3.6 Social Environment

3.6.1 Social Environment Overview

In order to clarify a part of social conditions, the numbers of primary schools, junior high schools, hospitals and health centers in proportion to the population are compared with other Provinces in Indonesia (Source: BPS-Statistics Indonesia, "Statistical Year Book of Indonesia 2000"). The ranks are almost the 20th in 26 Provinces. Comparing with other Provinces in Sumatra Island, South Sumatra Province is not necessarily ranked high in terms of accessibility of services on education and health. Although the rank itself does not show low social levels, because it relates to the size of the area and population density, namely, congested areas tend to give higher values.

Another part of social conditions of South Sumatra Province is the population below poverty line. The rank of South Sumatra declined from the 12th among 26 Provinces in 1996 to the 14th in 1999 with the number of population below poverty line increasing as much as 57.5%.

Humans have been inhabited in South Sumatra since prehistoric times. Megalithic cultural heritages can be found in Lahat District, OKU District, and Muaraenim District. In addition, Limas house can also be counted as a cultural property, which can be seen Palembang and other places. It is a combination of Hinduism, Buddhism, Islamic architecture and old traditional house of South Sumatra. The Chinese pattern was adopted in carving because the influence of Sriwijaya culture was strongly dominant.

The native people in South Sumatra consist of various ethnic groups with local languages and dialects. Ethnic groups or tribes include Palembang, Ogan, Komering, Semendo, Pasemah, Gumay, Lintang, Musirawas, Meranjat, Kayuagung, Ranau, Kisam, Bangka, Belitung, and so on. These ethnic groups mix each other and even with migrating ethnic groups or foreigners by inter-ethnic marriage.

Planned resettlement started in 1905 by Dutch colonial government for the purpose of solving poverty and unemployment in Java. The scheme has been continuing under the name of "transmigration" after the independence in 1945. At the same time, considerable number of families also moved as spontaneous transmigrants without any assistance from the government except land. South Sumatra has been one of the most important destinations since its low population density. The majority of transmigrants from Java are cultivating rice, rubber or coffee in rural centers.

3.6.2 Results of Questionnaire Survey

Issues on social environment are identified with various tools in the Study. Results from one tool are crosschecked with those from others.

A questionnaire survey was held in order to collect basic information on water management as well as to get rough illustration of the Study area. The questionnaire contains questions on water use in general and water quality.

River Utilization

Although rivers are used for many purposes, they are very important for the people's daily lives as they are used for the water source of drinking and washing clothes almost everyday by the majority of the people (68.0% and 62.7% in total respectively). In addition, more than 45% says they use rivers for toilet. Usage of rivers other than drinking and washing are different in areas. Transportation of people and fishery are the first and the second highest in the lower area while transportation of people is not the first although fishery is the second in the middle area. In the upper area, agriculture and fishpond are the first and the second.

Problems on River Water Use

There are various problems on river water. Above all, sedimentation is the highest in both the lower and the middle area. Its percentage increases from upper to lower. Thus, it should be considered as "inter-local" problem. Inter-local solutions are necessary for this type of problems. On the other hand, smell is relatively low percentage and almost the same among areas. This can be a "local" problem. Low water level is a kind of local problems but it is the second highest in the middle. It can be called a "local-serious" problem due to local specific causes. Contamination is a mix of inter-local and local-serious features as the percentage increase from upper to lower and it is the second highest in the lower area.

River Water Quality

Percentage of "no" in river water quality problems decreases in the wet season except smell in the lower area. Change in water quality between dry and wet season is large in the upper and middle area.

Drinking Water

The majority in total uses “well” for drinking water but not a few people use “rivers” as more than 40% in the lower and middle area and more than 30% in the upper area in the dry season. Number of “river” decreases in wet season because the water quality deteriorates in wet season. Control of river water quality should be an important matter for people's health. As a matter of fact, more than 20% have got disease due to the drinking water. Further, only 44% can get enough water for drinking in dry season. Supplying enough water in dry season is another important matter, especially in the lower and upper area.

Agriculture Water

Only one third use irrigation channel for agriculture while a half use rivers. Percentage distribution differs in areas. The lower area shows very low percentage. Three areas have different patterns of the water use due to the change from wet season to dry season. The upper area increases irrigation channel. The middle area increases river and decreases well. The lower increases river and decreases irrigation.

Aquaculture Water

More than a quarter use irrigation channel for aquaculture in wet season. Especially in the upper area, nearly 40% use irrigation channel all the seasons. No distinct difference in seasonal patters of the water use can be seen in the three areas.

Industry/Service Water

River is the most important water source for industry and service. In the middle area, well is also an important source.

3.6.3 Issues on Spatial Planning

Government Regulation No. 35/1991 (River) decrees protection, development, utilization and control over rivers including lakes and reservoirs. Ministerial Regulation No. 63/PRT/1993 (Borders, Channels, and Ex-channels of River) defines river borders and decrees details of their utilization. (See Section 3.11 for detail.)

In spited of regulations mentioned above, so many houses are built in the river borders in urban areas. Such illegal houses have been built by the people who came from rural areas and have no land titles in authorized areas. Illegal buildings are not removed by the related authorities unless some development plans are implemented in the relevant area. As a matter of fact, it would be extremely difficult to enforce the regulations by removing such illegal buildings without preparing alternate lands nor a program of returning the inhabitants to their original villages. Such mitigation programs may not be implemented due to lack of budget and personnel.

3.6.4 Conservation of Forest Area

Conservation and sustainable use of forest ecosystem and forest biodiversity are critical components to alleviate poverty and support sustainable development. Encroachment and illegal logging are the most emergent threat to the forest ecosystem not only in South Sumatra.

Encroachment

Encroachment is an invasion to forest areas by people farming the land without concession. Encroachment is a serious problem.

- People clear the land by slash and burn of forests. It changes the ecosystem of the forest area. It also increase land erosion and decreases water-holding capacity of land. Erosion gets much more severe since they often clear slopes.
- People often give up farming and leave the land not maintained and clear new lands when the fertility of land deteriorates (shifting cultivation). People also give up farming and leave the land not maintained when the price of crops goes down and they lose interest in cropping.

- People invade natural conservation forests or protected forests. It causes biodiversity problems in the former case while it causes problems on water source, flood protection, erosion control, etc. in the latter case.

The primary reason why people encroach is land scarcity in accordance with population growth as well as lack of awareness of the people. It is sometimes another reason that the border of forest conservation area is unclear. This problem cannot be solved simply by law enforcement since the many factors are inter-related.

Illegal Logging

Illegal logging is the log cutting for the purpose of making wood products without receiving concession from governments. Only bared land is left after illegal logging because the loggers have no interest in the land that they clear. Causes of illegal logging can be divided into two aspects: supply side and demand side.

