SECTOR H

RIVER CONDITIONS, FLOODING AND INUNDATION

1. RIVER CONDITIONS

1.1 Musi River Basin

The Musi River Basin is in the southern part of Sumatra Island. The Musi River and the major tributaries originate in the Barisan Range. The Musi River originates at Gunung Dempo (3159m) 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 the Palembang City. 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 H1.1.1.**

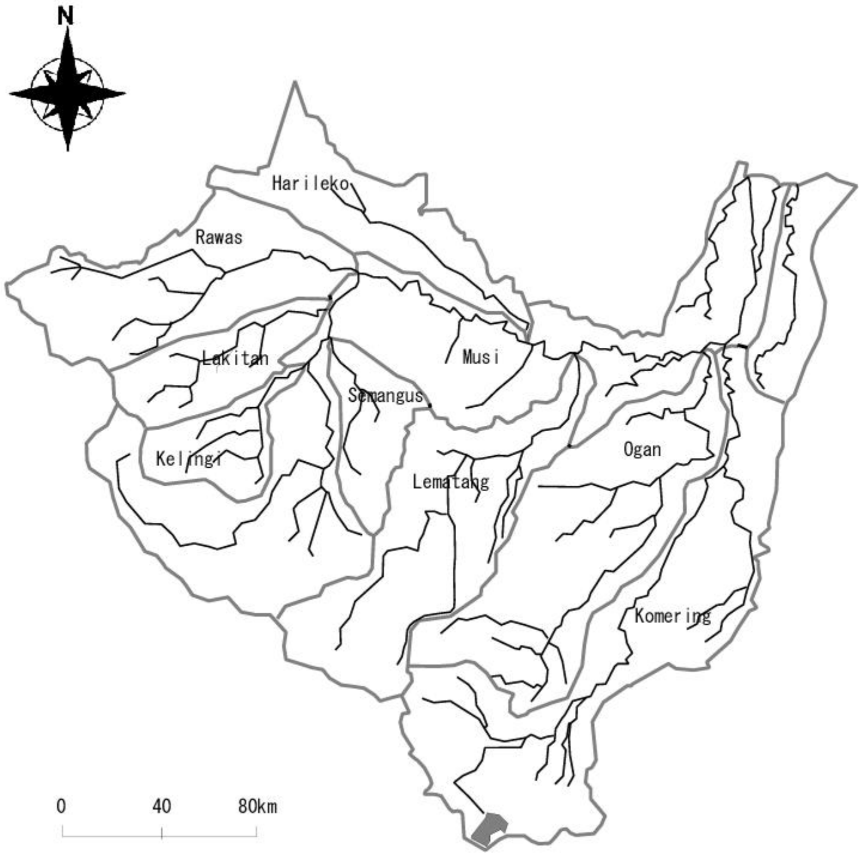

Figure H1.1.1 Musi River Basin

The Musi River 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 H1.1.1**.

Table H1.1.1 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 (South China Sea)

The Musi River Basin is characterized by its wide low-lying lands. Simplified contour map of the basin is shown in **Figure H1.1.2**. 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%).

