2.8)	3.1	3.5	3.8	4.3	4.8	6.5			
5. Kota Belud	(1.3)	(1.5)	(1.7)	(1.9)	(2.1)	6.9	7.6	8.4	11.1			
6. Labuan	(12.5)	(13.6)	(14.9)	(16.3)	(17.8)	(19.5)	21.3	23.4	30.8			
7. Kudat	(2.0)	(2.2)	(2.4)	(2.6)	(2.9)	(3.2)	3.5	3.9	5.1			
Total	62.6 (82.0)	69.0 (90.3)	77.8 (99.6)	88.7 (109.5)	97.8 (120.6)	114.5 (137.2)	150.9	165.9	220.1	353.5	519.4	695.1
(Low Estimate)												
1. Kota Kinabalu	59.0	63.0	67.4	72.0	77.0	82.2	87.8	93.7	114.2			
2. Tenom	1.1	1.1	1.2	1.2	1.3	1.3	1.5	1.5	1.8			
3. Beaufort	1.0(2.3)	1.1(2.6)	2.8	3.1	3.4	3.7	4.1	4.5	5.9			
4. Keningau	(2.2)	(2.4)	(2.6)	2.9	3.2	3.4	3.7	4.1	5.3			
5. Kota Belud	(1.3)	(1.4)	(1.5)	(1.6)	(1.7)	6.4	7.0	7.6	9.7			
6. Labuan	(12.2)	(13.0)	(13.9)	(14.9)	(15.9)	(16.9)	18.1	19.4	23.7			
7. Kudat	(1.9)	(2.0)	(2.2)	(2.3)	(2.4)	(2.6)	2.8	3.0	3.6			
Total	61.0 (80.0)	65.2 (85.5)	71.4 (91.6)	79.2 (98.0)	84.9 (104.9)	97.0 (116.5)	125.0	133.8	164.2	230.9	304.0	374.3

Note: 1. Assumed dates for starting operation of the interconnections are as given below:
1987: Beaufort rural   1990: Kota Belud
1988: Keningau   1991: Labuan and Kudat

2. For Tenom, Beaufort, Keningau, Kota Belud and Kudat, day time peak values are given in the table.

3. Figures in parentheses are non-interconnected peak demands.