CHAPTER 6 NATURAL CONDITION SURVEYS AND ANALYSIS

6.1 Hydrology

6.1.1 Review of Existing Data and Plans

(1) Rainfall Data

The daily/hourly rainfall data were collected from rainfall gauging stations in the study area to review the recent rainfall tendency and update probable rainfall analyses. The existing probable rainfall analyses should be revised for evaluation of the current flood level after including the additional rainfall data into the revision. In addition, the probable rainfall intensity-duration-frequency curves were prepared to calculate the flood peak discharge for the design of the proposed roads and bridges in the relatively small catchment area.

Table 6.1.1 Collected Rainfall Data

River Basin	Name of Rainfall Station	Station Code	Collected Rainfall Data	Period of Record
Maros	Salorijang	28(H)	Daily: Hourly:	1970 - 2006 1984 Dec.-1989 Dec.
Maros	Pucua	29 (OP)	Daily:	1985 - 2006
Maros	Pakelli	97(OP)	Daily:	1975 - 2006
Maros	Batu Bessi	102(OP)	Daily:	1970 - 2006
Maros	Tanralili	103(Op)	Daily:	1970 - 2006
Tallo	Ujunpandang	27(H)	Daily:	1979 - 2006
Jeneberang	Malino	22(H)	Daily:	1977 - 2006
Pappa	Takalar	19(H)	Hourly:	1985 Mar.-1989 Jul.
Pappa	Malolo	20(OP)	Daily:	1971 - 2005

Source: Comprehensive Water Management Plan Study for Maros-Jeneberang River Basin, Nov. 2001

The daily maximum rainfall value of each rainfall station is essential to introduce the probable flood runoff discharge. The flood runoff discharge was estimated based on the basin average daily rainfall through a runoff simulation model.

The average maximum daily rainfall of each river basin had beebn calculated by the “Thiessen Polygon Method”, the “Arithmetric Mean Method” or the “Isohyetal Method”, in the previous study. Therefore correlations between the basin average daily maximum rainfall and the point rainfall of each rainfall station were calculated, and the correlation ratios were determined.

The point rainfall can be converted to the basin average rainfall by using the correlation ratios (conversion factor: Area Reduction Factor). In this study, these conversion factors were used as described below for estimation of the maximum basin average daily rainfall.

Table 6.1.2 Basin Average Maximum One-day Rainfall

River Basin	Rainfall Station *1	Maximum 1-day Rainfall *2 (mm/day)	Basin Average Max. Rainfall (mm/day)	Area Reduction Factor
Maros	Pakelli	191	154	0.81
Tallo	Ujunpandang	153	127	0.83
Jeneberang	Malino	144	114	0.80
Gamanti	Bontosellang	158	134	0.85
Pappa	Malolo	147	123	0.83

Note: *1: Observation Period 1980 – 1999, 20 years
*2: Average Values during the observation period 1980 – 1999, 20 years
Source: Comprehensive Water Management Plan Study for Maros-Jeneberang River Basin, Nov. 2001

The accumulative rainfall data by minute/hour were collected from the Salorijang Rainfall Station (the Maros River Basin) and Takalar Rainfall Station (the Pappa River Basin) to prepare probable rainfall intensity-duration-frequency curves. As mentioned in Section 2.1.2 of Chapter 2, the annual rainfall in the study area tends to increase from around 1,500 mm in the southern part to around 4,000 mm in the northern part. Therefore, two probable rainfall intensity-duration-frequency curves are necessary for two regional areas: the northern part and the southern part of the study area.

The regional rainfall intensity curves should be prepared based on hourly rainfall data of the two representative rainfall stations, the Salorijang and Takalar Rainfall Stations, of the northern and southern parts.

However, the existing hourly rainfall data of the two rainfall stations were quite inadequate for calculation of the probable rainfall intensity analyses, which had not been recorded from 1989 due to machine problems. The missing hourly rainfall data were supplemented with the following correlation as shown in **Figures 6.1.1** and **6.1.2**.

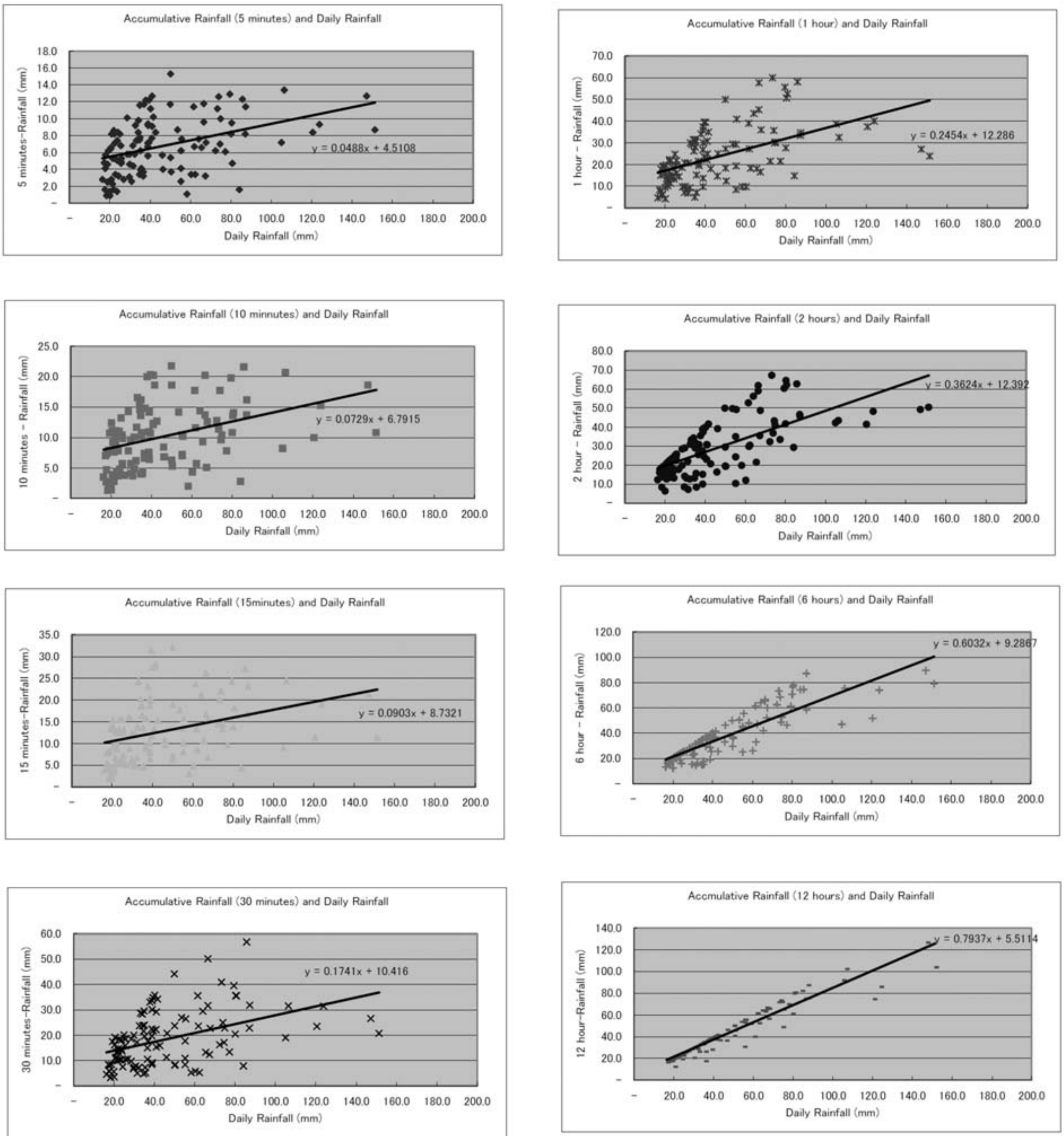


Figure 6.1.1 Correlation between Rainfall Intensity and Daily Storm Rainfall (Salorijang and Pakelli Rainfall Stations)

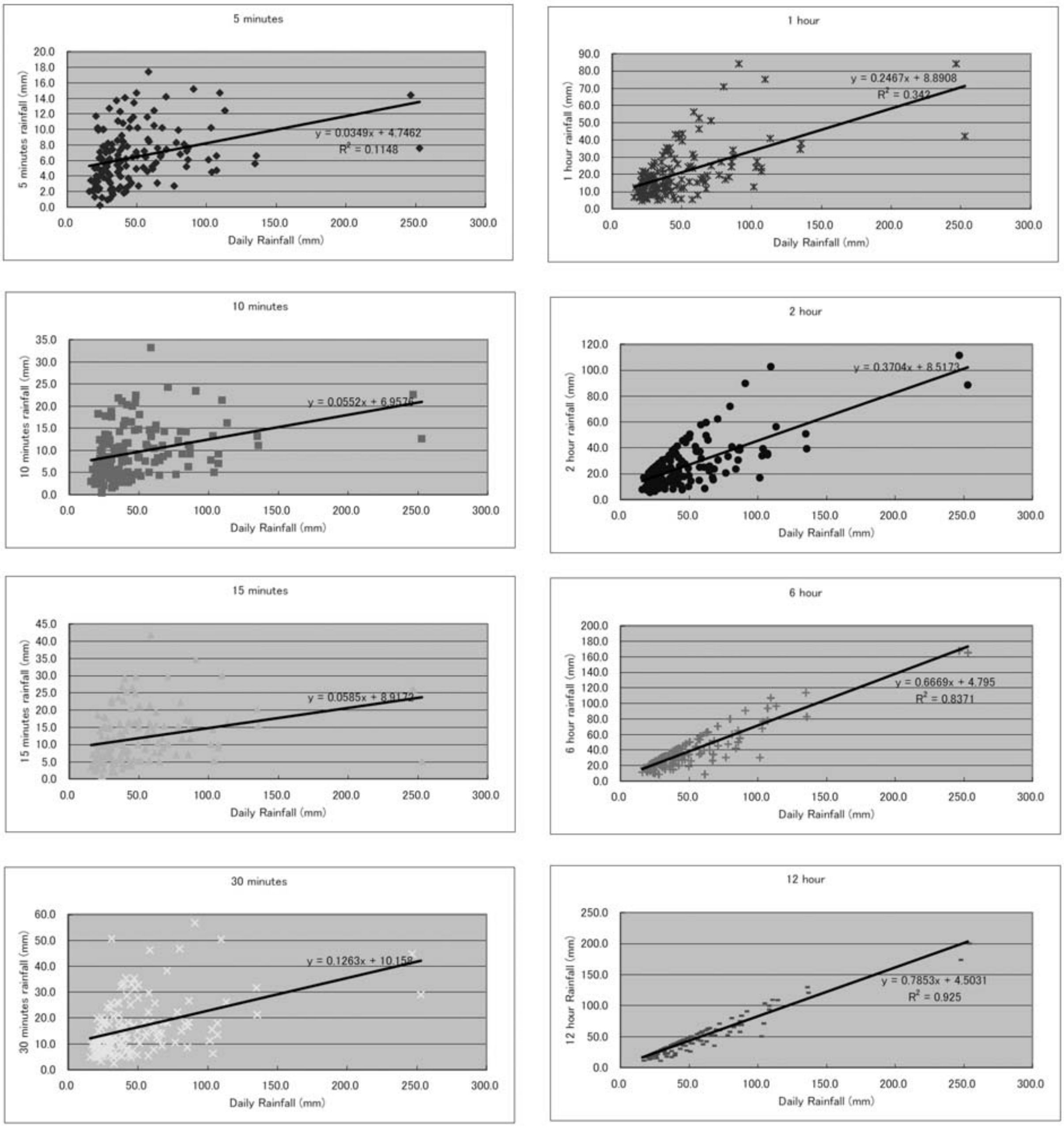


Figure 6.1.2 Correlation between Rainfall Intensity and Daily Storm Rainfall (Takalar and Malolo Rainfall Stations)

Table 6.1.3 Correlation for Supplement of Hourly Rainfall Data (Hourly Rainfall and One-day Storm Rainfall)

Region for Rainfall Intensity	**Correlation between:**	
	Hourly Rainfall	**One-day Storm Rainfall**
Northern Part	Salorijang Rainfall Station 1984 Dec.-1989 Dec.	Pakelli Rainfall Station 1984 Dec.-1989 Dec.
Southern Part	Takalar Rainfall Station 1985 Mar.-1989 Jul.	Malolo Rainfall Station 1985 Mar.-1989 Jul.

The rainfall intensity of the Pakelli (Maros) and Malolo (Takalar) rainfall stations were estimated with maximum daily rainfall as shown in **Tables 6.1.4** and **6.1.5**. The estimated rainfall intensity data of the Pakelli and Malolo rainfall stations located in the northern part and southern part of the study area respectively were selected to show the regional rainfall intensity patterns, from which the regional probable rainfall intensity-duration-frequency curves could be prepared accordingly.

Table 6.1.4 Estimated Rainfall Intensity at Pakelli (Maros)

Pakelli (Unit:mm)

Year	Max Daily Rainfall	5 minute	10 minute	15 minute	30 minute	1 hour	2 hour	6 hour	12 hour
1976	275	17.9	26.8	33.6	58.3	79.8	112.1	175.2	223.8
1977	150	11.8	17.7	22.3	36.5	49.1	66.8	99.8	124.6
1978	200	14.3	21.4	26.8	45.2	61.4	84.9	129.9	164.3
1979	175	13.1	19.5	24.5	40.9	55.2	75.8	114.8	144.4
1980	200	14.3	21.4	26.8	45.2	61.4	84.9	129.9	164.3
1981	175	13.1	19.5	24.5	40.9	55.2	75.8	114.8	144.4
1982	175	13.1	19.5	24.5	40.9	55.2	75.8	114.8	144.4
1983	215	15.0	22.5	28.1	47.8	65.0	90.3	139.0	176.2
1984	175	13.1	19.5	24.5	40.9	55.2	75.8	114.8	144.4
1985	100	9.4	14.1	17.8	27.8	36.8	48.6	69.6	84.9
1986	250	16.7	25.0	31.3	53.9	73.6	103.0	160.1	203.9
1987	250	16.7	25.0	31.3	53.9	73.6	103.0	160.1	203.9
1988	300	19.2	28.7	35.8	62.6	85.9	121.1	190.2	243.6
1989	150	11.8	17.7	22.3	36.5	49.1	66.8	99.8	124.6
1990	250	16.7	25.0	31.3	53.9	73.6	103.0	160.1	203.9
1991	115	10.1	15.2	19.1	30.4	40.5	54.1	78.7	96.8
1992	150	11.8	17.7	22.3	36.5	49.1	66.8	99.8	124.6
1993	175	13.1	19.5	24.5	40.9	55.2	75.8	114.8	144.4
1994	175	13.1	19.5	24.5	40.9	55.2	75.8	114.8	144.4
1995	250	16.7	25.0	31.3	53.9	73.6	103.0	160.1	203.9
1996	200	14.3	21.4	26.8	45.2	61.4	84.9	129.9	164.3
1997	155	12.1	18.1	22.7	37.4	50.3	68.6	102.8	128.5
1998	120	10.4	15.5	19.6	31.3	41.7	55.9	81.7	100.8
1999	275	17.9	26.8	33.6	58.3	79.8	112.1	175.2	223.8
2000	200	14.3	21.4	26.8	45.2	61.4	84.9	129.9	164.3
2001	217	15.1	22.6	28.3	48.2	65.5	91.0	140.2	177.7
2002	250	16.7	25.0	31.3	53.9	73.6	103.0	160.1	203.9
2003	300	19.2	28.7	35.8	62.6	85.9	121.1	190.2	243.6
2004	250	16.7	25.0	31.3	53.9	73.6	103.0	160.1	203.9
2005	200	14.3	21.4	26.8	45.2	61.4	84.9	129.9	164.3
2006	180	13.3	19.9	25.0	41.8	56.5	77.6	117.9	148.4

Table 6.1.5 Estimated Rainfall Intensity at Malolo (Takalar)

Malolo (Unit:mm)

Year	Max Daily Rainfall	5 minute	10 minute	15 minute	30 minute	1 hour	2 hour	6 hour	12 hour
1978	89	7.9	11.9	14.1	21.4	30.8	41.5	64.1	74.4
1979	128	9.2	14.0	16.4	26.3	40.5	55.9	90.2	105.0
1980	84	7.7	11.6	13.8	20.8	29.6	39.6	60.8	70.5
1981	104	8.4	12.7	15.0	23.3	34.5	47.0	74.2	86.2
1982	94	8.0	12.1	14.4	22.0	32.1	43.3	67.5	78.3
1983	123	9.0	13.7	16.1	25.7	39.2	54.1	86.8	101.1
1984	143	9.7	14.9	17.3	28.2	44.2	61.5	100.2	116.8
1985	201	11.8	18.1	20.7	35.5	58.5	83.0	138.8	162.3
1986	150	10.0	15.2	17.7	29.1	45.9	64.1	104.8	122.3
1987	284	14.7	22.6	25.5	46.0	79.0	113.7	194.2	227.5
1988	163	10.4	16.0	18.5	30.7	49.1	68.9	113.5	132.5
1989	250	13.5	20.8	23.5	41.7	70.6	101.1	171.5	200.8
1990	112	8.7	13.1	15.5	24.3	36.5	50.0	79.5	92.5
1991	130	9.3	14.1	16.5	26.6	41.0	56.7	91.5	106.6
1992	94	8.0	12.1	14.4	22.0	32.1	43.3	67.5	78.3
1993	140	9.6	14.7	17.1	27.8	43.4	60.4	98.2	114.4
1994	140	9.6	14.7	17.1	27.8	43.4	60.4	98.2	114.4
1995	132	9.4	14.2	16.6	26.8	41.5	57.4	92.8	108.2
1996	131	9.3	14.2	16.6	26.7	41.2	57.0	92.2	107.4
1997	96	8.1	12.3	14.5	22.3	32.6	44.1	68.8	79.9
1998	163	10.4	16.0	18.5	30.7	49.1	68.9	113.5	132.5
1999	210	12.1	18.5	21.2	36.7	60.7	86.3	144.8	169.4
2000	112	8.7	13.1	15.5	24.3	36.5	50.0	79.5	92.5
2001	199	11.7	17.9	20.6	35.3	58.0	82.2	137.5	160.8
2002	134	9.4	14.4	16.8	27.1	41.9	58.2	94.2	109.7
2003	157	10.2	15.6	18.1	30.0	47.6	66.7	109.5	127.8
2004	120	8.9	13.6	15.9	25.3	38.5	53.0	84.8	98.7
2005	135	9.5	14.4	16.8	27.2	42.2	58.5	94.8	110.5

Note: Maximum Daily Rainfall in 2001 was estimated based on correlation with neighboring rainfall stations.

(2) Flood Inundation Records

1) Maros River

The river runs meandering through the downstream area along the town of Maros. Due to the meandering of the river, serious flood inundation frequently occurs particularly in and around the town of Maros during the rainy season despite the construction of a river embankment of about 4.5 km in length. Recent occurrences of major floods by river overflow are indicated below.

- i) In 1986, the dike of Maros was breached by flood discharge, and the low-lying area of about 13,000 ha along the river was inundated.
- ii) In 1999, flood overflow occurred causing inundation over an area of about 12,700 ha which recorded the maximum inundation depth of about 0.8 m and lasted for almost two (2) days.
- iii) In 2000, the river flood flow was blocked by an illegally constructed access road from the river channel leading to flood inundation over an area of about 500 ha.

The flood inundation area along the Maros River is shown in **Figure 6.1.3** based on existing flood records, which also shows existing flood control plans.