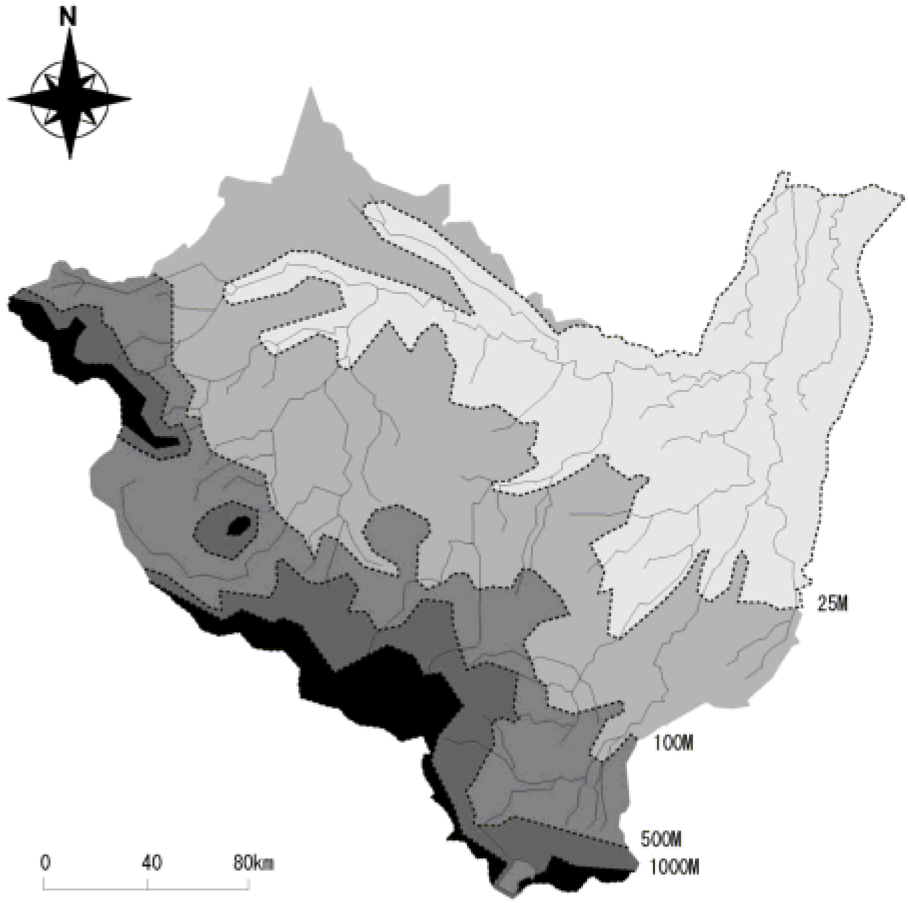

Figure H1.1.2 Contour Map of the Musi River Basin

1.2 River Channels

(1) Riverbed Slope

Longitudinal profiles of major rivers in the Musi River Basin are shown in **Figure H1.2.1**. Focusing on the lower reaches of these rivers, longitudinal profiles below 200 m,M.S.L. are also shown in the **Figure H1.2.2**.