Suppliers of illegal logging usually do not aware of the results from their logging. In addition, illegal logging is an easy way of making money for the people who have no good means for living in rural areas. If loggers are members of a village society, programs of increase in society's welfare can be a countermeasure. Establishment of a social forest is a good example. On the other hand, the village societies have to strengthen their effort to control and monitor conditions of forests because illegal logging may be the cause of many social and environmental problems for the entire village including land erosion, sedimentation, ecosystem change, and so on. Governments should support such efforts as a matter of course. Further, environmental education is an important key for reducing illegal logging in the long run.

Causes in demand side are a little bit complicated. In the past three decades, timber and wood product have been a good exporting industry for the country. Demand pressure on illegal logging is increasing because of the closure of concession due to a national policy to rehabilitate tropical forest and increase in timber price with adjustment of market price to international level. With considering those factors, countermeasures should be as follows:

- Restructure the logging industry for decreasing the production capacity to balance supply and demand of the forest resource
- Connect reforest program with logging industry
- Develop forest continuity management
- Develop technology to utilize wood more efficiently (presently only 20-30% of the usable wood is used) and usage of waste of wood
- Promote cooperation among authorities for effective control of forest conservation including court, prosecutor, police, telecommunication and custom, as well as encourage local people to participate

3.6.5 Water Allocation between Irrigation and Fishpond

It has been recognized in the Government Regulation No. 77/2001 (Irrigation) that irrigation water-use has been given priority to agricultural activities, especially rice fields. However, because this regulation has not been widely socialized, most farmers at the grass root level are not aware about the regulation. In addition, available water in the irrigation canals has given opportunity for various water usage, including fast-flow fishpond business.

Water Use for Fishponds

Fishponds need water flow for fast fish production. Sources of water for the ponds are primary and secondary canals of the Kelingi-Tugumulyo irrigation system that are diverted to the ponds. Few diversions are facilitated with control gates, while some are not. Has the water been used for the fishponds, most of the water is returned back to the canals, only little is drained out to the river or surrounding lowlands.

Development of fishponds, according to respondents (fishpond owners), had been given recommendation from the district government (Office of Water Resources). The recommendation did not indicate explicitly the right to use irrigation water. However by paying some money (up to Rp 3 million per year) for 5-year period to the 'actor' at the government office, the owner felt that he was given right to use the water.

The fishpond owners recognize that irrigation water be used mainly for food crop production. They admit that while operating the business they receipt complain from the farmers. The reason for that was damage of the canal being diverted and water shortage for paddy field.

Farmers' Respond on Water Use for Fishponds

All farmers said that fishponds get water by diverting canal with/without gate. When using gate, water intake can be controlled, otherwise cannot. In contrary to fishpond owners, farmers said that most of the water being used for fishpond is then drained-out to the river or surrounding lowlands. With this situation, more farmers demand that fishponds should not be allowed to use irrigation water. It is suggested that fishpond owners should develop other canal, take water from other sources or they might use water drained from rice field. Only few farmers allow fishponds to use irrigation water in wet season during high water supply.

Impacts of Water Use for Fishponds on Rice Field

With regard to the existence of fishponds, farmers respond that water availability before and after the development of fishponds is significantly different. The effect of fishpond development on water availability has significantly caused the decrease in rice productivity. This negative impact has ended in water use conflicts between rice field and fishpond.

Role of WUA in Irrigation Management

Most farmers agree that WUA has played important role in irrigation management, except gate operation. This role is no longer taken by WUA officials since the establishment of fishponds. Fishpond owners, who are considered “powerful” by farmers, take over gate operation for the benefits of fishponds. Therefore, WUAs is considered less functional even though WUAs have performed most of their roles in water management (except gate operation). Despite the fact that there has been regulation in WUA that applies to fishponds, the actions taken by WUA is considered insufficient to solve water use conflicts between fishpond and rice field. Therefore, farmers are unsatisfied with the current actions made by WUAs.

3.6.6 Development and Conservation in Swamp Area

Roles of Swamp Area

Swamp areas provide many ecological and hydrological functions to human beings. Among them, the most important ones are the roles of water supply, water purification and flood control. Swamp areas play a significant role for the river basin water management as a link of the total ecosystem. They also play many other important socio-economic roles including provision of habitat for fisheries and forestry resources and are critical for the conservation of biological diversity.

Development Projects of Swamp Area

The first stage swamp development employs a low-cost, low-technology approach, providing minimum infrastructures, e.g. uncontrolled (open) drainage system, partial land clearing, flood protection, construction of simple houses and unsurfaced rural roads. Due to soil conditions and salinity intrusion, limited control structures may be provided. Besides, only basic supporting services in agricultural extension, health care, and education are provided to the transmigrants. As a matter of fact, no consideration had been made for the conservation of swamp areas since nobody became aware of importance of the function in basin management.

The objective of the second stage is to promote intensive cultivation with farming systems and cropping patterns tuned to the potentials of the land. This stage includes upgrading and improvement of water management system (hydraulic infrastructure and its operation and maintenance), as well as providing additional services, e.g. marketing, transportation and communications, and sanitation. On the other hand, consideration on ecological role of the swamp areas is still unsatisfactory. Little attention is paid for the mitigation against the negative impacts on ecology.

Future stage of swampland development should consider further improvement of accessibility and communications, investigation and development of water supply and irrigation in addition to the existing drainage system (e.g. low-lift pumping), and provision of a basin-wide water management plan aimed mainly at preventing an increase of salinity intrusion.

Requirements of the Development Projects

The sustainability of the development projects requires the following conditions: Government commitment to integrate lowland development as a center for driving force; Inter-agency coordination in lowland management. -The responsibility is integrated among related agencies-; and Community involvement in project planning and implementation.

If these requirements were not fulfilled, the outcomes would be successful only partially due to obstacles such as unrealistic targets, poor site selections and top-down approaches. In order to avoid such failures, development of swamp areas should be reviewed from multi-disciplinary viewpoints including environmental conservation.

3.6.7 Komering Irrigation Project and Its Social Impacts

History of the Komering River Flow Shortage

During the 1970s, flood-drought yearly cycle of the Komering River can be summarized as follows:

- January-February at peak of rainy season: flood, village roads were inundated for about 2 months.
- March-April at the transition from rainy to dry season: water level decreased.
- May-October during the dry season: water level at the Komering River decreased to a minimum of 10 cm, but never been dried-out.
- October-December at the beginning of rainy season: water level at the Komering River returned to normal.

