maintenance flow, dredging works are recommended as the feasible measure against clogging of the river mouth.

(3) Maintenance Flow to Facilitate Navigation

Navigation is active only downstream from the Muda Barrage where the tidal level has a dominant influence on the available water level for navigation.

(4) Maintenance Flow to Prevent Saline Water Intrusion

The saline water intrusion is now being controlled and stopped by the Muda Barrage located about 10 km upstream from the river mouth. Therefore, no river maintenance flow is required to check the saline water intrusion.

(5) Maintenance Flow to Preserve Groundwater Level

The river maintenance flow is useful to maintain the groundwater level during a drought period. In the case of Muda river basin, however, the major water supply source is the river surface flow, and no particular requirement for river maintenance flow is indicated in this aspect.

8.1.3 Determination of Minimum Requirement of Discharge for River Maintenance Flow

The determination of minimum requirement of discharge for river maintenance flow has been carried in consideration of the following items:

(1) Checkpoint and Catchment Area for Estimation of River Maintenance Flow

The necessary discharges for each of the aforesaid dominant factors were estimated at the selected reference points, and the river maintenance flow was finally determined by synthetic evaluation. The selected reference points are herein enumerated as follows:

(a) Muda River at the existing Jeniang Gauging Station [Point M(JG)];
(b) Muda River at Jam S. Omar [Point M(JS];
(c) Muda River at Ldg. Victoria [Point M(LV)];
(d) Ketil River at Kuala Pegang [Point K (K)]; and
(e) Chepir River at Batu Lima [Point C(B)].

The catchment area of the above reference points is significant for the estimation of river maintenance flow. Among the above reference points, Jeniang, Jam. S. Omar and Ldg. Victoria are located downstream of Muda Dam.

All of the runoff discharge from the catchment area of Muda Dam (984 km^2) is diverted to Pedu Dam and does not flow down to these reference points. Accordingly, the catchment area of Muda Dam was excluded from that of the reference points in the estimation of river maintenance flow.

Thus, the following catchment areas were applied to the estimation for each reference point.

Catchment Area of Reference Point

Reference Point	Topographic Catchment Area (km^2)	Catchment Area Applied to Estimation (km^2)
Jeniang [M(JG)]	1,740	756
Jam S. Omar [M(JS)]	3,330	2,364
Ldg. Victoria [M(LV)]	4,010	3,026
Kuala Pegang [K (K)]	704	704
Batu Lima [C(B)]	233	233

(2) Necessary Discharge to Maintain the Appropriate River Water Quality

The river flow discharge was estimated by the following formula assuming that the discharge needs to dilute the BOD concentration to less than 6 mg/l, which is the allowable level for use of treated drinking water.

$$Qm = 1000 \times PL \div BOD(R)$$

Where,

Qm	:	Necessary river maintenance discharge (m^3/s)
PL	:	Gross weight of pollution loads generated at pollutant sources (mg/s)
$BOD(R)$	:	Required BOD concentration (assumed as 6 mg/l)

The estimated necessary discharges for reference points are as summarized below.

Necessary Discharge to Maintain River Water Quality

Checkpoint	River System	BOD Load (mg/s)	Discharge to Dilute (m^3/s)
Jeniang [M(JG)]	Muda	42,988	7.2
Jam S. Omar [M(JS)]	Muda	133,400	22.2
Ldg. Victoria [M(LV)]	Muda	172,066	28.7
Kuala Pegang [K(K)]	Ketil	43,087	7.2
Batu Lima [(C(B)]	Sic	14,260	2.4

(3) Necessary Discharge to Conserve Natural Low Flow Regime

The following two items were assumed to be guaranteed even after the construction of the proposed Beris Dam, Jeniang Transfer Canal, Naok Dam and Reman Dam:

(a) The specific discharge of 0.0069 m^3/s should be maintained even after the construction of water resources structures. The specific discharge is the average value of river maintenance flow guaranteed by dams in Japan and conventionally applied as the dam guarantee flow in the country.

(b) The present 355-day discharge also should be maintained even after the construction of water resources structures. The discharge was estimated as the third lowest among the values for a 33-year period from 1959 to 1991, approximately corresponding to a recurrence probability of 10-year return period.

The necessary discharge to conserve natural low flow regime was herein assumed as the larger value between the above items, and estimated as below.

Necessary Discharge to Conserve the Natural Flow Regime

Check Point	River System	Catchment Area (km^2)	Discharge of 0.0069 $m^3/s/km^2$ (m^3/s)	355-Day Discharge (m^3/s)	Necessary Discharge (m^3/s)
Jeniang [M(JG)]	Muda	756	5.2	7.7	7.7
Jam S. Omar [M(JS)]	Muda	2,364	16.2	15.7	16.2
Ldg. Victoria [M(LV)]	Muda	3,026	20.9	20.3	20.9
Kuala Pegang [K(K)]	Ketil	704	4.8	4.7	4.8
Batu Rima [(C(B)])	Sic	233	1.6	1.5	1.6

(4) Necessary Discharge to Conserve River Ecology

There exist the freshwater fishes of less than 50 cm in length in the lower stretch and 20 cm in length in the middle and upper stretches of Muda River. To conserve water space for these freshwater fishes, the minimum requirement of river water depth was assumed as 50 cm at Jam. S. Omar [M(JS)] and Ldg. Victoria [M(LV)], 30 cm at Jeniang [M(JG)] and Kuala Pegang [K(K)] and 25 cm at Batu Lima [C(B)]. To maintain the said water depth, the following discharges are required as river maintenance flow.

Necessary Discharge to Conserve the Present River Ecology

Checkpoint	River System	Catchment Area (km^2)	Discharge (m3/s)
Jeniang [M(JG)]	Muda	756	1.9
Jam S. Omar [M(JS)]	Muda	2,364	4.6
Ldg. Victoria [M(LV)]	Muda	3,026	11.4
Kuala Pegang [K(K)]	Ketil	704	3.1
Batu Lima [(C(B)]	Chepir	233	2.1

(5) Necessary Discharge to Maintain River Scenery

In accordance with the ongoing "Love Our River Campaign," the requirement of beautiful river scenery has increased. With reference to the environmental guidelines in Japan, it was assumed that about 20% of the river channel has to be constantly covered with water to maintain a desirable river scenery. To guarantee this condition, the following constant discharges are required.

Necessary Discharge to Maintain the River Scenery

Checkpoint	River System	Catchment Area (km^2)	Discharge (m^3/s)
Jeniang [M(JG)]	Muda	756	6.5
Jam S. Omar [M(JS)]	Muda	2,364	4.2
Ldg. Victoria [M(LV)]	Muda	3,026	17.4
Kuala Pegang [K(K)]	Ketil	704	3.5
Batu Lima [(C(B)]	Chepir	233	0.9

(6) Optimum River Maintenance Flow

As tabulated below, the dominant factor to determine the river maintenance flow is the discharge to maintain the river water quality, which corresponds

approximately to the specific discharge of 0.01 $m^3/s/km^2$. In other words, the specific discharge of 0.01 $m^3/s/km^2$ is the minimum requirement to cover the discharge required for the factors in (2) to (5).

Synthetic Evaluation on Necessary Discharge as River Maintenance Flow

Checkpoint	Necessary Discharge in Factors (m^3/s)				Applied (≒0.01 $m^3/s/km^2$)
	To Maintain River Water Quality	To Conserve Natural Flow Regime	To Conserve River Ecology System	To Maintain River Scenery	
M(JG)	7.2	7.7	1.9	6.5	7.7
M(JS)	22.2	6.2	4.6	4.2	23.4
M(LV)	28.7	20.3	11.4	17.4	30.3
K(K)	7.2	4.8	3.1	3.5	7.2
C(B)	2.4	1.6	2.1	0.9	2.3

Based on the above synthetic evaluation, the river maintenance flow was determined to correspond to the specific discharge of 0.01 m^3/s. This river maintenance flow is to be guaranteed from by the water released from the proposed dams and its supply plan is incorporated into the integrated dam operation rule described in CHAPTER 7.

The proposed dams such as Beris, Naok and Reman are constructed in the upper reaches of the confluence of Beris River. Accordingly, the proposed river maintenance flow could be guaranteed by the proposed dams for the main river stretch from the river mouth to the confluence of Beris River.

On the other hand, the tributaries as well as the upstream of main channel from the confluence of Beris River is not guaranteed. Particularly, the upstream from the confluence of Beris River will hardly have the low flow discharge, because Muda Dam which is located upstream from the confluence impounds almost all the basin runoff discharge and conveys it to Pedu Dam. Due to this, the river environment could be possibly aggravated should excessive basin development be induced. To cope with this issue, the monitoring and management of basin development is proposed as described CHAPTER 9, and no river maintenance flow is taken for the river stretch from the confluence of Beris Dam up to Muda Dam.

Nevertheless, the river maintenance flow is essential to preserve the appropriate river environment and therefore, whenever a new dam reservoir is proposed in

other river basins in Malaysia, an attempt shall be made to secure the maintenance flow released from the dam. The minimum requirement of the river maintenance flow will be variable according to the particular conditions of each river basin, and shall be determined through scrutinizing all of the nine (9) factors described in subsection 8.1.2. The factors shall include the dominant four (4) items applied to Muda river (items (a) to (d) in subsection 8.1.2) as well as other five (5) items (items (1) to (5) in the same subsection).