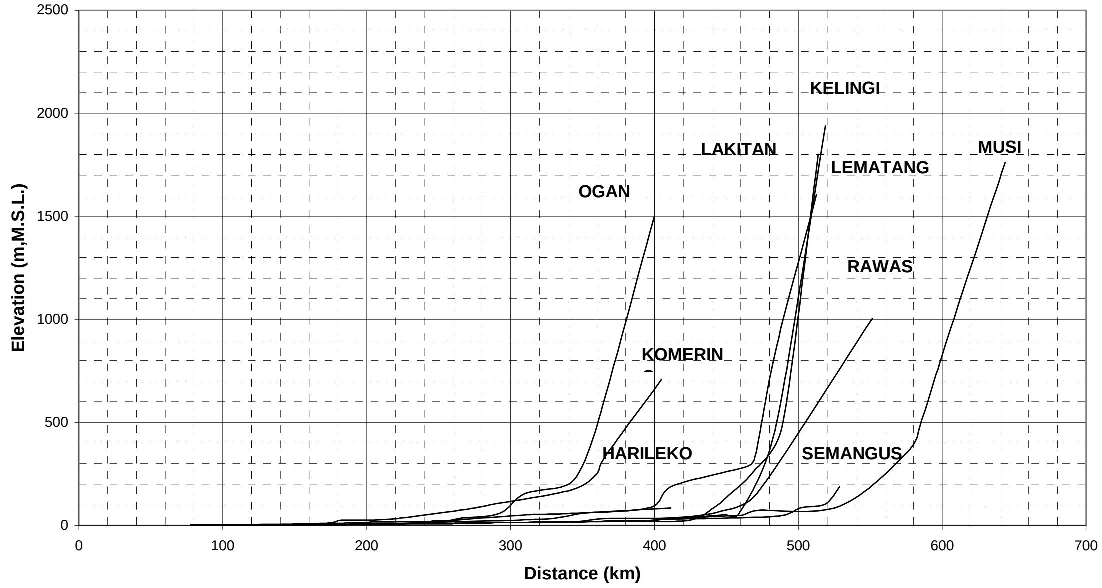

Figure H1.2.1 Longitudinal Profile of Major Rivers in the Musi River Basin

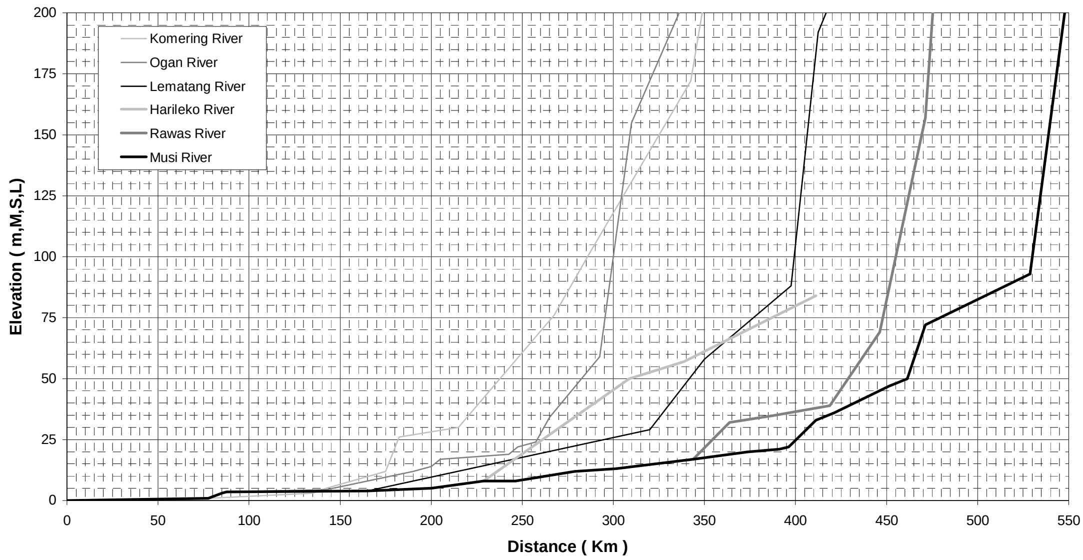

Figure H1.2.2 Longitudinal Profiles below 200 m, M.S.L.

The Musi River has a 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. Principal features of these rivers are described below in brief.

Musi River: 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.

Komering River: The riverbed slope of the Komering River is around 1/4,700 in the reaches from the Musi River junction to Rasuan (137 km from the junction), 1/900 from Rasuan to Muara Dua (265 km), and 1/120 in the upper reaches.

Ogan River: The riverbed slope of the Ogan River is around 1/8,300 in the reaches from the Musi River junction to Lubuk Rukem (170 km from the junction), 1/450 from Lubuk Rukem to Padang Bindu (255 km), and 1/45 in the upper reaches.

Lematang River: The average riverbed slope of the Lematang River is around 1/6,200 in the reaches from the Musi River junction to Beruge (155 km from the junction), 1/480 from Beruge to Pulau Pinang (255 km), and 1/34 in the upper reaches.

Harileko River: Watershed of the Harileko River is relatively low in elevation and the riverbed slope is also simple showing around 1/2,400.

Rawas River: The average riverbed slope of the Rawas River is around 1/2,000 in the reaches from the Musi River junction to Surolangun Rawas (103 km from the junction), and 1/110 in the upper reaches.

(2) Low-lying Lands

Bed slope of the lower Musi River is very gentle, and the riverbed lower than 25 m, M.S.L. extends far about 400 km upstream from the river mouth. Major tributaries such as the Komering, Ogan, Lematang, Harileko and Rawas rivers flow into the low-lying Musi River. Stretches of the riverbed lower than 25 m, M.S.L. are summarized for these rivers in the **Table H1.2.1**.

Table H1.2.1 Stretch of Riverbed Lower Than 25 m, M.S.L.

River	Stretch length from river mouth in km	Stretch length from the Musi confluence in km
Musi River	400	—
Komering River	182	104
Ogan River	258	170
Lematang River	294	129
Harileko River	261	32
Rawas River	354	10

Lands are flat and low-lying in these stretches and swampy lands are found everywhere in the low-lying lands. River courses in these stretches are meandering.

1.3 Existing Problems

These low-lying lands extending along the main Musi River and its tributaries serve for retardation of flood and sediment runoffs. The existing low-lying lands have been serving significantly for alleviation of the flood and sediment damages in the down stream areas owing to its wide area. However, there still exist flood and sediment problems as described below in the Musi River Basin.

(1) Musi River:

Riverbed in the lower reaches has been silted up due to sediment deposition mainly caused by erosion in the upper catchments and geological anticline conditions. The rise of riverbed results not only in the reduction of discharge capacity and flooding, but also in the extension of back swamp areas.

River banks have been eroded around the bends, and the bank erosion damages roads and houses during very short period. The critical riverbanks are protected by small-scale revetment works made of concrete walls and gabion mattresses.

Some urban areas and food-crop lands are located in the low-lying land suffering from inundation due to over-bank flood flows. Large back swamp areas are formed in the downstream reaches of the river caused by long-lasting flood flow and sedimentation.

The main problems of the upper Musi River Basin including the Lakitan, Semangus and the Kelingi rivers are inundation due to over-bank flooding and riverbank erosion.

(2) Komering River

In the middle reaches of the Komering River, elevation of the floodplain is about 10 m higher than that of the Ogan River probably due to difference of sediment yields. Therefore, greater part of the river flow of the Komering River diverges to the Ogan River through several irrigation channels such as Randu, Arisan, Jambu, Sigonang and Anyar which were constructed during Dutch colonial era.

