CHAPTER 6

HYDROLOGY AND WATER BALANCE STUDY

6.1 Meteorological Conditions in Jeneberang River Basin

The Jeneberang river basin experiences a tropical climate, showing high and rather constant air temperature throughout the year but with a distinct variation in rainfall in the wet and dry seasons during the year. The northwest monsoon prevails from December to June, while the southeast monsoon extends from May to November. The northwest monsoon has a high moisture content, which is precipitated on Mt. Bawakaraeng, Mt. Lompobatang and their adjacent mountain ranges at the west edge of the river basin. As a result, the mountainous/hilly area in particular receives a large volume of rainfall during the northwest monsoon period. On the other hand, the river basin receives little rainfall during the east monsoon due to the sheltering effect by the mountain ranges.

According to the average monthly rainfall records at four gauging stations, namely Malino, Bili-Bili, Kampili and Bonto Suggu in and around Jeneberang River basin, the monthly rainfall in a rainy season from December to May is far less than in the dry season from June to November, as listed below. About 80 % to 90 % of the annual rainfall is received from December to May, and the remainder in the dry season.

Monthly Rainfall in Jeneberang River Basin

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Malino	864	706	532	439	216	145	91	25	49	101	381	735	4284
Bili-Bili	677	529	448	336	130	60	70	17	63	88	356	615	3389
Kampili	656	465	330	235	94	58	28	16	36	107	346	556	2926
Bonto Sunggu	669	410	273	140	89	47	23	6	24	83	203	482	2449

In addition to the above large variations in monthly rainfall, Jeneberang river basin has a large spatial variation in rainfall due to the topographic effect of the mountain ranges in the eastern part of the river basin. Among the four gauging stations, the highest gauging station is Malino followed by Bili-Bili, Kampili and Bonto Sunggu. Malino, located in the up-most reaches of the river, receives an average annual rainfall of 4,284 mm, while the annual rainfall at the lower stations decreases. Bonto Sunggu, at the lowest elevation, receives only 2,449 mm or 60 % of the total at Malino.

Climatic indices such as temperature, humidity, wind velocity, sunshine hour and evaporation were extracted from two meteorological gauging stations at Bonto Sunggu and Bonto Bili. These are summarized below:

Observed Parameter	Bonto Sunggu In Lower Reaches of Bili-Bili Dam	Bonto Bili Located adjacent to Bili-Bili dam
Mean Temperature (°C)	27.5	23.6
Mean Max. Temperature (°C)	31.4	25.9
Mean Min. Temperature (°C)	22.4	21.3
Relative Humidity (%)	85.0	81.0
Wind Velocity (m/s)	0.9	1.3
Sunshine Hour (hr/day)	7.0	4.0
Evaporation (mm/day)	5.3	4.3

The gauging station at Bonto Sunggu is located in the lower reaches below Bili-Bili dam. The station at Bonto Bili is located adjacent to Bili-Bili dam, and therefore in the more mountainous upper reaches. The particular characteristics of the above climatic indices are discussed below:

(1) Temperature

The average monthly temperatures at Bonto Sunggu show small fluctuations with a minimal difference between the highest, about 28 °C in May and November, and the lowest of about 27°C in August. On the other hand, Bonto Bili shows more fluctuation with a larger difference between about 24.5 °C in December to May and 21.4 °C in August and September. Moreover, the annual average temperature of 23.6 °C at Bonto Bili is much lower than that at Bonto Sunggu of 27.5 °C. Thus, the temperature in the upper reaches tends to be lower with a greater monthly fluctuation than in the lower reaches.

(2) Relative Humidity

Both climatic gauging stations show rather small monthly variations in relative humidity, with a range from about 79 % to 88 %. There is also no distinct difference in the average annual humidity between the two stations.

(3) Wind

Similar to the relative humidity, there is no distinct variation in the monthly wind velocities at each of the two gauging stations. The annual average wind velocities between the two stations are also small with a range of only 0.9 m/s to 1.2 m/s.

(4) Sunshine

Bonto Sunggu has rather larger monthly variations in one-day sunshine hours with a range from 4.4 hours/day in January (rainy season) to 9.2 hours/day in August (dry season). On the other hand, Bonto Bili tends to show a more constant but shorter duration of sunshine hours with a range of 3.3 to 4.9 hours/day.

(5) Evaporation

Bonto Sunggu and Bonto Bili indicate average annual one-day evaporation of 5.3 mm/day (1,930 mm/year) and 4.3 mm/day (1,570 mm/year). Thus, the evaporation at Bonto Bili in the upper reaches is lower, which could be attributed to the cooler temperature and shorter sunshine hours.

6.2 Rainfall Analysis

6.2.1 Objectives of Analysis and Basic Data

The analysis aimed at clarifying: (a) the variations in long-term rainfall and (b) magnitude of probable storm rainfall in Jeneberang River Basin. Item (a) is used as the basic data to generate the long-term basin runoff discharge through a simulation model as described in the following Subsection 6.3. For item (b), the estimated value could be used as basic information for proposed flood management.

Rainfall is currently gauged at three climatic gauging stations and thirty-two rainfall stations in total in the Jeneberang river basin. These stations are under the administration of Meteorology and Geophysics Agency (BMD), Provincial Water Resources Management (Dinas PSDA) and JRBDP as listed below.

Meteorological and Rainfall Stations in Jeneberang River Basin

	BMG	Dinas PSDA	JRBDP	Total
Climatic Gauging Station	1	2	-	3
Rainfall Station	5	(20)	7	(32)

Among the above existing gauging stations, the rainfall gauged at the following nine stations were selected as the basic data for analysis of long-term average basin rainfall in due consideration of their locations and the available data length.

(1) Malino (Old non-telemetry station used before 1997);
(2) Malino (New telemetry gauging station shifted from the above old station in 1998);
(3) Jonggoa;
(4) Bili-Bili (Old non-telemetry station installed adjacent to the existing Bili-Bili dam site in 1975);
(5) Bili-Bili (New telemetry gauging station installed at the intake of the Bili-Bili dam in 1998);
(6) Kampili (New telemetry gauging station installed in 1999);
(7) Maccini Sombala;
(8) Limbunga; and
(9) Mangempang.

The irrigation water requirement for three major irrigation areas of Bili-Bili, Bissua, and Kampili irrigation areas in Jeneberang river basin had been estimated as part of the Bili-Bili Irrigation

Project in 1998. The basic rainfall data for the estimation were given from the following seven gauging stations.

(1) Kampili (Old non-telemetry gauging stations in 1974):
(2) Bontosunggu;
(3) Mandalle;
(4) Kalabajeng;
(5) Bonto Sallang;
(6) Barembeng; and
(7) Sandro Bone.

The estimated irrigation water requirement is essential for water supply-demand balance simulation, while the length of the estimation is limited to a period from 1972 to 1997. In this connection, an attempt was made to estimate the irrigation water requirement for the supplementary years from 1998 to 2001 using the rainfall records at the above seven gauging stations.

Thus, the rainfall data used in this Study totaled sixteen gauging stations. An inventory list and location map of these selected stations are shown in Table 6.1 and Figure 6.1, respectively.

6.2.2 Analysis on Long-term Rainfall

The rainfall data at the above gauging stations were collected and processed in the form of annual rainfall tables. As a result, the average monthly rainfalls for a 30-year period from 1972 to 2003 are estimated as listed below (refer to Table 6.2 and Figure 6.2):

Average Monthly and Annual Rainfall

(Unit: mm)

Gauging Station	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Gauge Period
Malino	864	706	532	439	216	145	91	25	49	101	381	735	4,284	72 - 03
Jonggoa	794	484	386	197	50	106	15	22	5	172	346	677	3,254	99 - 03
Bili-Bili	677	529	448	336	130	60	70	17	63	88	356	615	3,389	72 - 03
Kampili	656	465	330	235	94	58	28	16	36	107	346	556	2,926	72 - 03
M. Sombala	797	561	295	132	42	44	4	0	13	54	184	587	2,712	99 - 03
Limbunga	726	602	408	272	99	88	48	9	21	164	223	729	3,388	99 - 03
Mangenpang	1057	854	511	330	157	102	38	4	32	197	546	1097	4,925	99 - 03
B. Sunggu	669	410	273	140	89	47	23	6	24	83	203	482	2,449	78 - 02

As listed above, the Malino gauging station, which is located upstream from Bili-Bili dam reservoir, recorded an average annual rainfall of more than 4,000 mm. Mangenpang in the upper reaches of Jenelata river basin also recorded a similar range to the annual rainfall at Malino. In contrast to these gauging stations, those in the lower reaches such as Kampili, Bontosunggu and Maccini Sombala recorded far lower annual rainfalls in the range of 2,400 to 2,500 mm.

The variations in the average annual basin rainfalls from 1972 to 2003 were further estimated through the Thiessen Polygon Method. As shown in Table 6.3, the annual rainfall at each of the gauging stations tends to have a large variation year to year. The rainfall gauging station at Malino in particular shows largest variations in annual rainfall, with a range of 2,344mm in 1972 to

7,230mm in 1989. Due to this, the variation of the annual basin mean rainfall also has a large variation with a range of about 2,500mm to 5,300mm.

The seasonal distribution of rainfall is described by two (2) distinct seasons, dry from June to November and wet from December to May. Heaviest months of rainfall are December and January, while lightest rainfalls occur in August. More than 80% of the annual rainfall is concentrated in the rainy season as listed below:

Gauging Station	Rainfall in a Dry Season (Jun.-Nov.) Depth (mm)	Share to Annual Total (%)	Rainfall in Rainy Season (Dec.-May) Depth (mm)	Share to Annual Total (%)
Malino	792	18.5	3,492	81.51
Jonggoa	666	20.5	2,587	79.52
Bili-Bili	654	19.3	2,735	80.69
Kampili	589	20.1	2,337	79.86
Maccini Sombala	299	11.0	2,413	88.98
Limbunga	552	16.3	2,836	83.71
Mangenpang	919	18.7	4,006	81.34
Bonto Sunggu	386	15.8	2,064	84.25
Average	607	17.8	2,809	82.22

6.2.3 Analysis of Probable Storm Rainfall

The annual one-day maximum rainfalls gauged at the two key gauging stations, Malino and Bili-Bili, were collected for a period from 1923 to 2003. As listed in Table 6.4, the annual maxim one-day rainfall has a range from about 70 mm to the recorded maximum rainfall of 296mm.

Based on annual maximum rainfall data, probable one-day rainfall was estimated based on the Gumbel Distribution Method as listed below (refer to Figure 6.3):

Probable One-day Rainfall

Return Period	Malino	Bili-Bili
100 -years	333 mm/day	317 mm/day
50 -years	303 mm/day	291 mm/day
20 -years	264 mm/day	255 mm/day
10 -years	234 mm/day	228 mm/day
5 -years	202 mm/day	200 mm/day
2 -years	154 mm/day	157 mm/day

6.3 Runoff Analysis

6.3.1 Objectives of Analysis and Basic Data

The runoff analysis aims at estimating the long-term basin runoff discharge, which is essential for the water supply-demand balance simulation (refer to Subsection 6.3.2). The analysis was concentrated on the following two sub-basins, which are the principal water sources in Jeneberang: (a) upper reaches of Jeneberang River above Bili-Bili dam reservoir, and (b) the whole of Jenelata river basin.

(1) Discharge Data Converted from Gauged Water Level

Before completion of Bili-Bili dam, the water level had been gauged at two key gauging stations. One is Patarikan Gauging Station on Jeneberang River, which was located near the present Bili-Bili dam site and the other was Patarikan Gauging Station on Jenelata River, located at the existing Patarikan Bridge adjacent to the confluence with the mainstream of Jeneberang River. The reliability of H-Q rating curves for the two gauging stations was verified through the Detailed Design of Bili-Bili Irrigation Project. The river flow discharge converted from the water levels gauged at these key gauging stations were therefore applied to the proposed water supply-balance simulation.

After completion of Bili-Bili dam reservoir, however, the above two gauging stations were abandoned, and instead, seven telemetry water level gauging stations were newly installed in Jeneberang river basin, as shown in Figure 6.4. All H-Q rating curves at these new gauging stations have never been updated since they were originally installed, as shown in Table 6.5. As a result, the accuracy of the river flow discharge converted from the water level could not be confirmed and it is difficult to apply the available river flow discharge as a basis for the runoff-analysis.

Therefore, the available discharge data at the two gauging stations used for the water supply-demand simulation were adopted for the following gauging periods:

- Runoff discharge from Jeneberang river: From 1978 to 1990 gauged at Patarikan gauging station on Jeneberang River;
- Runoff Discharge from Jenelata River: From 1990 to 1997 gauged at Patarikan Station on Jenelata River.

(2) Rainfall and Evaporation Data Used for Runoff Simulation

In order to generate the daily runoff discharge for the period not covered by the above available water level gauging periods, a runoff simulation was undertaken based on the following rainfall and evaporation data:

- *Rainfall Gauging Data*: The rainfall gauging data applied included the sixteen rainfall gauging stations as described in the Subsection 6.2.1.
- *Evaporation*: The following monthly average evaporation gauged in Bontosunggu station from 1972 to 1997:

Evaporation for Runoff Simulation

(Unit: mm/day)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
4.3	4.2	4.7	5.1	4.9	4.7	5.1	6.1	6.9	6.7	5.6	4.9

6.3.2 Runoff Simulation Model

A runoff simulation was undertaken to generate long-term runoff discharge. The simulation was based on the "Tank Model Method", which has been widely practiced to simulate low flow discharge. The model physically expresses the actual runoff mechanism, which is in nature non-linear in relation to rainfall and has a function of rain infiltration into the surface or sub-surface soils.

A serial three-staged tank was applied for the Tank Model in this Study. The model structure and parameters are presented in Figure 6.5. The process of the simulation is in serial order from the upper to the middle and lower tanks as presented below:

(1) Upper Tank

Ss1(t)	= S11(t-1) + Fc x R (t-1) – Fe.Ev (t-1)	
Sql(t)	= Alf1 x [Ss1 (t) – Ha1]	: upper side outlet
Sq2(t)	= Alf2 x [Ss1 (t) – Ha2]	: lower side outlet
Sq3(t)	= Alf3 x Ss1 (t)	: bottom outlet
S11(t)	= Ss1(t) – [Sq1(t) + Sq2(t) + Sq3(t)]	

(2) Middle Tank

Ss2(t)	= S12(t-1) + Sq3 (t)	
Sq4(t)	= Bet1 x [Ss2 (t) – Hb]	: side outlet
Sq5(t)	= Bet2 x Ss2 (t)	: bottom outlet
S12(t)	= Ss2(t) – [Sq4(t) + Sq5(t)]	

(3) Lower Tank

Ss3(t)	= S13(t-1) + Sq5 (t)	
Sq6(t)	= Gam1 x [Ss3 (t) – Hg]	: side outlet
Sq7(t)	= Gam2 x Ss3 (t)	: bottom outlet
S13(t)	= Ss3(t) – [Sq6(t) + Sq7(t)]	

(4) Runoff Discharge

Q (t) = Aa x [Sq1(t) + Sq2(t) + Sq4(t) + Sq6 (t)] / 86.4

Where,

Aa	: Catchment area (km^2)
Sq1 – Sq6	: Runoff from side outlet or infiltration through bottom outlet (mm/day)
S11, S12, S13	: Storage depth of previous time in upper, middle and lower tanks (mm)
Ss1, Ss2, Ss3	: Total storage depth in upper, middle and lower tanks (mm)
Ha1, Ha2	: Height of upper and lower side outlets in upper tank (mm)
Hb	: Height of side outlet in middle tank (mm)
Hg	: Height of side outlet in lower tank (mm)
Alf1, Alf2, Alf3	: Multiplying constant of upper tank
Bet1, Bet2	: Multiplying constant of middle tank
Gam1, Gam2	: Multiplying constant of lower tank

Fc	:	Effective rainfall ratio
Fe	:	Evaporation factor
Ev	:	Evaporation (mm/day)
R	:	Rainfall (mm/day).

6.3.3 Estimated Long-term Runoff Discharge

Based on the runoff simulation, the annual average rainfall, runoff depth and runoff ratios for a 30-year period from 1972 to 2001 are estimated as below (refer to Table 6.6):

Average Annual Rainfall Depth, Runoff Depth and Runoff Ratio

Item	Upper Reaches of Bili-Bili Dam ($384.4\ km^2$)	Jenelata River Basin ($226.3\ km^2$)
Rainfall Depth	4,200 mm	4,400 mm
Runoff Depth	2,900 mm	2,500 mm
Runoff Ratio	0.68	0.57

As estimated above, the annual runoff depth from the upper reaches of Bili-Bili Dam is about 2,900 mm or 1,100 million m^3 (= 2,900 mm x 384.4 km^2), which is equivalent to almost three times the effective storage capacity of Bili-Bili Dam. Adding the annual runoff of 570 million m^3 from Jenelata River Basin (= 2,500 mm x 226.3 km^2) to the runoff from the upper reaches of Bili-Bili Dam, the effective water resources of Jeneberang river basin are estimated at about 1,670 million m^3.

The long-term discharge runoff from the upper reaches of Bili-Bili dam reservoir (Bili-Bili inflow) and Jenelata River from 1972 to 2001 is further estimated as shown in Figures 6.6 to 6.8. The minimum mean monthly discharges are extracted from the results of estimation as below:

Monthly and Annual Discharge

(Unit m^3/s)

Month	Discharge at	
	Bili-Bili Inflow	Jenelata
Jan.	93.8	43.3
Feb.	85.5	43.1
Mar.	60.2	30.2
Apr.	39.4	23.2
May.	19.1	11.3
Jun.	11.5	7.4
Jul.	7.7	3.9
Aug.	3.8	1.8
Sep.	4.5	1.9
Oct.	7.4	3.1
Nov.	23.6	12.4
Dec.	64.9	33.9
Ave.	35.1	18.0

The average flow regime of Bili-Bili inflow and the discharge of Jenelata station are further described below:

Average Flow Regime

Item	Bili-Bili Inflow	Jenelata
95-day discharge	47.5 m^3/s	26.3 m^3/s,
185-day discharge	14.7 m^3/s	8.0 m^3/s,
275-day discharge	4.8 m^3/s	2.2 m^3/s
355-day discharge	2.3 m^3/s	0.8 m^3/s

6.4 Water Balance Simulation

The simulation was made to clarify the balance between the available water supply volume from and the water demand to the source of Jeneberang River. The available water supply is classified into: (a) the regulated outflow discharge from Bili-Bili dam reservoir, (b) the non-regulated runoff discharge from Jenelata River, and (c) the non-regulated runoff discharge from other residual areas. Among others, the regulated outflow discharge of item (a) is estimated from the aforesaid simulated long-term inflow discharge to Bili-Bili dam reservoir and the flow regulation effect by the dam reservoir. On the other hand, the long-term runoff discharge from Jenelata river basin could be directly assumed as the value of item (b). For the runoff discharge from other residual area (item (c)), this was assumed to be the average of the simulated runoff discharge from the upper reaches of Bili-Bili dam (item (a)) and from Jenelata river basin (item (b)).

The water demand to the source of Jeneberang River includes the municipal water demand, irrigation water demand, private factory water demand and the requirement for river maintenance flow. The water balance simulation was made on the premise of present and future incremental water demands. The future water demand is assumed on the premise of the increment of only municipal water demand. Details of these water requirements are as described in Subsection 6.4.2.

6.4.1 Water Demand

The water demand is classified into irrigation water demand, municipal water demand, and others. The details of each of these demands are described below:

(1) Irrigation Water Demand

The water demand for irrigation use is exclusively for three irrigation schemes of Bili-Bili, Bissua and Kampili, which are being developed under the on-going Bili-Bili Irrigation Project (refer to Chapter 4). The demand could be expressed as the “Net Field Requirement” and was estimated by the following formula:

(Net Field Requirement) = (Crop Requirement) – (Effective Rainfall for Cropping)

The diversion requirement from the river for the above Net Field Requirement is further estimated by the following formula:

(Diversion Requirement) = (Net Field Requirement) x (Irrigation Efficiency)
(Irrigation Efficiency) = 1 / (L1 x L2 x L3)

where:

L1: Irrigation loss of main irrigation canal (assumed at 0.90)
L2: Irrigation loss of secondary irrigation canal (assumed at 0.90)
L2: Irrigation loss of tertiary irrigation canal (assumed at 0.85)

As presented above, the irrigation water demand varies year by year depending on the effective rainfall of each year. In this connection, the half-month water demand in each of the 26 years from 1972 to 1997 had been estimated by the Bili-Bili Irrigation Project on the basis of 100% cropping intensity for both wet and dry season paddy and 40% for palawija (refer to “Design Note on Bili-Bili Irrigation Project”). In addition to the estimated value, the water demands in each of four years from 1998 to 2001 were further estimated in this Study on the same basis.

In the above estimation, the effective rainfall was assumed as 70 % of the half-month rainfalls. The half-month rainfalls from 1972 to 2001 were calculated as the average of the gauged data at seven gauging stations as mentioned in Sub-section 6.2.1 (i.e., Kampili, Bontosunggu, Mandalle, Kalabajeng, Bontosallang, Barembeng and Sandrobone) (refer to Table 6.7).

Based on the results of the estimation, the water requirement to Jeneberang River for each year from 1972 to 2001 was estimated as shown in Figure 6.9 and summarized as listed below:

Average Monthly Crop Requirement and Net Field Requirement

Month	Crop Requirement		Net Field Requirement	
	liter/s/ha	10^6m^3	liter/s/ha	10^6m^3
Jan	0.96	61.28	0.13	8.22
Feb	0.94	55.89	0.15	8.88
Mar	0.81	51.66	0.19	12.06
Apr	0.81	49.89	0.35	21.47
May	1.03	65.27	0.80	50.76
Jun	0.94	57.76	0.84	51.44
Jul	0.78	49.67	0.71	44.75
Aug	0.39	24.37	0.34	21.45
Sep	0.20	12.56	0.17	10.38
Oct	0.20	12.51	0.14	8.86
Nov	0.12	7.27	0.02	1.36
Dec	0.49	31.33	0.05	3.20
Annual		479.45		242.83

As listed above, the crop requirement shows two peaks in January and May. The peak in January is, however, in a rainy season and could be substantially covered by the effective rainfall. On the other hand, the other peak in May is in the dry season and, therefore, most of the water requirement needs to be supplied from Jeneberang River. As a result, the peak net field requirement occurs in May to June.

(2) Municipal Water Demand

The following present and future municipal water demands to Jeneberang River are estimated through clarification and assumptions in items (a) and (b) outlined below (refer to Table 6.8).

Present and Future Municipal Water to the Source of Jeneberang River

Year	Wet Season m^3/s	Dry Season m^3/s	Annual 10^6m^3/year
Present (2004)	1.66	2.16	60.3
2018	4.02	4.52	134.8
2019	4.23	4.73	141.2
2020	4.43	4.93	147.6

(a) Present Water Demand

The actual outputs of the existing water treatment plants (WTP) for Jeneberang River in year 2003 were clarified in Chapter 5, and were assumed as the present potential municipal water demand. The actual water demand to Jeneberang River was further estimated on the premise of the following conveyance losses from the river to WTPs: 10 % for Somba Opu and Borong Loe WTP and 5 % for other existing WTPs.

(b) Future Water Demand

The future municipal water demand for PDAM Makassar was clarified in Chapter 5 and was assumed as the future water demand to the source of Jeneberang. In addition, the future water demand for PDAM Gowa was estimated as part of the future municipal water demand with reference to the projection in "Consulting Engineering Services for Comprehensive Water Management Plan Study for Maros-Jeneponto River Basin, Nov. 2001".

The treatment capacity of WTP was further assumed to increase to meet the future incremental water demand on the premise of the following conditions:

(a) All existing WTPs would recover to their designed full treatment capacity levels.
(b) The water requirement of Somba Opu WTP would increase from 1.1 m^3/s to 3.3 m^3/s[1], which corresponds to the present capacity of the raw water transmission line from Bili-Bili dam reservoir to the WTP;
(c) New WTPs would be constructed to meet part of the future incremental water demand, which could not be covered by the above two items.

(3) Other Water Demand

The following water demands are regarded as customary water use rights to be promised by supply from Bili-Bili dam reservoir and incorporated into the water supply-demand simulation:

(a) 0.5 m^3/s for water demand of Sugar Factory in Takalar District (refer to Chapter 5); and
(b) 1.0 m^3/s for river maintenance flow along the downstream reaches of Jeneberang River below Sungguminasa Bridge (as programmed under the present reservoir operation rule of Bili-Bili Dam).

[1] Alternatively, water will be partly sent to Panaikang WTP, being branched off from water transmission main

6.4.2 Result of Water Supply-Demand Balance Simulation

The results of the water balance simulation for the present water demand are as shown in Table 6.9 and Figure 6.10. As shown in this Table and Figure, among the simulated 30-year period from 1972 to 2001, three years in 1972, 1982 and 1997 are identified as drought years. During these years Bili-Bili dam reservoir dropped to its Lowest Water Level (EL. 65.0 m) with no available water supply capacity to meet the present water demand. Thus, the drought years could occur with a frequency of once every ten years (= 3 years as an identified drought year divided by 30 years of the simulation period). It was therefore concluded that the present supply capacity of Bili-Bili dam could satisfy present water demand against a 10-year drought.

The water balance simulation was further made on the premise of the future incremental municipal water demand. Based on the results of the simulation, the following years were identified as droughts years (i.e., when Bili-Bili dam reservoir could not satisfy the allocated water demand):

Drought Years against Water Demand
(in Consideration of Growth of Municipal Demand)

Year of Demand Projection	Drought year	Number of Drought Years	Frequency of Drought Years
Present (2003)	1972, 82, 97	3/30	1/10 years
2018	1972, 76, 82, 87, 92, 97	6/30	1/5 years
2019	1972, 76, 82, 83, 87, 91, 92, 97	8/30	1/3.8 years
2020	1972, 76, 82, 83, 87, 91, 92, 97	8/30	1/3.8 years

As estimated above, the frequency of occurrence of drought year would increase from 1 in 10 years at present to 1 in 5 years in 2018 and 1 in 3.8 years in 2019.

The irrigation water demand takes a dominant share of the whole water demand and, therefore, is a decisive factor in the failure to meet demands during drought years. The typical influence of irrigation water demand on occurrence of drought is seen in a three-month period from April to June. The three-month period is regarded as the critical duration such that the period is at the beginning of the dry season and, at the same time, the crop water requirements start to increase significantly during this period. The drought years tend to occur when the rainfall during this critical period is far less than those in ‘normal’ years as below (refer to Table 6.10):

(a) The drought years of 1972, 1982 and 1997 received rainfall of less than 110mm during the critical three-month period, which is far less than the average of 273 mm from 1972 to 2001 during those same months;

(b) On the other hand, the years of 1985, 1990 and 1993 received an annual rainfall of less than 2,000m, which is rather small value when compared to the average of 2,434 mm from 1972 to 2001. However, these years received a relatively large rainfall during the critical three-month period from April to June, and therefore did not cause droughts.

The year of 1976 is identified as the marginal non-drought year, during which full supply of the net field requirement of 381.70m^3/year is just met by the supply capacity of Bili-Bili dam reservoir on the premise that the dam reservoir also needs to meet the full supply for municipal water and other all allocated water demands. Accordingly, the following diversion requirement for irrigation use in 1976 could be regarded as the marginal limit to be met by the supply capacity of Bili-Bili dam. This marginal limit of 381.70 million m^3 corresponds to about 1.6 times the average net field requirement from 1972 to 1983 (i.e., 242.83 million m^3).

Diversion Requirement for Irrigation in the Standard Drought Year of 1976

Month	Bili-Bili Irrigation Scheme	Bissua Irrigation Scheme	Kampili Irrigation Scheme	Total
Jan	2.35	10.72	10.49	23.56
Feb	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00
Apr	5.71	26.11	25.53	57.36
May	7.92	36.17	35.37	79.46
Jun	7.64	34.94	34.16	76.74
Jul	7.21	32.93	32.20	72.33
Aug	3.64	16.63	16.26	36.53
Sep	1.96	8.95	8.75	19.66
Oct	1.22	5.56	5.43	12.21
Nov	0.00	0.00	0.00	0.00
Dec	0.38	1.76	1.72	3.86
Annual	38.03	173.77	169.91	381.70

6.5 Improvement Plan of Hydrological Gauging Network

The improvement plan for the hydrological gauging network was initially proposed to facilitate river basin management, including low flow and flood management as described in the following subsections.

6.5.1 Proposed Telemetry Rainfall Gauging Network

JRBDP currently gauge rainfall on a real-time basis through seven telemetry rainfall gauging station in order to facilitate effective gate operations for Bili-Bili dam, the rubber dam and other various river structures. Dinas PSDA also gauges daily rainfall through information from gauge keepers assigned to twenty non-telemetry gauging stations in order to facilitate the water management for irrigation. Moreover, BMG has six climatic gauging stations in Jeneberang river basin, of which five are now operational with one being temporarily suspended due to trouble with gauging equipment. Thus, there exist 33 rainfall-gauging stations in Jeneberang river basin, but locations are mostly biased to the lower reaches below Bili-Bili dam, as shown in Figure 6.11.

Among these, the telemetry gauging stations in particular are useful for real-time flood management as well as for low flow management. The density of the telemetry-gauging stations is 109km^2/station (=seven stations/catchment area of 762km^2), which satisfies the minimum density of 100 to 250 km^2/station recommended by the World Meteorological Organization (WMO).

However, there are some hydrological blind areas in Jeneberang river basin, and telemetry gauging stations are provisionally proposed to remove these areas (refer to Figure 6.12).

(a) Upper most area of Jeneberang River: The existing two non-telemetry gauging stations at Tanralili and Bungabaji operated by Dinas PSDA should be provided with telemetry equipment. Another new telemetry gauging station is also proposed at Lengkese, which is located just downstream of the huge sediment deposit produced from the collapse of Mt. Bawakaraeng.
(b) Upper reaches of Jene Rakikang River: One new gauging station is proposed at Patuku Village.
(c) Upstream of Jeneberang River between Bili-Bili dam reservoir and the existing Jonggoa station; Telemetry rainfall equipment should be installed at the existing telemetry water level gauging station at Bonto Jai.
(d) Upstream of Binanga Tokka; One new gauging station is proposed at Parang-Parang.

An open space with a diameter of around 10m should preferably be selected as being suitable as a rainfall gauging site. It will also be necessary to avoid narrow passes in topography, where the deviations in wind direction and velocity would cause difficulties in accurately gauging the rainfall. It is also necessary to consider accessibility of the gauging site and to avoid the risk of flood inundation.

6.5.2 Proposed Telemetry Water Level Gauging Network

JRBDP currently gauge the water level of Jeneberang River as well as its tributaries on a real-time base through seven water level gauging stations. The gauged data are useful for low flow and flood management including the gate operations of Bili-Bili dam and other various river structures.

The present water level gauging stations are well distributed to observe all critical river flow discharges. The gauging station at Bonto Jai on the mainstream of Jeneberang, in particular, is important to observe the inflow discharge into Bili-Bili dam reservoir. The Jenelata Station installed at the Patarikan Bridge is also important to observe the natural flow discharge from Jenelata River. Accordingly, it would not be necessary to expand the existing telemetry gauging network.

However, Bayang water level gauging station at the estuary of Jeneberang River has been not operational, as the gauging equipment was stolen in 2002. This gauging station is useful to observe the salinity intrusion into the river, and therefore, it is important to resume gauging operations at the earliest opportunity.

Relocation of the gauging site would be also required for Bonto Jai water level gauging station. The present location of the gauging station is just downstream of the existing Sand Pocket No.1, where stable river flow is unlikely and the riverbed tends to fluctuate readily. From these viewpoints, it is preferable to transfer the location of this gauging site to a location above the sand pocket dam, where the flow channel is fixed and more accurate flow discharge could be estimated from the gauged water level.

In addition to the necessary rehabilitation and relocation of the existing telemetry gauging stations discussed above, another crucial issue is the renewal of H-Q rating curves derived for the existing water level gauging stations.

Among the existing seven water level gauging stations, four stations, namely Jonggoa, Bonto Jai, Kampili and Jenelata station have H-Q rating curves. However, these have never been updated after their original development in 1999. The riverbeds tend to fluctuate particularly after a flood, which seriously affects the accuracy of the rating curves. In fact, extensive riverbed fluctuation has been confirmed after the collapse of Mt. Bawakaraeng in March 2004, and it is indispensable that existing H-Q rating curves be updated at the same time. This should also be followed on an ongoing basis by the establishment of a new system of rating curves at the end of the every rainy season and/or immediately after the occurrence of large floods.

Table 6.1 Climetological and Rainfall station Collected Data in this Study

	Station Name	Location		Year Installed	Type	Administration	Purpose	Remarks
		Longitude (E)	Latitude (S)					
-	Kalabajen	119 26'00"	5 19'00"	1975	Mnual	Dinas	*1	
-	Mandalle/Patarungan	119 24'00"	5 18'00"	1975	Mnual	Dinas	*1	
-	Sandro Bone	119 22'00"	5 26'00"	1975	Mnual	Dinas	*1	
-	Bontosunggu	119 25'30"	5 16'44"	1977	Automatic	Dinas	*1	Climetological Station
-	Bonto Sallang	119 24'51"	5 19'51"	1975	Mnual	Dinas	*1	
-	Barembeng	119 24'36"	5 20'01"	1975	Mnual	Dinas	*1	
**	Malino	119 51'14.6"	5 15'11.5"	1971	Mnual	Dinas	*2	
**	Malino	119 51'12"	5 15'10"	1998	Telemetring	JRDBP	*2	
**	Jonggoa	119 44'37"	5 16'26"	1998	Telemetring	JRDBP	*2	
**	Limbunga	119 44'05"	5 21'48"	1998	Telemetring	JRDBP	*2	
**	Mangempang	119 40'50"	5 20'07"	1998	Telemetring	JRDBP	*2	
**	Intake Bili-Bili	119 34'27"	5 17'20"	1975	Mnual	Dinas	*2	
**	Bili-Bili	119 35'08"	5 16'46"	1998	Telemetring	JRDBP	*2	
**	Kampili	119 30'40"	5 16'51"	1974	Manual	Dinas	*1, *2	
**	Kampili	119 34'02"	5 17'13"	1998	Telemetring	JRDBP	*1, *2	
**	Macini Sombala	119 24'50"	5 11'41"	1998	Telemetring	JRDBP	*2	

** : in the Jeneberang river basin
*1 : utilizede for calculation of Irrigation Water Requirement
*2 : utilizede for Runoff calculation by Tank model

Table 6.2 (1/5) Mean Monthly Rainfall (Malino)

Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1972	1624	566	273	221	63	0	0	0	0	0	352	342	3441
1973	532	315	491	311	292	88	243	110	241	26	730	591	3970
1974	375	700	1393	313	265	116	181	11	161	527	348	795	5185
1975	621	621	558	570	275	205	63	64	23	194	472	615	4281
1976	831	784	912	238	196	46	5	5	0	269	187	495	3968
1977	900	1476	663	475	195	324	0	17	0	0	241	684	4975
1978	765	655	378	371	236	237	282	111	154	156	446	987	4778
1979	771	589	821	287	278	134	26	0	4	70	170	671	3821
1980	969	1480	1075	868	488	129	32	12	0	252	610	1124	7039
1981	1026	678	417	498	267	184	253	3	231	46	744	1231	5578
1982	1114	690	818	954	190	111	1	0	2	2	113	419	4414
1983	684	552	274	606	542	332	60	18	1	49	613	207	3938
1984	830	770	694	794	474	220	68	48	232	218	314	1062	5724
1985	667	486	660	595	411	199	277	0	59	105	566	460	4485
1986	1453	415	262	416	68	113	174	42	1	134	298	436	3812
1987	1376	952	373	264	100	11	0	0	0	6	436	1327	4845
1988	677	1726	622	167	218	52	56	64	75	103	718	2005	6483
1989	2015	1234	702	1133	466	604	140	105	46	89	197	499	7230
1990	648	363	404	209	140	92	120	2	0	0	168	549	2695
1991	1207	584	135	525	86	27	12	3	0	6	343	450	3378
1992	579	374	328	252	94	103	94	11	46	108	86	269	2344
1993	1039	608	877	558	176	203	14	0	36	13	357	1104	4985
1994	575	378	583	373	249	11	3	8	0	66	172	439	2857
1995	948	475	619	643	169	429	62	7	41	120	986	1110	5609
1996	871	767	481	351	119	59	127	141	78	310	359	1638	5301
1997	1028	1244	937	473	23	20	68	0	0	0	0	433	4226
1998	338	276	474	284	138	142	249	54	124	210	413	677	3379
1999	786	829	483	202	0	0	0	7	1	169	448	873	3798 *
2000	616	636	567	424	224	390	80	35	3	215	379	816	4385 *
2001	677	702	410	267	89	219	8	2	0	268	361	1129	4132 *
2002	705	583	498	265	173	90	7	0	0	2	125	362	2810 *
2003	1005	727	420	132	79	40	23	41	17	80	-	-	- *
Ave.	883	726	581	439	212	154	85	29	49	119	379	768	4424

Note : 1972 - 1977 data were obtained from previous report.
* : obtained from telemetric system.

Table 6.2 (2/5)   Mean Monthly Rainfall (Intake Bili-Bili & Bili-Bili)

Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	
1972	1175	807	594	152	23	0	0	6	0	0	204	312	3273	
1973	505	135	407	699	193	30	168	26	371	126	772	733	4165	
1974	319	654	919	261	109	53	167	7	124	356	478	702	4149	
1975	416	565	481	737	151	25	213	16	91	52	616	593	3956	
1976	746	496	390	49	73	78	80	55	0	188	264	401	2820	
1977	1177	1527	374	442	36	81	0	24	0	0	258	540	4459	
1978	610	584	350	209	379	101	303	52	211	134	322	664	3919	
1979	877	676	538	249	134	122	0	0	7	0	239	745	3587	
1980	754	703	369	325	70	0	0	15	0	13	384	790	3423	
1981	587	390	276	262	104	88	144	0	162	121	360	824	3318	
1982	566	530	374	328	117	0	0	12	0	0	34	624	2585	
1983	245	160	265	441	184	66	87	0	28	114	445	693	2728	
1984	633	620	612	517	312	91	0	0	144	148	254	557	3888	
1985	315	404	477	405	105	106	70	0	0	102	407	353	2744	
1986	1488	275	350	189	74	58	350	0	0	170	293	479	3726	
1987	1339	384	434	157	57	0	0	0	0	0	109	1272	3752	
1988	278	757	418	218	159	40	0	42	182	129	404	442	3069	
1989	735	460	596	545	78	174	148	53	38	174	208	273	3482	
1990	679	352	257	267	319	0	0	0	0	44	119	648	2685	
1991	760	206	208	415	24	0	0	0	0	0	828	803	3244	
1992	482	422	410	17	41	7	0	0	214	114	490	318	2515	
1993	582	442	336	382	1003	408	9	0	13	45	329	818	4367	**
1994	733	523	1205	260	27	15	0	3	0	25	6	380	3177	
1995	975	477	473	381	220	217	43	0	32	86	405	642	3951	
1996	596	872	328	281	24	26	34	59	66	133	526	1166	4111	
1997	435	723	223	71	22	1	24	0	0	39	214	393	2145	
1998	188	148	406	817	221	158	41	96	23	108	714	471	3391	
1999	543	686	377	119	0	0	0	2	5	255	367	577	2931	*
2000	787	629	505	299	167	220	72	0	5	274	313	440	3711	*
2001	691	758	509	180	78	118	1	0	10	179	270	770	3564	*
2002	561	448	400	323	186	31	0	0	0	9	151	497	2606	*
2003	725	341	218	154	30	18	3	0	4	61	178	920	2652	*
Ave.	672	536	440	317	148	73	61	15	54	100	343	620	3378	

Note : 1972 - 1998 at Intake Bili-Bili station

* : 1999 - 2003 at Bili-Bili station of telemetric system.