8.2 River Corridor Management Plan

8.2.1 Extent of Zoning Plan

The delineation of river reserve and controlled area is proposed along the river corridor to reserve the land for river improvement works and, at the same time, to preserve the natural flood retarding effect (refer to CHAPTER 6). It is further proposed that the river reserve and controlled area is under the jurisdiction of the river management body, and land development activities and alienation or temporary occupation of the land therein are subject to the approval of the river management body. To facilitate these public purposes of the river reserve and controlled area, the zoning plan for the area is essential. The zoning plan around the dam reservoirs is also indispensable to preserve the natural features of the dam reservoirs and to promote inland agro-tourism.

From these viewpoints, the zoning plan was applied to the following four (4) blocks which are located within the limits of the proposed river reserve and controlled area and the lakeshore areas around the reservoirs of Muda and Beris dams (refer to Fig. 8.2.1).

(1) Lower Reach Block

The river improvement plan is formulated for the purpose of flood mitigation from the river mouth up to about 40 km upstream. The river corridor along the improvement section is subject to land acquisition by the Government. The zoning is formulated for the entire land acquisition area.

(2) Middle Reach Block

The river corridor is not subject to land acquisition by the Government. Accordingly, only a spot development plan is proposed. The objective area is along the Muda main stream starting from the upstream end of the above river improvement section up to the proposed site of Jeniang Barrage. The objective area is also placed along Ketil River starting from the confluence of Muda River up to the confluence of Kepang River.

(3) Muda Dam Reservoir Block

Spot development plans for the lake park and campsite are proposed on a small scale around the existing dam reservoir due to the steep slope of the lakeshore. The principal purpose of this development is to provide a resort space for the local residents in particular.

(4) Beris Dam Reservoir Block

An extensive plain land is located along the southern part of the lakeshore. The land will have easy accessibility via a proposed connection road and, further, an island located in front of the land could be used as a part of the resort spot. From this viewpoint, a large recreational park is proposed along the southern part of the lakeshore. There exist the international resort area called Pedu Resort along the shoreline of the Pedu dam reservoir. In this connection, the park proposed for Beris dam reservoir is expected to promote inland tourism development for the State of Kedah together with the Pedu Resort.

8.2.2 Alternative Land Development Types to be Applied to Zoning Plan

The following alternative types for land use and/or development are applied to the proposed zoning:

(1) Type A: Land for Nature Reserve

This type is applied to the area covered with natural vegetation such as trees, shrubs, and, weeds. The area is useful to preserve the scenery of the river and proposed as a natural reserve. No structure should be introduced in principle to

the area except the minimum facilities for the conservation purpose. A typical layout of this type is illustrated in Fig. 8.2.2.

(2) Types B: Land for Nature Use

This type is applied to the area used for nature-oriented recreation by utilizing the existing natural conditions as much as possible. Some facilities are provided in this zone but for the purpose of enjoying nature. The typical layout of this type is illustrated in Fig. 8.2.3.

(3) Type C: Land for Agriculture

This type is applied to a quasi-natural area covered with agricultural land such as paddy field, vegetation garden, oil-palm and rubber plantation. This type aims at preserving the present agricultural activities, as well as the scenery of the river. At the same time, this type is used as a part of the recreation space for walking, jogging, cycling, etc. The typical layout of this type is illustrated in Fig. 8.2.4.

(4) Type D: Land for Recreation Development

This type is for the area to be developed as a principal recreation space by structures and facilities with care on the natural resources. The typical layout of this type is illustrated in Fig. 8.2.5. The typical facilities required for this type are as shown in Table 8.2.1. Some of these facilities may be used also for Types B and C (refer to Table 8.2.2).

8.2.3 Zoning Plan in Each Block

The following zoning plan is proposed for each of the aforesaid four (4) blocks as described below.

(1) Zoning in Lower Reach Block

The zoning is made, in principle, for the space of the high water channel proposed in the river improvement plan assuming that the space is to be acquired by the Government. The objective area is located near the existing urban centers such as Sungai Petani and Butterworh. In due consideration of easy accessibility from the urban areas, the principal purpose of zoning is set in

developing the recreation space along the river as well as the scenery of the river.

A shown in Fig. 8.2.6, the proposed zoning includes seven (7) areas for recreation development and two (2) for agricultural land. Among the areas for recreation development, those around Muda Barrage and Bumbung Lima are proposed as large-scale development areas containing a recreation complex as shown in Figs. 8.2.7 to 8.2.9.

(2) Zoning in Middle Reach Block

The river corridor is not subject to land acquisition by the Government. Accordingly, the land development for recreation purpose is proposed to the limited spots currently owned by the Government. The total number of development areas is seven (7), and the principal purpose of development is to provide a riverside park for the neighboring local residents in particular (refer to Fig. 8.2.10).

In addition to the spot development areas, natural reserve areas and natural use areas are proposed at three (3) locations, respectively (refer to Fig. 8.2.10). These natural reserve and natural use areas cover the major river meandering extent containing a high flood damage potential as well as significant flood retarding effects. The selected natural reserve areas are far from the settlement areas, while the natural use area has easy accessibility containing potentials for a nature-oriented recreational area.

The conservation of the present extensive agricultural land is also proposed at the right bank upstream from the confluence of Ketil River (refer to Fig. 8.2.11). The area is presently owned by the Government and used as agricultural land and at the same time as recreation space for jogging, cycling and walking.

(3) Zoning in Muda Dam Reservoir Block

As described above, the lakeshore has a steep slope, and any large-scale resort development is judged to cause serious aggravation to the morphology of the dam reservoir. From these viewpoint, a natural use zone such as lake park and campsite is proposed on a small scale along the left bank about 2 km

downstream from Muda Dam (refer to Fig. 8.2.12). A development zone as recreational area is also proposed on a small scale around the dam site. Aside from the above natural use zone and development zone, the entire lakeshore area is proposed as a nature reserve area.

(4) Zoning in Beris Dam Reservoir Block

As described above, there exists an extensive plain land of about 222 ha along the southern part of the lakeshore where a recreational park is proposed as the development zone on a rather large scale (refer to Fig. 8.2.12). The proposed development zone contains a recreation complex as illustrated in Fig. 8.2.13. A development zone is also proposed around the proposed dam site containing a recreational park and a dam exhibition hall. A bird sanctuary area is also proposed as a natural use zone in the island (refer to Fig. 8.2.12). Aside from the development and natural use zone, the entire lakeshore is proposed as a nature reserve area.

8.3 Management Plan for Sand Mining Operations

Muda River is the biggest source of sand for the states of Kedah and Pulau Pinang. About 1.0 million m^3 of sand are excavated annually for use as construction material on concrete buildings, roads and foundation works. However, riverbed subsidence due to sand mining is so serious that river structures or their functions are threatened to be damaged (refer to Section 2.3).

The present guideline for sand mining operations was reviewed, and field reconnaissance was also made on the present actual mining conditions. Based on these studies, the following items are proposed as major issues for controlling future sand mining operations.

8.3.1 Environmental Impact Assessment and Monitoring Work

According to the present regulation, Environmental Impact Assessment (EIA) is made for development activities with a land size of more than 50 ha. All of the present sand mining operations is, however, made within the limits of less than 50 ha and, therefore, are not subject to EIA. In consideration of the present various adverse

effects of sand mining operations, the present regulation on EIA shall have to be amended and EIA should be required for all proposed mining works. EIA for sand mining operations and the control of sand mining volume shall be made in the following manners:

(a) All river sand mining operations in one river basin shall be integrated into one package, and EIA on the basin-wide mining operation in the past one year shall be annually made for every river basin regardless of the mining size.

(b) An increment of basin-wide mining volume shall be permitted when EIA evaluates that the mining operations in the past one year could not affect any significant river environment. However, the maximum annual increment of basin-wide mining volume shall be limited to 10% of the present volume in order to avoid the drastic alternation on the river environments.

(c) Should EIA evaluate that the basin-wide mining volume in the past one year could cause the significant adverse effects on the river biology, morphology and other related environment aspects, any issue of further license for mining shall be frozen.

The monitoring of sand mining operations is also quite insufficient due to lack of manpower at the related government agencies, and should be improved with particular attention on the benefits to inhabitants. The periodical river channel survey should be also carried out to monitor the effects of the mining works on the river channel. Moreover, a consistent gauging system on the basin sediment yield is urgently required to be established to clarify the relationship between the sand mining volume and the available sand supplied from the basin. Details of the proposed gauging system is described in CHAPTER 9.

8.3.2 Gradual Reduction in Riversand Mining

The design riverbed profile is proposed in CHAPTER 6 to stabilize the riverbed and to increase the river channel flow capacity. To avoid any further adverse effects on the design riverbed profile, the future sand mining volume shall be taken from the

layer between the original riverbed and the design riverbed. The available sand deposit in the allowable mining layer is estimated on the basis of the proposed design riverbed profile and the results of the river channel survey undertaken by JICA in 1994. As the results, the following volumes are taken as the allowable sand deposit for mining operations.

Sand Deposit Allowable for Mining

River System	Stretch	Length (km)	Sand Deposit (m^3)
Main Stream	River Mouth to Muda Barrage	10.4	620,000
Main Stream	Muda Barrage to Merdeka Bridge	2.7	160,000
Main Stream	43 to 50 km upstream from River Mouth	6.7	310,000
Main Stream	63 to 68 km upstream from River Mouth	2.0	130,000
Total		21.8	1,220,000

The above estimated sand deposit is almost equivalent only to the actual annual mining volume in 1993, and out of the total deposit, about 50% (620,000 m^3) is located downstream from Muda Barrage containing salinity. Moreover, the annual basin sediment yield is estimated at about 10,000 m^3 which is much less than the actual mining volume in 1993.

Since the sand deposit for allowable mining is quite limited, and sand supply from the upstream is hardly expected, the riverbed will subside as long as sand mining operations are pursued. In due consideration of these conditions, gradual reduction and finally freezing of sand mining from the riverbed is strongly recommended.