In the downstream reaches of the bifurcation of the Randu channel, the river is left almost dry in the dry season, and the riverbed slope becomes very mild and braided with numerous sand bars rising due to the sediment deposition.

(3) Ogan River

River channel of the Ogan River is meandering with high sinuosity and has a narrow and deep channel. Sediment discharge is mostly suspended load.

The Ogan River receives diverged flow from the Komering in the middle reaches mainly through the Randu channel. The road connecting Payama and Muara Kuang is often submerged and damaged by over-spilling. The settlement areas and food-crop lands suffer from inundation during rainy season.

In the lower reaches of the Ogan River, river discharge increases fast encouraged by inflows from the Komering River. The Ogan River is clearly enlarging its bed by straightening and widening the channel with numerous bank cuttings. Between Kayu Agung and Palembang, there are lots of swamp areas flooded for several months a year.

(4) Lematang River

The main problem of the Lematang River is inundation due to over-land flows mainly on the left bank. In the middle reaches, the areas between Lubuk Mompo and Modong are suffering from frequent flooding during the rainy season.

The Enim River of the Lematang River system is also suffering from bank erosion and inundation due to over spilling. The riverbank erosion threatens the public road, and the erosion is still progressing at several places. In the reaches between Penyandingan and Tanjung Karangan, flood flows overtop the natural banks every rainy season.

(5) Harileko River

No significant flood and sediment problems are reported except for the inundation at the confluence of the main Musi River.

(6) Rawas River

The main problems of the Rawas River are inundation due to flooding and riverbank erosion which threaten the settlements.

Bank erosion is shown in **Photo H1.2.1** and **Photo H1.2.2**.

Photo H1.2.1 Bank Erosion at Concave of River

Photo H1.2.2 Bank Erosion at River Side Village

2. RIVER FLOODING

2.1 Flood Disasters

(1) Musi River

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.

The main problems of the upper Musi River Basin including the Lakitan, Sumangus and the Kelingi rivers are inundation due to over-bank flooding and riverbank erosion which threaten the settlements in Muara Lakitan, Muara Kelingi and other places.

Debris flow occurred at Talang Padang, in Kembahang River of the Musi River system in 1999. Several houses were damaged by debris flow and bank erosions occurred at many locations.

(2) Komering River

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 at downstream. After the disaster, the affected people were resettled in the safety upstream sites.

(3) Ogan River

Bank erosion is active in the middle reaches near Ulak Kembahang, Tanjung Raja, Baturaja, Pengandonan, etc., and at the confluence with the Randu channel. Flooding occurs at Muara Kuang and in its lower reaches.

(4) Lematang River

Debris flows caused by deforestation occurred and small bridge was damaged at Kerinjing (18 km upstream from Pagaralam) in 2001. Flood occurred every year at Belimbing and it’s downstream of Muara Enim District.

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 the lower reaches.

(5) 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.

(6) Rawas River

Bank erosion is active in the upper and middle reaches. Flooding occurs at Bingin Teluk in the main Rawas River and at Noman in the Rupit River of the Rawas River system.

(7) Other Rivers in Upper Watershed

Disasters in the upper river basin are various depending on the basin conditions. For example, bank erosion is active in the lower reaches of the Lakitan River, deforestation is going on in the Kelingi River Basin, no significant flooding takes place in the Semangus River Basin, etc.

At and around the confluences of the Musi River with the Kelingi, Lakitan and Rawas rivers, inundations occur frequently when the flood peaks of the both rivers meet simultaneously. The floods often damage nearby roads.

(8) Low-lying Urban Areas

This type of flood often occurs in Palembang and Sekayu. 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.

2.2 Previous Studies and Works

(1) Musi River Basin Study

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 financed by the Commission of the European Communities (EU).

Objective of 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 programme for the short and long term integrated multipurpose development of the Musi River Basin. The objectives of the study may be summarized as follows:

- Increase agricultural production, specially food crops, and including fisheries to improve the diet balance of the population and for export;
- Increase opportunities for the employment of local population and for the settlement of transmigrates;
- Increase the income of poor families in the study area;
- Reduce erosion, sedimentation and saline intrusion;
- Develop the transportation system; and
- Develop domestic and industrial water supply, and hydropower.

Steps of Study: The study was carried out in four steps:

- Inventory of national resources and analysis of the present situation,
- Engineering studies of water development projects and identification of possible sectoral development program,
- Analysis of possible development strategies including the study of alternative development scenarios,
- Elaboration of the recommended development Master Plan.