Table 6.2 (3/5) Mean Monthly Rainfall (Kampili)

Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1972	935	494	383	69	15	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	94	203	327	452	-
1975	362	345	310	381	99	24	82	13	69	154	326	513	2678
1976	658	379	341	26	37	14	8	0	0	98	255	309	2125
1977	976	618	128	107	12	82	0	41	0	0	84	393	2441
1978	470	388	209	212	232	170	140	41	109	44	333	558	2906
1979	657	627	385	84	135	128	0	28	13	34	69	507	2667
1980	674	417	330	86	50	0	0	11	14	58	175	614	2429
1981	408	200	157	198	85	33	70	13	32	62	199	366	1823
1982	304	241	142	56	28	3	0	0	0	0	26	427	1227
1983	272	222	120	304	121	51	49	0	3	112	482	557	2293
1984	506	613	426	303	182	43	17	5	142	57	250	581	3125
1985	433	273	493	213	89	73	45	3	11	34	214	315	2196
1986	1018	355	513	143	101	151	11	0	33	348	215	311	3199
1987	1129	371	385	167	102	10	-	0	0	8	112	1379	-
1988	328	473	405	193	168	60	0	15	192	174	342	600	2950
1989	750	204	285	459	82	118	116	30	24	163	330	397	2958
1990	673	350	195	112	247	8	25	0	0	90	194	153	2047
1991	609	489	123	251	15	0	0	0	0	0	289	483	2259
1992	456	328	720	186	13	91	65	0	245	78	394	318	2894
1993	873	514	247	370	157	98	0	0	0	80	28	776	3143
1994	537	517	526	89	105	11	0	0	0	5	344	400	2534
1995	750	406	241	449	-	7	30	0	11	52	442	798	-
1996	483	617	237	184	0	0	0	25	0	40	97	974	2657
1997	427	638	127	98	56	5	0	0	11	9	75	270	1716
1998	60	168	380	1129	196	100	100	90	50	498	813	514	4098
1999	-	-	286	127	0	0	0	0	0	122	271	501	1307 *
2000	571	651	355	183	81	95	53	4	0	0	192	410	2595 *
2001	618	900	468	151	33	76	0	0	0	119	284	817	3466 *
2002	617	441	436	168	102	42	1	0	0	0	128	139	2074 *
2003	901	406	155	121	61	25	1	0	21	87	228	802	2808 *
Ave.	602	436	317	221	90	52	29	11	36	91	251	521	2656

* : 1999 - 2003 Kampili station of telemetric system

Table 6.2 (4/5) Mean Monthly Rainfall

Station : Jonggoa Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1999	1019	356	521	138	0	0	0	3	5	224	360	768	3394
2000	805	398	484	281	139	295	27	40	3	351	537	496	3856
2001	702	902	440	464	34	131	33	4	3	204	213	488	3618
2002	464	122	0	0	0	82	1	0	0	1	388	506	1564
2003	978	640	484	104	76	23	12	65	16	78	233	1128	3837
Ave.	794	484	386	197	50	106	15	22	5	172	346	677	3254

Station : Maccini Sombala Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1999	1178	432	318	73	0	0	0	0	7	112	185	521	2826
2000	510	735	242	226	38	61	12	2	21	75	293	403	2618
2001	801	729	430	122	50	87	0	0	27	42	244	898	3430
2002	748	473	396	125	49	57	4	0	0	0	112	409	2373
2003	749	436	89	112	72	13	4	0	9	43	84	703	2314
Ave.	797	561	295	132	42	44	4	0	13	54	184	587	2712

Station : Limbunga Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1999	648	412	492	176	0	0	0	3	49	291	242	682	2995
2000	673	690	590	349	133	232	137	30	6	196	108	548	3692
2001	729	956	366	365	73	109	77	4	8	217	367	841	4112
2002	704	512	347	275	103	79	11	0	0	0	180	534	2745
2003	878	439	244	195	187	21	13	6	43	114	216	1038	3394
Ave.	726	602	408	272	99	88	48	9	21	164	223	729	3388

Station : Mangempang Unit : mm

	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	919	632	577	117	0	0	0	5	29	275	588	662	3804
2000	772	784	452	313	180	319	156	4	14	227	647	488	4356
2001	965	1147	503	369	78	21	0	3	19	238	643	1483	5469
2002	1210	887	499	553	342	137	14	0	0	7	374	1101	5124
2003	1421	819	525	296	187	34	21	7	98	239	477	1749	5873
Ave.	1057	854	511	330	157	102	38	4	32	197	546	1097	4925

Table 6.2 (5/5) Mean Monthly Rainfall (Bontosunggu)

Unit : mm

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1978	408	482	220	168	356	78	97	19	49	12	161	626	2675
1979	805	407	313	90	100	136	0	0	2	5	147	538	2539
1980	643	524	316	159	32	12	0	0	16	19	111	736	2567
1981	601	329	138	36	41	35	109	0	16	6	406	-	-
1982	604	463	374	69	55	0	0	0	0	0	0	159	1723
1983	126	46	25	170	55	18	0	0	0	31	415	548	1433
1984	638	599	347	180	150	9	26	0	120	52	145	518	2784
1985	452	287	470	256	109	27	28	5	106	18	207	56	2020
1986	866	184	364	170	31	27	46	3	3	85	164	152	2094
1987	975	388	495	59	63	0	0	0	6	0	66	1181	3232
1988	480	769	201	184	222	18	15	14	94	186	528	741	3452
1989	760	756	285	277	87	57	11	12	17	24	181	140	2606
1990	355	145	155	29	214	0	2	4	0	53	92	335	1384
1991	726	460	43	211	11	0	5	0	0	8	60	215	1739
1992	375	241	423	153	13	71	24	15	72	20	114	317	1837
1993	450	357	227	166	41	25	0	-	-	34	202	782	-
1994	704	364	497	143	16	10	0	0	0	12	217	232	2193
1995	772	546	408	333	111	74	11	0	19	37	412	584	3305
1996	787	782	236	115	0	11	12	0	15	59	317	1398	3731
1997	410	848	230	214	13	0	12	0	0	0	21	274	2021
1998	155	53	196	253	64	45	147	74	0	0	0	0	986
1999	2791	32	94	36	29	24	18	-	-	1190	741	630	-
2000	819	244	542	0	322	432	16	0	0	219	211	521	3326
2001	543	810	202	25	35	39	0	0	3	0	94	682	2433
2002	472	147	33	12	62	27	5	0	14	0	54	205	1031
Ave.	669	410	273	140	89	47	23	6	24	83	203	482	2449

Table 6.3 Thiessen Ratio and Basin mean Rainfall

Pattarn	Station name	Area (km^2)	Thiessen Ratio
1	Malino	200.26	0.263
	Jonggoa	128.25	0.168
	Bili-Bili	81.45	0.107
	Kampili	65.74	0.086
	Macini Sombala	66.18	0.087
	Limbunga	116.92	0.153
	Mangempang	103.19	0.135
2	Malino	377.03	0.495
	Bili-Bili	384.96	0.505
3	Malino	380.98	0.500
	Bili-Bili	249.12	0.327
	Kampili	131.90	0.173
4	Malino	200.26	0.263
	Jonggoa	128.26	0.168
	Bili-Bili	120.47	0.158
	Macini Sombala	92.91	0.122
	Limbunga	116.91	0.153
	Mangempang	103.19	0.135
5	Jonggoa	328.20	0.431
	Bili-Bili	81.46	0.107
	Kampili	65.74	0.086
	Macini Sombala	66.18	0.087
	Limbunga	117.18	0.154
	Mangempang	103.24	0.135
6	Bili-Bili	630.10	0.827
	Kampili	131.90	0.173

C.A. = 762.0 km^2

Unit : mm

Year	Malino	Jonggoa	Bili-Bili	Kampili	Macini Sombala	Limbunga	Mangempang	Basin Mean
1972	3441	-	3273	-	-	-	-	3356
1973	3970	-	4165	-	-	-	-	4069
1974	5185	-	4149	-	-	-	-	4662
1975	4281	-	3956	2678	-	-	-	3897
1976	3968	-	2820	2125	-	-	-	3274
1977	4975	-	4459	2441	-	-	-	4368
1978	4778	-	3919	2906	-	-	-	4173
1979	3821	-	3587	2667	-	-	-	3545
1980	7039	-	3423	2429	-	-	-	5059
1981	5578	-	3318	1823	-	-	-	4189
1982	4414	-	2585	1227	-	-	-	3264
1983	3938	-	2728	2293	-	-	-	3258
1984	5724	-	3888	3125	-	-	-	4674
1985	4485	-	2744	2196	-	-	-	3520
1986	3812	-	3726	3199	-	-	-	3678
1987	4845	-	3752	-	-	-	-	4293
1988	6483	-	3069	2950	-	-	-	4755
1989	7230	-	3482	2958	-	-	-	5265
1990	2695	-	2685	2047	-	-	-	2580
1991	3378	-	3244	2259	-	-	-	3140
1992	2344	-	2515	2894	-	-	-	2495
1993	4985	-	4367	3143	-	-	-	4464
1994	2857	-	3177	2534	-	-	-	3066
1995	5609	-	3951	-	-	-	-	4771
1996	5301	-	4111	2657	-	-	-	4454
1997	4226	-	2145	1716	-	-	-	3111
1998	3379	-	3391	4098	-	-	-	3507
1999	3798	3394	2931	1307	2826	2995	3804	3352
2000	4385	3856	3711	2595	2618	3692	4356	3806
2001	4132	3618	3564	3466	3430	4112	5469	4044
2002	2810	1564	2606	2074	2373	2745	5124	2780
2003	-	3837	2652	2808	2314	3394	5873	3697

Table 6.4 Maximum One-day Rainfall

Unit : mm

Year	Malino	Bili-Bili	Year	Malino	Bili-Bili	Year	Malino	Bili-Bili
1923	-	97	1950	-	-	1977	208	235
1924	-	98	1951	-	-	1978	168	148
1925	-	235	1952	-	-	1979	131	211
1926	-	113	1953	225	157	1980	138	108
1927	-	143	1954	225	102	1981	135	118
1928	-	113	1955	-	182	1982	135	147
1929	-	182	1956	193	145	1983	130	206
1930	-	152	1957	-	143	1984	190	129
1931	117	125	1958	-	143	1985	143	131
1932	115	217	1959	150	200	1986	200	215
1933	202	156	1960	235	-	1987	133	296
1934	150	210	1961	201	-	1988	275	155
1935	252	210	1962	169	-	1989	221	118
1936	118	97	1963	119	-	1990	86	169
1937	154	139	1964	-	-	1991	160	170
1938	225	165	1965	200	-	1992	99	143
1939	181	138	1966	111	147	1993	246	198
1940	143	117	1967	190	172	1994	71	193
1941	216	-	1968	127	87	1995	177	140
1942	-	-	1969	88	213	1996	108	178
1943	-	-	1970	130	131	1997	160	121
1944	-	-	1971	150	151	1998	101	138
1945	-	-	1972	205	249	1999	185	200
1946	-	-	1973	105	271	2000	237	183
1947	-	-	1974	294	194	2001	130	167
1948	-	-	1975	86	264	2002	134	213
1949	-	-	1976	134	160	2003	161	116

Source : 1931 - 1977 Malino and 1923 - 1971 Bili-Bili data are obtained from Supporting Report on Detailed Design of Bili-Bili Multipurpose Dam Project
Others are newly collected

Table 6.5 Rating Curve of Water Level Gauging Station

Station Name	Rating Curve	The Date of Creation	Update	Formula	Remarks
Jonggoa	○	1999	×	$Q=12.295(h-0.1826)^2$	No check for high flows*
Bont Jai	○	1999	×	$Q=475.22h^3-3961h^2+11046h-10272$	
Bili-Bili	×	—	—	—	dam reservoir
Kampili	○	1999	×	$Q=205.5(h+0.1451)^2$	
Maccini Sombala	×	—	—	—	
Bayang	×	—	—	—	Equipment were stallen in 2002 Now Interrupting
Jenelata	○	1999	×	$Q=82.93(h-0.614)^2$	2002.1 Flushed out 2004.2 Reconstruction

* : The water level gauge was not functioning during the peak flood period

Source : JRBDP information

Table 6.6 Railfall and Runoff Depth at each Station

Bili-Bili Dam Site

C.A. = 384.4 km^2

Hydrological Year (Jun.-May)	Rainfall (mm)	Runoff Depth (mm)	Ratio (%)	loss
1972	2594	1806 *	70	788
1973	4782	4034	84	747
1974	4511	3677	82	834
1975	3979	2952	74	1027
1976	4669	3733	80	936
1977	3353	2568	77	785
1978	4916	3405 *	69	1510
1979	5334	4260 *	80	1073
1980	4518	3185 *	70	1333
1981	5784	3554 *	61	2230
1982	2988	833 *	28	2155
1983	4672	3339 *	71	1333
1984	4488	2540 *	57	1947
1985	4075	2610 *	64	1465
1986	4134	2761 *	67	1374
1987	4721	2834 *	60	1887
1988	7445	3288 *	44	4156
1989	3325	2052 *	62	1273
1990	3220	3299 *	102	-78
1991	2595	1366 *	53	1229
1992	3932	2726	69	1205
1993	4128	3054	74	1074
1994	3254	2315	71	939
1995	4435	3248	73	1187
1996	4951	3607	73	1344
1997	2241	1344	60	897
1998	3971	2683	68	1289
1999	3768	2609	69	1159
2000	4130	2947	71	1183
Ave.	4169	2849	68	

Jenelata Station

C.A. = 226.3 km^2

Hydrological Year (Jun.-May)	Rainfall (mm)	Runoff Depth (mm)	Ratio (%)	loss
1972	2635	1174	45	1461
1973	5075	2861	56	2214
1974	4784	2482	52	2302
1975	4597	2371	52	2226
1976	4716	2695	57	2021
1977	3671	1893	52	1778
1978	5119	2630	51	2489
1979	5955	3589	60	2366
1980	5045	2870	57	2175
1981	6458	3773	58	2685
1982	3306	1645	50	1661
1983	4842	2604	54	2238
1984	4981	2573	52	2408
1985	4280	2327	54	1953
1986	4263	2152	50	2111
1987	5190	3189	61	2001
1988	8623	5488	64	3135
1989	3444	1759	51	1685
1990	2800	2489 *	89	311
1991	2810	1524 *	54	1287
1992	3919	1986 *	51	1934
1993	4195	2702 *	64	1493
1994	3170	1985 *	63	1186
1995	4181	2403 *	57	1778
1996	4541	2108 *	46	2432
1997	2300	1142 *	50	1157
1998	3636	2254	62	1382
1999	3817	2450	64	1367
2000	4144	2796	67	1348
Ave.	4362	2480	57	

Note : * the figures are obtained from the discharge converted from gaugied water level

Table 6.7 Half Monthly Rainfall in the Irrigation Area for Calcuration of Net Field Requirement (NFR)

Average Rainfall for seven (7) Stations

(Kampili, Bontosunggu, Mandalle, Kalabajeng, Bontosallang, Barembeng, Sandro Bone)

Unit : mm

Year	Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sept.		Oct.		Nov.		Dec.		Total
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	
1972	784	38	106	328	216	120	0	61	13	0	0	0	0	0	0	4	0	0	0	0	24	106	78	120	1,998
1973	109	212	76	10	170	89	228	217	72	51	16	3	107	0	10	7	60	176	48	32	111	380	68	398	2,647
1974	192	11	219	196	402	182	126	40	22	47	8	26	27	79	0	4	78	4	137	41	71	216	183	214	2,528
1975	163	156	193	111	178	94	38	285	48	24	41	3	4	53	16	2	62	41	64	147	94	249	421	215	2,698
1976	592	101	226	192	202	250	33	10	55	2	17	17	8	0	0	0	0	0	5	47	105	154	277	147	2,438
1977	366	618	475	577	112	155	133	2	24	15	63	12	0	0	11	0	0	3	0	0	3	97	157	156	2,979
1978	274	198	289	194	95	174	136	43	132	130	48	37	87	9	7	14	43	10	32	8	72	105	159	477	2,774
1979	651	180	237	261	288	56	21	44	87	28	109	3	1	0	5	0	2	2	1	7	33	61	410	129	2,618
1980	365	306	294	192	198	117	86	86	16	11	0	9	1	0	2	0	0	5	4	11	40	44	358	306	2,451
1981	297	298	207	130	47	123	64	33	59	19	2	25	113	14	1	4	13	1	15	10	77	316	393	281	2,543
1982	287	313	412	53	205	137	12	52	34	1	12	0	0	0	0	0	0	0	0	0	1	4	14	185	1,721
1983	165	72	65	36	8	70	85	101	65	4	10	13	10	8	0	0	0	1	19	54	56	361	149	349	1,698
1984	201	389	339	179	189	56	76	70	114	33	7	6	0	13	0	1	55	8	30	30	40	132	186	381	2,536
1985	162	276	164	183	435	10	120	47	70	27	29	0	12	18	0	5	0	35	2	24	54	112	80	98	1,961
1986	534	308	186	155	170	144	109	21	29	1	42	9	8	14	0	0	0	7	52	39	72	115	101	121	2,237
1987	376	566	207	121	82	250	75	9	72	1	2	0	0	0	0	0	0	1	0	5	37	33	290	913	3,040
1988	122	236	682	146	74	274	128	16	103	44	10	6	2	3	11	10	48	35	59	71	150	201	389	204	3,025
1989	57	627	282	278	297	23	84	221	59	4	31	47	15	32	0	9	3	23	41	83	103	94	199	59	2,671
1990	373	299	176	91	172	17	35	31	62	114	7	0	4	3	0	1	0	2	0	50	65	56	80	315	1,953
1991	205	534	244	127	30	76	56	121	0	4	0	1	1	0	0	0	0	0	0	1	25	49	236	48	1,760
1992	258	79	88	94	265	188	86	19	8	3	26	17	26	0	10	1	52	39	9	17	34	111	154	172	1,755
1993	75	346	178	173	86	90	136	42	59	19	28	6	0	0	0	0	0	0	17	5	20	58	147	501	1,987
1994	205	497	175	132	288	210	40	59	36	0	0	11	0	0	0	0	0	0	4	10	41	99	124	127	2,057
1995	305	289	216	190	266	106	285	23	68	12	32	17	8	0	0	0	2	8	5	19	66	177	433	122	2,649
1996	172	432	641	210	104	181	42	38	20	3	8	7	2	2	4	0	4	2	51	24	125	74	470	476	3,092
1997	290	183	209	412	130	5	48	35	12	4	0	1	5	0	0	0	0	2	2	0	0	27	72	172	1,609
1998	65	19	56	11	5	211	226	95	105	57	36	75	32	118	26	30	2	57	45	124	263	204	241	430	2,532
1999	716	583	270	270	183	109	61	113	61	1	2	19	15	0	0	0	0	0	132	95	178	89	290	233	3,419
2000	233	441	453	188	141	231	110	92	36	46	85	46	12	5	1	0	0	0	8	60	12	190	258	121	2,766
2001	498	148	715	101	283	121	47	22	8	10	51	6	0	0	0	0	1	1	3	20	76	112	466	193	2,882
Mean	303	292	269	178	177	129	91	68	52	24	24	14	17	12	3	3	14	15	26	34	68	134	229	255	2,434

Note : Jan.-May 1972, Sep.74-Mar.75 : R(Project Area) = 0.879xR(Kampili)
Jun.1972-Aug.74 : R(Project Area) = 0.879x(0.723xR(Bili Bili))

Source : 1972 - 1997 obteined from Supporting Report for Detaile Design on Bili-Bili Irrigation Project in Dec.1999
: 1998 - 2001 Newly Collecting from Balai PSDA Jeneberang

Missing data :

Sandro Bone	Jan. and Feb. 1998
Kampili	Jan. and Feb. 1999
Bontosunggu	Aug. and Sep. 1999
Bontosallang	Jan. - Mar. 2000
Mandalle	Feb. 2000

Table 6.8 (1/2) Projected Municipal Water Demand and Diversion Requirement

Supplier	Present Condition in 2003								
	All Supply Area				from the Jeneberang River				
	WTP		Intake		WTP		Intake		
					Wet Season	Dry Season	Wet Season	Dry Season	Amount
	(m^3/s)	(MCM)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(MCM)
PDAM Makassar	**2.36** *1	74.30	unknown	unknoun	1.34	1.84	1.47	1.97	54.18
PDAM Gowa	**0.19** *1	5.99	unknown	unknoun	0.18	0.18	0.19	0.19	6.10

Supplier	in 2010								
	All Supply Area				from the Jeneberang River				
	WTP		Intake		WTP		Intake		
					Wet Season	Dry Season	Wet Season	Dry Season	Amount
	(m^3/s)	(MCM)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(MCM)
PDAM Makassar	**2.74** *1	86.25	unknown	unknown	1.65	unknown	1.80	2.30	64.71
PDAM Gowa	uknown	unknown	0.37	**11.82** *2	unknown	unknown	0.36	0.36	11.50

Supplier	in 2018								
	All Supply Area				from the Jeneberang River				
	WTP		Intake		WTP		Intake		
					Wet Season	Dry Season	Wet Season	Dry Season	Amount
	(m^3/s)	(MCM)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(MCM)
PDAM Makassar	**4.11** *1	129.48	unknown	unknown	3.02	unknown	3.31	3.81	112.26
PDAM Gowa	unknown	unknown	0.72	**22.81** *3	unknown	unknown	0.71	0.71	22.50

Supplier	in 2019								
	All Supply Area				from the Jeneberang River				
	WTP		Intake		WTP		Intake		
					Wet Season	Dry Season	Wet Season	Dry Season	Amount
	(m^3/s)	(MCM)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(MCM)
PDAM Makassar	**4.25** *1	134.11	unknown	unknown	3.16	unknown	3.47	3.97	117.30
PDAM Gowa	unknown	unknown	0.77	**24.19** *3	unknown	unknown	0.76	0.76	23.87

Supplier	in 2020								
	All Supply Area				from the Jeneberang River				
	WTP		Intake		WTP		Intake		
					Wet Season	Dry Season	Wet Season	Dry Season	Amount
	(m^3/s)	(MCM)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(MCM)
PDAM Makassar	**4.40** *1	138.90	unknown	unknown	3.31	unknown	3.63	4.13	122.33
PDAM Gowa	unknown	unknown	0.81	**25.56** *2	unknown	unknown	0.80	0.80	25.24

*1: Refer to Water Supply Section
*2: Refer to Main Report on Consulting Engineering Services for Comprehensive Water Management Plam Stud
for MAROS-JENEPONTO River Basin, Sector 10
*3: estimated to interpolate linear between 2010 and 2020

WTP : Requirement of Water Treatment Plant
Intake : Diversion requirement from the intake

Table 6.8 (2/2) Projected Municipal Water Demand and Diversion Requirement from the Jeneberang River

Facility Name	Originally Programmed		Present Condition				in 2010			in 2018			Intake Point
			Plant Capacity	Actual*5	Intake		Actual	Intake		Actual	Intake		
	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(MCM)	
*1 Somba Opu WTP	3.30	104.07	1.00	1.19	1.31	41.33	1.50	1.64	51.86	2.87	3.15	99.42	Bili-Bili*3
*1 Ratulangi WTP	-	-	0.05	0.06	0.07	2.07	0.06	0.07	2.07	0.06	0.07	2.07	Ujung Pandang
*1 Maccini Sombala WTP	-	-	0.20	0.09	0.09	2.90	0.09	0.09	2.90	0.09	0.09	2.90	Malingkeli-1
*1 the growth*4	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	Downstream
*1 Panaikang WTP (for dry season)	-	-	1.00	unknown	0.50	7.88	unknown	0.50	7.88	unknown	0.50	7.88	Malingkeli-2
*2 Bajeng WTP	-	-	0.02	0.02	0.02	0.66	0.02	0.02	0.66	0.02	0.02	0.66	Kampili Weir
*2 Borong Loe WTP	-	-	0.02	0.01	0.01	0.44	0.02	0.02	0.69	0.02	0.02	0.69	Bili-Bili*3
*2 Tompo Balang WTP	0.10	3.15	0.04	0.03	0.03	0.83	0.04	0.04	1.32	0.04	0.04	1.32	Sungguminasa
*2 Pandang-Pandang WTP	-	-	0.20	0.13	0.13	4.17	0.20	0.21	6.62	0.20	0.21	6.62	Padang-Pandang
*2 the growth*4	-	-	-	-	-	-	0.07	0.07	2.20	0.40	0.42	13.19	Downstream

Facility Name	in 2019			in 2020			Intake Point
	Actual	Intake		Actual	Intake		
	(m^3/s)	(m^3/s)	(MCM)	(m^3/s)	(m^3/s)	(MCM)	
*1 Somba Opu WTP	2.98	3.28	103.38	2.98	3.28	103.38	Bili-Bili*3
*1 Ratulangi WTP	0.06	0.07	2.07	0.06	0.07	2.07	Ujung Pandang
*1 Maccini Sombala WTP	0.12	0.13	3.98	0.20	0.21	6.62	Malingkeli-1
*1 the growth*4	0.00	0.00	0.00	0.07	0.08	2.39	Downstream
*1 Panaikang WTP (for dry season)	unknown	0.50	7.88	unknown	0.50	7.88	Malingkeli-2
*2 Bajeng WTP	0.02	0.02	0.66	0.02	0.02	0.66	Kampili Weir
*2 Borong Loe WTP	0.02	0.02	0.69	0.02	0.02	0.69	Bili-Bili*3
*2 Tompo Balang WTP	0.04	0.04	1.32	0.04	0.04	1.32	Sungguminasa
*2 Pandang-Pandang WTP	0.20	0.21	6.62	0.20	0.21	6.62	Padang-Pandang
*2 the growth*4	0.44	0.46	14.57	0.48	0.51	15.94	Downstream

*1 : Operated by PDAM Makassar
*2 : Operated by PDAM Gowa
*3 : Intake point between Bili-Bili MultipurposeDam and Bili-Bilii Weir
*4 : Water Demand Increament which cannot be provided from existing WTP capacity and Somba Opu reinforcement
*5 : Refer to Water Supply Sector
Actual : actual requirement of Water Treatment Plant
Intake : estimated diversion requiremenr from the intake

Table 6.9 Result of Bili-Bili Reservoir Simulation

Year	Minimum Water Level (m)				Minimum Storage Volume above LWL (MCM)			
	Present (2003)	2018	2019	2020	Present (2003)	2018	2019	2020
1972	65.0	65.0	65.0	65.0	0.0	0.0	0.0	0.0
1973	87.2	86.3	86.2	86.2	130.5	120.7	119.9	119.6
1974	91.1	88.9	88.7	88.5	178.2	150.4	148.0	145.6
1975	89.7	87.3	87.0	86.8	159.9	131.0	128.3	125.6
1976	73.0	65.0	65.0	65.0	23.5	0.0	0.0	0.0
1977	82.5	76.2	75.7	75.1	84.1	42.7	39.1	35.6
1978	98.6	96.6	96.4	96.2	292.1	259.3	255.3	251.9
1979	83.8	79.1	78.4	77.9	96.1	59.7	56.4	53.2
1980	81.4	75.7	75.3	74.8	75.3	39.5	36.5	33.6
1981	90.3	87.5	87.2	87.0	167.5	133.4	130.5	127.9
1982	65.0	65.0	65.0	65.0	0.0	0.0	0.0	0.0
1983	67.4	65.0	65.0	65.0	5.2	0.0	0.0	0.0
1984	89.2	86.0	85.7	85.4	153.4	117.1	114.0	111.2
1985	89.8	87.4	87.1	86.9	161.0	132.3	129.7	127.4
1986	84.2	80.3	79.6	78.9	99.2	65.2	61.9	58.6
1987	75.1	65.9	65.0	65.0	35.6	1.9	0.0	0.0
1988	87.9	84.5	84.2	83.9	138.3	102.7	99.6	96.5
1989	98.5	97.9	97.8	97.7	289.4	279.4	278.4	277.4
1990	93.4	91.8	91.7	91.5	209.6	187.8	186.0	184.0
1991	76.1	66.4	65.0	65.0	41.9	3.0	0.0	0.0
1992	72.8	65.0	65.0	65.0	22.8	0.0	0.0	0.0
1993	86.1	83.0	82.9	82.9	118.6	88.6	88.1	88.0
1994	76.8	68.2	66.7	65.0	46.5	7.1	3.7	0.3
1995	86.3	81.5	81.1	80.6	120.3	76.3	72.6	69.3
1996	79.4	73.3	72.6	71.8	61.4	24.8	21.7	18.5
1997	65.0	65.0	65.0	65.0	0.0	0.0	0.0	0.0
1998	81.0	77.8	77.6	77.4	71.9	53.0	51.4	50.2
1999	82.1	76.6	76.2	75.7	81.3	45.6	42.5	39.4
2000	95.5	94.0	93.8	93.7	241.1	218.3	216.3	214.3
2001	95.5	94.0	93.8	93.7	126.5	92.6	89.7	86.7

Table 6.10 Areal Average Raindall in Lower Reaches of Jeneberang River below Bili-Bili Dam in the Drought Year

Year	Occurrence of Drought				Areal Average Raindall				
	Present	2018	2019	2020	Apr.	May	Jun	Total	Annual
1972	*	*	*	*	61	13	0	74	1,998
1973					444	123	19	586	2,647
1974					166	69	34	269	2,528
1975					323	72	44	438	2,698
1976		*	*	*	42	58	34	134	2,438
1977					135	39	75	249	2,979
1978					178	263	86	527	2,774
1979					65	115	112	292	2,618
1980					172	27	9	208	2,451
1981					97	79	27	203	2,543
1982	*	*	*	*	64	34	12	110	1,721
1983		*	*	*	186	69	23	277	1,698
1984					146	148	13	306	2,536
1985					166	97	30	293	1,961
1986					130	29	51	211	2,237
1987			*	*	84	73	2	158	3,040
1988					144	147	16	307	3,025
1989					305	63	77	446	2,671
1990					66	176	7	249	1,953
1991			*	*	177	5	1	183	1,760
1992		*	*	*	105	11	43	159	1,755
1993					178	79	34	291	1,987
1994					99	36	12	146	2,057
1995					308	80	48	436	2,649
1996					79	23	15	117	3,092
1997	*	*	*	*	83	16	1	100	1,609
1998					321	162	111	595	2,532
1999					174	62	21	257	3,419
2000					202	83	130	415	2,766
2001					69	17	57	144	2,882
Average					159	76	38	273	2,434

* : The year during which the storage volume of Bili-Bili dam reservoir drops to zero.

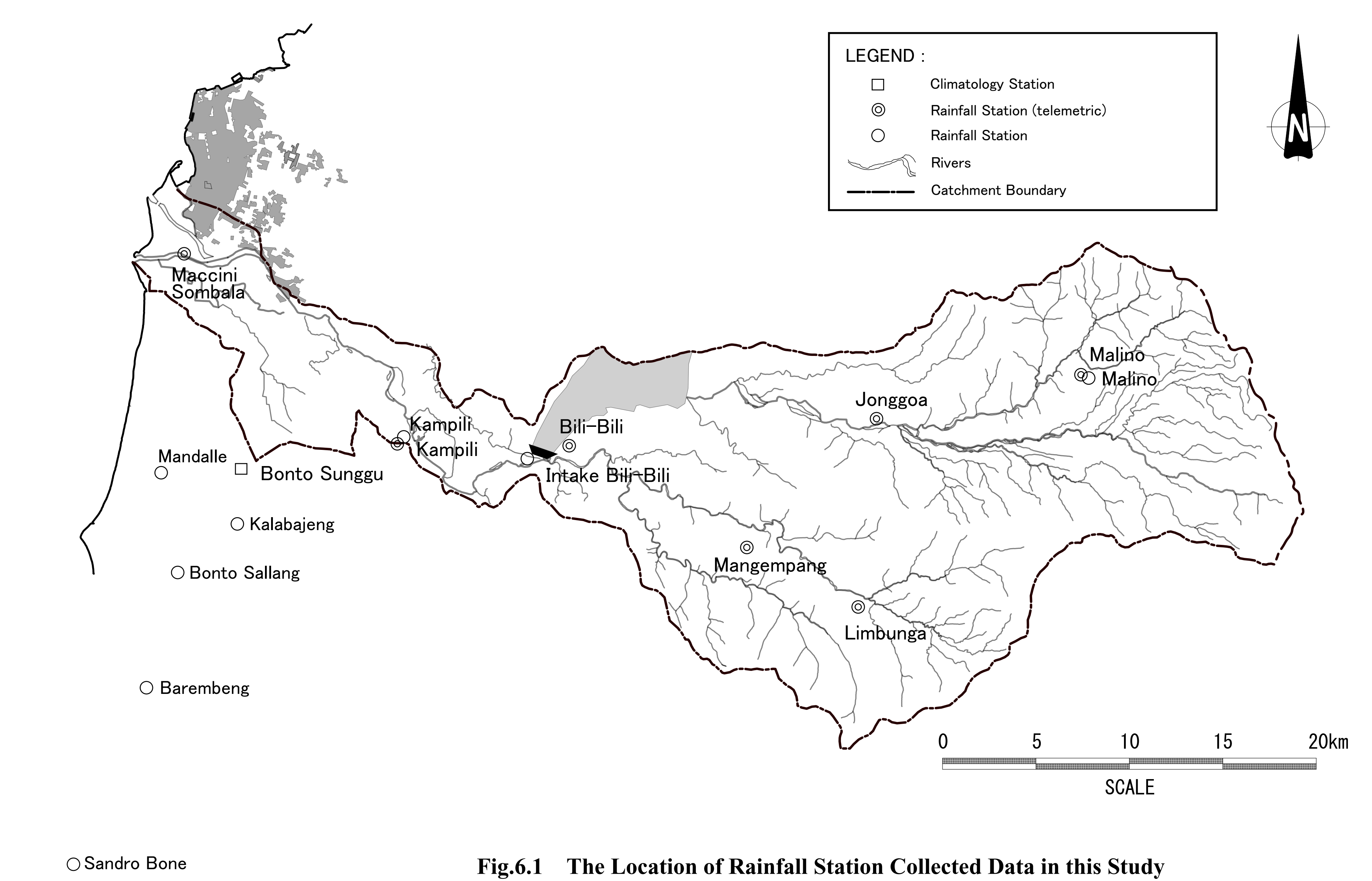


Fig.6.1 The Location of Rainfall Station Collected Data in this Study

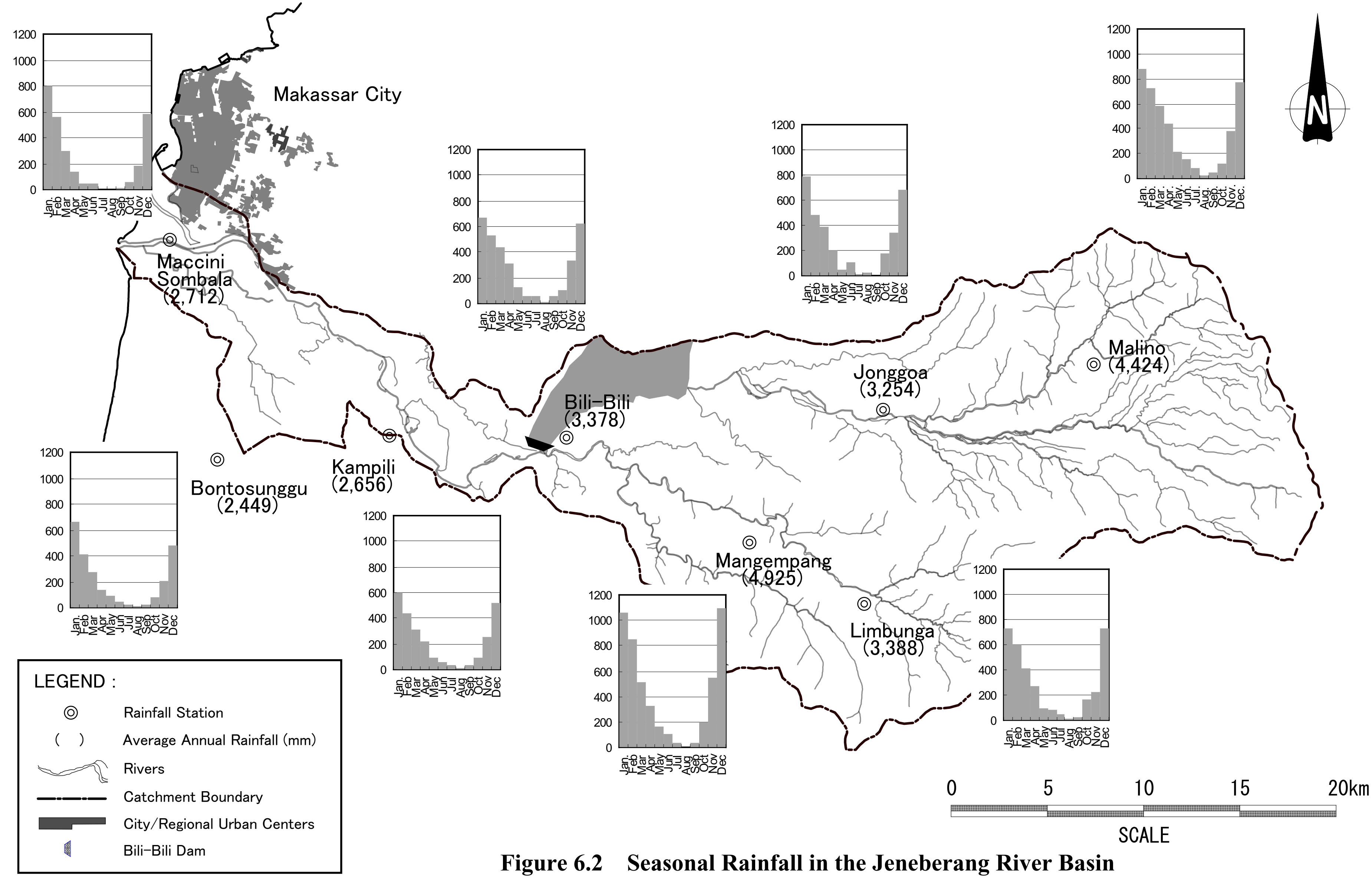
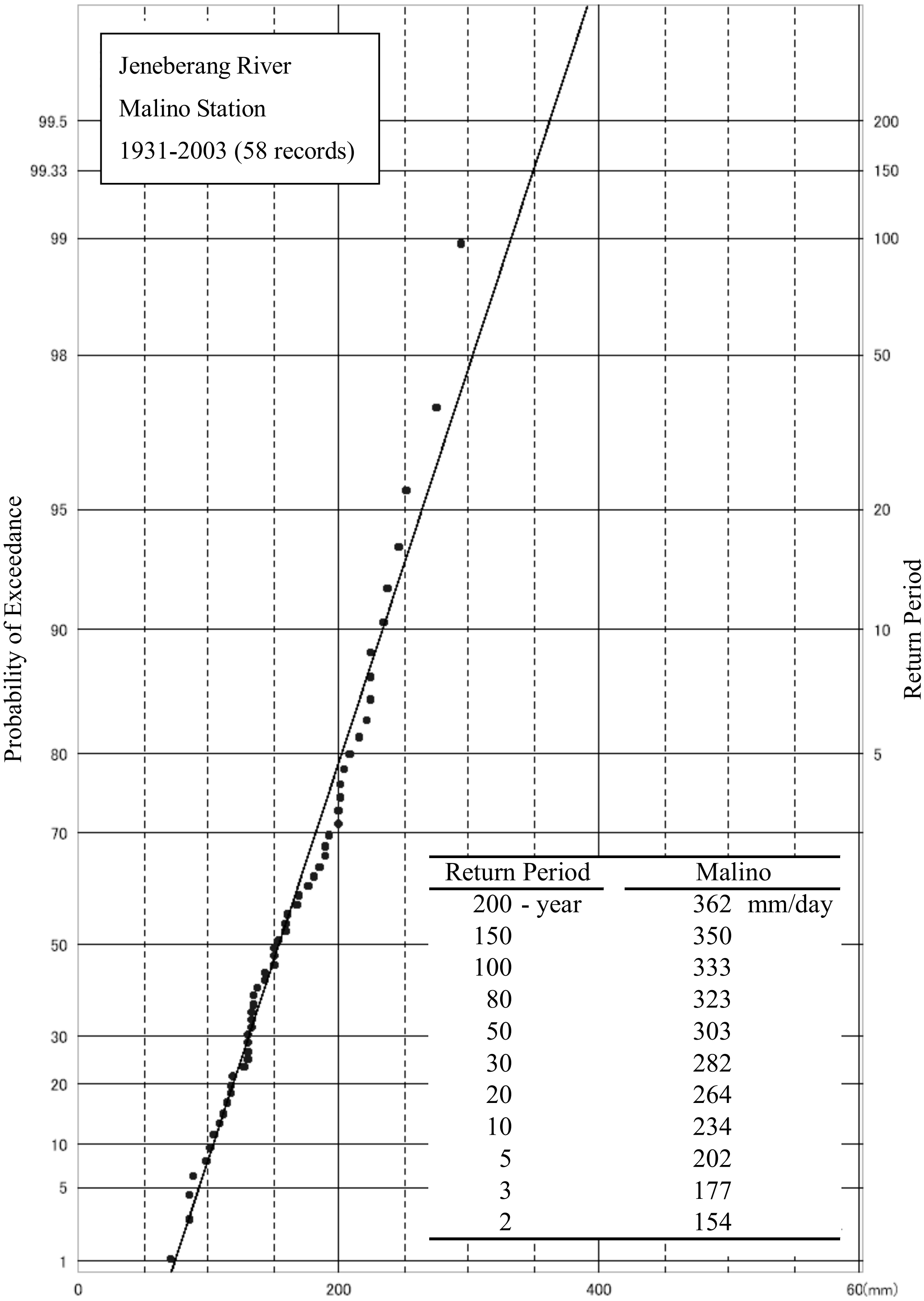


