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FOR
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WATER RESOURCES DEVELOPMENT PROJECT

SUPPORTING REPORT
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PART THREE FLOOD CONTROL

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CHAPTER I INTRODUCTION

This SUPPORTING REPORT presents the present conditions of the rivers within the extent of the objective area, the results of estimation of flood damages, the results of studies of flood control methods and the proposed flood control plans. The evaluation of the proposed flood control plans is not included in this supporting report.

CHAPTER II PRESENT CONDITIONS OF RIVERS

2.1 RIVER SYSTEM

The objective area is composed of the Cenranae River and the Gilirang River basins which are located in Latitude 3°30' to 5°10' South and Longitude 125° East, and occupies the middle part of the Central Sulawesi.

The main river system of the Cenranae River basin is composed of Lake Tempe at the center of the basin, the Walanae River flowing into the Lake from the south, the Bila River flowing into the Lake from the north, other small rivers such as the Batu-Batu and the Lawo Rivers which also flow into the Lake from the south and the west, and the Cenranae River flowing out from the Lake to the Bay of Bone. This may be called Cenranae River system.

The Gilirang River basin is located in the north-east of Lake Tempe and the river flows directly to the Bay of Bone.

The river systems in the objective area and the profiles of the rivers are shown in Figs. 2.1 and 2.2 respectively.

2.2 DISTINCTIVE FEATURES OF RIVERS

2.2.1 <u>Cenranae River</u>

The Cenranae River flows out from Lake Tempe, running to the south-east, pours to the Bay of Bone. The catchment area at the river mouth is 7,294 km^2 in which 1,155 km^2 is an area from Senkang to the river mouth.

The length of the channel is 69 km from the river mouth to Lake Tempe, and the river has a natural channel with single section. The width of the channel ranges from 70 m to 120 m and the water surface slope is extremely gentle. From the longitudinal profile of the channel, the average water surface slope is estimated at 1/20,000 in time of drought, 1/14,000 in normal time and 1/8,000 in time of flooding. The carrying capacities of the channel between the river mouth and the confluence with the Walanae River are estimated to be from 400 to 670 m^3/s by calculation.

The river banks consist of clayey soil. However, grain size investigation of river bed materials shows that the stream bed consists of fine sand including silty soil and mean diameters of the materials range from 0.3 to 0.6 mm. Although some meanderings and bank erosions are found, the channel seems to be comparatively stable except around its river mouth.

Many large and small swamps exist along the Cenranae River. Among them, a large swamp in the downstream area from Kampiri (41 km from the river mouth) acts as a natural retarding basin on the mainstream.

Near the river mouth, the Cenranae river branches mainly into three channels, flowing to the Bay of Bone as shown in Fig. 2.3. Among them, the Ceppitengngae River seems to have been the main channel on a map of 1/50,000 scale surveyed around 1920, but this channel is shallow at present due to sediments carried down by the river. The survey carried out by the Team in November 1978 shows that the Watu River is the main channel with widths from 100 to 400 m and depths from 2.5 to 4.0 m in the time of ebb tide.

2.2.2 Lake Tempe

Lake Tempe is located at the center of the basin. During the dry season, the Lake is divided into three lakes of Tempe, Sindenreng and Buaya, connected with Lake Tempe by water channels. However, they form one lake during a flood season. A contour map of Lake Tempe has been prepared as shown in Fig. 2.4, based on the topographic map of 1/25,000 scale and the result of sounding survey of Lake Tempe by the JICA Survey Team in Feb. 1974.

The water level records indicate that high-water levels occur from June to August and low-water levels occur from October to December. Most of annual maximum water levels occur in June, and the highest water level was recorded in June 1970 as 9.58 m in elevation. On the other hand, the lowest water level was recorded in Nov. 1977 as 3.2 m.

The area around Lake Tempe is an alluvial zone formed by sediment from the Walanae, the Bila and other rivers and it seems that the Lake is still in the sedimentation stage.

2.2.3 Walanae River

(1) Mainstream

The Walanae River is the largest river among those flowing into Lake Tempe with a catchment area of 3,190 km^2. The river rises from a mountain zone in the south of Lake Tempe, flowing through the central part of South Sulawesi, and joins the Cenranae River at Sengkang. The shape of the basin is comparatively narrow, 30 km wide and 100 km long. The river has three main tributaries which are the Sanrego, the Menraleng and the Mario Rivers.

In the reaches of the mainstream from Sengkang to Pacongkang, the mean width of the channel is about 100 m and the longitudinal profile shows that the average water surface slope varies from 1/3,000 to 1/5,000. The carrying capacities of the channel are estimated to be from 400 to 2,300 m^3/s by calculation. In the downstream reaches, the carrying capacity is extremely small under the influence of backwater from Lake Tempe.

The river has some developed meanderings accompanied by erosion. However, they are relatively stable forming meanderings in so-called floodplain. Around 60 km from the confluence with the Cenranae River, the river slope increases to 1/1,000, with sand bars and gravel on the river bed. The bank erosion is seen at many places in the middle and upstream reaches.

(2) Tributaries of Walanae

The tributaries have steep slopes more than 1/400, with gravel and cobble stones on the stream bed. It seems that the river channel is in an erosion stage with bank erosion especially in the upstream reaches.

(a) Sanrego River

The Sanrego River rises from the mountain zone in the south of the Walanae basin and flows through a high plain of the southern part of the basin, and joins with the mainstream of the Walanae at Mattirowalie, Kec.Kahu, Kab.Bone. The catchment area at its confluence is 230 km^2. The mean width of the channel in the downstream reaches is about 50 m and the average river slope is about 1/400. The carrying capacity at Sanrego Water Level Gauging Station is estimated at 700 m^3/s by calculation.

(b) Menraleng River

The Menraleng River rises from the south-western mountain zone in the south-west of the Walanae basin flowing down through a high plain in the southern part of the basin, and joins to the mainstream of the Walanae at Bune, Kec.Libureng, Kab.Bone. The catchment area at its confluence is 515 km^2. The mean width of the channel in the downstream reaches is about 70 m and the average river slope is 1/400. The carrying capacity in the downstream reaches is roughly estimated at 1,500 m^3/s by field investigation.

(c) Mario River

The Mario River consists of the Sero and the Langkemme Rivers which rises from the mountain zone in the west and the south-west of the Walanae basin. It flows through a mountain zone, and joins to the mainstream of the Walanae at Mong, Kec.Mario Riwawo, Kab.Soppeng. The river is called Mario from the confluence with the mainstream to the confluence with the Langkemme River, and the river is called Sero upstream from there. The total catchment area at the confluence with the mainstream is 485 km^2. The mean width of the channel in the downstream reaches is about 70 m and the average river slope is about 1/300. The carrying capacity at a road bridge in the downstream reaches is roughly estimated at 1,500 m^3/s by field investigation.

(d) Langkemme River

The Langkemme River is a tributary of the Mario River which has a catchment area of 104 km^2. The mean width of channel in the downstream reaches is about 30 m and the average river slope is about 1/300. The carrying capacity at Langkemme Water Level Gauging Station is estimated at 500 m^3/s by calculation.

(e) Belo River

The Belo River rises from the mountain zone in the southwest of Lake Tempe and flows through the town of Watan Soppeng. It joins to the mainstream of Walanae at the downstream of Cabenge, with a catchment area of 216 km^2. The mean width of the channel in the downstream reaches is about 20 m and the average river slope is about 1/1,000. The carrying capacity in the downstream reaches is roughly estimated at 150 m^3/s by field investigation. But during a flood season, the carrying capacity becomes extremely small under the influence of backwater from the mainstream.

2.2.4 Bila River

(1) Mainstream

The Bila River rises from the mountain zone in the north of Lake Tempe and flows into Lake Tempe. The river consists of four rivers which are the Bila, the Boya, the Lancirang and the Kalola Rivers. They run in parallel and join in the downstream reaches of the Bila River. The total catchment area at the river mouth is 1,368 km^2.

In the downstream reaches from the confluence of the Boya, the river has a natural channel with single section. The mean width of the channel is about 70 m and the average river slope is estimated at about 1/3,000 on the longitudinal profile. The carrying capacities of the channel are estimated to be from 340 m to 1,130 m^3/s by calculation.

A delta is formed near the river mouth by the sediment carried down by the river. The river bifurcates in the delta into two channels leading to Lake Tempe. During a flood season, the downstream area from the bifurcation is submerged below the high-water level of Lake Tempe. In the stretch 10 km upstream from the bifurcation, the small scale levees exist on both banks. Repairing and reinforcement of these levees have been carried out occasionally.

As for the mainstream of the Bila, although some developed meanderings accompanied by bank erosion are found along the river course, erosion and sedimentation are almost balanced in the reaches upstream from the above-mentioned bifurcation. The river channel from the bifurcation to the river mouth seems to be in a slight sedimentation stage.

