6.3 Hydropower Development Alternatives

No alternative study was conducted for hydropower development in Peninsular Malaysia, becuase the target was set to develop all known potential of economical potential by 2000. For Sarawak, hydropower development for the supply to Kuching only was studied and alternative study was left for further study.

The Tenom Pangi, Phase I/II of 3 x 22 MW is being constructed for the immediate supply to Kota Kinabalu. A diesel power station of 4 x 12 MW will be constructed to support the Pangi power station in the dry period, in which the power output of the Pangi power station reduces by the nature of run-of-river power development. SEB intends to implement the Tenom Pangi, Phase III, in order to increase the power generation capacity and firm up the output during the dry period. The Tenom Pangi, Phase III consists of the construction of the Sook dam with an active storage capacity of 480 million m^3 in an upstream tributary of the Padas river to augment the low flow from 40 m^3/s to 116 m^3/s, and expansion of the Pangi power station by 2 x 22 MW in installed capacity. The power generation of 40 MW is also contemplated at the Sook dam. If Phase III is implemented, annual energy production at the Pangi power station will be increased from 475 GWh to 684 GWh. Under the driest condition, the Pangi power station can generate 66 MW for 4 hours per day if Phase I/II only is implemented, but it can generate 110 MW for 12 hours per day after the completion of Phase III. The proposed Sook power station can develop 100 GWh of potential, though the dependable output will not be large.

The Papar dam project (see Section 7.2.17) proposed for the domestic and industrial water supply to Kota Kinabalu incidentally create a water head between the Papar dam site and the Kinalut river. Power generation of 30 MW will be possible, if the size of the Papar dam is increased.

The water head below the Pangi power station can be developed for power generation. The Lower Halogilat project of 144 MW has been proposed as a storage development. The cost of power is expected to be quite low. Flooding of the existing railway is the constraint, but the development of road network seems to be reducing the importance of this problem. One of the alternatives in this area is the Pangi No. 2 power station of 90 MW, which is a run-of-river development below the Pangi power station.

There are some possible sites for hydropower development in the upper basin of the Padas river, according to a map study. The Upper Padas Project, among others, could develop 170 MW of Power.

The Pensiangan river flows from southern part of Sabah to the territory of Indonesia. The catchment area is 5,200 km^2 at the borderline. Large potential in this river system can be developed at a low cost of power even if the cost of transmission lines both to the west coast and to the east coast is included. An example is the Pensiangan Project of 370 MW near the borderline.

According to a power demand projection and expansion schedule for major power stations in Sabah provided by SEB in June, 1982, the total power demand in 1979 was 73 MW and it will grow to 155 MW in 1985, 326 MW in 1990 and 1,013 MW in 2000. The largest demand center is Kota Kinabalu, in which projected power demand is 148 MW for 1990 and 460 MW for 2000. The second largest power demand center in the future is Labuan, in which SEC will supply bulk of industrial power, while SEB is responsible only for domestic power supply. The power demand in Tawau is estimated to be 36 MW for 1990 and 112 MW for 2000. The projected power demand in Sandakan is 54 MW in 1990 and 168 MW in 2000. The power demand in other areas will be still minor in 2000.

Potential power sites studied are illustrated in Fig. 9 and those seemingly of high priority projects are listed in Table 34, in which the Pangi No. 2 and Lower Halogilat are mutually exclusive.

The Tenom Pangi, Phase III is best accessible among the potential projects and it can develop a large potential at the Sook site and Pangi power station. It can also provide favorable condition for the future Pangi No. 2 or Lower Halogilat project. The Tenom Pangi, Phase III should be implemented in order to meet the power demand up to 1990 in Kota Kinabalu. The Papar multipurpose project should also be developed in the near future not only for power supply but in view of the urgent need for water supply to Kota Kinabalu.

Two alternative power development plans are conceivable for the period after the Tenom Pangi, Phase III and Papar multipurpose project depending on the power supply policy in Sabah. One is to supply Kota Kinabalu and its vicinity by developing potential in the Padas river basin. The other is to supply not only Kota Kinabalu but towns in the east coast such as Labuan, Tawau and Sandakan, if interconnection among these towns is implemented before 2000. In this case the Pensiangan river as well as the Padas river should be developed, further study being required for phasing of development. Selection between above-mentioned alternatives depends on a long term power demand and supply master plan in Sabah which has not been formulated yet. Herein the former alternative is assumed, but the development of the Pensiangan river should be seriously considered in preparing the long term power demand and supply master plan.

6.4 Water Pollution Abatement Alternatives

Two alternative plans for water pollution abatement were proposed setting target BOD concentration in the river.

Alternative P1: 5 mg/lit in BOD concentration in 1990 onwards

Alternative P2: 10 mg/lit in BOD concentration in 1990 onwards

If the reduction of BOD concentration in a stretch of a river is found necessary to attain the target, the improvement of purification method in all palm oil mills and rubber factories in the river was, first of all proposed. The Basins where the improvement was proposed for both the alternatives were all Basins between the Buloh and Johor Basins, and the Merbok, Perai, Kurau, Perak, Bernam, Endau, Rompin and Kemaman Basins in Peninsular Malaysia, and the Silibukan and Bongan Basins in Sabah, and the Suai Basin in Sarawak.

If there still remains a river stretch of higher BOD concentration than the proposed limit, the construction of a sewerage system in the urban area upstream of the river stretch was proposed. The proposed sewerage development was as shown in Table 35 for Alternative P1 and Table 36 for Alternative P2.

No treatment measure was assumed for the sewage from the towns of less than 50,000 in population and rural areas and effluent from animal husbandry. With these conditions, it was estimated that some river stretches in the west coast of Peninsular Malaysia would show higher BOD concentration than the target value.

The ordinary treatment method for the domestic water supply is the sedimentation, filtration and chlorination, if BOD concentration in raw water is not more than 2 mg/lit. The ordinary treatment method for the industrial water supply is the sedimentation, if BOD concentration in raw water is not more than 5 mg/lit. Pre-treatment facilities are needed to varying extent for raw water above these limits. For BOD concentration in raw water more than the above-mentioned limit but not more than 20 mg/lit, pre-treatment is carried out by the rapid sand-filter bed and activated carbon absorption (secondary treatment). For BOD concentration between 20 and 200 mg/lit, an aerated lagoon process such as aerated lagoon or maturing pond (primary treatment) is further needed. The cost for pre-treatment facilities was taken into account for the economic comparison of the alternatives.

Estimated public development expenditure is as shown in Table 37 and manpower requirement is estimated as shown in Table 38. These tables indicate that the public development expenditure and manpower requirement will be little different between the alternatives, but they will be concentrated in the earlier part of development, i.e., in 4MP and 5MP periods. It is necessary to slow down the rate of development up to 1990. The results of economic benefit cost analysis as summarized in Table 39 also show little difference between the alternatives. Although the economic cost is larger than the economic benefit, the water pollution abatement should be conducted from the viewpoint of environmental and social well-being impact. The length of river stretch where BOD concentration is estimated to be more than 5 mg/lit for 2000 will be reduced by 700 km if Alternative P1 is implemented and by 450 km if Alternative P2 is implemented. In this respect, Alternative P1 is preferable. With these considerations, it is recommended that the pollution in the river should be gradually abated setting the target BOD concentration at 5 mg/lit for 2000.

6.5 Flood Mitigation Alternatives

Three alternatives are proposed for the flood mitigation:

Alternative F1: Structural measures are provided by 2000 for the entire river system to protect 90% of people within the flood prone area.

Alternative F2: Structural and non-structural measures are provided by 2000 for densely populated areas to protect 50% of people within the flood prone area.

Alternative F3: Structural and non-structural measures are provided by 2000 so far as such measures are economically viable.

The return period of design flood is assumed to be 20 years for the river stretch where the estimated annual flood damage is less than M$20,000/km and the population is 500 persons/km, and 50 years for the other river stretches, but 100 years if loss of life has been recorded.

The problem rivers were divided into stretches of 30 to 60 km in length. The measures explained in Section 5.7 were compared and the most economical measure was selected for each river stretch. The resulted alternative plans are as outlined in Tables 40 to 42.

The public development expenditure and manpower requirement for each alternative were estimated as shown in Table 43 and Table 44, respectively. Economic benefit and cost were estimated as summarized in Table 45. Number of people protected and those to be removed due to construction were estimated as shown in Table 46.

Alternative F1 seems to require a prohibitively large expenditure. Alternative F3 should be implemented if considered from the viewpoint of national economic development, but it will increase the disparity between developed and underdeveloped areas. Taking into account the fact that social well-being objective has been emphasized through discussions between officials and the Study Team, it is recommended that Alternative F2 should be taken up for the period up to 2000.