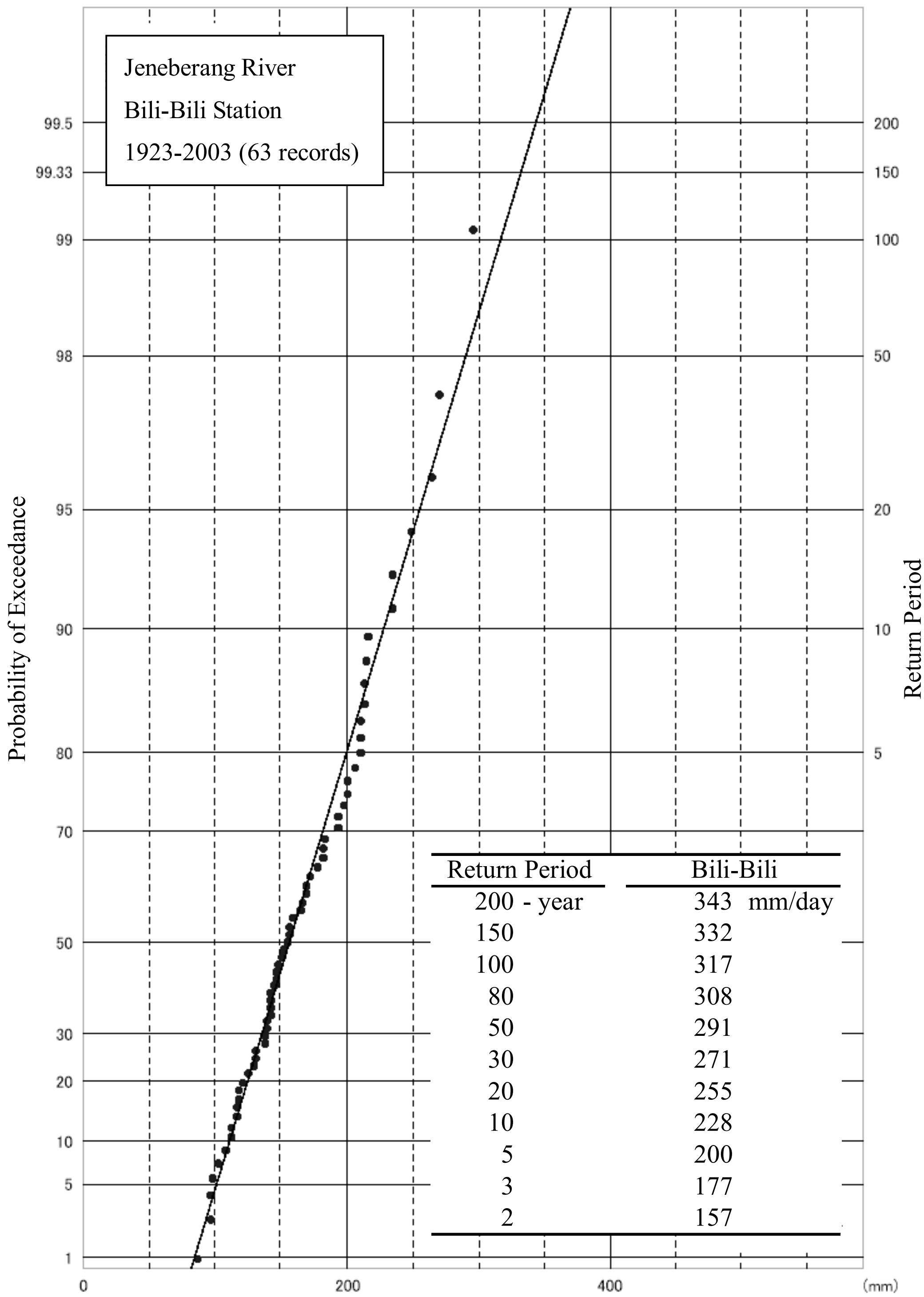
Figure 6.2 Seasonal Rainfall in the Jeneberang River Basin



Return Period	Malino
200 - year	362 mm/day
150	350
100	333
80	323
50	303
30	282
20	264
10	234
5	202
3	177
2	154

Gumbell Probability Paper

Figure 6.3 (1/2) Probable Maximum One-day Rainfall (Malino)



Return Period	Bili-Bili
200 - year	343 mm/day
150	332
100	317
80	308
50	291
30	271
20	255
10	228
5	200
3	177
2	157

Gumbell Probability Paper

Figure 6.3 (2/2) Probable Maximum One-day Rainfall (Bili-Bili)

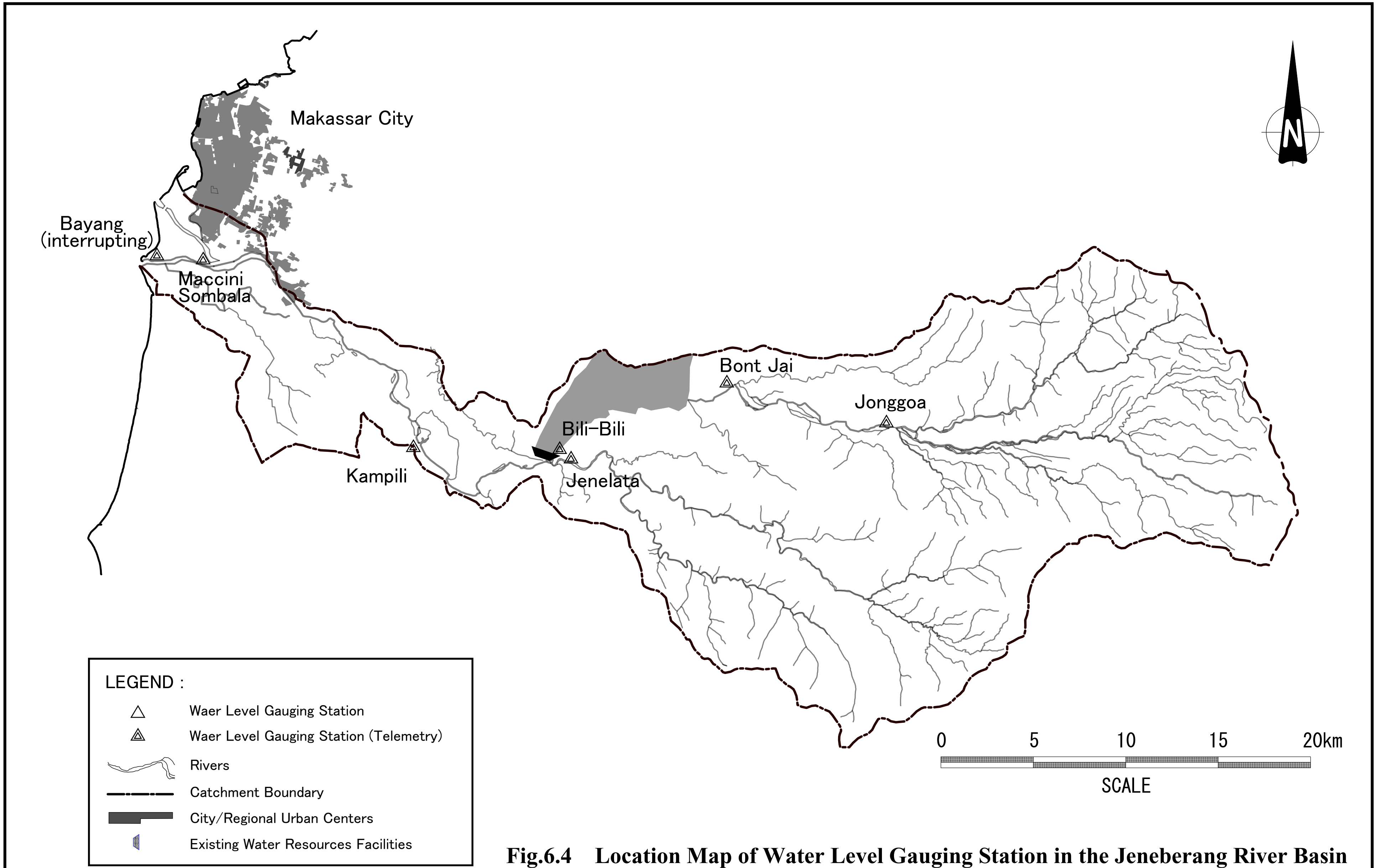
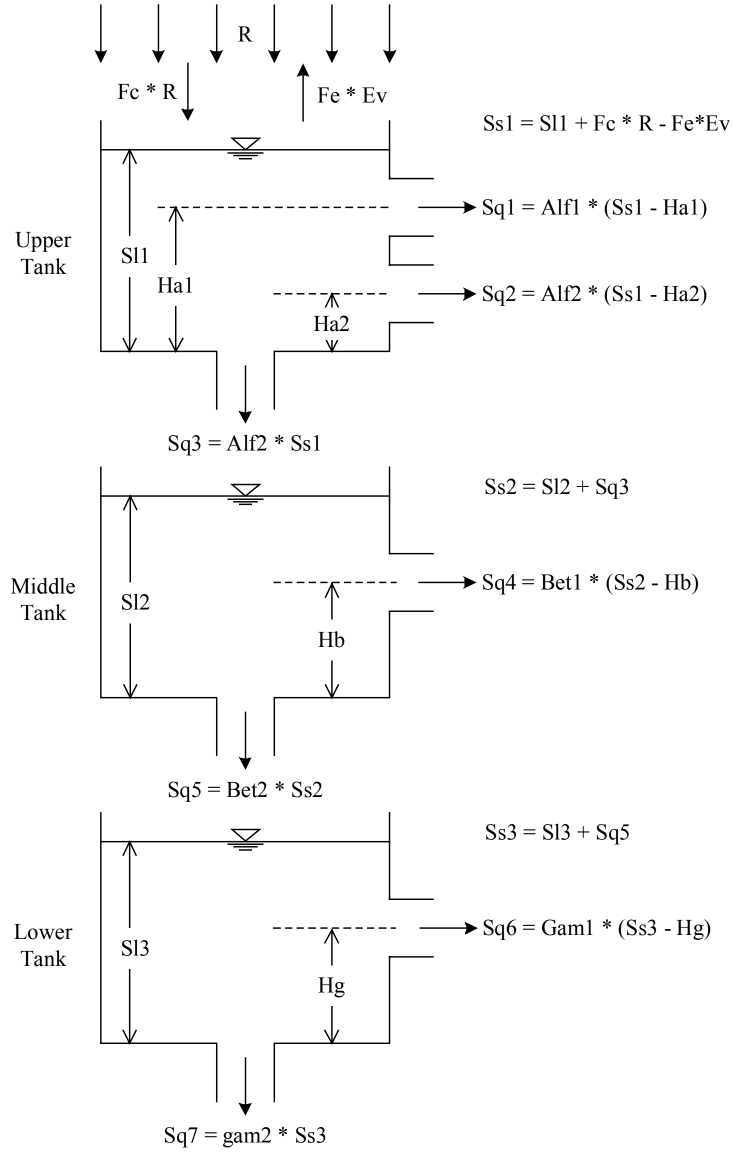
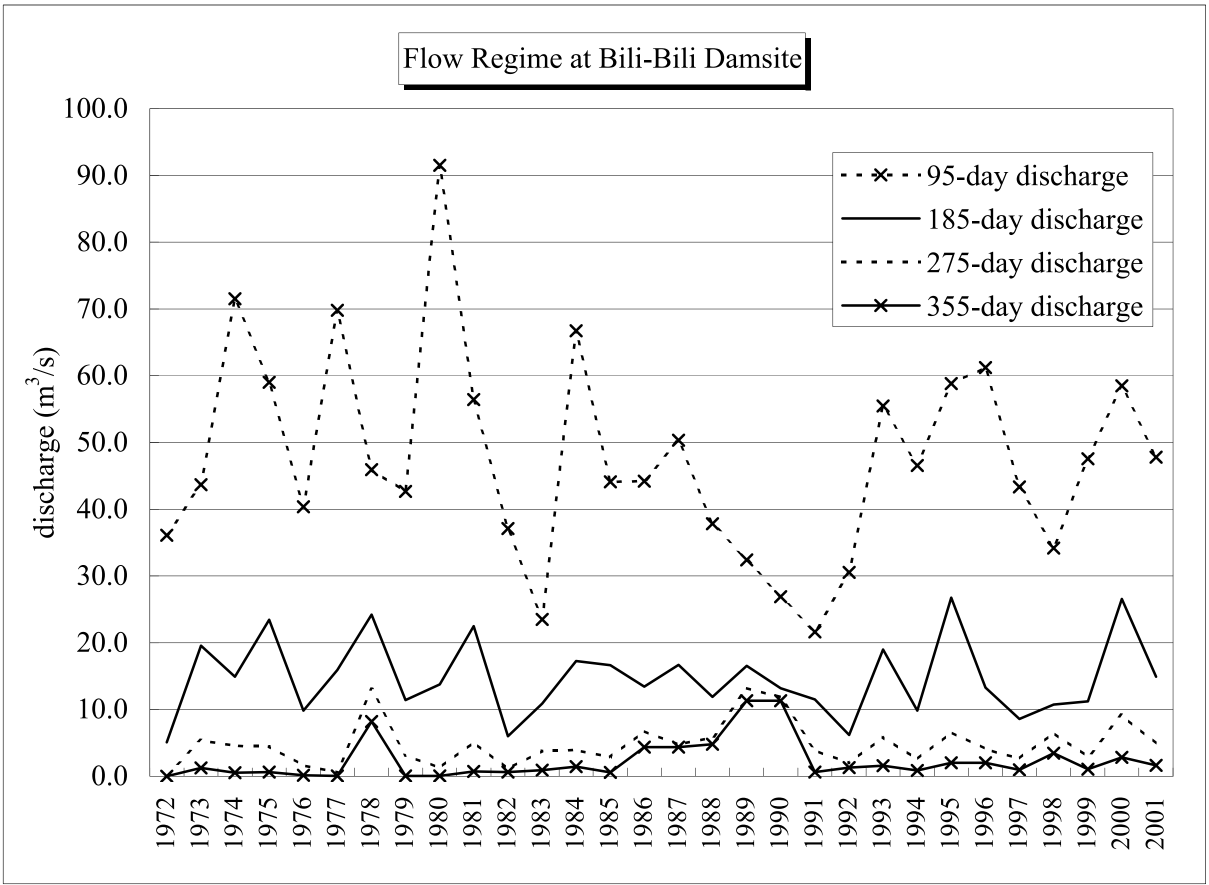


Fig.6.4 Location Map of Water Level Gauging Station in the Jeneberang River Basin



Parameter	Jeneberang River			Jenelata River		
Catchment Area (km^2)	384.4			226.3		
Multiplying Constant of Outlet (mm)						
- Upper Tank	0.900	0.600	0.200	0.700	0.260	0.130
- Middle Tank	0.050	0.030		0.060	0.020	
- Lower Tank	0.004	0.015		0.008	0.001	
Height of Outlet (mm)						
- Upper Tank	50	10		90	20	
- Middle Tank	10			20		
- Lower Tank	10			20		
Evaporation Factor	0.55			0.65		
Effective Rainfall Ratio	1.00			0.93		

Figure 6.5 Structure and Parameter of Tank Model in this Study



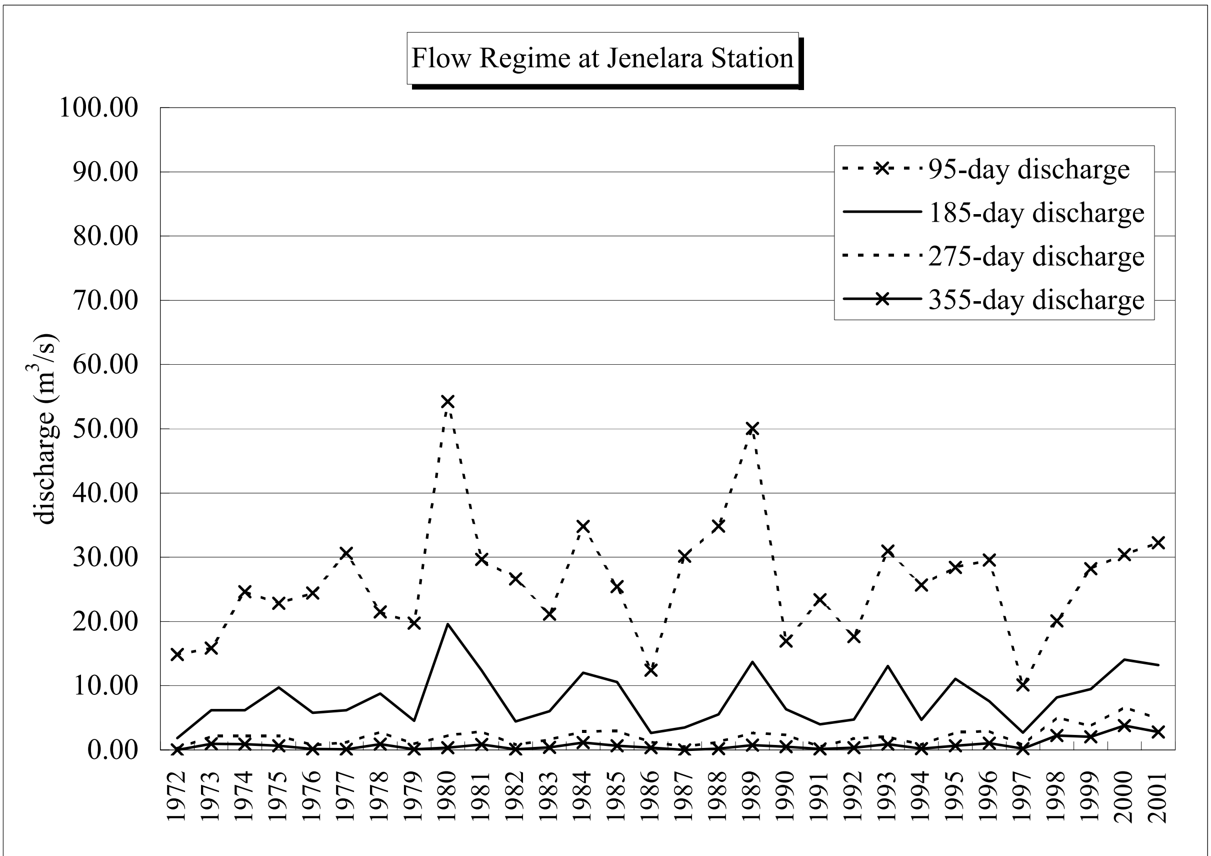


Figure 6.6 Flow Regime in the Jeneberang River Basin

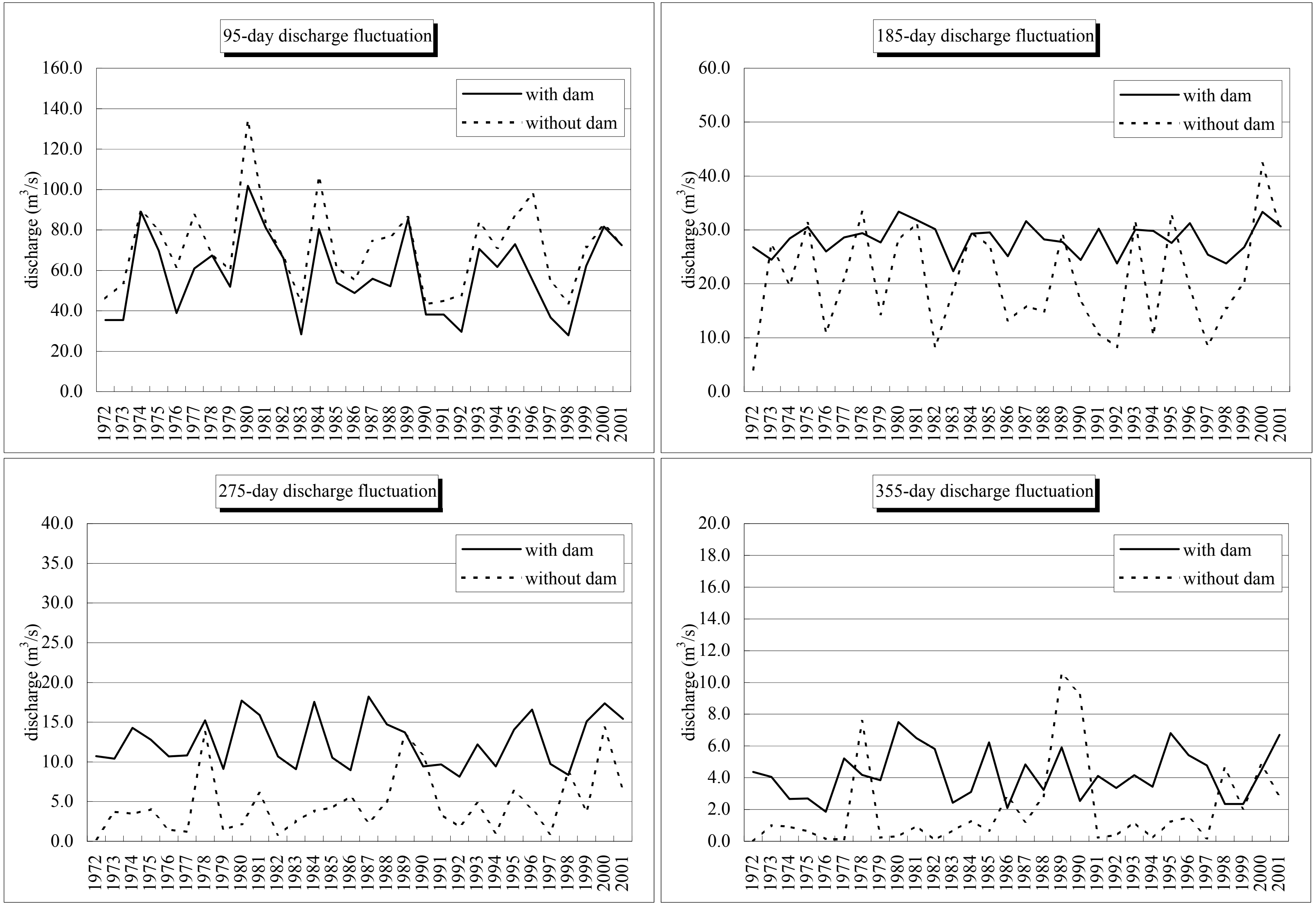
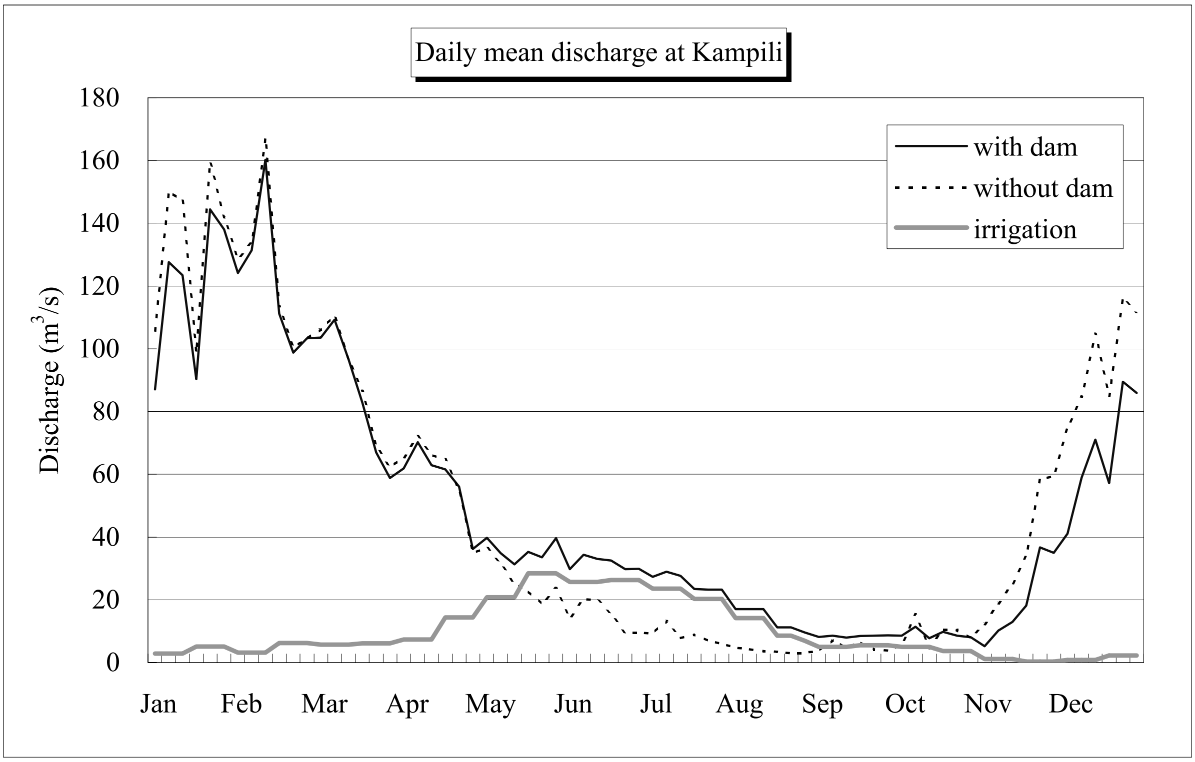
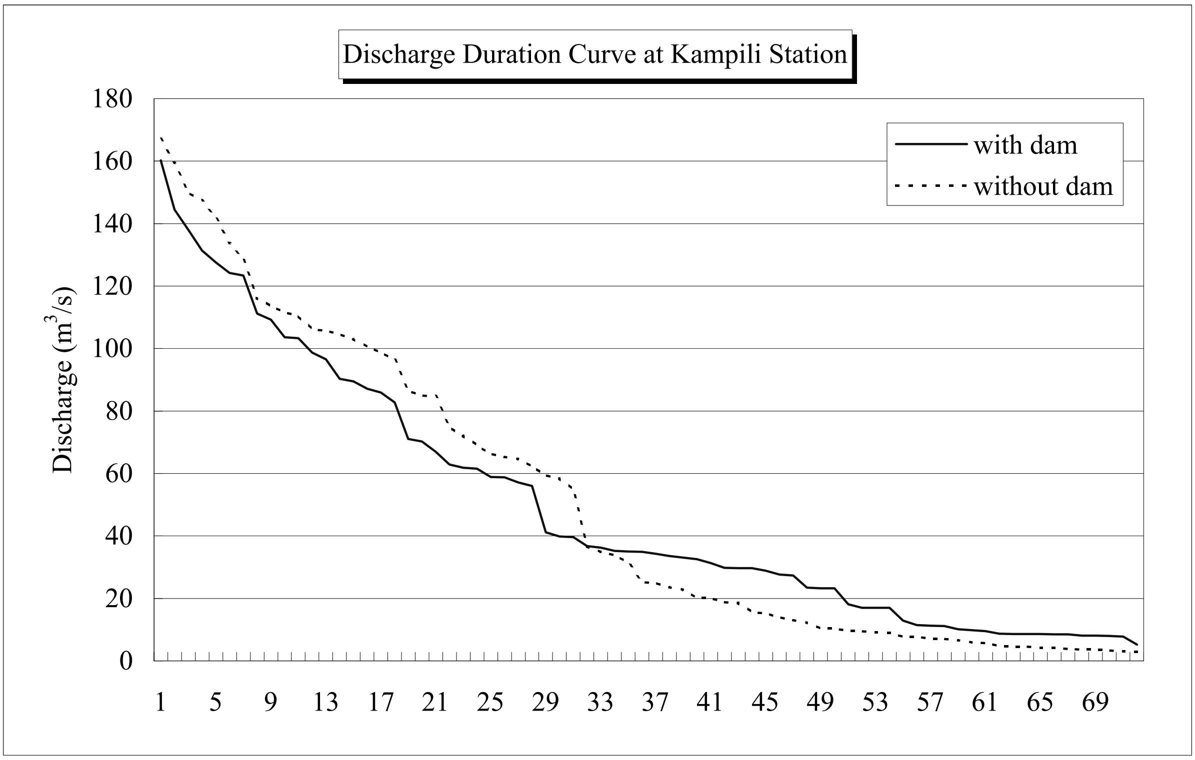


Figure 6.7 Flow Regime at Kampili Station





Data : Averaged from 1972 to 2001based on 5-days discharge

Figure 6.8 Flow Regime Improvement by Bili-Bili Multipurpose Dam

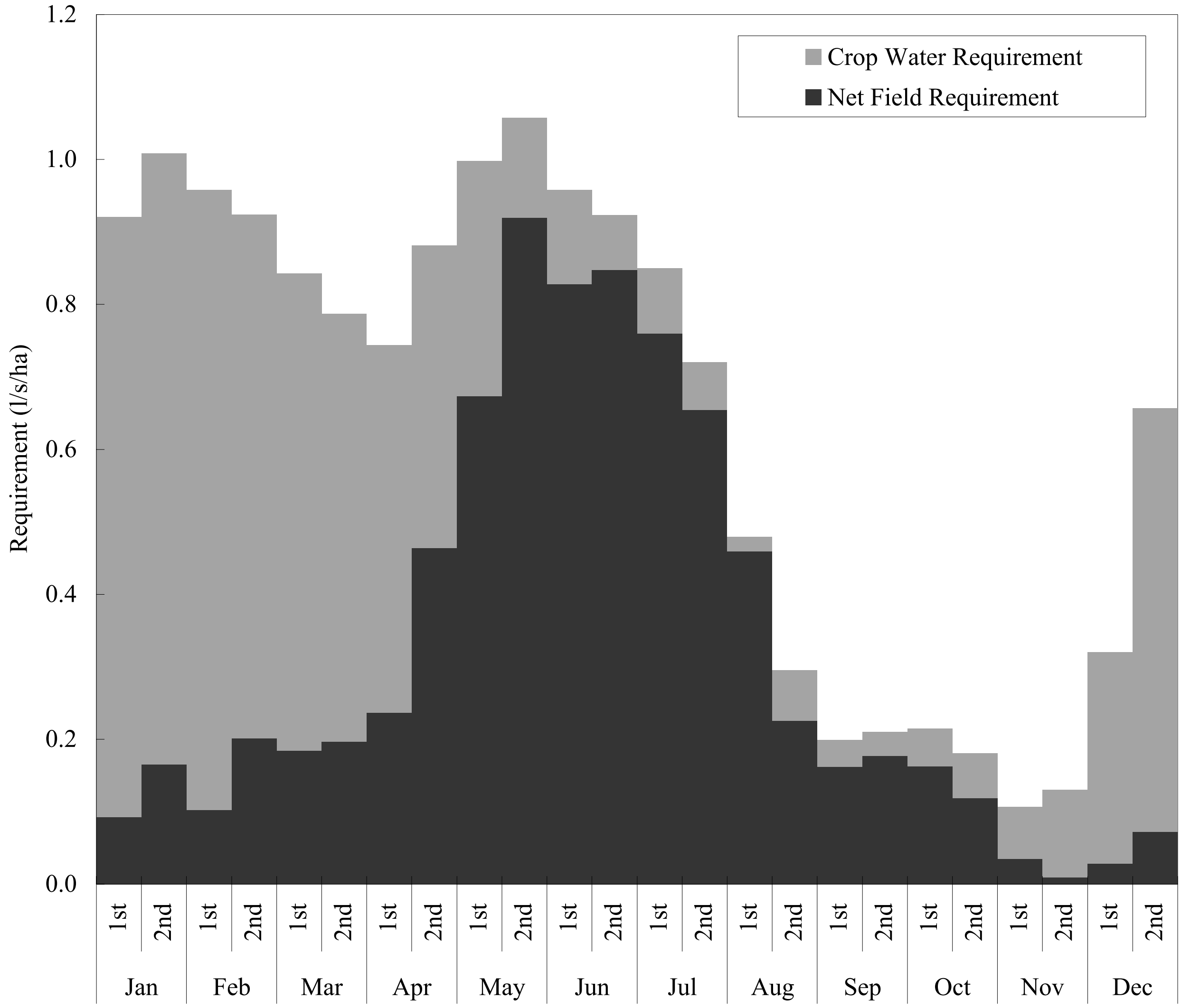
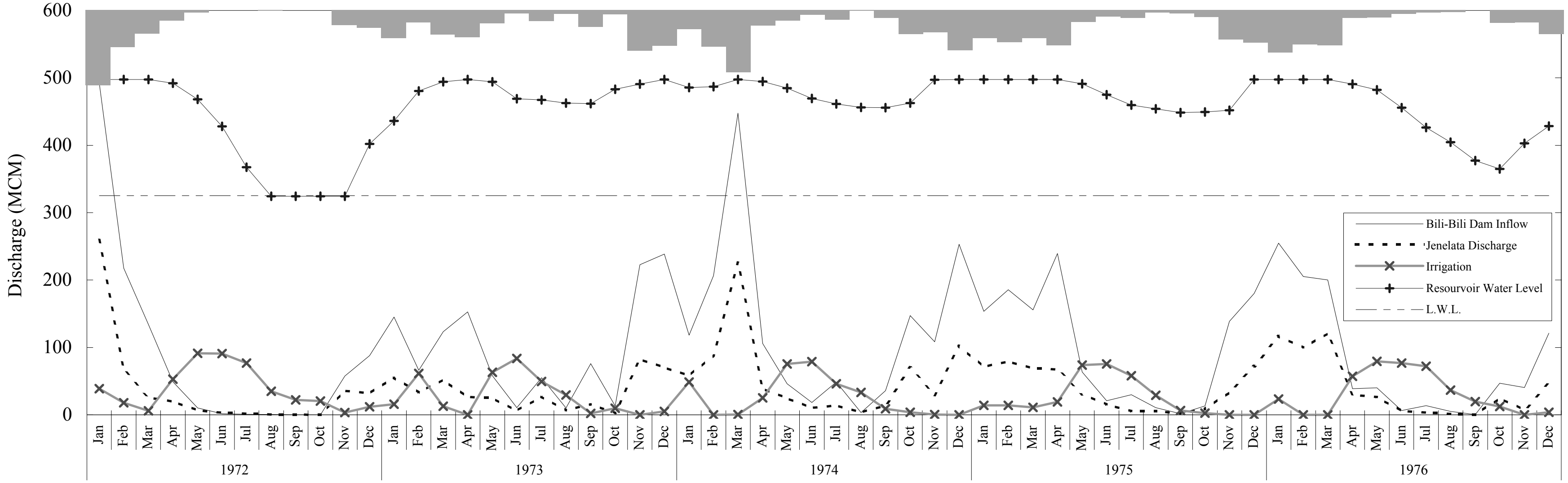


Figure 6.9 Irrigation Water Requirement



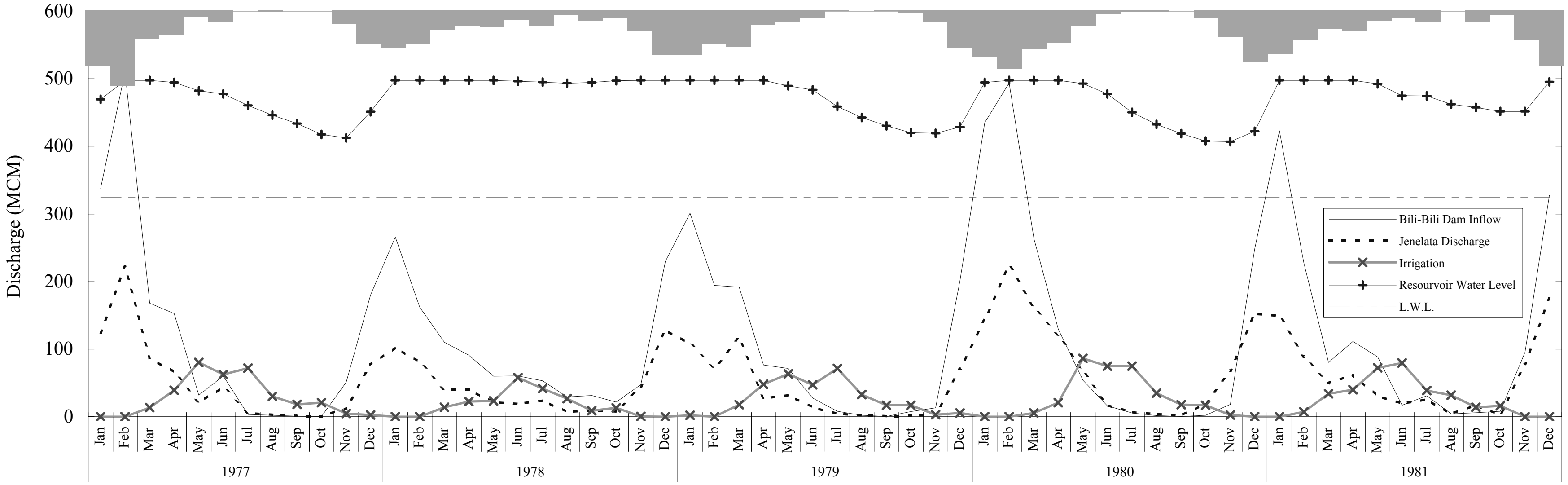


Figure 6.10 (1/3) Result of Water Balance Calculation

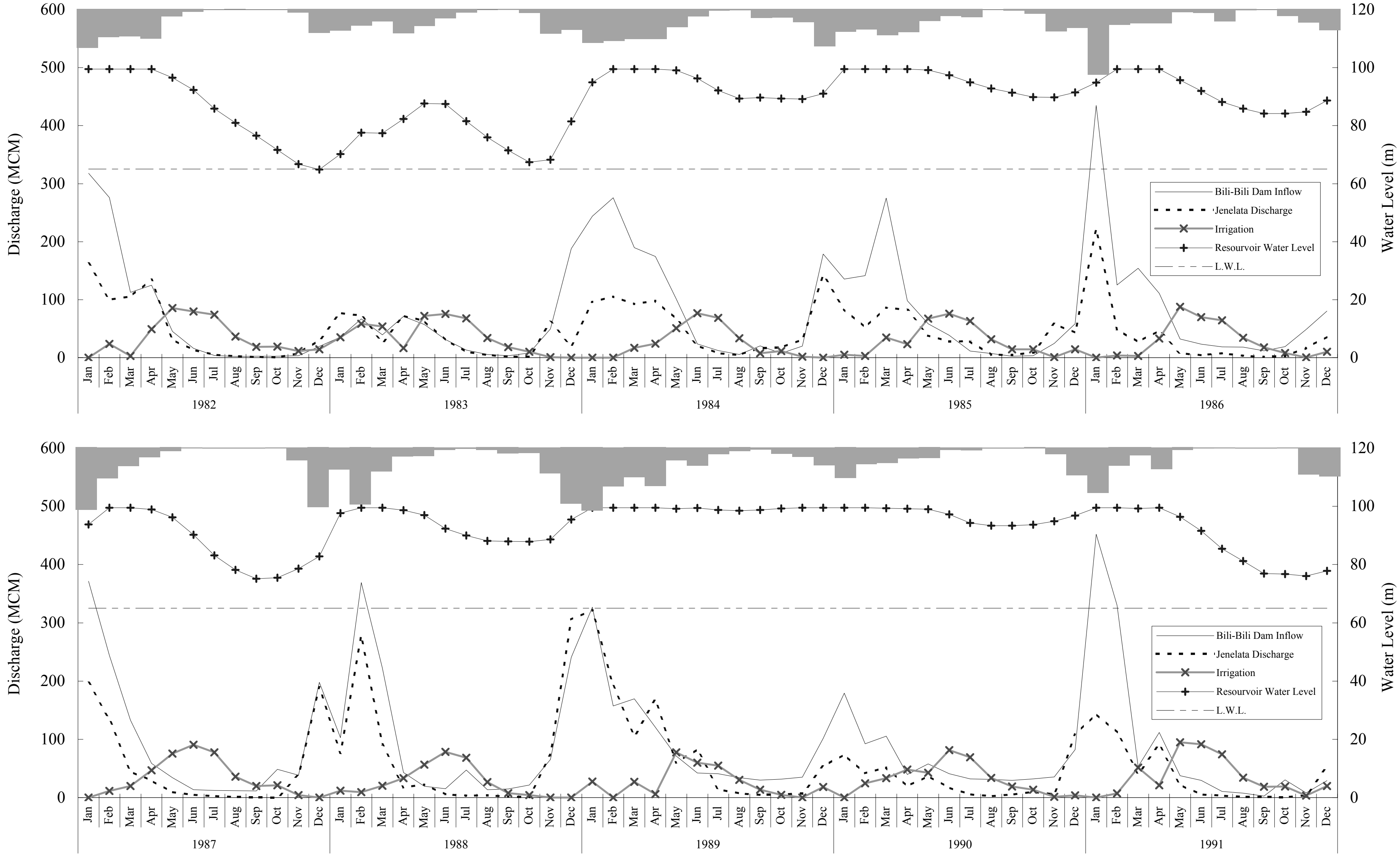
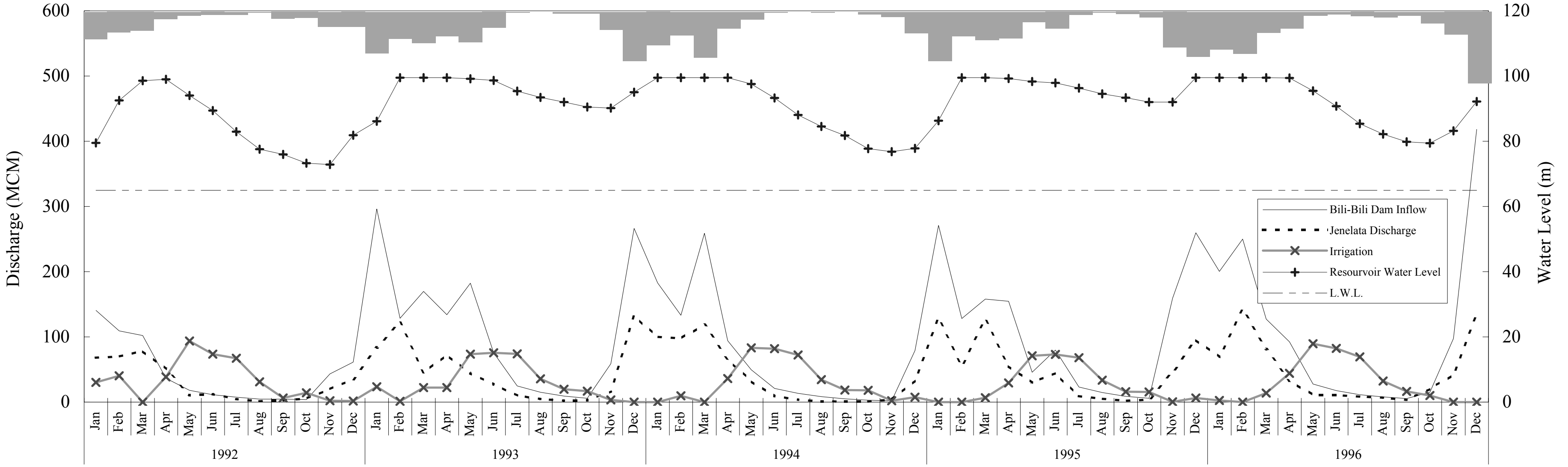