(2) Tributaries of Bila

(a) Boya River

The Boya River rises from the mountain zone in the north of Lake Tempe, flows through a plain in the middle part of the basin, and joins to the mainstream of the Bila upstream near Tanru Tedong. The catchment area at its confluence is 536 km^2. The mean width of the channel in the downstream reaches is about 50 m and the average river slope is about 1/1,000. The carrying capacity in the reaches between the confluence of the mainstream and Bulu Cenrana Water Level Gauging Station is estimated at 830 m^3/s by calculation. The river has a natural channel with single section. Some developed meanderings accompanied by bank erosion are found. However, the erosion and sedimentation seem to be almost balance.

(b) Lancirang River

The Lancirang River flows in parallel with the Boya River and joins to the mainstream in the downstream reaches. The catchment area at its confluence is 180 km^2. The channel in the downstream reaches is too small, so that the flooded water forms a swampy area during a flood season.

(c) Kalola River

The Kalola River flows in parallel with the Bila River, and joins to the mainstream in the upstream reaches from the confluence of the Boya. The catchment area at its confluence is 167 km^2. This river joins to the main stream after flowing upstream for about 1.5 km, so that the water surface slope is extremely gentle during a flood season. In the downstream reaches of the river, the carrying capacity becomes small under the influence of backwater from the mainstream.

2.2.5 Gilirang River

The Gilirang River rises from the mountain zone in the northeast of Lake Tempe and flows directly to the Bay of Bone. The catchment area at the river mouth is 518 km^2. The mean width of the channel in the downstream reaches is about 60 m and the average slope varies from 1/1,000 to 1/2,000. The carrying capacity at Tarumpakkae Water Level Gauging Station is estimated at 350 m^3/s by calculation. The river has a natural channel with single section. The bank erosion of the river still continues, but the erosion is limited locally.

2.2.6 Lawo River

The Lawo River rises from the mountain zone in the south-west of Lake Tempe and flows into Lake Tempe. The catchment area at the river mouth is 168 km^2. The mean width of the channel is about 5 m in the downstream reaches and is about 20 m in the middlestream reaches. The average river slope is about 1/1,000 in the downstream reaches and is about 1/200 in the middlestream reaches. The carrying capacity at Lawo Water Level Gauging Station is estimated at 250 m^3/s by calculation. In the downstream reaches, the channel is too narrow and the water surface slope is also extremely gentle, so that during a flood season, the flooded water forms a swampy area in the downstream reaches.

2.2.7 Batu-Batu River

The Batu-Batu River rises from the mountain zone in the south-west of Lake Tempe and flows into Lake Tempe. The catchment area at the river mouth is 113 km^2. The mean width of the channel in the downstream reaches is about 20 m and the average river slope is about 1/500. The carrying capacity at Batu-Batu Water Level Gauging Station is estimated at 90 m^3/s by calculation. The river channel seems to be in the erosion stage with bank erosion at many places.

2.3 CARRYING CAPACITY OF RIVER CHANNEL

2.3.1 Cross-section of River Channel

For calculation of carrying capacity of river channel, 39 cross-sections on the Cenranae, the Walanae and the Bila Rivers were surveyed by the Team. The locations of cross-section survey are shown in Fig. 2.5. The surveyed river cross-sections and longitudinal profiles are shown in Figs. 2.6 and 2.7 respectively.

2.3.2 Zero Gauge Elevation of the Gauging Station

For hydraulic calculation, the zero gauge elevation of the following water level gauging stations was surveyed by the Team.

Station	Kind of Gauge	River	Zero Gauge Elevation (m)
Sengkang (Tampangeng)	AWLR	R.Cenranae	2.802
Kampiri	Staff	R.Cenranae	0.583
Solo	AWLR	R.Cenranae	-0.126
Cenrana	Staff	R.Cenranae	-0.359
T.Pallete	AWLR	Bay of Bone	-1.250
L.Tempe	AWLR	Lake Tempe	3.285
L.Tempe	Staff	Lake Tempe	3.875
L.Sidenreng	Staff	Lake Sidenreng	5.726
Bulu Cenrana	AWLR	R.Boya	19.845
Bila	AWLR	R.Bila	22.980
Tanru Tedong	AWLR	R.Bila	10.824
Cabenge (Sempajeruk)	AWLR	R.Walanae	12.807

Remarks, AWLR: Automatic Water Level Recorder

2.3.3 Manning's Roughness Coefficient

Manning's roughness coefficients of the Bila River at Tanru Tedong and the Walanae River at Cabenge are calculated from the observed discharge data using the following equation;

$$n = \frac{AR^{2/3}}{Q} I^{1/2}$$

where, Q: discharge (m^3/s)
A: flow area (m^2)
R: hydraulic mean depth (m)
I: river bed slope

As the water surface slope of the Cenranae River is extremely gentle, the calculation was made by the Standard Step Method of non-uniform flow in the stretch between Solo and Sengkang. The equation is as follows;

$$H_i = H_{i-1} + \frac{aQ^2}{2g} \left(\frac{1}{A_{i-1}^2} - \frac{1}{A_i^2}\right) + \frac{QXn^2}{2} \left(\frac{1}{A_{i-1}^2 R_{i-1}^{4/3}} + \frac{1}{A_i^2 R_i^{4/3}}\right)$$

where, i: serial number showing a river cross-section
H: water level (m)
g: acceleration of gravity (m/sec^2)
Q: discharge (m^3/sec)
A: flow area (m^2)
X: distance between cross-sections i and i-1 (m)
a: correction coefficient for velocity distribution (a = 1.0)
n: Manning's roughness coefficient
R: hydraulic mean depth (m)

The results of calculation are as follows;

River	Stretch	m
R. Cenranae	Solo - Sengkang	0.020
R. Bila	at Tanru Tedong	0.025
R. Walanae	at Cabenge	0.025

Considering the results of the above-mentioned calculations and the conditions of river channel, Manning's roughness coefficient "n" for the calculation of carrying capacity is determined as follows;

River	Stretch	Manning's n
R. Cenranae	River mouth - Sengkang	0.021
Mainstream of R. Bila	River mouth - Confluence of Boya	0.025
Mainstream of R. Bila	Confluence of R.Boya - Bila AWLR	0.030
R. Boya	Confluence of R.Bila - Balu Cenrana AWLR	0.030
Mainstream of R. Walanae	River mouth - Pacongkang	0.025
Tributaries	more than i = 1/200	0.040
	i = 1/200 - 1/500	0.035
	less than i = 1/500	0.030

2.3.4 High-water Level at the River Mouth of the Cenranae River

The data of T.Pallete Tide-gauge Station, the Bay of Bone shows that the Mean High Water Springs is 0.67 m above the mean sea level (see Supporting Report Part-I, Hydrology). Hence, the high-water level at the river mouth of the Cenranae River is determined at EL. 0.67 m.

2.3.5 Carrying Capacity of the River Channel

The carrying capacities of the existing river channel are calculated by the non-uniform flow method for the Cenranae and the Walanae Rivers, and by the uniform flow method for the Bila River and other steep-sloped rivers, assuming that the water surface slope is equal to the average slope of river bed. The results of calculation are shown in Table 2.1.

2.4 SEDIMENTATION

2.4.1 Sediment Transportation

In order to estimate sediment transport from the basin, sediment discharges at Cabenge Bridge on the Walanae River, Tanru Tedong Bridge on the Bila River and Sengkang Bridge on the Cenranae River are calculated by use of the Sato-Kikkawa-Ashida formula and the data on sediment discharges observed by the Team during a period from February to April 1979.

River bed materials were sampled by the Team at the locations shown in Fig. 2.8, and the results of sieving are listed in Table 2.2. Based on the longitudinal profile of the river channels and the results of sieve analyses of bed materials, the following values are obtained.

Site	$d_m(d_{65})$ (mm)	d_{50} (mm)	I	n
Cabenge Bridge	0.8	0.6	1/3500	0.025
Tanru Tedong Bridge	7.5	5.0	1/2000	0.025
Sengkang Bridge	0.33	0.27	1/8000	0.021

The data on sediment discharges (suspended load including wash load) observed by the Team are shown in Table 2.3 and these data are plotted as shown in Fig. 2.9 which shows a relationship between sediment discharge and water discharge. However, it is difficult to make up a formula from this figure because of limited samples. On the other hand, the relationship between sediment discharge and water discharge may be expressed in the form of the following formulae.

For bed load : $Q_B = k_1 q^{p1}$

For suspended load: $Q_S = k_2 q^{p2}$

Therefore, the following procedure is adopted to make formulae for the said three sites.

(i) For bed load, the values k_1 and p_1 are estimated by use of the Sato-Kikkawa-Ashida formula.

(ii) For suspended load including wash load, the value p_2 is estimated by use of the Engelund-Hansen formula, and the value k_2 is estimated from the observed data.