Proposed River Training and Flood Control Schemes: A development programme 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 Musi River Basin. And river training and flood control have been identified as one of the components to support the implementation of the programme. Major schemes proposed are as follows:

- 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.
- Enclosures scheme to alleviate the problem of flooding in the lower Ogan-Komering river system.
- Lematang/Enim flood protection schemes with construction of levees.

(2) Structural Measures

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 river bank 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. Where the bank protections have not yet been carried out, the erosions have reached at the roads in some sites, and require costly emergency works.

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. as presented below. Gabion works are commonly adopted for riverbank protection in the Musi River Basin, since they are more economical than other structures.

Concrete sheet pile walls, stone masonry walls and gabion mattresses were used for bank protections at Sangadesa, Muara Lakitan and Bailangu in the Musi River. Concrete sheet pile walls are used also at Palembang. Concrete retaining walls, masonry retaining walls, and gabion jetties were used at Muara Rupit, Lesung Batu, and Kartadewa in the Rawas River.

Gabion jetties are used as river training works at Kertadewa in the Rawas River, Tanjung Karangan in Enim River of the Lematang River system, and Simpang in the Komering River. Bamboo net jetty is used at Paduraksa in Enim River of the Lematang River system for bank protection. Typical gabion jetties are shown in Photo H2.2.1, and bamboo net jetties in Photo H2.2.2.

Photo H2.2.1 Typical Gabion Jetty

Photo H2.2.2 Bamboo Net Jetty

Dredging of river channel is executed at Randu in the Komering River for channel normalization.

Two check dams were constructed in the Lingsing River of the Musi River system.

(3) Non Structural Measures

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.

For instance, in Gunung Megang Dalam village, floods occur every year. Houses in the village are of stilt type coping with long lasting inundation, and boats are used for transportation during the flood, because the road is submerged under water. In case of this village, these measures would be practical. An example of stilt house is shown in Photo H2.2.3.

Photo H2.2.3 Stilt House

In the flood prone areas, residents prepare for coming flood season and farmers adjust the cropping and other farm works to avoid the damages, knowing by experience when and how the inundation occurs seasonally.

If these individual activities are organized and guided with more reliable information by government agencies and institutions, these flood alleviation efforts would be more effective.

2.3 Flood Control Budget

There are three sources of budgets for implementation of flood control projects in the Musi River Basin. They are the budgets from Central Government (Kimpraswil), Local Governments of province and district levels as follows:

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

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

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

2.4 Issues of Flooding

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

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

The riverbank erosions occur in many places of the upper, middle and lower reaches of the main Musi River and its tributaries. The bank erosion is the most serious problems to secure the safety of settlement areas and infrastructures along the river.

The flush floods are limited to the local area in the upper reaches. The damages, however, are serious sometimes with the loss of casualties.

The affected areas of the inundation amount to approximately 114,100 ha in total, but the damages are not so serious comparing to the bank erosions and flush floods, since people in the basin used to live adjusting to them. On the contrary, the flooding brings about fertile silt to their farmlands, and alleviates flood and sediment damages in the lower urban areas.

3. INUNDATION OF LOCAL RAINFALL

3.1 Inundation Conditions 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.

Ground elevation of the lower basin of the Musi River is very flat and low ranging +2 m to +5 m,M.S.L. Because of the flatness of the land, drainage conditions are bad as a whole and many areas are frequently inundated after rainfall. The swamp areas are found along the main Musi, Ogan, Komering, Keramasan rivers, and other tributaries and branches.

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 farm lands and residential areas of the Palembang City located in low-lying areas suffer from serious damages due to the inundation.

The storm water from the city area is finally drained to the Musi River through 19 major drainage systems. To mitigate the inundation damages, drainage improvement works have been carried by improving drainage channels and constructing detention pond.

However, the urban center and main roads of Palembang City are still suffering from inundations, since existing capacities of these facilities are still far from the required level. Political, economical and social activities of the city have been interrupted due to these frequent inundations. In addition, the inundation also aggravates seriously the living environment and causes sanitary problems to the residents of the city. Typical inundation of Palembang is shown in **Photo H3.1.1.**

Photo H3.1.1 Typical Inundation of Palembang

3.2 Drainage Systems of Palembang

(1) Existing Drainage Facilities

During the period from 1993 to 1998, following drainage facilities were built:

- Primary drainage channels: 18.63 km
- Secondary drainage channels: 31.19 km
- Tertiary drainage channels: 23.69 km
- Detention ponds: 13 places

The drainage in Palembang City is divided into 19 drainage systems with a total area of 403 km^2. The drainage system is shown in **Annex H3.2.1**. The drainage system consists of detention ponds, primary channels, secondary channels, and tertiary channels.