Mining operations shall not be allowed when any of the adverse effects mentioned below are detected and/or expected. Furthermore, whenever any adverse effect or damage happens at the site, the contractor/mining operator shall be required to remedy or repair them at his own expense.

(a) Reduction of river channel flow capacity;
(b) Great hindrance to navigation;
(c) Danger or serious inconvenience to inhabitants; and
(d) Serious influence to vegetation and aquatic life in and around Muda River.

8.3.3 Alternative Source for Construction Sand and Method of Sand Mining

It is indispensable to locate a new mining source aside from the riverbed. In this connection, ocean sand is regarded as the most probable alternative source for sand mining. In Japan, the present major source for sand mining is either the mountains or the ocean, and mining from rivers is less made because of erosion of the river channel. The ratio of sand mining volume from each source in Japan recorded in 1992 are as summarized below.

Sand from the Ocean	36.7%
Sand from the Mountain	36.2%
Sand from the River and Others	27.1%

The method of sand mining from the ocean is classified into two methods as mentioned below. Among them, the pumping method is for fine sand and useful to mine a large volume of sand. On the other hand, the clamshell method is adopted to mine the sand mixed with gravel and other rough materials.

(1) Clamshell Method

The sand is mined by clamshell crawler on pontoon barge. The loadage of the barge is some hundred tons, and the bucket capacity is 1.5 to 3.0 m^3. The sand with sea water is stored in storage container equipped on the pontoon barge, and the sea water is naturally drained into the sea after a certain volume of the sand is accumulated.

(2) Pumping Method

The sand is mind by either suction pump, booster pump or water pump equipped on a pontoon barge. The loadage of the barge is about 1,000 tons.

After mining, the salt (NaCl, KCl, CaCL, MgCl) is removed from the sand for use as concrete material. According to the Japanese Standard (JIS A5308), the sand after removal of salt must contain the salinity deposit (NaCl) of less than 0.04%. The methods for removal of salt are classified into the following four (4) groups:

(1) Pouring Method

Freshwater is poured through either spring cooler or pipe into the mining sand. The necessary water volume is about 0.2 m^3 per sand of 1.0 m^3. The pouring time is about 12 hours including the time to strain out the water from the sand.

(2) Soaking Method

The mining sand is soaked in freshwater. The necessary water volume is about 0.8 m^3 per sand of 1.0 m^3. The soaking time is 12 to 24 hours including the time to strain the water from the sand.

(3) Drying Method

The mining sand is dried under sunshine for more than 2 months.

(4) Mechanical Method

The mining sand is washed by a special plant. The plant developed in Japan requires a large volume of freshwater of about 1.5 m^3 per sand of 1.0 m^3, but the necessary time for treatment is short.

Shells and other deposits must be segregated from the sand. When the mining sand is too fine and its particle size is rather uniform, crushed rock is mixed with the sand to make the appropriate distribution of particle size.

The mining for ocean sand will require additional treatment as well as mining cost as compared with river sand. Moreover, the material of ocean sand is not always applicable to the construction material. Detailed sampling test will be required in advance, and the appropriate area for mining will need to be selected, when ocean sand is applied.

CHAPTER 9. WATERSHED MANAGEMENT AND MONITORING PLAN

9.1 Purpose of Watershed Management and Monitoring Plan

Government agencies and/or private firms are taking various basin development activities such as urban, agricultural and industrial development in the Muda river basin. These basin developments are closely related to the river management works, and possibly cause adverse effects on the river functions as enumerated below, unless appropriate coordination is made between the basin development and the river management works.

(a) Increment of basin flood runoff discharge and increment of properties in probable flood inundation areas that could increase flood damage potential;

(b) Aggravation of low flow regime and excessive growth of water demand inducing unstable water supply from the river; and

(c) River water pollution caused by increment of pollutant sources in the basin affecting fauna and flora and other river environments;

To minimize the above adverse effects, monitoring and management works are required for both the river and the basin with the following objectives:

(a) For River: Hydrology (river water level and discharge), morphology (river channel meandering, erosion and sedimentation), biology (fauna and flora), water quality, and scenery.

(b) For Basin: Structural development (urban and industrial development), agricultural activities, mining activities in and around the river channel, and logging activities.

In this Study, a zoning plan for the monitoring and management is proposed to specify the boundary for jurisdiction of river basin management and monitoring on the aforesaid items. Moreover, details of river basin monitoring and management objectives are clarified for each of the proposed zones, and a hydrological and water quality monitoring network is proposed to facilitate river basin monitoring works.

9.2 Zoning Plan for Watershed Management and Monitoring Plan

9.2.1 Overall Zoning Plan

The proposed zoning is divided into three (3) major classifications; namely, (a) water source reserve area, (b) river reserve and controlled area, and (c) potential land development area. The water source reserve area aims at basin-wide preservation, in particular, to the upper reaches of Muda River that play a major role of river water source. On the other hand, the river reserve and controlled area focuses on preservation of the river and its surrounding river corridor. The potential land development area is defined as the area other than the above reserved areas where land development and/or activities are not subject to monitoring. The extent, purpose and required management activities for each classified zone are as shown in Tables 9.2.1 and 9.2.2 and in Fig. 9.2.1.

Delineation of the above river reserve area has been proposed by DID for years but not successfully executed for the Muda river basin. In contrast with the river reserve area, the water source reserve area is newly delineated in this Study in due consideration of the necessity to preserve the basin runoff condition.

As described later, an integrated river management body is proposed with a three- tier structure composed of the Muda Council at the top supported by a Technical Committee at the second level and a Technical Secretariat at the third level. All river basin management and monitoring will be undertaken by the council. On the premise of this integrated river management body, detailed management and monitoring works for each reserve area proposed are as described in the following subsections.

9.2.2 Water Source Reserve Area

The proposed Beris and Reman dam reservoirs are surrounded by considerable agricultural land, and could be in danger of serious aggravation by polluted water and sediment load produced from the agricultural land.

Aside from these agricultural lands, the upper reaches of Muda River is now mostly delineated as forest reserve area. The management of the forest reserve area is, however, solely made by the Department of Forest and the excessive logging may

aggravate the basin runoff conditions and the water quality of the river flow and/or dam reservoir.

In due consideration of the above conditions, the actual logging as well as agricultural activities in the water source reserve area are proposed to be monitored and to relate them with the river hydrology, biology, water quality and morphology. The major purposes of the water resource reserve area are as enumerated below:

(a) To preserve the appropriate basin runoff discharge and sediment load;

(b) To restrain polluted water loads flowing out from the basin; and

(c) To protect the morphology of the dam reservoir from the undesirable activities along the lakeshore.

The proposed water source reserve area shall cover the catchment area of the existing Muda Dam, the proposed Beris Dam, and the Jeniang Barrage. The present major forest reserve area located in the upper reaches is also added to the water reserve area. Hence, the water source reserve area comes to about 2,529 km^2 or 60.1% of the entire Muda river basin. The water source reserve area is further divided into the present forest reserve area of 2,211 km^2 and agricultural area of 318 km^2 corresponding to about 52.5% and 7.6% of the basin total, respectively.

The water source reserve area overlaps with the forest reserve area and the agricultural land. The State Authority appointed the Department of Forest as a legal controller for the forest reserve area and the Department of Land and Mining for the agricultural land. The overlapping area is rather extensive, and it is deemed difficult to transfer such present jurisdiction to the proposed river management body. Due to this situation, it is proposed that the river management body will not directly control the reserve area. Instead, the body will monitor the logging and/or agricultural activities and will provide the technical reference related to the river conditions to the present legal controllers and/or the State Authority.

The water resource reserve area proposed above is further divided into the following six (6) sub-zones, to clarify more definitive monitoring and management objectives for each sub-zone (refer to Table 9.2.2 and Fig. 9.2.1).

(1) Zone 1

Zone 1 is proposed to cover the present forest reserve area of 240 km^2 surrounding the existing Muda Dam and the proposed Beris Dam. The zone is to be used as a buffer between the dam reserve area and its adjacent land. The area for Muda Dam is called "the catchment area" of 155 km^2 by the Department of Forest, where excessive logging activities are controlled to avoid aggravation of the dam environment. As for the area of Beris Dam, the whole present forest reserve area of 85 km^2 in the dam catchment area is included in Zone 1.

A research on the effect of logging activities on the basin runoff conditions was started in 1994 in the present forest reserve area of about 830 ha located in the upper reaches of Ketil River. The research is jointly undertaken by the Department of Forest, the Forest Research Institute, DID and the University of Pertanian Malaysia. Zone 1 will directly influence the morphology of the dam reservoir, and legal arrangement is proposed to be obtained to freeze all logging activities in Zone 1 for the time being until the effects of logging activities to the dam reservoir are clarified through the ongoing joint research.

(2) Zone 2

Zone 2 is proposed to cover the present forest reserve area of 829 km^2 located in the catchment area of Muda Dam. The river management body will monitor the logging activities as well as the basin runoff discharge and sediment yield, and provide the technical reference about ongoing logging activities to the Department of Forest when the conditions of basin runoff and sediment yield are judged to be seriously affected by the logging activities.

(3) Zone 3

Zone 3 is proposed to cover the agricultural land located in the catchment area of the proposed Beris Dam and the Reman Dam. The size of Zone 2 is 63 km^2 which is divided into 31 km^2 for Beris Dam and 32 km2 for Reman Dam. The river management body will monitor all of the agricultural activities and alienation or temporary occupation of the land. At the same time, the body will monitor the basin runoff discharge, pollution load and sediment load to the dam reservoir. Based on the monitoring results, the river management body will

provide the technical reference pertaining to the land activities to the Department of Land and Mining Office when the river environment are judged to be seriously affected by them.