Sato-Kikkawa-Ashida formula;

$$\frac{q_B}{U_* d_m} = \phi\ F\ (T_o/T_c) \cdot \frac{U_*^2}{(\frac{r_s}{r_w} - 1) g\ d_m}$$

where, q_B: bed load per unit river width per unit time ($m^3/s/m$)

U_*: friction velocity (m/sec)

d_m: mean diameter (m)

g : acceleration of gravity (9.8 m/sec^2)

T_o: tractive force of flow (t/m^2)

T_c: critical tractive force (t/m^2)

F : function of T_o/T_c

r_s: unit weight of bed material (t/m^3)

r_w: unit weight of water (t/m^3)

Engelund-Hansen formula;

$$q_s = 0.05\ r_s\ V^2 \sqrt{\frac{d_{50}}{g(\frac{r_s}{r_w} - 1)}} \left\{ \frac{T_o}{(r_s - 1)\ d_{50}} \right\}^{3/2}$$

where, q_s: sediment discharge including bed load and suspended load per unit river width per unit time (t/sec/m)

V : mean velocity (m/sec)

d_{50}: grain size of 50% of bed materials

The obtained formulae are as follows;

Bed load;

Cabenge Br. : $Q_B = 6.102 \times 10^{-5} q^{0.946}$

Tanru Tedong Br.: $Q_B = 6.204 \times 10^{-7} q^{1.652}$

Sengkang Br. : $Q_B = 9.872 \times 10^{-5} q^{0.640}$

Suspended load including wash load;

Cabenge Br. : $Q_S = 3.031 \times 10^{-6} q^{1.835}$

Tanru Tedong Br.: $Q_S = 1.833 \times 10^{-6} q^{1.958}$

Sengkang Br. : $Q_S = 1.2\text{-}6 \times 10^{-5} q^{1.568}$

Applying daily discharges during the period from 1975 to 1978, annual total sediment discharges at the said three sites are calculated using the above-mentioned formulae. The results are shown in Table 2.4.

2.4.2 Sedimentation in Lake Tempe

The rivers flowing into Lake Tempe are roughly classified into two major rivers (Walanae and Bila) and small rivers around the Lake. The Cenranae River is an only river which flows out from the Lake. Accordingly, the following equation is applicable to the balance of sediment transportation.

$$(Q_S)_W + (Q_S)_B + (Q_S)_S - \frac{ds}{dt} = (Q_S)_C$$

where, $(Q_S)_W$: sediment transport from the Walanae River

$(Q_S)_B$: sediment transport from the Bila River

$(Q_S)_S$: sediment transport from the small rivers around Lake Tempe

$(Q_S)_C$: sediment transport out of Lake Tempe through the Cenranae river

$\frac{ds}{dt}$: sedimentation in Lake Tempe during a period dt

Integrating the above-mentioned equation with regard to t, the equation is transformed to the following equation.

$$S = \int_0^t (Q_s)_W + (Q_s)_B + (Q_s)_S - (Q_s)_C$$

Using the calculated results of sediment discharge shown in Table 2.4, the sedimentation volume in Lake Tempe is estimated as shown in Table 2.5. In this table, the average value of specific sediment discharge of the Walanae River and the Bila River was applied to the sediment inflow from the small rivers around the Lake, as there are no available data to estimate them.

The Table 2.5 shows that the annual sedimentation thickness of Lake Tempe is 1.0 cm/yr on the average from 1975 to 1978. On the other hand, the study by P.T. Waskita Kerya reports that the sedimentation thickness of Lake Tempe is 0.4 cm/yr as shown in Table 2.6, assuming almost the same method as mentioned above. /1

Therefore, it is concluded from the estimation described above that the sedimentation in Lake Tempe is not a serious problem from the viewpoint of flood control function of Lake Tempe. However, the sedimentation forms alluvial zones around such river mouths as the Walanae and the Bila.

2.5 FLOOD CONTROL FUNCTION OF LAKE TEMPE

2.5.1 Water Surface Area and Storage Volume of Lake Tempe

Based on the contour map of Lake Tempe shown in Fig. 2.4, water surface area and storage volume for each elevation are calculated as shown in Table 2.7. The relations between elevation and water surface area or storage volume are also shown in Fig. 2.10.

2.5.2 Calculation of Water Level of Lake Tempe

Basic equations for hydraulic calculation to examine the storage function of a lake are as follows;

Equation

When water passes through a lake, the difference between inflow and outflow is equal to the rate of storage of water in the lake;

/1 : Final report: Pre-rencana Sistim Hidroteknik PENELITIAN DAN PENGUKURAN HIDROLOGI Danau Tempe, Maret 1975, PT.WASKITA KARYA that is,

$$\frac{ds}{dt} = I - Q$$

where, ds/dt: change in storage during a period dt
I: average inflow during dt
Q: average outflow during dt

Eliminating s from the above equation using the following equations,

$$ds = F\Delta H = \frac{F_{t-\Delta t} + F_t}{2} (H_t - H_{t-\Delta t})$$

$$I = 1/2 \ (I_{t-\Delta t} + I_t)$$

$$Q = 1/2 \ (Q_{t-\Delta t} + Q_t)$$

and solving for H_t, the following equation is obtained.

$$H_t = H_{t- \ t} + \frac{t}{F_{t-\Delta t} + F_t} \cdot \left\{ (I_{t-\Delta t} + I_t) - (Q_{t-\Delta t} + Q_t) \right\}$$

where, H: water level of lake
F: water surface area of lake

Applying the daily discharges in 1975, 1977 and 1978, the water level and outflow are calculated for the checking purpose. In the calculation, the discharges at Cabenge and Tanru Tedong are used as the inflow from the Walanae River and the Bila River respectively. As no data are available for the inflow from the other rivers into Lake Tempe, the following specific discharges are applied considering regional rainfall distribution.

Period	Discharge applied to Other Rivers
Jan. - Mar.:	specific discharge at Tanru Tedong
Apr. - July:	average specific discharge at Cabenge and Tanru Tedong
Aug. - Dec.:	specific discharge at Cabenge

The calculated water level hydrographs are shown in Figs. 2.11, 2.12 and 2.13 together with the observed water level.

2.5.3 Flood Control Function of Lake Tempe

Using data on inflows into Lake Tempe, water levels of Lake Tempe and outflows from Lake Tempe are calculated with regard to the cases of the floods of 1975, 1977 and 1978 which correspond to the water level probabilities of 1/2.3, 1/4.5 and 1/1.4 respectively. The results of calculation are shown in Figs. 2.14, 2.15 and 2.16.

CHAPTER III FLOOD DAMAGES

3.1 GENERAL

Based on the field investigations over all the areas along the rivers within the extent of the objective area, the following inundation areas are selected from the viewpoint of flood control, taking into consideration scale of inundated area, intensity of damage and frequency of inundation.

(a) Area around Lake Tempe (including Lake Sidenreng and Lake Buaya).

(b) Downstream area of the Bila River (including the right side area of the Boya River, the downstream area of the Lancirang and the Kalola Rivers).

(c) Downstream area of the Walanae River (including the downstream area of the Belo and the Lawo Rivers).

(d) Areas on both sides of the Cenranae River.

The situation of flooding in each area is as follows;

3.1.1 Area around Lake Tempe

During a flood season, the land around Lake Tempe (including L.Sidenreng and L.Buaya) and the land along the downstream reaches of the rivers flowing into the Lake are inundated due to the rise of water level of the Lake. Many houses and farm lands in the area around the Lake suffer severe damages from floods.

3.1.2 Downstream Area of the Bila River

Inundated area along the mainstream is located on both sides of the downstream reaches between its river mouth and Bila. The inundations are caused almost by over-topping of river water due to lack of carrying capacity of the channel, especially in the downstream area from Tanru Tedong.

In the case of the Boya River, flood water overflows from the right bank in the reaches upstream from the confluence with the mainstream. Flooded water runs over the paddy fields toward low land forming submergence in depressions.

As the channel of the downstream reaches of the Lancirang River is too small, flood water overflows the bank forming submergence in every flood season.

The Kalola River joins to the mainstream after flowing upstream for about 1.5 km, so that the water surface slope gets extremely gentle during a flood season. In every flood season, the downstream area of the river is inundated due to flood water caused by lack of carrying capacity of the channel.

3.1.3 Downstream Area of the Walanae River

Inundated area of the mainstream is located on both sides of the river downstream from Lakibong. The causes of inundation are almost over-topping of river water, especially in the downstream area from Cabenge. The over-topped flood water connects directly with the water of Lake Tempe and forms one lake during a flood season. As flooding occurs almost in every flood season, inhabitants, farm lands and other facilities in the area suffer severe damages from floods.

3.1.4 Area on Both Sides of the Cenranae River

Inundated areas of the Cenranae River are not so large, but limited only to areas on both sides of the river and swamps. The land on the left bank is comparatively high, while the land on the right bank is not so high. A provincial road connecting Sengkang with Watampone runs on the right bank of the Cenranae River, and on both sides of the road there are long stretches of houses. During a flood season, these high-floor type houses are inundated by 1 to 2 m in depth.

3.2 INUNDATION AREA

The inundation area map of past remarkable floods is prepared by the Team, based on the information collected from the officials in Desa and Kecamatan or local people around the inundated areas. The inundation areas are estimated as shown in Table 3.1 and Fig. 3.1. Data on the past floods are listed in Table 3.2.

3.3 FLOOD DAMAGES IN THE PAST

Flood damages consist of agricultural crops, buildings, household effects, public facilities and others. Among them, damages to paddy are most important. Damages to buildings and household effects are not so severe in this area, because most of the houses in the inundation area are of high-floor type.

As no data are available for estimation of flood damages, they are grouped into damages to paddy and other damages to such property as upland crops, buildings, household effects and public facilities.