Figure 6.10 (2/3) Result of Water Balance Calculation



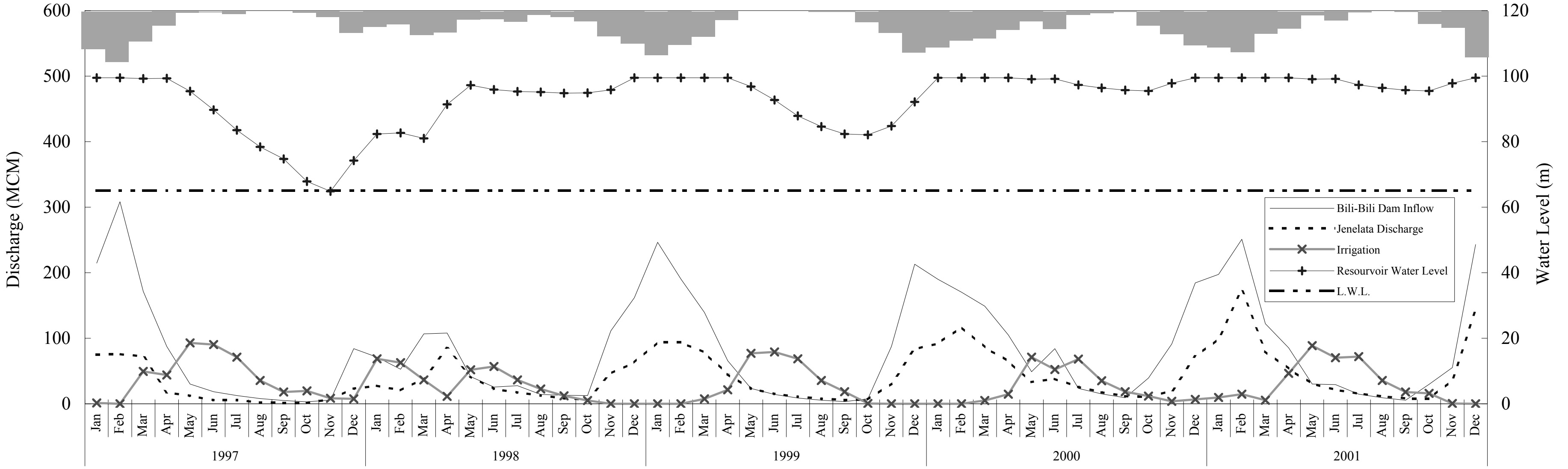


Figure 6.10 (3/3) Result of Water Balance Calculation

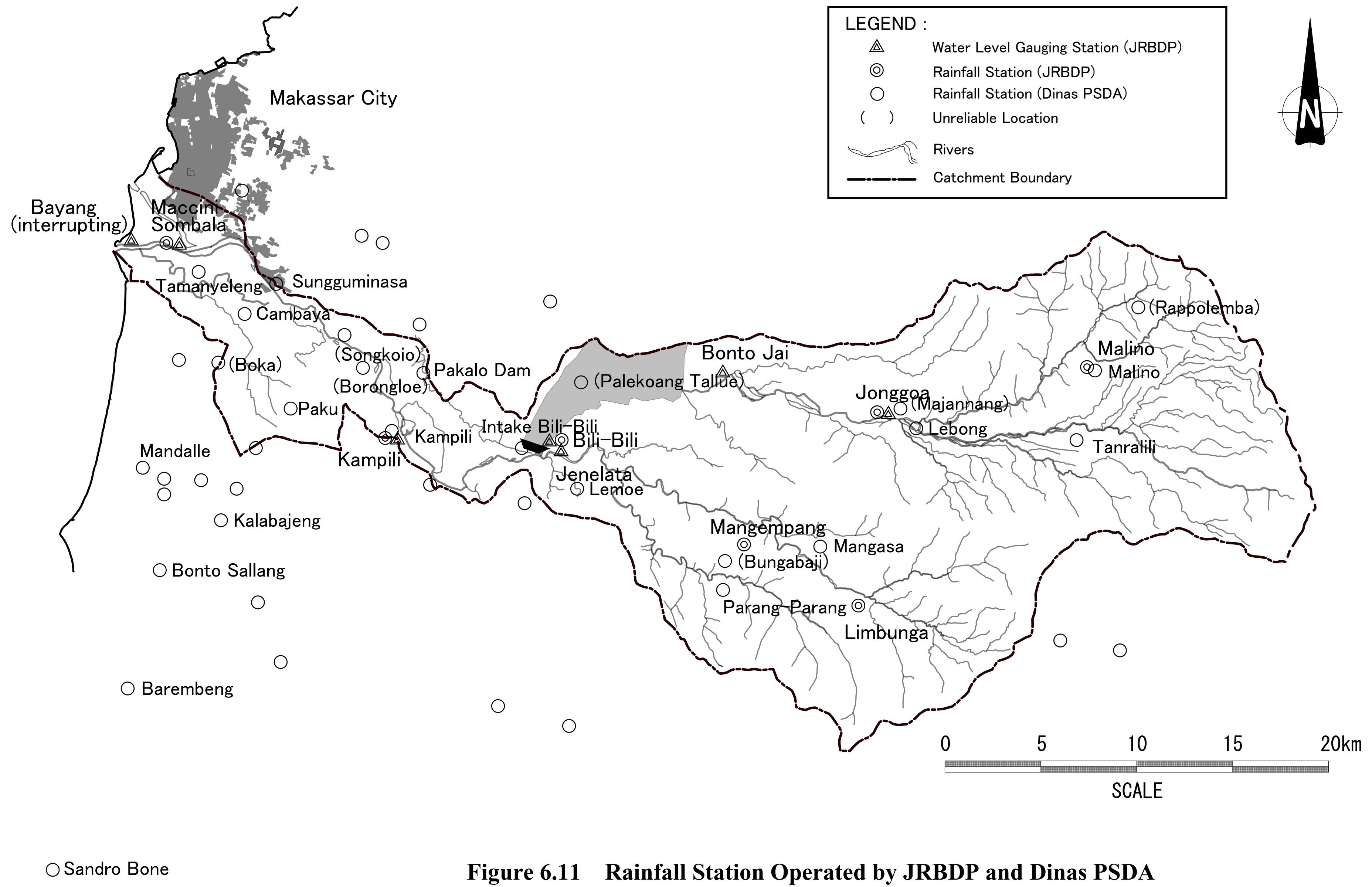


Figure 6.11 Rainfall Station Operated by JRBDP and Dinas PSDA

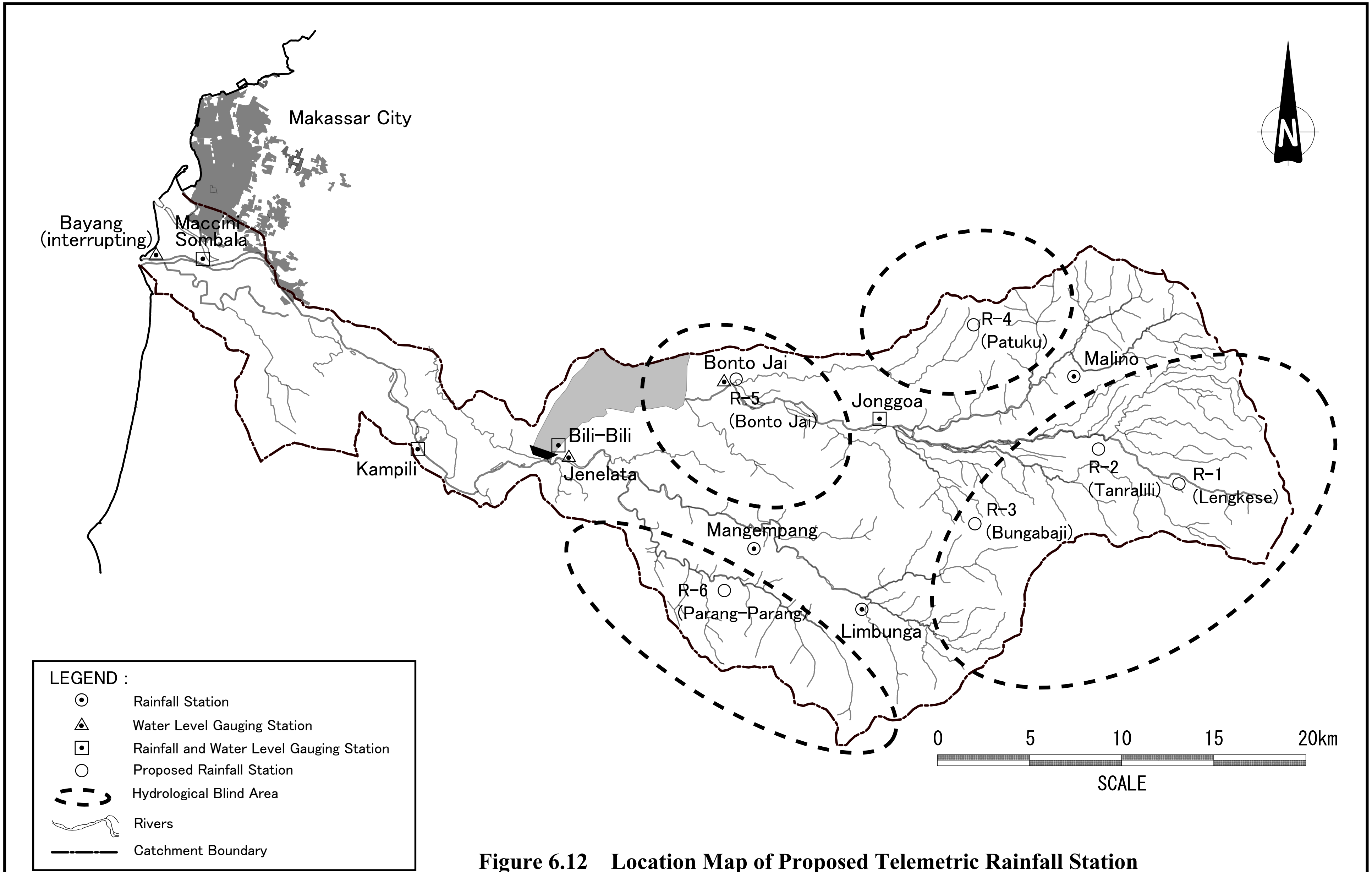


Figure 6.12 Location Map of Proposed Telemetric Rainfall Station

CHAPTER 7

RIVER AND INFRASTRUCTURE MANAGEMENT

7.1 Features of Existing River Infrastructures

7.1.1 Structural Features of Existing River Infrastructures

Intensive water resources development in the Jeneberang River basin has been undertaken since the 1970's in line with the national economic development policy. As a result many relevant infrastructures have been constructed (refer to Table 7.1 and Figures 7.1 and 7.2). The total investment for water resources development is about Rp.935 billion, which includes Rp.668 billion for water sources and distribution, Rp.166 billion for flood control and Rp.101 billion for watershed management as represented by sabo works. The cost breakdown for each of the major river infrastructures is listed below.

Investment Cost and Completion Year of Existing River Infrastructures

Purpose	Project/Facility	Investment Cost (Rp. Million))	Completion Year
Water Source and Distribution	Bili-Bili Dam and Raw Water Transmission Main	442,815 /1	Dec. 1999
	Rubber Dam	61,045	Dec. 1996
	Long Storage	12,158	Nov. 2001
	Diversion Weirs for Irrigation /2	152,216	Nov. 2004 /3
	Sub-total	668,234	
Flood Control	River Improvement & Drainage Improvement-I /4	96,469	Feb. 1992
	Drainage Improvement-II /5	69,577	Dec. 2001
	Sub-total	166,046	
Watershed Management	Sand Pocket Dam and Sabo Dam	101,185	Jan. 2001
	Sub-total	101,185	
Ground Total		935,465	

/1 : Excludes cost for the on-going hydropower plant
/2 : Bili-Bili, Bissua and Kampili Diversion Weirs
/3 : Scheduled
/4 : For Drainage System of Jongaya-Panampu-Sinrijala
/5 : For Drainage System of Pampang

Among others, the major structures used for water sources and distribution in the Jeneberang River basin are represented by Bili-Bili Multipurpose Dam, Rubber Dam, Long Storage and the three diversion weirs, namely Bili-Bili, Bissua and Kampili Weirs within the Bili-Bili Irrigation System. There are also a variety of riparian structures and urban drainage facilities for flood mitigation along the lower Jeneberang River. Five sand pocket dams and three sabo dams in the upper reaches of Bili-Bili dam also function to minimize the sediment inflow into Bili-Bili dam reservoir. The principal features of these infrastructures are described below (refer to Supporting Report-E for detailed structural features):

(1) Bili-Bili Multipurpose Dam

Bili-Bili Dam was constructed from 1992 to 1999 for the purposes of flood control, municipal water supply, irrigation water supply and preservation of sustainable river maintenance flow. The dam has a catchment area of 384.4 km^2, which occupies almost half the entire basin area (762km^2), and an effective storage capacity of 346 million m^3. The latter is divided into 41 million m^3 for flood control of the downstream reach of Jeneberang River and 305 million m^3 is reserved as a water source for irrigation, municipal water and river maintenance flow in the lower reaches of the Jeneberang River.

An additional facility of Bili-Bili Dam, the Raw Water Transmission Main (RWTM), was constructed in 1996 in order to transfer raw water for municipal supply through a single pipeline. This is about 17km in length and extends from Bili-Bili Dam to the existing downstream water treatment plant (named Somba Opu). The maximum transfer capacity is 3.3m^3/s.

A hydrological telemetric gauging network was also constructed from 1997 to 1999 in order to facilitate the monitoring by Bili-Bili Dam Control Office of hydrological conditions in Jeneberang river basin. This network comprises three rainfall gauging stations, four rainfall/water level gauging stations (including one reservoir level gauging station) and three water level gauging stations.

Moreover, the hydropower generation plant (Bili-Bili HEPP) will be completed in November 2005 at the tailwater of Bili-Bili Dam. As Bili-Bili dam does not provide an exclusive storage capacity for hydropower generation, the power plant could generate power only through discharge drawn from the dam reservoir to meet downstream water requirements. The rated capacity and annual energy of the power plant will be 20MW and 77GWh, respectively.

(2) Rubber Dam

An inflatable rubber dam with a width of 210m and height of 2.0m was constructed across the Jeneberang River 3.65km upstream of the river mouth. The principal function of the rubber dam is to prevent the intrusion of saline water into the Jeneberang River, and at the same time to stabilize the riverbed fluctuations.

(3) Long Storage

An old channel about 4km upstream of the river mouth was isolated on the right-bank of the Jeneberang River through the "Lower Jeneberang River Channel Improvement Project". Referred to as "Long Storage", it is connected with the main stream of the Jeneberang River and has an effective storage capacity of 1.6 million m^3 for storage of water diverted from Jeneberang River. Long Storage is used as: (a) the water supply source for municipal water demand in Makassar City, (b) the water source to dilute flows in the primary drainage channels in Makassar City and (c) an amenity space.

(4) Diversion Weirs for Bili-Bili Irrigation System

As a part of Bili-Bili Irrigation Project, the following three diversion weirs were completed as at November 2004: (a) Bili-Bili Weir placed just downstream of Bili-Bili Dam, (b) Bissua Weir 7km downstream of Bili-Bili Dam, and (c) Kampili Weir 11km downstream of Bili-Bili Dam. These weirs divert the necessary water for the following irrigation areas:

Intake Discharge through Intake Weirs of Bili-Bili Irrigation

Name of Weir	Intake Discharge (Annual Maximum) (m^3/s)	Irrigation Area (ha)
Bili-Bili	4.7	2,360
Bissua	25.0	10,758
Kampili	17.5	10,545

(5) Riparian Structures

River channel improvements along an approximate 9.5km length of the river from the mouth to Sungguminasa Bridge was implemented from 1988 to 1992. This was part of the "Lower Jeneberang River Improvement Project" and was constructed to control a design flood discharge with a 50-year return period in conjunction with the flood control effect of Bili-Bili Dam. The major structural components of the Project are river dikes about 21 km in total along both right and left banks, revetments some 8,786 m long, two groundsills, one jetty about 300 m in length at the river mouth, and 14 sluices.

(6) Urban Drainage Facilities in Makassar City

The storm rainfall in the lowland area in Makassar City (about 64.3km^2) is drained through four primary drainage channels about 33km in length, namely Jongaya, Panampu, Sinrijala and Pampang (refer to Figure 7.1). The Jongaya, Panampu and Sinrijala channels were completed as part of the above "Lower Jeneberang River Improvement Project" during the period from 1992 to 1993, while Pampang channel was constructed from 1997 to 2000. All drainage channels were designed for the 20-year return period flood. The Pampang drainage channel is based on pumping drainage and has a capacity of 6m^3/s, while the remainder are gravity drainage channels.

Jongaya channel is connected to the "Long Storage" through a flush gate, and is also connected to the Panampu and Sinrijala primary channels (refer to Figure 7.1). During a dry season, the flush gate is occasionally opened to release the water stored in the Long Storage into the drainage channels in order to dilute stagnant water in the drainage.

(7) Sand Pockets and Sabo Dams

Five sand pocket dams and three sabo dams were constructed in the upper reaches of Bili-Bili dam from 1997 to 2001 in order to mitigate the sediment inflow into the Bili-Bili dam reservoir and at the same time contribute to prevention of the local sediment disaster. However, one sand pocket dam ("Sand Pocket No.4") and one sabo dam ("Sabo Dam No.4") were damaged by the extraordinary flood in January 2002. Sabo Dam No.4, which is the most upstream of the existing sand pocket and sabo dams, was seriously damaged and abandoned. Sand Pocket No.4 is, however, to be rehabilitated in 2005.

7.1.2 Power Supply System to River Infrastructures in Jeneberang River Basin

The PLN is the State Electric Company undertaking commercial electric power supply throughout Indonesia. Most river infrastructures in Jeneberang river basin are connected with the following three 20 kV PLN feeders as their main power supply sources (refer to Figure 7.3):

PLN Feeders Connected to Water Resources Facilities in Jeneberang River Basin

Name of Feeder	Number of Circuits	Water Resource Facilities Connected to Feeder
Kampili Feeder	Single Circuit	– Kampili Irrigation Weir
Rindam Feeder	Single Circuit	– Bissua Irrigation Weir
GMTDC feeder	Double Circuit	– Rubber Dam – Intake Gate for Long Storage – Tidal Gate for Long Storage – Pampang Pumping Station

Electric power failures have occasionally occurred in South Sulawesi. The number of trips and duration of electric power failures of the above three feeders from 2001 to 2003 are listed below:

Electric Power Failure in Jeneberang River Basin

Year	Name of Feeder	Trip of Power Failures (times)	Duration of Power Failure (min.)	Unsupplied Power (kWh)
2001	Kampili	3	86	60
	Rindam	145	1,101	14,192
	GMTDC	15	94	1,125
2002	Kampili	26	461	609
	Rindam	193	2,911	36,342
	GMTDC	57	200	6,784
2003	Kampili	9	306	387
	Rindam	190	1,452	23,349
	GMTDC	81	365	10,542
Ave.	Kampili	13	284	352
	Rindam	176	1,821	24,628
	GMTDC	51	220	6,150

Source : PLN information dated October 2004

As listed above, Rindam Feeder in particular is estimated to have failed as a power supply every two days on average (=365days/176trips), with each of failure continuing for around 10 minutes (=1,821minutes/176 times). On the other hand, failure of power supply by the other two feeders is far less than for the Rindam Feeder. Among the river infrastructures, Bissua Irrigation Weir is connected to Rindam feeder, and therefore, its diesel engine generator would play a more important role as an emergency source of power supply than for other irrigation weirs.

Bili-Bili Dam and Bili-Bili Irrigation weir currently use the internal micro-hydro power plant, which is managed by JRBDP as the dam operator. This has an installed capacity of 325kVA. The micro-hydro power plant is equipped with a ballast load governor system, which functions to control a constant power load on the plant. However, this governor system currently does not function well, and the frequency and voltage supplied by the micro-hydro power plant is not stable, which could in turn lead to damage to the electric equipment. Due to this defect, the main power source of Bili-Bili Dam and Bili-Bili irrigation weir is going to shift to the Bili-Bili HEPP upon its completion in November 2005.

7.2 Present River Management in Jeneberang River Basin

7.2.1 Water Quantity Management

The present practices relevant to the water quantity management for Jeneberang River are as described below:

(1) Present Water Users and Water Requirement

Almost the entire water demand sourced from the Jeneberang River currently depends on a stable supply based on flow control by Bili-Bili dam reservoir. The water supply capacity of Bili-Bili Dam (i.e. 305 million m^3) was originally designed to meet full supply for a diversion water requirement of about 541 million m^3/year during a 5-year drought (i.e., a drought year with a 5-year return period). However, some of the requirements programmed at the time of dam design have not yet taken place. As a result, the updated diversion water requirement is limited to about 490 million m^3/year. This includes irrigation by the on-going Bili-Bili Irrigation Project (about 382 million m^3/year). Due to this limitation in the diversion water requirement, Bili-Bili dam reservoir could meet full supply for the updated water requirement during a 10-year drought. This is far higher than the design supply level (based on a 5-year drought) referred to in Chapter 6. The detailed breakdown of the water requirement originally programmed and the now updated value is listed below:

Annual Diversion Water Requirement Dependent of Water Source of Bili-Bili Dam

Item of Water Demand	Original Program		Updated	
	(m^3/s)	(m^3 million/year)	(m^3/s)	(m^3 million/year)
1. Municipal Water Demand				
1.1 PDAM Makassar*[1]	3.30	104.07	1.97	54.30
1.2 PDAM Gowa	0.10	3.15	0.19	6.00
2. Demand for Private Factory				
2.1 Takalar Sugar Factory	0.40	12.61	0.50	15.77
2.2 Gowa Paper Mill	0.25	7.88	0.00	0.00
3. Irrigation Water Demand*[2]	Variable	381.70	Variable	381.70
4. Maintenance Flow	1.00	31.54	1.00	31.54
Total		540.95		489.31

Note *1: Of the WTPs owned by PDAM Makassar, Panaikang WTP takes the entire raw water (1,000 liter/sec) from Lekopancing weir throughout the rainy season, and half (500 liter/sec) from Jeneberang River during the dry season.

*2: The irrigation water demand will occur upon completion of the on-going Bili-Bili Irrigation Project. The target completion time was set at November 2004.

The Provincial Regulation of South Sulawesi on November 8, 1991 prescribes that all surface water abstraction is subject to formal permission of the Governor of South Sulawesi Province. In accordance with the Regulation, Takalar Sugar Factory, as one of the water users of Jeneberang

River, had acquired the formal permit for water abstraction from the Governor. However, other water users are not likely to acquire any formal document/list regarding permitted water abstraction, and the above updated water demand is substantially handled as a customary use right. This implies the water requirement of water users is based on the agreement between JRBDP, as the dam operator, and the water users. This would be attributed to a particular background in which Bili-Bili Dam still reserves enough supply capacity for the updated water demand, and therefore, there has been little need to introduce the formal permit.

In addition to above major water users, upstream village irrigators are also outlined as water users (refer to Chapter 3). Official permission for water use for village irrigation has never been issued. Nevertheless, village irrigation has always been managed by traditional leaders through general community agreement, and therefore, could be regarded as the customary water use right. Moreover, the abstraction volume of village irrigation is presumed to be far smaller than those of large-scale irrigation schemes in the lower reaches. This reflects the return of a substantial part of the abstracted irrigation water to the river due to the hilly/mountainous topography in the area of village irrigation. Accordingly, village irrigation would not have a substantial influence on the downstream flow regime or the inflow regime to the Bili-Bili Dam reservoir.[1]

(2) Present Water Distribution System

JRBDP currently distributes the water necessary to meet downstream water demand through operation of Bili-Bili Dam reservoir, and other water distribution facilities such as the Raw Water Transmission Main, intake for Long Storage and Rubber Dam. Water distribution is not, however, made appropriately due to the following causes and/or defects of monitoring devices:

(a) Bili-Bili Irrigation Project, which is the largest water user of Jeneberang River, has not commenced and substantial operations. Therefore, Bili-Bili Dam still retains enough supply capacity to meet downstream water demand with little need to introduce a more precise water distribution system.

(b) The existing telemetry gauging network for the river water level is essential to monitor the natural flow discharge and to determine necessary water distribution to meet downstream requirements. The telemetry gauging monitoring is, however, currently not operational due to defects at one of the telemetry gauging stations.

(c) H-Q rating curves at the existing telemetry water level gauging stations are also essential to estimate natural river discharge based on gauged river water levels. However, such curves have not been updated since they were originally developed in 1999 and there reliability is now judged to be extremely low.

(d) No definite institutional setup exists to coordinate and define the daily water distribution

[1] Moreover, the present estimate of water resources of both Jeneberang and Jenelata Rivers is based on hydrological records taken at points downstream from village irrigation schemes. Therefore present assessment of water resources has already taken into account the water abstraction by and return flow from the upstream village irrigations.

volume among JRBDP, which is the present operator of facilities for water distribution, the various water users and the relevant coordination committees such as PTPA and PPTPA. The downstream water requirement is informed to JRBDP at irregular intervals and by indefinite water users.

(4) Drought Management

As described above, Bili-Bili Dam still retains sufficient supply capacity to meet downstream water demands, and Jeneberang River has not experienced a serious drought since Bili-Bili Dam started reservoir operations in 2000. Due to these conditions, a definite drought management system for Jeneberang River including the following items has not yet been established. A drought management program has also never been implemented since Bili-Bili Dam was completed in 1999:

(a) Priority of water supply during drought period;

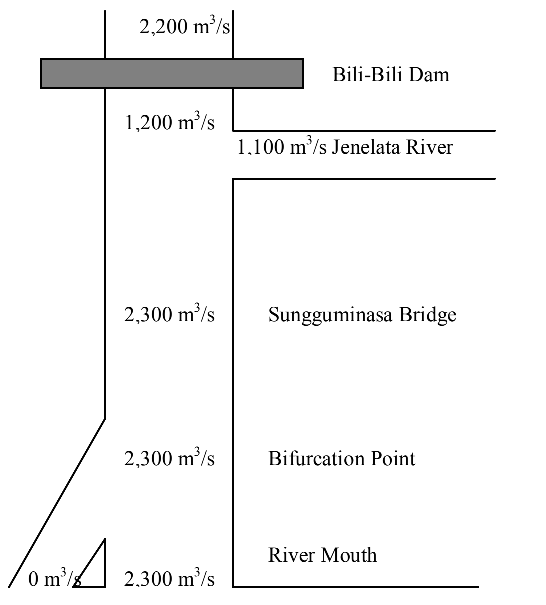
(b) Updating of the Reservoir Operation Curve, which defines daily reservoir operation and water level during the drought period; and

(c) Definite procedures to coordinate and determine reduction rate of water supply during the drought period.

7.2.2 Flood Management

The low-lying flood plain area spreads out in the densely populated areas of Makassar and Sungguminasa City downstream of Sungguminasa Bridge. In order to reduce the risk of flood overflow from the Jeneberang River to the flood plain area, river channel improvements have been implemented along a 9.5km stretch from the river mouth up to Sungguminasa Bridge. The improved river section currently has a flow capacity of 2,300m^3/s.

Following river channel improvement, Bili-Bili dam was constructed in 1999. This provides a flood control capacity of 41 million m^3 between the Normal Water Level (EL. 99.5m) and the Surcharge Water Level (EL. 101.60m). The flood control capacity of Bili-Bili dam was planned to control the flood discharge of the 50-year return period event along the river improvement section, at the same time maintaining a river flow capacity of 2,300m^3/s (refer to the flood design discharge as shown in the Figure to the right).



Flood Design Discharge (50-year Return Period) of Jeneberang River

Two large floods occurred after completion of Bili-Bili dam reservoir, in February 2000 and February 2002. The flood in February 2000 resulted in a peak dam inflow discharge of 1,670m^3/s. The gauged data of dam inflow discharge and flood runoff discharge of Jenelata River shows that if no flood control were available through Bili-Bili dam reservoir, the peak discharge at Sungguminasa Bridge would have reached 2,560m^3/s, exceeding the channel river flow capacity of 2,300m^3/s. The actual flood control by Bili-Bili dam was, however, executed in accordance with the specified gate operation procedures. As a result the release from Bili-Bili dam peaked at only 900m^3/s and used a flood control capacity of 14.6 million m^3. As a result, the actual peak discharge at Sungguminasa Bridge was controlled and reached only 1,650m^3/s (refer to Figure 7.4).

During the other flood in February 2002, Bili-Bili dam recorded a peak dam inflow of 1,960m^3/s. This corresponds to a flood with around a 25-year return period and was much larger than the event in 2000. During this flood, the water level gauging station on Jenelata River was washed away, and therefore the peak runoff discharge from the river is unknown. Nevertheless, the peak discharge released from Bili-Bili dam was limited to 850m^3/s, and any flood overflow of the Jeneberang River was not reported.

Judging from the operation records of Bili-Bili dam as described above, the present flood control operation for Jeneberang River is properly executed. The present flood control is, however, only possible for floods less than the design level (50-year return period) and no counter measures against more extreme floods exist. In order to minimize flood damage, including the death of people, during such extreme flood events, it is indispensable to formulate an emergency flood warning, fighting and evacuation system.

7.2.3 Control of River Area

"Government Regulation No. 35/1991" and "Provincial Regulation of Government of South Sulawesi No.5/1999" stipulated that the "River Borderline", as the outward river boundary to be managed by the river administrator, should cover the following areas:

Legal Outward Boundary of Jurisdiction by River Administrator

English Term	Indonesian Term	Definition
River Utilization Area	Daerah Manfaat Sungai	The area including: - **Water Body**: Whole extent of river, lake, and dam reservoir; - **River Corridor**: A certain extent of land along the water body, which has been acquired by the river administrator for the sake of river management; and - **River Retention Area**: A certain extent of land, which has been acquired by the river administrator for the specific purpose of flood control.
River Control Area	Daerah Penguasaan Sungai	The area including: - **River Corridor**: A certain extent of land along the water body, which is important for river administration but has not been acquired by the river administrator; - **River Retention Area**: A certain extent of land, which is retained as the future flood control work but has not been acquired by the river administrator. - **Flood Plain**: The potential flood inundation area in a certain scale of flood*.

* A probable flood of 50-year return period was applied in south Sulawesi Province
Note: The above English terms are based on literal translation of Indonesian terms

Of the above terms, the "Flood Plain" under the "River Control Area" is hardly defined due to difficulties in estimating the extent of the potential flood inundation area. Moreover, the "Flood Plain" in Jeneberang river basin would extend over a substantial part of Makassar City, where it is difficult to demarcate the administrative authorities of the local government and the river administrator. Due to this background, JRBDP, Dinas PSDA and any other present river administrative agencies do not currently possess any administrative authority over the flood plain in Jeneberang river basin.

It is further noted that there does not exist any "River Retention Area" under both River Utilization Area and River Control Area in Jeneberang River. As a result, the current potential area under jurisdiction of the river administrator would be limited to the Water Body and River Corridor both for the River Utilization Area and River Control Area.

The border of the River Corridor (i.e., the cross-sectional borders of the river area to be managed by the river administrator) is defined in accordance with the above Government and Provincial Regulations as listed below (refer to Figure 7.5):

Borderline of River Corridor

Type of Water Body	Borderline of River Corridor
River with dike in urban area	3m from edge of dike
River with dike in non-urban area	5m from edge of the dike
Major river (A>500km2) without dike in non-urban area	100m from the river bank
Minor river (A<500km2) without dike in non-urban area	50m from the river bank
Bili-Bili dam reservoir	Both of: – The land around the reservoir, which has a ground level between NWL and SWL of Bili-Bili Dam* – The land around the reservoir 50 m in distance from the shoreline of reservoir at NWL**

* : The land acquired by JRBDP as the dam operator.
** : The land as specified in the Provincial Government Regulation.

As described in Subsection 7.1.1, a river dike of about 9.5km in length was constructed along the main stream of Jeneberang River from the river mouth to Sungguminasa. The hinterland along the river dike is the urban area of Makassar and Sungguminasa. Accordingly, the extent of 3m from the edge of the river dike should be defined as the outer bound of the River Corridor. Likewise, upstream of the river channel improvement section is classified as the “major river without dike in non-urban area”; the 100m extent from the riverbank could be regarded as the outer bounds of the River Corridor.

JRBDP is currently responsible, as the affix of Ministry Public Works (MPW; former MSRI), to control these river corridors as well as their extent between the right and left dikes/banks. However, regular inspection of land use activities in the river area is hardly implemented. As a result, illegal activities such as sand mining without permit licensing and construction of houses in the river corridor are often seen along Jeneberang River.

7.2.4 Operation and Maintenance of River Infrastructures

The present practices relevant to the operation and maintenance of river infrastructures in Jeneberang river basin are described below:

(1) Jurisdiction for O&M Works of Facilities

JRBDP has been the implementing body for construction of all existing river infrastructures in Jeneberang river basin for over 14 years during which it has accumulated knowledge on the structures and/or their relevant mechanical facilities. Due to this background, JRBDP has prepared O&M manuals for the facilities and a substantial part of O&M works are also now being undertaken by JRBDP. JRBDP is, however, the affix of MPW (the former MSRI), and, therefore, O&M works in the Jeneberang River basin are apparently now under the jurisdiction of the central government. Due to the current national policy of decentralization, Dinas PSDA as the affix of the provincial government has begun to partially overtake the supervisory authority of JRBDP. Nonetheless, the boundary of supervisory authority between the Ministry of Public Works and

Dinas PSDA is not clear for JRBDP. The responsibility for O&M works will further shift to the provincial and local governments.

(2) Present Activities of JRBDP for O&M of Facilities

The O&M works for the existing river infrastructures are currently implemented by 52 staff members of JRBDP. The staff belongs to two (2) sections of JRBDP, namely "Jeneberang Water Resources Development and Management (PPSA)" and "Raw Water Development (PAB)". The annual budget of JRBDP in 2004 was Rp. 88 billion, of which Rp. 78 billion (89%) was allocated to water resources development. Thus, the present works by JRBDP are oriented to development work rather than O&M work. The budget of JRBDP from 2000 to 2004 are outlined below:

Budget of JRBDP for its Whole Administration Area in 2000 to 2004

(Unit: Rp. million)

Item	2000	2001	2002	2003	2004
Administration	853	897	1,633	1,181	1,483
Guidance/Planning	0	0	4,000	2,656	2,160
Development	80,177	18,601	4,728	16,662	78,465
Maintenance/Management	1,551	1,768	4,315	7,586	6,136
Total	82,582	21,266	14,676	28,085	88,245

The budget for maintenance/management for the whole area of jurisdiction for JRBDP has gradually increased from Rp. 1,551 million in 2000 to 7,586 million in 2003, although the budget slightly reduced from 2003 to 2004. Of the maintenance/management cost, the cost for Jeneberang River basin is summarized below:

Budget of JRBDP for O&M Works in Jeneberang River Basin in 2000 to 2004

(Unit: Rp. million)

Item	2000	2001	2002	2003	2004
O&M for Bili-Bili Dam	0	0	114	857	798
Rehabilitation of River Embankment	144	168	0	0	0
O&M for Rubber Dam/Drainage System	26	38	50	70	118
O&M for Raw Water Transmission Main	30	36	50	102	38
O&M for Long Storage	31	27	0	300	0
Total	230	268	214	1,329	954

As listed above, the cost for O&M works in Jeneberang river basin increased significantly in 2003 due to commencement of O&M for Bili-Bili dam. The O&M cost for Bili-Bili dam accounted for about 65% of the total O&M cost in 2003 and 84% in 2004. A rather substantial and continuous O&M cost has also been allocated to the Rubber Dam/Drainage System (Pampang Pumping Station) and RWTM. In contrast to these river infrastructures, however, the sand pocket dam /sabo dams and riparian structures such as river revetments, groynes and groundsills are not likely to have received any notable O&M work. Thus, the present O&M works are deemed to be inadequate.

7.3 Present River Management by PJT I and PJT II in Brantas and Citarum Basins

The present practices for river management by PJT1 and PJT II could be useful references for formulation of a river management plan by the new Public Corporation for Jeneberang River. From this point of view, they were reviewed through this Study with the results being summarized below.

7.3.1 Overview of Management

PJT I and PJT II currently undertake river basin management within the following working areas:

Working Area of PJT I and PJT II

Item	PJT-I	PJT-II
Name of objective river basin	Brantas and Bengawan Solo	Citarum and Ciliwung-Cisadane
Extent of catchment area	32,125 km^2	12,000 km^2
Number of rivers managed	64	74

Both PJT I and PJT II currently undertake comprehensive river basin management in the above working areas. This includes: (1) management of river infrastructures, (2) water quantity and quality management, (3) flood control management, and (4) river environmental management. However, there exists a distinct difference in the major concerns of river basin management by PJT I and PJT II.

PJT II directly undertakes management of hydropower generation and irrigation, which includes management for all primary, secondary and tertiary canals. On the other hand, PJT I takes a role in the supply of raw water, but management of hydropower plant as well as irrigation facilities (except intake weirs on the river) are the responsibility of PLN and Balai PSDA, respectively. PJT I also plays an important role in the control of negative impacts resulting from floods, sediment runoff and water pollution. Thus, the principal scope of river basin management by PJT I is oriented to more comprehensive river basin management, while that by PJT II is to increment the efficiency and effectiveness of the existing production infrastructures for hydropower generation and irrigation.

The major issues for river basin management in Jeneberang river basin are associated with raw water supply rather than management of hydropower generation and irrigation. From this viewpoint, the actual guidelines, procedures and/or manuals used for river basin management by PJT I serve as a better reference for management by the water corporation in Jeneberang river basin.