7. RECOMMENDED PLAN

The Water Resources Development and Use Plan is recommended as illustrated in Figs. 1 to 10, based on consideration described in foregoing chapters. Its outline is described hereunder.

7.1 Development Plan for Public Water Supply System and Irrigation System

The development plan for water supply system is recommended as shown in Tables 47 to 49, in accordance with the target described in Section 5.3. In the urban water supply system, the total treatment capacity will be 3.0 million m^3/d in 1985, 4.2 million m^3/d in 1990 and 8.3 million m^3/d in 2000 and the served population will be 6.3 million in 1985, 8.1 million in 1990 and 12.8 million in 2000. Corresponding service factor is estimated to be 95% in 1985, 97% in 1990 and 100% in 2000. Regarding to rural treated water supply, the total treatment capacity will be 1.0 million m^3/d in 1985, 1.4 million m^3/d in 1990 and 2.1 million m^3/d in 2000, and served population will be 5.1 million in 1985, 6.0 million in 1990 and 6.3 million in 2000. The supply capacity of rural untreated water supply system, in terms of source demand will be 41 million m^3/y in 1985, 60 million m^3/y in 1990 and 100 million m^3/y in 2000, and the served population will be 1.9 million in 1985, 2.3 million in 1990 and 2.7 million in 2000. The service factor made up by rural treated and untreated supply will be 73% in 1985, 83% in 1990 and 96% in 2000.

The irrigation system development up to 2000 will be as shown in Tables 11 and 12. Annual production of rice will be 1.60 million tons in 1985, 1.85 million tons in 1990 and 2.23 million tons in 2000, corresponding to a rice self-sufficiency ratio of 85% from 1985 onward.

7.2 Source Development Plan

7.2.1 Water stress areas

The water stress areas are the Perlis / Kedah / Pulau Pinang region, Kelang valley region, Melaka / Muar region, south Johor region and other 13 areas. The recommended water demand and supply plans for these areas indicating the water supply capacities and schedule for commission of the recommended dams are illustrated in Figs. 14 and 15.

The recommended source development plans are described hereunder and an outline of source facilities such as storage and division facilities is summarized in Tables 50 to 52. It is noted that the recommended plans include not only these for the areas identified as the water stress areas but major projects which have been implemented after 1980 and those which are going to be implemented in the near future.

7.2.2 Perlis/Kedah/Pulau Pinang region source development plan

The Perlis/Kedah/Pulau Pinang region herein defined is 10,500 km^2 of water stress area covering the entire land of the States of Perlis, Kedah and Pulau Pinang, excluding Pulau Langkwai and Kerian area. Major river systems are the Perlis, Kedah, Merbok, Muda and Perai river systems.

The Muda irrigation project of 95,860 ha encompasses eitire coastal plain of the States of Perlis and Kedah. The Muda and Pedu dams are operated to supply water to the project. The Muda dam of 123 million m^3 in active storage capacity conveys water from its catchment area of 984 km^2 in the upper Muda river basin through a diversion tunnel to an upper tributary of the Kedah river. The Pedu dam of 864 million m^3 in active storage capacity regulates the water from the Muda dam and inflow from its catchment area of 171 km^2 in the upper tributary of the Kedah river. The regulated outflow of 780 million m^3/y from the Pedu dam is discharged through the Kedah river and collected at the Pelubang barrage for the supply to the Muda irrigation project. There are 10,000 ha of minor irrigation projects in the fringe area of the Muda irrigation project, depending on the Perlis, Kedah and Merbok river systems. Water resources in the Perlis, Kedah and Merbok river basins are insufficient to meet the present water demand of 2.1 billion m^3/y, which is mostly for irrigation.

The above-mentioned minor irrigation area will increase to 21,500 ha by 1990 and 29,000 ha by 2000. Although irrigation efficiency in the Muda irrigation project will be improved by the on-going tertiary irrigation and drainage development under the Muda II Irrigation Project with a financial assistance by IBRD, increased minor irrigation projects and domestic and irrigation demand will push up the total water demand to 2.2 billion m^3/y by 1990 and 2.5 billion m^3/y by 2000, widening the imbalance between water demand and supply in the Perlis, Kedah and Merbok river basins.

Population in the State of Pulau Pinang in 1980 was 969,000, of which 480,000, or 50% were urban population living in Butterworth, Georgetown and other towns. The present sources of domestic and industrial water are the rivers in Pulau Pinang, Muda river and Perai river. The supply capacity within Pulau Pinang including that by the Ayer Hitam dam is estimated to be 30 million m^3/y. The River Muda Water Scheme diverts water from the lower stretch of the Muda river through the River Muda Canal to the Sungei Dua Treatment Works on the right bank of the Perai river to feed the water supply system for the towns in Seberang Perai and Georgetown. The Muda barrage was constructed to protect the intakes from sea water intrusion. The Mengkuang dam in a tributary of the Perai river is a pumped-storage reservoir project to increase the Supply capacity of the River Muda Water Scheme. Stage I recently completed takes water from the Kulim river, a tributary of the Perai river and Stage II is envisaged further to pump water from the River Muda Canal. Total water supply capacity of Mengkuang dam Stages I & II is estimated to be 24 million m^3/y.

The Muda and Perai rivers are also utilized for irrigation of 21,600 ha; 7,100 ha depending on the Muda river below the Muda dam, 13,500 ha utilizing both the Muda and Perai rivers and 1,000 ha taking water from the Perai river. The irrigation area in Pulau Pinang in 1,200 ha. The present irrigation water demand in these areas is estimated to be 709 million m^3/y.

Population in the Muda and Perai river basins and Pulau Pinang is estimated to be 1.3 million for 1980, 1.5 million for 1990 and 1.6 million for 2000, and the corresponding domestic and industrial water demand is estimated to be 137 million m^3 for 1980, 263 million m^3 for 1990 and 390 million m^3 including urban water demand within the State of Pulau Pinang of 85 million m^3 in 1980, 182 million m^3 in 1990 and 278 million m^3, even if water intensive industries do not increase beyond 1985. Irrigation development will take place mainly in the areas wholly or partly depending on the Muda river. Irrigation area of 22,800 ha in 1980 will increase to 30,000 ha by 1990 and 31,200 ha by 2000. Total irrigation water demand is estimated to be 709 million m^3 for 1980, 738 million m^3 for 1990 and 815 million m^3 for 2000. These large water demand cannot be met by water resources in the Muda river below the Muda dam, Perai river and small rivers in Pulau Pinang.

The water demand in the Perlis/Kedah/Pulau Pinang region together makes up 2.9 billion m^3 for 1980, 3.2 billion m^3 for 1990 and 3.7 billion m^3 for 2000.

The recommended plan includes the construction of the Timah Tasoh dam in the Perlis river, the Badak - Temin, Sari, Durian and Ahning dams in the tributaries of the Kedah river, the Beris dam and Jeniang transfer including the Naok and Reman dams in the Muda river system and the Rui dam and diversion tunnel in a tributary of the Perak river.

The Jeniang transfer and the Rui dam and diversion tunnel are particularly important projects. The Jeniang transfer will consist of the Jeniang weir on the Main stream of the Muda river, Naok and Reman dams and transfer canals to the Muda irrigation project and the Merbok river basin. It will collect flood flow at the Jeniang weir and store it in the Naok and Reman reservoirs. The water stored can be used either to augment the low flow in the Muda river or to supply water to the Muda irrigation project and the Merbok river basin in the dry season. The net supply capacity of the Jeniang transfer has been estimated to be as large as 350 million m^3/y. The Rui dam will be located in the Rui river, an upper tributary of the Perak river within the State of Perak. Inflow from the catchment area of 215 km^2 will be regulated by the Rui dam and transferred to the upper stretch of the Kechil river, a tributary of the Muda river, through a diversion tunnel, while certain river maintenance flow will be released into the Perak river. Net transferable water will be 140 million m^3/y. The proposed Rui reservoir will submerge a 2 MW hydropower plant of a private company and it will reduce secondary energy at the Kenering and Chenderoh power stations on the Perak river. On the other hand a potential of about 4 MW will be developed at the outlet of the diversion tunnel. These two projects together with the existing and recommended 6 dams can meet water demand expected up to 2,000 and they will form a water resources system covering the Perlis, Kedah and Pulau Pinang region, in which any area suffering from drought can receive complemental water by co-ordinated operation of dams in other area.