In estimating probable flood damages, damages caused by the past floods described above are first estimated, and then damages due to probable floods of selected return periods are estimated based on the past flood damages.

3.3.1 Damages to Paddy

In estimating damages to paddy due to flood, price of paddy (dry stalked paddy) is assumed to be Rp.133 per kg, and the following yields of paddy at present are applied (see Supporting Report Part - II).

Area around Lake Tempe

Rainfed Paddy = 2.7 t/ha : Average yield in Kec.Tanasitolo, Maniang Pajo, Belawa, Sabbang Paru, Mario Riwa, Panca Lautang, Tellu Limpoe and Maritengga.

Irrigated Paddy = 4.7 t/ha: Average yield in Kec. Tellu Limpoe and Maritengga.

Downstream Area of the Bila River

Rainfed Paddy = 3.2 t/ha : Average yield in Kec.Dua Pitue and Belawa.

Irrigated Paddy = 6.0 t/ha: Average yield in Kec.Dua Pitue.

Downstream Area of the Walanae River

Rainfed Paddy = 2.6 t/ha : Average yield in Kec.Lilirilau, Liliriaja and Sabbang Paru.

Areas on Both Sides of the Cenranae River

Rainfed Paddy = 2.8 t/ha : Average yield in Kec.Pammana, Majauleng and Takkalalla.

In regard to rate of damage to paddy due to submergence, damage rates shown Table 3.3 (or Fig. 3.2) are applied to damage estimation, considering the topographic conditions of the inundated area. In the case of the inundation along the Walanae River, the rate of damages is estimated assuming that flooded water runs on the land.

3.3.2 Other Damages

Percentage of other damages to total damage is estimated based on the damage report by Kec.Lilirilau, Kab.Soppeng in 1977 as shown in Table 3.4. Although the data show the amount of damage in total for each Desa, breakdown of its amount of damage is not given. Desa Basingeng suffered a loss of paddy production from flooding without other kinds of damages, and the amount of damage to paddy per hectare was R_p.400 thousand.

With this value, percentage of damage to paddy and others to the total damage for the other Desa is calculated assuming that 70% of the planted paddy was damaged from flooding, and the results are shown in Table 3.5.

On the other hand, damage characteristics in the following areas have been revealed by the field survey.

(a) Area around Lake Tempe

Population density is not so high around Lake Tempe and there are many fishermen's houses. Productivity of paddy is low or 2.7 t/ha. Duration of inundation is comparatively long and the houses are always damaged.

(b) Downstream Area of the Bila River

The northern part of this flooded area is located in Kec.Dua Pitue where irrigation facilities are well arranged. Flood damages to paddy are extremely severe compared with other damages in this area. The southern part of the flooded area is located in Kec.Belawa where flood damages to buildings and household effects are slight, because most of the inhabitants live on high land safe from floods. When desa roads and bridges are damaged by floods, the inhabitants must repair them by themselves.

(c) Downstream Area of the Walanae River

This area includes a part of Kab.Soppeng where tabacco is one of the important agricultural products as well as rice. The tabacco and Kabupaten road (along the left side of the river) suffer damages from floods.

(d) Areas on Both Sides of the Cenranae River

Flood damages are not severe in this area. Inundated area is limited since swamps act as retarding basins for the mainstream. Houses, roads and other public facilities are not so severely damaged.

Based on the data of Table 3.5 and the damage characteristics of these areas, percentage of damages to paddy and that of others are assumed as shown below for the estimation of flood damages.

Area	Percentage of Damage (%)		
	Paddy	Others	Total
L.Tempe	50	50	100
R.Bila	70	30	100
R.Walanae	50	50	100
R.Cenranae	70	30	100

3.3.3 Damages in the Past

The damages to paddy caused by the past floods are estimated as shown in Table 3.6, and then the amount of damages including other damages are estimated as shown in Table 3.7. In the table, the damages are classified into two components related to the mainstream and to the tributary in accordance with the causes of inundations.

3.3.4 Probable Flood Damages under the Present Conditions

Using the data on the past flood damages shown in Table 3.7, the probable flood damages are calculated on each return period. In the calculation, the return periods of the damages in the area around Lake Tempe are calculated by use of the Thomas method applying the estimated damages which occurred in the period from 1968 to 1978. As for other rivers, return periods of damages are calculated by the flood discharges in the past (See Supporting Report Part - I). The average annual flood damages under the present conditions are estimated as shown in Table 3.8.

3.4 POTENTIAL FLOOD DAMAGES

Among the flooded areas, swamps are utilized as natural fish ponds which have at present only low level of economic value. The flood control will give this area higher potentiality for agricultural production. In this study, it is assumed that the net income with project obtained from the swamps is estimated at Rp.93 per kg as production of rainfed paddy, and decrease in net income from fish production due to flood control works is neglected because of its low productivity. The potential flood damage by year and its annual average value are estimated as shown in Tables 3.9 and 3.10 respectively.

3.5 FLOOD DAMAGES UNDER THE PROPOSED CONDITIONS

When the proposed irrigation projects are completed, agricultural production will be increased thereby. However, flood damage will also be increased if no flood control works are carried out. Among the proposed irrigation project areas, Bila, Boya and Walanae areas are vulnerable to floods. Especially, the Walanae area habitually suffers flood damages not only in rainy seasons but also in dry seasons. Because the Walanae River causes flooding usually twice a year or in the two periods from December to February and from May to July.

In estimating flood damages under the proposed conditions, the yield of paddy is assumed at 6.0 t/ha. The flood damages to paddy under the proposed conditions in the areas of the Bila and the Walanae Rivers are estimated by the same method as in estimation of damages under the present conditions. They are shown in Table 3.11.

Using the values shown in Table 3.11, probable flood damages to paddy area under the proposed conditions are estimated as shown in Table 3.12, and then the amount of damages and its average annual values are estimated as shown in Table 3.13. In Table 3.13, the other damages are assumed to be the same amount as those under the present conditions, because the increased damages for irrigation facilities and others are difficult to estimate at present.

CHAPTER IV FLOOD CONTROL METHODS

4.1 GENERAL

As mentioned in Chapter III, habitually inundated areas are as follows;

(i) Area around Lake Tempe

(ii) Downstream area of the Bila River

(iii) Downstream area of the Walanae River

(iv) Areas on both sides of the Cenranae River.

To mitigate flood damages in these areas, the following flood control methods are studied to formulate flood control plans.

(i) Flood regulation by dam

(ii) Lowering of water level of Lake Tempe or construction of lakeside polders

(iii) Improvement of the downstream channel of the Bila River including major tributaries such as the Boya, the Lancirang and the Kalola Rivers

(iv) Improvement of the downstream channel of the Walanae River including the downstream reaches of the Lawo and the Belo Rivers

(v) Improvement of the Cenranae River including the Leceleceng River

4.2 DESIGN CRITERIA

4.2.1 Sources of Data for Design

(i) A series of the topographic maps of 1/25,000 scale are used for design of river channel alignment.

(ii) Data on river cross-sections surveyed by the Team shown in the foregoing Fig. 2.6 are used for design of river cross-sections.

(iii) Data on soil property collected by the Team are used for design of construction works (see Supporting Report Part-IX, Geology).

4.2.2 Manning's Roughness Coefficient

Manning's roughness coefficient "n" for design is determined as shown in Table 4.1 considering the results of analysis described in Chapter II and the conditions of river channel after improvement.

4.2.3 Design Criteria for Levee

Standard levee cross-section for design is shown in Table 4.2.

4.3 DESIGN FLOOD DISCHARGE

4.3.1 Probable Flood Discharge

Using the discharge formulae described in Supporting Report Part-I, Hydrology, probable flood discharges of rivers on several return periods to be applied to flood control plans are calculated as shown in Table 4.3.

4.3.2 Design Flood Discharge

Level of a flood control plan should be determined taking account of economic importance of the project but also sociopolitical factors such as stabilization of people's livelihood and preservation of land for living and production. In the present study, only the former factor is considered to determine design flood.

With regard to the mainstream of the Walanae and the Bila Rivers, construction costs and benefits of the river improvement works are calculated on design floods of several return periods. The benefits are estimated as estimated as effects of decrease in flood damages under the conditions of the proposed irrigation projects. After that, the construction costs and the benefits are calculated, and then values of B/C are calculated. In these calculations, three kinds of discount rate, 8, 10, 12%, and a 50-year project life are assumed. The results of calculations are given in Table 4.4, which shows that the value of B/C has a maximum at a return period of 20 years.

At present, a level of 20 to 50-year flood discharge is actually applied to flood control projects in Indonesia as shown in Table 4.5. Therefore, the return period calculated in the above is recommendable as the level of design discharge for the rivers.

As regard to the tributaries, a level of 5-yr flood is assumed by the following reasons.

(i) The tributaries usually causes locally limited flooding and flood damages are not seriousl.

(ii) The inundated areas of the tributaries have no such towns as Cabenge on the Walanae River and Tanru Tedong on the Bila River, and a few houses are distributed in the areas.

The determined design flood discharges without floodway and dam are illustrated in Fig. 4.1 (a).