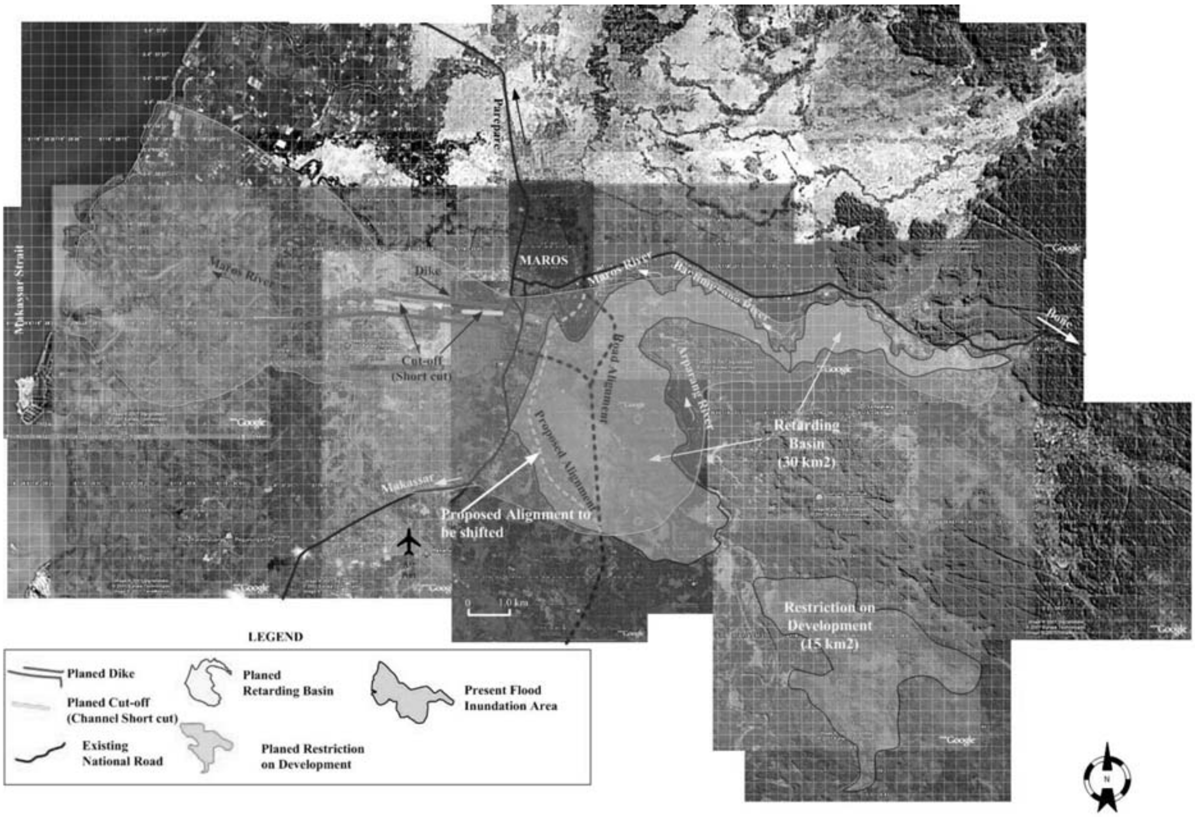


Figure 6.1.3 Flood Inundation Area, Flood Control Plan and Proposed Road Alignments in the Maros River Basin

2) Tallo River

In spite of habitual flood inundation, industrial estates tend to expand along the new arterial road constructed in the lower reaches of the Tallo River, which leads to the increment of flood damage potential. A recent flood occurred in February 2000, inundating an area of 2,535 ha with the maximum inundation depth reaching 1.5m.

The flood inundation area along the Tallo River is shown in **Figure 6.1.4** based on existing flood records, which also shows existing flood control plans.

Figure 6.1.4 Flood Inundation Area, Flood Control Plan and Proposed Road Alignments in the Tallo River Basin

3) Jeneberang River

At present, the river can cope with the probable flood discharge of 50-year return period. In fact, the Jeneberang River has not caused any serious flood overflow since the completion of the river improvement works and construction of the Bili-Bili Dam.

4) Gamanti River and Pappa River

The Pappa River caused flood overflow in 2000 when a residential area of 3,000 ha and fishponds of 700 ha in total were inundated. Flood overflow also occurred along the Gamanti River in 1999 causing flood inundation in an area of 1,415 ha.

The flood inundation area along the Gamanti and Pappa Rivers is shown in **Figure 6.1.5** based on existing flood records, which also shows existing flood control plans.

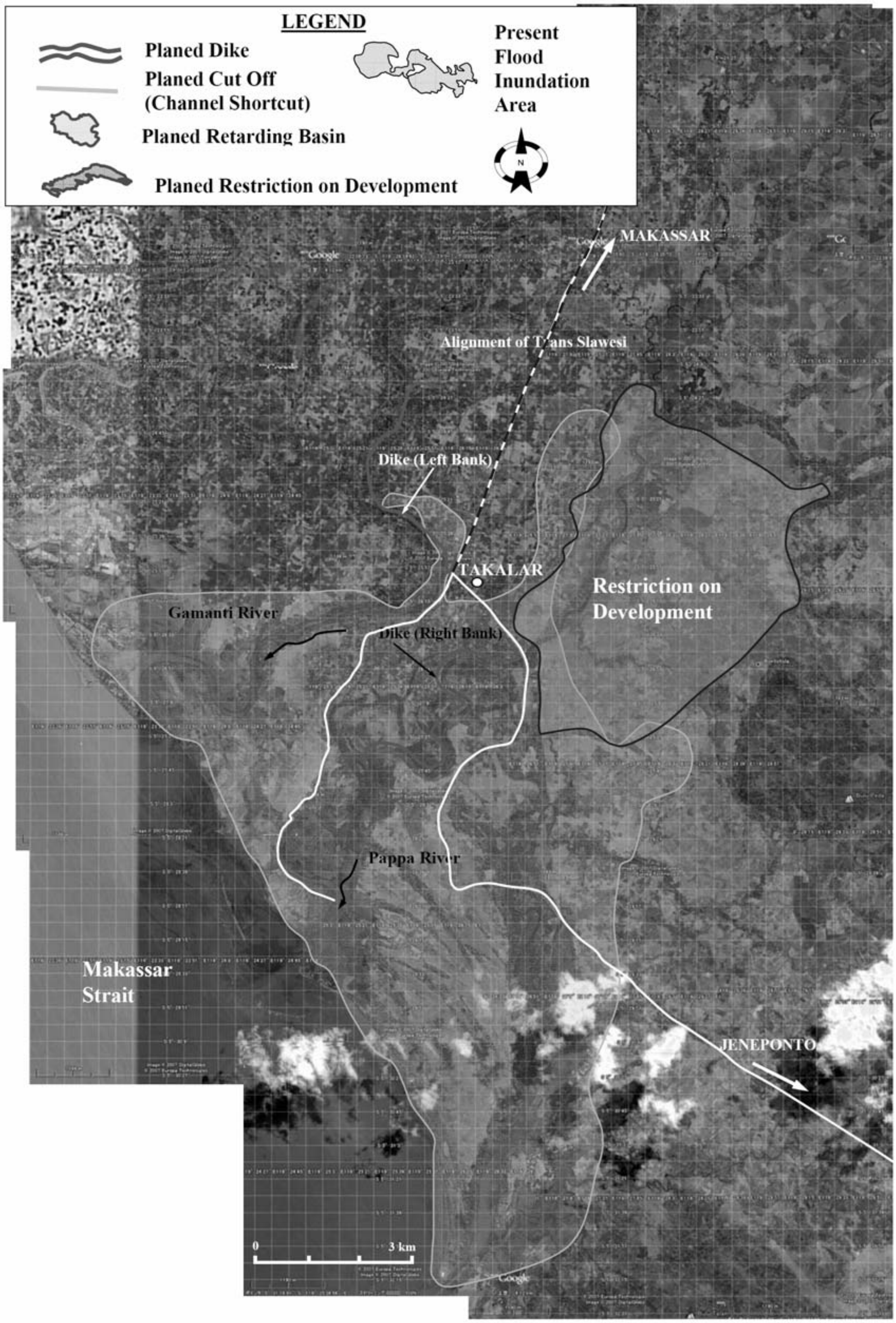


Figure 6.1.5 Flood Control Plan (Gamanti and Pappa Rivers) and the Road Alignments

(3) Design Standard of Flood Control

1) Factors for Determination of Design Scale

The following two key factors were taken into consideration in the determination of the target design level for the aforesaid target river stretches:

(a) Design Level in the Guideline

The following design levels are recommended in the Flood Control Manual, 1993, issued by the Ministry of Public Works as shown in **Table 6.1.6**:

Table 6.1.6 Design Scale in the Guideline

Type of Flood Control Project	Target Design Scale	
	Initial Phase	Final Phase
1. Emergency Project	5-year	10-year
2. New Project	10-year	25-year
3. Updating Project		
3.1. Population < 2,000,000	25-year	50-year
3.2. Population > 2,000,000	25-year	100-year

Source: Flood Control Manual prepared by Ministry of Public Works, June 1993

Note: 1. Higher design standard should be applied if economic analysis indicated that it is desirable, or if flooding is a significant risk to human life.
2. Emergency projects are developed without preliminary engineering and economic feasibility studies at site where flooding is excessive and flooding problem present risk to human life.
3. New projects include flood control projects where no previous flood control projects have been developed or where emergency projects have been developed.
4. Updating projects include rehabilitation projects and improvements to existing projects. Most of the river basin development projects are considered as updating projects.

(b) Design Scale in Previous Studies and Projects

The previous studies/projects for flood mitigation in South Sulawesi had adopted design levels of 5 to 50-year return period, as shown in **Table 6.1.7**:

Table 6.1.7 Target Design Scales Adopted in Indonesia

River	Target City	Design Scale	Status
Maros	Maros	5-year	D/D 1988
Tallo	Makassar	25-year	D/D 1997
Topa	Topa	10-year	D/D 1997
Allu	Allu	10-year	D/D 1997
Jeneberang	Makassar	50-year	completed

Source: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001 prepared by P.U.

2) Design Scale in the Study Area

Taking the above two factors into consideration, the following scales were adopted for each of the target river stretches.

Table 6.1.8 Design Scale by Rivers

River	Protection Area (ha)	Target City to be protected	Population to be protected	Design Scale	Design Discharge (m^3/sec)
Maros	13,000	Maros	22,000	25-year	1,240
Tallo	4,600	Makassar	430,000	50-year	1,010
Bringkassi	1,500	Takalar	6,300	10-year	130
Pappa					520

Source: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001 prepared by P.U.

3) Design Criteria of Freeboard for Height of Dike

The crest level of a dike is set by adding the following freeboard to the design high water level.

Table 6.1.9 Design Criteria for Height of Freeboard

Design Discharge (m^3/sec)	Freeboard
Q < 200	0.5
200 < Q <500	0.8
500 < Q < 2,000	1.0
2,000 < Q < 5,000	1.2
5,000 < Q < 10,000	1.5
10,000 < Q	2.0

(4) Flood Control Plans

The Makassar City and all regencies in the study area suffer from chronic inundation by river overflow and storm water discharge. The causes of flood are classified into the following:

- Insufficiency of river flow capacity;
- Insufficiency of urban drainage capacity; and
- Incremental flood runoff discharge associated with lack of vegetation in the upper reaches.

The following flood control projects were identified by the 2001 JICA Study for the study area:

- Maros River Flood Control Project (Maros City);
- Tallo River Flood Control Project (Makassar City); and
- Gamanti/Pappa River Flood Control Project (Takalar City).

A summary of the measures to be included in the optimum flood mitigation plan for each of the target river is presented in **Table 6.1.10**:

Table 6.1.10 Measures Included in the Flood Mitigation Plan

River	Structural Measures			Non-structural Measures		
	Dike	Shortcut	Retarding Basin	Restriction Area	Flood Information	Flood Risk Map
Maros	O	O	O	O	O	O
Tallo	O	O	O	O	O	O
Gamanti	O	-	-	-	O	O
Pappa	O	-	-	O	O	O

Source: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001 prepared by P.U.

The proposed design longitudinal river profiles of the Maros and Tallo Rivers are summarized in **Table 6.1.11**:

Table 6.1.11 Design Riverbed Slope

River	Distance from River Mounth		Length	Design Riverbed Slope
	from	to	(m)	
Maros	100	3,450	3,350	1/9,000
	3,450	6,000	2,550	1/4,500
Tallo	0	7,000	7,000	1/10,000
	7,000	12,200	5,200	1/5,000
	12,200	15,000	2,800	1/2,500
	15,000	18,300	3,300	1/1,600

Source: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001 prepared by P.U.

The economic viability of these projects is not so much high according to the 2001 JBIC Study. Furthermore, the viability was assessed under the scenario that the urbanization is assumed to occur in the riverine area in the future. It is judged that the urgency of the structural improvement projects is relatively low so far, therefore further detailed studies are necessary.

1) Maros City

(a) Maros River

The optimum plan is the river channel improvement a 6.0 km length which includes the shortcut channel of 1.6 km. Two potential retarding basins of about 30 km^2 in total were also considered. The layout of the structural measures is shown in **Figure 6.1.3**.

In addition, the non-structural measures including delineation of “Development Restricted Area” (about 15 km^2), dissemination of flood information, and preparation of flood risk map were recommended.

2) Makassar City

The flood control projects for the Makassar City have a combination of river and drainage improvement projects for the city core. Project features are described below.

(a) Tallo River

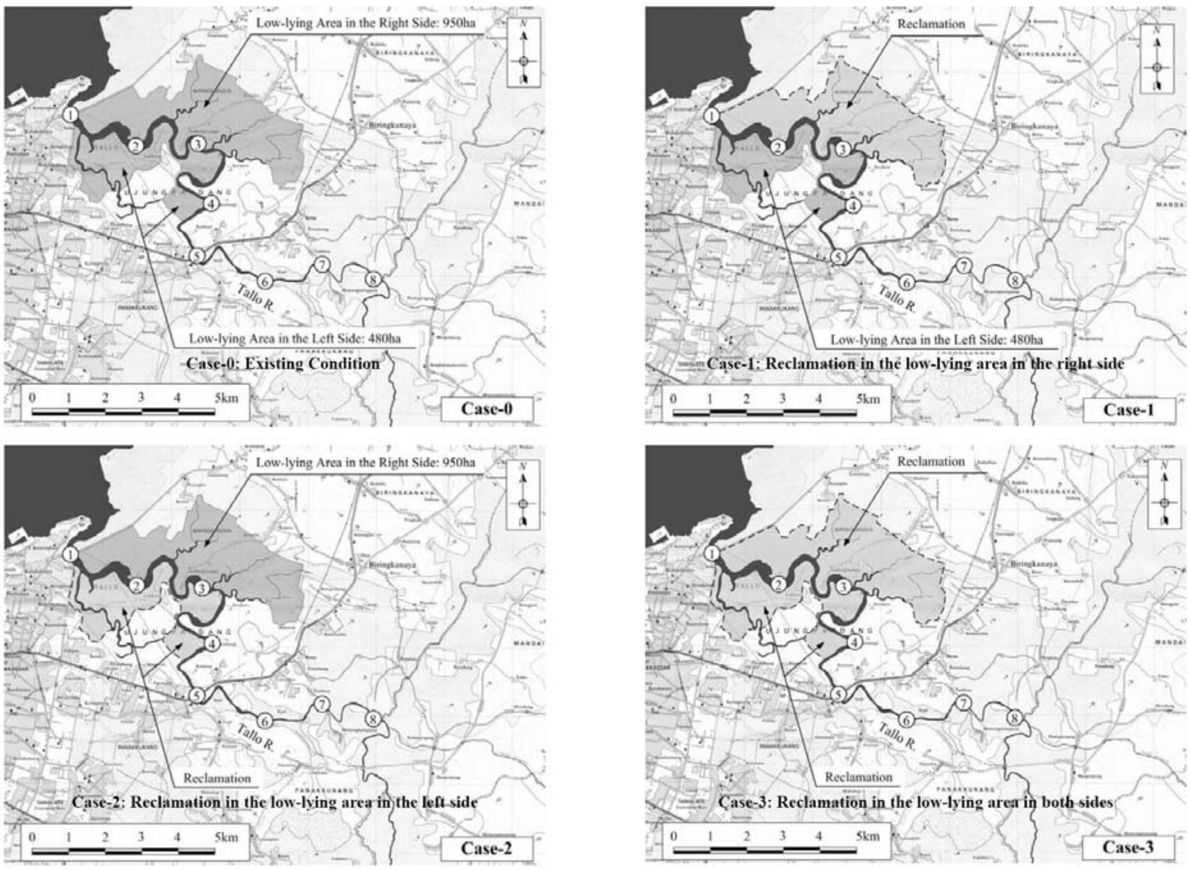
The optimum plan is the river channel improvement over a 19.3 km length and the Bankala River, the major tributary of 1.3 km long including the shortcut channel for the mainstream of 2.0 km. One flood retarding basin of about 4.7 km^2 in extent was also considered. The layout of the structural measures is shown in **Figure 6.1.4**.

It should be noted that in the Study on Implementation of Integration Spatial Plan for the Mamminasata Metropolitan Area, December 2005, the arrangement of the dike was modified from the original plan considering its landuse policy, in which the flood plain in the lower Tallo shall be preserved.

The existing low-lying areas in the downstream reaches of the Tallo River are now encountering a pressure of further development because of its nearness from the Makassar city center. However, in the study it was recommended that the existing low-lying area in the downstream reaches of the Tallo River shall be preserved from the viewpoint of flood hydrology: the development or reclamation in the existing low-lying area might increase the flood inundation risks not only in the vicinity area but also in other unexpected areas. These developments surely make the flood situation worse.

The influence of the land reclamation in the low-lying areas was assessed through the hydraulic calculation based on the following cases (refer to **Figure 6.1.6**):

Case-0: The existing low-lying areas are preserved as it is (existing condition),
Case-1: The low-lying areas on the right bank of the Tallo River are reclaimed,
Case-2: The low-lying areas on the left bank of the Tallo River are reclaimed, and
Case-3: All of the low-lying areas are reclaimed.



Source: The Study on Implementation of Integration Spatial Plan for the Maninasata Metropolitan Area, December 2005 (JICA)

Figure 6.1.6 Cases of Flood Risk due to Land Reclamation in the Lower Reaches of the Tallo River

The quasi-2-dimentional unsteady flow calculation was executed with the following simulation conditions:

(i) Manning's rough coefficient in the river channel is assumed to be 0.03.
(ii) The downstream boundary water level (tidal level) is set at 0.80 m above the mean sea level (MSL),
(iii) The land level in the low-lying areas is assumed to be -0.5 0m above MSL.
(iv) The same river cross-section data and inflow hydrographs (2-yr, 10-yr and 50-yr probable floods) as the 2001 JBIC Study are employed.

The probable flood inflow hydrographs used for the simulation are shown in **Figure 6.1.7**. The inflow hydrographs awere input to the hydraulic simulation model. The results of the simulation are given in **Tables 6.1.12** and **6.1.13**. The maximum discharge at the mouth of the Tallo River is shown in **Table 6.1.12**. The increase of the flood water level from the existing condition is shown in **Table 6.1.13**.

As shown by the results of simulation, in the Case-1 (the right bank of the Tallo River is reclaimed) under 10-year probable flood inflow, flood water levels in the downstream area (downstream of the Tallo Bridge) increased by 15 cm to 35 cm excluding those at the river mouth.

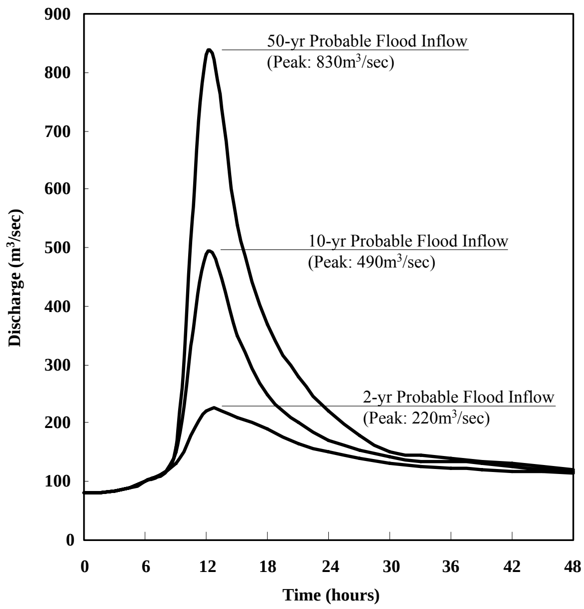


Figure 6.1.7 Probable Flood Inflow Hydrographs

Source: The Study on Implementation of Integration Spatial Plan for the Maninasata Metropolitan Area, December 2005

Table 6.1.12 Increase in the Maximum Discharge at the River Mouth from "Existing Condition (Case-0)" due to the Reclamation in the Low-lying Areas f the Tallo River

Return Period	Max. Inflow (m^3/sec)	Case-0	Case-1		Case-2		Case-3	
		Max. Outflow (m^3/sec)	Max. Outflow (m^3/sec)	Increase (%)	Max. Outflow (m^3/sec)	Increase (%)	Max. Outflow (m^3/sec)	Increase (%)
2-yr	220.0	162.7	191.5	17.7	169.5	4.2	204.7	25.9
10-yr	490.0	230.7	309.6	34.2	248.7	7.8	367.5	59.3
50-yr	830.0	324.0	466.7	44.0	356.5	10.0	591.8	82.7

Table 6.1.13 Increase in the Flood Water Level from "Existing Condition (Case-0)" due to the Reclamation in the Low-lying Areas of the Tallo River

BP	2-yr Probable Flood Inflow			10-yr Probable Flood Inflow			50-yr Probable Flood Inflow		
	Case-1	Case-2	Case-3	Case-1	Case-2	Case-3	Case-1	Case-2	Case-3
1	0.7	0.2	1.0	2.8	0.6	5.4	7.3	1.5	15.6
2	4.5	1.0	6.8	15.8	3.4	28.2	31.6	7.0	59.3
3	10.6	2.2	15.3	32.0	5.9	51.1	55.4	10.0	91.8
4	11.6	2.5	17.2	24.6	6.8	44.4	34.7	10.4	70.3
5	11.1	2.6	17.0	18.0	7.1	37.5	23.7	11.6	58.2
6	9.7	2.1	16.0	8.5	5.8	24.6	12.4	9.7	42.4
7	6.6	2.1	12.5	2.3	2.6	9.9	4.1	7.2	26.0
8	3.1	1.3	6.7	1.6	2.0	2.5	0.5	1.6	7.0

Notes: BP: Base Point

The increase in the water level of the Tallo River reduces the flow capacity of the drainage channels, and inundation situation in the Makassar City surely becomes severer.