7.2.3 Pulau Langkawi source development plan

Irrigation areas in Pulau Langkawi of 2,700 ha will increase to 3,100 ha by 1990. Population is estimated to be 31,000 for 1980 and 38,000 for 2000. Natural flow in small rivers cannot meet total water demand which is estimated to be 47 million m^3 for 1990 and 48 million m^3 for 2000.

It is recommended to construct the Aver Tawar dam and Ulu Melaka dam.

7.2.4 Kerian and Kurau river basins source development plan

The Krian Irrigation Project of 23,490 ha is entirely located in the northwest coast of the State of Perak, but 1,504 ha out of the total area is located in the State of Pulau Pinang. It takes water from the Kerian and Kurau rivers. The Bukit Merah dam in the Kurau river and Kerian barrage serve for irrigation. The tertiary irrigation and drainage development is on-going as a part of Krian-Sungei Manik Integrated Agricultural Development Project, assisted by IBRD. There are minor irrigation areas of about 3,000 ha, which will increase to 4,000 ha by 2000. Population of 350,000 will grow to 670,000 in the two river basins. It is estimated that these river basins will often suffer from water deficit in the near future. The construction of the Kerian dam is recommended in the Kerian river, which is the boundary between the State of Kedah and the State of Perak.

7.2.5 Kinta valley source development plan

The Perak river basin as a whole has an ample water for use and more water will become available, if the Temengor dam is fully operated. The problem area is the Kinta valley, where Ipoh is located. Population in Ipoh is estimated to be 320,000 for 1980, 377,000 for 1990 and 446,000 for 2000. Natural flow in the Kinta valley will become insufficient before 1990 because of high increase in domestic and industrial water demand in Ipoh, which is estimated to be 41 million m^3 in 1980, 84 million m^3 in 1990 and 154 million m^3 in 2000. It is recommended to construct the Kinta dam in the upstream reaches of the Kinta river.

7.2.6 Kelang valley source development plan

The Kelang valley including the Federal Territory, Petaling Jaya, Shah Alam and Kelang is most densely populated and industrialized region in Malaysia. Total population is mostly urban and it is estimated to be 1.8 million for 1980, 2.7 million for 1990 and 4 million for 2000. Domestic and industrial water demand was already 367 million m^3, or 34% of natural flow, in 1980 and it will grow to 686 million m^3/y by 1990 and 1,091 million m^3/y by 2000, even if water intensive industries remain at 1985 level.

The Kelang Gates dam is located in the valley. It was heightened recently in order to integrate the flood mitigation purpose. The Langat dam and a pipeline to divert water from the Langat river to the Kelang valley was completed. The Batu dam is going to be constructed in a tributary of the Kelang river for domestic and industrial water supply in the suburbs of Kuala Lumpur, where many housing and industrial development projects are being implemented. In order to prepare for tight water demand and supply balance in the Kelang valley, the construction of the Semenyih dam in a tributary of the Langat river and a pipeline from Semenyih river to the Kelang valley is being implemented.

Total water supply capacity of these dams, estimated to be 168 million m^3/y, together with available natural flow is just enough to meet the present water demand, and additional source development is still urgently needed in view of high increase in demand.

The additional projects recommended are the Selangor and Batang Kali dams in the Selangor river, pipeline system between the Selangor river to the Kelang valley, the Gombak dam in a tributary of the Kelang river, the Kenaboi and Kongkoi dams with basin transfer system in the Teriang river system of the Pahang river basin, and the Perting dam and basin transfer system in a tributary of the Pahang river.

7.2.7 Sepang river basin source development plan

Population in Port Dickson is estimated to be 42,000 for 1980, 55,000 for 1990 and 72,000 for 2000. Domestic and industrial water demand in Port Dickson and its vicinity will grow high even if the establishment of water intensive industries are restricted. It is estimated to be 30 million m^3 for 1980, 71 million m^3 for 1990 and 111 million m^3 for 2000. It is necessary to divert water from other basin to meet the future water demand, under the condition that rivers near Port Dickson are small.

It is recommended to construct the Teriang and Gelami dams in the Teriang river system of the Pahang river basin to draw water therefrom to Port Dickson.

7.2.8 Linggi river basin source development plan

There are 4,100 ha of minor irrigation projects in the Linggi river basin and they will increase to 4,300 ha by 1990 and 4,400 ha by 2000. Population in the river basin including Seremban of 321,000 in 1980 will grow to 385,000 by 1990 and 486,000 by 2000. Total water demand estimated to be 135 million m^3 for 1980, 143 million m^3 for 1990 and 178 million m^3 in 2000 is high compared with the size of the Linggi river. The recommended project is the Terip dam in the upper stretch of the Linggi river.

7.2.9 Melaka / Muar region source development plan

Population in the Melaka river basin is estimated to be 372,000 for 1980, 414,000 for 1990 and 426,000 for 2000. Irrigation area of 6,400 ha in 1980 will increase to 7,200 ha in 1990 and 7,500 ha in 2000. The proportion of domestic and industrial water demand is going to increase in the total demand which is estimated to be 166 million m^3 for 1980, 224 million m^3 for 1990 and 281 million m^3. There are the Durian Tunggal dam of 48 million m^3 per year in water supply capacity in the Melaka river and the Asahan dam of small supply capacity, both supplying domestic and industrial water. Water demand and supply seem to be just balanced at present and there is no suitable dam site to meet the incremental water demand in the future, because of small basin area of flat topography.

Population in the Muar river basin is estimated to be 552,000 for 1980, 606,000 for 1990 and 629,000 for 2000. There are minor irrigation projects of 7,000 ha and it will grow to 8,600 ha by 1990 and 9,100 ha by 2000. Total water demand in the basin is estimated to be 227 million m^3 for 1980, 308 million m^3 for 1990 and 358 million m^3 for 2000. Water resources are ample but possible dam sites are limited, because land is flat and intensively cultivated.

The recommended plan includes the Palong dam in the upper reaches of the Palong river, a tributary of the Muar river, the Muar dam in the uppermost reaches of the Muar river, the Muar barrage in the lower reaches of the Muar river and a diversion canal between the Muar barrage and Malaka.

7.2.10 South Johor source development plan

Population in Johor Bahru is estimated to be 266,000 for 1980, 439,000 for 1990 and 686,000 for 2000. The corresponding domestic and industrial water demand is estimated to be 37 million m^3 for 1980, 85 million m^3 for 1990 and 159 million m^3 for 2000 assuming that the establishment of water intensive industries is restricted. Raw water taken to Singapore was 198 million m^3 in 1980 and it is increasing rapidly. It is estimated that raw water to Singapore will be 316 million m^3 in 1990 and will reach to 414 million m^3 by 2000, the maximum volume in the agreement between the Government of the State of Johor and City Council of the State of Singapore, by 2000. The supply capacity of 7 million m^3/y by the existing 3 dams is not enough and the rivers in the vicinity of Johor Bahru is too small to supply these demands.

It is recommended to develop the Johor and Sedili Besar rivers for domestic and industrial water supply to Johor Bahru and Singapore. The Semengar dam and Linggiu dam will be constructed in the tributaries of the Johor river. The Johor barrage will be constructed in the main stream of the Johor river in order to develop water by combined operation with the Linggiu dam and divert it from the Johor river to the Semengar dam. Water in the Semengar dam will be diverted to the Teberau river, in which the Teberau barrage will be constructed for the supply to Johor Bahru and Singapore. These development cannot meet all water demand in 1990. The Sedili dam will be also constructed in the Sedili Besar river and water will be diverted from the Sedili dam to the Linggiu dam. In order to meet the incremental water demand up to 2000, the Pengeli dam will be further constructed in a tributary of the Johor river.

7.2.11 Kelantan river basin source development plan

The coastal flood plain of the Kelantan river basin has been developed for paddy cultivation. There are the North Kelantan irrigation project of 11,600 ha and Kembu irrigation project of 18,000 ha. Minor irrigation projects of 8,600 ha in 1980 will increase to 12,800 ha by 1990 and 17,000 ha by 2000. Population of the Kelantan river basin of 555,000 in 1980 will grow to 758,000 by 1990 and 971,000 by 2000. Total water demand is estimated to be 876 million m^3 for 1980, 931 million m^3 for 1990 and 1,201 million m^3 for 2000. Water resources as a whole is sufficient to support the water demand up to 2000, but the Nal dam has been proposed in a tributary for balancing local water demand and supply.

It is herein recommended that the Nenggiri dam, which has been proposed for hydropower development, should be constructed as a multipurpose dam integrating water demand and supply balance purpose.