4.4 FLOOD REGULATION BY DAM

A multipurpose dam is planned in the middle reaches of the Walanae River at Mong site with an alternative site at Walimpong located 1.5 km upstream of Mong dam site. The effective storage capacity for flood control of Mong and Walimpong dams are allocated to 50 million m^3 and 300 million m^3 (at maximum) respectively, /1 since, the effective storage capacity of the dam at Mong site is not expected to be large because of geological uncertainty of dam foundation. /2

The purpose of flood regulation by the dam is mainly to diminish flood damages in the downstream area of the Walanae River. For this purpose, in order to examine flood control effect to the downstream reaches, the calculations of flood regulation by dam are made for floods of several return periods with regard to four cases for flood control volumes that are as follows;

Case 1: Mong dam; V = 50 million m^3
Case 2: Walimpong dam; V = 100 million m^3
Case 3: Walimpong dam; V = 200 million m^3
Case 4: Walimpong dam; V = 300 million m^3

The calculated results are shown in Table 4.6. From the results, the discharge distribution for 20-yr flood is illustrated in Fig. 4.2. With regard to lowering of high-water level of Lake Tempe by means of flood regulation by dam, the hydraulic calculation for the floods of 1975 and 1977 is made by selecting Case 1, 3 and 4 out of the above-cases. The results show that the flood regulation by Mong dam has no effect to Lake Tempe because of small storage capacity, and the flood regulation by Walimpong dam will have some effect as shown below.

Item	1975-Flood		1977-Flood	
	HWL	Lowering	HWL	Lowering
Without Flood Control	El.8.34 m	-	El.8.97 m	-
With Flood Regulation by Walimpong Dam				
- Case 3 (V = 200 x $10^6 m^3$)	El.8.26 m	0.08 m	El.8.87 m	0.10 m
- Case 4 (V = 300 x $10^6 m^3$)	El.8.25 m	0.09 m	El.8.86 m	0.11 m

/1: Refer to Supporting Report, Part-V, Multipurpose Dam.
/2: Refer to Supporting Report, Part-IX, Geology.

Using the above-values, the lowering of HWL of Lake Tempe is calculated for floods of several return periods with regard to three cases of Case 2, 3 and 4, and then the decreased damages in the area around Lake Tempe are estimated as shown in Table 4.7.

4.5 LOWERING OF WATER LEVEL OF LAKE TEMPE OR CONSTRUCTION OF LAKESIDE DIKES

The following flood control methods are studied to choose a most effective flood control plan to mitigate flood damages in the area around Lake Tempe.

(i) Dredging of the Cenranae River

(ii) Construction of lakeside Dikes

4.5.1 Dredging of the Cenranae River

The purpose of dredging of the Cenranae River is to lower flood water level of Lake Tempe and the Cenranae River. The dredging will give decrease in inundated area around Lake Tempe and on both sides of the Cenranae River, and cultivable land will be increased thereby. The dredged soils will be dumped to swamps along the Cenranae River to create new lands.

In order to estimate dredging effect to Lake Tempe, a hydraulic calculation is made in regard to the following six cases.

Case No.	Calculated Period	Dredging Volume (10^3m^3)	Dredging Stretch
I - 1	Jan. - Dec., 1977	500	55 km - Sengkang
I - 2	- do -	2,000	Solo - Sengkang
I - 3	- do -	18,800	River mouth - Sengkang
II - 1	Jan. - Dec., 1978	500	55 km - Sengkang
II - 2	- do -	2,000	Solo - Sengkang
II - 3	- do -	18,800	River mouth - Sengkang

The results of calculation are shown in Table 4.8. The calculated water level hydrographs for 1977 and 1978 are shown in Fig. 4.3 and 4.4, together with hydrographs under the existing conditions. In the hydraulic calculation, discharge rating curves at Sengkang are first prepared based on the calculation by the non-uniform flow method under the conditions after dredging. Then water levels of Lake Tempe are calculated giving the obtained rating curves as the outflow conditwon from Lake Tempe.

In addition to the above, the water level of Lake Tempe is calculated with regard to the 1975-flood by the same method mentioned above. Using the results obtained on the three years of 1975, 1977 and 1978, the curves are drawn of correlation between dredged volume and lowering quantity of peak water level of Lake Tempe, and it is shown in Fig. 4.5.

Fig. 4.3 and 4.4 show that the dredging will give not only lowering of high-water level but also lowering of low-water level. The latter will certainly cause troubles in fishery in the Lake. Therefore, to keep the same low-water level as the existing, a barrage for water level control will be needed from the stand point of preservation of fishery resources and other environmental conditions.

To determine an optimum dredging scale of the Cenranae River, an economic study is made from the viewpoint of profit maximization: B/C is maximum. The benefits are estimated with flood damage reduction under the existing conditions and potential flood damages. The results are shown in Table 4.9 which shows the comparison of benefit and cost thus calculated. The ratio of B/C will have a maximum value in the case of 2 million m^3 dredging.

4.5.2 Construction of Lakeside Dikes

The purpose of construction of lakeside dikes is to protect the farm land around Lake Tempe from floods. The areas to be protect are selected as shown in Fig. 4.6, taking account of ground elevation and scale of protected area compared with dike length. The present land use in the planned polders is shown in Table 4.10.

With the completion of lakeside dikes, water level of Lake Tempe will be raised during a flood season due to decrease in its water surface area. In a calculation of the range of high-water in 1977, the peak water level of Lake Tempe will rise to El.9.19 m which is 0.24 m higher than that of water level under the existing conditions. Therefore, the dredging of the Cenranae River will be needed to keep the former condition of water level. The required dredging volume is estimated at 1.3 million m^3 using the foregoing Fig. 4.5.

To estimate cultivable areas for paddy in the planned polders, pond areas for drainage are estimated in the polders based on the result of a study of the Belawa planned polder as shown in Fig. 4.7. The estimated areas cultivable for paddy are shown in Table 4.11.

To evaluate this flood control method, an economic study is made based on estimated construction cost and benefit. The results are shown in Table 4.12 which shows that B/C value is too low. Consequently, this method for flood control is unrecommendable.

With regard to Lake Sidenreng, to protect the farm land around the lake from flooding of Lake Tempe, a study is made to separate the lake from Lake Tempe by a levee. The value of B/C of this method is also calculated, but it is low as seen in Table 4.13. Consequently, this method of flood control is not recommendable.

4.6 IMPROVEMENT OF BILA RIVER

To diminish flood damages in the downstream area of the Bila River, channel improvement plans are studied on the following stretches.

(i) The mainstream : a stretch between its river mouth and a point 1.5 km upstream from the confluence of the Boya River.

(ii) The Boya River : a stretch between the confluence to the mainstream and a point 2 km upstream from the confluence.

(iii) The Lancirang River: a stretch between the confluence to the mainstream and a point 8 km upstream from the confluence.

(iv) The Kalola River : a stretch between the confluence to the mainstream and a point 4 km upstream from the confluence.

4.6.1 Mainstream

For improvement of the mainstream of the Bila, it is studied about two methods of improvement of the existing channel and construction of a new floodway (flood bypass). The former aims at increase in channel capacity by excavation and embankment. The latter aims to release flood flow without removal of houses standing along the river due to enlargement of its channel. The idea of the latter method is as follows;

(i) To divert high-discharge into floodway.

(ii) To minimize the improvement of existing channel.

(iii) To flow low-discharge in the existing channel.

To compare the above-mentioned two methods, construction costs are estimated as shown in Table 4.14, which shows that the construction cost of the floodway method is lower than that of the improvement of the existing channel. Therefore, the floodway method is adopted in this study.

At present, the Bila River bifurcates near the river mouth into two channels leading to Lake Tempe. During a flood season, the downstream area from the bifurcation is submerged below the high-water level of Lake Tempe. For the channel improvement in the stretch between the bifurcation and Lake Tempe, therefore, an excavation work without embankment is planned to enlarge the left channel for low-discharge leading to Lake Tempe.

4.6.2 Tributaries

For the channel improvement of the Boya River, excavation and embankment area planned. As the existing channel of the Lancirang River is too small, channel improvement mainly by excavation is planned for this river. Water surface slope of the Kalola River is extremely gentle, because the river joins to the mainstream against ground slope. In this study, it is planned to change the point of confluence to a point downstream from Tanru Tedong.

4.6.3 Planned Profile

The planned alignment of channels, longitudinal profiles and cross-sections are shown in Figs. 4.8 and 4.9.

4.7 IMPROVEMENT OF WALANAE RIVER

To diminish flood damages in the downstream area of the Walanae River, channel improvement plans are studied on the following stretches in regard to the cases of without and with dam.

(i) The mainstream: a stretch between the confluence with the Cenranae River and a point 30 km upstream from there.

(ii) The Belo River: a stretch of back-water reaches.

(iii) The Lawo River: a stretch of 2.4 km in the downstream reaches.

4.7.1 Channel Improvement without Dam

(1) Mainstream

Channel improvement of the mainstream of the Walanae aims at increase in carrying capacity by excavation and embankment. The following are considered for study of improvement plan.

(i) Meanderings of river course are smoothened by cutoff.

(ii) In the branched stretch betwpen 9.0 km and 16.6 km, the right channel is mainly improved.