Therefore, the low-lying area in the downstream reaches of the Tallo River shall be preserved, otherwise huge additional investments must be required in order to compensate the adverse effect brought by the development activity.

In addition, the non-structural measures were recommended including delineation of a "Development Restricted Area" (about 9.0 km^2), dissemination of flood information, and preparation of flood risk map.

(b) Jeneberang River

The river improvement works for about 20 km along the lower stretch of the Jeneberang River from the river mouth to Sungguminasa Bridge were completed in 1993. The major works included the construction of river dike of 11.8 km, river dredging of 5 km, revetment of 3,000 m^2, construction of two groundsills, and construction of a jetty of 300 m. The construction of a diversion channel along the estuary was further completed as an extension of the above river channel improvement in 1994. The river flow capacity was increased by these river channel improvement works and diversion channel from 600-1,000 m^3/sec to the design discharge of 2,300 m^3/sec, which corresponds to the probable flood runoff discharge of 10-year return period.

In 1999, the Bili-Bili Multipurpose Dam with a flood capacity of 41 million m^3 was further completed to control the flood discharge of the Lower Jeneberang River, particularly, along the urban area of the Makassar City. As a result, the city is currently protected against the probable river flood overflow of 50-year return period.

The design discharges brought about by the above river channel improvement and flood regulation by the Bili-Bili Dam are summarized in **Table 6.1.14**:

Table 6.1.14 Design Discharge at Sungguminasa Bridge

Description	Discharge (m^3/sec)
Basic Flood Discharge (50-year return period)	3,700 m^3/sec
Discharge regulated by the Bili-Bili Dam	1,200 m^3/sec
Design Flood Discharge	2,500 m^3/sec
Design Return Period	50-year return period

Source: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001 prepared by P.U.

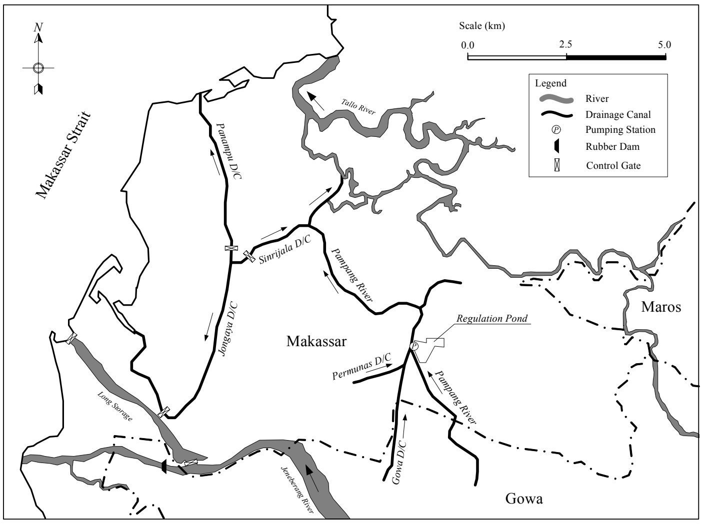
(c) Improvement of Urban Drainage Channel

Primary drainage channel improvement of 30.7 km was carried out with financial assistance from the Overseas Economic Cooperation Fund (OECF, presently JBIC) for a drainage area of 64.3 km^2 in the Makassar City. It consisted of the City area of 18.9 km^2 and the Pampang River Basin 45.4 km^2, as shown in **Figure 6.1.8**. The City Area covers the western part of the Makassar City, while the Pampang River Basin extends over the eastern part of the Makassar City and Gowa Regency. The design scale of this improvement work was determined for a 20-year return period.

The local inundation problem in the Makassar City, however, still remains. It is reported that the overflow of the existing drainage canals occurs several time in one rainy season and the inundation may occur when the rainfall of high intensity comes during the high tide situation at the river mouths. The duration of inundation is 2 to 3 hours at longest.

The following were recommended to cope with the drainage problem in the Makassar City:

a) Improvement/upgrading of existing drainage canals;
b) Strengthening of maintenance works on drainage canals; and
c) Installation of pumping facilities or runoff regulation system.



Source: The Study on Implementation of Integration Spatial Plan for the Maninasata Metropolitan Area, December 2005

Figure 6.1.8 Existing Drainage System

3) Takalar Regency

(a) Gamanti and Pappa Rivers

The optimum plan is the construction of dike (3.8 km in length along the left bank of the Gamanti River and 4.5 km along the right bank of the Pappa River) to protect the town of Takalar against flood overflow from the rivers.

In addition, the non-structural measures including delineation of a “Development Restricted Area” of about 18 km^2 along the Pappa River and dissemination of flood information and flood risk map for rivers were recommended. The layout of the structural measures is shown in **Figure 6.1.5**.

6.1.2 Flood Analysis

(1) Storm Rainfall

The occurrence date of recent storm needs to be confirmed from the colleted rainfall data for feedback on the field flood investigations, interview surveys, etc. Design flood levels, design flood peak discharge and inundation area and depth are basically set through analyses and field investigations: runoff analysis, inundation analysis, and field investigations and interview survey, which are made based on not only maximum hourly/daily rainfall data but also accumulative rainfall volume on a monthly basis.

The maximum daily rainfall data, point rainfall and basin average rainfall in the study area are summarized in **Table 6.1.15.** The variations of monthly rainfall at Salojirang (Maros) and Ujungpandang (Makassar) Rainfall Stations are shown in **Figures 6.1.9** and **6.1.10**. According to the rainfall records, recently most heavy rainfall on monthly basis, 1,473 mm/month at the Salorijang (Maros) station, and 1,469 mm/month at the Ujung Pandang station (Makassar) occurred on January 1999 respectively.

Table 6.1.15 Maximum Daily Point Rainfall and Basin Average Rainfall

(Unit: mm)

River Basin:	Maros		Tallo		Jeneberang		Tappa	
C.A. (Km^3):	645 Km^3		407 Km^3		762 Km^3		389 Km^3	
Station (Code)	Pakelli 97(OP)		Ujunpandang 27(H)		Malino 22(H)		Malolo 20(H)	
ARF	0.81		0.83		0.80		0.83	
Year	Point Rainfall	Average Basin Rainfall	Point Rainfall	Average Basin Rainfall	Point Rainfall	Average Basin Rainfall	Point Rainfall	Average Basin Rainfall
1976	275	223						
1977	150	122						
1978	200	162			168	134	89	74
1979	175	142	90	109	131	105	128	106
1980	200	162	115	139	138	110	84	70
1981	175	142	100	121	135	108	104	86
1982	175	142	100	120	135	108	94	78
1983	215	174	100	120	130	104	123	102
1984	175	142	234	282	125	100	143	119
1985	100	81	100	120	105	84	201	167
1986	250	203	129	155	122	98	150	125
1987	250	203	233	281	115	92	284	236
1988	300	243	107	129	210	168	163	135
1989	150	122	99	119	155	124	250	208
1990	250	203	162	195	126	101	112	93
1991	115	93	86	104	125	100	130	108
1992	150	122	117	141	50	40	94	78
1993	175	142	130	157	328	262	140	116
1994	175	142	108	130	98	78	140	116
1995	250	203	146	176	177	142	132	110
1996	200	162	120	144	123	98	131	109
1997	155	126	76	91	187	150	96	80
1998	120	97	85	103	101	81	163	135
1999	275	223	195	235	185	148	210	174
2000	200	162	312	376	118	94	112	93
2001	***217***	**176**	166	200	***148***	**118**	199	165
2002	250	203	203	245	125	100	134	111
2003	300	243	174	210	163	130	157	130
2004	250	203	105	126	137	110	120	100
2005	200	162	117	141	82	66	135	112
2006	180	146	91	110	220	176		

Note: The maximum daily rainfall data of Pakelli and Malino Rainfall Station in 2001 were supplemented based on the correlation between Pakelli and Pucua rainfall data, and between Ujungpandang and Malio rainfall data.

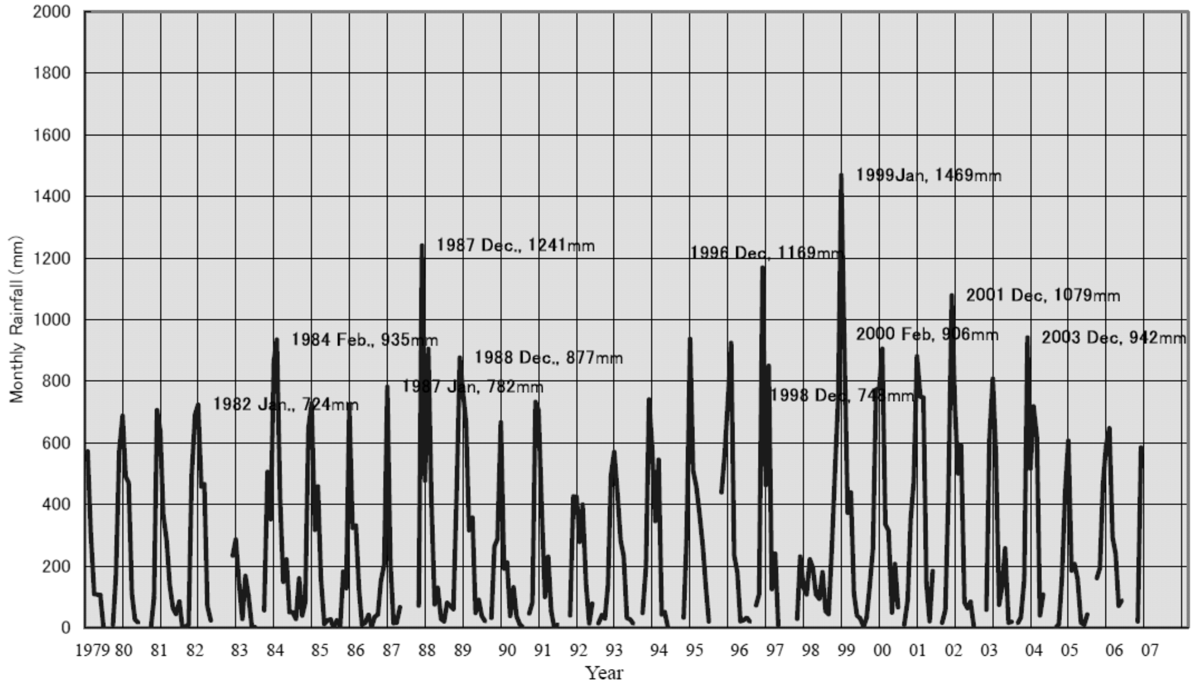


Figure 6.1.9 Monthly Rainfall Variation of Ujung Pandang Rainfall Stations (Makassar)

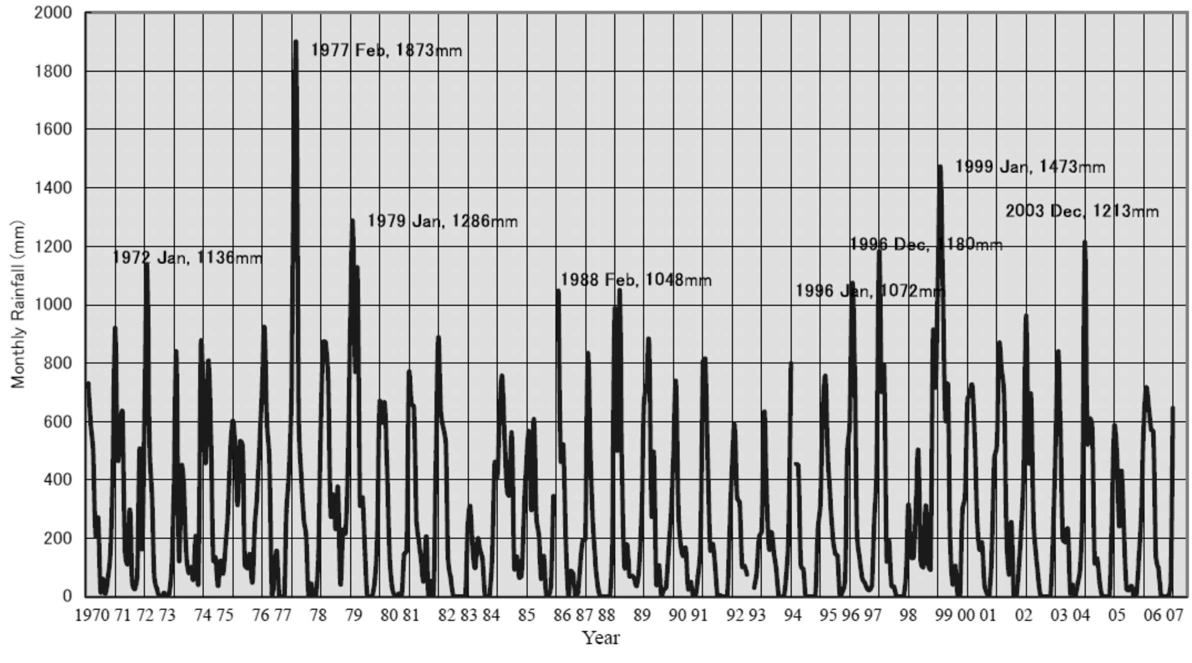


Figure 6.1.10 Monthly Rainfall Variation of Salojirang Rainfall Stations (Maros)

The variations of annual storm rainfall at the Ujung Pandang Rainfall Station, whose rainfall data were measured from October to September including a consecutive storm rainfall from October to March, is shown in **Figure 6.1.11**, and that of the Salorijiang Rainfall Station is shown in **Figure 6.1.12**.

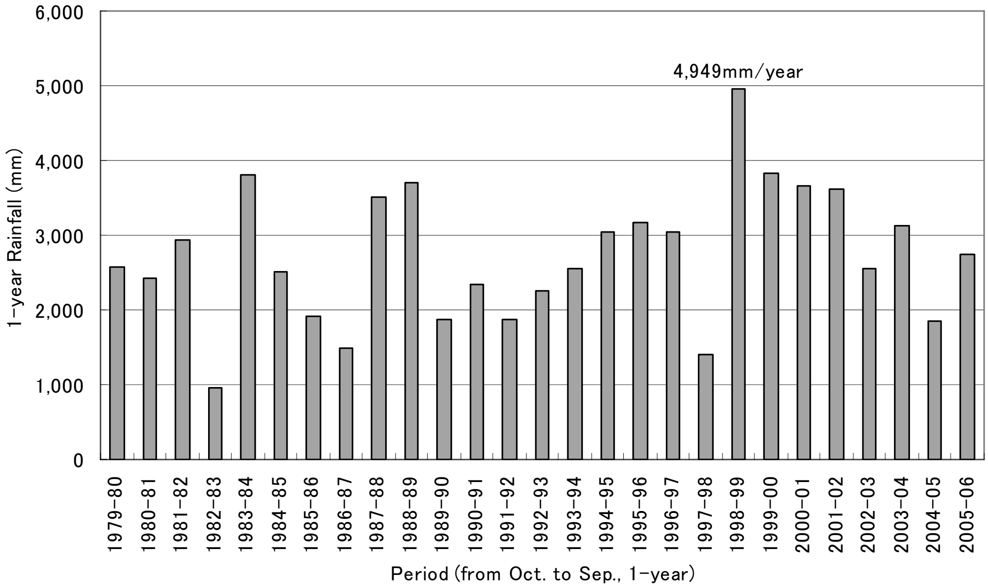


Figure 6.1.11 One-Year Storm Rainfall at Ujung Pandang Rainfall Station (Makassar)

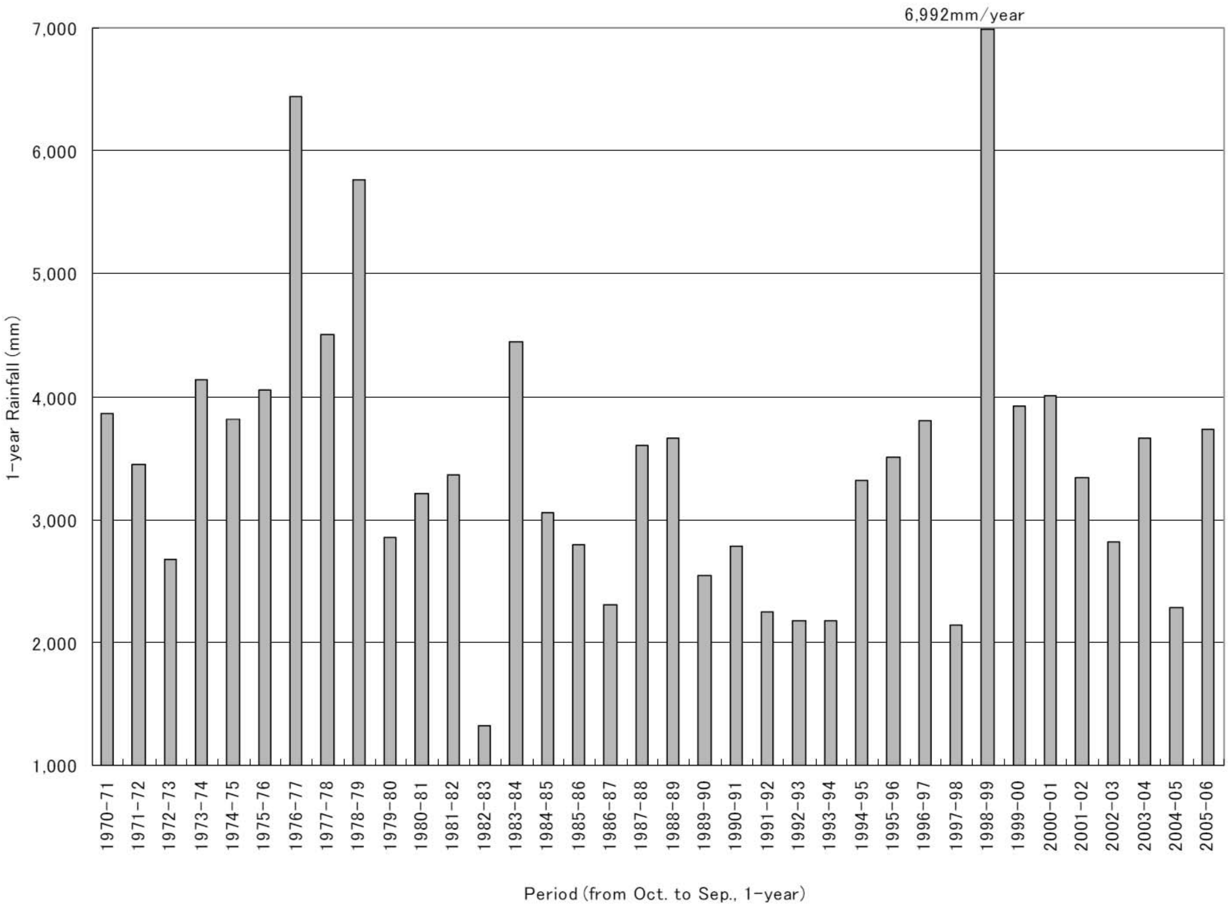


Figure 6.1.12 One-year Rainfall at Salorijiang Rainfall Station (Maros)

The most heavy one-year rainfall, 6,992 mm/year and 4,949 mm/year, were recorded during the period from October 1998 to September 1999, at the Salorijiang and Ujung Pandang rainfall stations respectively.

(2) Probable Rainfall

The following probable rainfall analyses were conducted including recent additional data from 2000 to 2006 for the following purposes:

1) Probable Maximum Daily Rainfall: to obtain the design flood peak discharge of the river basin by the Storage Function Method

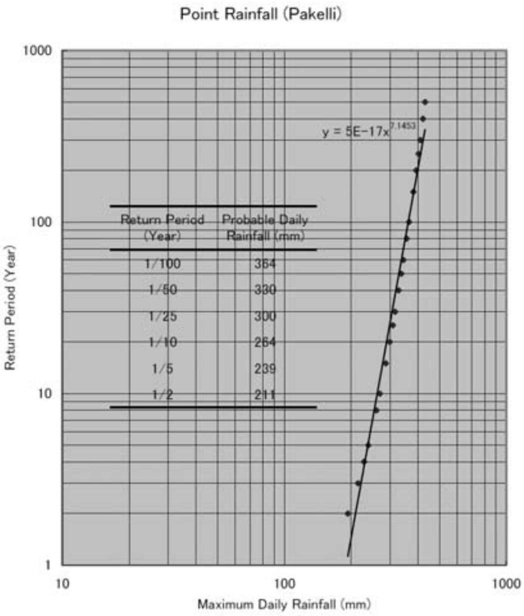
2) Probable Rainfall Intensity: to obtain the design flood peak discharge in the relatively small catchment by the Rational Method

3) Probable Annual Rainfall: to evaluate the flood level of the year, and inundation area and depth from interview survey

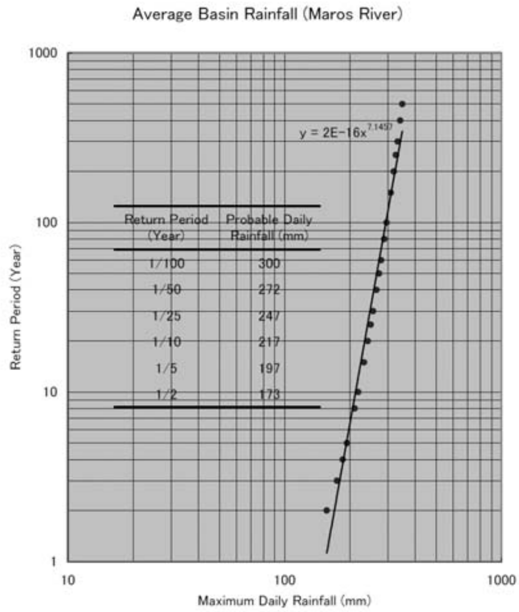
The probable rainfall analyses were made by Gumbel-Chow Method, which is the same method as the existing flood control plan: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001.