(4) Zone 4

Zone 4 is proposed to cover the present forest reserve area of 1,142 km^2 located in non-catchment area of the existing and proposed dams. The river management body will monitor the logging activities and relate them with the natural river conditions (river hydrology, biography, morphology and water quality). Based on the monitoring results, the river management body will provide the technical reference as in Zone 2.

(5) Zone 5

Zone 5 is proposed to cover the agricultural land of 89 km^2 located in the catchment area of the proposed Jeniang Barrage but out of the dam catchment area in the upper reaches.

Muda Dam is located about 40 km upstream of Jeniang Barrage, impounding all basin runoff discharge and conveying it to Pedu Dam. As the result, the river maintenance flow could be released solely by the proposed Beris Dam, and no river maintenance flow is guaranteed for the river stretch between the Muda dam site and the confluence with Beris River. Due to this, the river water quality could be possibly aggravated, should excessive basin development be induced along the river stretch. To prevent such aggravation, monitoring and management of basin development in this zone is indispensable.

The river management body will take the same basin monitoring objectives as those for Zone 4 and relate them with the natural river conditions (river hydrology, biography, morphology and water quality). Based on the monitoring results, the river management body will provide the necessary technical reference to the Department of Land and Mining.

9.2.3 River Reserve and Controlled Area

The various land development activities such as urban, industrial and agricultural development is now expanding to the riverside area. In parallel with such land

development, land acquisition for the river improvement works tends to be difficult. At the same time, the flood damage potential is going to increase, and the river morphology as well as the river environment are seriously affected by the land development activities. In due consideration of these conditions, the major purposes for the river reserve and controlled area are placed on the following items (refer to CHAPTER 6):

(a) To facilitate river improvement works;

(b) To preserve the natural flood retarding effects and protect the river from the undesirable activities; and

(c) To minimize the damage caused by flood inundation and channel erosion and/or meandering.

The river reserve and controlled area is limited to the possible flood inundation area extending in the lower and middle reaches of the river basin. Details of the extent have been determined through the study on flood mitigation plan in CHAPTER 6. Moreover, the detailed zoning plan within the limits of the river reserve and controlled area is proposed as a part of the river environmental management plan, as described in CHAPTER 8.

The river reserve and controlled area is significant in particular for controlling the present excessive sand mining activities on Muda River, and it is deemed necessary that the river management body will take jurisdiction over the reserve area.

9.3 Objectives of Watershed Management and Monitoring

The river management body will integrate the various monitoring items related both to the river conditions and the land development activities in the water source reserve area and the river reserve area (refer to Table 9.3.1). Based on the integrated monitoring data, the river management body will execute the short-term actions for flood mitigation works, water allocation, and river environmental improvement works. The body will also formulate the long-term basin development and management plans. The proposed monitoring items are as discussed below. The

proposed river management works are carried out on the basis of the monitoring results, as shown in Table 9.3.1 and Fig. 9.3.1.

(1) Monitoring on Hydrological Data

The data include basin rainfall, river water level/discharge, sediment load, water quality and inflow/outflow of the dams and barrages. The data are presently gauged by DID in the states of Kedah and Pulau Pinang, PWA and MADA. The existing gauging network will be built-up as described in the following Section 9.4. In the proposed system, the present competent agency on the actual gauging works will remain as it is, but the gauged data will be integrated by the river management body.

(2) Monitoring on Water Abstraction Volume from Muda River

The water abstraction volume at each intake point is monitored independently by competent government authorities such as DID, PWA and PWD. In the proposed system, the water abstraction volume at each intake is calibrated and the monitored data will be integrated by the river management body so as to execute the appropriate water allocation for each water user. The calibration will be entrusted to the present competent government agencies based on the specification as well as budget of the river management body.

(2) Monitoring on Land Development/Activities and Construction of Infrastructure

The local government or other competent government authorities will inform the river management body about the structural plan for urban and industrial development and/or the alienation or temporary occupation of the land. The river management body will also directly monitor the excessive agricultural activities in the dam catchment area.

(3) Monitoring on Sand Mining and River Morphology

River channel erosion extensively occurs due to the present excessive sand mining operations. In this connection, the sand mining activities as well as the related river morphology are being monitored by DID in the states of Kedah and Pulau Pinang. In the proposed system, the monitoring data will be transferred to the river management body.

(4) Monitoring on Other Items

The flood damage conditions are surveyed by DID after every major flood inundation occurs and submitted to the DID HQ. Survey on fauna/flora and navigation in Muda river system are also monitored by the Department of Wildlife and Natural Park and the Department of Fisheries, respectively. In the proposed system, the results of these surveys will be integrated by the river management body.

9.4 Proposed Hydrological Monitoring Network

The overall monitoring measures will be classified into the following five (5) groups according to the aforesaid proposed monitoring items (refer to Table 9.3.1):

(a) Hydrological gauging to monitor rainfall, basin runoff discharge and sediment load;

(b) Sampling and laboratory tests to monitor water quality;

(c) Field survey (river channel survey) to monitor the river morphology;

(d) On-site inspection to monitor the sand mining operations, construction of river structures, fauna/flora and flood damage; and

(e) Notification from competent government authorities to know the water abstraction volume from the river and the detailed applications for sand mining operations, the land development, construction of river structures and navigation.

Among the above monitoring measures, major facilities are required for the hydrological gauging under items (a) and (b). In this connection, the integrated hydrological gauging networks for items (a) and (b) are newly proposed as described in the following subsections.

9.4.1 Reference Point

The present monitoring network is not consistently arranged for the sake of integrated river monitoring and management. For instance, the water level gauging stations are

independently monitored by the State DID of Kedah and Pulau Pinang at almost the same locations but on the opposite banks along the state boundary located downstream from Ldg. Victoria. Due to the present conditions, integrated reference points are proposed to consistently monitor the river hydrology and water quality. The location of the reference points are selected considering the locations of the existing gauging stations, the confluence of the major tributaries and the major river structures (refer to Table 9.4.1 and Fig. 9.4.1), as below.

Proposed Reference Points in Muda River System

Principal Reference Point (Class 1)			Sub-Reference Point (Class 2)		
Name	River	Catchment Area (km^2)	Name	River	Catchment Area (km^2)
(1) Muda Dam	Muda	984	(1) Telui Timor	Muda	2,377
(2) Jeniang	Muda	1,740	(2) Reman Dam	Reman	32
(3) Jam. Syed Omar	Muda	3,330	(3) Batu Lima	Chepir	233
(4) Ldg. Victoria	Muda	4,010	(4) Muda Barrage	Muda	4,201
(5) Beris Dam	Beris	116	(5) Merbau Pulas	Sedim	219
(6) Kuala Pegang	Ketil	704			

As listed above, the proposed reference points are classified into the principal and sub-reference points. The principal reference points (Class 1) are placed along the main stream of Muda River and/or downstream of the major tributaries. The data monitored at the principal reference points are used as the principal information for all river management works including flood mitigation, water resources management and sediment control. Accordingly, the monitoring works need to be constantly made throughout a year including the flood and low river flow regime. The objectives of monitoring at the principal reference points will include the water level, the runoff discharge (dam inflow/outflow discharge in case of Muda and Beris dams), water quality, sediment load and fluctuation of the river channel cross-section. Furthermore, priority on-line system is given to the data transmittal of runoff discharge monitored at the principal reference point.

The sub-reference points (Class 2) are placed to supplement the information for water allocation and/or flood mitigation works. Among the sub-reference points, those at Muda Dam, Beris Dam and Reman Dam will be used to monitor the dam inflow discharge and the flood discharge spilled over the dam. As for the reference point at Telui Timor, the monitoring works are carried out during the period of low flow

regime for the sake of water allocation. The principal objective of monitoring at these sub-reference points will be the runoff discharge.

In addition to the above reference points (Class 1 and Class 2), those for Class 3 are proposed for the purpose of flood forecasting. The reference points for Class 3 are placed at four (4) sites of the existing gauging stations controlled by DID (refer to Table 9.4.1).

9.4.2 Rainfall Gauging Network

There exist 15 rainfall gauging stations in the Muda river basin. These gauging stations are, however, unevenly distributed in the lower reaches of the basin. Out of the existing gauging stations, only two (2) stations are located in the proposed water source reserve area, as shown in Fig. 9.4.2.

This uneven distribution is attributed to the difficult accessibility to the mountainous side in the upper reaches. Nevertheless, the proposed water source reserve area is regarded as a hydrological blind area at present, and it is difficult to evaluate the basin runoff discharge under the present rainfall gauging network. For this reason, 10 rainfall gauging stations are newly proposed to monitor the rainfall conditions principally for the water source reserve area (refer to Table 9.4.2 and Fig. 9.4.2). All proposed rainfall gauging stations are accessible via the existing road or the waterway.

Muda river basin will have 25 rainfall gauging stations in total for the whole catchment area of 4,210 km^2 when all gauging stations are installed. Thus, the average coverage per gauging station could reach about 170 km^2 which is not enough but available to evaluate the basin average rainfall.

9.4.3 River Water Quality and Hydrological Gauging Network

Gauging stations are proposed for each reference point as described below.

(1) Class 1 Gauging Station

The stations are placed at the principal reference points to monitor all hydrological items of water level, discharge and sediment load both for flood and low flow terms, and also to periodically monitor the water quality.

(2) Class 2 Gauging Station

The stations are placed at the sub-reference point to monitor the above items for Class 1 other than the sediment load. Out of the stations, however, the station at Kuala Pegang is now used as a flood forecasting station, therefore, the flood water level is also monitored at the station.