7.2.12 Other source development plans in Peninsular Malaysia

There are three plans of local importance proposed by relevant agencies, though they were not identified in the Study. The Anak Endau dam and weir, and the Kemelai dam are under construction for the Sawah Endau irrigation project of 6,100 ha. The Kuantan barrage will be constructed in the near future to protect water supply intakes against sea water intrusion. An international committee has been established for the development of the Golok river, which flows along the borderline between the State of Kelantan and Tailand and the construction of the Golok dam has been proposed.

7.2.13 Tawau river source development plan

Tawau has a population of 50,000. There are two waterworks of PWD with the total treatment capacity of 11,380 m^3/d in the Tawau river. Water demand has already exceeded the supply capacity, and water rationing has been conducted since 1979. In 1980, PWD delivered 4.9 million m^3 of water to 35,200 people. The Tawau Water Supply Extension Project, Stage I, of 20,000 m^3/d in treatment capacity depending also on the Tawau river, is going to be completed by 1983. Population in Tawau is projected to be 82,000 for 1990 and 150,000 for 2000. The corresponding domestic and industrial water demand is estimated to be 8 million m^3/y in 1990 and 26 million m^3/y in 2000. It is foreseen that supply will often fail in the future, because the projected water demand is large compared with natural flow in the Tawau river. The recommended source facility is the Tawau dam in the upper reaches of the Tawau river, in order to regulate the run-off in the river.

7.2.14 Meliau river source development plan

Sandakan has a population of 80,800. Water supply system depends on 21 boreholes and two river intakes. Groundwater supply is 75% of total supply. There are two treatment plants, their total capacity being 20,880 to 22,320 m^3/d. PWD delivered 7.5 million m^3 of water to 64,700 people in 1980. Failure in supply often takes place, because of high demand. The Sandakan Stage I - Interim will be completed by 1983, as the interim measure until a new surface supply is made available. It consists of the construction of 13 boreholes and extension of treatment plant capacity by 18,000 m^3/d.

Population in Sandakan is projected to be 127,000 for 1990 and 222,000 for 2000. The corresponding domestic and industrial water demand is estimated to be 15 million m^3/y in 1990 and 50 million m^3/y in 2000. A study has been carried out for the Sandakan Water Supply Extension Project, Stage I, which envisages to draw water either from the Labuk river or the Kinabatangan river.

The recommended plan herein assumes that water will be taken from the Labuk river. A pipeline system is constructed in stages in a distance of 120 km between the Meliau river and Sandakan, and the Meliau dam is constructed in order to regulate the Meliau river flow.

7.2.15 Milau river source development plan

Kudat has a population of 12,000. PWD public water supply is conducted with a rain storage reservoir of 2.7 million m^3 in storage capacity. The treatment capacity is 4,550 m^3/d. PWD delivered 0.9 million m^3 of water to 7,500 people in 1980.

Population in Kudat is projected to be 21,000 for 1990 and 43,000 for 2000. The corresponding water demand is estimated to be 2.2 million m^3 in 1990 and 8.1 million m^3 in 2000. Little water resources are available near Kudat for the future water supply.

The recommended source development comprises a 30-km long pipeline between the Milau river and Kudat to convey water, and the Milau dam to augment low flow in the Milau river.

7.2.16 Wariu river source development plan

There are 5,400 ha of irrigation schemes including the Tempasuk north irrigation schemes in the surrounding area of Kota Belud in the Kadamaian and Wariu river basin. It is estimated that additional 1,000 ha will be developed by 2000.

The Wariu dam is recommended in the upstream reaches of the Wariu river, in order to regulate river flow for irrigation and domestic and industrial water supply in the above-mentioned area.

7.2.17 Papar river source development plan

Kota Kinabalu has a population of 71,000. There are two intakes of PWD in the Moyog river (Basin 220). The total treatment capacity is 45,500 m^3/d. PWD delivered 15.6 million m^3 of water to 119,000 people including those living in sub-urban area. The Kota Kinabalu Water Supply Extension Project, Stage I, is going to be completed by 1983. This project envisages to install 54,000 m^3/d of additional capacity by diverting water from the Tuaran river to Kota Kinabalu.

Population in Kota Kinabalu including suburban area is projected to be 211,000 for 1990 and 364,000 for 2000. The corresponding domestic and industrial water demand is estimated to be 23 million m^3 in 1990 and 62 million m^3 in 2000.

Water supply from the Moyog river has to be often interrupted, because the water demand in the existing irrigation area of 1,822 ha is more than what can be totally supplied by natural flow in the Moyog river. Water supply from the Tuaran river will also be interrupted, if the natural flow only is depended on. It is necessary to construct a dam in order to sustain the safe supply. There are several sites suitable for the dam construction in the upstream reaches of the Tuaran, Moyog and Papar river. Herein the Papar dam site is preliminarily selected.

The Papar dam is proposed in the upstream reaches of the Papar river (Basin 221) in order to provide safe water supply to Kota Kinabalu, while augmenting downstream flow for the purpose of irrigation and domestic and industrial water supply within the Papar river basin. The diversion of water includes the regular supply to the incremental water demand and temporary supply when the intakes in the Moyog and Tuaran rivers are encountered with drought. This project can integrate hydropower generation at the outlet of the diversion tunnel.

7.2.18 Padas river diversion project

Labuan island has a population of 29,000. PWD water supply system of 9,100 m^3/d entirely depends on 31 boreholes. In 1980, PWD delivered 1.8 million m^3 of water to 14,900 people in Labuan. The expansion plan of water supply includes tubewells, three dams and artificial recharging system.

Population in Labuan island is projected to be 52,000 for 1990 and 105,000 for 2000. Corresponding domestic and industrial demand is high of 13 million m^3/y in 1990 and 24 million m^3/y, because large scale industries will be established.

Total exploitable water resources within Labuan island are estimated to 11 million m^3/y including 7 million m^3/y of groundwater and 4 million m^3/y of surface water. Further water source has to be sought from the main land.

The recommended source development is diversion of water from the Padas river by means of submarine pipelines, which will be commissioned by stages.

7.2.19 Miri river source development plan

Miri has a population of 55,000. PWD water supply system has a treatment capacity of 9,100 m^3/d, conveying water from the Liku river by a pipeline of 10 km in length. Sarawak Shell Berhad has its own water supply system of 7,000 m^3/d to provide water to its oil refinery and residential quarters. PWD delivered 3.1 million m^3 of water in 1980, but the supply was not enough for the served population of 37,000. PWD purchased 0.7 million m^3 of treated water from Sarawak Shell Berhad in the same year.

Population in Miri is projected to be 94,000 for 1990 and 177,000 for 2000. Corresponding domestic and industrial water demand is estimated to be 13 million m^3 in 1990 and 51 million m^3 in 2000.

The Liku river has a catchment area of only 150 km^2 at the PWD intake and the water demand in 2000 is expected to reach 21% of the natural flow. Augmentation of river flow is necessary for supporting future water demand.

The recommended source development plan is the construction of the Liku dam in the Liku river for the domestic and industrial water supply in Miri.

7.2.20 Remarks on water resources development in the coastal plain in Sarawak

The present macro study cannot identify individual surface water or groundwater development projects for domestic water supply in the coastal plain in Sarawak. Generally applicable solution seems to be the rain harvesting by constructing storage tanks as has been envisaged by the state PWD. More reasonable solution will be groundwater development where applicable. It is recommended that groundwater survey should be implemented in the downstream areas of the Sarawak river and Rajang river.

It has been pointed out, in a meeting between the officials of the State of Sabah and the Study Team, that the intake of the Kuching Water Board in the Sarawak river is affected by the pollution load disposed by people in the Bungo range. Analysis by the Study could, however, not confirm this problem. If there is the problem, the solution will be the construction of a dam in the upstream reaches of the Sarawak river and pipeline between the dam and Kuching.

7.3 Hydropower Development Plan

It is recommended to implement 13 hydropower projects of 1,026 MW in total installed capacity in Peninsular Malaysia by 2000 as included in Table 53. If these projects are implemented, the installed capacity of hydropower in Peninsular Malaysia will be 2,232 MW, corresponding to about 20% of the total installed capacity, including thermal and hydro, required in 2000.

The implementation of the Tenom Pangi, Phase III, is first of all recommended for the hydropower development in Sabah, because the firming-up of power production and increase in the installed capacity will be needed soon after the Tenom Pangi, Phase I/II, is completed in 1984. The implementation of the Papar dam is urgently needed for the purpose of domestic and industrial water supply in Kota Kinabalu as described in Sub-section. Papar power, if multipurpose development is justified, should be commissioned in accordance with the program for Kota Kinabalu water supply. Further, the implementation of the Pangi No. 2 and Upper Padas projects is recommended. This recommendation is made taking into account uncertainties in the interconnection between the east and west coasts and interface between the existing railway and the Lower Halogilat project. The recommended hydropower development for Sabah is as included in Table 53.