(iii) The stretch between the confluence with the Cenranae and 9.0 km is improved by excavation without embankment, because the area to be protected by levee is small.

(2) Tributaries

The reaches under the influence of back-water of the Belo River is planned to be improved to increase its carrying capacity. The Lawo River flows directly into Lake Tempe with a very small channel at present. Therefore, the Lawo River is planned to connect with the Belo River considering ground slope.

4.7.2 Channel Improvement with Dam

Channel improvement of the mainstream is studied in combination with flood regulation by each dam given below.

(i) Mong dam: V = 50 million m^3
(ii) Walimpong dam: V = 100 million m^3
(iii) Walimpong dam: V = 200 million m^3
(iv) Walimpong dam: V = 300 million m^3

The design flood discharges shown in the foregoing Fig. 4.2 are applied to the study of the channel improvement.

4.7.3 Planned Profile

The planned channel alignment of the rivers is shown in Fig. 4.10, and the planned longitudinal profile and cross-sections without dam are shown in Fig. 4.11, and those with dam are shown in Figs. 4.12 and 4.13 for the cases of with Mong dam and Walimpong dam (V = 200 million m^3) as representative cases.

4.8 IMPROVEMENT OF CENRANAE RIVER

4.8.1 Improvement of Mainstream

The purpose of channel improvement of the mainstream of the Cenranae is to increase its carrying capacity. This purpose can achieved by dredging and embankment. However, in the Cenranae River, dredging method is most effective, since high-water level of the river and Lake Tempe cannot be lowered by embankment, and the area to be protected by levee is small. The dredging works of 2 million m^3 is planned by the reason mentioned in the foregoing Section 4.5, but some embankments are also adopted for protecting some particular areas. The existing swamps in the middle and the downstream areas are planned to be used as natural retarding basins for flood control of the mainstream without changing the present conditions. The planned channel alignment, longitudinal profile and cross-sections are shown in Figs. 4.14 and 4.15.

A study made by the Team on salt water intrusion into the Cenranae River from the sea shown that salinity intrusion during a severe drought period reaches up to a point about 35 km at maximum (see Supporting Report, Part-I, Hydrology). Therefore, it is presumable that the dredging of the channel between Solo and Sengkang will not cause any change in the existing conditions of salinity intrusion.

4.8.2 Construction of Barrage

When the dredging of the Cenranae River is completed, water level of Lake Tempe will be lowered thereby. To keep the same low water level as the existing, a barrage for water level control is planned at a site as shown in Fig. 4.16. The barrage is designed to keep the water level not to fall below El.3.5 m for preservation of fishery resources and other environmental conditions. The general profile of the planned barrage is shown in Fig. 4.17.

4.8.3 Improvement of Tributary

When the channel improvement of the mainstream of the Cenranae is completed, over-topping of river water from the mainstream will be decreased and also flood duration will be shorterned. As a result, some swamps along the mainstream can be dried up by improvement of tributary. As a case study, the Leceleceng River is picked up, and an improvement plan is studied.

The Leceleceng River is a tributary of the Cenranae River, and is located in the east of Lake Tempe. The river joins to the mainstream at Kampiri, and the catchment area at the confluence is 274 km^2. The mean width of the existing channel is only about 10 m and the average river slope is about 1/5,000. The carrying capacity at the confluence is estimated at 25 m^3/s. Large and small swamps exist along the river and they act as natural retarding basins.

Improvement of the channel is planned mainly by excavation. In order to reduce the influence of back-water from the mainstream, the point of confluence to the mainstream is planned to change to Solo through a swamp which is located between Kampiri and Solo.

To determine the design flood discharge of the river, a calculation is made by use of a method of triangle hydrograph based on the following assumptions.

(i) Rainfall = 110 mm, 1/5 probable daily rainfall at Sengkang.

(ii) Runoff coefficient = 0.7

(iii) Peak discharges are calculated using a formula described in Supporting Report Part-I, Hydrology, that is as follows.

$$q = 26.214\ A^{-0.444} \text{ (for 1/5 probable flood)}$$

Where q is specific discharge ($m^3/s/km^2$) and A is catchment area (km^2).

The calculated sub-basin hydrographs and composed hydrographs are shown in Fig. 4.18. Based on the calculated results, the design flood discharge is determined as shown in Fig. 4.19, considering flood retardation by swamps.

The planned profile of the Leceleceng River is shown in Fig. 4.20. To evaluate this plan, an economic study is made based on estimated benefits and construction costs. The results are shown in Table 4.15, which shows the B/C value is too low. Therefore, this plan is not recommendable.

4.9 CONSTRUCTION COSTS

4.9.1 Unit Costs

Based on the following assumptions and conditions, unit construction costs are estimated as shown in Table 4.16.

(i) The 1979-price and the following conversion rate of US$ to Rupiah and Japanese Yen are used to estimate costs.
US$1 = Rp.625 = ¥200

(ii) Wages of laborers and unit prices of construction materials, fuel and oil are shown in Table 4.17.

(iii) Construction equipment, spare parts and special construction materials are purchased from abroad. Equipment costs are estimated by depreciation costs.

(iv) Cost for spare parts is estimated by applying experiencial percentage to procurement cost based on the prices required for similar works in South Sulawesi.

(v) Unit costs for land acquisition and compensation are estimated based on the prices required for similar works in South Sulawesi.

4.9.2 Construction Quantity

In estimating construction quantity, civil works are assumed to be done by the following methods.

(i) In dredging works, small-scale dredging is executed by use of amphibious excavators and back-hoes, and large-scale dredging is executed by use of pump dredgers. Dredged soils are mainly used to reclaim swamps.

(ii) Excavation is major bed is executed by use of swamp bulldozers and back-hoes. Excavated soils are transported and dumped to embankment sites nearby or to depressions by use of swamp bulldozers or dump trucks combined with back-hoes.

(iii) Embankment is made with materials transported from excavation sites nearby or temporary spoil bank by use of bulldozers. Bulldozers, vibrating rollers and vibrating plate compactors are used for compaction of transported soils.

4.9.3 Construction Costs

Construction costs are composed of costs required for land acquisition and compensation, cost for civil works, cost for contingency and cost for engineering & administration. Cost required for civil works is calculated by multiplying work quantity by unit cost. The quantity is obtained from planned profiles. Cost for contingency is assumed at about 20¢ of costs for civil works, land acquisition and compensation. Engineering & administration cost is also assumed at about 10¢ of the sum of the above-mentioned costs.

The estimated construction costs for flood control plans are shown in Tables 4.18, 2.19, 2.20, 4.21 and 4.22. They are summarized as shown in Table 4.23.

CHAPTER V FLOOD CONTROL PLAN

5.1 PROPOSED FLOOD CONTROL PLANS

To mitigate flood control damages in the flooded areas, the following flood control plans are proposed in the frame work of the Master Plan based on the studies of flood control methods as described in the foregoing Chapter IV. The design flood discharges with floodway and dam are shown in Fig. 4.1 (b).

(i) Improvement plan of the Bila River

(ii) Improvement plan of the Walanae River combined with *flood regulation* by dam.

(iii) Improvement plan of the Cenranae River.

The locations of the proposed flood control projects are shown in Fig. 5.1.

5.1.1 Improvement Plan of the Bila River

The purpose of the improvement of the Bila River is to protect the land of about 11,000 ha in the downstream area of the river by means of channel improvement by excavation and embankment.

The proposed river channel stretches for improvement are as follows;

(i) The mainstream : the stretch between its river mouth and a point 1.5 km upstream from the confluence of the Boya River.

(ii) The Boya River : the stretch between the confluence to the mainstream and a point 2 km upstream from the confluence.

(iii) The Lancirang River: the stretch between the confluence to the mainstream and a point 8 km upstream from the confluence.

(iv) The Kalola River : the stretch between the confluence to the mainstream and a point 4 km upstream from the confluence.

In this plan, a floodway is proposed in the stretch between the river mouth and the appoint 13 km, based on the comparative study as described in Chapter IV. The proposed channel alignment, longitudinal profile and cross-sections are shown in Figs. 4.8 and 4.9.

5.1.2 Improvement Plan of the Walanae River Combined with Flood Regulation by Dam

The purpose of the improvement of the Walanae River is to protect the land of about 9,000 ha in the downstream area of the river by means of flood control by channel improvement and dam.

The proposed river channel stretches for improvement are as follows;

(i) The mainstream: the stretch between the confluence to the Cenranae River and a point 30 km upstream from the confluence.

(ii) The Belo River: the stretch under back-water.

(iii) The Lawo River: the stretch of 2.4 km in the downstream reaches.

Although the following plans are studied for flood control of the mainstream of the Walanae as described in Chapter IV, a plan should be selected from among these plans based on economic evaluation.

(i) Improvement plan without dam.
(ii) Improvement plan with Mong dam.
(iii) Improvement plan with Walimpong dam (V = 100 million m^3)
(iv) Improvement plan with Walimpong dam (V = 200 million m^3)
(v) Improvement plan with Walimpong dam (V = 300 million m^3)

However, the economic evaluation of the plans cannot be made only for flood control portion, because the flood control plan of the Walanae River is closely related to irrigation and hydro-power plans. Therefore, at this stage of study, the above-mentioned five plans are proposed from the viewpoint of flood control.