That drainage of the city is affected by the water level of the Musi River influenced by the tidal variation. According to the water level records at Palembang, the water level of the Musi River varies from +0.3 m to +1.8 m, M.S.L. in rainy season.

Principal dimensions of the major drainage channels are shown in Table H3.2.1, and the dimensions of the detention ponds are shown in Table H3.2.2.

Table H3.2.1 Dimensions of Major Drainage Channels

No.	Drainage system	Catchment area (km^2)	Main channel			
			Length (m)	Width (m)	Height (m)	Slope
1	Gandus	23.946	-	-	-	-
2	Gasing	52.108	-	-	-	-
3	Lambidaro	50.515	3,400	7	2.0	0.00080
4	Boang	8.668	3,400	30	3.2	0.00003
5	Sekanak	11.395	8,200	14	2.0	0.00003
6	Bendung	19.186	2,800	7	1.7	0.00040
7	Lawang Kidul	2.343	2,400	5	1.0	0.00100
8	Buah	10.422	6,400	5	2.0	0.00020
9	Juaro	6.864	-	-	-	-
10	Batang	5.586	4,200	15	2.0	0.00045
11	Sei Lincah	4.830	3,000	15	1.5	0.00040
12	Borang	71.210	-	-	-	-
13	Simpang Nyiur	22.854	-	-	-	-
14	Sriguna	4.910	1,000	15	1.5	0.00003
15	Aur	6.578	1,400	11	2.5	0.00130
16	Kedukan	9.316	3,500	25	3.0	0.00003
17	Jaka Baring	37.067	2,000	25	2.5	0.00003
18	Kertapati	25.008	1,000	10	2.5	0.00003
19	Keramasan	30.092	1,400	20	2.5	0.00003

Table H3.2.2 Dimensions of Detention Ponds

No.	Pond	Drainage system	Pond 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

Out of the above drainage systems, the following 5 systems have inundation problems:

- **Lambidaro System:** The drainage area consists of settlement areas and open lands (bushes, swamp). Inundation area is 7 hectares in total at 2 locations.
- **Sekanak System:** There are 4 detention ponds with a total area of 4.9 ha. The drainage area consists of settlement and commercial areas. Inundation area is 16.7 hectares at 7 locations.
- **Bendung System:** There are 5 detention ponds with a total area of 7.3 ha. The drainage area consists of settlement and commercial areas. Inundation area is 14.6 hectares in total at 7 locations.
- **Buah System:** The drainage area consists of settlement and industrial areas. Inundation area is 6.3 hectares in total at 6 locations.
- **Sriguna System:** There are 8 inundation areas totaling 13.8 hectares.

Drains are often blocked by solid waste or sediment, and the drainage structures are left broken and collapsed in many places. Lack of personnel and funds is said to be the cause of difficulty in implementing the programmed operation and maintenance services. No maintenance records are kept.

(2) 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.

3.3 Causes of Inundation

(1) Physical Factors 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,
- Many water supply pipes crossing the drains,
- Drains partly blocked by vegetation and solid waste,
- Houses built over the waterway,
- Several drains without bank protection walls.

In addition to the physical factors mentioned above, the following social factors should also 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.

(2) Storm Runoff

Runoff records of the drainage systems are not available. According to the result of runoff analysis, probable discharges for respective drainage systems are shown in Table H3.3.1.

Table H3.3.1 Probable Storm Runoff of Each Drainage System

No.	Sub-Basin	Basin A(km^2)	2 year Q2(m^3/s)	5 year Q5(m^3/s)	15 year Q15(m^3/s)	Q2/A ($m^3/s/km^2$)
1	Gandus	23,964	17.0	22.1	27.7	0.71
2	Gasing	52,108	36.5	47.4	59.5	0.70
3	Lambidaro	50,515	23.5	31.2	40.1	0.47
4	Boang	8,668	6.2	8.0	10.0	0.72
5	Sekanak	11,395	21.1	24.2	30.4	1.85
6	Bendung	19,186	36.7	42.0	52.7	1.91
7	Lawang Kidul	2,343	6.0	6.7	8.2	2.56
8	Buah	10,422	17.1	19.5	24.4	1.64
9	Juaro	6,864	6.4	8.6	10.9	0.93
10	Batang	5,586	6.2	8.2	10.3	1.11
11	Sei Lincah	4,830	5.6	7.3	9.1	1.16
12	Borang	71,210	46.6	61.0	76.9	0.65
13	Simpang Nyiur	22,854	19.8	26.4	33.6	0.87
14	Sriguna	4,910	10.7	12.0	14.5	2.18
15	Aur	6,578	14.8	16.5	19.9	2.25
16	Kedukan	9,316	18.7	21.1	25.9	2.01
17	Jaka Baring	37,067	26.7	34.7	43.5	0.72
18	Kertapati	25,008	33.9	43.2	53.4	1.36
19	Keramasan	30,092	25.3	33.4	42.7	0.84