(3) Class 3 Gauging Station

These are placed at the present water level gauging stations to monitor the flood river flow for the purpose of flood forecasting and warning.

The total number of proposed gauging stations is 15, composed of 6 for Class 1 station, 5 for Class 2 station, and 4 for Class 3 station. All stations for Class 1 are converted from the existing gauging stations, therefore, their hydrological data so far recorded could be incorporated into the further monitoring works (refer to Table 9.4.1). On the other hand, the Class 2 gauging stations are newly proposed, except the station at Muda Barrage, to supplement the present hydrological gauging network.

9.5 Necessity of Nationwide River Information System

To realize a well-balanced basin development, this Study proposes, in addition to the various structural measures, the following non-structural measures: (1) institutional setup for the river management body; (2) zoning to delineate the boundary of jurisdiction for river management; and (3) establishment of integrated river monitoring system.

In Malaysia, the comprehensive river basin management plan is the first attempt in case of Muda River, and has never been implemented for other rivers. Accordingly, the results of this Study should be used as a model case and applied as a guide and reference for other rivers in the country.

In the country, there are more than 1,500 rivers experiencing habitual flood inundation and the recurrent shortage of water supply. Deterioration of river conditions could be attributed specially to the lack of non-structural river management measures. In this connection, the first step for the comprehensive river

basin management must be given to such non-structural measures as institutional setup of a nationwide river management body, zoning for jurisdiction of river management, and the establishment of a river monitoring system on a nationwide scale.

Among the above three non-structural measures mentioned above, essentially required is the nationwide river monitoring system for the purpose of planning and design, as well as development and regular management for the rivers, so that prompt action can be taken whenever necessary. The river information to be monitored by the system will be voluminous and dynamic in nature, requiring frequent updating and systematic storage. A computerized information system is therefore essential to improve in efficiency and effectiveness in the management of rivers.

The Government of Malaysia is keen to establish the nationwide river information system through the technical cooperation program of Japan. This nationwide river information will be useful for the aforesaid comprehensive river basin management and, therefore, its early implementation is strongly recommended.

CHAPTER 10. INSTITUTIONAL SETUP FOR RIVER MANAGEMENT

10.1 Optimum Institutional Arrangement for River Management

There are two major problems faced in the management of water resources of the Muda River. The first problem is the lack of an inter-agency coordinating body within each of the concerned states. As a result, various inconsistent river management practices are carried out in the states of Kedah and Pulau Pinang.

The second problem is the lack of an interstate coordinating body for river management among the states of Kedah, Pulau Pinang and Perlis. A majority of the catchment area of Muda River lies in the State of Kedah, and the downstream stretch of the river of about 20 km flowing into the sea forms the boundary between the states of Kedah and Pulau Pinang. However, over 80% of the total water used in the State of Pulau Pinang is drawn from Muda River for domestic and industrial purposes as well as for agriculture. In spite of the shared lower stretch of the river and shared utilization of the water resources of Muda River, there is no integrated coordinating body or any agreement between the states of Kedah and Pulau Pinang.

To ensure that a comprehensive management plan for Muda river basin is properly implemented and administered, three alternatives for the institutional setup of Muda river basin are proposed. The first calls for Muda River to be declared an interstate river, thereby placing it under Federal jurisdiction. Under the Legislative List in the Federal Constitution, Ninth Schedule, Item II includes in the Federal List Federal works and powers, including '(b) Water supplies, rivers and canals, except those wholly within one state or regulated by an agreement between all the States concerned;' ..."

Since Muda River is not wholly within one state (the last 20 km stretch of the river flowing into the sea is shared) and there is no agreement between the states concerned, it is legally possible for parliament to pass an Act placing Muda River under Federal jurisdiction. However, this process is rather tedious and can become an issue affecting State-Federal relationship. In addition, after the passing of the Federal Act, the actual establishment of a Federal Agency to manage Muda river basin can be expensive and will take time. Hence this alternative is not recommended.

The second alternative is to promote an interstate agreement to be signed between the states of Kedah and Pulau Pinang. In 1963, an unsuccessful attempt was made to sign an agreement between the states concerned as part of the conditions for the World Bank Loan for the construction of the Muda Barrage. Since then there has been no further attempts, the chances for an agreement appears to be slim at this stage. Hence this alternative also is not recommended.

In due consideration of consistency with the existing government structure, the following third alternative is proposed to organize three-tier structure of the river management body including the Muda River Basin Management Council at the top supported by a Technical Committee at the second level, and a Technical Secretariat.

Composition	Members	Functions/Scope of Works
Muda River Basin Management Council	1. EPU of Kedah and Penang 2. DID of Kedah and Penang 3. MADA 4. PWA 5. Department of Lands and Mines of Kedah and Penang 6. Forestry Department of Kedah 7. Water Supply Division of Kedah PWD	1. To approve Long-Term and Five-Year Basin Water Resources Development and Management Master Plan; 2. To approve basin policies on water use priorities and allocation, flood mitigation measures, river reserves, river environment management, etc.; 3. To approve emergency actions to be taken during extreme droughts and floods 4. To approve water pricing policies both for the water abstraction from and water discharges into the Muda River.
Technical Committee	1. DID of Kedah and Penang 2. MADA 3. PWA 4. Water Supply Division of Kedah PWD 5. Forestry Department of Kedah 6. Town and Country Planning Department of Kedah 7. Lands and Mines Department of Kedah and Penang	1. To promote and implement rational management of water resources of the Muda River Basin through integrated and coordinated planning of water resources development 2. To prepare the Long-Term and the Five-Year Basin Water Resources Development and Management Master Plan of the Muda River basin 3. To establish procedures so as to determine water use priorities during periods of inadequate water supplies due to drought or other causes 4. To establish guidelines and procedures for the prevention and control of flooding, soil erosion and damage to catchment areas and water causes 5. To formulate policies and legal provisions for the management of the Muda River Basin for consideration and endorsement by the Muda River Basin Management Council; 6. To coordinate and integrate the different development and management plans and projects of the various department and agencies within the Basin; and 7. To coordinate land use planning and land use changes with water resources planning, development and management of the Basin.
Technical Secretariat	Federal Unit of DID	1. To collate all the hydrological data, water extraction data, water use data, water pollution data, etc., from the existing government departments and agencies in the states of Kedah and Pulau Pinang; 2. To collate all development plans, management plans, design standards, etc., for the preparation of the preliminary Long-Term and the Five-Year Basin Development and Management Master Plan; 3. To monitor all activities related to the Muda River Basin which have major negative impacts on the water resources of the Basin; 4. To submit proposals to the Technical Committee on resolving issues and problems encountered in the implementation of the Master Plan; 5. To prepare procedures for the consideration of the Technical Committee on proper management of sand mining, designation of river reserves, and issues related to the management of the Basin; 6. To act as the River Administrator of the Muda River where appropriate, and with endorsement of the Muda River Management Council 7. To enforce the emergency actions to be taken during droughts and floods as and when directed by the Muda River basin Management Council.

Through a series of discussion with and agreements from the officials concerned to the State Governments of Kedah and Penang, the following arrangements for the above organization are provisionally proposed:

(a) The Muda River Basin Management Council shall be chaired by an appropriate Executive Council Member of the State of Kedah and the Secretariat to the Council shall be the Kedah State Economic Planning Unit;

(b) The Chairman of Technical Committee shall be the Director of the River Division of the Federal Department of Irrigation and Drainage; and

(c) The Technical Secretariat shall be a Federal Unit under the Director of River Engineering Division of the Department of Irrigation and Drainage and shall be established in the office of the Kedah State Department of Irrigation and Drainage.

As described above, both of the Chairman and Secretariat for the Muda River Basin Council are entrusted to Kedah State Government instead of the neutral organization. This proposed setup is, however, agreed by both of the Economic Planning Units of Kedah and Penang State. Moreover, it is immaterial to which State Government the tasks of Chairman and Secretariat are entrusted. The important point is to ensure the function of the Technical Committee and Technical Secretariat as proposed, and to prepare an acceptable Long-Term and Five-Year Master Plan.

It is further noted that in the event that the Muda River Basin Management Council cannot reach a consensus or an agreement on any matter, particularly on matters of an interstate nature, the aggrieved party/State may appeal to the Northern Region Committee for a decision. The members of this Northern Region Committee are the Menteri Besar of the states of Kedah, Perlis and Perak, and the Chief Minister of the State of Pulau Pinang.

10.2 The Long-Term and Five-Year Development and Management Master Plan

To promote the rational management of the Muda river basin, long-term and 5-year policy plans should be prepared for the optimum development, use, conservation and

protection of its water resources. The long-term and 5-year basin development and management master plans prepared by the Technical Secretariat should propose actions concerning the following subjects:

(1) Water Demand

The Plan should separately identify existing and projected domestic, industrial, and irrigation water demand and river maintenance flow. A list of specifically identified works or actions to be undertaken within 5 years and within 20 years for the purpose of satisfying existing and projected water demand should be included.

(2) Flooding and Drainage

The Plan should identify areas where there exists a substantial risk of flood damage as well as urban areas suffering from inadequate drainage. A list of specifically identified works or actions to be undertaken within 5 years and within 20 years to mitigate flooding or improve urban drainage should also be included.

(3) Water Conservation

The Plan should describe all presently existing circumstances involving a substantial waste of water as well as all actions which shall be taken to conserve water. A list of specifically identified conservation measures to be undertaken within 5 years and within 20 years should also be included.

(4) River Reserves

The Plan should describe the width of land along the riverbanks to be gazetted as river reserves. A list of specifically identified works or actions to be undertaken within 5 years and within 20 years to develop recreation areas and to beautify the area should be included.