Between 1970s and 90s, drought at the Komering River happened only during the dry season. In certain places of the river body, the water level was still 0.4-0.5 meter except in 1997 when dry season lengthened and the Komering River dried-out. Residents adapted to the water shortage by digging wells in the Komering River channel. The depth of the wells was 0.5-1.0 meter. The cause of drought was riverbed siltation due to sedimentation at the river channel. The respondents think that this situation has been worsened since the operation of the Perjaya Headworks.

Incidence of the Komering River Flow Shortage in 2001

In 2001, the incidence of drought happened in the period of June to December. But severe effects of drought were experienced by the residents in the period of July to September. During this 3 months period, the Komering River channel passing the villages surveyed was almost completely dried. In some places at the river body, water was only 5 cm high. In addition, wells developed near the houses were no longer sufficient to meet daily water need of the households. The residents have to build wells at the (mid of) river channel. This severe effect was experienced by almost all of the people in these villages since most of daily water needs were fulfilled by the Komering River.

As mentioned above, the respondents think that the effects of water shortage after the operation of the Perjaya Headworks were considerably severer than before. In 2001, this situation was worsened by the lengthened dry season.

Impacts of the Komering River Flow Shortage

Water shortage in the Komering River has caused negative impacts to almost all the people in the survey areas. The severe effects were experienced by the people living in the upper part of these villages, especially in Menanga Sari Sub-village (Dusun) where 20% of Menanga Besar Village inhabitants lived in this sub-village. Each well in these villages only produced 3 buckets of water every day. In addition, soil in the fields and house lots were dried-out and broken which led to unsatisfied harvest of food crops and fruit trees.

Difference of Benefits between Local People and Transmigrants in Irrigation Projects and Social Impacts

Positive impacts of the irrigation development as reported by respondents are as follows: Public transportation services and facilities increase; Trade activities increase; Information accessibility increase; and Direct benefits from sand and stone trading.

Negative impacts of the Belitang irrigation development as reported by respondents are: Household income decrease due to the decrease in production of food crops, tree/fruit crops, and fish as a result of water shortage in the Komering River presumably caused by the development of Belitang irrigation schemes; Psychologically, local people feel to be subordinate to people in Belitang since development activities (especially agriculture) have been focused more to Belitang than to local villages; Number of people in productive ages staying in local villages decreased since many of them out-migrated for non-agricultural employment; and, Water transportation disturbed or disappeared due to limited water on river body.

Up to now, there have not been any efforts made by the government to mitigate these negative impacts, except dredging of river channel in Gunung Batu Village for 8 km long (FY 2002). Under theses sever conditions, local people were in search for non-agricultural employment for additional household income, e.g. *ojek* (motor-cycle transportation provider), trader (fabrics and clothes), etc.

Social Interaction between Transmigrants and Local People

It is recognized by respondents that local people have interacted with people of Belitang for quite a long time. The forms of interactions as reported by respondents are trade relationships, out-migration of Belitang people to local villages and vice versa, marriages, information exchanges (mainly in agriculture), etc. These interactions can in general be classified as cooperation since they may give advantageous to both sides much more than disadvantageous. In Menanga Sari Sub-villabe of Menanga Besar Village, 20 percent of its inhabitants are people from Belitang (originally Javanese).

Conflicts are part of social interactions. Conflicts between transmigrants and local people have never been reported to exist, even though interactions between the two groups have been existed for quite long.

Local People's Opinions and Expectations

Until now, only people living in irrigated areas gain direct benefits from the development of the Belitang irrigation schemes. On the other hand, most local people do not, except those who have out-migrated to Belitang areas. Local people's perception regarding the Belitang irrigation development is reportedly positive since this development has increased the cropping intensity to 200-300 percent. With this development, the price of rice is considerably low and stabilized, and the supply is reportedly sufficient. However, as local people perceived that water shortage in the Komering River worsened since the development of the Belitang irrigation schemes, they felt somewhat unsatisfied with this condition.

3.6.8 Survey on Water Level Increase in the Lake Ranau and the Regulation Dam

The Ranau Regulation Dam is being operated with the "Tentative HWL" of 541.7 m (Effective Depth: 1.2 m) of the Lake Ranau from 1995. JICA Study Team conducted in 2003 an interview survey about the impacts of the increase in water level of the Lake Ranau to residents of Village Kota Batu, Village Bandar Agung, and Village Pilla, which are all adjacent to the lake. Most of the respondents (93.5 %) have experienced floods in the rain season from between 1995 to 1998, which depends on their locations, although they had never experienced any flood incidences before 1995.

The impacts of flood as reported by the respondents were the inundation of paddy fields and houses. Respondents whose paddy fields are inundated reported that water level on the paddy fields was 0.3 to 0.5 meter. On the other hand, houses were inundated up to 1 meter above the floor. Perceiving the flood caused by the increase of water level in the lake, most of the respondents put improper gate operation at the Ranau Regulation Dam as the main cause. In order to prevent from flooding, they propose that gates be kept open to maintain water level on the lake at the safe level.

All the respondents reported that their paddy fields would be inundated if the water level increased above the current level. More than 60 % of the respondents mentioned that their houses would be inundated, while those who lived in Village Pilla which is located at the higher part reported that their house and the roads in their village would be safe from the flood.

3.7 Hydrological Analysis

3.7.1 Hydrological Observation Condition

The hydrological data (rainfall, water level and discharge) in the Musi River Basin are observed mainly by two agencies, BMG and Musi Balai PSDA, and management is also performed separately.

Rainfall Observation

Rainfall observation has been conducted by Musi Balai PSDA at 14 gaging stations and by BMG at more than 39 stations in and around the Musi River Basin. According to the inventory of the information on gaging stations, installation period of gaging station was missing, and the oldest data on record was in the beginning of 1970s. Stations under Musi Balai PSDA had installed both the automatic type and the manual type at all sites. All the gages of BMG except for the Plaju Station at Palembang Airport are of the manual type.

Water Level Observation

Musi Balai PSDA is the principal agency responsible for the water level observation in the rivers of the Musi River Basin. There are a total of 22 automatic water level gages with staff gage operated by Balai PSDA in the Musi River Basin. Judging from the compilation of water level data and the past reports (Musi River Survey, 1989), the daily water level has been observed by PWRS of South Sumatra since the beginning of 1970s. Hourly water level is available after 1985.

The water level gages are of the float type, installed in a shelter house and stilling well. The staff gage is also installed near the automatic water level gage station. Water level is the elevation above some arbitrary zero datum of the water surface at a station. The datum is sometimes taken as the mean sea level but there are a few stations in the Musi River Basin that have the datum from the mean sea level.