PJT I has prepared the basic procedures and job instructions certified by ISO 2000 for river basin management. The procedures and job instructions contain 66 items of categories related to river basin management including the procedures for O&M works. These were evaluated as being useful as a reference for preparation of O&M manuals for the water cooperation of Jeneberang River.

7.3.2 Water Quantity Management

PJT I simulates the water supply capacity of water resource development facilities based on updated water requirements in the year and the gauging record of reservoir water levels and dam inflows over the last six months. Based on the results of simulation, PJT I prepares a water allocation plan at the end of every dry and rainy season. The water allocation plan is submitted to PTPA and Dinas PSDA, and finally approved by the Vice-Governor.

In a drought year, the water demand is not fully supplied and is curtailed to a certain level in accordance with the water allocation plan. In fact, Brantas river basin has suffered from a critical drought and water demand has not been fully supplied for the last five years.

The priorities of water supply in a drought year are given in accordance with the “Law No. 11 in 1974” to the following water uses: (1) First priority for domestic & municipal water use, (2) Second priority for water use for agriculture, animal husbandry, plantation and fishery, and (3) Third priority for water use for energy, industry, mining, navigation and recreation.

7.3.3 Flood Management

PJT I prepares the “Annual Emergency Action Plan for Flood” once a year and submits to Dinas PSDA, Kabupatens and Committee for Flood Fighting, which is chaired by the Governor, at the end of every dry season. The plan contains the following items, which could be used for flood evacuation and flood fighting:

(1) Areas and residents in danger of flooding, which are identified through inspection of the river structures as well as land use on the floodplain;

(2) Available communication measures to the residents in danger of flooding;

(3) Procedures for flood forecasting and issue of flood warning, and

(4) Procedures for flood evacuation and flood fighting.

7.3.4 Management of River Infrastructures

Both PJT I and PJT II operate and maintain a full variety of river infrastructures including dam reservoirs, diversion weirs, intake facilities, check dams, and river structures such as groundsills, groynes and levees. Among others, PJT I operates eight dams, including Wonogi dam reservoir (storage capacity of 440 million m3) in Bengawan Solo river basin, and Karankates dam reservoir (storage capacity of 232.5 million m^3) in Brantas river basin. These dams aim to provide some 390 million m^3 of raw water for municipal use. In the Citarum river basin being managed by PJT II, three (3) major dam reservoirs exist, namely: Jatiluhur (storage capacity of 3 billion m^3), Cirata (2.2 billion m^3) and Saguling (1 billion m^3). These dam reservoirs contribute hydropower generation based on an installed capacity of 1,888 MW. PJT II is responsible for O&M of Jatiluhur dam.

O&M manuals written in Indonesia for all of the major river infrastructures have been prepared and updated through several revisions. The revisions are based on the difficulties encountered and the countermeasures taken in the actual O&M works. These could serve as references for O&M of water resources facilities in Jeneberang river basin.

7.3.5 Water Quality Management

Both PJT I and II sample river discharge as well as effluent from factories and analyze the water quality at their own laboratories. They also monitor the water quality of effluent from factories and collect a monitoring/testing fee from the factories. Based of the results of water quality monitoring, PJT I and II implement improvement works for water quality through releasing a river maintenance flow and/or de-clogging of solid wastes accumulated in the river channels. Nevertheless, they do not possess any legal capacity to enforce or control the effluent from the factories acting as point pollutant sources.

7.4 Proposed Water Quantity Management Plan for Jeneberang River Basin

7.4.1 Water Allocation Plan

JRBDP has granted an annual water requirement of 489.39 million m^3/year in total to be diverted from Jeneberang River. This granted diversion water requirement could be regarded as the customary water use right and adopted as the basis of water quantity management by the Public Corporation. The breakdown of this granted water requirement is listed below (refer to Table 7.2 and Figure 7.6).

Granted Annual Diversion Water Requirement from Jeneberang River

Month	Municipal Water Demand*1		Irrigation Water Demand *2		Takalar Sugar Factory Demand		River Maintenance. Flow		Monthly Total	
	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s	10^6m^3	m^3/s
Jan.	4.45	1.66	23.56	8.80	1.34	0.50	2.68	1.00	32.03	11.96
Feb.	4.02	1.66	0.00	0.00	1.21	0.50	2.42	1.00	7.65	3.16
Mar.	4.45	1.66	0.00	0.00	1.34	0.50	2.68	1.00	8.47	3.16
Apr.	4.31	1.66	57.36	22.13	1.30	0.50	2.59	1.00	65.56	25.29
May	5.79	2.16	79.46	29.67	1.34	0.50	2.68	1.00	89.27	33.33
Jun.	5.60	2.16	76.74	29.61	1.30	0.50	2.59	1.00	86.23	33.27
Jul.	5.79	2.16	72.33	27.01	1.34	0.50	2.68	1.00	82.14	30.67
Aug.	5.79	2.16	36.53	13.64	1.34	0.50	2.68	1.00	46.34	17.30
Sep.	5.60	2.16	19.66	7.59	1.30	0.50	2.59	1.00	29.15	11.25
Oct.	5.79	2.16	12.21	4.56	1.34	0.50	2.68	1.00	22.02	8.22
Nov.	4.31	1.66	0.00	0.00	1.30	0.50	2.59	1.00	8.20	3.16
Dec.	4.45	1.66	3.86	1.44	1.34	0.50	2.68	1.00	12.33	4.60
Total	60.35		381.70		15.79		31.54		489.39	

According to results of the water demand-supply balance simulation, the supply capacity of Bili-Bili Dam reservoir will be barely able to meet the water demand in 2018. At that time, shortage in water supply capacity to meet water demand will occur in a 5-year drought due to the incremental increase in municipal water demand (refer to Chapter 6). Hence, in order to ensure the present water demand against future incremental demands, and to establish more effective and fair rules over water allocation, a water use right (WUR) is necessary for Jeneberang River. From this viewpoint, it is proposed that the WUR should be granted to the above updated diversion water requirement of 489.39 m^3 million/year, since it prevails over general community recognition and therefore could be accepted as the customary water use. The proposed WUR would be based on the following concepts:

(a) The reservoir capacity of Bili-Bili dam could currently ensure full supply of the WUR both for municipal and irrigation water against a 10-year drought. However, the marginal drought safety level of the WUR for irrigation water use in particular should be set at the 5-year return period. Therefore, Bili-Bili dam reservoir capacity still possesses excess supply capacity for the present WUR.

(b) The excess supply capacity of Bili-Bili dam reservoir should be reserved to secure future incremental municipal water demand as an essential social need. According to the water supply-demand simulation, the reservoir capacity of Bili-Bili Dam would still meet full supply of the future 2018 municipal water demand (133.5 million m^3 and a maximum of 4.52 m^3/s) assuming the marginal drought safety level associated with a 5-year return period for irrigation water use (refer to Chapter 6).

(c) Water requirement for irrigation use is variable each year depending on rainfall. Moreover, the cropping schedules occasionally change, which also influences the variation in water requirements for irrigation. Thus, the actual water requirement for irrigation use is varied. In due consideration of these changes, the WUR for irrigation water is provisionally proposed on the basis of the following conditions:

  - The WUR should be limited to the above diversion water requirement of 381.7 million m^3/year granted by JRBDP.
  - The seasonal values of WUR should follow the standard cropping schedules for Bili-Bili, Bissua and Kampili irrigation schemes.
  - The actual water distribution for irrigation requirement should be decided annually through coordination with the irrigators, taking the above WUR grant into account.

7.4.2 Water Distribution Plan

In order to achieve a fair and effective water distribution for the above water allocation, the following items are proposed.

(1) Monitoring of River Flow Regime and Water Abstraction Volume

The Public Corporation, as the river basin management agency, has an obligation to distribute water for the requirement of the above WURs. In order to ensure the obligation, it is essential to precisely monitor seasonal variations in both river discharge and requirement of water users, and determine the appropriate water distribution based on the monitoring results. Such monitoring works would be more crucial especially after completion of the on-going Bili-Bili irrigation project.

From the above viewpoints, establishment of the monitoring system for the river flow and water intake discharge is proposed. The proposed system is used to monitor: (1) inflow/outflow of dam reservoir, (2) unregulated flow discharge from the Jenelata River, (3) river flow discharge below major water intake points and (4) water abstraction volume at all intake points, where the WUR is granted. Among these monitoring items, nos. (1) to (3) should be monitored by the Public Corporation, and no. (4) by the water users under surveillance of the Public Corporation.

Proposed Monitoring System for River Flow Discharge and Water Use

Objectives of Monitoring			Device for Monitoring	Monitored by
Monitoring of Flow Discharge	(1)	Inflow discharge to Bili-Bili dam reservoir	Dam Control and Monitoring System at Dam Control Office (Existing)	Public Corporation
	(2)	Outflow discharge from Bili-Bili Dam reservoir	Dam Control and Monitoring System at Dam Control Office (Existing)	Public Corporation
	(3)	PDAM Intake to Somba Opu WTP	Dam Control and Monitoring System at Dam Control Office (Existing)	Public Corporation
	(4)	Runoff discharge from Jenelata River	Dam Control and Monitoring System at Dam Control Office (Existing)	Public Corporation
	(5)	Flow discharge from Kampili Weir	Dam Control and Monitoring System at Dam Control Office (Existing)	Public Corporation
	(6)	Overflow discharge of the lower groundsill (at K5.97)	Staff gauge	Public Corporation
	(7)	Inflow discharge to Long Storage	Off-line gate opening gauge (exist)	Public Corporation
	(8)	Overflow discharge of Rubber Dam	Water level gauge at Rubber Dam (Existing)	Public Corporation
Monitoring of Water Use	(9)	PDAM Intake other than that for Soma Opu	Flow meter (To be newly installed)	PDAM Makassar and Gowa
	(10)	Bili-Bili Irrigation System	Staff gauge (Existing)	Dinas PSDA
	(11)	Bissua Irrigation System	Staff gauge (Existing)	Dinas PSDA
	(12)	Kampili Irrigation System	Staff gauge (Existing)	Dinas PSDA
	(13)	Takalar Sugar Factory	Flow meter (To be newly installed)	Takalar Sugar Factory
	(14)	River Maintenance Flow	Estimate from (6), (7) and (8) above	Public Corporation

The proposed monitoring network above includes water level gauging stations at Patarikan Gauging Station on the Jenelata River and Kampili Gauging Station on the Jeneberang River. In order to acquire precise information on the discharge from these water level gauging points, it is essential to revise the H-Q rating curves at the end of every rainy season.

7.4.3 Procedures of Water Distribution

In order to achieve sustainable water distribution throughout the year, the following work procedures for daily water distribution are proposed with reference to those currently applied by PJT I:

(1) Preparatory Works

The Public Corporation should undertake the following preparatory works before the end of May (the end of rainy season) and at the end of November (the end of dry season):

a) To check the updated water supply capacities/workability of water supply facilities, which include the following items:
   - Bili-Bili dam reservoir,
   - PLN hydropower station,
   - Raw Water Transmission Main (RWTM);
   - Three irrigation intake weirs, namely, Bili-Bili, Bissua, and Kampili weir.
   - Rubber dam and intake/outlet facilities for Long Storage; and
   - PDAM intake facilities.

a) To check and repair all flow meters and hydrological gauging devices to be used to monitor the daily operation of water allocation

b) To update the H-Q rating curves to be used to monitor the operation of the daily water allocation, as discussed below

c) To forecast the meteorological conditions for the succeeding six months based on the information from Meteorology and Geophysics Agency.

(2) Formulation of Water Allocation Plan

The Public Corporation should prepare a draft of the semi-annual water allocation plan at the end of May (end of the rainy season) and at the end of November (end of dry season). The draft of the plan should stipulate the updated water users and the seasonal variations of their water abstraction volumes for the next six months.

The draft plan is to be submitted to, evaluated and finalized by the Water Resources Coordination Committee (PTPA). PTPA would distribute the finalized semi-annual water allocation plan at least four (4) days before commencement of the daily operation for water allocation to the following relevant agencies:

a) Public Corporation

b) Dinas PSDA

c) Balai PSDA

d) PDAM Makassar

e) PDAM Gowa

f) Takalar Sugar Factory

g) PLN and

h) Other agencies as required

(3) Daily Operation for Water Distribution

Based on the above semi-annual water allocation plan, the Public Corporation should formulate the daily operation plan for water distribution, stipulating the time schedule of operation, the necessary personnel in charge and their duties. The Public Corporation is further required to undertake the following works:

a) To prepare assignment schedules of staff to be engaged (including the gate operator, observer/inspector, security force, telecommunications operator, etc.) every month;

b) To collect the bi-monthly water requirement from the following water users:
   - Balai PSDA, which estimates the water volume to be taken from three irrigation weirs (Bili-Bili, Bissua, and Kampili) to their respective irrigation areas taking into account the cropping schedules and effective rainfall;
   - Takalar Sugar Factory, which estimates the bi-monthly water requirement necessary for sugar plantations and refining; and
   - PDAM Makassar and Gowa, which estimate the necessary water intake volumes for their municipal water supply.

c) To estimate the possible discharge to be released from Bili-Bili dam reservoir to meet downstream water demand twice monthly, based on the above water requirement, the water storage volume stored in the reservoir and the necessary river maintenance flow.

d) To instruct PLN to release the discharge passing through the turbines of Bili-Bili Electric Hydropower Plant in accordance with the above estimation.

e) To monitor and measure the results of daily water allocation.

f) To rearrange water allocation in accordance with Steps 1 to 3 for drought management on the basis of approval by PTPA as described in the following Subsection 7.4.4, if difficulties arise in fulfilling the requirement of water users as programmed in the semi-annual water allocation plan due to the drought.

g) To compile the following records:
   - Daily reservoir operation record including daily water supply volumes to each water user
   - Records of collection of water service fee from the users

h) To review the daily water allocation executed for the foregoing six months, and to make the necessary revisions on the procedures for daily water allocation, as required.

7.4.4 Drought Management Plan

Bili-Bili dam reservoir is operated during normal years to fulfill the entire requirement for downstream water use. However, should the dam unconditionally release its stored water in accordance with downstream water requirements, the available supply capacity of the dam reservoir could possibly drop to zero during an extreme drought year. This would cause a sudden and drastic reduction in available water supply for the whole water use community.

According to the results of the water demand-supply simulation, of the 30 years from 1972 to 2001, three hydrological years[2] in 1972/1973, 1982/1983 and 1997/1998 were identified as being extreme drought years, that is with a recurrence interval of 10-years or more (refer to Figure 7.7). During these three years, the dam supply capacity could not meet the entire requirement of the allocated water demand.

The year of 1972/1973 in particular was recognized as being the most severe drought year, with less rainfall throughout the rainy season. On the other hand, 1982/1983 and 1997/1998 resulted in drought conditions only because the dry season lasted about one month longer than usual. If the Bili-Bili Dam had maintained full supply of the allocated water demand in the year 1972/1973, the low dam reservoir storage levels would have continued from the later half of June to the end of November. On the other hand, in 1982/1983 and 1997/1998, the period of the low reservoir storage was limited to less than one month.

During the above three drought years of 1972/1973, 1982/1983 and 1997/1998, the allocated water demand could not be fully supplied, and a reduction in water supply would have been required. In this connection, the priority of water supply and the procedures for its reduction in drought years are proposed as being essential issues for drought management, as discussed below.

(1) Priority of Water Supply in Drought Years

The priority of supply during the drought years (those exceeding a 10-year return period) should be given to municipal water supply and supply for river maintenance flow. These priority water supplies are the basic need for communities, and the objective of reducing water supply in a drought year should be addressed to the irrigation water supply.

(2) Updating of Reservoir Operation Curve

The Reservoir Operation Curve (RC) defines the lowest daily reservoir water level rule. The dam operator is required to always maintain the reservoir water level (RWL) above RC so as to facilitate drought management. The RC was developed as a curve, which envelops the overall lowest daily reservoir water levels (RWLs) estimated. This was based on the water

[2] The hydrological year is herein defined as a hydrological cycle of a year from the beginning of the dry season (June 1st) to the end of the next rainy season (May 31st).

supply-demand simulation under the past low flow regimes from the period from 1972 to 2001, excluding those in the above extreme drought years of 1972/1973, 1982/1983 and 1997/1998.

Thus, the RC is closely related to the allocated water demand and should be updated according to every renewal of water allocation. However, the present Bili-Bili dam reservoir operation is based on the RC established in 1993. No updating of the RC has been made despite changes in downstream requirements of water users. In this connection, the RC was revised based on the new water allocation as proposed in the above Subsection 7.4.1 and the past low flow regime from 1972 to 2001 (refer to Figure 7.8). The present and newly revised RCs are listed below. Detailed reservoir operation plans based on the newly developed RC are described in item (3) below.

Present and Proposed Reservoir Operation Rule Curve

Month	RC on the beginning of the Month (EL. m)	
	Existing	Newly Proposed
May	99.0	84.0
Jun.	95.0	88.5
Jul.	88.0	84.0
Aug.	81.0	79.5
Sep.	74.0	75.0
Oct.	66.0	70.5
Nov.	65.0	66.0
Dec.	67.0	66.0

Note: The daily RCs are defined as the values interpolated from the above RCs at the beginning of each month.

(3) Procedures to Reduce Supply to Allocated Water Demand in Drought Years

The operator of the dam reservoir needs to firstly reduce the irrigation water supply in advance before the RWL drops below the RC. In order to facilitate the appropriate reduction of water supply, the basic concepts for the necessary procedures were provisionally determined as below:

Basic Concept on Procedures for Reduction of Water Supply

Step1: (Stand by)	A particular dam operation team against drought should be organized when the RWL and/or daily rate of reduction of RWL reach a certain designated level showing an initial incidence of drought. The team should undertake the following tasks: (a) to estimate the expected dam inflow discharge based the long-term weather forecast, (b) to inform the relevant water council and water users about possibility of reduction of irrigation water supply.
Step2: (Coordination)	When the RWL continues to drop at the critical rate, the dam operation team should estimate the necessary reduction of irrigation water supply and propose the estimated value to the water council and water users.
Step3: (Reduction of Irrigation Water Supply)	When the RWL reaches a certain critical level, the dam operation team should execute the necessary reduction of irrigation water supply as estimated in Step2.
Step4: (Stop of Irrigation Water Supply	When the RWL reaches RC, the dam operation team should totally stop the supply of irrigation water.

Based on the above concept, the definite procedures for reduction of water supply were further examined through trial simulation for the low flow regime in the extreme drought years of

1972/1973, 1982/1983 and 1997/1998. As a result, the following drought management procedures are proposed:

Proposed Procedures to Reduce Water Supply in Drought Years

Steps	Approx. Leading Time to Next Step	Flood Discharge/Water Level to Commence the Steps	Necessary Activities
Step1: Standby	10days	• {RWL < RC +2.0m} and • The daily descending rate of RWL >0.25 m/day	• Set up a dam operation team against drought • Estimate the expected dam inflow discharge based on the long term weather forecast • Inform the relevant water councils/committees and water users about possible reduction of irrigation water supply
Step2: Coordination	5days	• {RWL < RC + 1.0m} and • The daily descending rate of RWL >0.25 m	• Estimate the necessary reduction of irrigation water supply • Propose the above estimated value to water council and water users
Step3: Reduction of Water Supply for Irrigation	2days	• {RWL < RC + 0.5m} and • The daily descending rate of RWL >0.25 m	• Execute the above estimated necessary reduction of irrigation water supply
Step4: Stop of Irrigation Water Supply	-	• When RWL = RC	• Reduce 100% of irrigation water supply
Step4 Stop of Whole Water Supply	-	• When RWL = LWL	• Reduce a certain volume of municipal water supply from dam reservoir

According to results of the water supply-demand balance simulation, the above-proposed procedures for reservoir operation would require the following reductions of irrigation water supply for dry paddy, wet paddy and palawija in case of the drought years experienced in 1972/1973, 1982/1983 and 1997/1998 (refer to Figure 7.9).

Simulated Necessary Reduction Rates of Irrigation Water Supply in Drought Year

Drought Year	Reduction Rate Rates of Irrigation water		
	For Dry Paddy	Palawija	Wet Paddy
1972/1973	55%	100%	0%
1982/1983	0%	0%	20%
1997/1998	0%	100%	0%

Note: Irrigation Period for Dry Paddy = from June to September for Dry Paddy
Irrigation Period for Palawija = from July to December
Irrigation Period for Wet Paddy = from November to May

7.5 Proposed Flood Management Plan for Jeneberang River Basin

7.5.1 Plan for Flood Warning, Evacuation and Fighting

As described in the foregoing Subsection 7.2.2, the flood control capacity of Bili-Bili dam reservoir as well as the river channel flow is limited to being able to cope with the 50-year return period flood. Once floods exceed the design capacity, disastrous flood damage including death of people is expected due to floods overflowing the river. Despite this, no flood warning and evacuation plan exits against extreme floods above the design flood. Hence, the following flood management plan was preliminarily delineated in this Study.

(1) Setup of Flood Warning Levels

The warning levels are classified into: (1) Step1 for Standby, (2) Step2 for Warning, and (3) Step 3 for Evacuation/Flood Fighting. These were determined based on the discharge/water levels gauged using the following four principal telemetry stations (refer to Figure 7.10):

Principal Hydrological Gauging Stations for Flood Warning and Evacuation

Name of Gauging Station	Hydrological Data to be Gauged	Critical Discharge to Initiate Each of Steps for Flood Warning and Evacuation		
		Step 1	Step 2	Step 3
Bili-Bili Dam	Bili-Bili Dam Inflow Discharge	642.3m^3/s	1,000.0m^3/s	1,200.0m^3/s
Patarikan bridge	Discharge of Jenelata River	400.0m^3/s	900.0m^3/s	1,100.0m^3/s
Kampili Weir	Discharge of Jeneberang River	1,150.0m^3/s	1,800.0m^3/s	2,300.0m^3/s
Maccini Sombala	Water Level Below Crown Level	1.5m (EL. 4.7m)	1.0m (EL. 5.2m)	0.6m (El. 5.6m)

Note:
Step1 corresponds to the probable flood with about a 2-year return period,
Step2 corresponds to the probable flood with about a 20-year return period
Step3 corresponds to the probable flood with about a 50-year return period

In addition to the above principal gauging stations, there also exist several water level and rainfall telemetry gauging stations that transmit their gauging data to the Dam Control Office and Monitoring Office (refer to Figure 7.10). These should be used as supporting gauging stations and their gauged data taken into consideration as reference for forecasting of succeeding flood conditions.

Sub-Hydrological Gauging Stations for Flood Waning and Evacuation

Name of Gauging Station	Hydrological Data to be Gauged	Use of Gauged Data
Jonggoa Bonto Jai	Water level of the upstream of Jeneberang River from Bili-Bili Dam	Evaluate the succeeding tendency of the increase/ decrease of dam inflow based on rise/drop of the gauged water level.
Bayang	Tidal level at river mouth of Jeneberang River	Evaluate the succeeding tendency of the rise/drop of the downstream water level of Jeneberang River on rise/drop of the gauged tidal level.
Malino Jonggoa	Rainfall in upper reaches of Bili-Bili Dam	Evaluate the succeeding tendency of the increase/ decrease of dam inflow based on the increase/ decrease of the gauged rainfall.
Limbua Mangepang	Rainfall in Jenelata River Basin	Evaluate the succeeding tendency of the increase/ decrease of the downstream discharge of Jeneberang River based on increase/decrease of the gauged rainfall.

(2) Required Work Activities at Each Flood Warning Level

The Public Corporation would place its flood-warning center at the existing Monitoring Station for Bili-Bili Dam in Makassar City. This is where the Operation Director of Public Corporation should be stationed during a flood to make all critical determinations and issue flood warning, evacuation and fighting statements. A further secondary center would be placed at the Dam Control Office at Bili-Bili dam site. Its functions would be to undertake the necessary flood control operation of gate facilities at Bili-Bili Dam based on the flood conditions (flood discharge, rainfall intensity and dam inflow discharge). The Public Corporation for the proposed flood warning center would undertake the following activities during the flood:

(a) Works for Step 1 of Warning Levels

When the dam inflow discharge, river flow discharge and river water level reach levels associated with Step 1 of the warning level, the following activities should be implemented:

- Monitoring of river flow discharge and water at the principal and sub-flood monitoring points specified in Subsection 7.5.1,
- Forecasting flood conditions based on the above monitoring river flow discharge and water level stations as well as the meteorological information provided from Meteorology and Geophysics Agency (BMD),
- Start flood control operation of dam reservoir,
- Stand by a team for patrol of the potential flood area along the river course, and
- Stand by a team to disseminate flood evacuation warnings to the residents.

(b) Works for Step 2 of Warning Levels

When the dam inflow discharge, river flow discharge and river water level reach levels associated with Step 2 of the warning level, the following activities should be implemented:

- Start river patrol along the potential flooding area,
- Disseminate the necessity for flood evacuation to the residents,
- Stand by a term to carry out emergency protection works against flooding, and
- Issue flood warning to the external relevant organizations as required.

(c) Works for Step 3 of Warning Levels

When the dam inflow discharge, river flow discharge and river water level reach levels associated with Step 3 of the warning level, the following activities should be implemented:

- Issue request for flood evacuation to the external relevant organization,
- Dispatch a team to facilitate flood evacuation and flood fighting,
- Request the Implementation Unit for Disaster Management (SATLAK PB)[3] to mobilize their personnel, heavy equipment and materials to execute necessary prevention works against flood overflow under technical instruction from the Public Corporation and the necessary rescue works in case of occurrence of flood overflow.

(d) Works after Flood

The Operation Director of Public Corporation would announce the end of flood operation, once the flood is judged to have subsided. This would be based on a comprehensive evaluation of hydrological information from the telemetry gauging stations and

[3] The SATLAK PB is composed of (a) Mayor of Makassar City as the head of SATLAK PB, (b) the territorial military commander (PALGDAM) and/or the commander of regional military administrative unit (DANREM) as the deputy head of SATLAK PB; (c) the head of provincial police (KAPOLDA) and/or the head of regional police (/KAPOLWIL) as the another deputy head of SATLAK PB; (d) the heads of relevant provincial and regional government agencies such as Water Resources Management Services of Public Works and Housing, Planning and Urban Development Service of Public Works; and (e) the relevant regional communities.

metrological information furnished by the Meteorology and Geophysics Agency. The Operation Director may further need to request the Governor of South Sulawesi Province to make necessary coordination for the technical/financial support from the central government, as the member of National Coordination Board of Disaster management (BOKORNAS PB).

7.5.2 Development and Dissemination of Flood Risk Map

Earth embankment was constructed in 1993 along the right and left bank of Lower Jeneberang River 9.6km long from the river mouth to Sungguminasa Bridge. The embankment together with the flood storage capacity of Bili-Bili Dam was designed to cope with the probable flood discharge of 50-year return period. However, once an extreme flood with a recurrence probability above 50-year return period occurs, the river flow would overtop the embankment and flow into the hinterland. The flood could further possibly wash a substantial part of the embankment away, since the crown level of the embankment is higher than the ground level of the hinterland. Hence, in order to minimize the disastrous flood damage, which may involve death of the residents, dissemination of flood risk map is proposed.

Dissemination of the flood risk map has been broadly adapted throughout the world as one of the useful non-structural flood mitigation measures. Through dissemination of the flood risk map, the residents are made aware of the extent of the potential flood inundation area and the available evacuation routes during a flood. The flood risk map can also provide guidance for appropriate urban planning and land development.

The movement of flood overflow discharge is highly influenced by the topographic conditions (i.e., undulations and ground levels) in the hinterland. The movement is also varied by the uncertain factors such as location of flooding over embankment, and flood hydrological conditions in the river basin (i.e., the spatial and temporal variation of the storm rainfall and the variations of flood runoff hydrograph). Despite of these complex and uncertain factors on the movement of flood overflow, the available information on them is limited to the following items in case of Jeneberang river basin:

(a) Ortho-photo contour maps with ground levels at 1.0 m intervals, which were developed under the “Bili-Bili Irrigation Project in 2000”,

(b) The existing dike levels and/or design high water levels of Jeneberang River for a design discharge with a 50-year return period; and

(c) The actual inundation area in the 1976 flood estimated through an interview survey of residents in the Study on “Jeneberang River Flood Control Project (Phase II), by JICA in 1983”.

Due to the limitation on information, it is virtually difficult to estimate the precise extent of flood inundation. Nevertheless, the water head of the flood overflow is most likely to be less than the crown level of the embankment considering that the flood overflow could possibly wash a substantial part of the embankment away as described above. From these viewpoints, the low-lying areas with the ground levels below the design high water level were preliminarily outlined as the maximum extent of the potential flood area. Then, the area, where the flood overflow could be interrupted by the roads, the dikes of drainage channels and other boundaries with high ground levels, were identified based on the actual flood inundation area in 1976, and such areas were excluded from the potential flood inundation area.

As a result, potential flood inundation area was preliminarily estimated to cover about 58.5km^2 spreading out over a substantial part of Makassar and Sungguminasa City on the right bank of the Jeneberang River, as shown in Figure 7.11. The areas not inundated would be the east part of Makassar City surrounded by the dike alignments of Jongaya, Panampu drainage channels, north of the Jalan Urip Sumoharjo, and the slightly elevated area in and around Kel. Tibung and Bontomakkio. In contrast to the area on the right bank, the possible inundation area on the left bank is confined to a rather limited area between the dikes of the Jeneberang River and the Garassi River.

In addition to the above flood inundation areas, particular attention should be given to illegal dwellers living in the flood high water channels. The areas of illegal dwellers are designated as river utilization areas and are exposed to a high risk of flood damage. Accordingly, the Public Corporation should exert maximum effort to evacuate the illegal dwellers and at the same time, record the location of all illegal dwellers in advance so at to issue early warnings to them during periods of flood. The dominant areas of illegal dwellers are outlined below:

(a) The stretch along the left bank 2 to 3 km upstream from the river mouth (just downstream from the Rubber Dam); and

(b) The stretch along the right bank 5 to 6 km upstream from the river mouth (adjacent to the existing groundsill).

The evacuation centers as well as evacuation routes would be placed to the west side on the Sinrijala-Panampu, or east of the Central Ring Road. However, their detailed locations could not be specified in this Study due to the limited information, and should be designated in the future by the relevant local government agencies based on the base flood risk map. The flood risk map thus prepared should be disseminated to the public through a bulletin, an information board and other available information tools.

7.6 Proposed Management Plan of River Area in Jeneberang River Basin

7.6.1 Extent of River Area

As described in Subsection 7.2.3, the cross-sectional extent of the river area to be managed by the river administrator would cover the water body and river corridor with a certain width along the water body. On the other hand, there does not exist any clear definition on the longitudinal extent of the river area. JRBDP is the present principal river administrator for Jeneberang River, and its authority is likely to prevail over the main stream of Jeneberang River from the river mouth up to Bili-Bili Dam, at least. Upstream of Jeneberang River and/or along the tributaries of Jeneberang River, however, there does not exist a clear definition on the administrative boundary between JRBDP and other possible administrative entities such as Dinas PSDA and local governments at Kabupaten level. Moreover, when a certain level of river administration authority is handed over to the Public Corporation, it is extremely difficult for the Corporation to manage the overall river systems due to its limited manpower and budgetary capacity.

From these viewpoints, it is proposed that the Public Corporation would initially manage the following river stretches of Jeneberang River, their associated river control areas and river structures, as proposed in Chapter 9. These proposed river stretches contain the principal river infrastructures and/or possess significant hydrological/ hydraulic effects on the flood and water quantity management.

Longitudinal Extent of River Area to be Managed by Public Corporation

River	Stretch	Length	Classifi-cation*	Remarks
Mainstream (1)	From river mouth to Sungguminasa Bridge	9.60	A	1st order River
Mainstream (2)	From Sungguminasa Bridge to Lengkese Village	75.90	B	1st order River
Long Storage	From river mouth to confluence with the mainstream	4.50	A	2nd order River (old channel of Jeneberang River
Jenelata River	Between the confluences with the mainstream and Sapaya Village	38.45	B	2nd order River (the largest tributary)
Binanga Tokka	From the confluence with the mainstream to Sapakeke Village	24.26	B	3rd order Ricer (tributary of Jenelata River)
Salo Malino	From the confluence with mainstream to Sabo Dam No.6	18.67	B	2nd order River
Kausis	From the confluence with mainstream to Sabo Dam No.8	18.91	B	2nd order River
Total		190.29		

*: Classification of River A = Land of the river corridor has been acquired by the river administrator.
Classification of River B = Land of the river corridor has not been acquired by the river administrator
.

7.6.2 Extent of Authority of Public Corporation for Watershed Management

The river administrator would possess direct authority to manage the aforesaid river area, but would have little authority in terms of watershed management over the entire river basin. Instead, the principal function of watershed management should be delegated to the organizations relevant to forest management and soil conservation. These are represented by the Watershed Management Center (Balai Pengelolaan Daerah Aliran Sungai) and the function of the river administrator is oriented to collaboration with these organizations. Refer to Chapter 8 for further description of watershed management.

7.6.3 Development of Inventory of River Area

In order to facilitate the management of the river area, it is proposed that the Public Corporation should develop the inventory of the river stretches and river corridors in its river area. The inventory should be made based on the following segments of river stretches/corridors:

(1) An approximately uniform morphology for a river and river corridor of about 500 m in longitudinal length,

(2) A shorter length of river and river corridor displaying a particular problem, if it exists, such as severe bank erosion, and

(3) A shorter length of river containing a particular structure of interest.

It is further proposed that each of the above segments should contain the following information (refer to Supporting Report E for details):

(1) Classification for each segment of river corridors including the information of a unique identity number of the segment, name of river/river basin, type of river corridors (either with-levee or without-levee), name of adjacent village, riparian structures located along the river corridor, and GPS coordinates/ channel length of the segment.

(2) Land use states of river corridor including information on land ownership, classification of land use, type and densities of vegetation and sand mining activity, if any, together with evaluation on whether or not the activity could cause danger to the levee.

7.6.4 Land Use Control in River Area

As described in Subsection 7.2.3, the river area could be classified into the following three categories: (a) river utilization area, where land of the river corridor had been acquired by the river administrator, (b) circumference of Bili-Bili dam reservoir, where the land with ground levels below SWL (EL.101.6 m) had been acquired by the river administrator; and (c) river control area, where the land is privately-owned. These three types of river areas would differ in criteria of land use control as described below:

(1) Land Use Control in River Utilization Area

Land use in the high water channel along the existing river dike from the river mouth to Sungguminasa (9.5 km in length) should be subject to approval by the Public Corporation, and any illegal land use therein should be strictly prohibited. The existing illegal dwellers in the flood channel area in particular are a great hindrance to the safe passage of flood discharge, and at the same time they are exposed to a high risk of flood damage. Accordingly, major effort for land use control should be oriented to evacuation of these illegal dwellers.

The allowable land uses in the flood high water channel should be limited to those for public interest such as river-parks and public grounds. Moreover, structures in the flood high water channel should be limited to those that would not hamper flood flows and/or riparian structures such as water level gauging stations and drainage sluices, which must be constructed within the river corridor.

(2) Land Use Control in River Control Area

The river corridor 100m wide along both the right and left river banks of the upstream channel above the river utilization area could be specified as the river control area. The land of this river corridor is privately owned, and therefore, the Public Corporation would hardly execute the authority of land control over the river corridor. Nevertheless, the Public Corporation should monitor the progress of land exploitation in the river corridor, and control any excessive exploitation whenever it is judged to have significant effects on the river morphology, river flow conditions, and/or river environment.

(3) Circumference of Bili-Bili Dam Reservoir

Any removal of grass/trees and/or logging activities in the circumference of the dam reservoir as designated in Sub-section 7.2.3 should be subject to approval of the Public Corporation so as to preserve the existing green belt around the dam reservoir. Moreover, all construction works in the circumference of the dam reservoir should be subject to approval by the Public Corporation on the basis that construction of structures except those for public interest, such as roads and riparian structures, should be prohibited in the area.

7.6.5 Plan for Control of Sand-mining

As described in Chapter 3, the current excessive sand mining activities have caused serious degradation of the downstream riverbed of Jeneberang River below Bili-Bili dam. In order to minimize this, any sand mining activities below Bili-Bili dam should preferably be prohibited, and the mining sites should be transferred upstream of the dam. The potential sand mining sites upstream of Bili-Bili dam could be at the upstream end of the reservoir area and the sabo pocket dams Nos.1 to 4, as shown in Figure 7.12.

Many difficulties are, however, foreseen in completely ending the downstream mining in due consideration of accessibility to the upstream mining site and disputes on conventional territories of each sand miner. From these viewpoints, it is proposed that the relevant authorities should stop any renewal of mining licenses for the downstream channel below Bili-Bili dam and at the same time, the Public Corporation should undertake the following activities:

(1) Carry out a river channel survey at the end of every rainy season and clarify the tendencies of riverbed degradation at each major river structure based on the results of the river channel survey;

(2) Estimate the sediment deposition on the riverbeds at each of the major river structures after stopping renewal of mining licenses;

(3) Estimate the allowable sand mining volume and available mining sites on the downstream reach of Jeneberang River based on the results of clarification on the above.

(4) Carry out a river patrol to control illegal sand mining activities.

7.6.6 Prevention Plan against Sediment Runoff from Collapse of Mt. Bawakaraeng

As described in Chapter 3, the collapse of a quay in the caldera of Mt. Bawakaraeng is now producing a tremendous volume of sediment runoff, which could fill about 90% of the dead storage capacity of Bili-Bili Dam (29 million m^3) within five years. Moreover, the collapse has produced several natural ponds in the caldera of Mt. Bawakaraeng. Should these ponds break out, a tremendous volume of impounded water would flow down with debris causing extensive damage to the residents and houses in the lower reaches. In order to reduce the sediment accumulation in the dam reservoir and at the same time preventing the water impounded in the natural ponds from flowing down, JRBDP is going to implement urgent countermeasures as recommended by the JSUIT, as described below. In this connection, the Public Corporation would need to undertake monitoring works on the sediment runoff, in parallel with the implementation of the urgent countermeasures.

(1) To increase sand trap capacity of sand pocket dams and sabo dams based on the following measures: (a) excavation of the sediment deposits at the existing sand pocket dams/sabo dams, (b) raising height of the existing sand pocket dams and sabo dams, (c) construction of the new sabo dams[4], and (d) rehabilitation of the existing damaged sand pocket dams and sabo dams;

(2) To construct a waterway (such as drainage channel and siphon) to drain the water impounded in the ponds;

(3) To establish a monitoring system including assigning of watchman and setting of telemetry hydrological gauging stations at critical points;

(4) To establish mudflow warning system including: (a) organizing of the community network[5], (b) setup of the warning siren, and (c) use of the radio broadcast system for early warning; and

(5) To disseminate the hazard map.

---

4 Eleven sabo dams are proposed. One is about 1.2 km downstream from Daraha Bridge and other ten dams are about 1.5 km upstream from the Bridge.

5 The community named "Komunitas Sabo Jeneberang" has already been established for the sake of early dissemination and evacuation against the mud-flow.

7.7 Operation and Maintenance (O&M) Plan of River Infrastructures

7.7.1 Objective River Infrastructures for O&M by Public Corporation

As described in Sub-section 7.2.4, JRBDP currently undertakes O&M of a variety of river infrastructures. All infrastructures other than the urban drainage facilities are indispensable for the consistent management of Jeneberang River, functioning as important water source/water distribution facilities as well as flood mitigation facilities for a wide range of beneficiaries.

On the other hand, the urban drainage facilities contribute to the benefit of Makassar City and their function is less related to consistent river management. Due to the particular functions of facilities, the Public Corporation should undertake O&M for all river infrastructures other than the urban drainage facilities, while O&M for the urban drainage facilities should be handed over directly to Makassar City.

The limits of O&M by Public Corporation should extend to the Flush Gate placed at the outlet of Long Storage, and O&M of all drainage facilities located downstream of this site should be under the authority and responsibility of Makassar City.

7.7.2 Expansion Program of O&M by Public Corporation

Due to the limited potential human resources and budgetary constraints, it is deemed to be difficult for the Public Corporation to initially undertake O&M for all river infrastructures as proposed in the above subsection, and the following expansion program of O&M is proposed:

(1) O&M During First Two-year Operation Period

It is proposed that O&M by Public Corporation should focus on the following facilities during its first two-year period of operation in 2007 and 2008:

- Bili-Bili Dam and its associated Raw Water Transmission Main (RWTM);
- Rubber Dam and Long Storage; and
- Three irrigation weirs of Bili-Bili, Bissua, and Kampili.