1) Probable Maximum Daily Rainfall

Probable 1-day rainfall of each representative rainfall station and river basin was calculated by Gumbel-Chow Method, which includes the additional rainfall data (2000-2006) as shown in **Table 6.1.13** and **Figure 6.1.10** The updated probable average basin rainfall of each station, Pakelli (Maros), Ujung Pandang (Makassar), Malino (Gowa), Malolo (Takalar), is almost same as the existing values as shown in **Figure 6.1.11** and its values are summarized in **Table 6.1.16**, which were different from the existing study's values within about 11 % only under a range of 20- to 50-year return periods (shown in yellow color).



Probable Maximum Daily Rainfall at Pakelli (Maros)



Probable Maximum Daily Rainfall in The Maros River Basin

Figure 6.1.13 (1/4) Probable Daily Rainfall in the Maros River Basin (Maros)

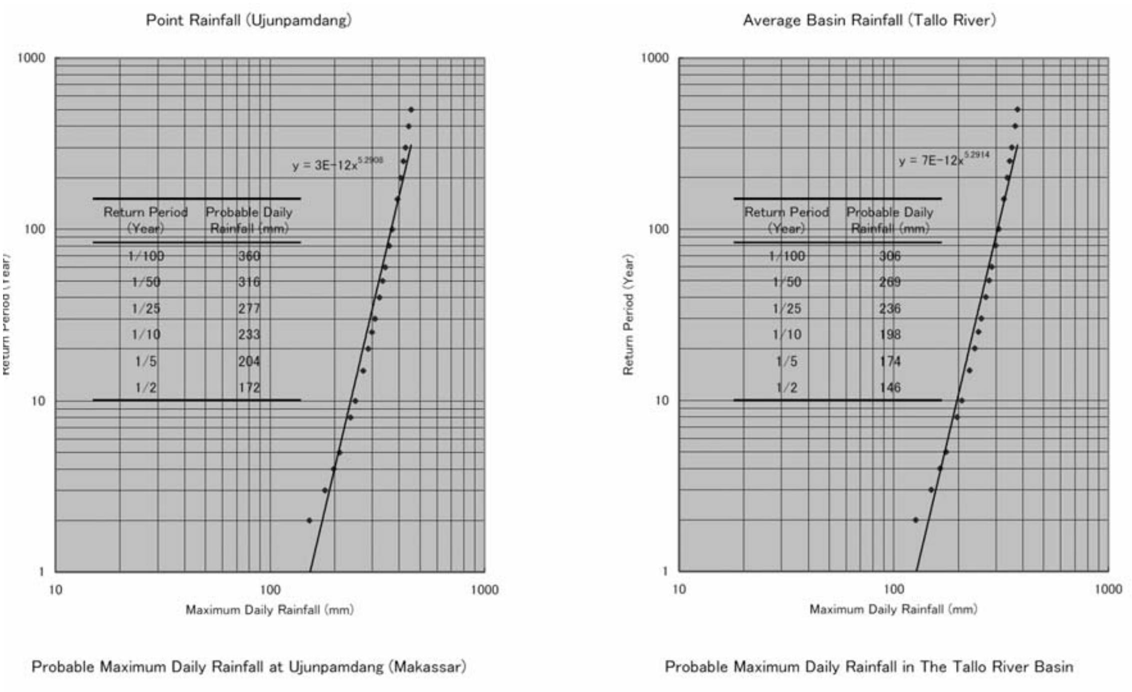


Figure 6.1.13 (2/4) Probable Daily Rainfall in the Tallo River Basin (Makassar)

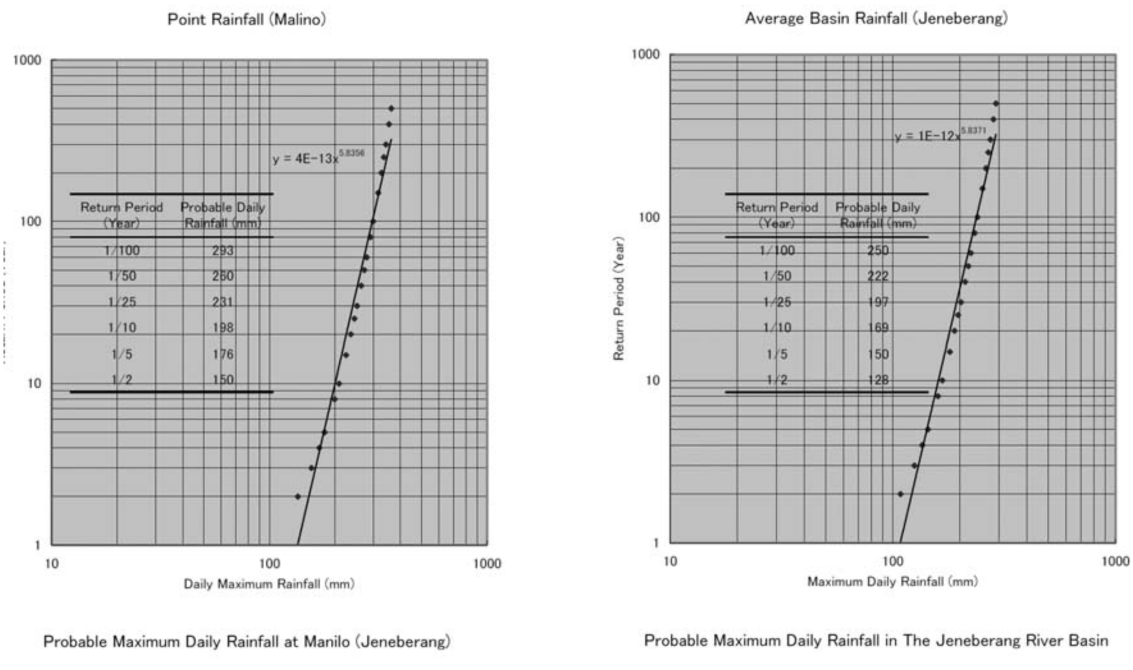
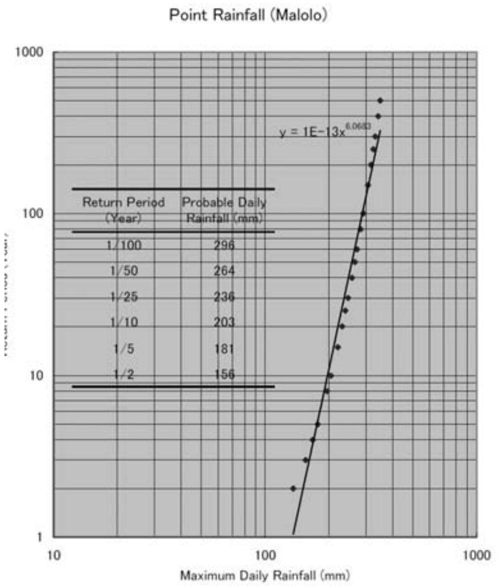
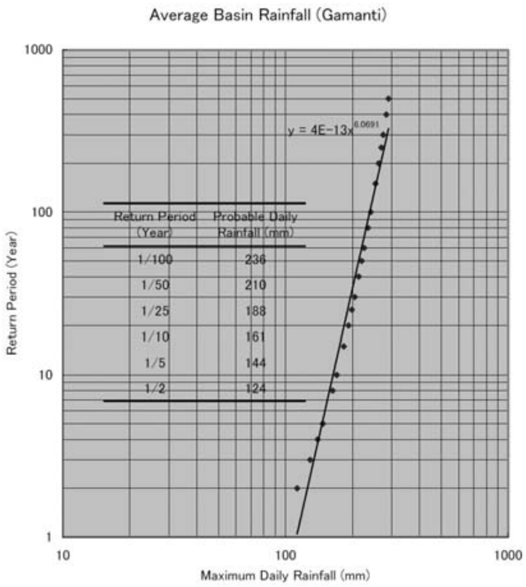


Figure 6.1.13 (3/4) Probable Daily Rainfall in the Jeneberang River Basin (Makassar and Gowa)



Probable Maximum Daily Rainfall at Malolo (Takalar)



Probable Maximum Daily Rainfall in The Gamanti River Basin

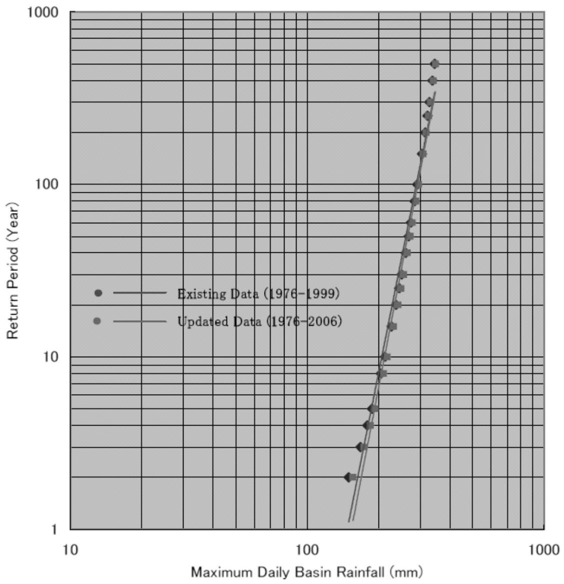
Figure 6.1.13 (4/4) Probable Daily Rainfall in the Pappa River Basin (Takalar)

Table 6.1.16 Revised Probable Maximum Daily Rainfall

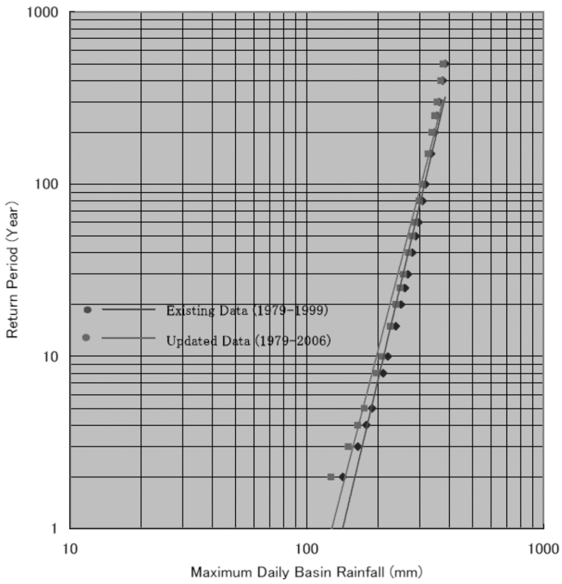
(Unit:mm)

River Basin	Maros			Tallo			Jeneberang			Pappa		
Return Period (Year)	Existing Study *1	Revised Values*2	Change Rate(%)	Existing Study *1	Revised Values*2	Change Rate(%)	Existing Study *1	Revised Values*2	Change Rate(%)	Existing Study *1	Revised Values*2	Change Rate(%)
2	146	173	19%	120	146	22%	107	128	20%	116	124	7%
5	186	197	6%	160	174	9%	145	150	3%	154	144	-7%
10	212	217	2%	185	198	7%	171	169	-1%	179	161	-10%
20	237	239	1%	210	226	8%	196	190	-3%	202	181	-11%
50	269	272	1%	243	269	11%	228	222	-3%	234	210	-10%
100	293	300	2%	266	306	15%	251	250	0%	258	236	-9%
200	317	330	4%	290	349	20%	275	282	2%	280	264	-6%

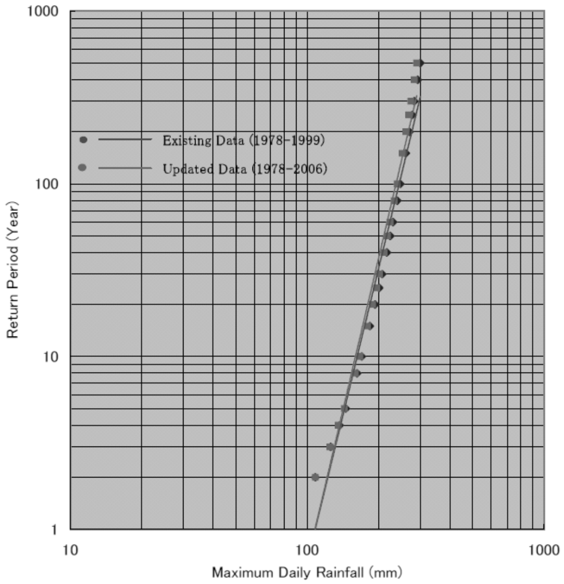
*1: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001
*2: Probable Rainfall Analyses were made with including additional rainfall data from 2000 to 2006.



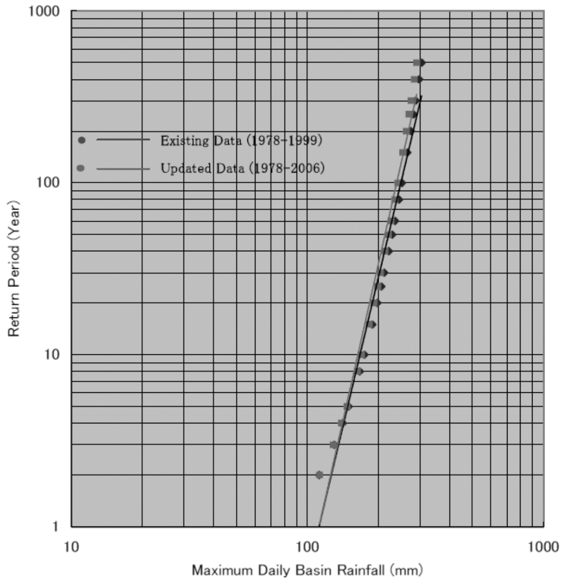
Probable Rainfall Analyses in the Maros River Basin (Existing and Updated)



Probable Rainfall Analyses in the Tallo River Basin (Existing and Updated)



Probable Rainfall Analyses in the Jeneberang River Basin (Existing and Updated)

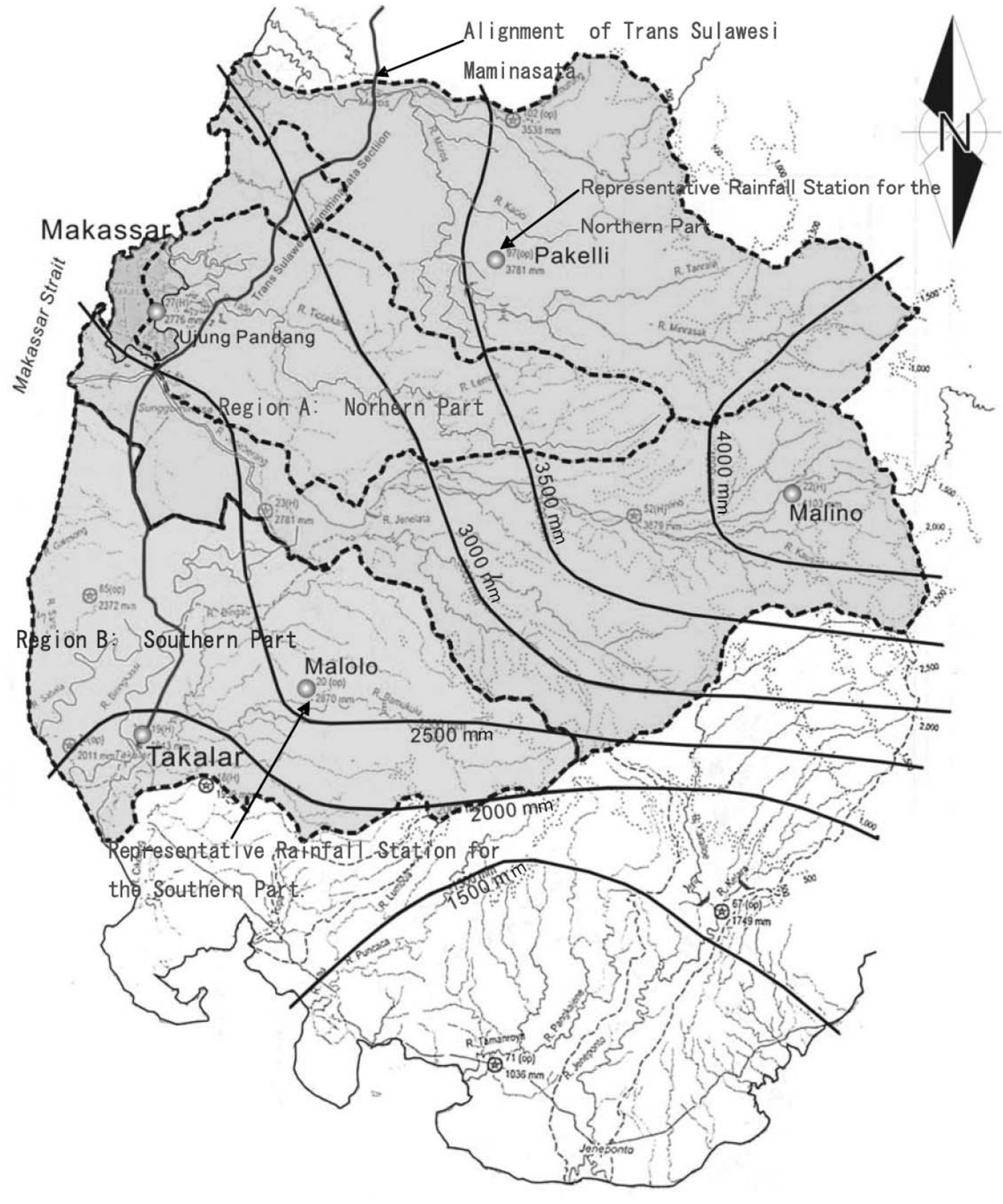


Probable Rainfall Analyses in the Pappa River Basin (Existing and Updated)

Figure 6.1.14 Comparison of Probable Maximum Rainfall (Existing and Updated Curves)

2) Probable Rainfall Intensity

The rainfall intensity data recorded at the Pakelli (Maros River Basin) and Malolo (Pappa River Basin, Takalar) rainfall stations shall be adopted to show the regional rainfall intensity pattern of the northern part and southern part of the study area. The regional area for calculation of rainfall intensity is shown in **Figure 6.1.15**.



Source: Isohyetal Map, Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001

Figure 6.1.15 Area of Regional Rainfall Intensity Analysis

The results of probable rainfall intensity of the Pakelli and Malolo rainfall stations are summarized in **Tables 6.1.4** and **6.1.5**, and their probable rainfall intensity-duration-frequency curves were made as representative of the regional rainfall intensity in the study area as shown in **Figure 6.1.16**.