Discharge Measurement

Discharge measurements have been carried out from the beginning of 1970s at 52 stations. Based on the discharge measurements, the Center of Research and Development in Bandung prepares the relationship between water level and discharge (i.e., Discharge Rating Curve), then, calculates the daily discharge using such relationship. Discharge measurements, as well as water level and rainfall observations, were also suspended starting from 2002.

Management of Hydrological Observation

No definite organization had managed the hydrological observation station in South Sumatra Province. The management history is as listed below.

- Between 1976 and 1985, the hydrological observation station in South Sumatra Province was managed by the Project of Development Planning of Water Resources (P3SA);
- Until 1987, it was managed by the Investigation Directorate of Water Problem (DPMA);
- Between 1987 and 1995, it was managed by the hydrology unit in region;
- In 1996, it was managed by the Branch Office (Cabang Dinas); and
- Between 1996 and 2001, Project PSAPB (Development Project of Water Resources and Flood Control) and the Hydrology Division in Sub-Dinas of Bina Program Water Resource Service managed the station.

The Project PSAPB implemented the operation and maintenance work until they were handed over to Musi Balai PSDA. The O&M work was discontinued gradually during Project PSAPB's control as mentioned before because of the inadequate budget for the hydrological activities (only Rp. 50 million for fiscal year 2001). Additionally, the proper institutional approach for managing hydrological activities has not been developed, even with Musi Balai PSDA. Therefore, the strengthening of hydrology activities as the primary responsibility of the BPSDA in fiscal year 2002 was recommended under the Project IWIRIP.

3.7.2 Rainfall Analysis

Storm Rainfall

The mass curves at the Kenten Station were evaluated and it was judged that the duration of storm rainfalls could be fixed at 12 hours. The average concentration ratio of storm rainfall was evaluated, and it showed that more than 70% of storm rainfall occurs at the beginning of rain. As a result of this analysis, it was determined that intense rainfall concentrates in the front of the storm rainfall in around Palembang.

Probable Rainfall for 12-Hours

The probable 12-hour rainfall was calculated from the data observed at Kenten Station from 1994-2001 as shown in **Table 3.7.1**.

Table 3.7.1 Probable 12-hour Rainfall (Kenten Station at Palembang)

Return Period	1/2	1/5	1/10	1/15	1/20	1/30	1/50	1/100
Probable Rainfall (mm)	104.0	122.5	133.9	140.8	145.3	151.8	160.1	171.1

3.7.3 Runoff Analysis on Flow Regime Estimation

The Runoff Analysis was carried out at each sub-basin for the purpose of gap-filling of discharge time series data for the water balance analysis. The runoff simulation model covers the entire Musi River Basin of about 60,000 km^2.

Outline of Model Structure

The runoff model was established by using the software MIKE 11that was applied for the runoff analysis in the Musi River Basin Study of 1989. In the MIKE 11, runoff generated in the sub-basins is calculated by NAM module.

Data Availability

The hydrological data (rainfall, water level and discharge) presented in this report were collected from BMG and Musi Balai PSDA. According to the report "Musi River Basin Study in 1989", the BMG has been observing rainfall in the Musi River basin since 1970. Unfortunately, however, the data before 1985 are either incomplete or contain many gaps (missing data), so that only data between 1985 and 2001 were collected from BMG. Data of Musi Balai PSDA from 1985 were also collected with some gaps.

Boundary Conditions

Based on the topographical maps of the Musi River Basin, the catchment delineation was made (see **Table 3.7.2** and **Annex 3.7.1**). The NAM module was used as the rainfall-runoff model for each river basin. The Thiessen Method was applied to calculate basin mean rainfall for a period of 16 years from 1985 to 2001.

Table 3.7.2 Catchment Area of Sub-Basins

Sub-Basin	Catchment area*1 (km^2)	Sub-Basin	Catchment area*1 (km^2)
Komering 1	4,527	Kelingi	1,928
Komering 2	5,381	Harileko	3,765
Ogan 1	3,990	Musi 1	2,389
Ogan 2	4,232	Musi 2	2,740
Lematan 1	3,930	Musi 3	1,013
Lematan 2	3,410	Musi 4	564
Semangus	2,146	Musi 5	2,499
Lakitan 1	2,290	Musi 6	1,648
Lakitan 2	473	Musi 7	1,822
Rawas 1	3,548	Musi 8	2,646
Rawas 2	2,478	Padang	2,513

*1 Source: Musi River Basin Study, 1989

The evapotranspiration data were set from the meteorological record at representative stations: Talang Betutu, Sekayu, Lubuk Lingau, Muara Enim, and Pagar Alam. The evapotranspiration for each sub basin is set at 80% of potential evapotranspiration. The parameters already settled during the Musi River Basin Study were applied for the model in this study.

Simulation

The gaps in the time series of discharge were filled as the result of the simulation using the established model as shown in **Table 3.7.3**. The time series will thus be used for the water balance/use analysis.

Table 3.7.3 Natural Flow Regime Resulting from Simulation

(m^3/s)

No.	Sub-Basin	C.A. (km^2)	25%	50%	75%	95%	Ave.(Wet)	Ave.(Dry)	Annual Ave.	
									m^3/s	$m^3/s/100km^2$
1	KO1	4,527	72.8	116.5	188.2	305.8	308.3	163.9	235.9	5.2
2	KO1+KO2	9,908	144.4	229.3	390.5	613.4	608.8	283.1	445.6	4.5
3	OG1	3,990	35.3	58.0	101.6	194.9	193.1	71.9	132.4	3.3
4	OG1+OG2	8,222	73.2	116.4	217.9	388.5	389.7	141.0	265.1	3.2
5	LE1	3,930	61.5	87.3	118.1	201.1	223.4	131.2	177.2	4.5
6	LE1+LE2	7,340	103.1	148.0	231.6	376.1	396.5	197.9	297.0	4.0
7	SE	2,146	19.9	32.6	50.9	72.6	71.9	40.1	56.0	2.6
8	LA1	2,290	23.0	37.8	57.1	88.5	91.8	47.8	69.8	3.0
9	LA1+LA2	2,763	28.1	45.9	69.7	106.9	109.8	57.6	83.6	3.0
10	RA1	3,548	40.1	72.6	116.0	189.4	181.5	114.0	147.7	4.2
11	RA1+RA2	6,026	64.4	104.3	164.9	262.4	256.0	151.5	203.6	3.4
12	KE	1,928	20.1	33.3	52.4	79.3	81.2	41.3	61.2	3.2
13	HA	3,765	46.7	83.3	130.4	209.2	195.0	122.7	158.8	4.2
14	Before KE	6,142	124.7	171.2	229.3	358.3	429.5	229.6	329.3	5.4
15	After RA	19,569	329.7	466.6	681.4	1,015.7	1,032.2	562.9	797.0	4.1
16	After LE	34,821	550.0	798.4	1,191.8	1,776.8	1,774.5	944.1	1,358.4	3.9
17	After KO	54,773	868.8	1,271.1	1,911.0	2,976.2	2,920.7	1,440.0	2,178.7	4.0

3.7.4 Flood Routing Simulation for Musi River and Tributaries

The Flood Routing Simulation was carried out for the purpose of estimating the peak discharge of flood and its probability. The flood routing was made along the Musi main stretch and its tributaries; namely, Komering, Ogan, Lematang, Semangus, Kelingi, Lakitan, Rawas and Harileko River. The Kinematic Channel Routing Module was integrated with the runoff model established in Sub-Section 3.7.3. A statistical analysis was carried out to estimate the probable discharge at the downstream end of tributaries and the representative point of the Musi main stretch based on the simulated maximum discharge as shown in **Table 3.7.4**.