The projected power demand in Sarawak to 2000 is less than 100 MW in each demand center except for Kuching. It is appropriate to install thermal power of 10 MW ±, probably diesel, in unit capacity as an additional expansion plan to 2000 in these demand centers. On the other hand, in Kuching, hydropower development or thermal plant of larger unit capacity should be considered for the period after 1990, in which power demand will be 150 to 300 MW. It is estimated that 190 MW of additional capacity including reserved capacity is necessary to meet the growing demand in Kuching up to 2000, after the Batang Ai power station.

It is herein recommended to implement some potential hydropower projects near the Batang Ai project. They are the Upper Batang Ai, Batang Sekrang and Konowit (identified as KONO 110 in SESCO, Master Plan) projects as included in Table 53.

If the energy-intensive industries is established in Bintulu, the power demand there will be more than 500 MW. In this case, the Raja 284 of 770 MW, proposed in the Upper Rajang Hydroelectric Development, should be constructed, and the interconnection of Kuching, Sarikei, Sibu and Bintulu should be considered, even if the interconnection with other states is not considered.

7.4 Water Pollution Abatement Plan

The problem areas in river water quality distribute approximately corresponding to water stress areas. The most serious areas are located in the west coast of Peninsular Malaysia.

The recommended plan for pollution abatement consists of improvement of purification method of effluent from palm oil mills and rubber factories as shown in Table 54 and sewerage development as shown in Table 55. If this plan is implemented, BOD load into the rivers will be reduced as shown in Table 56. Estimated BOD concentration in 2000 with the recommended plan implemented is illustrated in Fig. 13. Rural sewage and animal husbandry effluent cannot be controlled for the time being. Under these circumstances, the target BOD concentration of 5 mg/lit cannot necessarily be attained in all the rivers. Encouragement of improved septic tank in rural areas and economical method for purifying effluent from animal husbandry should be seriously studied if further pollution abatement is envisaged.

Other than these recommended herein, sewerage development projects have been proposed from the viewpoint of improvement of public health and they are in various stages of investigation. These projects are not effective for water pollution abatement in rivers because most are proposed for coastal towns and some are for the towns located in clean river stretches. The development schedule of sewerage projects not affecting river water quality is estimated as shown in Table 57.

7.5 Flood Mitigation Plan

7.5.1 Overview

The flood problem areas are distributed over Malaysia. The problem is especially serious in the densely populated Kelang and Kelantan river basins. Flooding by rivers coupled with poor drainage has been a problem in agriculture in the west Johor region. The floods in the Pahang river are large and they inundate a vast land. The recommended flood mitigation plan by Basin is summarized in Tables 58 and 59 and illustrated in Figs. 1 to 10.

The recommended plan involves the improvement of 805 km length of stretches of rivers, the construction of 82 km length of bypass floodway, the construction of 12 dams (all proposed as multipurpose dams) and the protection of 12 major flood-prone areas by polders. Non-structural measure (resettlement plan) is proposed for one basin. Flood forecasting and warning system (telemetric) is proposed for 37 basins up to 2000 as shown in Table 60.

Dams effective for flood control are the Timah Tasoh (Perlis), Batu and Gombak (Kelang), Upper Muar (N. Sembilan), Bekok (Johor), Telom/Jelai Kechil, Tembeling Upper and Tekai Lower (Pahang), Dabong and Lebir (Kelantan), Limbang (Sarawak) and Bengoh (Sarawak). Among them the Bekok, Limbang and Bengoh dams are envisaged for flood mitigation as major purpose. Besides the above new dams, the flood control function of the Temengor and Kenyir dams also can be taken into account.

7.5.2 Perlis river flood mitigation plan

The Perlis river, bifurcating into many tributaries, flooded 49 km^2 in 1976. Population in 1980 in the flooded area was estimated to be 28,000 including 9,000 in Kangar. The recommended plan is the multipurpose development of the proposed Timah-Tasoh dam and channel improvement of 34 km to protect paddy field and Kangar.

7.5.3 Muda river flood mitigation plan

The Muda river flooded 99 km^2 in 1973. The recommended plan is channel improvement of 45 km along the Kechil river, a tributary where flush floods have endangered the inhabitants, and 27 km in the lower stretch of the main stream allowing flood retardation between the above-mentioned two river stretches. The plan also includes the on-going channel improvement to increase the discharge capacity in the lower reaches of the Tembus river which is a distributary of the Muda river.

7.5.4 Perai river flood mitigation plan

The estuary area of the Perai river located in the south of Butterworth is densely populated. The recommended plan is to provide channel improvement in the lowermost stretch of the Perai river for 4 km below the Perai barrage which is under construction.

7.5.5 Pinang river flood mitigation plan

The pinang river flooded 1.4 km^2 in the south of Georgetown in 1980. The recommended plan is channel improvement of 2.5 km below Scotland road including the widening of existing river course. Occasional dredging of river-mouth mud will be necessary even after the recommended plan is implemented.

7.5.6 Kurau river flood mitigation plan

The Kurau river often inundate the land especially below the Bukit Merah dam. The recommended plan is to protect the Krian irrigation project from flooding by providing channel improvement for 13 km of river stretch which is located across the irrigation area.

7.5.7 Perak river flood mitigation plan

The Perak river flooded 1,300 km^2 in 1967. The affected population was estimated to be 200,000 mostly in the downstream area. The same magnitude of flood if occurs in the future will still cause serious problem in the downstream areas, though the Temengor dam can largely decapitate the flood discharge. Teluk Anson, populated by 53,000, sometimes suffers from flooding due to high spring tide. Bank erosion is also significant near Teluk Anson. The recommended plan includes the construction of a 50 km long floodway to divert flood flow from the middle stretch of the Perak river to the estuary, construction of a low ring bund (polder) surrounding Teluk Anson and bank protection work in the river stretch near Teluk Anson.

7.5.8 Kelang river flood mitigation plan

Flood problem is serious in the Kelang valley being densely populated. In 1971, the Kelang river flooded 142 km^2 affecting 177,000 people. The then flood damage was estimated to be M$36 million at 1980 price. The Kelang Gates dam supplying domestic and industrial water to Kuala Lumpur was heightened to incorporate the flood mitigation purpose. The Batu dam was designed as a multipurpose project for water supply and flood control. The recommended plan includes 36 km of channel improvement and the multipurpose development of the proposed Batu and Gombak dams for water supply and flood mitigation.

7.5.9 Linggi river flood mitigation plan

The Linggi river flooded 122 km^2 in 1971. The recommended plan includes channel improvement for 15 km in the upper stretch of the main stream to protect Seremban and its environs, 14 km in the upper stretch of the Sipur river, a tributary, and 12 km in the Bharu river which is southwest adjacent to the Linggi river to protect people and paddy field. Special attention should be paid not to cause sedimentation in the river in carrying out land development, because sedimentation has obviously deteriorated the channel discharge capacity.

7.5.10 Melaka river flood mitigation plan

The Seri Melaka river flooded 82 km^2 including Melaka town in 1971. The recommended plan is the construction of a 5 km long bypass floodway to protect Melaka town by draining swamp which is extending upstream of the town.

7.5.11 Kesang river flood mitigation plan

The Kesang river flooded 114 km^2 in 1971. A preliminary channel improvement has been completed for the lower stretch up to the confluence between the Kesang river and Chohong river. The recommended plan is widening of the above-mentioned river stretch and improvement of the Chohong river approximately as scheduled under 4MP.

7.5.12 Muar river flood mitigation plan

Flat valley of the Muar river is intensively utilized for paddy cultivation. Flood in 1971 inundated an area of 380 km^2 in which 50,000 people live. The recommended plan for protection of paddy field includes channel improvement for 20 km in the upper stretch of the Muar river, 16 km of Jempol river and 17 km of Gemanche river and integration of a flood control space of 24.4 million m^3 in the Muar dam which is proposed for balancing water demand and supply. The construction of ring bund is also recommended to protect a southwestern part of Segamat town.