The proposed channel alignments, longitudinal profiles and cross-sections in the case of without dam are shown in Figs. 4.10 and 4.11, and those in the case of with dam are shown in Figs. 4.12 and 4.14.

5.1.3 Improvement Plan of the Cenranae River

The purpose of the improvement of the mainstream of the Cenranae is to protect the areas on both sides of the river and to lower flood water level of Lake Tempe. As dredging of the channel is effective as described in Chapter IV, the dredging works of 2 million m^3 are proposed and the embankment is also proposed in the stretches as shown in Fig. 4.15. A barrage for water level control of Lake Tempe is proposed to be constructed at the site upstream from Sengkang bridge to maintain a required water level during a dry season by reason of the description in Chapter IV.

The proposed channel alignment, longitudinal profile and cross-sections are shown in Fig. 4.14 and 4.15.

5.2 BENEFITS AND CONSTRUCTION COSTS

5.2.1 Benefits

Average annual damages caused by floods are estimated as described in Chapter III. Benefits that will accure from executing flood control projects are given as effects of decrease in flood damages. Table 5.1 shows the estimated average annual benefits of the proposed flood control projects under the existing and the proposed conditions. In regard to flood control by dam on the Walanae River, Benefits are estimated with channel improvement under the conditions of the proposed irrigation project.

5.2.2 Construction Costs

The construction costs required for the flood control works mentioned in the foregoing Section 5.1 are summarized in Table 5.1 together with annual operation & maintenance cost which is assumed at 0.5% of construction costs excluding engineering & administration cost. The annual construction costs required for the flood control plans by means of river channel improvement are alloted as shown in Table 5.2.

5.3 FIRST PHASE FLOOD CONTROL PLAN

In respect to implementation of flood control project, the Indonesian Government currently adopt two phase system in some rivers in Jawa Island such as Bengawan Solo, Kali Madiun and Kali Brantas. They have been implemented dividing into first and second phases considering production, economy and other factors in area to be protected.

In the above-mentioned three rivers, 10-year flood has been adopted as design discharge for first-phase. However, the objective area is in a development stage, and it seems that economy importance in the area lower than that of the river basins in Jawa Island. Therefore, in this study, 5-year flood is adopted as design discharge for the first-phase flood control plans considering the above-mentioned circumstances.

In this study, it is studied the first-phase flood control plan of the Bila River by means of channel improvement.

5.3.1 Design Flood Discharge

The adopted design flood discharges for the first-phase plan are illustrated in Fig. 5.2. These are determined on the basis of the calculated discharges described in Table 4.3.

5.3.2 Improvement Plan of the Bila River

The proposed river channel stretches for improvement are planned the same as the Master Plan. The construction of a flood-way is planned also in this phase, but the excavation in the major bed and the heighntening of levee is left for a later phase. The improvement of the tributaries is planned to be completed in this phase. The planned longitudinal profiles and cross-sections are shown in Fig. 5.3.

5.3.3 Benefit and Construction Cost

The construction quantity and its cost for the first-phase flood control plan is estimated as shown in Table 5.3. The economic cost and the benefit are converted to respective present values, and then values; namely IRR are calculated assuming a 50-year project life. The results of calculation is shown in Table 5.4.

Table 2.1 Carrying Capacities of River Channel at the Present Conditions

River	Stretch (River km)	Carrying Capacity (m^3/s)
R.Cenranae	0 - 14.2	450
	14.2 - 27.0	500
	27.0 - 28.0	670
	28.0 - 39.7	480
	39.7 - 56.2	450
	56.2 - 64.0	650
	64.0 - 67.0	590
R.Bila	0 - 6.8	410
	6.8 - 11.7	340
	11.7 - 15.6	1,130
	15.6 - 17.0	920
	17.0 - 27.6	1,040
R.Boya	17.0 - 26.6	830
R.Walanae	0 - 6.1	400
	6.1 - 18.1	450
	18.1 - 33.1	1,200
	33.1 - 37.0	1,300
	37.0 - 48.6	1,400
	48.6 - 63.6	2,300
R.Sanrego	at Sanrego AWLR	700
R.Lang Kemme	at Lang Kemme AWLR	500
R.Gilirang	at Tarumpakkae Staff Gauging Station	350
R.Lawo	at Lawo Staff Gauging Station	250
R.Batu-Batu	at Batu-Batu Staff Gauging Station	90

Remarks, AWLR: Automatic Water Level Recording Station

Table 2.2 Sampling Test Data of River Bed Material

(Unit: mm)

River	Sampling Location (km)		Percentage of Weight Passing through the Seive																
			66	61	38	25.5	19.1	12.7	9.52	4.76	2.00	0.841	0.420	0.177	0.149	0.074	60%	30%	10%
Cenranae	Ce - 1	0							100	99.70	97.77	95.42	89.89	22.80	19.99	2.20	0.28	0.19	0.10
	Ce - 2	2.95									100	99.88	94.12	4.51	1.51	0.24	0.30	0.22	0.18
	Ce - 3	8.60				100	98.28	95.46	93.44	82.89	64.81	46.84	22.62	7.04	5.41	1.92	1.60	0.52	0.21
	Ce - 4	35.68									100	99.69	99.03	34.79	29.40	7.22	0.25	0.15	0.08
	Ce - 5	41.08								100	94.96	66.46	14.31	2.05	1.41	0.22	0.75	0.52	0.31
	Ce - 6	52.18								100	99.96	98.68	83.84	56.76	38.38	11.60	0.19	0.12	-
	Ce - 7	57.43								100	99.92	99.06	33.89	2.63	2.07	0.60	0.56	0.38	0.22
	Ce - 8	63.03								100	99.03	95.64	87.09	48.79	45.43	12.10	0.23	0.11	-
Walanae	Wa - 1	6.10								100	99.97	97.20	51.55	4.35	3.10	1.18	0.48	0.28	0.20
	Wa - 2	18.10							100	99.84	99.07	92.92	48.85	4.85	3.15	0.35	0.50	0.29	0.19
	Wa - 3	34.45					100	99.45	97.70	89.94	68.84	43.96	25.29	4.45	3.32	0.58	1.48	0.50	0.22
	Wa - 4	48.60							100	96.77	85.62	55.36	14.97	2.12	1.39	0.38	0.98	0.55	0.29
	Wa - 5	63.55							100	99.61	97.61	79.97	22.60	1.62	1.03	0.21	0.66	0.42	0.25
	Wa - 6	118.20				100	95.87	92.58	90.83	87.88	80.58	60.04	12.93	3.87	3.15	1.32	0.83	0.54	0.31
	Wa - 7	118.20					100	99.14	98.63	97.56	95.04	90.85	83.36	21.20	9.91	1.48	0.30	0.20	0.15
Bila	Bi - 1	-6.58				100	98.66	93.08	85.21	57.09	33.20	18.13	8.21	2.32	1.87	0.58	5.10	1.68	0.48
	Bi - 2	7.10					100	98.82	97.19	88.93	71.57	49.50	32.51	15.84	10.70	2.53	1.28	0.37	0.14
	Bi - 3	10.43				100	92.64	82.50	74.64	55.48	39.36	25.35	6.60	0.70	-	0.13	5.52	1.15	0.47
	Bi - 4	15.53				100	97.15	83.76	75.09	57.82	39.35	30.05	18.07	1.84	1.26	0.25	5.20	0.85	0.27
	Bi - 5	17.15			100	96.14	89.13	71.25	60.09	38.15	23.06	14.14	3.35	0.28	0.12	0.02	9.50	2.96	0.65
	Bi - 6	17.35			100	95.63	89.02	77.83	69.59	48.92	32.14	23.40	11.45	0.87	0.59	0.10	6.80	1.60	0.36
	Bi - 7	27.10			100	98.62	87.07	70.61	63.11	39.68	17.93	6.67	4.45	1.88	1.56	0.65	8.60	3.20	1.80
Boya	Bo - 1	0.3				100	95.73	86.20	78.82	60.77	43.07	35.48	21.76	2.54	1.63	0.26	4.50	0.65	0.25
	Bo - 2	7.5			100	98.36	87.88	75.55	67.19	48.87	34.55	25.59	14.37	2.53	1.72	0.51	7.20	1.26	0.30
	Bo - 3	12.0			100	88.67	81.18	69.52	62.66	48.70	31.99	12.89	3.19	1.04	0.89	0.42	8.40	1.84	0.67
Gilirang	Gi - 1	11.10							100	99.30	96.07	77.64	16.30	2.65	1.86	0.53	0.68	0.48	0.275
	Gi - 2	33.0								100	99.88	99.18	90.85	8.31	5.97	1.52	0.30	0.22	0.18
	Gi - 3	40.0			100	76.73	91.74	75.53	66.34	48.73	35.51	22.19	13.61	3.25	2.49	0.58	7.50	1.40	0.30
Sanrego	Sa - 1	186.70		100	70.75	51.48	36.85	26.50	22.18	16.11	11.02	5.52	1.70	0.31	0.26	0.08	30.00	14.50	1.70
	Sa - 2	193.10	100	87.45	40.56	31.80	25.90	20.41	16.93	11.22	7.05	4.32	2.10	0.48	0.39	0.18	46.20	23.00	3.65
Mario	Ma - 1	12.40		100	58.07	46.10	38.50	30.03	25.32	14.46	7.64	4.11	2.15	0.73	0.59	0.19	39.50	12.20	2.64
Lawo	La - 1	28.40		100	69.85	54.15	47.45	37.12	31.12	20.58	11.53	4.35	1.01	0.13	0.10	0.02	29.60	8.80	1.62
Sidenreng	DS - 1							100	99.88	99.63	98.17	87.10	45.89	14.60	10.65	4.03	0.53	0.275	0.14
Tempe	DT - 1									100	77.41	46.65	32.33	21.44	18.78	5.12	1.24	0.42	0.10