Table 3.7.4 Probable Discharge Resulting from Simulation

(m^3/s)

R.P.(Year)	Musi[1]	Musi[2]	Komering	Ogan	Lematang	Semangus	Kelingi	Lakitan	Rawas	Harileko
2	2,610	4,078	899	690	823	146	168	233	625	445
3	2,872	4,381	990	783	925	171	192	271	771	580
5	3,165	4,718	1092	886	1,039	199	218	313	934	729
10	3,532	5,142	1,221	1,017	1,182	234	251	367	1,138	917
20	3,884	5,549	1,344	1,141	1,319	267	282	418	1,334	1,097
50	4,339	6,076	1,503	1,303	1,496	311	323	484	1,588	1,330
100	4,681	6,470	1,622	1,424	1,629	343	354	534	1,778	1,504

Musi[1]:Tebing Abang, Musi[2]: After confluence of the Komering River

3.7.5 Runoff and Inundation Analysis for Palembang Drainage Planning

To identify the probable flood inundation area at present and future conditions, the inundation analysis was carried out for Palembang. Additionally, the basic hydrological boundary or parameters, which were set up during the establishment of the simulation model for the inundation analysis, made use of the drainage plan of Palembang.

Target Area

The target area covers almost all of Palembang City considering the past inundation-damaged area, the future drainage plan, and the location of infrastructure and houses. The target area of approximately 400 km^2 is divided into 19 catchment areas considering the existing drainage network system.

Inundation Regime

According to the report entitled "PERENCANNAAN TEKNIS DRAINASE KOTAMADAYA PALEMBANG, FINAL REPORT, 1995/7", inundation happened frequently spreading from the drainage channel. Insufficient capacity of the channel, as well as high tide, have been the primary causes of the inundation. Until now, spot inundations often take place at 59 areas when rainfall intensity becomes higher.

Elaboration of Flood Simulation Model

The Storage Function method is employed as the flood run-off model for sub-basins, because this method receives wide recognition as the de-facto standard method for flood control planning in Japan and Asian countries. Rainfall transforms into discharge, and on the way to transformation there must be some storage. The Storage Function method had been developed to express non-linear characteristics of run-off phenomena. This method can give the process of transformation from rainfall to run-off on the assumption that there is a one-to-one functional relation between the storage volume in the sub-basin and the run-off discharge.

Calculations of run-off from rainfall are made through the use of the storage volume as the medium function. The relation between the storage volume in the basin and the discharge is expressed as:

$$S = K \times q^P$$

where, S : Depth of storage (mm)
q : Depth of run-off (mm/hr)
K, P : Constants

The hydrograph corresponding to the return period was calculated by using the established model. The drainage planning in this study was carried on the basis of this hydrograph as a boundary condition.

3.7.6 Sedimentation

Sedimentation in Musi Main Stretch (at Tebing Abang)

The Musi River Basin Study of 1989 had empirically assumed that the average specific annual total sediment load at Tebing Abang (after confluence with the Lematang River) is between 1.0 and 2.0 ton/day/km^2, giving the average total sediment load of between 13 and 25 million ton/year.

Sedimentation in Upstream of Komering River (at Martapura)

Between 1986 and 1987, the Ministry of Public Works, Institute of Hydraulic Engineering carried out a sediment load survey. Based on the rating curve presented in the survey and the data collected in the present study, the total amount of sediment between 1988 and 1998 was calculated, as shown in **Table 3.7.5**. The bed load is given as 15% of sediment load based

Table 3.7.5 Estimation Result of Sediment Load at Martapura

Year	Suspended Load (mil. ton)	Bed Load (mil. ton)	Total (mil. ton)	Specific Sediment Load (Ton/day/km^2)
1988	7.78	1.1	8.88	5.60
1991	3.29	0.5	3.79	2.40
1992	2.59	0.39	2.98	1.89
1993	3.63	0.54	4.17	2.64
1998	5.59	0.83	6.42	4.07

The estimation and survey results give 5.02 million tons of annual average total sediment. Hence, the annual average specific sediment load (the catchment area at Martapura is 4,320 km^2) is estimated at 3.18 ton/day/km^2.

Sedimentation in Lower Musi River

Sediment during low flow is deposited along the Lower Musi River, mainly from Tebing Abang to the sea, because the river flow in this section slows down due to the backwater (tidal) affect. During high flow, however, the riverbed is scoured and most of the sediment is transported into the sea. The remaining sediment deposit after scouring would require dredging, which is presently being carried out annually. The results of sedimentation studies on the Musi River give the sediment level as follows:

- Frankle USA, 1968: approx. 40 cm/month
- JICA Japan, 1976 : approx. 43 cm/month
- Observation of Pimbagro Faskespel South Sumatra, 1999: approx. 2-4 cm/day
- Observation of Third Pelindo Company, 1999: approx. 2-4 cm/day

3.8 River Conditions, Flooding and Inundation

3.8.1 Present River Morphological Condition

The Musi River Basin is in the southern part of Sumatra Island. The Musi main stream and most of the major tributaries originate in the Barisan Range. The Musi River originates at Mt. Dempo (3,159m) and flows to the northward, joining the Kelingi, Semangus, Lakitan and Rawas rivers. At the confluence of the Rawas River, the Musi River changes its flow direction toward east and joins the Harileko and Lematang rivers before it reaches at Palembang City. Two big tributaries, the Ogan and Komering rivers, join from the right bank at Palembang. The Komering River is the largest tributary of the Musi River followed by the Ogan River. At the Komering junction, the flow of the Musi River changes to the north again and finally empties into Bangka Strait. The Musi River Basin is shown in **Figure 3.8.1**.