Taking 2-year discharge for example, the peak runoffs from the drainage basins range from 5.6 to 46.6 m^3/s, and the specific discharges (Q2/A) ranges from 0.47 to 2.56 $m^3/s/km^2$ mainly depending on the basin size.

(3) 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. Water level of the Musi River at Palembang is shown in Figure H3.3.1. Mean water level of the Musi River 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. In rainy season, the drainage of the low-lying areas of Palembang City mainly depends on daily tidal variations, comparing the ground elevation with the river water levels.

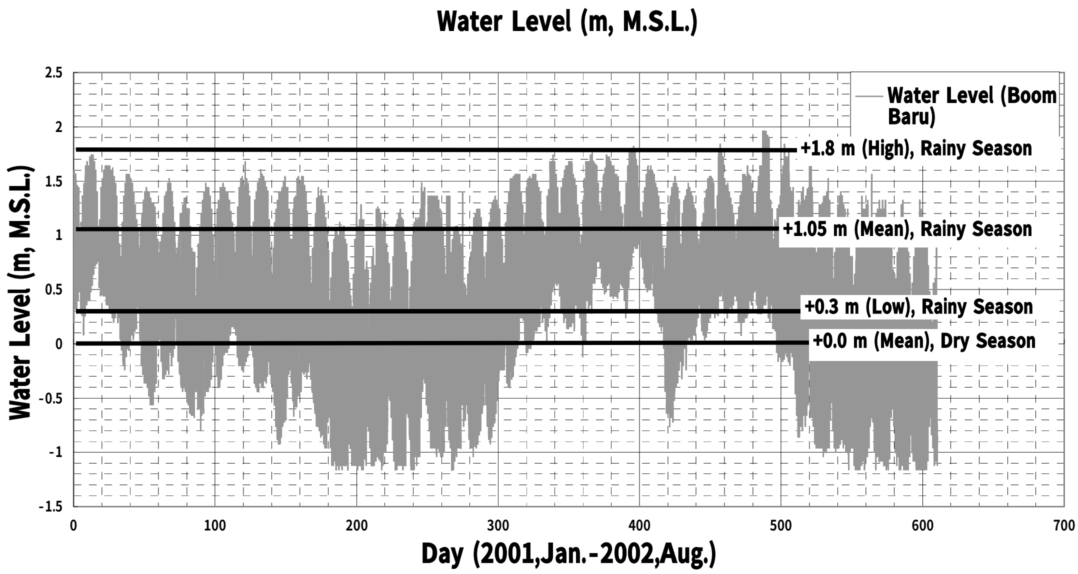

Figure H3.3.1 Water Level of the Musi River at Palembang

3.4 Issues of Inundation

Based on the above discussions the inundation issues of Palembang City are summarized as follows:

- Shortage of the drainage facilities such as drainage channels and detention ponds, and devastation of existing facilities.
- Lack of continuous and periodic maintenance activities of the drainage facilities and networks.
- Lack of society's participants to keep the living environment clean, especially in relation with sediment and garbage disposal.

4. EROSION, SEDIMENTATION AND DROUGHT

4.1 Erosion Rate

According to the report of the Musi River Basin Study by EU, the critical land in erosion of the Musi River basin is approximately 1,510,000 ha, which is about 30% of the whole forest area (5,251,000 ha) based on the inventory made by Directorate General Land Rehabilitation, Ministry of Forestry, 1985. This critical condition will become worse, if sustainable mitigation measures against the erosion are not taken properly and intensively.

Regarding the erosion rate in the Musi River basin, some data are available in the report of the Musi River Basin Study by EU, though the data available for the Study are limited. They are introduced below to show the magnitude of erosion rate, as an example:

- Erosion at the foot of the Barisan Range is mostly caused by the infiltration of water. The annual soil loss has been estimated at 180 ton/year/km^2.
- Erosion rate has been estimated at 719 ton/year/km^2 in the Komering River, and 507 ton/year/km^2 in the upper catchments of the Lematang River.
- Bed load at Tebing Abang in the Musi River has been estimated at 172 ton/year/km^2. The sediment load at Martapura in the Komering River has been estimated at 456 ton/year/km^2.