(5) Emergency Action

The Plan should describe the action which shall be taken, when one or both the states are affected by drought, flooding or other natural or man-made disasters. Such actions may include, but are not limited to, reduced or terminated water

diversions by any person or any sector of the economy; the institutional or diversion priorities for particular users; and the establishment of a command structure to deal with water-related emergencies.

(6) Water Pricing Policy

The Plan should include a description of the pricing policy which will apply to the distribution of water for domestic and industrial purposes from public water supply works. Such policy should be founded upon the principle that the beneficiaries of water resources projects are expected to pay; provided that for the purpose of ensuring the minimum necessities of life, a limited amount of water may be supplied for domestic purposes at a subsidized rate. A pricing policy should also be developed for the distribution of water for irrigation purposes which policy will encourage the optimum use of land and discourage the waste of water.

One of the means to discourage the waste of water is to introduce a pricing policy with different rates dependent on the season of the year. During the wet months when water is in abundance, normal rates are charges. However, during dry months or drought periods, higher rates should be charged to reduce the unnecessary use or the wastage of water. By the same token, paddy farmers who are advised to forego planting due to lack of water will be compensated for the quantity of water not utilized or saved.

At present daily domestic and industrial water use is not metered. To increase irrigation efficiency and to charge irrigation water use, the proposed Technical Secretariat shall meter the quantity of water used by each farmer or by a group of farmers. In the absence of any measurement on irrigation water use, an assessment on water not utilized or saved during droughts will have to be made based on past data. From the assessment, some form of compensation can be paid to the farmers.

Since water charges on domestic and industrial as well as irrigation water usage during droughts will be increased, the additional revenue collected could go toward payment of the compensation. to those who forego planting during

droughts. The detail implementation procedures will have to be worked out as one of the tasks of the Technical Secretariat.

(7) Water Project Financing Policy

The Plan should contain financing policy to apply to water resource development works including, but not limited to, multipurpose and interbasin transfer projects for the next five years. Such policy should describe the cost allocation practices to be followed in water project financing by the states and federal governments. In the development of such a policy, consideration should be given to the following factors: the relative financial position of the two states, the distribution of project benefit among and between the Federal Government, the two states and the private sector; the distribution of project impacts including direct and indirect social, economic and environmental impacts among and between the Federal Government, the two states and the private sector; and in the case of multipurpose projects, the relative cost of project components and their beneficiaries.

(8) Water Policy use

The Plan should formulate a Water Use Policy for the basin. The policy should include, but not necessarily be confined to the following:

(a) Order of priority for water use during drought;

(b) Relocation of heavy water user(s) from water scarce area(s) to water abundance area(s);

(c) Conversion of heavy water user(s) activities to low water user(s) activities;

(d) Water use charges for raw water and treated water; and

(e) Compensation or incentives to be provided for stoppages or savings in water use.

10.3 Implementation of the Proposed Institutional Setup

The proposed institutional setup can be established with the existing government departments and agencies . There will only be one new unit, the Technical Secretariat, which will be seconded from the Federal Department of Irrigation and Drainage, to the Kedah State Department of Irrigation and Drainage. Thus, the proposed institutional setup can be established almost immediately with minimal additional costs.

The existing government departments and agencies in the states of Kedah and Pulau Pinang will continue with their normal activities, but with the additional responsibility of having to integrate, cooperate and work closely with the Technical Secretariat.

The initial task of the Technical Secretariat will be to implement the Comprehensive Management Plan of Muda River Basin. As a start, it will be the central collating organization for the monitoring system of Muda river basin. It will not immediately take over the existing monitoring activities of the various government departments and agencies, but will complement and enhance the existing monitoring system by advising on additional monitoring required and providing some funds from the Federal Government for the purchase of new equipment. The Technical Secretariat will also collate and integrate all existing data collected and carry out studies and analysis on the data when necessary. As the Technical Secretariat becomes better established, it can and should slowly take over the operation and management of the whole monitoring system of Muda river basin in an integrated manner.

On water resources management, the Technical Secretariat will prepare the water allocation policy of the Basin based on the present and projected future demands of the various water users, and between the states of Kedah and Pulau Pinang. It will also prepare procedures for water allocation during serious drought years. The draft policy and procedures will be forwarded to the Technical Committee for study and reviewed before finalizing of approval by the Basin Council

As the State Irrigation and Drainage departments of Kedah and Pulau Pinang are in charge of flood mitigation management in their respective states, the Technical Secretariat shall request and advise the State Irrigation and Drainage Departments to prepare structural measures for flood mitigation along their respective bank of Muda

River. The Technical Secretariat will then integrate the plans with the overall flood mitigation plan of the upper basin and submit it to the Technical Committee and the Basin Council for study and approval. The Technical Secretariat is a new unit under the Director of River Engineering Division of Federal Department of Irrigation and Drainage. However, it will be supported by the River Engineering Unit of Kedah State Department of Irrigation and Drainage for the day to day running of the Office. These situations for Technical Secretariat will be similar to those for Muda Office under Federal Department of Irrigation and Drainage. The Technical Secretariat will also collate the hydrological data being separately collected by the Hydrological Unit of Departments of Irrigation and Drainage of Kedah and Pulau Pinang States, and utilize these data for analysis and management purposes. These functions of Technical Secretariat will be complementary and supplementary but not duplicate to the works being presently carried out by the River Engineering and Hydrological Units of State Department of Irrigation and Drainage.

The Technical Secretariat should initially take over the responsibility, from the State Department of Irrigation and Drainage of each state, of providing technical guidelines on sand mining to the Land Office. By so doing, the Technical Secretariat will be able to integrate all sand mining activities along the whole Muda River. Eventually, at an appropriate time, the Technical Secretariat should be delegated the powers under the Water Enactment, which will effectively make it the River Administrator, The Technical Secretariat will then be responsible for the issuance of abstraction and impounding licenses to water users, sand mining licenses and licenses for water discharge points into the river. With the power for licensing, the Technical Secretariat will also have the power to collect fees and to prosecute offenders. All these powers will of course be under the supervision of the Basin Council.

With regard to the integration of land use changes and water resources management, the Technical Secretariat will be the coordinating body between the various government departments and agencies involved in land use conversion, land development, forest logging, etc. In the long term, the structural plans of local authorities should be extended to cover the whole Muda river basin. This would include non-urban areas as well as water catchment areas and river reserves, the management of which must be integrated with water resources management of the Basin.

To offset part of the cost for the integrated management of Muda river basin, the Council could consider charging fees for the direct abstraction of water from Muda River by the main water suppliers. The charge to be levied will be based on the quantity and the usage of the water suppliers. A fee could also be levied on the discharge of water from point sources, and the charge will be based on the quantity and the level of pollution of the water being discharged at each point.

At present, there is no charge on the water abstraction or the water diverted from Muda River by the government department and/or agencies. However, it would be appropriate to institute some administrative or legal provisions to charge all abstraction or diversion of water from the Muda River. As for private abstraction, the waters enactment has provisions for the collector of land Revenue (PHT) to charge the water users. Thus, if the proposal to charge all abstraction, whether private or government, then the collector of Land Revenue can do the collection, while the Technical Secretariat will issue the monthly or bimonthly bills to the Land Office. The same procedure can be followed for the collection of fees for water being discharged into Muda River by Town Councils and Industries.

10.4. Regional Water Resources Development Corporation

Both the National Water Resources Study, Malaysia (JICA, October 1982) and the Consultancy on National Water Law - Malaysia Report by Mr. Gregory K. Wilkinson, Legal Officer, FAV, 1984, proposed the establishment through legislation of a Regional Water Resources Development Corporation for the Perlis-Kedah-Pulau Pinang Region. The functions of the Corporation are to construct, operate and maintain the multipurpose, interstate and inter-basin water resource projects which are identified and approved by the Muda River Basin Management Council. The Corporation will be under the authority of the Muda River Basin Management Council. In the mid to long term, the Corporation could replace the Technical Secretariat, thereby corporatizing and eventually privatizing the whole operation and maintenance of source works, and leaving the existing specialized departments and agencies to continue with the distribution of water to the users.

CHAPTER 11. CONSTRUCTION PLAN AND COST ESTIMATE

11.1 Construction Plan

The construction plan is prepared for the structures proposed for three (3) major sectors of the flood mitigation plan, the water resources management plan and the river environmental management plan.

11.1.1 Basic Conditions for Construction Works

The following basic conditions are employed for the construction plan.

(1) Construction Materials

The price of basic construction materials such as cement, reinforcement bars, bitumen, diesel oil, and gasoline is controlled by the Government. The unit prices of these materials including some other major ones are shown in Table 11.1.1. Labor wages are also shown in Table 11.1.2. The availability of construction materials in and around Muda river basin is as described below.

(a) Sand

The middle and lower reaches of Muda River is the major source of sand in and around the river basin. Sand mining is being carried out by private firms and fluctuates to a certain extent in accordance with the demand of construction works. The quality of sand from Muda River is generally good and utilized as fine aggregate for concrete. There are also the sand quarries at Karangan in Kulim District and at Terap in Kuala Muda District. They are classified as second class and often used for plastering because of mixture with very fine materials.

(b) Coarse Aggregate

Gravel is available in Pendang, Sik, Baling and Kulim districts which are located in the middle reaches of Muda River. The size and amount of deposits vary depending on the location of the mining area. The types of deposit are mainly granite and limestone. In addition to these quarry sites,

Syarikat Bina & Kuari Kedah Sendivian Co., Ltd. has a granodiorite quarry at the foot of Mt. Perak in Pendang District which is located at around 16 km north of the Jeniang Transfer Canal project site. Crusher run, aggregate for concrete and asphalt are available here.