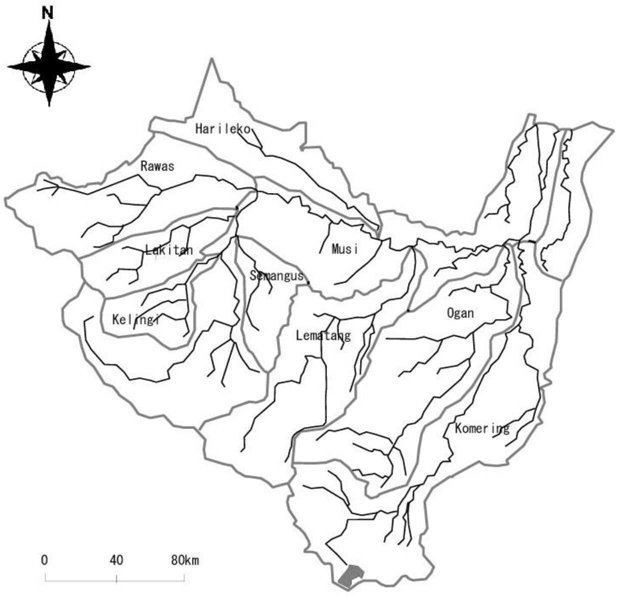

Figure 3.8.1 Musi River Basin

The Musi River Basin has a total catchment area of 59,942 km^2 at the river mouth with channel length of about 640 km. At the city of Palembang, it amounts to 34,836 km^2 before joining the Komering and Ogan rivers. Catchment areas of the main Musi River and its major tributaries are summarized in the **Table 3.8.1**.

Table 3.8.1 Drainage Areas at Major Points of the Musi River

Main river and tributaries	Basin area (km^2)	Cumulative area (km^2)	Location
Musi R.	6,251		
Kelingi R.	1,928	8,179	Confluence of Kelingi R.
Semangus R.	2,146		
Lakitan R.	2,763		
Rawas R.	6,026		
Residual basins	552	19,666	Confluence of Rawas R.
Harileko R.	3,765		
Lematang R.	7,340		
Residual basins	4,065	34,836	Confluence of Lematang R.
Ogan R.	8,233		
Residual basins	1,696	44,765	Palembang City
Komering R.	9,980	54,673	Confluence of Komering R.
Residual basins	5,269	59,942	River mouth (Bangka Strait)

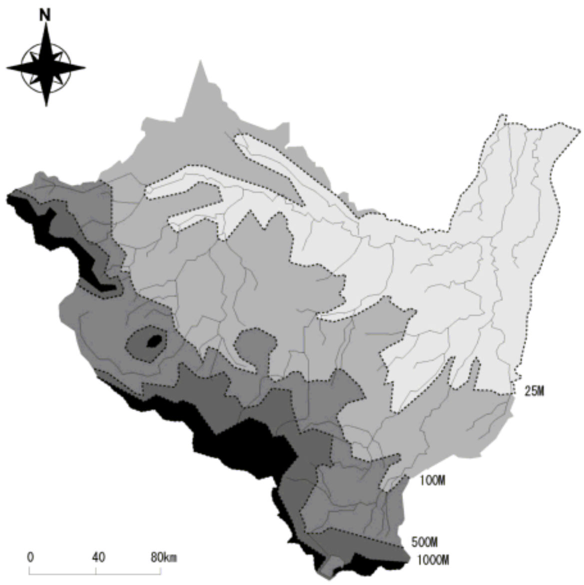

Figure 3.8.2 Contour Map of the Musi Rive Basin

The Musi River Basin is characterized by its wide low-lying lands. Simplified contour map of the basin is shown in **Figure 3.8.2**. As seen in the Figure, the land lower than 25 m above mean sea level (M.S.L.) shares about one third (32%) of the total basin area and the land lower than 100 m M.S.L. shares about two thirds (67%).

Longitudinal profiles of major rivers focusing on the lower reaches below 200 m M.S.L. are also shown in the **Figure 3.8.3**.

The Musi River has long stretch of gentle bed slope in the lower reaches. The riverbed slope changes to steep in the upper reaches within relatively short transitional reaches. Flash floods with active erosion take place in the upper reaches of the main Musi River and tributaries, and they are absorbed in the lower gentle slope reaches. The average bed slope of the Musi River is 1/40,000 from river mouth to Petaling (200 km from the mouth), 1/12,000 from Petaling to the Semangus River junction (391 km), 1/1,900 from the Semangus River junction to Tebing Tinggi (529 km), and 1/69 in the upstream reaches from Tebing Tinggi. Palembang City is located at about 85 km upstream from the river mouth.

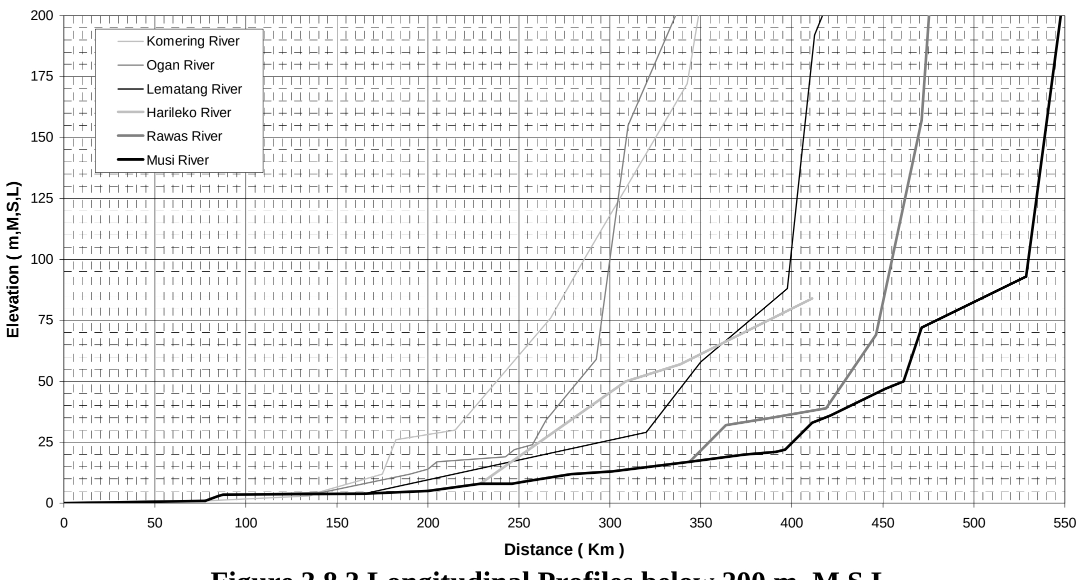

Figure 3.8.3 Longitudinal Profiles below 200 m, M.S.L.