The erosion rate of the Komering River basin is relatively larger than those of other river basins.

River bank erosion is active at many locations along the Musi River.

4.2 Sedimentation Problems

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.

Almost whole reaches of the lower Kemering River have been silted up due to the deposition of sediment, mainly caused by erosion in the upper watershed and geological anticline in the lower basin. The rise of riverbed results not only in the reduction of discharge capacity, but also in the extension of back swamp areas. Sedimentation of the Komering River is shown in **Photo H4.2.1.**

Photo H4.2.1 Sedimentation of the Komering River

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 been raised by sedimentation.

The rising riverbed raises the water level during flood. Ground elevation of the Komering River is higher than that of the Ogan River by about 10 m, and bed slope of the Randu channel connecting both rivers is rather steep. Therefore, the Randu channel was widened and the bank at the inlet was washed out by the fast flow during floods. Width of the Randu channel which was originally 5 m wide became about 100 m after the flood. Scoring due to the flood broke stilling basin of the regulating dam of the Randu channel.

After the widenning of the Randu channel, almost all discharge of the Komering River flows into the Randu channel, which causes the sedimentation problems in the Komering River in the downstream of the Randu diversion.

4.3 Drought

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 such as in Minanga, Adu Manis, Sukanegri, Kangkung, Ulak Baru, G. Jati Campang Tiga, Kuripan, Sukaraja, and Negeri Sakti.

In order to control the diversion water from the Komering to the Ogan River river flows to stabilize the river flows and water use in the lower reaches, control structures were built across the Randu and other diversion channels at their inlets. Unfortunately, these structures were damaged soon. In the middle of the year 2000, Dinas PU Pengairan, Province of South Sumatera released a program to stabilize the Randu channel with construction of a gabion weir in combination with dredging of the Komering River for about 8 km from Sukabumi village of OKU district to the downstream.

The gabion weir was constructed in 2002 across the Randu channel. Width of the weir is about 100 m and crown elevation is +29.5 m above mean sea level. A gated regulating weir at another inlet of the Randu channel is left broken waiting for immediate reconstruction. The width of the gated weir is 10 m and crown elevation of bottom sill is +29.5m above mean sea levels.

As to the channel dredging, bottom width of the channel is 8m and upper width is 20m. Elevation of bottom of channel is +27 m above mean sea level. Dredged channel is shown in **Photo H4.3.1.**

Photo H4.3.1 Dredged Channel

5. ISSUES AND MASTER PLAN SKELETONS

5.1 Principles for Formulation of Master Plan

Principles for the formulation of the Master Plan of Comprehensive Water Management were set as follows:

(1) Proper management of water and basin of the Musi River is an indispensable requirement for the sustainable development of South Sumatra Province.

(2) The Master Plan is to show principles and an overall direction for water management in the Musi River Basin.

(3) The Master Plan should be formulated focusing on the important matters in implementing the water management in the Musi River Basin, paying attention to what is more important, what is more urgent, what is more comprehensive in water management.

(4) “Comprehensive” as in “Comprehensive Water Management” of the study title includes the following aspects of issues related to water management:

- Issues over the whole Musi River Basin
- Issues relating to multiple sectors, e.g., water use, water related disasters, environment, etc.
- Issues of conflict among sectors, users and regions.

National and regional development plans such as PJP II (Second Long-Term National Development Program), GBHN (General Guideline for National Development), PROPENAS 2000-2004 (National Development Program) and development plans of the provinces and districts should also be referred as super-ordinate policies for formulation of the Master Plan. Target year of the Master Plan was set at the year 2020.

5.2 Components Related to Flood and Inundation

According to the studies of flood and inundation conditions in the previous chapters and comments made in the public consultation meetings, flood and inundation issues in the Musi River Basin were identified as follows:

- Deterioration of river regime (extreme drought);
- Riverbank erosion;
- Riverbed sedimentation;
- Flush flood in mountainous areas;
- Rain inundation in low-lying urban areas;
- Water quality deterioration (urban and rural areas);

- Devastation of watershed; and
- Severe life condition in migration sites in tidal swamp.

These issues were classified into two components which compose a part of the Comprehensive Water Management Master Plan as follows:

(1) Flood: Deterioration of river regime (extreme drought), riverbank erosion and riverbed sedimentation, flush flood in mountainous areas, and rain inundation in low-lying urban areas

(2) Environment: Water quality deterioration (urban and rural areas), devastation of watershed, severe life condition in migration sites in tidal swamp.

Discussions on the above two components are made in the succeeding chapter to develop sub-component programs as sectoral master plan.