All of these river infrastructures are indispensable to ensure the sustainable water supply for the specific water users such as PLN, PDAM and the farmers, and the higher priority of O&M should be given to them. Moreover, Public Corporation could collect its water service fee from the water users other than farmers, which would contribute a substantial part of the revenue for Public Corporation. It is herein noted that difficulties are foreseeable in collecting the water service fee from the farmers according to the new water law[6]. Nevertheless, of the overall water abstraction

---

[6] The new water law in 2004 prescribes that the necessary O&M cost only for the tertiary irrigation channel would be charged to the farmer but the farmer is not the subject of collection of any irrigation service fee.

volume from Jeneberang River the irrigation requirement accounts for about 80%. Accordingly, operation of irrigation weirs is influential in managing the entire water distribution of Jeneberang River and indispensable for the consistent river management of Jeneberang River.

(2) O&M After First-Two-year Operation Period

Public Corporation should add the following facilities as additional objectives of their O&M works after the first two-year operation period (i.e., from 2009 onwards):

- Four sand pocket dams and three sabo dams (other than Sabo Dam No.4, which was seriously damaged and abandoned) in upper reaches of Bili-Bili dam reservoir, and
- Riparian structures such as embankment, revetment, groyne, and groundsill, and sluices along the downstream reach of Jeneberang River from the river mouth up to the Sungguminasa Bridge.

Both sand pocket dams and sabo dams could reduce the sediment inflow into Bili-Bili dam reservoir contributing to a longer durable life for the reservoir and preservation of a suitable river channel morphology. The riparian structures also play an important role for flood mitigation in the low-lying area along the downstream reach of the Jeneberang River. Thus, all facilities are important for river management but are rather independent from the daily water distribution, and Public Corporation could hardly obtain revenue through O&M of these facilities. Accordingly, O&M of the facilities should preferably be undertaken by JRBDP during the initial operation stage of Public Corporation and turned over from JRBDP to Public Corporation, after the latter secures a more stable revenue from other service sources.

7.7.3 Development of Inventory and Location Map of Water Resources Facilities

There exist neither a detailed inventory nor detailed location maps for all existing river infrastructures. In order to achieve the effective inspection and maintenance, an inventory of all major river infrastructures in Jeneberang river basin should be developed and updated. This would contain the following information:

(1) A unique identity number (ID) and name of each infrastructure,

(2) Location of the infrastructure and name of river on which the infrastructure is located; and

(3) Structural size, type and quantities of river infrastructures.

A preliminary inventory of river infrastructures as of 2004, as well as the location maps of the river infrastructures located from the river mouth to Sungguminasa, were developed in this Study as shown in Table 7.3 and Figure 7.13.

7.7.4 Maintenance Plan

The Maintenance Plan aims at detecting and rehabilitating deterioration in the function of facilities including fatigue/deterioration of facilities and mechanical problems. The works are broadly classified into the following three categories:

(1) Preventative Maintenance: This aims at keeping the originally designed function of the river infrastructure through the following three activities:

- Routine Maintenance, which includes all repetitive activities to be performed throughout a year such as lubrication of mechanical facilities, removal of weed/garbage, and removal of sediment deposit,
- Periodic Maintenance, which includes all activities such as overhaul of mechanical facilities and re-painting of substantial parts of metal sections, to be performed at intermittent intervals in accordance with a schedule programmed beforehand, and
- Small Repair Work, which includes works of a small-scale necessary for restoration of a facility such as repair of small cracks, holes or detachment on structures and replacement of damaged facilities.

(2) Corrective Maintenance: This aims at more substantial repair/replacement works than the Preventative Maintenance to restore a facility, which has considerably reduced its function as originally designed due to operating beyond the period of durability and/or destructive damage. The ongoing rehabilitation works for the damaged Rubber Dam, Groundsill No.2 and Sand Pocket dam No.4 are outlined as typical cases of the Corrective Maintenance. It is herein proposed that the repair works costing more than about Rp. 500 million should be classified as Corrective Maintenance, while those of less than Rp. 500 million would be small repairs.

(3) Emergency Maintenance: This is executed against the imminent failure of infrastructures due to extensive disasters such as floods, landslides and earthquakes.

Among others, the Preventative Maintenance could be performed based on a definite and consistent maintenance plan. On the other hand, both the Corrective and Emergency Maintenance are ad-hoc works in nature, and it is extremely difficult to formulate in advance a consistent annual plan for them. Moreover, when the Preventative Maintenance is adequately achieved, Corrective Maintenance could at least be minimized. From these viewpoints, the maintenance plan should be formulated for Preventative Maintenance, and in due consideration of the present states of river infrastructures, the standard maintenance works were delineated as described in Volume IV-1 "Part I - Guidelines and Manuals for River Infrastructure Operation and Maintenance".

The maintenance works, except for relevant inspection works, could hardly be executed and paid by Public Corporation, particularly during its initial operation stage, due to difficulties in effective use of heavy equipment and machines. It is commercially better to spend the budget for maintenance directly on actual mplementation of contracts through the following measures[7]:

(1) Direct appointment of small Class C2 contractors with contract values up to Rp. 50 million using highly standardized contracts, and
(2) Award of large proportion of the work to large contractors of more than one year based on "period contract", where the unit prices are tendered for and fixed, and there is flexibility in directing actual work item packages and quantities during the course of the contract.
(3) The small repair work would be executed based on the sketch drawing of the area and a standard typical drawing together with brief work instruction and technical specification but without detailed design. It is desirable, whenever possible, to implement the works by labor-intensive means using local labor.

7.7.5 Operation Plan

The operation procedures for all objective river infrastructures are described in the existing O&M manuals currently applied by JRBDP. The list of the available O&M manuals is shown in Table 7.4. All O&M manuals, other than those for irrigation intake facilities, were prepared from 1994 to 2001, but no updating of the contents of the manuals has ever been made. As a result, some instructions for operation in the manuals are not compatible to the present water demand, present land uses and other existing relevant conditions. Moreover, the manuals contain no definitive technical instructions against emergency cases such as occurrences of extreme droughts and floods exceeding design capacity. Given this background, the necessary revisions and updating on the contents of the existing manuals was made in this Study based on the O&M plan of the relevant river infrastructures outlined below. Its results are compiled in Volume IV-1 "Part I - Guidelines and Manuals for River Infrastructure Operation and Maintenance". The principal revisions and/or renewals of the existing operation rules and procedures in the Manual are outlined below:

(1) Bili-Bili Dam

The operation rules of the regular gates/control gate for Bili-Bili dam and the guide vane for Bili-Bili HEPP were recently revised. Detailed guidance was also made on the configuration and operation method of the remote monitoring and control system. This renewal of operation rules and the detailed guidance are required due to the following:

- After Bili-Bili Hydroelectric Power Plant (Bili-Bili HEPP) starts operation in November 2005, integrated gate operation for the above three gates is required.
- The Rule Curve (RC) for Bili-Bili reservoir was revised in accordance with the updated water demand allocated to Bili-Bili dam in this Study. The drought management rules were also newly developed based on the revised RC. In accordance with the revision of the RC

[7] Recommended in "Guideline Manual for River Infrastructure Maintenance (RIM)" by SMEC in 1997.

and the new drought management rules, revisions were also made to the operation rules of the control gate for Bili-Bili dam and the guide vane for Bili-Bili HEPP.

(2) Rubber Dam and Long Storage

The following contents are compiled in the Manual:

- Detailed guidance on the synchronized operation rules and procedures for Rubber Dam and the Inlet/Outlet gates of Long Storage;
- Temporary operation rules of the Inlet Gate of Long Storage to control salinity intrusion during the non-operational period of the Rubber Dam (the current non-operational conditions of the Rubber Dam are expected to continue until the mid-term of the 2005 dry season); and
- Operation rules of the flushing water to dilute stagnant water in the drainage channels of Jongaya, Sinrijala and Panampu.

(3) Raw Water Transmission Main

The operation rules for butterfly valves, sluice valves and air valves for replacement of pipes are not described in the present manual and are therefore supplemented in the Manual of this Study.

(4) Bili-Bili, Bissua and Kampili Irrigation Weirs

Operation rules for the gate structures were extracted from the existing manual (“Bili-Bili-Irrigation Project, Operation & Maintenance Manual by CTI Engineering Co. LTD. in 2001” in which a supplementary explanation on them was given.

(5) Drainage Sluice Gates along the Lower Jeneberang River

The operation rules for the existing eleven sluice gates were recently established on the premise that local residents would undertake the operation as gatekeepers entrusted by Public Corporation, and their operation works would be under the supervision and control of Bili-Bili Dam Control Office.

7.7.6 Required Rehabilitation Works for Existing River Infrastructures

JRBDP currently undertakes rehabilitation of the damaged river infrastructures including Rubber Dam, Groundsill and Sand Pocket Dam no.4. In addition to these structures, however, other damaged facilities remain that have not been rehabilitated and/or replaced. The damage to the facilities results in the potential to cause significant adverse effects on river management. Therefore, JRBDP would be required as the present administrator of the structures to repair and/or replace them before hand-over of O&M works of the structures to Public Corporation. The major required rehabilitation works together with their rehabilitation costs are summarized below:

Required Rehabilitation Works for Existing River Infrastructures

Objective Facilities	Required Rehabilitation Works	Required Cost (Rp. million)
Telemetry gauging system for monitoring and operation for Bili-Bili Dam	– To replace whole telemetry gauging equipment at Bayang, which was stolen in Nov. 2005	503.8
	– To revise the present software system for control of entire telemetry gauging system	200.0
Flow meter placed at inlet of RWTM	– The flow meter should be replaced	7.5
Eleven drainage gates along the downstream reach of Jeneberang River	– To replace the gate hoists for all gates; – To repair the gate leaf/flame for two gates namely, Bayang (K.1.220-R) and K9.60 (K9.663-R); and – To replace the seal rubber at Bayang Gate (K1.22-R).	1,250.0
Total		1,961.3

7.8 Required Cost for O&M of River Infrastructure and River Management

7.8.1 Cost Borne by Public Corporation

The present conditions of river infrastructures were clarified in detail through:

(1) Field reconnaissance,
(2) Interview survey from JRBDP,
(3) Review of the actual budget allocated to O&M by JRBDP, and
(4) Review of the relevant documents such as O&M manuals/completion drawings.

Based on these clarifications, the necessary full-scale O&M cost of the river infrastructures and the relevant river basin management was estimated at Rp. 4,054 million. This corresponds to more than three to four times the actual budget disbursed by JRBDP (JRBDP had disbursed O&M costs of Rp. 1,329 million in 2003 and Rp. 954 million in 2004, as described in Subsection 7.2.4). The break down of the estimated cost is listed below:

Summary of Cost for O&M of River Infrastructures and Cost for River Management

(Unit: Rp. million)

Item	Facility/management Field	2007-2008*	From 2009 onward
O&M of River Infrastructures	Bili-Bili Dam/RWTM	933	996
	Irrigation Intake Weir	566	593
	Rubber Dam/Long Storage	353	437
	Riparian Structure	0	428
	Sand Pocket Dam and Sabo Dam	0	468
	Sub-total	1,852	2,917
River Management	Water Quantity management	188	259
	Flood Management	229	278
	Drought Management	227	267
	River Conservation Management	209	334
	Sub-total	854	1,137
Total		2,706	4,054

*: In accordance with the proposed expansion Program of O&M as described in Subsection 7.7.2, Public Corporation would not undertake O&M for the sand pocket dam/sabo dam and riparian structures during the first operation period in 2007-2008.

The above cost is divided into: (1) routine and periodic maintenance of river infrastructures, (2) overhaul of mechanical facilities, (3) operation cost of river infrastructures, (4) overhead for O&M of river infrastructures, and (5) cost for the relevant river management activities as listed in Table 7.5. The estimating basis for these cost components is given below (refer to Tables E10.2 to E10.10 in Vol. 3 Supporting Report-E):

(1) Routine and Periodic Maintenance Cost of River Infrastructure: The actual field maintenance works were assumed to be executed on a contract basis, and the unit cost for each work item was estimated based on the current prevailing contract price. The annual work volume for each work quantity was further estimated based on field reconnaissance, with the necessary maintenance cost finally derived by the annual work volume multiplied with the unit cost of the work.

(2) Overhaul of Mechanical Facilities: The annual cost for overhaul of mechanical facilities was estimated based on the necessary time interval of overhaul, work quantity, and unit cost. All necessary information was derived from the contract price of the facilities, the supplier's instruction manual and the standards on the overhaul of mechanical facilities prepared by Ministry of Land and Transportation in Japan.

(3) Operation Cost of River Infrastructures: The operation cost includes the cost for power supply, spare parts, materials (such as grease and oil), consumables and personnel expenditures for gatekeepers. The operation of infrastructures is in principal assumed to be by internal staff of Public Corporation and required personnel expenditure as well as other overhead was separately estimated under the following item (4). The exceptional case of this principal is, however, given to the gatekeepers for eleven drainage sluice gates along the downstream reach of Jeneberang River and three inlet/outlet gates for Long Storage. It is assumed that these gatekeeper roles should be entrusted to the local residents, and their necessary costs were included as part of the operation cost.

(4) Overhead of O&M: The annual salary for the permanent staff of Public Corporation to be involved in O&M was first estimated. The whole overhead of O&M was then estimated by adding the incidental costs such as material, equipment, and duty trip costs.

(5) Cost for the Relevant River Management Works: The objective river management herein includes water quantity management, flood management, drought management and river conservation management.[8] The annual salary for the permanent staff to be involved in these river management works was firstly estimated. The overall cost necessary for river management works was then estimated by adding the incidental costs such as material, equipment, and duty trip costs.

[8] O&M costs for water quality and watershed management are separately estimated in Chapter 8

7.8.2 Cost for Corrective and Emergency Maintenance

The maintenance cost as estimated above is limited to the preventative maintenance cost. In addition to this, however, maintenance may cover corrective and emergency maintenance as described in Subsection 7.7.4.

The ongoing repair of the damaged Rubber Dam, Groundsill No.2 and Sand Pocket Dam No.4 are as outlined in the typical cases for Corrective Maintenance. However, there still exist other damaged facilities, which are regarded as objectives of corrective maintenance and are yet to be rehabilitated and/or replaced. The overall necessary cost for these corrective maintenance works total Rp. 13,648 million as listed below. In addition to this amount, the Corrective Maintenance Cost further needs to cover all replacement costs of those facilities extending beyond their period of service durability. (The period of service durability is in a range of 10 to 25 years).

Corrective Maintenance Cost for River Infrastructures in Jeneberang River Basin

Objective Facilities of Corrective Maintenance	Year of Completion	Occurrence of Damage	Present Status of Corrective Works	Required Corrective Cost (Rp. million)
Sand Pocket Dam No.4	2000	2002	On-going	908
Rubber Dam	1996	2004	On-going	5,343
Groundsill No.2	1992	2003	On-going	5,407
Eleven Drainage Sluice Gates	1992	Unknown	Suspended	1,250
Telemetry Gauging System	1997	2002	Suspended	703
RWTM flow meter	1999	Unknown	Suspended	7.5
Total				13,648

As described in Chapter 3, the collapse of the enormous caldera-wall at Mt. Bawakaraeng occurred on 26 March 2004, and Bili-Bili dam reservoir is now in danger of substantially reducing its reservoir capacity as a result of the huge volume of sediment discharge. In order to cope with this problem, JRBDP is going to implement an urgent sediment control project with the financial assistance of JBIC. The sediment control project could be regarded as a type of emergency maintenance. The cost for the urgent sediment control project is estimated at Rp. 87,000 million.

As described above, both the corrective maintenance and emergency maintenance require huge implementation costs within a rather short period, and the budgetary arrangement for them is deemed to be far beyond the capacity of Public Corporation. Thus, the corrective and emergency maintenance could hardly fall within the scope of Public Corporation and needs to be implemented as part of the national projects.

Moreover, both the corrective and emergency maintenance are oriented to replacement of the assets (river infrastructure), which exceeded the period of service durability and/or have been damaged by extreme natural disasters such as floods, land slides and earthquakes. Such replacement of the assets is deemed to be under the responsibility of JRBDP as the possessor of the assets and not the Public Corporation as the executor of O&M for the assets. From these viewpoints, the cost for both corrective and emergency maintenance was excluded from the budgetary burden on the Public Corporation.

Table 7.1 Principal River Structures in Jeneberang River Basin (1/2)

Project/Purpose	Components of Structures	Quantity/Structural Size			Time of Completion	River	Agencies Responsible
		Description	Quantity/Size				
Bili-Bili Dam for Water Supply and Flood Control	Main Dam	Type	Rock fill		Aug. 1999	Jeneberang	PPSA*
		Height	76	m			
		Crest Length	750	m			
		Crest Width	10	m			
		Dam Volume	3,559,000	m^3			
	Left Wing Dam	Height	42	m	Aug. 1999	Jeneberang	PPSA*
		Crest Length	646	m			
		Crest Width	10	m			
		Dam Volume	1,515,000	m^3			
	Right Wing Dam	Height	52	m			
		Crest Length	412	m			
		Crest Width	10	m			
		Dam Volume	1,153,000	m^3			
	Reservoir	Catchment Area	384.4	km^2	Aug. 1999	Jeneberang	PPSA*
		Effective Water Depth	36.6	m			
		Reservoir Area	18.5	km^2			
		Total Storage	375,000,000	m^3			
		Effective Storage Vol.	346,000,000	m^3			
		Flood Control Vol.	41,000,000	m^3			
		Water Utilization Vol.	305,000,000	m^3			
		Municipal Water Vol.	35,000,000	m^3			
		Irrigation Water Vol.	270,000,000	m^3			
		Sediment Deposit	29,000,000	m^3			
	Telemetry System				May 1999	Jeneberang	PPSA*
	Control Station	Number	1	Sta.			
	Monitoring Station	Number	1	Sta.			
	Rainfall Gauging Sta.	Number	7	Sta.			
	Water Level Gauging Sta.	Number	7	Sta.			
	Warning Station	Number	2	Sta.			
	Bridges	Number	2	units	Nov. 1994	Jeneberang	PPSA*
River Improvement for Flood Control	River Dike	Length	20,970	m	Dec. 1993	Jeneberang (River Mouth to Sungguminasa)	PPSA*
	Revetment	Length	8,786	m			
	Groyne	Number	40	units			
	Groundsill at K5.96	Width	265.0	m			
	Groundsill at K9.00	Width	204.5	m			
	Sluice	Number	12	units			
	Intake	Number	2	units			
	Drainage ditch	Length	5,700	m			
	Jetty	Length	300	m			
Jongaya-Panampu-Sinrijala Drainage System for Flood Control	Drainage Channel	Length	13,870	m	Dec. 1993	Jongaya-Panampu-Sinrijala	PPSA*
	Control Gate	Number	4	units			
	Sluice (Box Culvert)	Number	34	units			
	Sluice (Pipe Culvert)	Number	291	units			
	Bridges	Number	23	units			
	Fence	Length	14,995	m			
	Inspection Road	Length	13,870	m			
	Jetty	Length	50	m			
Pampang Drainage System for Flood Control	Pump (Submersible)	Capacity	6	m^3/s	Dec. 2001	Pampang	PPSA*
	Regulation Pond	Storage Capacity	1,100,000	m^3			
		Area	39	ha			
	Sluice	Number	2	units			
	Bridges	Number	4	units			
Long Storage for Water Supply and Channel Cleaning	Reservoir	Length	4	km	Nov. 2001	Jeneberang (Old Estuary Channel)	PAB**
		Width	200 to 300	m			
		Effective Storage Vol.	1,600,000	m^3			
	Intake Sluice	Number	1	unit			
	Outlet Sluice	Number	1	unit			
	Tidal Barrage	Number	1	unit			

* PPSA = Jeneberang Water Resources Developmernt & Management, Jeneberang River Basin Development Project

** PAB = Raw Water Development, Jeneberang River Basin Development Project

Table 7.1 Principal River Structures in Jeneberang River Basin (2/2)

Project/Purpose	Components of Structures	Quantity/Structural Size			Time of Completion	River	Agencies Responsible
		Description	Quantity/Size				
Rubber Dam for Water Supply	Dam	Width	210	m	Dec. 1996	Jeneberang	PAB**
		Height	2	m			
	Main body	Length	10	m			
	Upstream Apron	Length	5	m			
	Downstream Apron	Length	12	m			
	Revetment	Length	336	m			
	Control house	Number	1	unit			
Raw Water Transmission System for Water Supply	Pipeline	Design Discharge	3.3	m^3/s	Mar. 1999	-	PAB**
	Pipe of 1600mm dia	Length	6,630	m			
	Pipe of 1,500mm dia	Length	10,380	m			
	Valve	Number	30	units			
	Fire Hydrant	Number	15	units			
	Flow-meter Chamber	Number	2	units			
	Blow-off Chamber	Number	5	units			
	Air Valve Chamber	Number	15	units			
	Fire Hydrant Chamber	Number	3	units			
Sand Pocket and Sabo Dam	Sand Pocket Dam No.1	Dam Volume	31,800	m^3	Oct. 1997	Jeneberang	PAB**
		Length of Dam Crest	620	m			
		Dam Height	7.5	m			
		Sediment Capacity	164,000	m^3			
		Mining Capacity	113,000	m^3			
	Sand Pocket Dam No.3	Dam Volume	16,100	m^3	Oct. 1997	Jeneberang	PPSA*
		Length of Dam Crest	336	m			
		Dam height	7	m			
		Sediment Capacity	129,000	m^3			
		Mining Capacity	93,000	m^3			
	Sand Pocket Dam No.2	Dam Volume	28,000	m^3	Sep. 2000	Jeneberang	PPSA*
		Length of Dam Crest	465	m			
		Dam height	7	m			
		Sediment Capacity	202,000	m^3			
		Mining Capacity	153,000	m^3			
	Sand Pocket Dam No.4	Dam Volume	35,800	m^3	Nov. 2000	Jeneberang	PPSA*
		Length of Dam Crest	644	m			
		Dam height	7	m			
		Sediment Capacity	444,000	m^3			
		Mining Capacity	359,000	m^3			
	Sand Pocket Dam No.5	Dam Volume	26,800	m^3	Nov. 2000	Jeneberang	PPSA*
		Length of Dam Crest	441	m			
		Dam height	7	m			
		Sediment Capacity	142,000	m^3			
		Mining Capacity	106,000	m^3			
	Sabo Dam No.4	Dam Volume	8,400	m^3	Jan. 2001	Jeneberang	PPSA*
		Length of Dam Crest	150	m			
		Dam height	8	m			
		Sediment Capacity	129,000	m^3			
		Mining Capacity	92,000	m^3			
	Sabo Dam No.6	Dam Volume	8,400	m^3	Jan. 2001	Marino	PPSA*
		Length of Dam Crest	230	m			
		Dam height	10	m			
		Sediment Capacity	74,400	m^3			
		Mining Capacity	62,000	m^3			
	Sabo Dam No.8	Dam Volume	28,000	m^3	Jan. 2001	Salo Bengo	PPSA*
		Length of Dam Crest	104	m			
		Dam height	10	m			
		Sediment Capacity	122,400	m^3			
		Mining Capacity	73,150	m^3			

* PPSA = Jeneberang Water Resources Developmernt & Management, Jeneberang River Basin Development Project

** PAB = Raw Water Development, Jeneberang River Basin Development Project

Table 7.2 Diversion Water Requirement Granted by JRBDP for the Source of Jeneberang River

(unit: m^3/s)

Water User			Diversion Water Requirement											
Sector	Name of User	Intake Point	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Irrigation	Bili-Bili Irrigation	Bili-Bili Weie	0.88	0.00	0.00	2.20	2.96	2.95	2.69	1.36	0.76	0.45	0.00	0.14
	Bissua Irrigation	Bissua Weir	4.00	0.00	0.00	10.07	13.51	13.48	12.29	6.21	3.45	2.08	0.00	0.66
	Kampili Irrigation	Kampili Weir	3.92	0.00	0.00	9.85	13.20	13.18	12.02	6.07	3.38	2.03	0.00	0.64
	Sub-total		8.80	0.00	0.00	22.13	29.67	29.61	27.01	13.64	7.59	4.56	0.00	1.44
Municipal	PDAM Makassar	Somba Opu	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31
		Ratulangi	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
		Macchini Simbala	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
		Panaikang	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.00
	PDAM Gowa	Bajeng	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
		Borong Loe	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Tompo Balang	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
		Pandang-Pandang	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	Sub-total		1.66	1.66	1.66	1.66	2.16	2.16	2.16	2.16	2.16	2.16	1.66	1.66
Industry	Takalar Sugar Factory	Bissua Weir	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
River Maintenance	None	None	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Total			11.96	3.16	3.16	25.29	33.33	33.27	30.67	17.30	11.25	8.22	3.16	4.60

(unit: $10^6 m^3$)

Water User			Diversion Water Requirement												
Sector	Name of User	Intake Point	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Irrigation	Bili-Bili Irrigation	Bili-Bili Weie	2.35	0.00	0.00	5.71	7.92	7.64	7.21	3.64	1.96	1.22	0.00	0.38	38.03
	Bissua Irrigation	Bissua Weir	10.72	0.00	0.00	26.11	36.17	34.94	32.93	16.63	8.95	5.56	0.00	1.76	173.77
	Kampili Irrigation	Kampili Weir	10.49	0.00	0.00	25.53	35.37	34.16	32.20	16.26	8.75	5.43	0.00	1.72	169.91
	Sub-total		23.56	0.00	0.00	57.36	79.46	76.74	72.33	36.53	19.66	12.21	0.00	3.86	381.70
Municipal	PDAM Makassar	Somba Opu	3.51	3.17	3.51	3.40	3.51	3.40	3.51	3.51	3.40	3.51	3.40	3.51	41.31
		Ratulangi	0.18	0.17	0.19	0.18	0.19	0.18	0.19	0.19	0.18	0.19	0.18	0.19	2.20
		Macchini Simbala	0.25	0.22	0.24	0.23	0.24	0.23	0.24	0.24	0.23	0.24	0.23	0.24	2.84
		Panaikang	0.00	0.00	0.00	0.00	1.34	1.30	1.34	1.34	1.30	1.34	0.00	0.00	7.95
	PDAM Gowa	Bajeng	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.63
		Borong Loe	0.04	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.33
		Tompo Balang	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.94
		Pandang-Pandang	0.35	0.31	0.35	0.34	0.35	0.34	0.35	0.35	0.34	0.35	0.34	0.35	4.11
	Sub-total		4.45	4.02	4.45	4.30	5.79	5.60	5.79	5.79	5.60	5.79	4.30	4.45	60.30
Industry	Takalar Sugar Factory	Bissua Weir	1.34	1.21	1.34	1.30	1.34	1.30	1.34	1.34	1.30	1.34	1.30	1.34	15.77
River Maintenance	None	None	2.68	2.42	2.68	2.59	2.68	2.59	2.68	2.68	2.59	2.68	2.59	2.68	31.54
Total			32.03	7.64	8.46	65.55	89.26	86.23	82.14	46.33	29.15	22.01	8.19	12.33	489.31

Table 7.3 Inventory of River Infrastructures (1/3)

River: Name of River	River Order	Structure: Classification	Name	ID No.	Location (Sta. No.): Right or Left Bank	From	To	Number of Units	Structural Type	Structural Size	Year of Completion	Investment (Rp. Million)	Agencies Responsible	Remarks
Jeneberang	1st	Jetty		JET -1	Both	K0.000 (River Mouth)		1	Rubble Aggregate	4.5 m (B) x 3.5m (H) x 100m (L)	1993	2,675	PPSA	
Jeneberang	1st	River Dike	Right Lower Dike	RD -1	R	K0.310	K5.203	1	Earth Dike	4,920 m	1993	3,842	PPSA	
Jeneberang	1st		Right Upper Dike	RD -2	R	K5.200	K11.500	1	Earth Dike	6,740 m	1992	5,263	PPSA	With Maintenance Road
Jeneberang	1st		Left Lower Dike	RD -3	L	K0.050	K5.000	1	Earth Dike	4,950 m	1993	3,865	PPSA	
Jeneberang	1st		Left Upper Dike	RD -4	L	K5.000	K9.600	1	Earth Dike	4,700 m	1992	3,670	PPSA	With Maintenance Road
			Sub-total							21,310 m		16,639		
Jeneberang	1st	Revetment	Low Water Dike (1)	RVT -1	R	K2.350	H2.775	1	Random Masonry	425 m	1993	337	PPSA	
Jeneberang	1st		Low Water Dike (2)	RVT -2	R	K2.775	K3.762	1	Dry Masonry	996 m	1993	1,000	PPSA	
Jeneberang	1st		Low Water Dike (3)	RVT -3	R	K3.762	K3.968	1	Wet Masonry	250 m	1993	251	PPSA	
Jeneberang	1st		Low Water Dike (4)	RVT -4	R	K5.918	K6.659	1	Wet Masonry	927 m	1992	930	PPSA	
Jeneberang	1st		Low Water Dike (5)	RVT -5	R	K8.200	K9.586	1	Wet Masonry	1,370 m	1992	1,375	PPSA	
Jeneberang	1st		Low Water Dike (6)	RVT -6	L	K8.797	K9.332	1	Wet Masonry	1,045 m	1992	1,049	PPSA	
Jeneberang	1st		High Water Dike (1)	RVT -7	R	K0.310	K4.800	1	Wet Masonry	1,990 m	1993	1,997	PPSA	
Jeneberang	1st		High Water Dike (2)	RVT -8	R	K6.398	K6.632	1	Wet Masonry	305 m	1992	306	PPSA	
Jeneberang	1st		High Water Dike (3)	RVT -9	R	K8.259	K10.589	1	Wet Masonry	2,305 m	1992	2,313	PPSA	
Jeneberang	1st		High Water Dike (4)	RVT -10	L	K0.050	K0.730	1	Wet Masonry	680 m	1993	682	PPSA	
Jeneberang	1st		High Water Dike (5)	RVT -11	L	K0.751	K1.180	1	Wet Masonry	420 m	1993	422	PPSA	
Jeneberang	1st		High Water Dike (6)	RVT -12	L	K8.720	K9.387	1	Wet Masonry	684 m	1992	686	PPSA	
			Sub-total							11,397 m		11,349		
Jeneberang Jeneberang	1st 1st	Rubber Dam		RDM -1		K3.650		1	Inflatable rubber-dam	210m (B) x 2m(H) with main dam (3 spans x 59m) and sub-dam (2 spans x	1996	61,045	PAB	
Jeneberang	1st	Groundsill	Lower Groundsill	GRS -1		K5.970		1	Concrete Apron and Bed Protection with Gabion Mattress	Approx. 200m (B)	1992	1,035	PPSA	
Jeneberang	1st		Upper Groundsill	GRS -2		K9.000		1			1992	1,035	PPSA	
			Sub-total					2				2,069		
Jeneberang	1st	Groyne	Groyne (R-1)	GRN -1	R	K0.350	K0.450	3	Pile Groyne of Permeable Type	6m (B) x 1.5m (H) x 5 to 29m (L)	1993	68	PPSA	
Jeneberang	1st		Groyne (R-2)	GRN -2	R	K2.000	K2.300	7			1993	159	PPSA	
Jeneberang	1st		Groyne (R-3)	GRN -3	R	K5.200	K5.300	3			1993	68	PPSA	
Jeneberang	1st		Groyne (R-4)	GRN -4	R	K6.000	K6.700	8			1992	182	PPSA	
Jeneberang	1st		Groyne (R-5)	GRN -5	R	K7.800	K8.300	5			1992	114	PPSA	
Jeneberang	1st		Groyne (L-1)	GRN -6	L	K1.150	K1.300	3			1993	68	PPSA	
Jeneberang	1st		Groyne (L-2)	GRN -7	L	K4.700	K4.950	4			1993	91	PPSA	
Jeneberang	1st		Groyne (L-3)	GRN -8	L	K7.900	K8.200	4			1992	91	PPSA	
Jeneberang	1st		Groyne (L-4)	GRN -9	L	K8.850	K9.350	6			1992	137	PPSA	
			Sub-total					43				979		
Jeneberang	1st	Drainage Sluice Gate	Bayang	DSG -1	R	K1.220		1	Box Culvert with Steel Slide Gate	2.0m(B) x 2.0m(H) x 2units x 19.0m (L)	1993	467	PPSA	
Jeneberang	1st		Taeng	DSG -2	L	K5.473		1		2.0m(B) x 2.0m(H) x 2units x 16.5m (L)	1992	153	PPSA	
Jeneberang	1st		Lambengi	DSG -3	L	K8.776		1		1.5m(B) x 1.5m(H) x 1unit x 16.0m (L)	1992	153	PPSA	
Jeneberang	1st		K7.00	DSG -4	R	K7.012		1		1.5m(B) x 1.5m(H) x 1unit x 16.5m (L)	1992	153	PPSA	
Jeneberang	1st		Bili-Bili	DSG -5	R	K7.722		1		1.5m(B) x 1.5m(H) x 1unit x 16.0m (L)	1992	153	PPSA	
Jeneberang	1st		Sungguminasa	DSG -6	R	K8.392		1		1.7m(B) x 1.7m(H) x 1unit x 16.3m (L)	1992	153	PPSA	
Jeneberang	1st		K9.10	DSG -7	R	K9.135		1		1.5m(B) x 1.5m(H) x 1unit x 16.5m (L)	1992	153	PPSA	
Jeneberang	1st		K9.60	DSG -8	R	K9.563		1		1.5m(B) x 1.5m(H) x 1unit x 16.0m (L)	1992	153	PPSA	
Jeneberang	1st		Batang Kaluku No.1	DSG -9	R	K9.816		1		1.7m(B) x 1.7m(H) x 2units x 17.5m (L)	1992	153	PPSA	
Jeneberang	1st		Batang Kaluku No.2	DSG -10	R	K10.333		1		1.7m(B) x 1.7m(H) x 2units x 17.5m (L)	1992	153	PPSA	
Jeneberang	1st		Batang Kaluku No.3	DSG -11	R	K10.862		1		1.7m(B) x 1.7m(H) x 2units x 17.5m (L)	1992	153	PPSA	
			Sub-total					11				1,992		
Jeneberang	1st	PDAM Intake	Malingkeli-1	PDAM -1	R			1	Intake Pump	Pump Capacity = 100 l/s			PDAM	To Machini Sombala WTP
Jeneberang	1st		Malingkeli-2	PDAM -2	R			1	Intake Pump	Pump Capacity = 500 l/s			PDAM	To Panaikang WTP (for dry season)
Jeneberang	1st		Pandang-Pandang	PDAM -3	R			1	Intake Pump	Pump Capacity = 200 l/s			PDAM	To Pandang-Pandang WTP
Jeneberang	1st		Ujung Pandang	PDAM -4	R			1	Intake Pump	Pump Capacity = 200 l /s			PDAM	To Ratulangi WTP
Jeneberang	1st		Sungguminasa	PDAM -5	R			1	Intake Pump	Pump Capacity = 40 l/s			PDAM	To Tompo Balang WTP

Note: PPSA = Jeneberang Water Resources Development and Management, Jeneberang River Basin Development Project
PAB = Raw Water Development, Jeneberang River Basin Development Project
PDAM = Regional Drinking Water Supply Comapany
PIRASS = Bili-Bili Irrigation Project Office

Table 7.3 Inventory of River Infrastructures (2/3)

River		Structure			Location (Sta. No.)			Number	Structural Type	Structural Size	Year of	Investment	Agencies	Remarks
Name of River	River Order	Classification	Name	ID. No.	Right or Left	From	To	of			Completion	(Rp. Million)	Responsible	
Jeneberang	1st		Bissua Weir	IRRW -1				1			2004		PIRASS	Irrigation area of 3,850 ha
Jeneberang	1st		(1) Diversion Weir						Concrete gravity	239.3m (L) x 8.2m (H)				
Jeneberang	1st		(2) Intake Structure		L				Fixed wheel	3.0m (B) x 1.9m (H) x 4gates				
Jeneberang	1st		Kampili Weir	IRRW -2				1			2004	93,424	PIRASS	Irrigation area of 17,480 ha
Jeneberang	1st		(1) Diversion Weir						Masonry	91.0m (L) x 9.0m (H)				
Jeneberang	1st	Irrigation Intake	(2) Intake Structure		L				Steel slide	2.05m (B) x 1.5m (H) x 4 gates				
Jeneberang	1st		Bili-Bili Weir	IRRW -3				1			2004		PIRASS	Irrigation area of 2,360 ha
Jeneberang	1st		(1) Diversion Weir						Concrete gravity	69.0m (L) x 2.0m (H)		10,116		
Jeneberang	1st		(2) Intake Structure		R				Fixed wheel	2.5m (B) x 1.2m (H) x 2 gates				
Jeneberang	1st		Sub-total									103,539		
Jeneberang	1st	Bridge	Bili-Bili	BR -1				1		5.0m (B) x 30.6m (L) (6 spans)	1994	222		
Jeneberang	1st		Pattalikang	BR -2				1		5.0m (B) x 30.4m (L) (6 spans)	1994	220		
Jeneberang	1st		Bili-Bili	Dam -1									PPSA	
Jeneberang	1st		(1) Main Dam					1	Center core type rockfill	10m (B) x 73m (H) x 750m (L)	1999			
Jeneberang	1st		(2) Left Wing Dam					1	Center core type rockfill	10m (B) x 42m (H) x 646m (L)	1999			
Jeneberang	1st		(3) Right Wing Dam					1	Center core type rockfill	10m (B) x 52m (H) x 412m (L)	1999			
Jeneberang	1st		(4) Spillway					1	Concrete Chute-way	99.5 to 55m (B) x 225m (L)	1999	174,797		
Jeneberang	1st	Multipurpose Dam	(5) Intake					1	Inclined	47m (H) with	1999			
Jeneberang	1st		(6) Outlet					1	Jet Flow Gate	Control Gate: 2m in dia	1999			
Jeneberang	1st								Gate Valve	Guard Gate: 3.0m in dia.				
Jeneberang	1st		(7) Building					1	RC Building	1,141 m2, 1-storey	1999			
Jeneberang	1st		(8) Micro-power Plant					1	Cross Flow Type of Turbine	Generator: 380v, 50hz	2005			
Jeneberang	1st									Gate Valve: 600mm in dia x 2units				
Jeneberang	1st		(9) Diversion Tunnel					2	Circular section type	9.3m (dia.) X 290m (L) & 300m (L)	1994	23,346		
Jeneberang	1st	Water Transmission Pipe	Raw Water Trasmission Main (RWTM)	RWTM -1		Bili-Bili Dam to Smba Opu-WTP		1	Single Pipe Line	6.63km (L) with 1,650mm in dia., 10.38km (L) with 1,500mm in dia.	1996	84,135	PAB	Trasmission Capacity = 3.3 m3/s
Jeneberang	1st		Bayang	HYGS -1				1			1997		PPSA	
Jeneberang	1st		Maccinni Sombala	HYGS -2				1			1997			
Jeneberang	1st	Hydrological Gauging Sta.	Kampili	HYGS -3				1			1997	1,500		
Jeneberang	1st		Bont Jai	HYGS -4				1			1997			
Jeneberang	1st		Jonggoa	HYGS -5				1			1997			
Jeneberang	1st		Sand Pocket Dam	SD -1				1	Gravity dam by wet stone masonry	3m (B) x 620m (L) x 7.5m (H)	1997	13,035	PPSA	
Jeneberang	1st		Sand Pocket Dam No.3	SD -2				1	Gravity dam by rubble-concrete	3m (B) x 336m (L) x 7.0m (H)	1997	5,887		
Jeneberang	1st	Sand Pocket/Sabo Dam	Sand Pocket Dam No.2	SD -3				1	Gravity dam by wet stone masonry	3m (B) x 465m (L) x 7.0m (H)	1998	13,035		
Jeneberang	1st		Sand Pocket Dam No. 4	SD -4				1	Gravity dam by wet stone masonry	3m (B) x 644m (L) x 7.0m (H)	2000	14,725		
Jeneberang	1st		Sand Pocket Dam No. 5	SD -5				1	Gravity dam by wet stone masonry	3m (B) x 441m (L) x 7.0m (H)	2000	12,900		
Jeneberang	1st		Sabo Dam No. 4	SD -6				1	Gravity dam by wet stone masonry	3m (B) x 150m (L) x 8.0m (H)	2000	5,880		
Salo Kausisi	2nd	Sabo Dam	Sabo Dam No. 8	SD -7				1	Gravity dam by wet stone masonry	3m (B) x 104m (L) x 10.0m (H)	2001	6,620	PPSA	
Jenelata	2nd		Jenelata	HYGS -6				1			1999		PPSA	
Jenelata	2nd	Hydrological Gauging Sta.	Mangempang	HYGS -7				1			1997	900	PPSA	
Jenelata	2nd		Limbunga	HYGS -8				1			1997		PPSA	
Salo Malino	2nd	Sabo Dam	Sabo Dam No. 6	SD -8				1	Gravity dam by wet stone masonry	3m (B) x 230m (L) x 10.0m (H)	2001	8,977	PPSA	
Salo Malino	2nd	Hydrological Gauging Sta.	Malino	HYGS -9				1			1997		PPSA	
Garassi	2nd	Bridge	Panakkukang	BR -3	L	K1.247		1	T-Beam	4.0m (B) x 29.8m (L)	1993	336		
Panampu		Jetty		JET -2	Both	K0.000 (River Mouth)		1	RC Boxes/Rubble Stones	5.0 m (B) x 3.0m (H) x 50m (L) x 2 unit	1991	1,338	PPSA	
Panampu	3rd	Revetment		RVT -13	R			1		4,940 m	1991	1,187	PPSA	
Panampu	3rd			RVT -14	L			1		4,940 m	1991	1,187	PPSA	
Panampu	3rd		BR. No.1	BR -4		K0.174		1	Hollow	7.8m (B) x 17.0m (L)	1991	193		
Panampu	3rd		BR. No.3	BR -5		K0.796		1	Hollow	18.6m (B) x 17.0m (L)	1991	460		
Panampu	3rd		BR. No. D	BR -6		K1.295		1	Hollow	7.8m (B) x 19.0m (L)	1991	216		
Panampu	3rd		BR. No. 4	BR -7		K2.318		1	Hollow	7.8m (B) x 17.0m (L)	1991	193		
Panampu	3rd		BR. No. 5	BR -8		K2.548		1	Hollow	19.8m (B) x 19.0m (L)	1991	547		
Panampu	3rd	Bridge	BR. No. 6	BR -9		K2.926		1	Hollow	21.8m (B) x 17.0m (L)	1991	539		
Panampu	3rd		BR. No. 7	BR -10		K3.251		1	Hollow	7.8m (B) x 17.0m (L)	1991	193		
Panampu	3rd		BR. No. 8	BR -11		K3.504		1	T-Beam	18.8m (B) x 11.5m (L)	1991	314		
Panampu	3rd		BR. No. 10	BR -12		K4.048		1	T-Beam	11.6m (B) x 12.0m (L)	1991	202		
Panampu	3rd		BR. No. A	BR -13		K4.390		1	T-Beam	11.6m (B) x 11.5m (L)	1991	194		
Panampu	3rd		Pedestrian Bridge	BR -14				6	T-Beam	1.5 to 3.0m (B) x 12.0 to 17.1 m (L)		262		