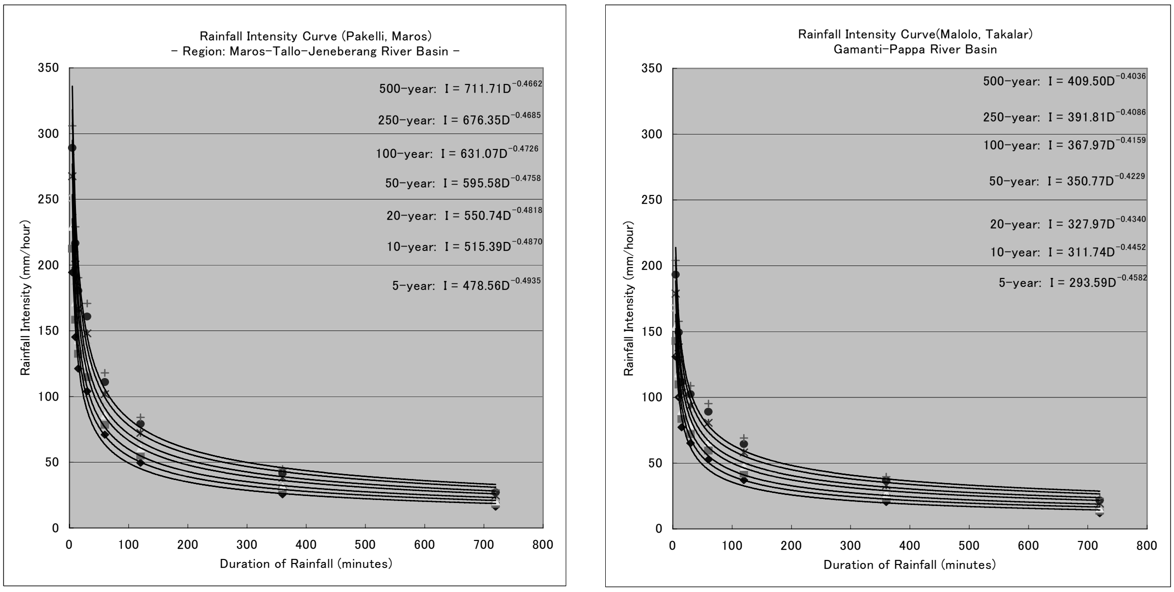
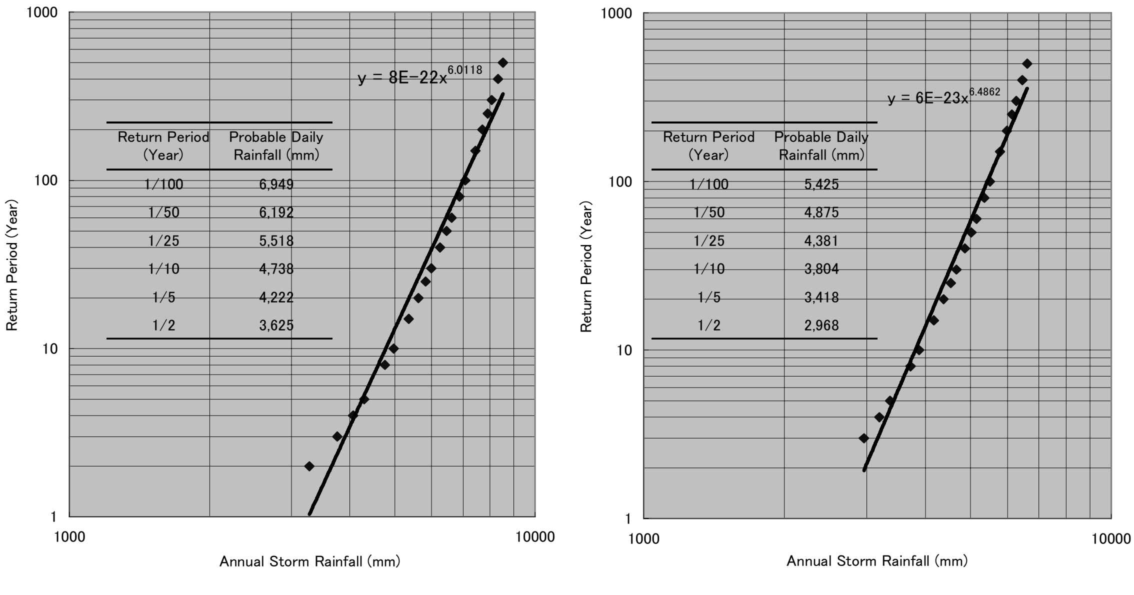


Figure 6.1.16 Probable Rainfall Intensity-Duration-Frequency Curves for the Study Area

3) Probable Annual Rainfall

The return period of annual storm rainfall depth at the Salojirang (Maros) and Ujungpandang (Makassar) rainfall stations from October to the next September was calculated to evaluate the level of recent floods, and the results are shown in **Figure 6.1.17**:



Probable Annual Storm Rainfall at Salorijiang (Maros River Basin) Probable Annual Storm Rainfall at Ujungpandang (Tallo River Basin)

Figure 6.1.17 Probable Annual Storm Rainfall in the Maros and Tallo River Basins

The results of probable rainfall analyses are summarized in **Table 6.1.17**:

Table 6.1.17 Results of Probable One-Year Storm Rainfall Analysis

(Unit: mm/year)

Station	Probable One-year Rainfall for Each of Return Period (Year)					
	2-year	5-year	10-year	25-year	50-year	100-year
Salojirang (Maros)	3,625	4,222	4,738	5,518	6,192	6,949
Ujungpandang (Makassar)	2,968	3,418	3,804	4,381	4,875	5,425

The most heavy one-year storm rainfall, 6,992 mm and 4,949 mm, was observed at the Salorijiang and Ujung Pandang rainfall stations respectively during a period from October 1998 to September 1999. From the results of the probable rainfall analyses, the annual storm rainfall records of these two rainfall stations in 1998-1999 can be evaluated as follows:

Annual Storm Rainfall Depth (from October to September) in 1998 - 1999

- Salojirang (Maros River Basin), 6,992 mm/year: about 100-year return period; and

- Ujung Pandang (Tallo River Basin), 4,949 mm/year: about 60-year return period.

(3) Peak Discharge

1) Rational Method

For the design of drain ditches of roads, the design peak discharge with relatively small catchment area shall be determined by the Rational Formula as follows:

$$Q = \frac{1}{3.6} \times C \times I \times A$$

where, *Q*: Peak discharge (m^3/s)

C: Runoff coefficient

I: Rainfall intensity (mm/hr) for time of concentration (tc), and

A: Catchment area (km^2)

By the statistical analysis of observed hourly rainfall records in the study area, the 2 probable rainfall intensity-duration-frequency curves were prepared for the regional areas, the Maros-Tallo-Jeneberang River Basin and Gamanti-Pappa River Basin as shown in **Figure 6.1.10**. These curves could be obtained by the following formula.

$$I = X \times D^{-Y}$$

where, *I*: Rainfall Intensity (mm / hour)

D: Storm Duration (minute)

X and *Y* are two constants as given below

Table 6.1.18 indicates the values of Rainfall Intensity Factors, X and Y by each area and return period.

Table 6.1.18 Regional Rainfall Intensity Factors (X,Y)

Return Period in Year		2-year		10-year		20-year		50-year		100-year		200-year		500-year	
		X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
Region- A (Maros-Tallo Jeneberang River Basin)	Maros Makassar Gowa	478.6	0.494	515.4	0.487	550.7	0.482	595.6	0.476	631.1	0.473	676.4	0.469	711.7	0.466
Region- B (Gamanti-Pappa River Basin)	Takalar	293.6	0.458	311.7	0.445	328.0	0.434	350.8	0.423	368.0	0.416	391.8	0.409	409.5	0.404

Storm duration *(D)* and runoff coefficient *(C)* are obtained by some different methods. The *D* can have durations such as time of concentration *(Tc)* or duration of the critical storm (*Dc)*. There are many formulas and nomograms available to determine the time of concentration of a catchment. The storm duration (*D)* can be generally considered as the time of concentration (*Tc)*. The *C* is defined by a simplified estimation method according to the conditions of each river basin.

The rainfall intensity *(I)* was based on the time of concentration for the catchment. The time of concentration *(Tc)* was derived based on the following methods in this study:

- * Rziha's formula; and
- * Bramsby-Williams formula.

Time of concentration (*Tc)*

i) Rziha's formula

The time of concentration *(Tc)* is given by the following formula:

$$Tc = L/V_f$$

$$V_f = 72(\Delta H/L)^{0.6}$$

where, V_f: Velocity of flood flow (km/hr)
ΔH: Elevation change from catchment outlet to boundary (km)
L: Longest water course (km)

The velocity of flood flow can be estimated by the Rziha's formula or Kraven's method as summarized below:

Rziha's / Kraven's Method

H/L=> 1/100	1/100 > H/L > 1/200	1/200 >= H/L
v = 3.5 m/sec	3.0 m/sec	2.1 m/sec

ii) Bramsby-Williams formula

The time of concentration *(Tc)* is defined by the following formula:

$$Tc = \frac{L^{1.15}}{51 \times \Delta H^{0.38}} \times \alpha$$

where, *Tc*: Time of concentration (min)
L: Length from catchment outlet to boundary (m), and
ΔH: Elevation change from catchment outlet to boundary
α: Basin Storage Factor

The topographic condition of the study area is almost flat area, in which an alluvial plain has been formulated, therefore the basin storage factor should be considered (α= 1.1 to 1.3).

Runoff coefficient *(C)*

The theoretical values of runoff coefficient related to watershed conditions are outlined in **Table 6.1.19**:

Table 6.1.19 Theoretical Values of Runoff Coefficient *C*

Watershed Condition	Recommended Range of *C* values
Concrete or Asphalt Pavement	0.90 – 1.00
Steep Mountainous Area	0.75 – 0.90
Alluvial Deposits in Mountainous Area	0.70 – 0.80
Silt and Sand (Up- and Downstream)	0.50 – 0.75
Flat Agricultural Area	0.45 – 0.60
Paddy Field with Water	0.70 – 0.80
River in Mountainous Area	0.75 – 0.85
Rivers in Flat Plain Area	0.45 – 0.75
Major River in Flood Plain Area	0.50 – 0.75
Rocky Surface	0.70 – 0.90
Residential Area (City)	0.30 – 0.60

The study area is almost flat, in which an alluvial fan has been developed by the Maros, Tallo, Jeneberang, and Gamanti-Pappa rivers. Accordingly the range of runoff coefficient C = 0.30-0.75 (Rivers in Flat Plain Areas, and Residential Areas) can be adopted in the calculation.

2) Storage Function Method

The Storage Function Method is recognized as de-facto standard model to simulate the hydrograph of probable flood runoff discharge. The model is usually applied to a flood runoff calculation in a catchment area ranging from 10 km^2 to 1,000 km^2, and is suitable for river basins where hydrologic data are scarce.

In the existing flood control plans, Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001, the probable peak discharge was calculated as follows through the storage function model based on the probable daily maximum rainfall:

Table 6.1.20 Probable Peak Discharge

(Unit: m^3/sec)

River Basin	Location	Catchment Area (km^2)	Return Period (Year)						
			2	5	10	25	50	100	200
Maros	Alliritengae Bridge	558	480	750	960	1,260	1,500	1,750	2,040
Tallo	Tallo Bridge	314	220	370	490	680	830	970	1,120
Jeneberang	Sungguminasa Bridge	684	815	1,491	2,002	3,021	3,428	3,650	3,920
Gamanti	Alluka Bridge	91	70	100	120	160	180	190	220
Pappa	Estuary	389	180	360	520	770	930	1,120	1,500

Source: Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001

The design peak discharge of the existing flood control plan would be adopted in this study for hydraulic calculations, and setting of design flood water level of bridges and roads if the following are satisfied:

(A) Difference of design rainfalls between the existing and updated values is relatively small based on the probable rainfall analyses;

(B) Topographic change has not occurred so much from the time of previous analyses by the storage function method.

The updated probable daily rainfalls are almost same, and slightly different from the values of the existing flood control plans within 11% only.

The aggradation of riverbed and unusual sediment flow caused by sand/gravel quarrying and deforestation in the upstream area have not been reported and confirmed from the field investigations.

In addition, the design peak discharges mentioned above are also reasonable compared with the values of a specific discharge curve (Creager's curve mentioned below) of Sulawesi as shown in **Figure 6.1.18**, and summarized in **Table 6.1.21**.

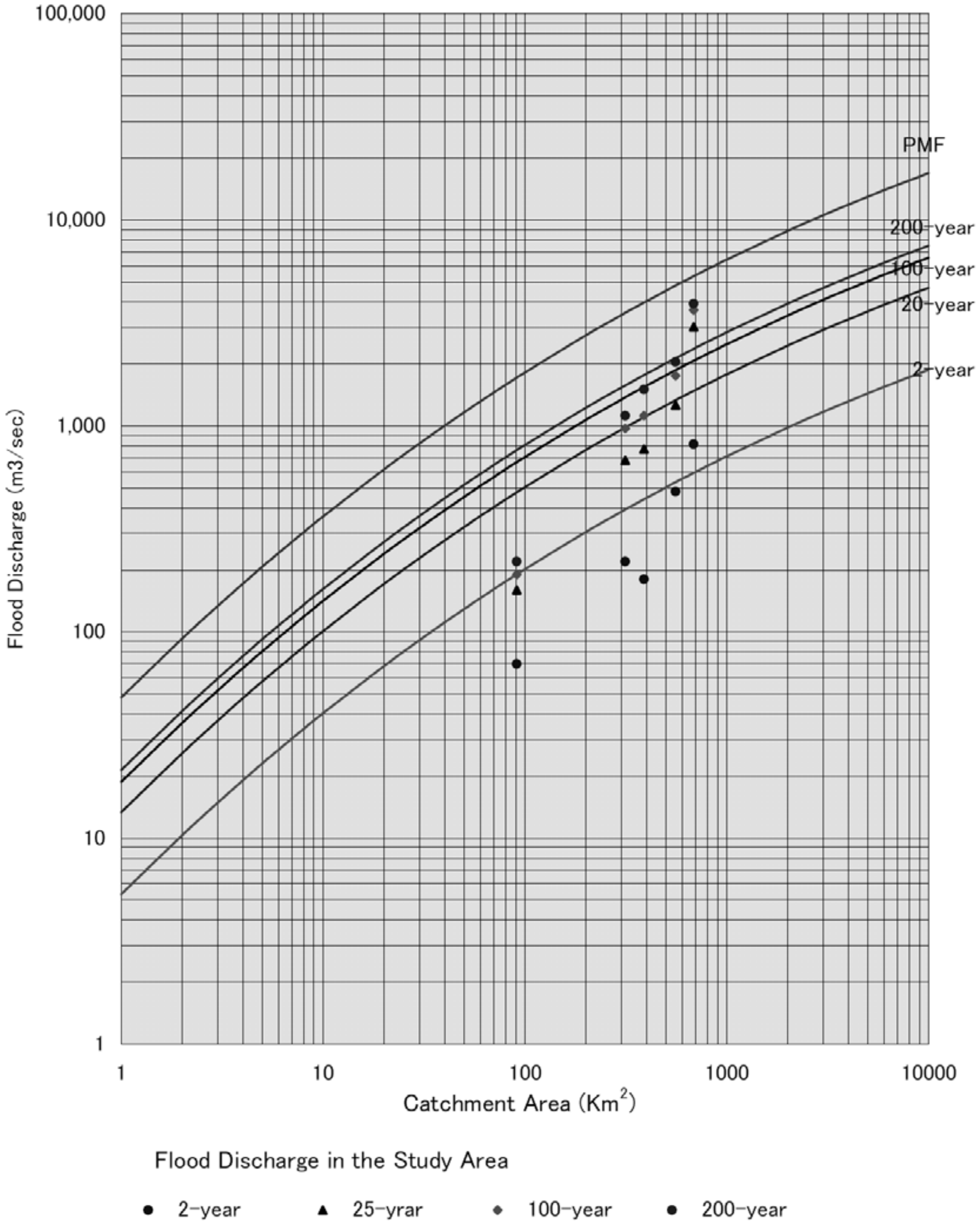


Figure 6.1.18 Specific Discharge Curve (Creager's Curve) of Sulawesi Island

Table 6.1.21 Flood Peak Discharge by Storage Function Method and Creager's Method

River Basin	Location	Catchment Area (km2)	Flood Peak Discharge (20-100-year return period) (m^3/sec)	
			Storage Function Method (25-100-year)	Creager's Method (20-100-year)
Maros	Alliritengae Bridge	558	1,260 – 1,750	1,332 – 1,865
Tallo	Tallo Bridge	314	680 – 970	983 – 1,376
Jeneberang	Sunggminasa Bridge	684	3,021 – 3,650	1,477 – 2,068
Pappa	Estuary	389	770 – 1,120	1,103 – 1,544

Therefore, the probable peak discharge of the existing flood control plan shall be used for the present study, which satisfies the conditions mentioned above.

The Creager's Method adopted in the study is explained below:

Creager's Method

The Creager's equation is given by the following formula (Reference: Hydro Inventory Study, PLN, Indonesia 1997):

$$Q_q = 46\ C\ A^{a-1}$$

$$a = 0.894\ A^{-0.048}$$

where, Q_q : Specific peak discharge (ft^3/sec/$mile^2$)
C : Creager's coefficient
A : Catchment area ($mile^2$)

The unit conversions for *feet* and *mile* as required are as follows:

$1\ ft^3 = 0.02832\ m^3$
$1\ km^2 = 0.3861\ mile^2$

Therefore the Creager's equation is further expressed by the following formula:

$$Q = (46 \times 0.02832)\ C\ (0.3861 \times A)^a$$

$$a = 0.894\ (0.3861 \times A)^{-0.048}$$

where, Q : Peak discharge (m^3/sec)
C : Creager's coefficient
A : Catchment area (km^2)

These plots of various probable design floods implicitly suggest that:

The Creager's coefficients of constructed regional probable design flood curves are summarized below. The probable design floods with various recurrence intervals at arbitrary scheme sites were thus predicted by using the respective Creager's coefficients corresponding to the island where they are located.

Table 6.1.22 Creager's Coefficient by Return Period in Indonesia

Island	Creager's Coefficient by Return Period				
	2-yr	20-yr	100-yr	200-yr	PMF
Sumatera	10	20	30	40	100
Jawa	20	30	40	50	120
Kalimantan	10	25	35	40	100
Sulawesi	**10**	**25**	**35**	**40**	**90**
Irian	10	20	25	30	100
Bali	10	30	40	50	110
Nusa Tenggara	10	30	40	50	110
Maluku	10	30	40	50	110

Source: Hydro Inventory Study, PLN, Indonesia 1997

(4) Design Flood Level

For the designs of roads and bridges in flood prone areas, the followings should be taken into consideration:

* Flood inundation area to the road alignment;
* Flood inundation depth for setting the design water level; and
* Existing flood control plans affecting the road and bridge designs, location, and elevation.

The following investigations were therefore conducted for preliminary estimate of the design flood water level and inundation area:

* Review of flood records, and design flood water levels of flood control plans; and
* Interview survey on flood inundation area and depth.

1) Flood Inundation Depth and Road Alignment

The design water levels of the proposed roads and bridges were preliminarily estimated based on the results of these investigations as follows. The interview survey on 122 people was conducted in the study area.

The results of interview survey are summarized in **Table 6.1.23**, according to which about 40% of the respondents answered that flood was most serious in the period of 1998 - 1999 as shown in **Figure 6.1.19**. The interview survey results of flood inundation by area (Village, City/District) are summarized in **Table 6.1.25**.

Year	Number of Answer (person)	
1997	10	13%
1998	19	24%
1999	12	15%
2000	6	8%
2001	2	3%
2002	13	17%
2003	3	4%
2004	1	1%
2005	1	1%
2006	9	12%
2007	2	3%
Total	78	100%

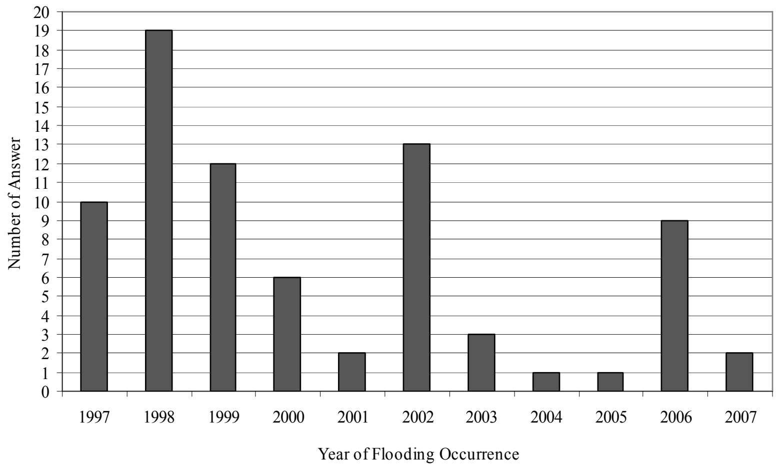


Figure 6.1.19 Answers on Serious Flooding Year

Table 6.1.23 Summary of Results of Interview Survey (1/2)