(c) Cement

The following cement factories are located in and around the Muda river basin:

Factory	Location	Brand
Cima	Chuping, Perlis	Lion
Kedah*	Langkawi, Kedah	Tiger
Perak-Anjung	Bt. Berapit, Perak	Camel
Tasik Cement	Ipoh, Perak	Crocodile

* Cement produced is mainly for export.

Perak-Anjung Cement was recently established and the other cement manufacturers are also upgrading their production facilities to cater to the increasing demand in the construction sector. The supply of cement has been satisfactory for the past few years.

(d) Steel Material

The manufacturing and supply of steel material are made only by Malayawata Company which is located at the Prai industrial area in the State of Penang. Steel products imported from Korea, Japan or some other countries are generally used in construction works.

(e) Timber

Plywood is the typical material of formwork. There are many manufacturers and suppliers, and shortage of the material has never been reported.

(2) Accessibility

Accessibility to the site is as described below.

(a) Port of Disembarkation

Three major ports are available for handling international and domestic cargoes. Port Klang near Kuala Lumpur and Butterworth Wharf in Prai are equipped with container handling facilities. Penang Port on Penang Island is also used for unloading bulk cargo, but container handling facilities are not available.

(b) Road

Penang Island and the mainland are linked by Penang Bridge, the length of which is about 13.5 km. A dual-carriage north-south national highway is available from Port Klang, Butterworth to Sungai Petani, Gurun and Alor Setar.

(c) Railway

The national railway has a cargo service and connects Port Klang, Butterworth, Sungai Petani and Alor Setar.

(3) Workable Days

The number of holidays and weather conditions, especially daily rainfall data, are used as the basic data to estimate possible workable days for the construction works.

(a) Public Holidays

Most of the public holidays in Malaysia are based on religious belief or customs. In public offices in the State of Kedah, Thursday is a half-working day and Friday is a non-working day instead of Saturday and Sunday. Thus, Fridays, national holidays and religious event days are considered as non-workable days.

(b) Daily Rainfall Record

The daily rainfall records from "Jeniang Klinik" near the proposed Jeniang Barrage were collected and the records from 1979 to 1988 were analyzed.

(c) Possible Workable Day

Both concrete and earth works are not possible in rainfall of more than 5 mm/day, and the number of possible workable days amounts to 295 annually. Moreover, earth works have suspended days according to the daily rainfall shown in the table below; therefore, the annual average workable days for earth works is decreased to 212 days.

Daily Rainfall Depth (mm)	No. of Suspended Days
5 < R < 10	0
10 < R < 15	0
15 < R < 30	1
30 < R	3

(d) Daily Working Hours and Work Shift

All construction works will be implemented under a single shift of 9-hour labor including 2-hour overtime per day.

(e) Construction Method

Standard construction methods will be adopted in combination with the equipment available in Malaysia and other countries.

11.1.2 Structural Design

The structural features proposed for the three (3) sectors are estimated as below:

(1) Flood Mitigation Plan

The principal features for the proposed river improvement works are as below:

Work Item	Unit	Work Volume			
		Lower Muda	Kuala Ketil	Baling	Sik
Improvement Length	km	40.30	2.79	0.75	0.8
Excavation/Dredging	10^3 m^3	10,400	522	37.5	6.2
Embankment	10^3 m^3	1,100	22.4	12.8	14.4
Revetment	10^3m^2	83	23.1	12.1	13.6
Sluices Constructed	place	28	3	2	2
Barrage Reconstructed	place	1	0	3	0
Drops Reconstructed	place	0	2	0	0
Pump Stations Relocated	place	3	0	0	0
Bridges Reconstructed	place	2	1	0	0
Bridges Reinforced	place	3	0	0	0
Land Acquisition	ha	510	11.8	2.3	1.5
House Evacuation	house	189	9	28	12

Among the above work items, reconstruction of the existing Muda Barrage is enumerated as the major construction works. The principal structural features of the proposed new Muda Barrage are as shown in Figs. 11.1.1 and 11.1.2.

(2) Water Resources Management Plan

As described in CHAPTER 7, the proposed water resources development structures include Beris Dam, Jeniang Transfer Canal, Naok Dam and Reman Dam. The principal features of these structures are as described below.

(a) Dams

The following principal features were extracted from the "Beris Dam Detailed Design Report" as well as the "Feasibility Study for Proposed Jeniang Diversion, Naok Reservoir and Transfer Canal" (refer to Figs. 11.1.3 to 11.1.8).

Item	Unit	Beris Dam	Naok Dam	Reman Dam
Reservoir				
Catchment Area	km^2	116	15	32
Maximum Water Level	El. m	86.40	30.0	58.3
Gross Storage Capacity	10^6m^3	112.4		283
Effective Capacity	10^6m^3	114.0	27.4	240
Main Dam				
Type		Rockfill	Earthfill	Zoned rolled-fill
Maximum Height	m	40	18	40
Crest Level	El. m	88.0	32	60
Crest Length	m	155	2,750	170
Crest Width	m	6	7	10
Upstream Slope		1 : 1.5	1 : 4.0	1 : 2.4
Downstream Slope		1 : 1.5	1 : 3.5	1 : 2.3
Embankment Volume	10^3m^3	158	2,200	286
Saddle Dam				
Number of Dams		1	0	8
Type		Rockfill	-	Earthfill
Maximum Height	m	27	-	80
Crest Level	El. m	89	-	60
Crest Length	m	200	-	1,283
Crest Width	m	6	-	8
Upstream Slope		1 : 2.0	-	1 : 3.0
Downstream Slope		1 : 1.8	-	1 : 2.7
Embankment Volume	10^3m^3	120	-	273
Compensation				
Land Acquisition	ha	1,600	6.5	35
House Evacuation	house	500	5	200

(b) Jeniang Transfer System

The following principal features were extracted from the "Feasibility Study for Proposed Jeniang Diversion, Naok Reservoir and Transfer Canal" (refer to Figs. 11.1.9 to Fig. 11.1.11).

Barrage		Transfer Canal		
Item	Feature	Item	Transfer	Conveyance
Max. Upstream Water Level	El. 34.13 m	Length	8 km	22 km
Normal Design Level	El. 34.00 m	Max. Capacity (m^3/s)	40 m^3/s	40 m^3/s
Normal Operating Level	El. 32.00 m	Normal Upstream Water Level	32 m	--
Crest Level	El. 27.50 m	Bed Width	12 m	10 m
Upstream Bed Level	El. 27.00 m	Depth	3.7 m	3 m
Apron Level	El. 25.50 m	Side Slope	1 : 1.5	1 : 1.5
Downstream Water Level	El. 33.70 m	Side Slope	1 : 2	1 : 2
Stilling Basin		Berm Width	3 m	3 m
Length (Downstream of Sill)	29 m	Freeboard	1 m	1 m
Slab Elevation	El. 25.50 m	Road Width	3.5 m	3.5 m
Intake		Bed Gradient	1 : 12,000	3 : 10,000
Sill Elevation	El. 29.00 m	Discharge	40 m^3/s	40 m^3/s
Number of Channels	2	Max. Velocity	0.62 m/s	0.96 m/s
Channel Width	2.75 m	Manning's Coefficient	0.028	0.028
Channel Length	39 m	Land Acquisition	34 ha	98 ha
		House Evacuation	0	0

(3) River Environmental Management Plan

The principal features for development along the river corridor and around the dam reservoir are as summarized below.

Item	Quantity
1. Number and Size of Development Area	
1.1 Along River Corridor	
Type A	5 (39 ha)
Type B	4 (25 ha)
Type C	3 (73 ha)
Type D	21 (166 ha)
1.2 Around Dam Reservoir	
Type D for Muda Dam Reservoir	1 (2 ha)
Type D for Beris Dam Reservoir	2 (277 ha)
2. Civil Works	
2.1 Clearing	64.5 ha
2.2 Excavation	160,000 m^3
2.3 Embankment	5,200 m^3
2.4 Sod Facing	2,800 m^2
2.5 Levee Road Pavement	800 m^2
3. Compensation	
3.1 House Evacuation	40 houses
3.2 Land Acquisition	45 ha

Type A: Land development for natural reserve.
Type B: Land development for natural use (natural-oriented recreation).
Type C: Land development for agriculture.
Type D: Land development for recreation.

11.1.3 Implementation Schedule

In due consideration of the aforesaid basic conditions for construction works as well as work quantities of the proposed structures, the implementation schedule is proposed as summarized below (refer to Fig. 11.1.12).

Work Item	Implementation Period Allocated to 5-Year Malaysia Plan					
	Preparatory/Engineering Works			Construction Works		
	7th (1996 - 2000)	8th (2001 - 2005)	9th (2006 - 2010)	7th (1996 - 2000)	8th (2001 - 2005)	9th (2006 - 2010)
1. Flood Mitigation						
1.1 Downstream of Muda River		O				O
1.2 Others		O			O	
2. Water Resources Management						
2.1 Beris Dam	O			O		
2.2 Jeniang Transfer System	O	O			O	
2.3 Naok Dam	O	O			O	
2.4 Reman Dam	O	O			O	O
3. River Environmental Management						
3.1 River Corridor Development		O			O	O
3.2 Dam Lakeshore Development	O			O		

To facilitate the successful implementation of the structural plans and the integrated operation of the structures, the watershed management and monitoring plans are further scheduled to be completed in the following Five-Year Malaysia plans (M.P.).