7.5.13 Batu Pahat river flood mitigation plan

Rubber and oil palm farms in the Batu Pahat river basin are suffered from ill-drainage and flooding. The Batu Pahat river bifurcating into the Simpang Kiri, Bekok and Semberong rivers flooded 350 km^2 where 30,000 people live. As a part of the West Johor Agricultural Development Project, the Semberong dam is being constructed and the Bekok dam has been planned for the purpose of flood mitigation. In addition to these, it is recommended to provide channel improvement of 32 km for the Simpang Kiri river, 40 km for the Bekok river and 21 km for the Semberong river and to construct a bypass floodway of 19 km by enlarging the Senggerang river between the confluent of the Bekok and Semberong rivers and the sea.

7.5.14 Sekudai river flood mitigation plan

Channel improvement of 25 km above the existing tidal gate to protect the area including Kulai town is recommended as a continuation of the on-going project.

7.5.15 Johor river flood mitigation plan

It is recommended to construct a ring bund to protect 4,700 people in Kota Tinggi.

7.5.16 Mersing river flood mitigation plan

The Mersing river flooded 42 km^2 and affected 16,000 people in 1971. It is recommended to protect Mersing town of 15,000 in population and agricultural lands by providing channel improvement for 6 km upstream of the town.

7.5.17 Endau river flood mitigation plan

The damage potential in the Endau river basin is small except the Mengkibol river, a tributary located in the south-west of the river basin and the lower most stretch of the main stream where the Sawah Endau irrigation project is under construction. It is recommended to protect Keluang town of 55,000 in population and its vicinity by providing channel improvement for 11 km along the Mengkibol river. The Sawah Endau irrigation project should include necessary protection for the project area.

7.5.18 Pahang river flood mitigation plan

Floods in the Pahang river is so large that they can significantly be mitigated by neither dam nor river improvement. The flood in 1971 inundated 3,000 km^2 in which population in 1980 was estimated to be 400,000. The recommended plan is to provide ring bunds to populated towns such as Pekan (2,000 people), Temerloh (15,000), Mentakab (9,000) and Kuala Lips

(11,000). Some contribution to flood mitigation can be expected from the dams proposed for hydropower generation, though the effect is minor. It is recommended to provide flood control storage spaces to the Tekai, Tembeling, Telom and Jelai Kechil dams. Even with these measures, number of protected people will be only 63,000, which is far below the target. Resettlement of people from the areas seriously affected by flood to the new towns of the Pahang Tenggara development project needs to be considered.

7.5.19 Kuantan river flood mitigation plan

The Kuantan river flooded 230 km^2 in 1981. The affected population was estimated to be 30,000. Kuantan town located at the estuary of the Kuantan river was partly flooded. The recommended plan is to protect 20,000 people in 22 km^2 within Kuantan town by providing channel improvement of 6 km at the estuary and ring bund surrounding Batu Tiga/Paya Besar area.

7.5.20 Kemaman river flood mitigation plan

The Kemaman river flooded 265 km^2 in 1971. The recommended plan is to protect 14,000 people by providing a ring bund for Chukai town.

7.5.21 Ibai river flood mitigation plan

The Ibai river located to the south of Kuala Trengganu flooded 36 km^2 in 1967. Channel improvement of 12 km is recommended for the lowermost stretch of the river to protect 23,000 people in 20 km^2.

7.5.22 Trengganu river flood mitigation plan

Trengganu river flooded 290 km^2 in 1967, but no overbank flow will take place in the main stream under 50-year flood, if the Kenyir dam is completed. The recommended plan includes channel improvement of 12 km in the lowermost stretch of the main stream and 5 km in the Nerus river, a tributary, to protect Kuala Trengganu of 199,000 in population from flood coming from the Nerus river, and ring bund to protect 3,900 people in Kuala Brang against flood originating from the Brang river which is also a tributary of the Trengganu river.

7.5.23 Setiu river flood mitigation plan

The Setiu river inundated 252 km^2 in 1967. The recommended plan is to protect 6,600 people by providing channel improvement for 9 km as a continuation of the on-going project.

7.5.24 Keluang Besar and Besut rivers flood mitigation plan

The Keluang Besar and Besut rivers, running across the Besut irrigation project area of 5,058 ha, flooded 266 km^2 in 1967. The recommended plan is to protect the irrigation area and 57,000 people by providing channel improvement for 12 km of the Keluang Besar river and 21 km of the Besut river.

7.5.25 Kelantan river flood mitigation plan

Severe flood occurred in 1926, 1931, 1965, 1967, 1969, 1972, 1973, 1975 and 1979. Of these the flood in 1967 is the biggest one. The damage potential and the number of people affected are estimated to be more than M$100 million and 625,000 respectively at 1980 level in the Kelantan plain. The flooding is caused by overbank from the Kelantan river.

The recommended flood mitigation program for the Kelantan river basin was worked out assuming that the Lebir and Dabong dams would be operational by 1995. It includes the river improvement for 65 km of river stretch between the Guillemard bridge and the estuary, construction of a polder (ring bund) for Kuala Kerai and provision of flood mitigation storage in the 2 dams, in order to protect 380,000 people in 78,000 ha. The construction cost was estimated to be M$400 million at 1980 constant price. An alternative if no dam would be constructed was also studied. The construction cost was estimated to be M$600 million. Although the estimated cost is very preliminary based on 1/63,360 map, this large difference in cost indicated that the proposed 2 dams are quite effective for the flood mitigation. The Lebir and Dabong dams together can regulate floods from almost 80% of the Kelantan river basin and they can reduce the flood discharge by 30%, beside generating a large hydropower. Furthermore, source development will, sooner or later, become necessary to support the growing water demand in the coastal plain. Early implementation of the Lebir and Dabong dams is worth for serious consideration from the viewpoint of integrated development of the Kelantan river basin.

7.5.26 Tawau river flood mitigation project

Tawau, populated by 50,000, is located at the estuary of the Tawau river. The town is often flooded, because the river, stretching for 9 km in the town, is not capable of discharging flood. For example, a flash flood in January, 1981 flooded 18 km^2 and affected 6,000 people, mostly within the town. The recommended flood mitigation plan consists of the excavation of a bypass floodway of 3 km in length and improvement of existing river channel of 9 km in length. Although incorporation of flood control storage was preliminary discarded in the proposed Tawau dam, it should be further studied in the stage of feasibility study.

7.5.27 Bandau plain flood mitigation project

The Langkon, Bongan, Kota Marudu and Tandek rivers run through the Bandau plain where several villages are located. A flood associated with high tide in January, 1981 inundated 109 km^2 including Langkon and Kota Marudu towns. A budget has been allocated under 4MP for the flood mitigation in the Bandau plain. The recommended flood mitigation plan is river channel improvement of 56 km in length in order to protect Bandau plain.

7.5.28 Putatan river channel improvement project

The Moyog river distributes into small channels of small discharge capacity in the south of Kota Kinabalu. The major distributary is the Putatan river causing drainage problem in the surrounding area. The Putatan river inundated 7 km^2 and affected 7,000 people in a flood in 1974. The recommended flood mitigation plan is river channel improvement of 12 km in length in the town area.

7.5.29 Kadamaian river channel improvement project

The flood of January, 1981 affected the low-lying area of Kota Belud town and the irrigation scheme. A comparatively large scale irrigation scheme is carried out and will be expanded in the flood prone area. The banks were eroded in several places by floods. The recommended flood mitigation plan is the river channel improvement of 16 km in length in the most downstream stretch.

7.5.30 Limbang flood mitigation dam project

The Limbang valley project has been proposed for agricultural development of 20,000 ha including 8,600 ha of paddy irrigation in the lower Limbang valley. The major constraint of the development is flood problem. The Limbang flood mitigation dam is proposed at just upstream of the Limbang valley project area. The storage capacity of 450 million m^3 can reduce flood discharge to a non-damage flow in the downstream river channel, and also power generation will be made possible. Since the project is for irrigation purpose, the project cost is included in the irrigation sector of this Study.

7.5.31 Miri river flood mitigation project

The Miri river inundated 674 km^2 in January, 1963. Miri town located near the estuary of the Miri river is an industrial town of 55,000 in population at present. The flood damage must be large if the same flood occurs under the present condition. The recommended flood mitigation plan is the construction of a bypass floodway of 5 km in length at just upstream of Luton, which is located 2 km to the north of Miri.

7.5.32 Construction of ring bund at Niah

The construction of ring bund including bank protection work is recommended for Niah of 900 in population.

7.5.33 Kemena river flood mitigation plan

The river channel improvement is recommended for a 30 km stretch in length of the Kemena river to protect 17,000 people in the flood prone area in Bintulu.

7.5.34 Matu river channel improvement plan

The Matu river flooded 226 km^2 in 1963 affecting 7,000 people. The recommended plan is the river channel improvement of 21 km.