No	Date	Sex	Age	Village	City / Kabupaten	Flooding Period (day)	Floor Level (m)	Year of Historical Flood	Remarks
1	2/23/2007	Female	36	Biringkanaya	Makassar	1	0.2	1997	arus kendaraan lambat
2	2/15/2007	Male	37	Pettuadae	Maros	3	0.7	1999	
3	2/15/2007	Male	65	Alliritengae	Maros	0	0.0	2002	
4	2/15/2007	Male	40	Allepolea	Maros	3	0.2	2003	
5	2/15/2007	Female	65	Bellaiya	Maros	7	1.5	2003	
6	2/15/2007	Male	51	Pettuadae	Maros	3	0.5	2003	
7	2/15/2007	Male	67	Allaere	Maros	15	0.0	2006	
8	2/15/2007	Male	31	Damai	Maros	7	0.2	2006	
9	2/15/2007	Female	70	Pettuadae	Maros	3 until 4	1.0	2006	
10	2/15/2007	Male	69	Raya	Maros	3 until 4	1.0	2006	
11	2/15/2007	Male	45	Damai	Maros	7	0.5	2007	
12	2/15/2007	Male	55	Allaere	Maros	10 until 20	0.5		
13	2/23/2007	Female	40	Tello Baru	Makassar	8	0.1	1997	arus kendaraan lambat
14	2/23/2007	Male	53	Tello Baru	Makassar	3	0.1	1997	car can run in the road
15	2/23/2007	Male	45	Tello Baru	Makassar	4	0.1	1997	car can run in the road
16	2/23/2007	Male	32	Tello Baru	Makassar	2	0.1	1997	car can run in the road
17	2/23/2007	Female	50	Biringkanaya	Makassar	3	1.0	1998	arus kendaraan lambat
18	2/23/2007	Male	40	Biringkanaya	Makassar	6	0.5	1998	arus kendaraan lambat
19	2/23/2007	Male	27	Tello Baru	Makassar	4	2.0	1998	car can't run in the road
20	2/23/2007	Male	28	Biringkanaya	Makassar	6	0.2	1999	car can't run in the road
21	2/23/2007	Male	70	Tello Baru	Makassar	6	3.0	1999	car can't run in the road
22	2/23/2007	Female	50	Tello Baru	Makassar	6	3.0	1999	car can't run in the road
23	2/23/2007	Female	30	Tello Baru	Makassar	6	2.5	1999	car can't run in the road
24	2/23/2007	Female	50	Tello Baru	Makassar	6	0.2	1999	car can't run in the road
25	2/23/2007	Female	40	Tello Baru	Makassar	6	3.0	1999	car can't run in the road
26	2/23/2007	Male	40	Biringkanaya	Makassar	1	0.5	2000	arus kendaraan lambat
27	2/23/2007	Male	34	Biringkanaya	Makassar	6	0.6	2000	arus kendaraan lambat
28	2/23/2007	Male	29	Biringkanaya	Makassar	6	0.5	2002	arus kendaraan lambat
29	2/23/2007	Male	49	Biringkanaya	Makassar	3	0.2	2002	car can't run in the road
30	2/23/2007	Male	53	Tello Baru	Makassar	0	0.0	2002	Inundation depth at road is 0m.
31	2/23/2007	Female	32	Tello Baru	Makassar	6	1.0	2006	car can't run in the road
32	2/23/2007	Male	42	Tello Baru	Makassar	5	0.6	2006	arus kendaraan lambat
33	2/23/2007	Male	48	Tello Baru	Makassar	5	0.2	2006	arus kendaraan lambat
34	2/23/2007	Male	29	Biringkanaya	Makassar	1	0.2		car can't run in the road
35	2/23/2007	Male	40	Tello Baru	Makassar	0	0.0		Inundation depth at road is 0m.
36	2/24/2007	Female	45	Tamalanrea	Makassar	3	0.5	1997	car can't run in the road
37	2/24/2007	Male	52	Tamalanrea	Makassar	3	0.7	1997	arus kendaraan lambat
38	2/24/2007	Female	32	Tamalanrea	Makassar	4	0.3	1998	car can't run in the road
39	2/24/2007	Female	40	Tamalanrea	Makassar	5	0.3	1998	car can't run in the road
40	2/24/2007	Male	60	Tamalanrea	Makassar	3	0.2	1998	car can't run in the road
41	2/24/2007	Male	50	Tamalanrea	Makassar	2	0.4	2000	car can't run in the road
42	2/24/2007	Male	57	Tamalanrea	Makassar	5	0.3	2002	car can't run in the road
43	2/24/2007	Male	30	Tamalanrea	Makassar	2	0.3	2004	car can't run in the road
44	2/24/2007	Female	30	Tamalanrea	Makassar	1	0.1	2006	car can't run in the road
45	2/24/2007	Male	55	Tamalanrea	Makassar	1	0.1	2006	car can't run in the road
46	2/24/2007	Male	49	Tamalanrea	Makassar	7	0.1	2007	car can't run in the road
47	2/24/2007	Male	30	Tamalanrea	Makassar	3	0.3		car can't run in the road
48	2/24/2007	Female	40	Tamalanrea	Makassar	4	0.2		car can't run in the road
49	2/26/2007	Male	58	Moncongloe	Maros	6	0.5	1997	Inundation depth at road is 0m.
50	2/26/2007	Female	36	Moncongloe	Maros	6	1.5	1997	Inundation depth at road is 0.5 m.
51	2/26/2007	Male	52	Mangempa	Makassar	2	0.1	1998	Inundation depth at road is 0m.
52	2/26/2007	Female	38	Moncongloe	Maros	6	1.5	1998	Inundation depth at road is 0.5 m.
53	2/26/2007	Female	48	Antang	Makassar	4	0.3	2002	Inundation depth at road, but car can run
54	2/26/2007	Male	47	Moncongloe	Maros	10	0.5	2002	Inundation depth at road is 0m.
55	2/26/2007	Male	45	Parangloe	Gowa	3	0.1	2002	mobil bisa lewat di jalan
56	2/26/2007	Female	47	Parangloe	Gowa	3	0.1	2002	mobil bisa lewat di jalan
57	2/26/2007	Female	52	Patalassang	Gowa	3	0.1	2002	mobil bisa lewat di jalan
58	2/26/2007	Male	50	Parangloe	Gowa	0	0.0	2005	mobil bisa lewat di jalan

Table 6.1.24 Summary of Results of Interview Survey (2/2)

No	Date	Sex	Age	Village	City / Kabupaten	Flooding Period (day)	Floor Level (m)	Year of Historical Flood	Remarks
59	2/26/2007	Male	52	Antang	Makassar	5	0.2		Inundation depth at road, but car can run
60	2/26/2007	Male	40	Antang	Makassar	3	0.3		Inundation depth at road, but car can run
61	2/26/2007	Male	50	Antang	Makassar	4	0.2		Inundation depth at road, but car can run
62	2/26/2007	Male	39	Antang	Makassar	5	0.2		mobil bisa lewat di jalan
63	2/26/2007	Male	47	Mangempa	Makassar	1	0.1		Inundation depth at road is 0m.
64	2/26/2007	Male	51	Mangempa	Makassar	0	0.0		Inundation depth at road is 0m.
65	2/26/2007	Female	43	Mangempa	Makassar	1	0.1		Inundation depth at road is 0m.
66	2/26/2007	Female	39	Mangempa	Makassar	1	0.1		Inundation depth at road is 0m.
67	2/26/2007	Female	30	Tamalanrea	Makassar	1	0.1		car can't run in the road
68	2/26/2007	Male	53	Tamalanrea	Makassar	2	0.1		car can't run in the road
69	2/26/2007	Male	45	Tamalanrea	Makassar	2	0.2		car can't run in the road
70	2/26/2007	Female	40	Tamalanrea	Makassar	2	0.1		car can't run in the road
71	2/26/2007	Male	50	Tamalanrea	Makassar	1	0.1		car can't run in the road
72	2/27/2007	Male	42	Turikale	Maros	4	0.5	1997	mobil bisa lewat di jalan
73	2/27/2007	Male	55	Turikale	Maros	6	0.5	1998	car can run in the road
74	2/27/2007	Female	45	Turikale	Maros	5	1.0	1998	jalan macet,car can't run in the road
75	2/27/2007	Male	50	Turikale	Maros	5	0.5	1998	mobil bisa lewat di jalan
76	2/27/2007	Female	40	Turikale	Maros	4	0.3	1998	mobil bisa lewat di jalan
77	2/27/2007	Male	53	Turikale	Maros	5	1.0	1998	jalan macet, mobil mogok
78	2/27/2007	Female	50	Turikale	Maros	4	0.5	1999	mobil bisa lewat di jalan
79	2/27/2007	Female	50	Turikale	Maros	4	0.2	2000	car can run in the road
80	2/27/2007	Male	45	Turikale	Maros	5	0.4	2000	mobil bisa lewat di jalan
81	2/27/2007	Male	40	Turikale	Maros	3	0.5	2000	mobil bisa lewat di jalan
82	2/27/2007	Female	47	Turikale	Maros	5	0.5	2002	mobil bisa lewat di jalan
83	2/28/2007	Male	45	Turikale	Maros	4	0.4	1998	Inundation depth at road is 0m.
84	2/28/2007	Male	50	Turikale	Maros	3	0.3	1998	Inundation depth at road is 0m.
85	2/28/2007	Female	40	Turikale	Maros	3	0.4	1998	Inundation depth at road is 0m.
86	2/28/2007	Male	44	Turikale	Maros	3	0.2	1998	Inundation depth at road is 0m.
87	2/28/2007	Female	47	Abd. Dg. Sirua	Makassar	2	0.1	1999	Inundation depth at road is 0m.
88	2/28/2007	Male	50	Turikale	Maros	3	0.5	1999	Inundation depth at road is 0m.
89	2/28/2007	Female	50	Abd. Dg. Sirua	Makassar	2	0.1	2001	Inundation depth at road is 0m.
90	2/28/2007	Female	42	Turikale	Maros	2	0.1	2001	Inundation depth at road is 0m.
91	2/28/2007	Male	52	Antang	Makassar	1	0.1	2002	Inundation depth at road is 0m.
92	2/28/2007	Female	35	Turikale	Maros	1	0.2	2002	Inundation depth at road is 0m.
93	2/28/2007	Female	51	Abd. Dg. Sirua	Makassar	0	0.0		Inundation depth at road is 0m.
94	2/28/2007	Male	46	Abd. Dg. Sirua	Makassar	0	0.0		Inundation depth at road is 0m.
95	2/28/2007	Male	40	Abd. Dg. Sirua	Makassar	0	0.0		Inundation depth at road is 0m.
96	2/28/2007	Female	34	Antang	Makassar	1	0.0		Inundation depth at road is 0m.
97	2/28/2007	Male	47	Antang	Makassar	1	0.1		Inundation depth at road is 0m.
98	2/28/2007	Female	40	Antang	Makassar	0	0.0		Inundation depth at road is 0m.
99	2/28/2007	Male	45	Antang	Makassar	0	0.0		Inundation depth at road is 0m.
100	2/28/2007	Female	54	Antang	Makassar	0	0.0		Inundation depth at road is 0m.
101	2/28/2007	Female	46	Antang	Makassar	1	0.1		Inundation depth at road is 0m.
102	2/28/2007	Female	48	Antang	Makassar	0	0.0		Inundation depth at road is 0m.
103	2/28/2007	Male	35	Turikale	Maros	1	0.0		Inundation depth at road is 0m.
104	2/28/2007	Male	45	Turikale	Maros	1	0.0		Inundation depth at road is 0m.
105	2/28/2007	Female	39	Turikale	Maros	1	0.0		Inundation depth at road is 0m.
106	2/28/2007	Female	39	Turikale	Maros	1	0.0		Inundation depth at road is 0m.
107	2/28/2007	Male	50	Turikale	Maros	0	0.1		Inundation depth at road is 0m.
108	3/1/2007	Female	40	Mallengkeri	Makassar	4	0.4	1998	car can run in the road
109	3/1/2007	Male	45	Mallengkeri	Makassar	3	0.3	1998	car can run in the road
110	3/1/2007	Male	50	Mallengkeri	Makassar	4	0.3	1999	car can run in the road
111	3/1/2007	Male	51	Mallengkeri	Makassar	4	0.4	1999	Inundation depth at road is 0m.
112	3/1/2007	Female	69	Bontomarannu	Gowa	0	0.0		Inundation depth at road is 0m.
113	3/1/2007	Male	40	Bontomarannu	Gowa	0	0.0		Inundation depth at road is 0m.
114	3/1/2007	Female	45	Bontomarannu	Gowa	0	0.0		Inundation depth at road is 0m.
115	3/1/2007	Female	52	Mallengkeri	Makassar	0	0.0		Inundation depth at road is 0m.
116	3/1/2007	Male	40	Mallengkeri	Makassar	0	0.0		Inundation depth at road is 0m.
117	3/1/2007	Male	50	Patalassang	Takalar	0	0.0		Inundation depth at road is 0m.
118	3/1/2007	Female	70	Patalassang	Takalar	1	0.3		car can run in the road
119	3/1/2007	Male	45	Patalassang	Takalar	2	0.1		car can run in the road
120	3/1/2007	Male	46	Patalassang	Takalar	0	0.0		Inundation depth at road is 0m.
121	3/1/2007	Female	40	Patalassang	Takalar	0	0.0		Inundation depth at road is 0m.
122	3/1/2007	Female	49	Patalassang	Takalar	0	0.0		Inundation depth at road is 0m.

Table 6.1.25 Summary of Interview Survey of Flood Inundation by Area (Village, City/District)

Area		No. of	Average	Inundation Period	Inundation Depth (m)	Remarks
Village	City / District	Sex	of Age	(day)		
Pattallassang	Takalar	M: 3	50.0	1 - 2 days	0 - 0.3 m	inundation depth at road is 0m, and car
		F: 3		Aver. 1.5 days	Aver. 0.06 m	can run in the road
Bontomarannu	Gowa	M: 1	51.3	0	0	Inundation depth at road is 0m.
		F: 2		0	0	
Mallengkeri	Makassar	M: 4	46.3	1 - 4 days	0 - 3 m	inundation depth at road is 0m, and car
		F: 2		Aver. 2.5 days	Aver. 0.68 m	can run in the road
Turikale	Maros	M: 13	44.8	1 - 6 days	0 - 1 m	Inundation depth at road is 0m, and car
		F: 10		Aver. 3.1 days	Aver. 0.35 m	can run in the road, traffic is jammed
Antang	Makassar	M: 7	45.7	1 - 5 days	0 - 0.3 m	Inundation depth at road is 0m, and car
		F: 6		Aver. 1.9 days	Aver. 0.11 m	can run in the road
Abd. Dg. Sirua	Makassar	M: 2	46.8	1 - 2 days	0 - 0.1 m	Inundation depth at road is 0m.
		F: 3		Aver. 0.8 days	Aver. 0.04 m	
Mangempa	Makassar	M: 3	46.4	1 - 2 days	0 - 0.1 m	Inundation depth at road is 0m.
		F: 2		Aver. 1 days	Aver. 0.08 m	
Parangloe	Gowa	M: 2	47.3	1 - 3 days	0 - 0.1 m	car can run in the road
		F: 1		Aver. 2 days	Aver. 0.06 m	
Pattallasang	Gowa	M: 0	52.0	3 days	0.1 m	car can run in the road
		F: 1		Aver. 3 days	Aver. 0.1 m	
Moncongloe	Maros	M: 2	44.8	6 -10 days	0 - 1.5 m	Inundation depth at road is 0-0.5 m.
		F: 2		Aver. 7 days	Aver. 1 m	
Tamalanrea	Makassar	M: 11	43.1	1 - 7 days	0 - 0.7 m	car can't run in the road, traffic flow is
		F: 7		Aver. 2.8 days	Aver. 0.24 m	slow
Biringkanaya	Makassar	M: 7	37.2	1 - 6 days	0 - 2 m	car can't run in the road, traffic flow is
		F: 2		Aver. 3.6 days	Aver. 0.63	slow
Tello Baru	Makassar	M: 9	43.4	1 - 8 days	0 - 3 m	car can't run in the road, traffic flow is
		F: 6		Aver. 4.4 days	Aver. 1.05 m	slow, inundation depth at road is 0m
Damai	Maros	M: 2	38.0	7 days	0 - 0.5 m	
		F: 0		Aver. 7 days	Aver. 0.35 m	
Allaere	Maros	M: 2	61.0	10 - 20 days	0 - 0.5 m	
		F: 0		Aver. 15 days	Aver. 0.25	
Bellaiya	Maros	M: 0	65.0	7 days	1.5 m	
		F: 1		Aver. 7 days	Aver. 1.5 m	
Pettuadae	Maros	M: 2	52.6	3 - 4 days	15 - 0.3 m	
		F: 1		Aver. 3.3 days	Aver. 0.21	
Alliritengae	Maros	M: 1	65.0	0	0 - 1 m	
		F: 0		0	Aver. 0.73 m	
Allepolea	Maros	M: 1	40.0	3 days	0.2 m	
		F: 0		Aver. 3 days	Aver. 0.2 m	
Raya	Maros	M: 1	69.0	3 - 4 days	0 - 1 m	
		F: 0		Aver. 3.5 days	Aver. 0.1 m	

According to probable storm rainfall analyses as explained in the above section, the 1998-1999 flood could be estimated to be a 50 to 100-year return period flood level.

The results of interview survey to respondents in Maros and Makassar who especially answered that the 1998 - 1999 flood was most serious are summarized as shown in **Table 6.1.26**:

Table 6.1.26 Interview Survey Results of 1998 – 1999 Flood

Location (Name of Area)	Flood Inundation		Descriptions of the Location
	Period (day)	Depth (m)	
Bringkanays (Makassar)	3 - 6 days	0.2 - 1.0 m	Right bank of the Tallo River along the proposed Outer Ring Road
Mallengkeri (Makassar)	3 – 4 days	0.3 – 0.5 m	Right abutment of the proposed new Sungguminasa bridge, Trans Sulawesi Mamminasata Road
Tamalanrea (Makassar)	3 – 5 days	0.2 – 0.5 m	Junction of JL. Perintis and Trans Sulawesi Mamminasata Road, right abutment of the proposed new Tallo bridge
Tello Baru (Makassar)	4 – 6 days	2.0 – 3.0 m	Left abutment of the proposed new Tallo bridge, Trans Sulawesi Mamminasata Road
Mangempang (Makassar)	2 days	0.1 m	Right bank of the Tallo River along JL. Abdullah Daeng Sirua
Moncongloe (Makassar)	6 days	1.0 – 1.5 m	Upstream area of the Tallo River
Pettuadae (Maros)	3 days	0.5 – 1.0 m	Left bank of the Maros River along the proposed Trans Sulawesi Mamminasata Road, in front of the City Hall
Turikale (Maros)	3 – 6 days	0.3 – 1.0 m	Left bank of the Maros River along the proposed Mamminasa Bypass, just left abutment of the Proposed new bridge

From the interview survey in Maros and Makassar, the following results were obtained with regard to the 1998-1999 flood (corresponding to a 50-100-year return period) as shown in **Figure 6.1.20**:

- Inundation depth less than 1.0 m : 77% (of the respondents); and
- Inundation period from 3 days to 6 days: 93% (of the respondents).

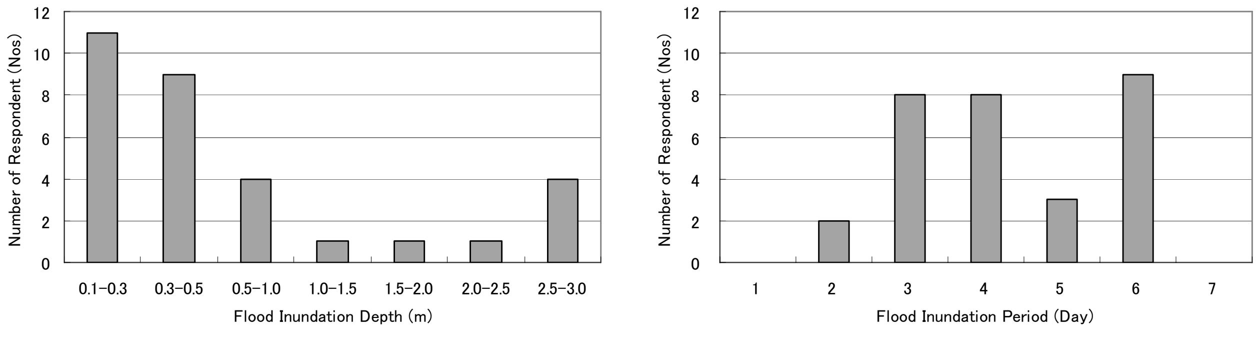


Figure 6.1.20 Interview Survey Results of 1998 – 1999 Flood

The average inundation period of the 1998 - 1999 flood in Maros and Makassar was calculated to be 4.3 days. According to the interview survey results, the maximum inundation depth of 3 m and inundation period of 6 days at the left abutment of the proposed new Tallo bridge, Tello Baru, were especially identified.

(a) Maros River Basin

The proposed alignments of the Trans Sulawesi road and Mamminasa Bypass run through the flood inundation area and flood retarding basin in/around the Maros City. A new bridge on the Mamminasa Bypass was designed. It will cross over the Maros River at 1 km upstream of the Alliritengae Bridge where no flood control structures such as dike will be constructed in the flood control plan.

A flood inundation survey was conducted in the proposed road alignments and a bridge site to set the design flood water levels temporarily. Locations of flood inundation areas, flood control plans, and interview surveys on the flood inundation in/around the Maros City are shown in **Figure 6.1.21**.