Note: PPSA = Jeneberang Water Resources Development and Management, Jeneberang River Basin Development Proje
PAB = Raw Water Development, Jeneberang River Basin Development Proje
PDAM = Regional Drinking Water Supply Comapany
PIRASS = Bili-Bili Irrigation Project Office

Table 7.3 Inventory of River Infrastructures (3/3)

River: Name of River	River Order	Structure: Classification	Structure: Name	ID. NO	Right or Left	Location (Sta. No.) From	To	Number of	Structural Type	Structural Size	Year of Completion	Investment (Rp. Million)	O&M Cost (Rp.	Remarks
Panampu	3rd	Drainage Sluice Culvert	One-box Culvert	SCV -1	R	Variable		6	Box Culvert		1991	68	PPSA	
Panampu	3rd		One-box Culvert	DSC -2	L	Variable		6			1991	68	PPSA	
Panampu	3rd		Two-box Culvert	DSC -3	R	K2.015		1		1.5 m (B) x 1.2m (H) per Box	1991	23	PPSA	
Jongaya	3rd	Revetment		RVT -15	L			1		6,565 m	1991	1,577	PPSA	
Jongaya	3rd			RVT -16	R			1		6,565 m	1991	1,577	PPSA	
Jongaya	3rd	Bridge	BR. No. B	BR -15		K1.000		1	T-Beam	11.6m (B) x 10.5m (L)	1991	177		
Jongaya	3rd		BR. No. 11	BR -16		K4.496		1	T-Beam	11.6m (B) x 10.5m (L)	1991	177		
Jongaya	3rd		BR. No. 12	BR -17		K4.916		1	T-Beam	7.8m (B) x 10.5m (L)	1991	119		
Jongaya	3rd		BR. No. C	BR -18		K5.720		1	T-Beam	18.8m (B) x 10.5m (L)	1991	287		
Jongaya	3rd		BR. No. 13	BR -19		K6.163		1	T-Beam	21.8m (B) x 11.0m (L)	1991	349		
Jongaya	3rd		BR. No. 14	BR -20		K6.772		1	Hollow	12.8m (B) x 17.0m (L)	1991	316		
Jongaya	3rd		BR. No. 18	BR -21		K7.235		1	Hollow	7.8m (B) x 19.0m (L)	1991	216		
Jongaya	3rd		BR. No. 15	BR -22		K7.773		1	Hollow	12.8m (B) x 19.0m (L)	1991	354		
Jongaya	3rd		BR. No. 16	BR -23		K7.982		1	Hollow	12.8m (B) x 19.0m (L)	1991	354		
Jongaya	3rd		BR. No. 17	BR -24		K8.153		1	Hollow	7.8m (B) x 19.0m (L)	1991	216		
Jongaya	3rd		BR. No. E	BR -25		K8.469		1	Hollow	9.8m (B) x 19.0m (L)	1991	271		
Jongaya	3rd		BR. No. F	BR -26		K9.126		1	Hollow	7.8m (B) x 19.0m (L)	1991	216		
Jongaya	3rd		BR. No. H	BR -27		K10.147		1	Hollow	7.8m (B) x 19.0m (L)	1991	216		
Jongaya	3rd		Pedestrian Bridge	BR -28		K11.086		1	T-Beam	2.5m (B) x 20.9m (L)	1991	76		
Jongaya	3rd	Drainage Sluice Culvert	One-box Culvert	DSC -4	L			1	Box Culvert	1.5 m (B) x 1.2m (H) per Box	1991	23	PPSA	
Jongaya	3rd		One-box Culvert	DSC -5	R	Variable		2			1991	79	PPSA	
Jongaya	3rd		Two-box Culvert	DSC -6	L	Variable		7			1991	91	PPSA	
Jongaya	3rd		Two-box Culvert	DSC -7	R	Variable		4			1991	91	PPSA	
Sinrijala	4th	Revetment		RVT -17	L	Variable		4		2,366 m	1991	569	PPSA	
Sinrijala	4th			RVT -18	R	Variable		1		2,366 m	1991	569	PPSA	
Sinrijala	4th	Drainage Sluice Gate	Sluice No. 1	DSG -12	L	K0.820			Box culvert with movable gates	3.3m(B) x 2.4m(H) x 2units x 48.0m (L)	1991	284	PPSA	Intersection with Jl. A.P. Pettarai
Sinrijala	4th		Sluice No. 2	DSG -13	L	K2.105		1	Box culvert with movable gates	3.3m(B) x 2.4m(H) x 1unit x 12.0m (L)	1991	142	PPSA	Intersection with Jl. S. Saddang Baru
Sinrijala	4th	Drainage Sluice Culvert	One-box Culvert	DSC -8	R	K0.795		1	Box Culvert	1.5 m (B) x 1.2m (H) per Box	1991	11	PPSA	
Sinrijala	4th		One-box Culvert	DSC -9		K8.835		1			1991	11	PPSA	
Sinrijala	4th	Fall		Fall -1		K2.350		1	RC Structure/Gabion Mattress	3.5m (Upper B) , 5.0m (Lower B), 1.76m (H	1991	2	PPSA	
Sinrijala	4th	Pedestrian Bridge		BR -29				1	T-Beam	1.5 to 3.0m (B) x 10.4m (L)	1991	151		
Pampang	5th	Drainage Pump Station		DRP -1							2000		PPSA	
Pampang	5th	(1) Pump						1	Submersible Pump	2m3/s, (100kw, dia 1m x 3 units)	2000	52,470		
Pampang	5th	(2) Regulation Pond						1		360,000m2 (Area) x 3.5m (Depth)	2000			
Pampang	5th	(3) Spillway						1	Concrete Fix Weir	4.3m (H) x 150m (L)	2000			
Pampang	5th	Drainage Sluice Gate	Pampang	DSG -1				1	Gate with motor drive hoist	5.0m (B) x 3.1m (H) x 2 gates	1998		PPSA	
Pampang	5th		Anotong	DSG -2				1	Gate with manual operation	1.5m (B) x 1.5m (H) x 2 gates	1998			
Pampang	5th	Revetment		RVT -19				1	Wet Masonry	1,000m (L)	1998		PPSA	
Pampang	5th	Bridge	Pettarani II	BR -30				1	PC girder bridge	L = 33.7 m	1998	17,107		
Pampang	5th		Antong	BR -31				1	PC girder bridge	L = 22.7 m	1998			
Pampang	5th		Sari I	BR -32				1	PC girder bridge	L = 22.7 m	1998			
Pampang	5th		Sari II	BR -33				1	PC girder bridge	L = 22.7 m	1998			
Pampang	5th		Banca	BR -34				1	PC girder bridge	L = 22.7 m	1998			
Long Storage	2nd	Tidal Barrage		TB -1		K0.004	K1.792	5			1993		PAB	
Long Storage	2nd	(1) Barrage							Earth dike	200m (B) x 200m (L) x 3.5m (H)	1993			
Long Storage	2nd	(2) Outlet Sluice							Box culvert		1993	11,917		
Long Storage	2nd	(3) Revetment							Wet Masonry	400m in length	1993			
Long Storage	2nd	(4) Tidal Gate							Steel Slide Gate	2.0m(B) x 2.0m(H) x 2 gates	1993			
Long Storage	2nd	Flushing Gate	Gate (A)	FG -1				1	Steel Gate	1.0m(B) x 1.6m(H) x 2 gates.	2001		PAB	
Long Storage	2nd		Gate (B)	FG -2				2	Steel Gate	1.1m(B) x 1.3m(H) x 2 gates	2001	11,158	PAB	
Long Storage	2nd	Revetment		RVT -19	R			1	Wet Masonry	2300m in length	2001		PAB	
Long Storage	2nd			RVT -20	L			1	Wet Masonry	2600m in length	2001		PAB	
Long Storage	2nd	Intake Sluice Gate		ISG -1	R	K4.054		1	Box culvert with movable gates	2.0m(B) x 2.0m(H) x 2units x 42.74m (L)	1993	1,051	PAB	To supply to Long Storage
Long Storage	2nd	PDAM Intake	Maccini Sombala	PDAM -6					Intake Pump	Pump Capacity = 200 l/s			PDAM	Closed (To Maccini Sombala WTP)

Note: PPSA = Jeneberang Water Resources Development and Management, Jeneberang River Basin Development Project
PAB = Raw Water Development, Jeneberang River Basin Development Project
PDAM = Regional Drinking Water Supply Comapany
PIRASS = Bili-Bili Irrigation Project Office

Table 7.4 Existing Operation and Maintenance Manuals of River Structures

Name of Project	Principal Structures in the Project	Principal Contents of O&M Manuals	Prepared in
Bili-Bili Dam	– Bili-Bili Dam	– Dam operation rule – Water control plant – Dam control and monitoring system – Telecommunication system – Micro hydropower plant – Dam instrumentation – Power supply system – Instruction manual of end suction volute pumps	Dec. 1999
Sand Pocket and Sabo Dam	– Sand Pocket and Sabo Dam	– List of structures and structural features – Institutional setup for O&M – Budgetary arrangement for O&M – Guideline for monitoring on progress of sedimentation – Operation guideline for mining of sand trapped in the Structures – Maintenance manual of structures	Nov. 2001
Pampang River Improvement Project	– Pampang Drainage Pump – Regulation Pond – Pampang Drainage Channel	– List of structures and structural features – Institutional setup for O&M – Budgetary arrangement for O&M – Guideline for the necessary inspection works – Guideline for gate and pump operation, – Maintenance manual of structures and facilities	Dec. 2001
Lower Jeneberang River Urgent Flood Control Works	– Lower Jeneberang – Drainage Channel	– List of structures and structural features – Institutional setup for O&M – Budgetary arrangement for O&M – Guideline for the necessary inspection works – Guideline for operation of drainage sluices – Maintenance manual of river channel, structures and facilities	Mar. 1994
Construction of Long Storage	– Long Storage	– List of structures and structural features – Organization for O&M – Budgetary arrangement for O&M – Guideline for the necessary inspection works – Guideline for operation of reservoir operation and gate operation – Maintenance manual of river channel, structures and facilities	Jan. 2002
Bili-Bili Irrigation Project (Draft)	– Bili-Bili Weir – Bissua Weir – Kampili Weir	– List of structures and structural features – Organization for O&M – Guideline for the necessary inspection works – Guideline for operation of Weirs – Maintenance manual of structures and facilities – Guideline for data collection and evaluation on maintenance works	Aug. 2003
Rubber Dam Construction	– Rubber Dam	– List of structures and structural features – Organization for O&M – Budgetary arrangement for O&M – Guideline for the necessary inspection works – Guideline for operation of rubber dam – Maintenance manual of structures and facilities	Mar. 1997
Raw Water Transmission Main	– Pipe Line	– List of Structures – Operation of gates – Maintenance Guideline of gates	Mar. 1999

Table 7.5 Summary of O&M Cost of River Infrastructures and Cost for River Management

Item	Structure/Management Filed	Work Item	Cost in Million Rp.	
			in 2007	in 2011
O&M	Bili-Bili Dam/RWTM	Routine & Periodical Maintenance	372	372
		Overhaul	75	75
		Operation	193	193
		Overhead	293	356
		Sub-total	933	996
	Irrigation Intake Weir	Routine & Periodical Maintenance	78	78
		Overhaul	21	21
		Operation	230	230
		Overhead	238	265
		Sub-total	566	593
	Long Storage/Rubber Dam	Routine & Periodical Maintenance	103	103
		Overhaul	36	36
		Operation	132	132
		Overhead	82	166
		Sub-total	353	437
	Riparian Structure	Routine & Periodical Maintenance	-	173
		Overhaul	-	41
		Operation	-	84
		Overhead	-	130
		Sub-total	-	428
	Sabo Dam	Routine & Periodical Maintenance	-	274
		Overhaul	-	-
		Operation	-	-
		Overhead	-	189
		Sub-total	-	463
	Total for O&M		1,852	2,917
River Management	Water Quantity management		188	259
	Flood Management		229	278
	Drought Management		227	267
	River Conservation Management		209	334
	Total for River Management		854	1,137
Grand Total			2,706	4,054

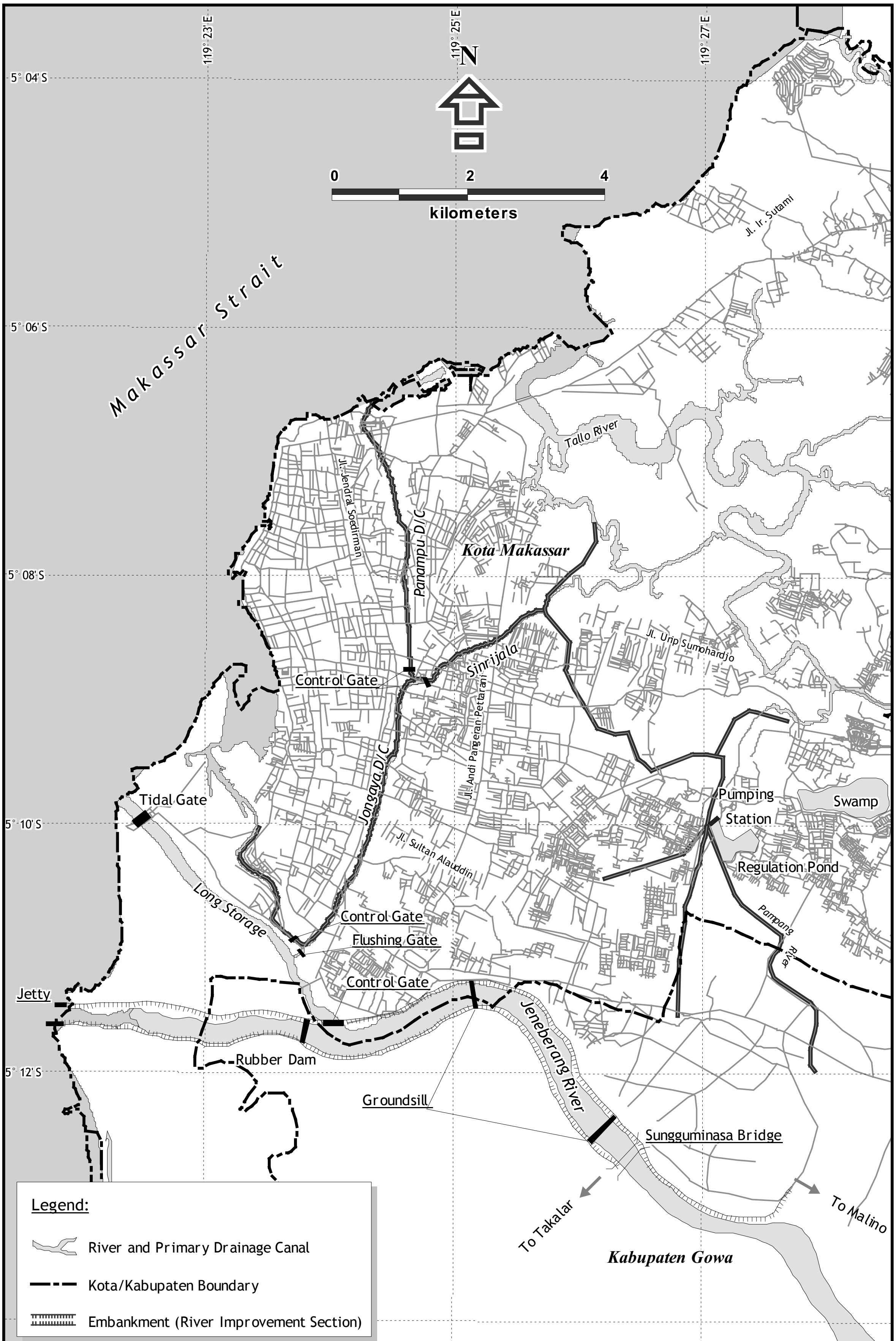


Figure 7.1 River Control Structures in Lower Jeneberang River Basin

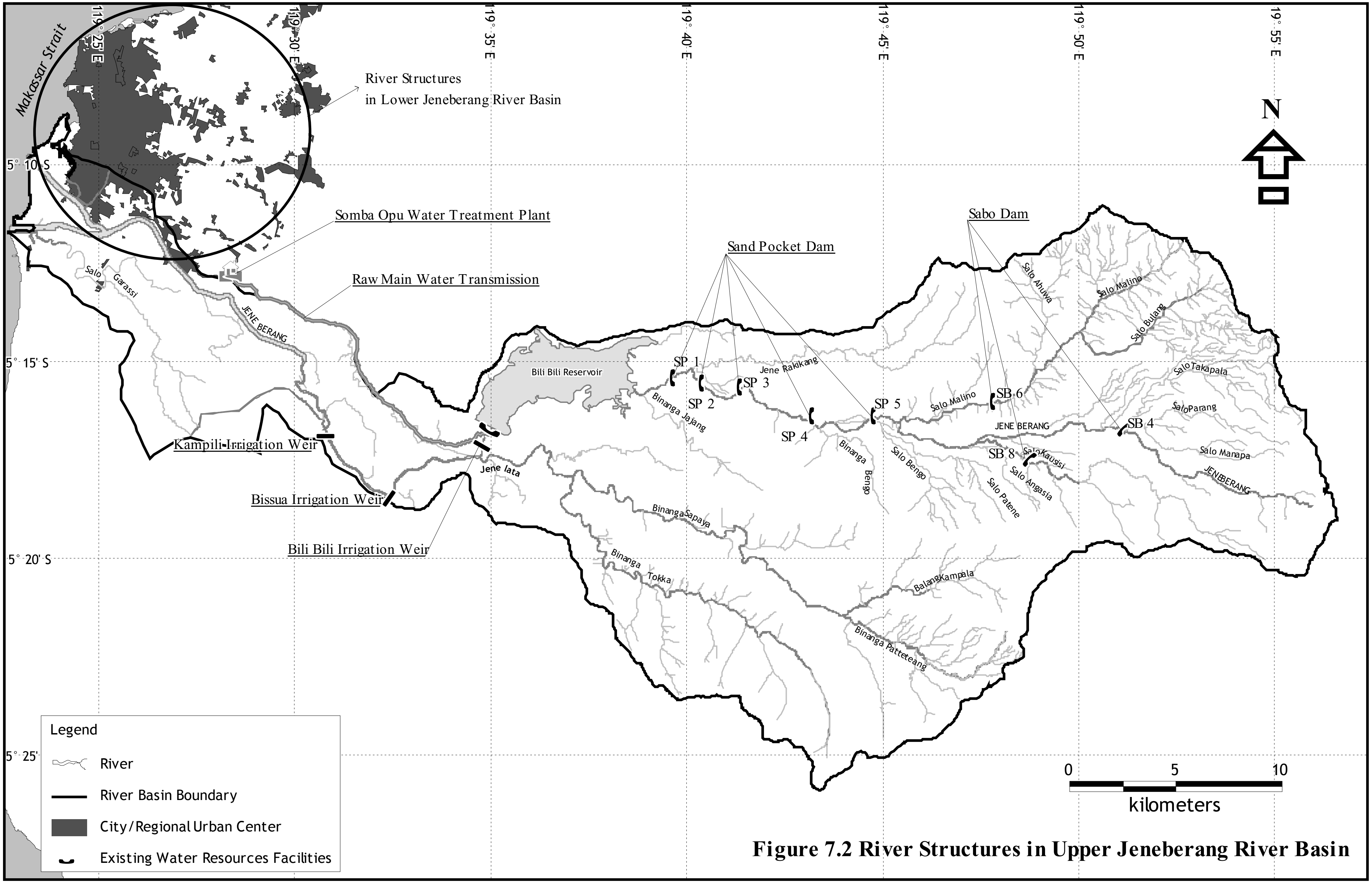


Figure 7.2 River Structures in Upper Jeneberang River Basin

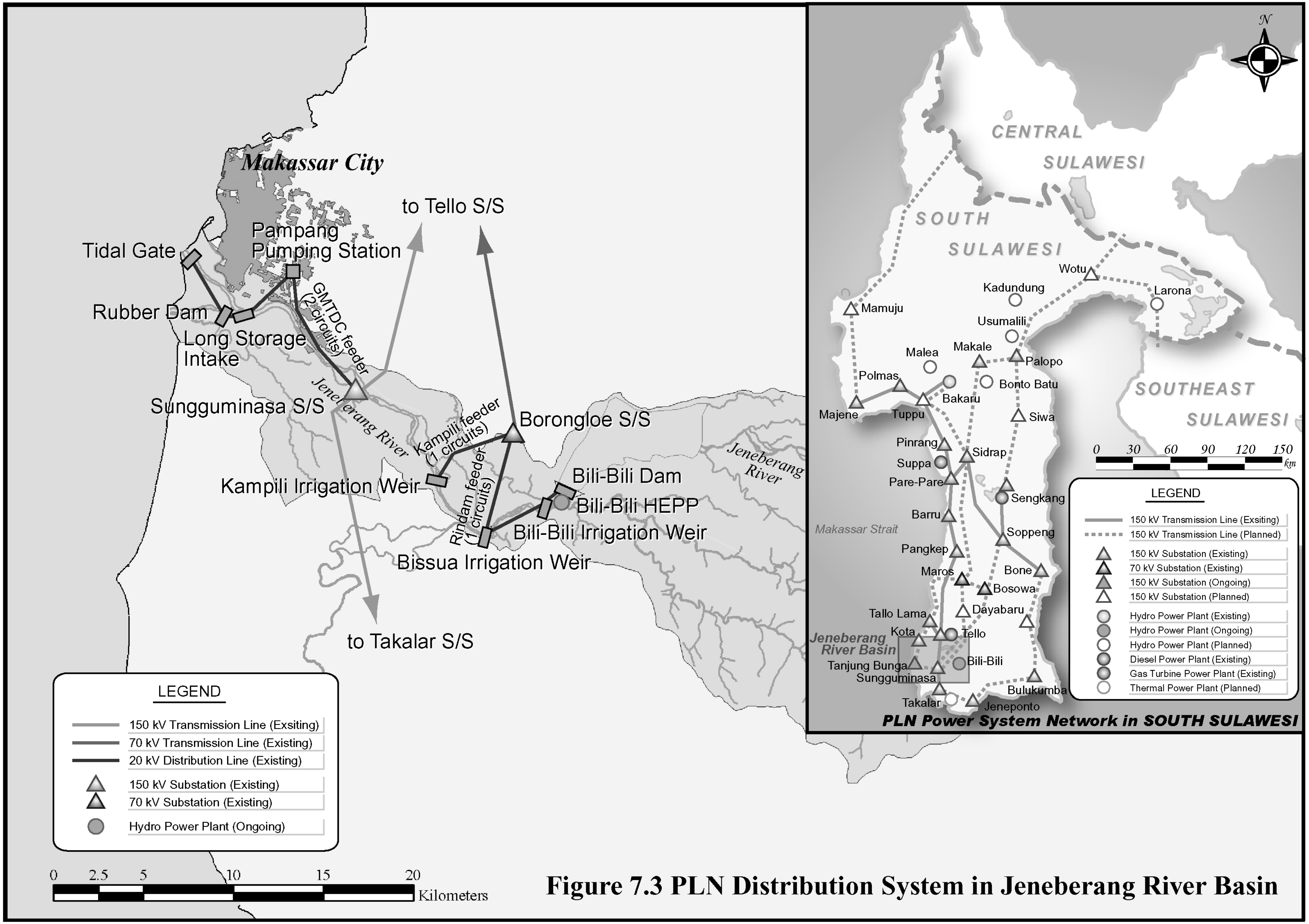
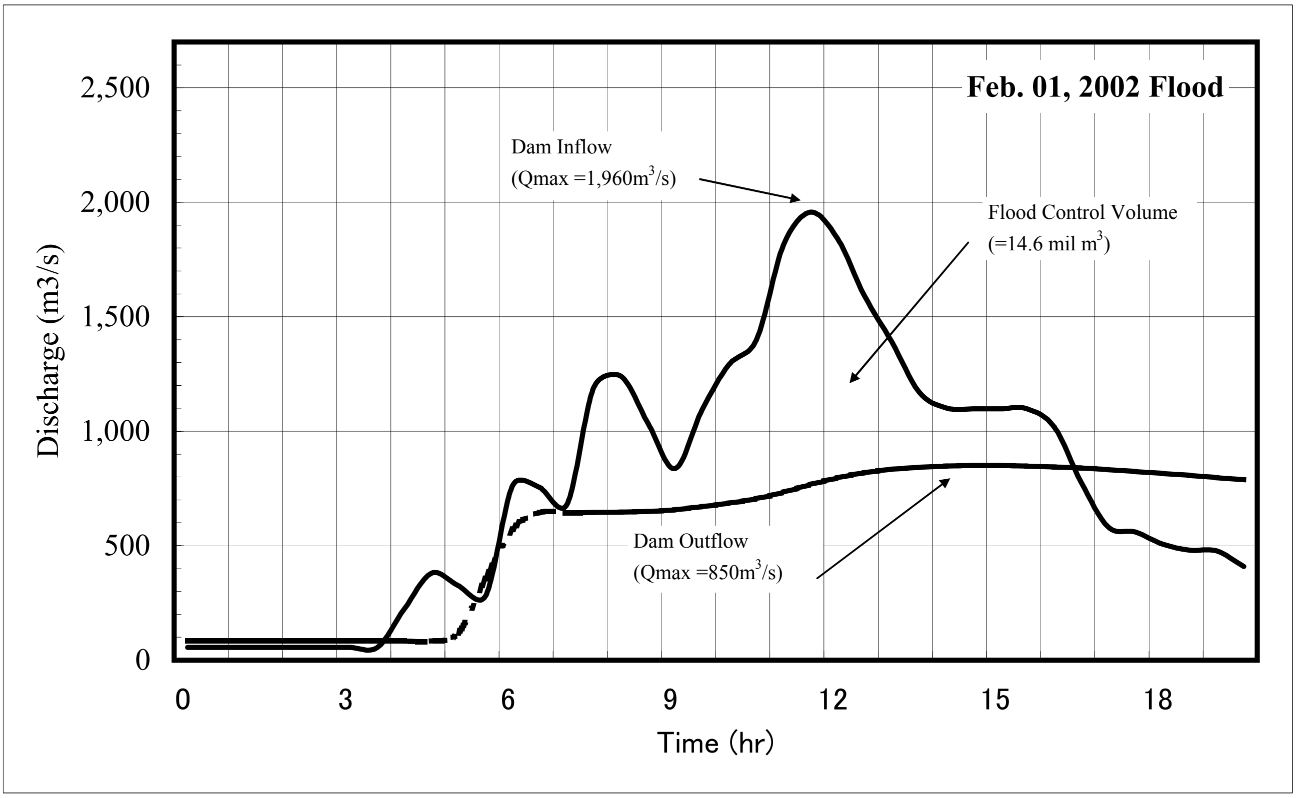


Figure 7.3 PLN Distribution System in Jeneberang River Basin



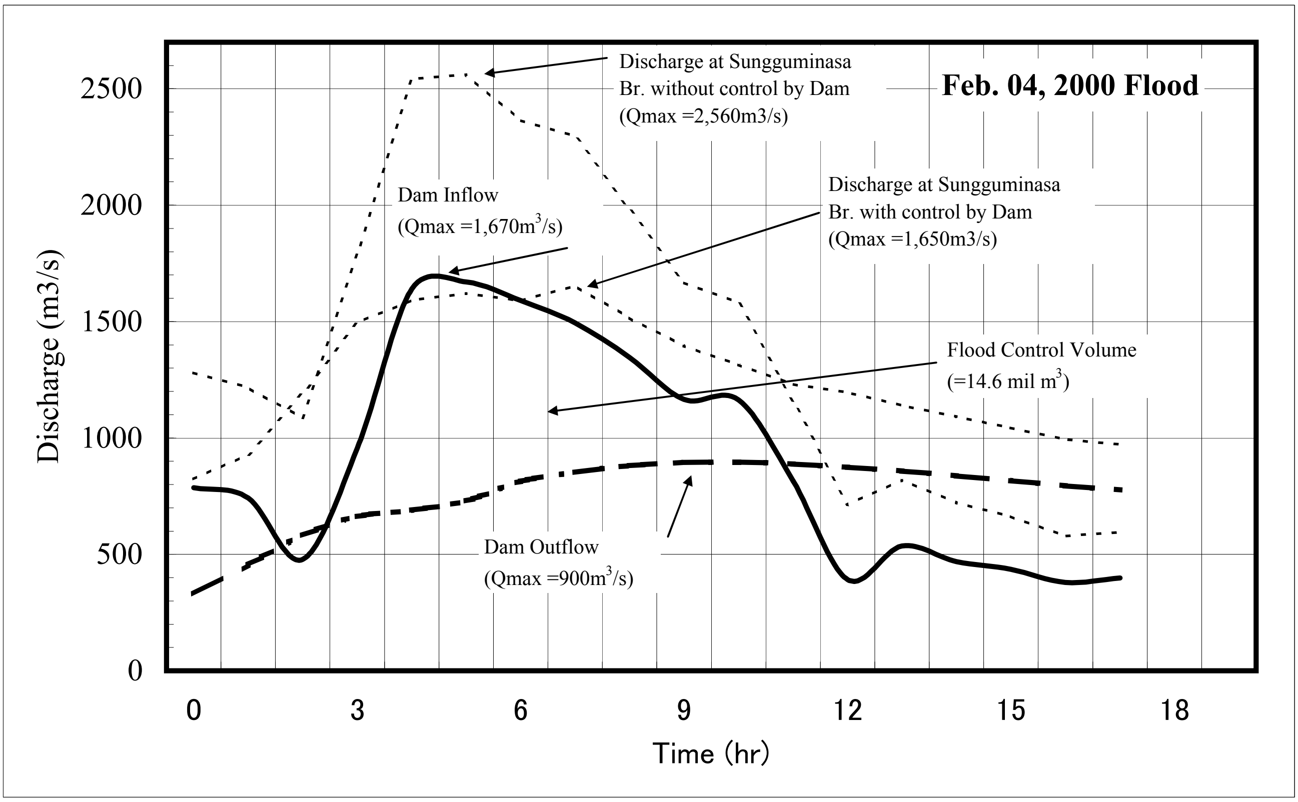
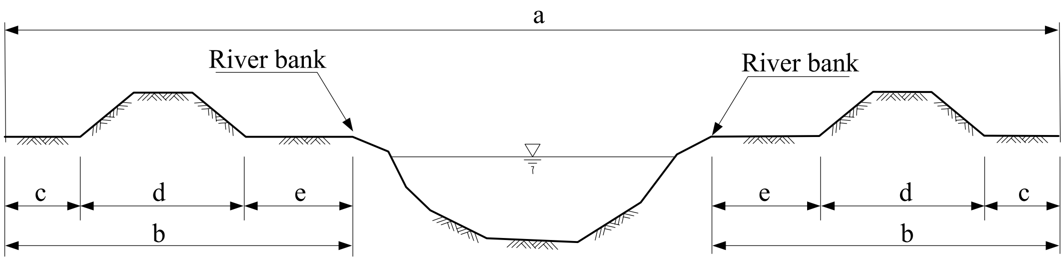


Figure 7.4 Results of Flood Control by Bili- Bili Dam

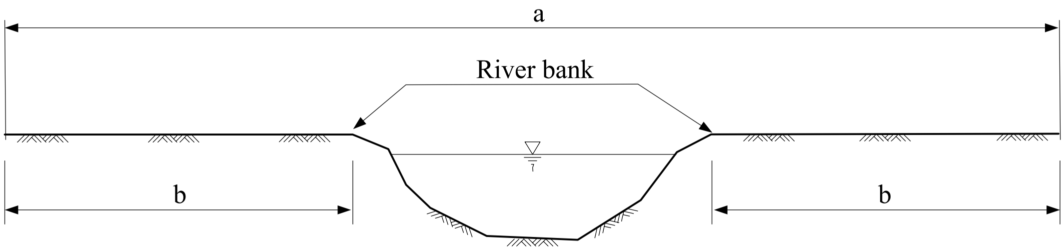
River with Dike



Notes:

a : River area to be managed by Public Corporation
b : River Corridor
c : W = 3m in urban area, W = 5m in rural area
d : River dike area
e : Flood channel

River without Dike



Notes:

a : River area to be managed by Public Corporation
b : River corridor (W = 100 m (A > 500 km^2), W = 50 m (A < 500 km^2))