Riverbeds of almost all the lower reaches have been silted up due to the deposition of sediment caused mainly by erosion in the upper catchments, and geological conditions (anticline). The rise of riverbed results not only in the reduction of discharge capacity and causing floods, but also in the extension of back swamp areas. Some low lying areas used as urban and food crop areas are inundated due to overtopping of flood flow over the natural bank. Large back swamp areas are formed in the downstream reaches.

3.8.2 Flooding and Bank Erosion

Present Conditions

The Musi River suffers from debris flow in the upper reaches, bank erosion in the middle reaches, and sedimentation and flooding in the lower reaches. Debris flow occurred at Talang Padang, in Kembahang River of the Musi system in 1999. Several houses were damaged by debris flow and bank erosions occurred at many locations.

In 2000, a debris flow occurred at Muaradua of the upper Komering and damaged houses, schools, and paddy field in three villages. About 20 houses were affected by the debris flow and a bridge was damaged in the downstream area. After the disaster, the affected people were resettled in the safety upstream sites. In the Ogan River, bank erosion is active in the middle reaches near Ulak Kembahang, Tanjung Raja, Baturaja, Pengandonan and at the confluence with the Randu channel. Flooding occurs at Muara Kuang and in its lower reaches.

In the Lakitan River, bank erosion is active in the lower reaches. Deforestation is going on in the Kelingi River Basin. In the Lematang River debris flows caused by deforestation occurred and small bridge was damaged at Kerinjing (18 km upstream point from Pagaralam) in 2001. Flood occurred every year at Belimbing and its downstream area of Muara Enim Regency. In 1986, a flush flood occurred at Muara Enim in the Enim River. The flush flood broke down many houses. Bank erosions are active in the middle reaches near Tanjung Raman-Kuripan and lower reaches.

In the Harileko River, flooding occurs at the confluence of the Musi River. The sediment material of the Harileko River is very fine, and the sediment problem of this river is not serious. Bank erosion is active in the upper and middle reaches in the Rawas River. Flooding occurs at Bingin Teluk in the Rawas River and at Noman in Rupit River of the Rawas River system.

At the confluences such as the Musi and Kelingi Rivers, the Musi and Lakitan Rivers, the Musi and Rawas Rivers, inundations occur frequently when the flood peaks of the two rivers occur simultaneously. The floods often damage nearby roads.

In Palembang City, damages due to flood inundation were not so serious formerly. However, due to rapid urbanization of the city keeping pace with the recent economic development, urban areas of Palembang City have been expanded even to the flood vulnerable low-lying areas. These urban areas have been suffering from frequent inundations. These inundations cause damages to private and public properties and interruption of traffic. Sekayu City is also located in the low-lying area along the Musi River. During the rainy season the city suffers from inundations caused by the backwater of the Musi River through drainage channel. The drainage channel has gates, but the gates are not functioning.

Previous Studies and Works

A master plan of land and water resources development in the Musi River Basin was formulated in 1989 as a result of Musi River Basin Study. The study intended to assist DGWRD in adopting the best policies, in selecting the most appropriate strategy, and for the preparation of an optimum program for the short and long term integrated multipurpose development of the Musi River Basin. A development program with positive investment to irrigation and drainage infrastructure and agricultural supporting services has been proposed as a result of discussions on alternative development scenarios of the Basin. And river training and flood control have been identified as one of the components to support the implementation of the program. Major schemes proposed include the following:

- River training schemes by gabion mattresses at 34 sites mostly to protect the road and houses.
- Flood control schemes for three large areas, i.e., in the lower Ogan river system, the lower Musi River from Sekayu to Palembang, and the Lematang/Enim rivers.
- Multipurpose diversion channel scheme to divert flows from Musi to Banyuasin aiming to solve the problems of floods and drainage in some 60,000 hectares of inland swamps in the lower Musi Basin.
- Warping enclosures scheme to alleviate the problem of flooding in the lower Ogan-Komering river system.

In order to cope with the problems, structural measures have been carried out so far, mainly in line with the river training schemes proposed by the Musi River Basin Study. The river training works have been executed aiming to protect and stabilize the banks where riverbank erosion has caused damages to the major road network. In general the existing measures seem so small to stop the progress of the bank erosion. To protect and stabilize the riverbank, bank protection and jetty works have been adopted. They are made of gabions, stone masonries, concrete sheet piles, concretes, etc. Gabion works are commonly adopted for riverbank protection in the Musi River Basin, since they are more economical than other structures.

Non-structural measures conducted by the guidance and/or initiatives of the local government and other organizations are not found in the Study Area. However, the people live in the flood prone and swampy areas individually have taken some traditional measures to alleviate damages adjusting to the flooding conditions. Stilt type houses are applied to cope with long lasting inundation, and boats are used for transportation during the flood, because the road is submerged under water.

Flood Control Budget

There are three sources of budgets for implementation of flood control projects in the Musi River Basin.

- Kimpraswil budget: Dinas PU Pengairan Province South Sumatra- Flood Control and Coastal Protection Project
- Provincial budget: Dinas PU Pengairan Province South Sumatra- Flood Control Project
- Regency budget: Dinas Kimpraswil Palembang Municipality- Flood Control Project.

In the year of 2001, these agencies carried out the following flood control works:

- Kimpraswil: Construction of jetties at 3 sites in OKU, dredging of the Komering River, and construction of retaining wall at Palembang.
- Province: Construction of concrete sheet piles at OKU, OKI, MURA and MUBA.
- Regency: Construction of drainage channel and detention pond in Palembang

Issues of Flooding

As a summary, major problems the Musi River Basin is facing are:

- Riverbank erosion that threatens infrastructures at the river bends,
- Flush floods in the upper reaches,
- Flood inundations of excess water during rainy season, and
- Riverbed rising due to sedimentation which aggravates flooding during the rainy season.

3.8.3 Inundation of Local Rainfall

Inundation Condition of Palembang

Palembang City is the capital of South Sumatra Province. In the year of 2002, the city has a population of 1.5 millions. Palembang City lies on the low elevation ranging +2 to +4 meters above mean sea level (m, M.S.L.), and has a total area of 403 km^2 of which almost half is in the swampy areas located in the low-lying topography. Palembang is located along the Musi River approximately at 85 km inland from the sea. At Palembang the Musi River is about 350 m in width and is affected by tides. The range of tidal variation is about 2.5 m at this section. During the rainy season, flood water level of the Musi River rises by about 1 m above that of the dry season.

In rainy season when the tidal swamp and back swamp of the Musi River receive strong rainfall, these lands suffer from inundation due to the stagnant water. The inundation is more serious when heavy rain occurs at the time of high water level of the main Musi River. The period of inundation varies from 1 to 12 hours. About 123 ha of farmlands and residential areas of the Palembang City located in low-lying areas suffer from serious damages due to the inundation.