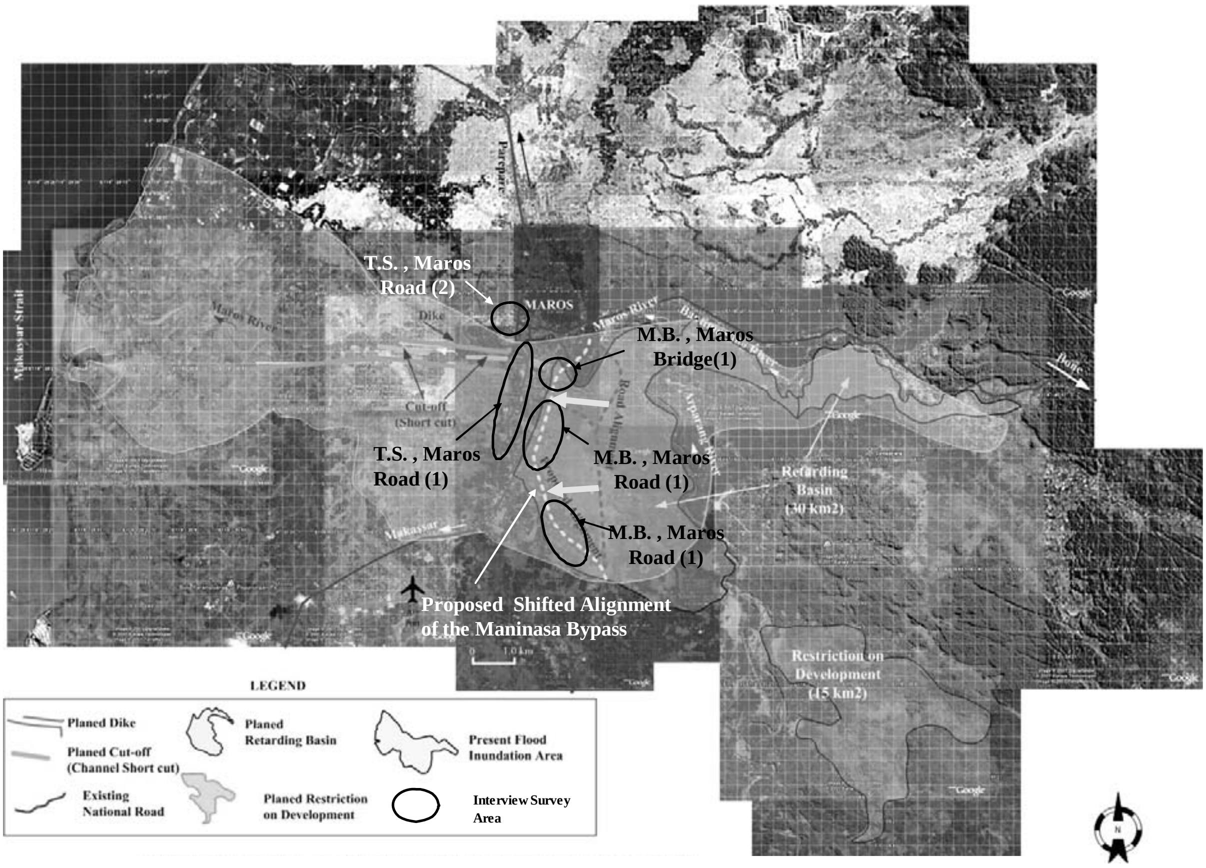


Figure 6.1.21 Locations of Flood Inundation Area, Flood Control Plan, and Interview Survey in Maros

From the flood control viewpoint, the originally proposed alignment of the Mamminasa Bypass passing through the retarding basin (existing paddy field) should be sifted to the existing national road (JL. Perintis) as much as possible to avoid reducing area of the flood retarding basin as shown in **Figure 6.1.22**.

An interview survey on flood inundation was carried out at the proposed road alignments and bridge sites in/around the Maros City as shown in **Figure 6.1.21**. Answers to the interview survey were obtained from 45 respondents in/around the Maros City. The results of inundation depth survey of each area are summarized in **Table 6.1.27**:

Table 6.1.27 Results of Interview Survey on Flood Inundation in/around Maros City

Area Code	Description of Location	Survey Result
T.S.-Maros-Road (1)	Trans Sulawesi Road, in front of Maros Regency Office (Kantor Kabupaten)	Inundation depth 0.3 m – 1.0 m in the existing national road
T.S.-Maros-Road (2)	Trans Sulawesi Road, around the Center of Maros City	Inundation depth 0.0 m – 0.1 m in the ground level of house
M.B-Maros-Road (1)	Mamminasa Bypass along the proposed route shifted from the original route (1)	Inundation depth 0.5 m – 0.7 m in the ground level of house
M.B.-Maros-Road (2)	Mamminasa Bypass along the proposed route shifted from the original route (2)	Inundation depth 0.0 m – 0.5 m in the ground level of house
M.B.-Maros-Bridge (1)	Mamminasa Bypass proposed new bridge, around left abutment	Inundation depth 0.5 m – 1.5 m in the ground level of house

The following should be taken into consideration for the study based on the interview survey results:

* A flood inundation depth of 0.3 m – 1.0 m from the existing road level was reported during rainy season in every year, especially in front of the Maros Regency Office [TS.-Maros-Road (1)].

* In the center of the Maros City [TS.-Maros-Road (2)], flood inundation has scarcely occurred. The maximum flood inundation depth was 0.1 m.

* Along the proposed route shifted from the original Mamminasa Bypass Route [TS.-Maros-Road (1) and (2)], a flood inundation depth of 0.5 m - 0.7 m from the ground level was reported during the rainy season in every year.

* At the left abutment of the new proposed bridge of the Mamminasa Bypass, a flood inundation depth of 0.5 m - 1.0 m from the ground level was reported during the rainy season in every year.

(b) Tallo River Basin

The proposed alignments of the Trans Sulawesi, Outer Ring Road, and Abdullah Daeng Sirua Road run through the flood inundation area, flood control facilities in/around the Tallo River. Three proposed bridges on the Trans Sulawesi (JL. Perintis), Outer Ring Road, and Abdullah Daeng Sirua Road were designed crossing the Tallo River, which will be affected by flood control structures such as dike and short cut channel.

Accordingly, the design level of theses proposed bridges and roads should be set based on the design level of the flood control facilities to be constructed such as dike. In addition, a flood inundation survey was conducted in/around the proposed road alignments and bridges to set the design flood water levels temporarily. Locations of flood inundation areas, flood control facilities, and interview survey on flood inundation in/around the Tallo River are shown in **Figure 6.1.22**.

The proposed alignment of the Outer Ring Road should be located on the left bank of the Tallo River to avoid reducing the areas of flood retarding basin and restriction of development from the hydraulic viewpoint as shown in **Figure 6.1.22**.

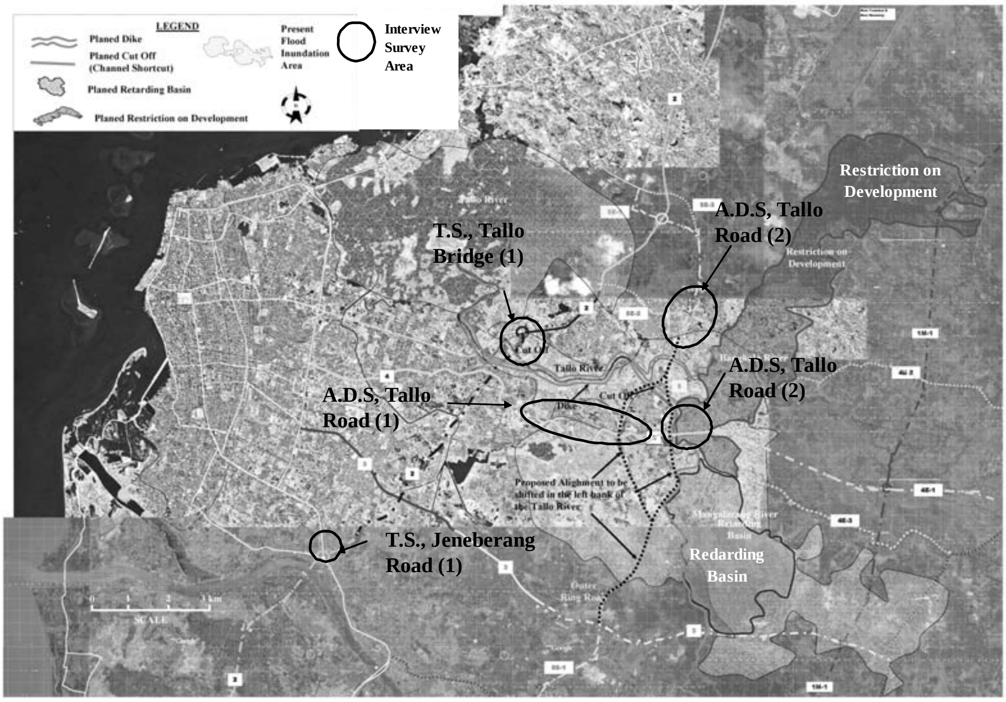


Figure 6.1.22 Locations of Flood Inundation Area, Flood Control Plan, and Interview Survey in Makassar City

An interview survey on flood inundation was carried out at the proposed road alignments and bridge sites in the Makassar City as shown in **Figure 6.1.22**. Answers to the interview survey were obtained from 60 respondents in/around the Makassar City. The results of inundation depth survey of each area are summarized in **Table 6.1.28**.

Table 6.1.28 Results of Interview Survey on Flood Inundation in/around Makassar City

Area Code	Description of Location	Interview Survey Result
T.S.-Tallo-Bridge (1)	Trans Sulawesi Road, proposed new bridge (left bank) and intersection (right bank)	Inundation depth 1.0 m – 3.0 m (Left bank) and 0.2 m – 1.0 m (right bank) from ground level
O.R.R..-Tallo-Road (1)	Outer Ring Road, around right bank of the Tallo River	Inundation depth 0.1 m – 0.7 m in the ground level of house
A.D.S.-Tallo-Road (1)	Abdullah Daeng Sirua, left bank of the Tallo River	Inundation depth 0.0 m – 0.1 m in the ground level of house
A.D.S.-Tallo-Road (2)	Abdullah Daeng Sirua, right bank of the Tallo River (1)	Inundation depth 0.1 m – 0.5 m in the ground level of house
T.S.-Jeneberang-Road (1)	Trans Sulawesi Road, Sungguminasa intersection, right bank of the Jeneberang River	Inundation depth 0.0 m – 0.6 m in the ground level of house
T.S.-Jeneberang-Road (2)	Trans Sulawesi Road, Left bank of the Jeneberang River	Inundation depth 0.0 m – 0.3 m in the ground level of house

The following should be taken into consideration for the study based on the interview survey results:

* A flood inundation depth of 1.0 m – 3.0 m from the ground level as reported during the rainy season in every year, especially on the left bank of the Tallo River [T.S.-Tallo-Bridge (1)]. The proposed intersection area near the Tallo Bridge on the right bank of the Tallo River, was flooded with a water depth of 0.2 m - 1.0 m

* On the right bank of the Tallo River along the Outer Ring Road [O.R.R.-Tallo-Road (1)], a flood inundation depth of 0.1 m – 0.7 m from the ground level was reported during the rainy season in every year.

* On the left and right banks of the Tallo River along the proposed Abdullah Daeng Sirua Road, a flood inundation depth of 0.0 m – 0.1 m on the left bank, and 0.1 m – 0.5 m on the right bank were reported.

* On right bank of the Jeneberang River, a new proposed intersection of the Trans Sulawesi in Sungguminasa, a flood inundation depth of 0.0 m – 0.5 m from the ground level was reported during the rainy season in every year.

(c) Gamanti and Pappa River Basins

According to the existing flood record, the proposed alignment of the Trans Sulawesi Mamminasata Road may not be affected by flood inundation so much in the center of Takalar City. The alignment was not designed to pass through the flood retarding basin and the area of restriction of development, and there will be no proposed bridges crossing the Gamanti and Pappa Rivers.

Therefore, a flood inundation survey was conducted at the proposed alignment of the Trans Sulawesi located in the center of Takalar City. Locations of flood inundation areas, flood control plans, and interview survey on flood inundation in/around the Takalar City are shown in **Figure 6.1.23**.

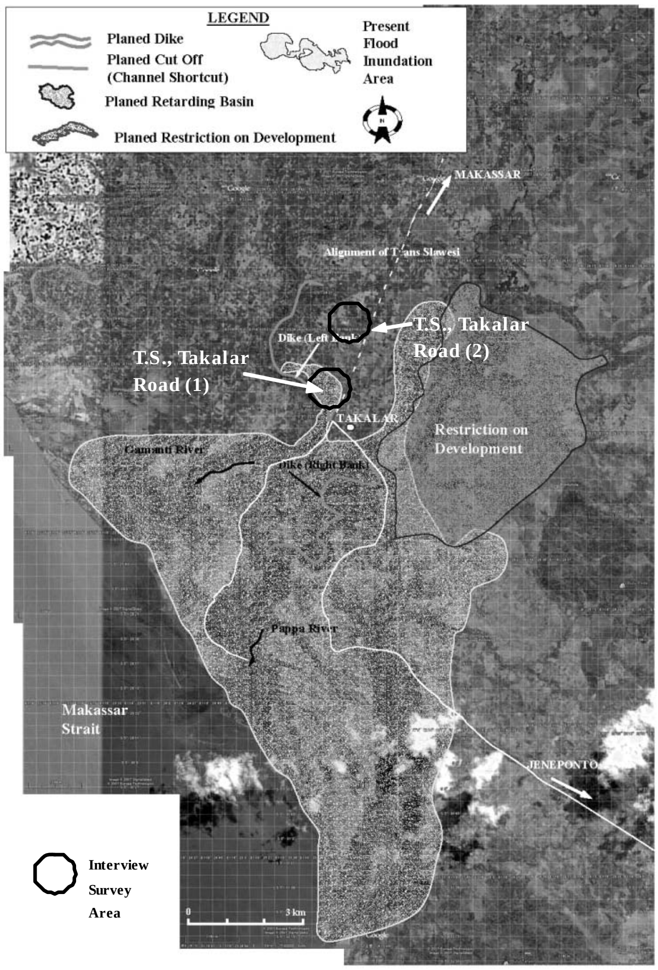


Figure 6.1.23 Locations of Flood Inundation Area, Flood Control Plan, and Interview Survey in Takalar City

An interview survey on flood inundation was carried out at the proposed road alignment in the Takalar City as shown in **Figure 6.1.23**. Answers to the interview survey were obtained from 6 respondents in/around the Takalar City. The results of inundation depth survey of each area are summarized in **Table 6.1.29**:

Table 6.1.29 Results of Interview Survey on Flood Inundation in/around Makassar City

Area Code	Description of Location	Interview Survey Result
T.S.-Takalar-Road (1)	Trans Sulawesi Road, ending portion of the road, center of Takalar City, left bank of the Gamanti River	Inundation depth 0.0 m – 0.3 m from ground level of house (Left bank of the Gamanti River)
T.S.-Takalar-Road (2)	Trans Sulawesi Road, Takalar City, left bank of the Gamanti River	Inundation depth 0.0 m in the ground level of house

The following should be taken into consideration for the study based on the interview survey results:

* On the left bank of the Gamanti River [T.S.-Takalar-Road (1)], a flood inundation depth of 0.0 m – 0.3 m from the ground level was reported during the rainy season in every

year.

* No flood inundation was reported in the area of [T.S.-Takalar-Road (2)], in the left bank of the Gamanti River.

(d) Jeneberang River Basin

Flood control projects on the Jeneberang River, such as construction of dike, river diversion, and river dredging, have been completed, and thus the Makassar City and Gowa Regency are currently protected against the probable river flood overflow of a 50-year return period. The design level of the proposed bridges crossing the Jeneberang River through the Trans Sulawesi and Outer Ring Road, should be set based on design level of the existing flood control facilities such as dike.

An interview survey on flood inundation was carried out at the proposed bridge sites in the Makassar City and Gowa Regency. Answers to the interview survey were obtained from 10 respondents in/around the Gowa Regency. The results of inundation depth survey of each area are summarized in **Table 6.1.30**:

Table 6.1.30 Results of Interview Survey on Flood Inundation in/around Makassar City

Area Code	Description of Location	Interview Survey Result
T.S.-Jeneberang-Road (1)	Trans Sulawesi Road, Sungguminasa intersection, right bank of the Jeneberang River	Inundation depth 0.0 m – 0.6 m in the ground level of house
M.B.-Jeneberang-Bridge (2)	Mamminasa Bypass, right bank of the Jeneberang River, 9.5 km upstream of the [TS. Jeneberang-Road (1)] along the river	Inundation depth 0.0 m – 0.1 m in the ground level of house

The following should be taken into consideration for the study based on the interview survey results:

* Inundation occurred due to insufficient drainage capacity around the proposed intersection of Trans Sulawesi at Sungguminasa; an inundation depth of 0.0 m – 0.6 m was reported.
* No flood inundation occurred at the site of the proposed bridge crossing the Jeneberang River, 9.5 km upstream of the proposed New Sungguminasa Bridge along the river.

The flood inundation depth and extent in the Maros River Basin, Tallo River Basin, and Gamanti-Pappa River Basin were prepared based on exiting flood damage records and the interview survey in the study as shown in **Figures 6.1.24, 6.1.25**, and **6.1.26** respectively