Figure 7.5 River Area to be Managed by Public Corporation

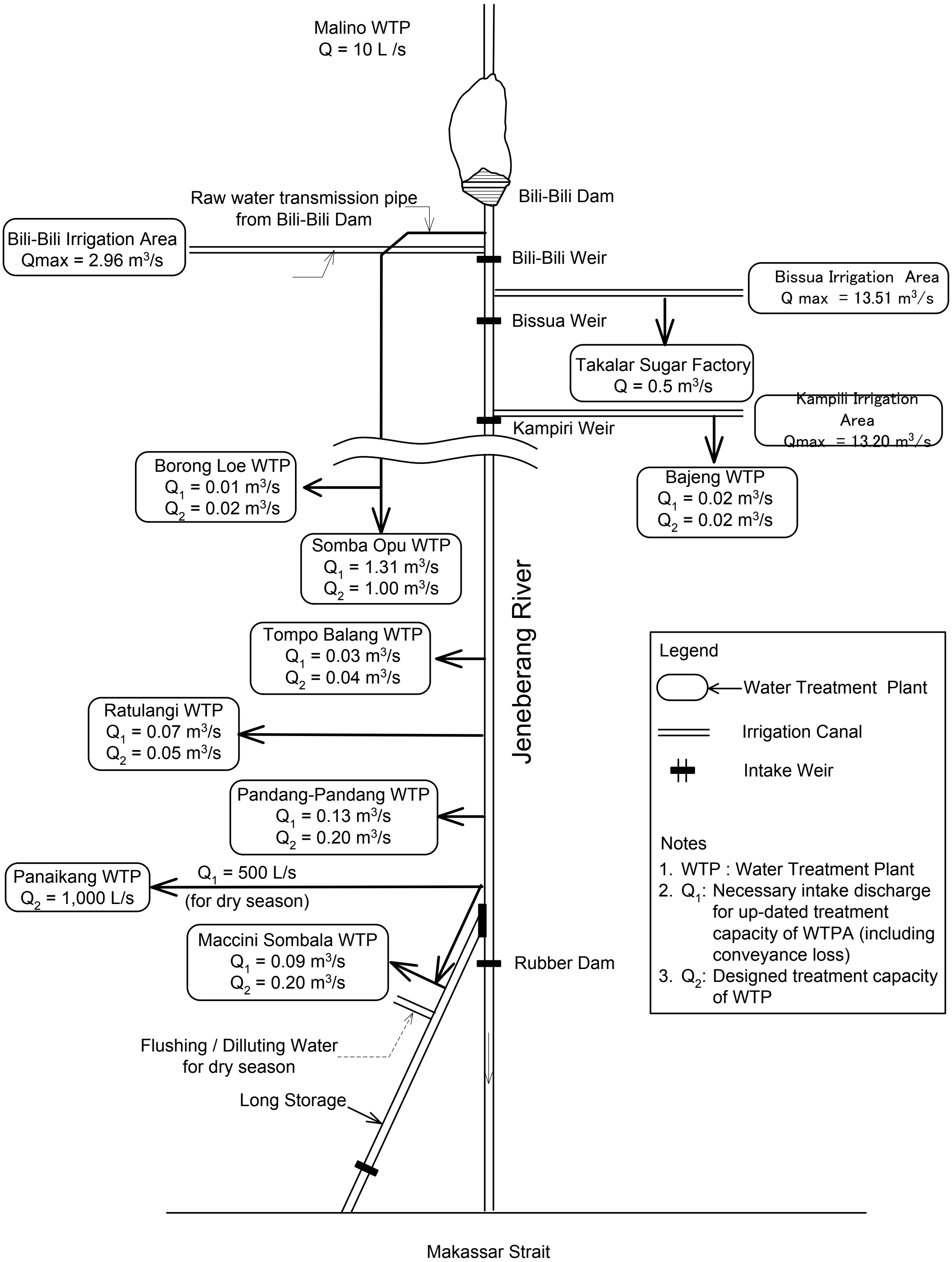


Figure 7.6 Water Allocation Plan

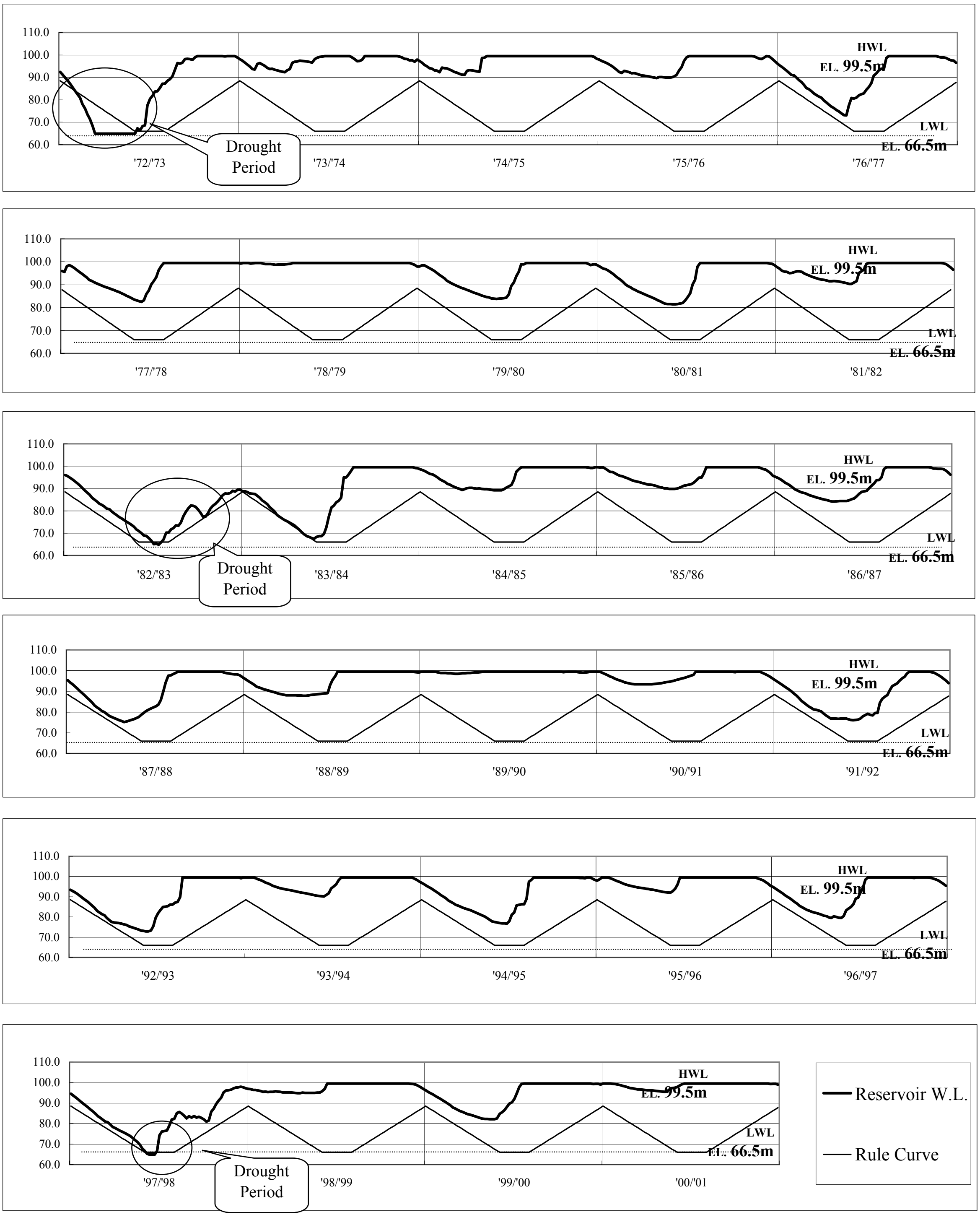


Figure 7.7 Fluctuation of Reservoir Water Levels

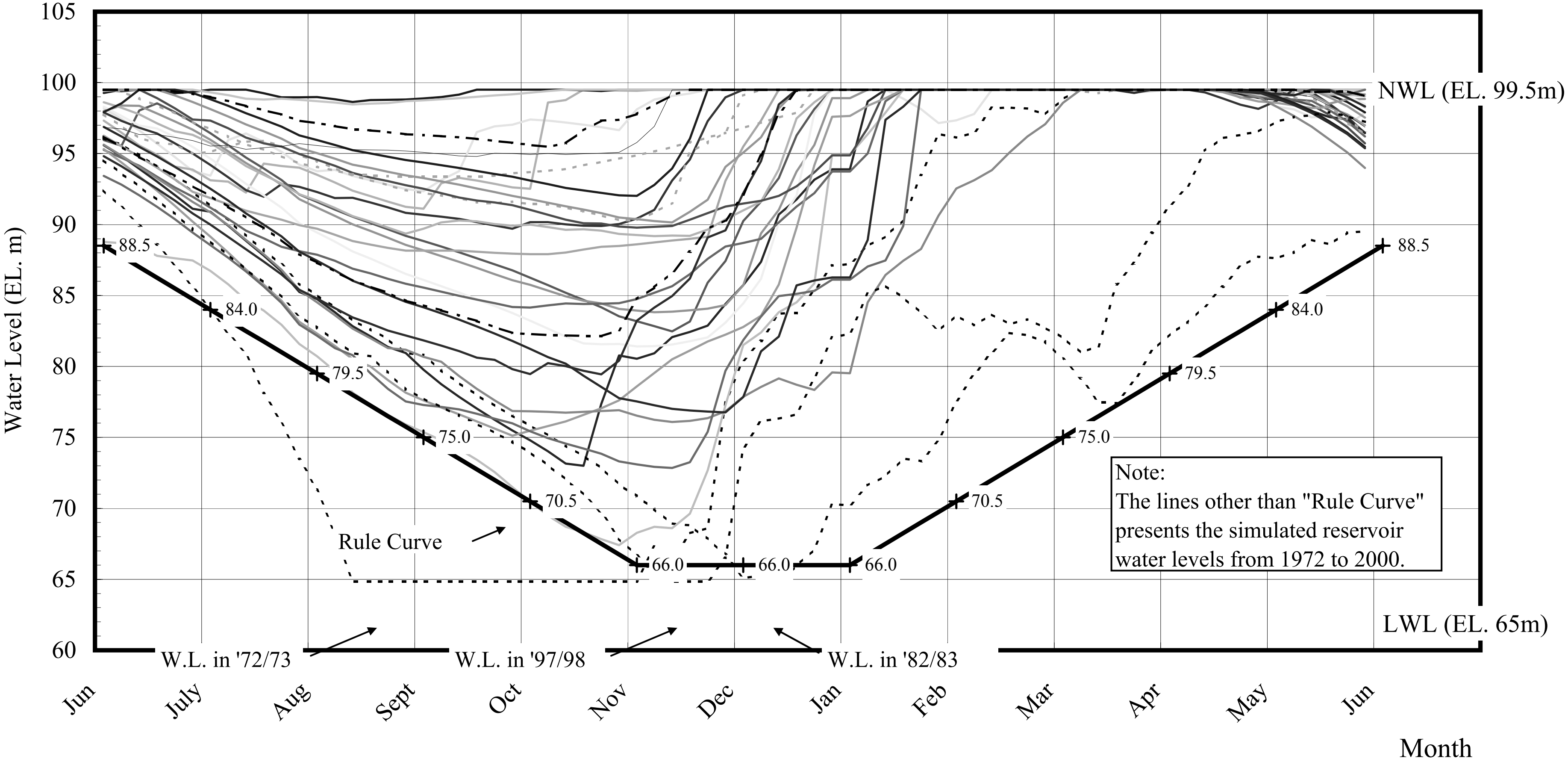
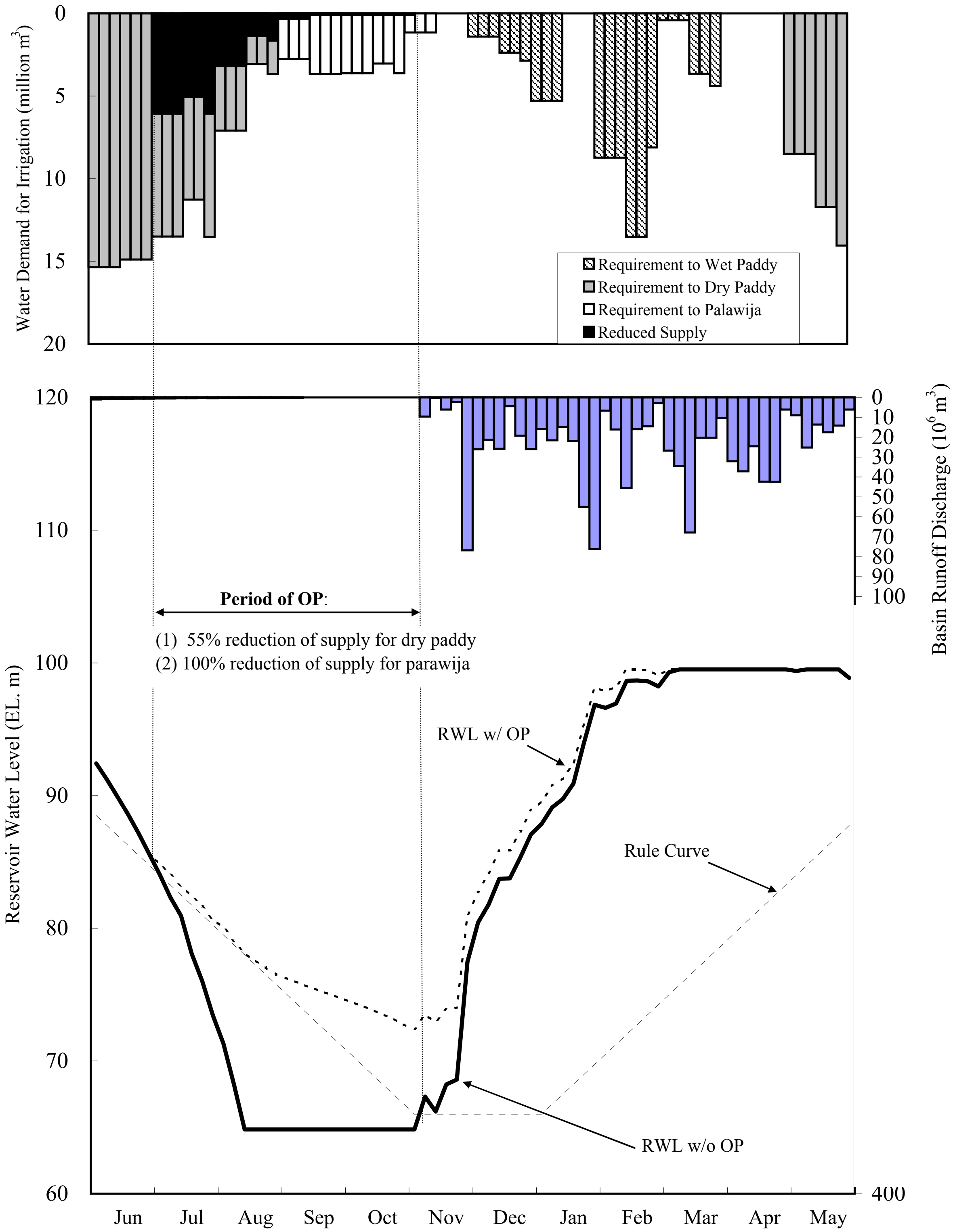


Figure 7.8 Simulated Reservoir Water Level and Rule Curve

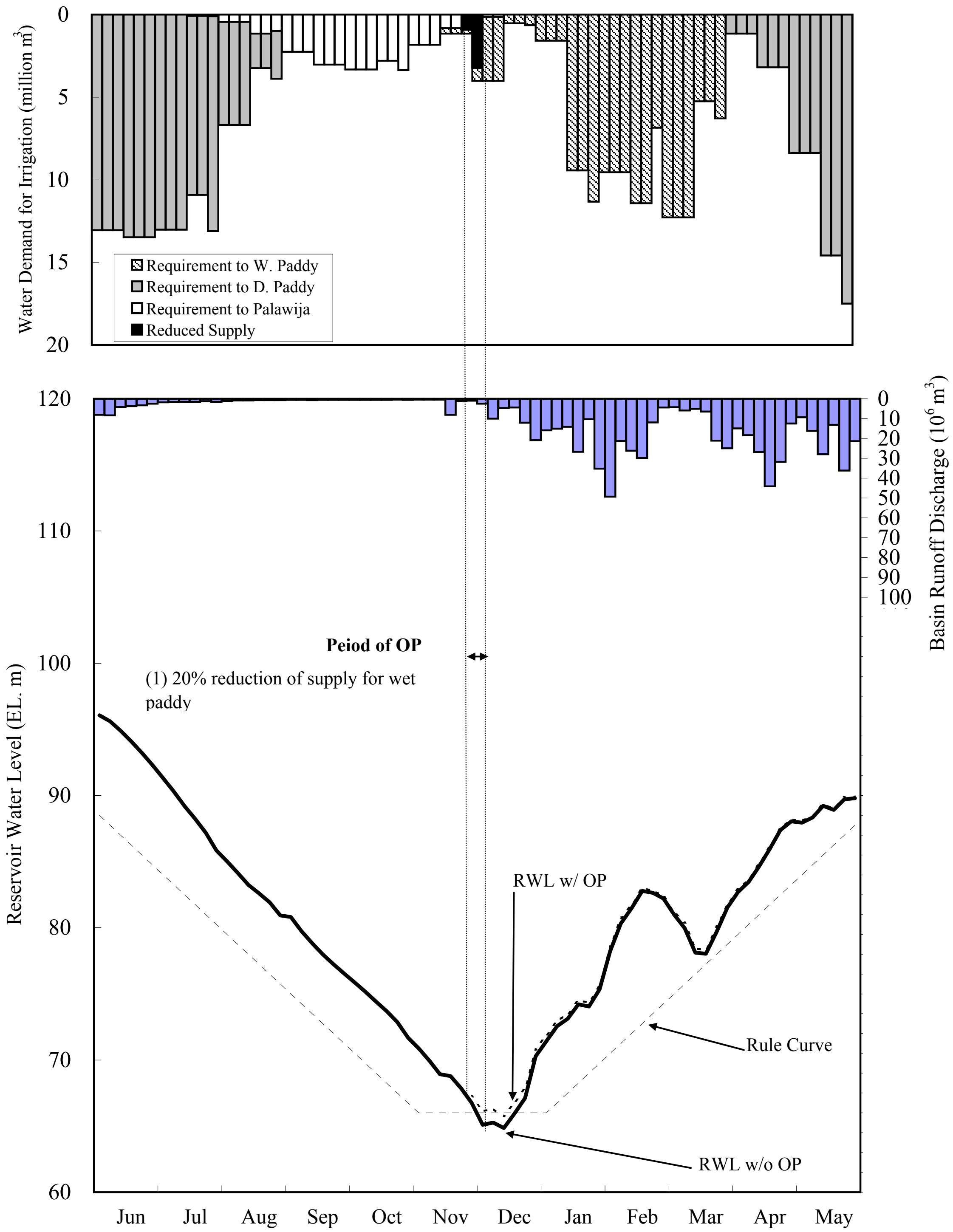


Note:

RWL : Reservoir Water Level

OP: Reservoir Operation Applied to Drought

Figure 7.9 (1/3)
Reservoir Water Level with- and without Drought Operation against Flow Regime in 1972

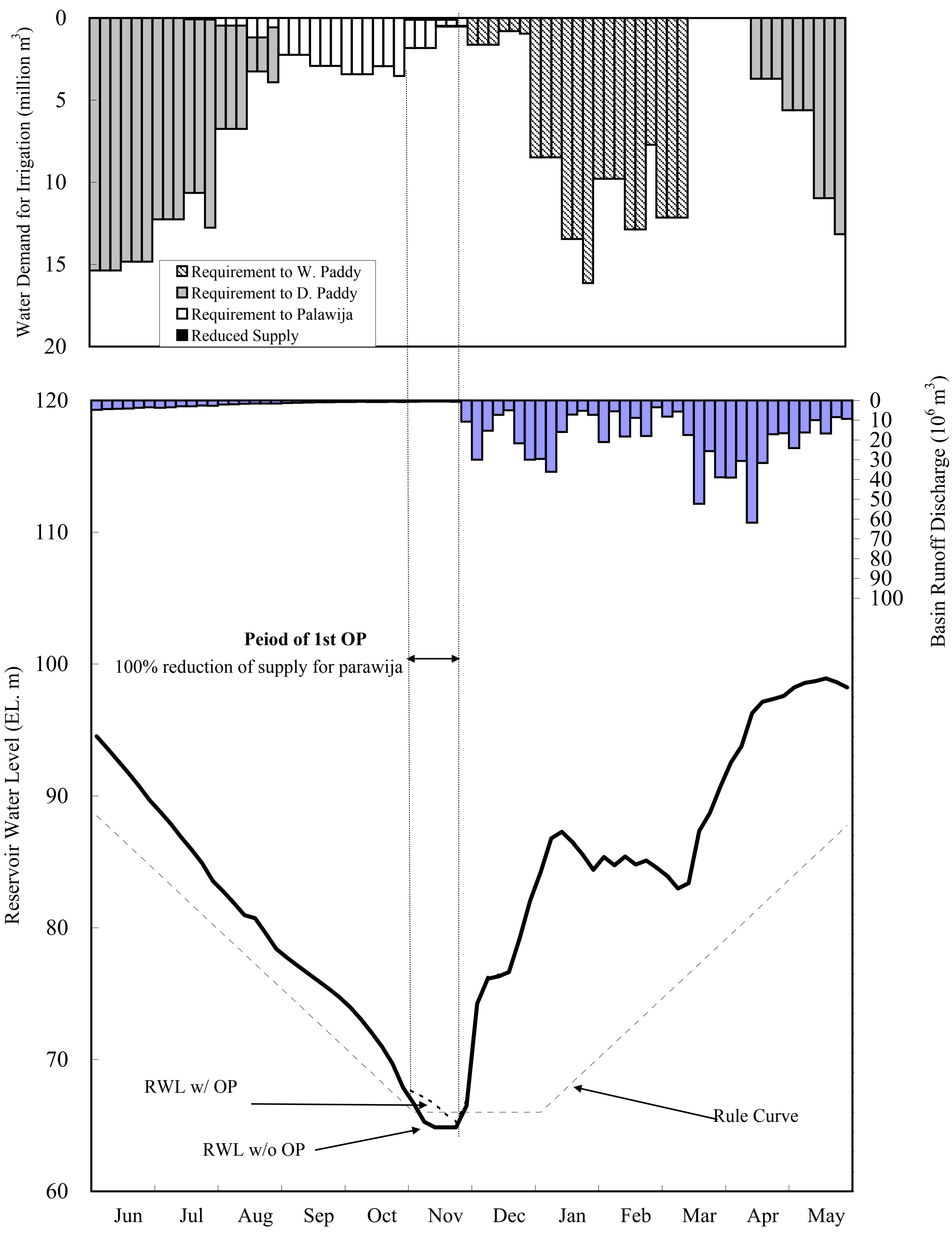


Note:

RWL : Reservoir Water Level

OP: Reservoir Operation Applied to Drought

Figure 7.9 (2/3)
Reservoir Water Level with- and without Drought Operation against Flow Regime in 1982



Note:

RWL : Reservoir Water Level

OP: Reservoir Operation Applied to Drought

Figure 7.9 (3/3)
Reservoir Water Level with- and without Drought Operation against Flow Regime in 1997/1998

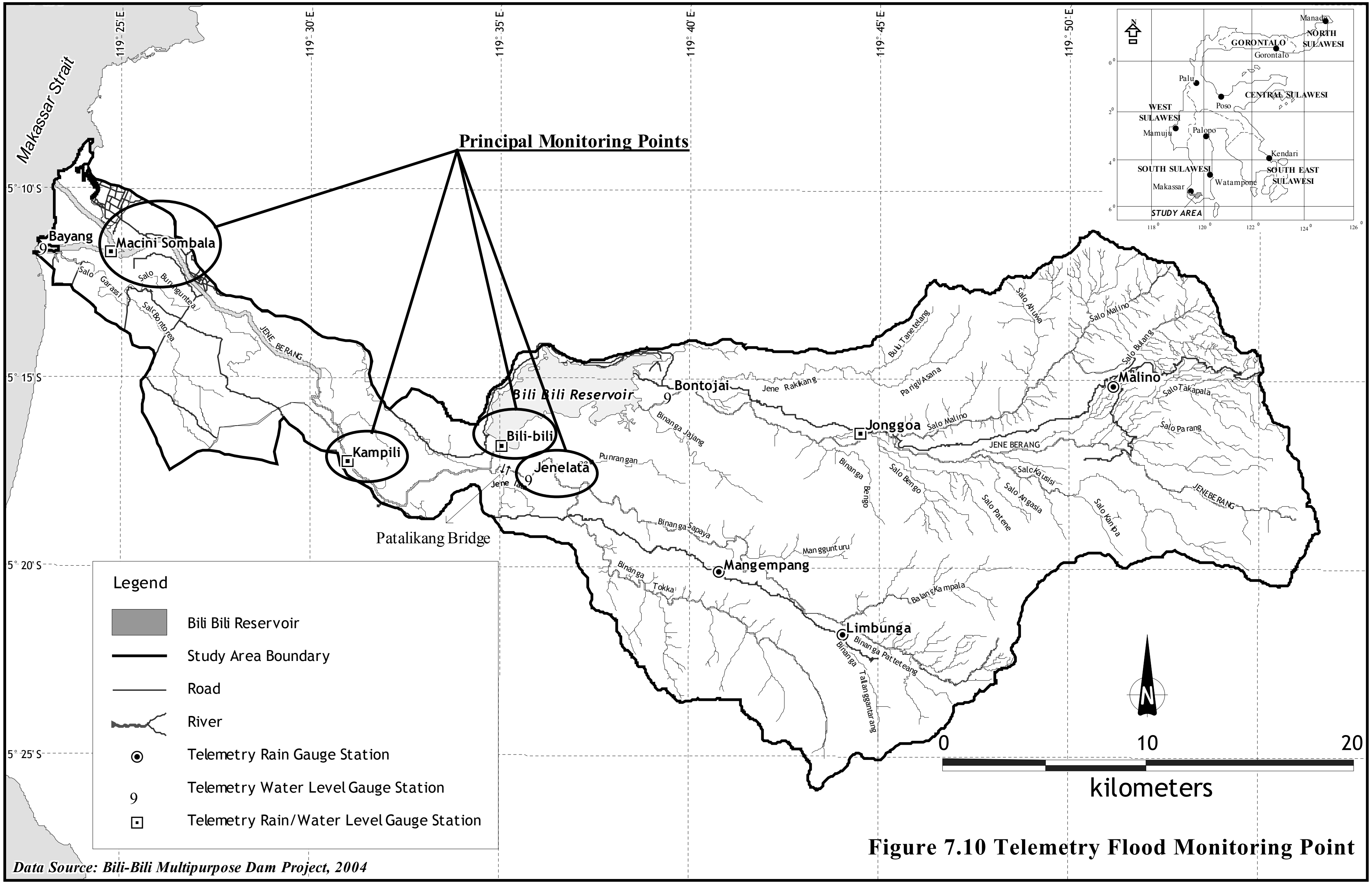


Figure 7.10 Telemetry Flood Monitoring Point

Data Source: Bili-Bili Multipurpose Dam Project, 2004

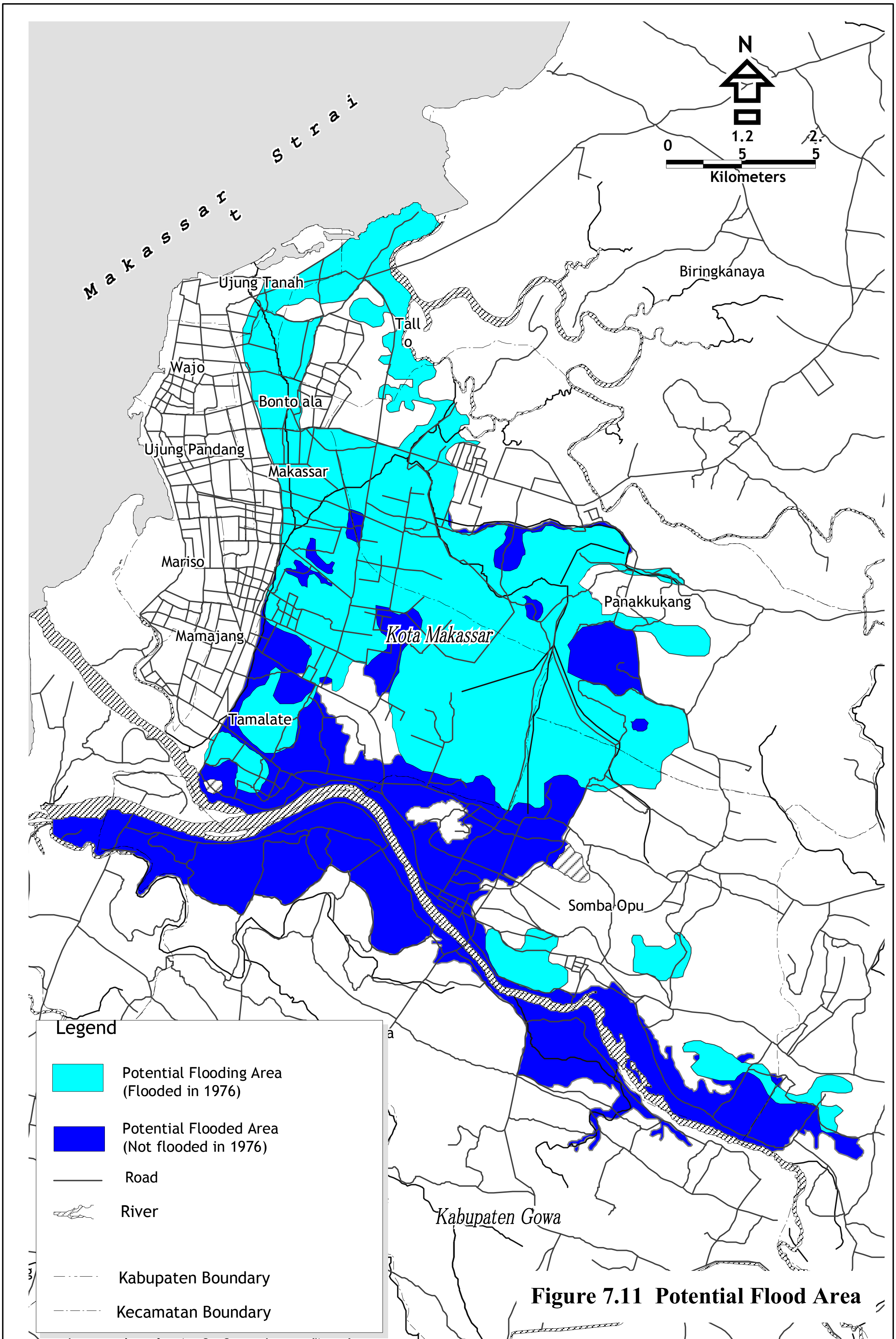


Figure 7.11 Potential Flood Area

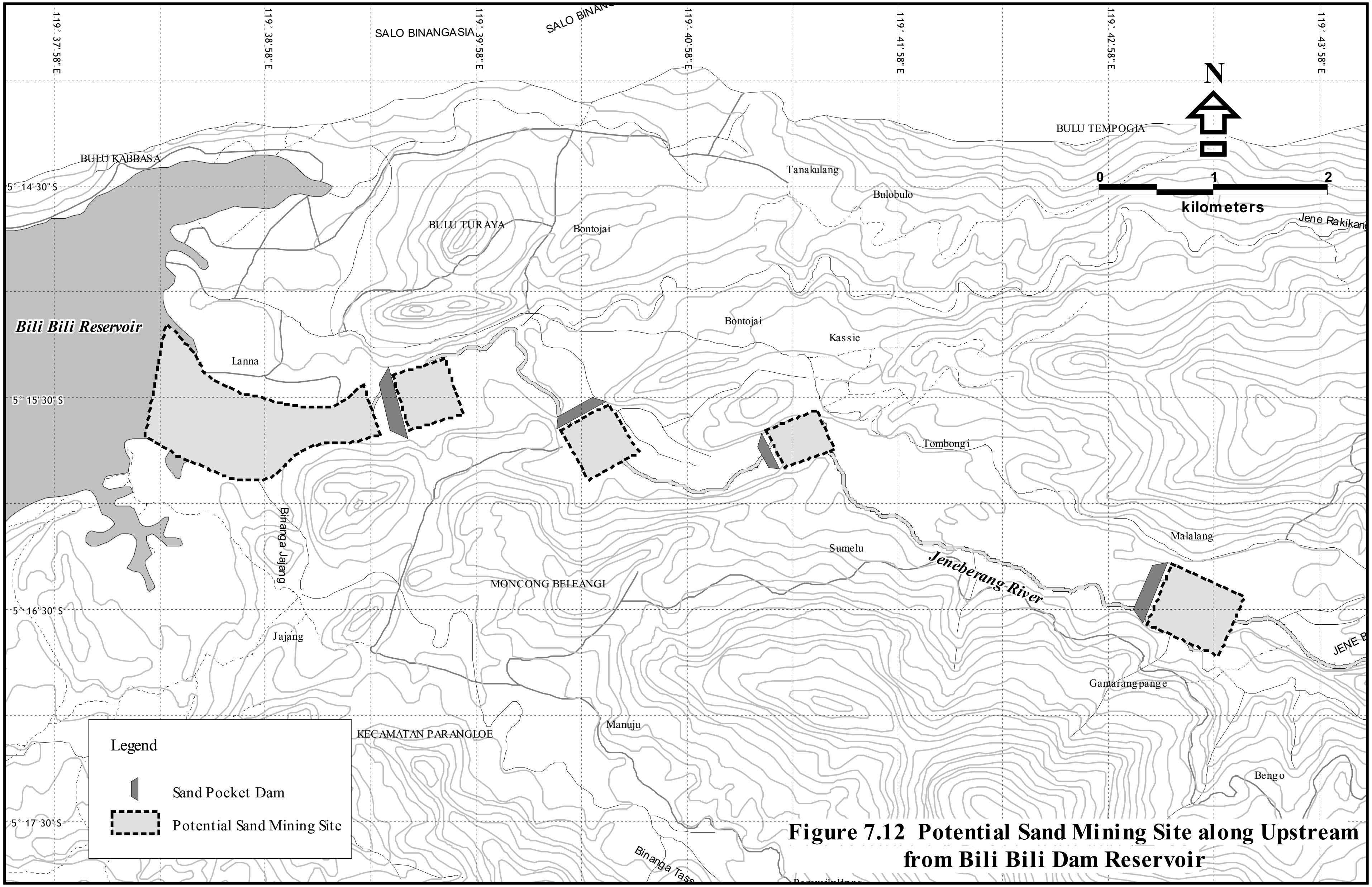


Figure 7.12 Potential Sand Mining Site along Upstream from Bili Bili Dam Reservoir

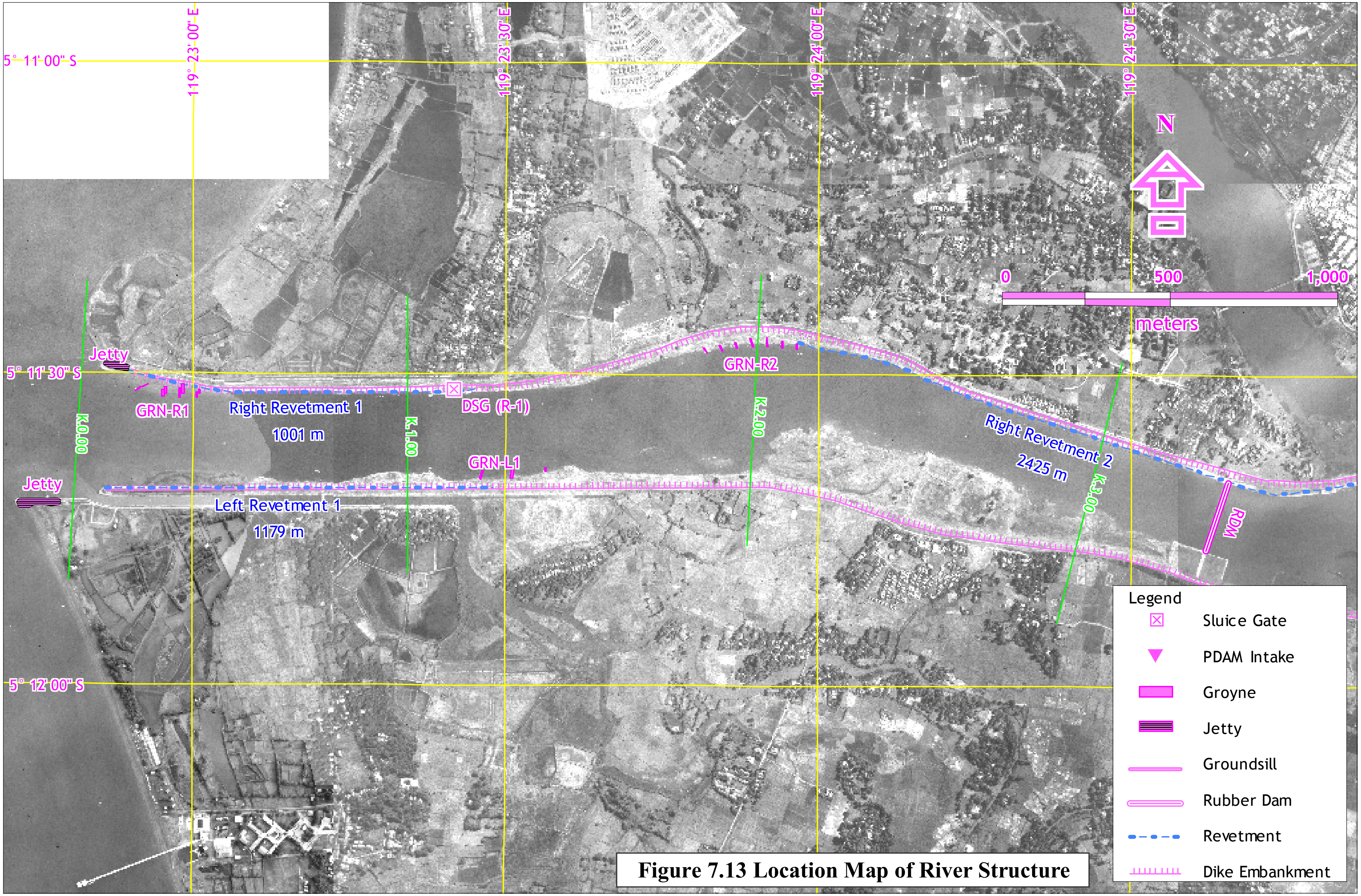


Figure 7.13 Location Map of River Structure

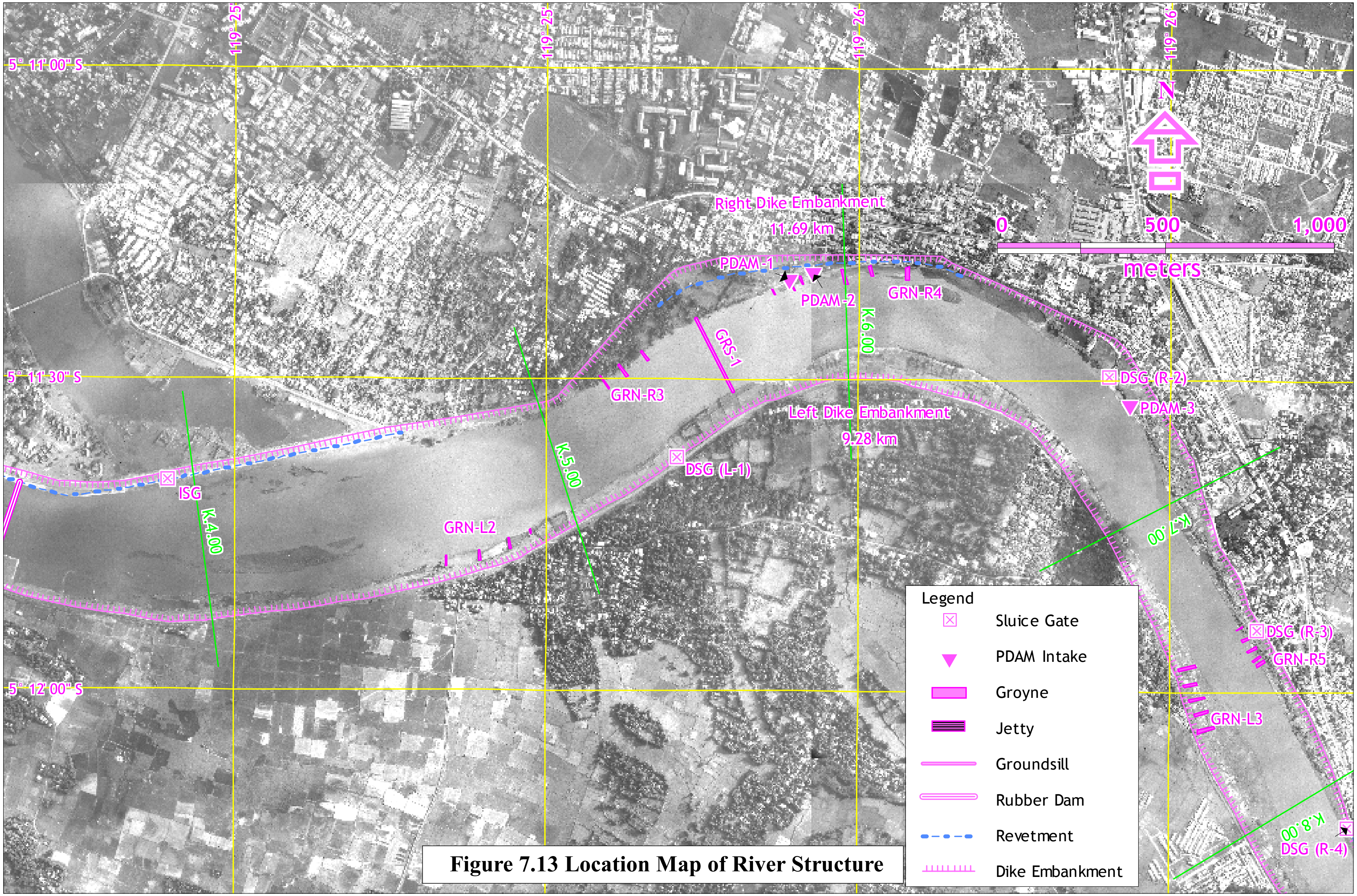


Figure 7.13 Location Map of River Structure

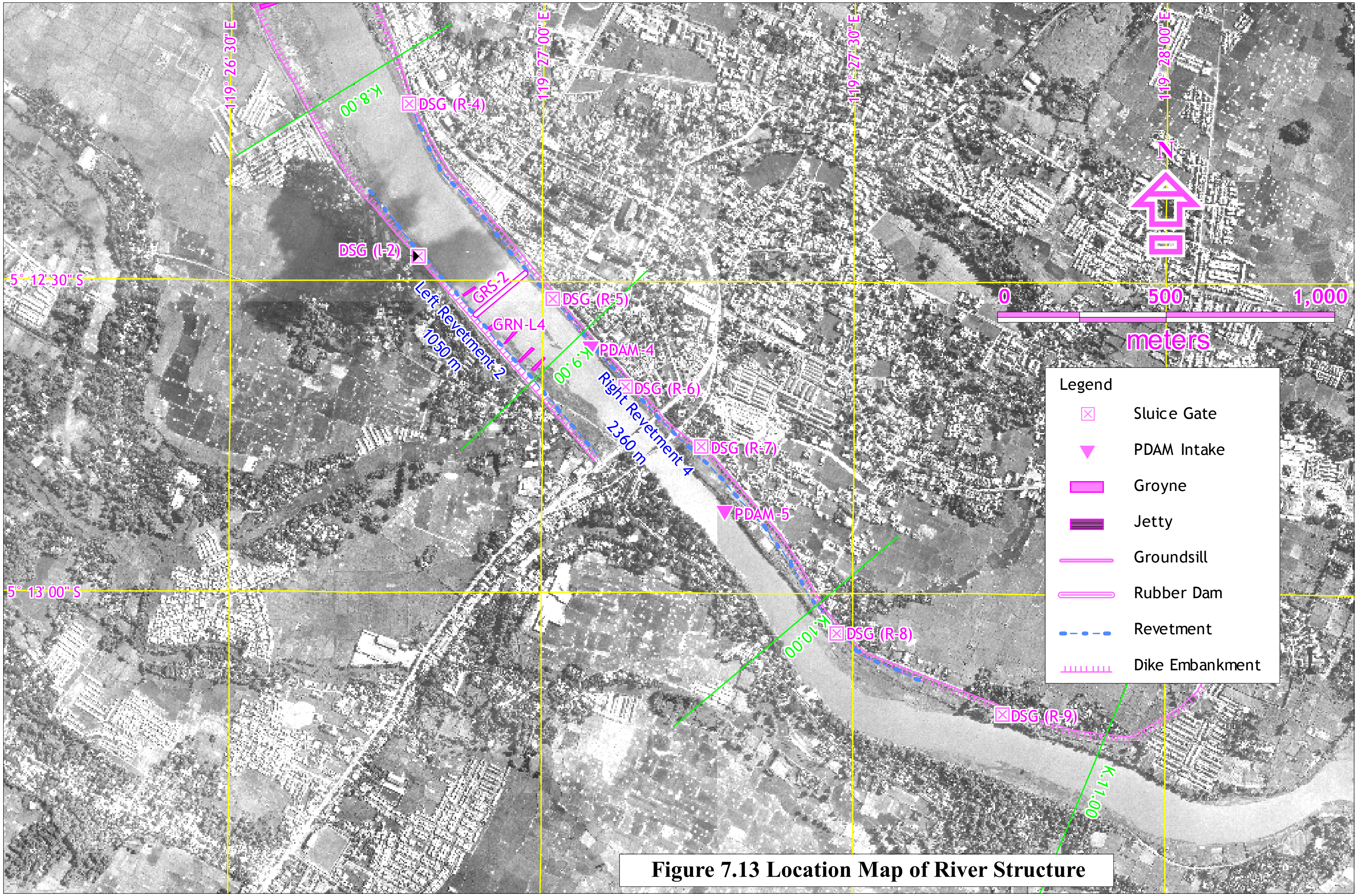


Figure 7.13 Location Map of River Structure