7.5.35 Sarawak river flood mitigation plan

The recommended plan includes the Bengoh flood mitigation dam in the Sarawak river and channel improvement of 142 km in the Sarawak and Samarahan rivers to protect 62,000 people in the flood prone area. The superiority from the technical and economic points of view is preliminarily given to the Bengoh dam over the Giam dam, however, the latter shall be examined in the feasibility study stage.

7.6 Inland Navigation Development Plan

Considering the significance of the inland navigation development for the economic development and the enhancement of social well-being in Sarawak, it is recommended that in the short-run the plan for 4MP, which envisages to implement 95 projects at the cost of about M$38 million proposed by the State PWD, should fully be implemented.

7.7 Cost Estimate

The construction costs of the proposed facilities were estimated at the constant price in December, 1980. The costs at this stage are only notional just to indicate the order of magnitude.

The construction costs consist of direct construction cost (contract amount), engineering and administration, land acquisition and physical contingency. The direct construction cost was estimated based on the actual costs and previous estimate for similar projects in Malaysia. Major unit costs assumed are listed in Tables 61 to 64. The physical contingency was assumed to be 30%. The construction cost is disbursed in five years antecedent to the year of commission of the proposed facilities except that the construction cost of rural untreated water supply project is assumed to be disbursed in one year.

The construction costs were estimated for all the facilities recommended herein and those of which construction was started after 1980, except that the existing budget for water supply in 4MP was assumed to be capable of constructing domestic and industrial water supply system and irrigation system to the extent required up to 1985 and was not included in the expenditure for 4MP.

All the purification facilities for the palm oil mills and rubber processing factories were assumed to be privately financed.

According to the present practice, it was assumed that the construction cost of sewerage system borne by private sector is the house connections in the existing town area, and branch sewers and house connections in the new town areas. In estimating the sewerage treatment capacity in the new town area, it was assumed that the population within the existing town area will remain unchanged and the treatment capacity is allocated in proportion to the population.

As shown in Table 65, the public development expenditure for the water resources development will be in the order of M$6 billion for 4MP, M$16 billion for 5MP, M$13 billion for 6MP and M$6 billion for 7MP. The total amount in the order of M$41 billion is about equal to the total development expenditure in the present budget of 4MP. In terms of share in the public development expenditure, public water supply is the largest of 35%, water source development for water resources development, sewerage and hydropower is 15% each and irrigation and flood mitigation together is 15%. Private development expenditure will be of the order of M$15 billion in 4MP to 7MP as shown in Table 66, contributing 27% to the total development expenditure. Private water supply mainly for industries will account for 1/3 of the private development expenditure. Public recurrent expenditure for the same period will be about M$8 billion or 20% of the public development expenditure as shown in Table 67.

7.8 Manpower Requirement

Assuming that design and construction supervision will be entrusted to consultants, construction work will be carried out by contractors, and operation and maintenance will be performed by inhouse staff, manpower requirement for the implementation, operation and management of the recommended plan in the public sector is indicatively estimated as shown in Table 68.

The manpower requirement for construction will be of the order of 2,000 persons for 4MP and it will be about 3,000 persons thereafter. The required manpower will include 400 to 500 engineers, 400 to 600 technical assistants, 500 to 800 technicians, and 600 to 1,100 other staff.

The manpower requirement for operation and maintenance will be increased from the order of 13,000 persons for 4MP to 26,000 persons for 7MP. Included will be 200 - 500 engineers, 300 - 800 technical assistants, 100 - 300 assistants and 11,000 - 22,000 other staff.

The aggregate manpower requirement will increase from 15,000 persons for 4MP to 29,000 persons for 7MP, including 600 - 1,000 engineers, 700 - 1,400 technical assistants, 600 - 1,100 assistants and 11,600 - 23,100 other staff.

7.9 Beneficial and Adverse Effects

The beneficial and adverse effects of recommended plans are evaluated from the viewpoints of national economic development, environmental quality and social well-being.

7.9.1 National economic development

The beneficial and adverse effects of proposed plans on the national economic development account are calculated as the annual equivalent of economic benefits and costs, assuming a discount rate of 8% for an evaluation period of 50 years between 1981 and 2030.

The prices of internationally traded goods and services were estimated based on the World Bank projection to 1990, or the international market price in December, 1980. The prices of locally traded goods and services were the normalized price in December, 1980. The transfer payments such as tax and local contractors' profit are deducted from all prices. The ratio of transfer payment to the financial cost is assumed to be 20% of financial cost referring to the ratio of tax revenue to GDP at purchasers' price in 1980 in 4MP.

The domestic and industrial water supply benefit is estimated based on the least-costly alternative facilities cost criteria. The water deficit is preliminarily allocated to domestic and industrial water supply and irrigation water supply in proportion to the demand. A construction schedule of dams to meet the deficit allocated to domestic and industrial water supply is thus prepared, assuming the least costly dams among those which are not included in the recommended plan. The cost of the above-mentioned dams and the recommended intake, conveyance, treatment and distribution system is regarded as the benefit of domestic and industrial water supply.

There should be established a rule for the emergency operation against the drought in which both the rate of water withdrawal and rate of river maintenance flow should be sustained as much as possible and the river flow should be kept not below the essential river maintenance flow. Herein a simplified rule is assumed: Water withdrawal for use continues until the river flow after the water withdrawal lowers to the essential river maintenance flow and thereafter the water withdrawal is reduced so that river flow no longer lowers. Consequently, the reduction in supply for domestic and industrial water demand and irrigation water demand is calculated through the period in which runoff record is available, allowing low flow after the water withdrawal to be equal to the essential river maintenance flow. The reduction in irrigation benefit is calculated assuming that it is proportional to the reduction in the supply.

The economic farmgate price of paddy during the evaluation period is estimated to be M$640/ton based on the projected price of 5% broken rice, FOB Bangkok. Paddy yield, gross value, production cost and net value are estimted for 1990 and 2000 by irrigation condition. The hectareage of newly reclaimed land and upgraded lands from rainfed paddy to irrigated or control drainaged paddy, single crop to double crop and minor scheme to major scheme are estimated for the future. Then the irrigation benefit is obtained as the incremental net production value.

Hydropower benefit is estimated assuming the unit value of power to be M$175/kW and M$0.122/kWh for Peninsular Malaysia and M$76/kW and M$0.149/kWh for Sabah and Sarawak.

The sewerage benefit is the willingness-to-pay by served people and saving in the cost of purification of industrial waste. It is tentatively assumed to be 0.6% of real income of served people and gross value of manufacturing production of served industries.

Pre-treatment facilities are necessary if BOD concentration in raw water is more than 2 mg/lit for domestic water supply and 5 mg/lit for industrial water supply. Its costs can be saved, if the proposed water pollution abatement measures reduce BOD concentration in the river below this limit.

This saving in cost is counted as a part of water pollution abatement benefit.

Under the flood mitigation benefit, average value of reduction in annual damage by the proposed measures only is counted, while land enhancement benefit is counted in the irrigation benefit. It is assumed that the damageable value in the flood prone area will increase at a certain moderate rate.

The fish culture benefit is estimated to be M$2,000/ha for the fish pond and M$1.6 million/reservoir for the cage culture in the created reservoir.

Benefit of recreation in the created reservoir is estimated by use of the concept of willingness-to-pay of the visitors to the reservoir. The willingness-to-pay is estimated to be M$0.1/km in terms of the travelling, or fuel cost of the vehicles to the recreation area.

The economic cost is calculated as the annual equivalent of the construction cost and OMR cost. It is noted that the private sector cost of water supply facilities, purification facilities in palm oil mills and rubber factories and sewerage facilities are included in the economic cost.

The economic internal rate of return (EIRR) is calculated as the discount rate with which the present worth of benefit equals to that of cost.

7.9.2 Environmental quality

The beneficial and adverse effects of proposed plans from the viewpoint of environmental quality are represented by the quantities of appropriate parameters.

The river maintenance flow is the requisite for the conservation of river environment and adequate water use. The effect on the river maintenance flow is evaluated as the number of days when the river maintenance flow can be sustained in the driest year ever recorded.

The water surface of created reservoir provides favorable scenery, place of recreation and enhancement of wildlife. The beneficial effect of created reservoir is counted by the water surface area.

The reduction in length of river stretches in which BOD concentration will be more than 5 mg/lit is regarded as the beneficial effect of water pollution abatement.

The channel improvement stabilizes the river channel and provides favorable condition for navigation and other instream water use. The length of improved river stretches is counted as a parameter showing the beneficial effect on environmental quality.