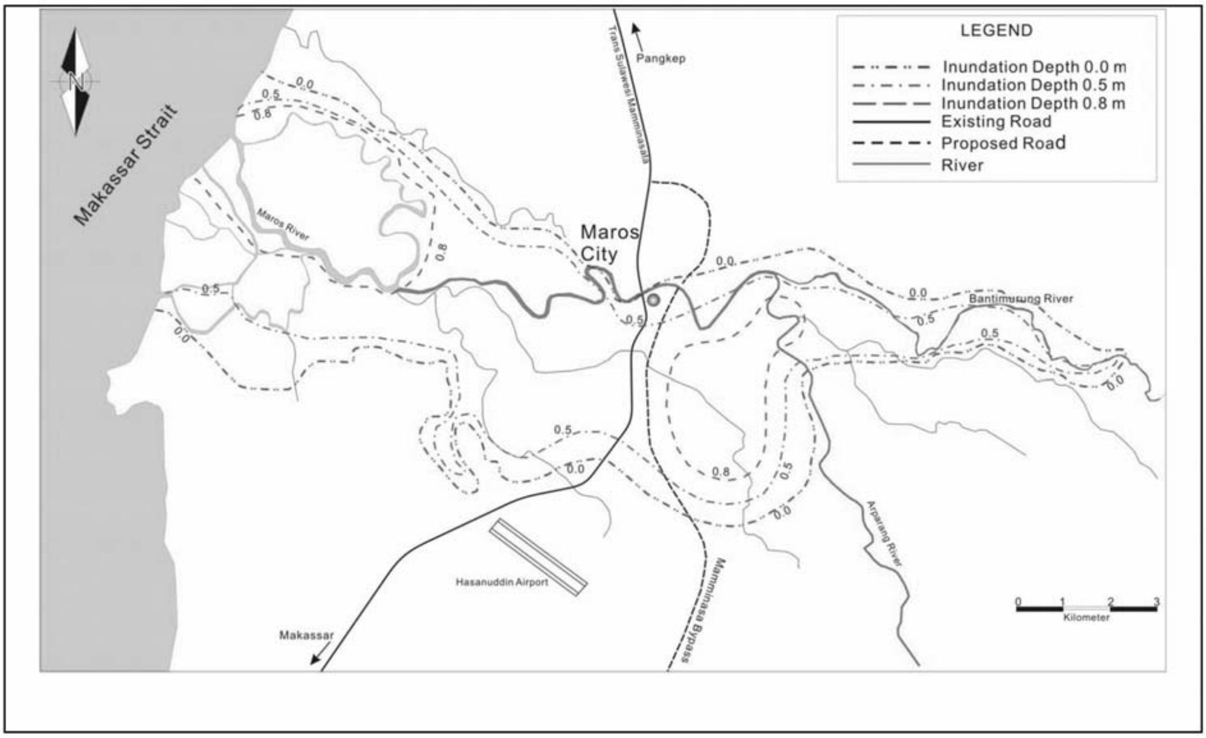


Figure 6.1.24 Flood Inundation Extent and Depth in the Maros River Basin

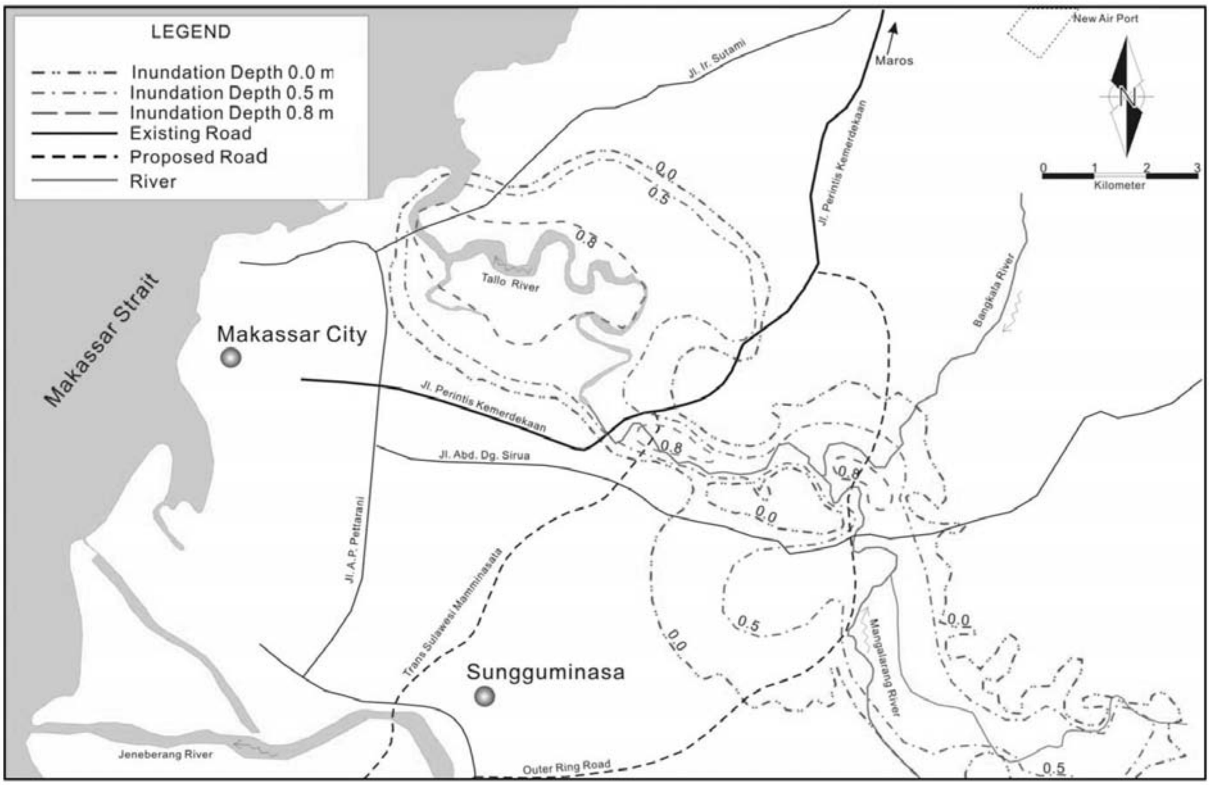


Figure 6.1.25 Flood Inundation Extent and Depth in the Tallo River Basin

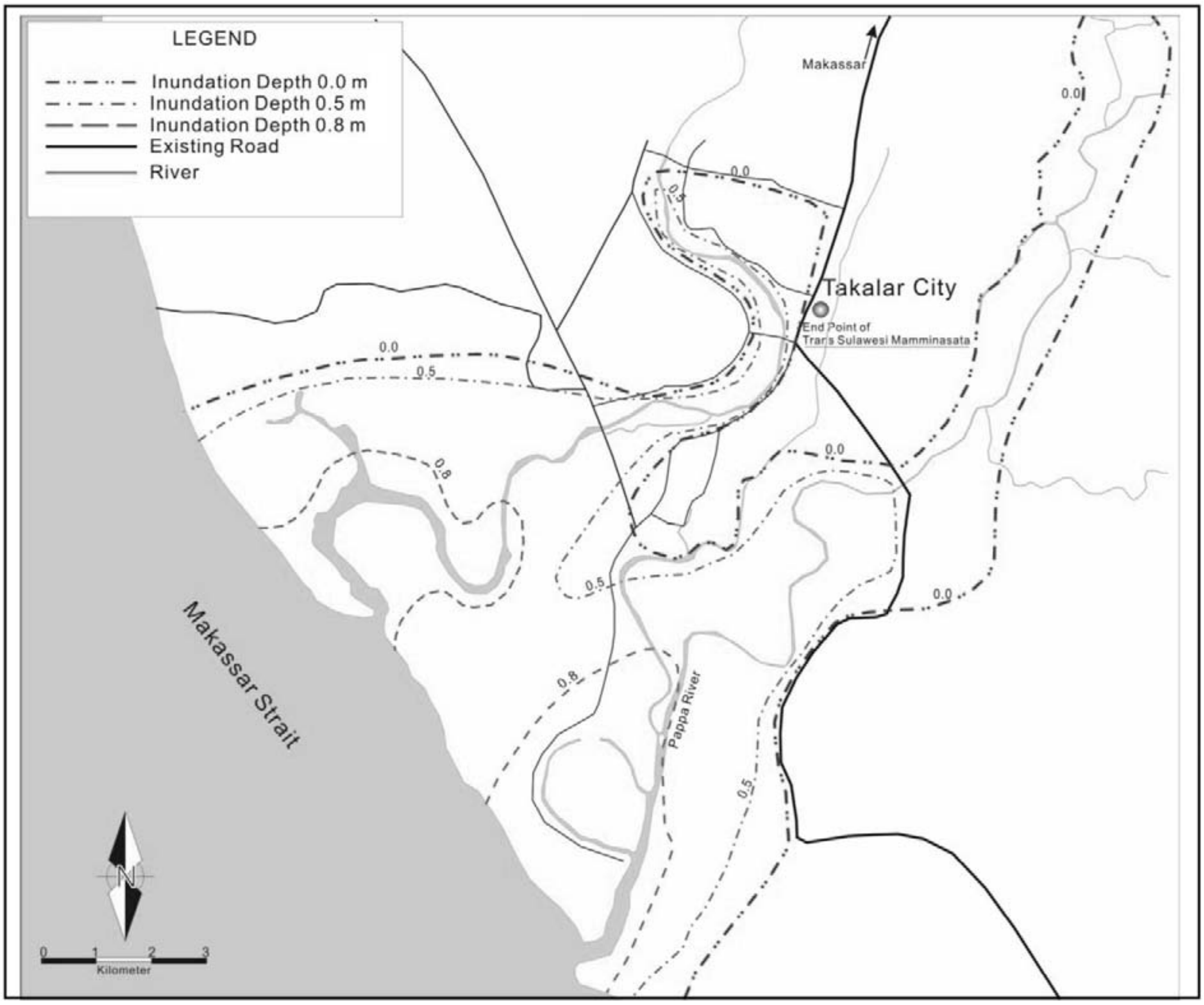


Figure 6.1.26 Flood Inundation Extent and Depth in the Gamanti-Pappa River Basin

2) Hydraulic Analysis

Normal flow analyses were conducted by using the computer software "HEC-RAS" to introduce flood water level at each design peak discharge for the following proposed 4 bridge sites:

i) Maros River
   a) 1.1 km upstream of the Alliritengae Bridge, along the Mamminasa Bypass Route

ii) Tallo River
   b) 1.3 km upstream of the Tallo Bridge (JL. Perintis), along the Trans-Sulawesi Mamminasata Route

iii) Jeneberang River
   c) 2.8 km downstream of the Sungguminasa Bridge, along the Trans-Sulawesi Mamminasata Route
   d) 9.5 km upstream of the Sungguminasa Bridge, along the Mamminasa Bypass Route

Hydraulic calculations by normal flow analyses were made based on the topographic survey data obtained during this study, and the results of the analyses are shown in **Table 6.1.31**.

Table 6.1.31 Hydraulic Calculation Results at Bridge Sites

Bridge Site	Riverbed Slope	Design Discharge (m^3/sec)	Max. Flow Velocity (m/sec)	Design Flood Water Level (EL. m)	Design Crest Level of Dyke *1 (EL. m)	Proposed Bridge Level *2 (EL. m)
a) Maros River	1/4,500	1,260 (25-year)	1.11	5.67	7.66	7.66
b) Tallo River	1/10,000	830 (50-year)	0.72	4.14	2.80	5.14
c) Jeneberang River (upstream)	1/1,120	2,500 (50-year)	3.31	8.86	10.96	10.96
d) Jeneberang River (downstream)	1/1,120	2,500 (50-year)	2.42	3.91	7.55	7.55

Note: *1: Proposed Design Crest Level of Dyke in existing flood control plan, Comprehensive Water Management Plan Study for Maros Jeneberang River Basin, Nov. 2001
*2: Bottom Level of Bridge Girder

6.1.3 Conclusions

For the feasibility study, the following matters were examined at a preliminary design level:

- Flood water level and inundation depth;
- Road alignment; and
- Flood protection works.

However, information on detailed ground level, river cross section and longitudinal riverbed profile for the flood water level and inundation area were not available, and therefore, it was virtually difficult to clarify the definitive hydraulic/hydrological deign values. Due to these difficulties, the design values of flood water level and inundation areas could not be determined accurately at this time. These design values should be determined based on further survey/study, and detailed topographic information in the next stage (Basic/Detailed Design).

(1) Flood Water Level

It is proposed that the flood water levels be set temporarily as follows, based on interview survey on flood inundation, review of flood control plans, and completed flood control facilities.

i) Maros River Basin (Locations of interview survey: refer to **Figure 6.1.21**)

- Trans Sulawesi (Road): 0.5 m to 1.0 m above existing road level in Maros City
- Mamminasa Bypass (Bridge): 1.0 m to 1.5 m above ground level (left bank)
- Mamminasa Bypass (Shifted Road): 0.5 m to 1.0 m above ground level (paddy field)

ii) Tallo River Basin (Locations of interview survey: refer to **Figure 6.1.22**)

- Trans Sulawesi (Bridge): 2.0 m to 3.0 m above ground level (left bank)
- Outer Ring Road (Bridge): 1.0 m to 1.5 m above ground level (left bank)
- Abdullah Daeng Sirua (Bridge): 1.0 m to 1.5 m above ground level (left bank)
- Outer Ring Road (Road): 0.1 m to 0.7 m above ground level (right bank)
- Abdullah Daeng Sirua (Road): 0.1 m to 0.5m above ground level (left and right banks)

iii) Jeneberang River Basin (Locations of interview survey: refer to **Figure 6.1.22**)

- Trans Sulawesi (Road): 0.3 m to 0.5 m above existing road level in Sungguminasa
- Mamminasa Bypass (Bridge): 2.0 m to 3.0 m above ground level (right bank)

iv) Gamanti-Pappa River Basin (Locations of interview survey: refer to **Figure 6.1.23**)

- Trans Sulawesi (Road): 0.3 m to 0.5 m above existing road level in Takalar City

The design flood water levels at the 4 bridge sites are summarized in **Table 6.1.31**, and the river cross section at each bridge site is shown in **Figures 6.1.27** and **6.1.28** with the design flood water level, inundation depth in landside area, and proposed level of the bottom of bridge girder.

Dyke construction works along the Tallo River have not yet been carried out, and the alignment of the Outer Ring Road is proposed to be located on the left bank, *Abdullah Daeng Sirua area*, along the Mangalarang River and the Tallo River. To ensure efficient landuse, combined design of the dike and traffic road is proposed as shown in **Figure 6.1.29**.

According to the Study on Implementation of Integration Spatial Plan for the Mamminasata Metropolitan Area, JICA, 2005, the lower area of the Tallo River Basin should be preserved from the social, environmental and flood control viewpoints. If development plans, designs of road and land reclamation, etc. in the lower area will be required, they should be made based on flood inundation analysis in more detail to avoid worse flood inundation in Makassar.

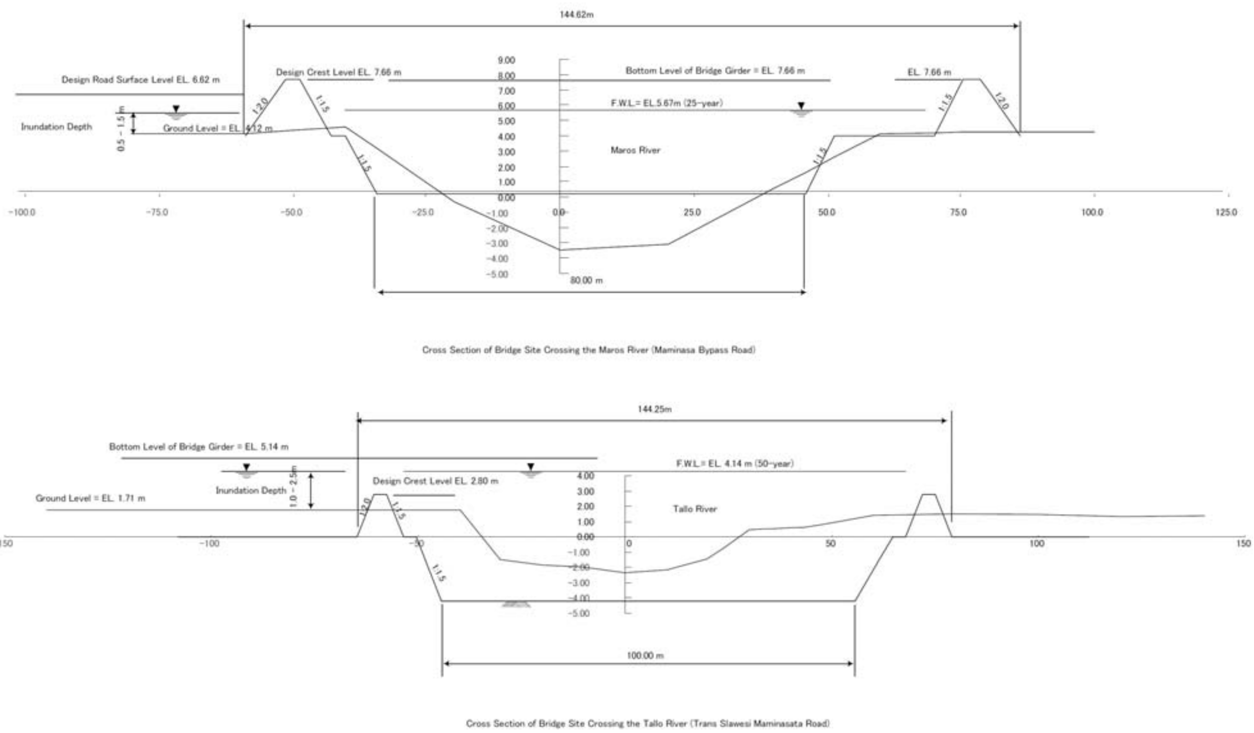


Figure 6.1.27 Section of Proposed Bridge Site over the Maros River and Tallo River

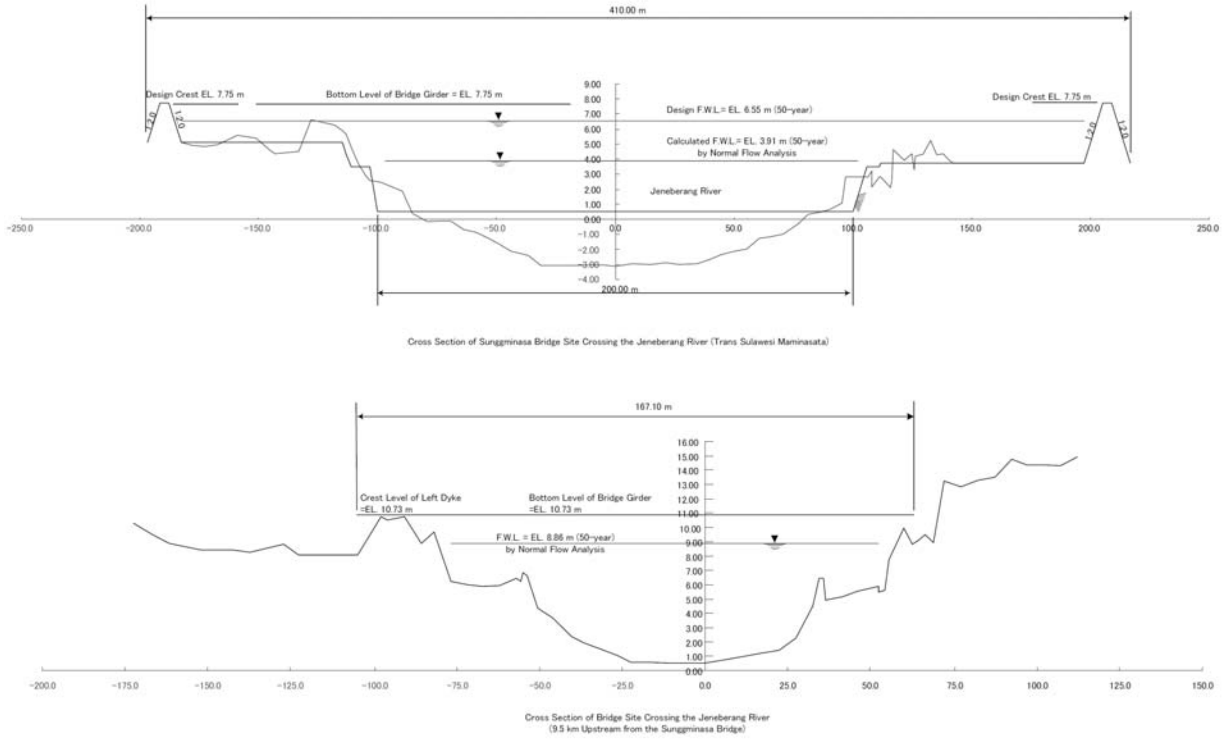


Figure 6.1.28 Section of Proposed Bridge Site over the Jeneberang River

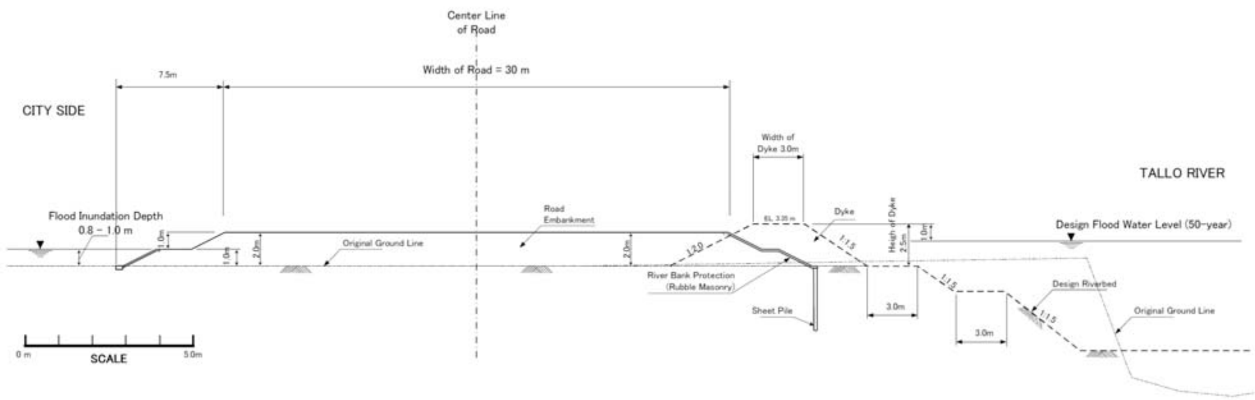


Figure 6.1.29 Typical Section of Dyke and Highway along Outer Ring Road

(2) Road Alignment

It is proposed that the original road alignment be shifted as mentioned below, based on the existing flood control plans and flood inundation conditions.

i) Maros River Basin

From a flood control viewpoint, the originally proposed alignment of the Mamminasa Bypass passing through the retarding basin (existing paddy field) should be sifted to the existing national road (JL. Perintis) as much as possible to avoid reducing the area of flood retarding basin as shown in **Figure 6.1.21**.

ii) Tallo River Basin

The proposed Outer Ring Road should be aligned on the left bank of the Tallo River to avoid reducing the areas of flood retarding basin and restriction of development from hydraulic viewpoints as shown in **Figure 6.1.22**.

iii) Jeneberang River Basin

The proposed road alignment which is not affected by the existing flood control plans and facilities and serious flood inundation from the hydrological/hydraulic viewpoint, can be adopted in the preliminary design.

iv) Gamanti and Pappa Rivers Basin

The proposed road alignment which is not affected by the existing flood control plans and facilities and serious flood inundation from the hydrological/hydraulic viewpoint, can be adopted in the preliminary design.

(3) Flood Protection Works

Designs of flood protection works should be made based on the maximum flood velocity at the following portions:

i) Bridge abutment and river bank;
ii) Bridge pier; and
iii) Slope protection on road embankment.

The maximum flood velocities at 4 bridge sites are summarized in Table 6.1.32.

Table 6.1.32 Maximum Flood Velocity at Bridge Sites

Bridge Site	Max. Flow Velocity (m/sec)	Design Discharge (m^3/sec)
a) Maros River	1.1	1,260 (25-year)
b) Tallo River	0.7	830 (50-year)
c) Jeneberang River (upstream)	3.3	2,500 (50-year)
d) Jeneberang River (downstream)	2.4	2,500 (50-year)

The following flood protection works should be designed at each bridge site against scouring, erosion:

a) Maros River (Maximum Flow Velocity = 1.1 m/sec)

i) Bridge abutment and river bank: - Concrete/Rubble Masonry Revetment with Foot Protection/Concrete Pile
ii) Bridge pier: - Steel Pile
iii) Slope protection on road embankment. - Concrete/Rubble Masonry Slope Protection
- Concrete Drain Pipes should be placed under the embankment located in flood inundation

area.

b) Tallo River (Maximum Flow Velocity = 0.7 m/sec)

i)	Bridge abutment and river bank:	- Concrete/Rubble Masonry Revetment with Foot Protection/Concrete Pile
ii)	Bridge pier:	- Steel Pile
iii)	Slope protection on road embankment.	- Concrete/Rubble Masonry Slope Protection - Concrete Drain Pipes should be placed under the embankment located in flood inundation area.

c) Jeneberang River (upstream) (Maximum Flow Velocity = 3.3 m/sec)

i)	Bridge abutment and river bank:	- Not required (the location is on landside)
ii)	Bridge pier:	- Steel Pile and Gabion Mattress
iii)	Slope protection on road embankment.	- Not required (the location is on landside)

d) Jeneberang River (downstream) (Maximum Flow Velocity = 2.4 m/sec)

i)	Bridge abutment and river bank:	- Not required (the location is on landside)
ii)	Bridge pier:	- Steel Pile and Gabion Mattress
iii)	Slope protection on road embankment.	- Not required (the location is on landside)