Drainage System of Palembang

The drainage in Palembang City is divided into 19 drainage systems with a total area of 403 km^2. The drainage system consists of detention ponds, primary channels, secondary channels, and tertiary channels. Principal dimensions of the major drainage channels are shown in **Table 3.8.2**, and the dimensions of the detention ponds are shown in **Table 3.8.3**.

Table 3.8.2 Dimensions of Major Drainage Channels

No.	Drainage System	Catchments Area (km^2)	Main Channel			
			Length (m)	Width (m)	Height (m)	Slope
1	Gandus	23.946	-	-	-	-
2	Gasin	52.108	-	-	-	-
3	Lambidaro	50.515	3,400	7	2.0	1/1,250
4	Boang	8.668	3,400	30	3.2	1/33,300
5	Sekanak	11.395	8,200	14	2.0	1/33,300
6	Bendung	19.186	2,800	7	1.7	1/2,500
7	Kidul	2.343	2,400	5	1.0	1/1,000
8	Buah	10.422	6,400	5	2.0	1/5,000
9	Juaro	6.864	-	-	-	-
10	Batang	5.586	4,200	15	2.0	1/2,200
11	Selincah	4.830	3,000	15	1.5	1/2,500
12	Borang	71.210	-	-	-	-
13	SP. Nyiur	22.854	-	-	-	-
14	Sriguna	4.910	1,000	15	1.5	1/33,300
15	Aur	6.578	1,400	11	2.5	1/770
16	Kedukan	9.316	3,500	25	3.0	1/33,300
17	Jaka Baring	37.067	2,000	25	2.5	1/33,300
18	Kertapati	25.008	1,000	10	2.5	1/33,300
19	Keramasan	30.092	1,400	20	2.5	1/33,300

Table 3.8.3 Dimensions of Detention Ponds

No.	Pond	Drainage System	Area (m^2)
1	Siti Khodijah	Sekanak	11,085
2	Polda	Bendung	5,655
3	Talang Aman	Bendung	16,898
4	Ario Kemuning	Bendung	16,267
5	Patal	Buah	5,202
6	IBA	Bendung	12,037
7	Sport Hall	Sekanak	8,070
8	Kambang Ikan Kecil	Sekanak	7,886
9	Kambang Ikan Besar	Sekanak	22,126
10	Seduduk Putih	Bendung	22,590
11	Taman Purbakala	Boang	5,393
12	Taman Ogan Komering	Jaka Baring	22,217
13	Sungai Unggas	Jaka Baring	15,619

Managing Offices of Drainage Facilities

There are three major government agencies related to the implementation of drainage projects in Palembang City. They are:

- APBN Drainage Project: Dinas PU Cipta Karya, Kimpraswil of Central Government;
- APBD-I Drainage Project: Dinas PU Cipta Karya of Provincial Government; and
- APBD-II Drainage Project, Dinas Kimpraswil of Palembang City

According to the current regulation, agencies responsible to the maintenance of the drainage facilities are as follows:

- Primary drainage network: DPU of Provincial Government;
- Secondary and tertiary drainage network: DPU of Palembang City;
- Operation and maintenance of drainage network, including sediment excavation and channel repair: DPU of Palembang City; and
- Garbage treatment in the channel: Cleaning Service Agent of Palembang City.

Causes of Inundation

Physical factors of the inundation are itemizes as follow: Small capacity of main drainage; Very mild slope of drains; Low-lying and flood prone areas; Constricted and silted drains; Solid waste deposited in the drains; Insufficient local drainage; No routine maintenance; Drains partly blocked by vegetation and solid waste; Houses built over the waterway; and, Several drains without bank protection walls.

In addition, the following social factors should be noted: Lack of control for the houses built and to be built within the channel areas; Lack of public awareness that the drains should not be used for solid waste disposal; and, Lack of funds, maintenance facilities and personnel to maintain the drainage facilities.

Drainage Discharge

Runoff discharges of 19 drainage systems are based on data obtained from the hydrological study. Criteria for selection of the appropriate return period for drainage planning can be obtained by referring to the Flood Control Manual (Volume 1, Project No WSTCF 091/011). According to the Manual, recommended minimum return period (years) for design flood pertaining to flood inundation is 5 year in initial phase and 15 year in final phase for Palembang City.

Water Level of the Musi River

The city center of Palembang is flat and low-lying, and drainage of the city is subject to local rainfall and tidal variation as well. Mean water level of the Musi River at

Palembang during the rainy season is +1.05 m M.S.L. raised by the flood water, while it is 0.0 m M.S.L. during dry season. The high water level of the Musi River is around +1.8 m M.S.L.

3.8.4 Erosion, Sedimentation and Drought

Erosion Rate

According to the critical land inventory done by Directorate General Land Rehabilitation, Ministry of Forestry, 1985, the critical land of the Musi River basin is approximately 1,510,000 ha, which is about 30% of total forest area of 5,251,000 ha. This critical land condition will continue becoming worse if sustainable mitigation measures against the damage will not be taken properly and intensively. Erosion in the Central Plain at the foot of the Barisan Range is mostly produced by the infiltration of water. The soil loss dissolution is estimated at 180 ton/year/km^2. (see Section 3.7 for detail.)

Sedimentation Problems

Sedimentation problem is distinguished in the Komering River. The Komering River is wide and shallow with sand bars, and the sinuosity of the river course is low. Sediment discharge is mostly bed load, because the upper watershed is covered with sandy soil produced by land sliding and sheet erosion due to deforestation. In the upper watershed, active erosion is still ongoing without controlling measures, and the sandy bed loads are transported further toward downstream.

In the middle reaches, the Komering River bifurcates toward the Ogan River through diversion channels, namely, the Randu, Arisan, Jambu, Sigonang and Anyar channels. In the downstream reaches of the Randu diversion, riverbed of the Komering is rather steep with slope of about 1/5,000, and the riverbed is left dry almost whole dry season. The river is braided with numerous sand bars, and the riverbed is rising due to sediment deposition.

There are serious sedimentation problems in the middle and lower reaches of the Komering River. River flow in the downstream of Perjaya Headworks is not stable because of sedimentation caused by the divergence. Riverbed of the Komering between Menanga and Cempaka has raised by sedimentation.

Drought

Drought problem in the Musi River Basin is distinguished in the Komering River. In the middle reaches of the Komering River, river channel is instable. Diversion discharge from the Komering River to the Ogan River is increasing, and the Komering River suffers from shortage of water in the downstream reaches of the diversion. In dry season, whole river water of the Komering flows into the Randu channel. Drought problems occur in the reaches from Randu up to Kayu Agung. Even in the upper reaches of the Randu diversion, the areas along the Komering suffer from drought.