If a dam is constructed, some species of fish would probably disappear in certain length of river stretch immediately downstream of the dam showing an adverse effect on ecological system, though such adverse effect can be compensated by possible cage culture in the created reservoir.

7.9.3 Social Well-being

The income increase, health improvement, life saving, and reduced risk in water supply are counted as the beneficial effect from the viewpoint of social well-being. The adverse effect is the inevitable removal of people for the purpose of construction of proposed facilities.

7.9.4 Beneficial and adverse effects of water demand and supply balance plan

The beneficial and adverse effects of water demand and supply balance plan are summarized in Table 69.

Economic benefits accrue from irrigation, domestic and industrial water supply, inland fishery including cage culture in the reservoirs created and pond culture, and recreation in the reservoir created. The annual equivalent of the above-mentioned benefits including those derived from proposed hydro-power projects is estimated to be M$1.5 billion, in which the benefit from domestic and water supply has the largest share of 78% and irrigation of 17% follows. In the cost side, dam and diversion facilities cost is separately counted from the facilities for specific purposes. The annual equivalent of cost is estimated to be M$1.3 billion in which 14% is accounted for by dam and diversion facilities, 10% by irrigation, 74% by domestic and industrial water supply, and the reminder by inland fishery. The value of EIRR is calculated to be 11%.

The safe maintenance flow period in the driest year ever recorded ranges between 290 days and 365 days showing a difference of 30 days to 293 days compared with that under the condition without the recommended plan to be implemented as shown in Table 70. Surface area of reservoir created is 409 km^2. Kind of fish may reduce immediately downstream of 41 dams/barrages recommended.

Number of farm households benefited by the proposed irrigation development will be 290,000 in 2000. People served by public water supply system by 2000 will be 21.8 million or 99% of total population. Safe supply period will be largely improved, it will range between 298 days and 365 days even in the driest year ever recorded, with increase between 25 days and 278 days as shown in Table 70. Number of people who have to be removed for the construction of proposed facilities will be 2,000 by 2000.

7.9.5 Beneficial and adverse effects of hydropower development plan

The beneficial and adverse effects of recommended hydropower development plan are summarized in Table 71. The economic benefits other than hydropower generation benefit are included in the relevant table of either water demand and supply balance plan or flood mitigation plan.

The annual equivalent of economic hydropower benefit will be M$502 million compared with the annual equivalent of economic cost of M$177 million resulting in the value of EIRR of 20%.

Surface area of reservoir created will be 1,307 km^2, while 20 dams may reduce kinds of fish in the river stretches immediately downstream.

About 30,000 people have to be removed for the construction of facilities.

7.9.6 Beneficial and adverse effects of water pollution abatement plan

The beneficial and adverse effects of water pollution abatement plan is as summarized in Table 72.

Economic benefits will accrue from sewerage service itself and from the saving in the pre-treatment facilities cost which would be incurred by water supply. The annual equivalent of benefits is estimated to be M$141 million. Economic costs include public and private costs for sewerage, purification of effluent from rubber factories and palm oil mills, and pre-treatment for the water supply which will have to depend on river stretch where BOD concentration will be still high. The annual equivalent of economic costs is estimated to be M$160 million, which is more than the benefit.

The major objective of water pollution abatement is improvement of environmental quality. If the recommended plan is implemented the river stretches in which BOD concentration is more than 5 mg/lit of 1,891 km in 1990 and 1,221 km in 2000 will be reduced to 402 km in 1990 and 427 km in 2000 as shown in Table 73.

Number of people served by sewerage system will be 3.9 million in 2000.

7.9.7 Beneficial and adverse effects of sewerage development plan not affecting river water quality

The beneficial and adverse effects of sewerage development plan in which sewerage projects are not effective to attain the target BOD concentration because they are proposed in either coastal towns or in the towns located adjacent to clean rivers, are summarized in Table 74.

The annual equivalent of economic benefit is estimated to be M$68 million against the annual equivalent of economic cost of M$191 million.

The beneficial effects on environmental quality can be expected in the improvement in water quality in estuary and sea, though they have not been quantified.

Number of people served by the proposed sewerage system will be 4.4 million.

7.9.8 Beneficial and adverse effects of flood mitigation plan

The beneficial and adverse effects of flood mitigation plan are summarized in Table 75.

Damage reduction only is counted while land enhancement benefit is not considered. The annual equivalent of economic benefit is estimated to be M$75 million and annual equivalent of cost is estimated to be M$71 million. The value of EIRR is calculated to be 8.4%.

Length of improved river stretch will be 932 km.

Major beneficial effects can be found in the social well-being aspect. If the plan is implemented, 1.8 million people will be protected from floods and 924,000 people will be served by the flood warning system. Area relived from flood hazard will be 503,000 ha. Number of people to be removed will be 63,000.

8. PLAN UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

8.1 Assumed GDP Growth Rate

The recommended plan described in the foregoing chapter is based on an assumption that the growth rate of GDP is 7.7% from 1980 to 1985, 8.4% from 1985 to 1990, in accordance with 4MP and OPP and further projected to be 7.5% from 1990 to 2000.

For reference, a plan under a lower economic growth was prepared, assuming that Malaysia's economy might be affected by a long-lasting world-wide economic depression. The growth rate of GDP assumed was 7% from 1980 to 1985, 6% from 1985 to 1990, and 5% from 1990 to 2000. With this assumption, GDP in 2000 is approximately equal to that in 1995 in the original assumption. Table 76 shows the projected GDP by state under the condition of lower economic growth.

8.2 Effects Induced by Lower Economic Growth

The parameters dominated by GDP per capita are the urbanization ratio, share of manufacturing sector in GDP, gross value of industrial output, power consumption per capita, domestic water consumption per capita and value of flood damage, so far related with the water resources development and use. These parameters under the condition of lower economic growth were estimated assuming a functional relationships with GDP per capita.

The service factor in domestic water supply and rate of irrigation development may be affected by the economic growth, but they are rather ruled by the socio-economic policy. It is herein assumed that the target service factor in domestic water supply for 2000 is delayed by five years but the rate of irrigation development does not change even under the lower economic development.

8.3 Reduced Demands Under the Condition of Lower Economic Growth

The projected GDP under the condition of lower economic growth is M$47.6 billion for 1990 and M$77.6 billion for 2000 at 1980 constant price. In terms of ratio to the original estimate, it is 87% for 1990 and 69% for 2000.

Domestic and industrial water demand under the condition of lower economic growth is projected to be 2.3 billion m^3/y for 1990 and 3.6 billion m^3/y for 2000 as shown in Tables 77 and 78. Its ratio to the original estimate is 89% for 1990 and 75% for 2000.

Overall service factor of public water supply system under the condition of lower economic growth is estimated to be 88% for 1990 and 96% for 2000, while it is, in the original estimate, 90% for 1990 and 99% for 2000.

Power demand in the whole Malaysia under the condition of lower economic growth is estimated to be 3,600 MW for 1990 and 6,400 MW for 2000, while the original estimate is 4,800 MW for 1990 and 10,800 MW for 2000.

Daily rate of BOD load discharged into river under the condition of lower economic growth is estimated to be 505 tons for 1990 and 588 tons for 2000. Compared with the original estimate of 533 tons for 1990 and 680 tons for 2000, it is 95% for 1990 and 86% for 2000.

8.4 Development Plan

The development plan under the condition of lower economic growth is tabulated in Tables 79 to 89.

8.5 Expenditure and Manpower Requirement

The public and private development expenditure and public recurrent expenditure are estimated for the case of lower economic growth as shown in Tables 90 to 92, and the corresponding manpower requirement is as shown in Table 93.

Public development expenditure will be M$4.4 billion for 4MP, M$11.7 billion for 5MP, M$10.2 billion for 6MP and M$5.3 billion for 7MP totalling M$31.6 billion, which is 77% of the original estimate. Private development expenditure will be M$8.1 billion, or 55% of the original estimate, and public recurrent expenditure will be M$5.9 billion or 78% of the original estimate.

Aggregate manpower requirement for implementation and operation and maintenance of the proposed facilities will be on the order for 2,000 persons for 4MP, 17,500 persons for 5MP, 21,000 persons for 6MP and 23,100 persons for 7MP, being about 80% - 85% compared with the original estimate. These requirement will include 400 - 900 engineers, 500 - 1,300 technical assistants, 500 - 3,200 technicians and 700 - 20,500 other staff.

8.6 Beneficial and Adverse Effects

The beneficial and adverse effects of the water resources development and use plan in the case of lower economic growth are summarized in Tables 94, 96, 97, 99 and 100.