Work Item	Target Completion
(1) Institutional Setup for River Management Body	7th M.P.
(2) Zoning (River Reserve Area and Water Source Reserve Area)	7th M.P.
(3) Monitoring System for : Hydrological Data	7th M.P.
: Water Abstraction Volume	8th M.P.
: Others	9th M.P.

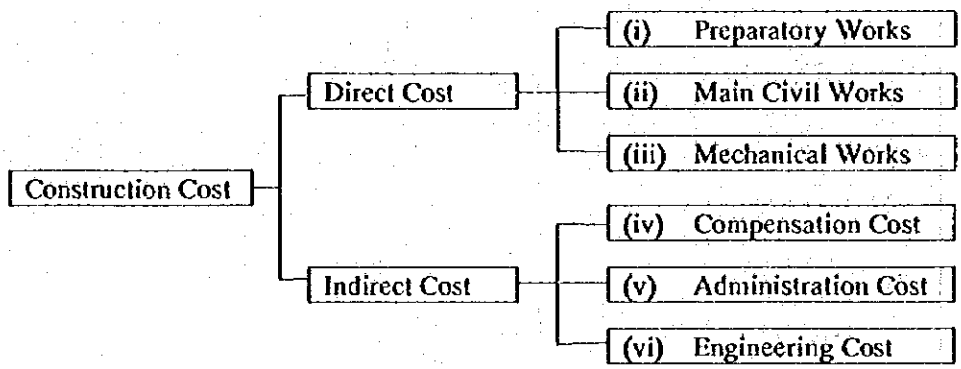
11.2 Project Cost

The project cost has been estimated on the basis of the design, construction plan and schedule, and the following assumptions and conditions:

(a) All unit costs are expressed based on the price level at the end of 1994.

(b) The exchange rate of currency is US$1.00 = RM 2.51.

(c) Project cost is composed of construction cost and contingencies. The construction cost is divided into direct and indirect costs which are further divided as follows:



(d) The calculation of costs is carried out as follows:

(i) Preparatory Works = 10 % of (ii) Main Civil Works and (iii) Mechanical/Related Works

(ii) Main Civil Works = Work Quantities x Unit Prices

(iii) Mechanical Works is estimated in accordance with the work quantities.

(iv) Compensation Cost = Area of Land and/or Number of Houses x Unit Compensation Cost

(v) Administration Cost = 5% of items (i) to (iv)

(vi) Engineering Cost = 10% of items (i) to (iii)

(vii) Price escalation rate of foreign currency and local currency portions is to be analyzed at the later stage.

(viii) Physical Contingencies = 10% of items (i) to (vii)

Based on the above premises, the project cost is estimated at about RM 871 million which is to be disbursed in three (3) terms of the 7th to 9th Five-Year Malaysia Plan (from 1996 to 2010). The average estimated project cost per one term of Five-Year Malaysia Plan is RM 290 million corresponding to about 8% of the actual investment for flood control and domestic water supply projects in the 6th Malaysia Plan. Judging from this percentage, it is thoroughly possible to implement the proposed project. The breakdown of project cost divided into foreign currency (F.C.) and local currency (L.C.) portions is as summarized below. Annual disbursement on each project is also made based on the implementation schedule and shown in Tables 11.2.1 to 11.2.8.

Unit: RM 1,000

Work Item	F.C.	L.C.	Total
1 Flood Mitigation Plan (River Improvement)			
1.1 Lower Muda River	171,143	152,443	323,586
1.2 Kuala Ketil Town Stretch	6,994	11,270	18,264
1.3 Baling Town Stretch	3,031	6,779	9,810
1.4 Sik Town Stretch	2,212	5,138	7,350
Sub-Total	183,380	175,630	359,010
2. Water Resources Management Plan			
2.1 Beris Dam	75,505	100,056	175,561
2.2 Jeniang Transfer System	56,576	109,509	166,086
2.3 Reman Dam	49,750	78,806	128,556
Sub-Total	181,831	288,371	470,203
3. River Environmental Management Plan	10,977	31,224	42,201
Grand Total	376,188	496,225	871,414

Note: Estimated at the price as of December 1994 (Exchange Rate: US$1.00 = RM 2.51 = ¥100.30

CHAPTER 12. PROJECT EVALUATION

12.1 Economic Evaluation

12.1.1 Economic Benefit

The economical evaluation is made for the proposed structural plans in the sectors of flood mitigation, water resources management and river environmental improvement. The economic benefit for each sector is estimated as described below.

(1) Benefit for Flood Mitigation Plan

The economic benefit is expressed as the difference of (a) direct flood damage to assets and agricultural crops and (b) indirect damage to economic activities and public facilities between "with the project" and "without the project" situations.

The direct flood damage to assets is estimated according to the number of assets to be inundated by flood, unit value of the assets and damage rate of assets inundated. The direct damage to agricultural crops is also estimated by the extent of agricultural areas inundated, agricultural, crop production per unit area, and damage rate of the agricultural crops inundated.

The indirect damage to public facilities is assumed to be 34% of the direct flood damage to assets in due consideration of the economic survey manual on flood control in Japan. Likewise, the indirect damage for the economic losses caused by suspension of business activities is assumed as 6% of the direct damage to assets.

(2) Benefit for Water Resources Management Plan

The proposed water resources development facilities could generate the economic benefit due to increment of water supply from the present to the projected year for domestic and industrial water as well as irrigation water. The economic benefit for domestic and industrial water is herein assumed to be RM 0.20/m^3 in terms of unit price of the increment of water supply, which corresponds to approximately half of the minimum actual domestic water tariff.

The benefit for irrigation water is given by the increment of paddy production generated by the increment of irrigation area and estimated through the following formula at RM 719/ha in terms of unit price of the increment of irrigation area:

$$B = A \times (Y \times P - C)$$

Where,

B: Net irrigation benefit
A: Increase in irrigation area
Y: Unit yield (assumed as 4 tons/ha)
P: Farm gate price of paddy (assumed as RM 1,840.0/ha)
C: Unit production cost (assumed as RM 1,361.6/ha)

(3) Benefit for River Environmental Management Plan

The economic benefit is estimated by multiplying the total number of the visitors (person-day) per annum for the proposed park, by a sum of the per capita income (RM/day) and the transport costs per trip (RM person).

12.1.2 Economic Cost

The project economic cost is estimated from the financial cost taking into account the conversion factors to economic prices. The conversion factors are herein assumed, on the basis of the "National Parameters for Project Appraisal in Malaysia," as below.

Goods and Services	Conversion Factors
Construction (general)	0.84
Unskilled Labor Wage	0.83
Government Administration	0.82
Agricultural Input	0.91
Agricultural Output	1.00
Machinery and Equipment	0.90
Transport	0.79
Land Acquisition	0.88
Standard Conversion Rate	0.88

12.3 Economic Rate of Return

The economic internal rate of return (EIRR) for proposed structural plans are estimated as below.

Sector	Proposed Structural Plan	EIRR (%)
Flood Mitigation	River improvement of 4 target river stretches	8.3
Water Resources Management	Construction of Beris Dam, Naok Dam, Reman Dam and Jeniang Transfer Canal	14.6
River Environmental Management	Land development of river corridor and lakeshore around reservoirs of Muda and Beris dams	23.8
Overall		13.6

According to the analysis of international agencies, the opportunity cost of capital is estimated at 10 to 12%. Among the proposed structural plans, those for water resources management and the river environmental management exceed the opportunity cost, and could be economically justifiable.

On the other hand, the EIRR of the structural plans for flood mitigation is somewhat low as compared with the opportunity cost of capital. The flood mitigation project is, however, essential to ensure an stable social environment and promote an economic development of the region. Accordingly, implementation of the flood mitigation project is recommended, not necessarily being tied down to the economic viability.

12.2 Environmental Impact Assessment

A preliminary environmental impact assessment was carried out for the following major proposed structures for water resources development, flood mitigation and river environmental improvement.

Sector	Objective Structures
Flood Mitigation	River Improvement of Lower Muda
Water Resources Management	Beris Dam Jeniang Transfer System including Naok and Reman dams
River Environment Management	Beris dam reservoir recreation park Muda barrage recreational park Bumbong Lima recreational park

The results of environmental impact assessment are summarized into assessment matrices as shown in Tables 12.2 1 to 12.2.6. According to the assessment matrices, the significant impacts by the proposed structures are seen in the following four issues: (a) resettlement, (b) disruption of community, (c) soil erosion, and (d) water pollution. The countermeasures and necessary monitoring items for these issues are proposed as below:

Issue	Causes	Countermeasures	Necessary Monitoring Items
Resettlement	1. Beris Dam 2. Jeniang Transfer System 3. River Channel Improvement 4. Bumbong Lima Recreational Park	1. Coordination with inhabitants 2. Reasonable compensation for resettlement 3. Assistance and guidance for suitable income of inhabitant to be resettled 4. Preparation of resettlement land based on the desire of inhabitant	1. Living conditions of inhabitant to be resettled 2. Regional socio economy 3. Precedents of resettlement of similar projects 4. Conditions of resettlement land
Disruption of Community	Beris Dam	1. Compensation to non-resettled inhabitant 2. Construction of new transportation network 3. Reorganization of administrative division 4. Establishment of new telecommunication service	1. Regional socio economy 2. New transportation system 3. Living conditions of inhabitants including non-settled people
Soil Erosion	1. Beris Dam 2. Jeniang Transfer System	1. Dredging works 2. Plantation 3. Land use control	1. Topography, geology and soil 2. Vegetation
Water Pollution	1. Beris Dam 2. Jeniang Transfer System 3. Beris Recreational Park	1. Control and treatment of pollution loads 2. Removal of vegetation before dam impounding	1. Pollution source 2. Water use in dam reservoir and river channel 3. Water quality survey.