Table 2.3 Sediment Discharge Observed by Team

(Feb. - Apr. 1979)

Site	Observed Date	Discharge (m^3/s)	Sediment Discharge (m^3/s)
Cabeng Br., R.Walanae	9, Mar. 1979	314.0	9.14×10^{-2}
	4, Apr. 1979	247.4	5.14×10^{-2}
	12, Apr. 1979	106.3	2.97×10^{-2}
Tanru Tedong Br., R.Bila	10, Apr. 1979	138.0	2.34×10^{-2}
	13, Apr. 1979	117.6	2.81×10^{-2}
Sengkang Br., R.Cenranae	28, Feb. 1979	261.7	8.46×10^{-2}
	9, Mar. 1979	134.0	2.58×10^{-2}
	10, Apr. 1979	272.4	8.24×10^{-2}
	12, Apr. 1979	240.0	7.25×10^{-2}

Table 2.4 Estimated Annual Total Sediment Discharge

Year	Item	Unit	Cabenge	Tanru Tedong	Sengkang
	Catchment Area (A)	km^2	2,846	1,123	6,007 /1
1975	Q_B	$10^3m^3/yr$	204	25	108
	Q_S	$10^3m^3/yr$	1,836	336	2,678
	$Q_B + Q_S$	$10^3m^3/yr$	2,040	361	2,786
	$(Q_B + Q_S)/A$	$m^3/yr/km^2$	716	321	464
1976	Q_B	$10^3m^3/yr$	93	11	65
	Q_S	$10^3m^3/yr$	338	131	800
	$Q_B + Q_S$	$10^3m^3/yr$	431	142	865
	$(Q_B + Q_S)/A$	$m^3/yr/km^2$	151	126	144
1977	Q_B	$10^3m^3/yr$	183	14	82
	Q_S	$10^3m^3/yr$	2,584	181	1,785
	$Q_B + Q_S$	$10^3m^3/yr$	2,767	195	1,867
	$(Q_B + Q_S)/A$	$m^3/yr/km^2$	972	174	311
1978	Q_B	$10^3m^3/yr$	126	25	84
	Q_S	$10^3m^3/yr$	643	367	1,510
	$Q_B + Q_S$	$10^3m^3/yr$	769	372	1,594
	$(Q_B + Q_S)/A$	$m^3/yr/km^2$	270	349	265
Average	Q_B	$10^3m^3/yr$	152	19	85
	Q_S	$10^3m^3/yr$	1,352	254	1,693
	$Q_B + Q_S$	$10^3m^3/yr$	1,502	273	1,778
	$(Q_B + Q_S)/A$	$m^3/yr/km^2$	528	243	296
	$(Q_B + Q_S)/A$ (including void of 50%)	$m^3/yr/km^2$	754	347	395

Remarks, Q_B: Annual total sediment discharge of bed load

Q_S: Annual total sediment discharge of suspended load including wash load

$(Q_B + Q_S)/A$: Specific sediment discharge

/1: Catchment area at Sengkang Bridge except water surface area of L.Tempe

Table 2.5 Sedimentation into Lake Tempe Estimated by Team

Item	Unit	Quantity
- Sediment Transport Volume from the Rivers (Average 1975 - 1978)		
Walanae River	$10^3m^3/yr$	1,502
Bila River	$10^3m^3/yr$	273
Others	$10^3m^3/yr$	619
Total	$10^3m^3/yr$	2,394
- Total Catchment Area of the Rivers into L.Tempe	km^2	6,007
- Specific Sediment Transport	$m^3/yr/km^2$	399
- Sediment Transport Volume out of L.Tempe through the R.Cenranae (Ave. 1975 - 1978)	$10^3m^3/yr$	1,778
- Lake Tempe		
Sedimentation Volume	$10^3m^3/yr$	616
Annual Average W.L. (1975 - 1978)	El.m	5.6
Annual Average Water Surface Area	km^2	132
Thickness of Sedimentation (net)	cm/yr	0.5
Thickness of Sedimentation (including voide of 50%)	cm/yr	1.0

Table 2.6 Sedimentation into Lake Tempe Estimated by P.T. Waskita Karya

Item	Unit	Quantity
- Sedimentation Volume into L.Tempe (including void of 50%)	$10^3m^3/yr$	672
- Water Surface Area of L.Tempe	km^2	170
- Thickness of Sedimentation	cm/yr	0.4

Data source: Final Report, Pre-rencana Sistim Hidroteknik PENELITIAN DAN PENGUKURAN HIDROLOGI Danau Tempe, Maret 1975, P.T Waskita Karya

Table 2.7 Water Surface Area and Storage Volume of Lake Tempe

Elevation	L.Tempe	L.Sidenreng	L.Buaya	Total
Water Surface Area (km^2)				
3.0 m	6.08	-	-	6.08
3.5 m	27.88	-	-	27.88
4.0 m	49.23	-	-	49.23
4.5 m	63.20	-	-	63.20
5.0 m	77.70	-	-	77.70
5.5 m	96.50	32.00	-	128.50
6.0 m	121.78	41.40	-	163.18
6.0 m	121.78	41.40	9.43	172.60
7.0 m	205.93	59.45	19.98	285.35
8.0 m	262.40	74.80	30.53	367.75
9.0 m	301.03	92.43	37.15	430.60
10.0 m	321.78	112.83	43.70	478.30
Storage Volume ($10^3 m^3$)				
3.0 m	-	-	-	-
3.5 m	8,488	-	-	8,488
4.0 m	19,275	-	-	19,275
4.5 m	28,106	-	-	28,106
5.0 m	35,225	-	-	35,225
5.5 m	43,530	-	-	43,530
6.0 m	54,569	18,350	-	72,919
7.0 m	163,850	50,425	14,700	228,975
8.0 m	234,162	67,125	25,263	326,550
9.0 m	281,712	83,613	33,850	399,175
10.0 m	311,400	102,625	40,425	454,450

Table 3.1 Estimated Inundation Area

(Unit: ha)

Area	Irrigated	Rainfed	Sub-total	Swamp	Others	Total	Remarks
	Inundation Area						
Small Flood							
L.Tempe	1,498	2,571	4,069	9,296	932	14,297	1978-Flood
R.Bila	1,799	2,490	4,289	730	1,493	6,512	1978-Flood
R.Walanae	-	1,845	1,845	369	969	3,183	1975-Flood
R.Cenranae	-	-	-	-	-	-	
Total	3,297	6,906	10,203	10,395	3,394	23,992	
Large Flood							
L.Tempe	3,668	5,653	9,321	10,494	2,423	22,238	1977-Flood
R.Bila	3,307	4,211	7,518	730	2,780	11,028	1974-Flood
R.Walanae	-	5,081	5,081	369	3,947	9,397	1977-Flood
R.Cenranae	-	1,491	1,491	8,694	700	10,885	1977-Flood
Total	6,975	16,436	23,411	20,287	9,850	53,548	
Area around Lake Tempe							
Less than EL. 6.0 m	19	63	82	1,525	113	1,720	
El. 7.0 m	644	1,232	1,876	8,088	539	10,503	
El. 8.0 m	2,319	3,857	6,176	10,457	1,309	17,942	
El. 9.0 m	3,769	5,788	9,557	10,497	2,507	22,561	
El. 10.0 m	5,344	6,676	12,020	10,513	3,334	25,869	
El. 15.0 m	16,426	11,645	28,071	10,865	7,504	46,439	

Table 3.2 (1) List of Past Floods

(1) Bila River

Year	Month	Date	Qmax /1 (m^3/s)	Duration (days)	Inundation Area (ha)	Inundation Depth (m)	2 Days Rainfall Rappang	2 Days Rainfall Bulu Cenrana (mm)
1974	July	15	629	1	2,850	0.3	-	51
	Sept	12-17	924	5	10,300	0.7	-	177
	Oct	16-17	710	2	3,850	0.3	-	70
	Nov	10	541	1	1,800	0.2	-	78
	Dec	25	659	1	3,200	0.3	-	107
1975	June	19	678	1	3,500	0.3	-	35
	July	28-30	831	3	5,300	0.5	-	9
	Aug	12-14	804	3	5,000	0.4	-	155
	Aug	31	732	1	4,100	0.4	-	57
	Oct	8	531	1	1,650	0.1	-	79
1976	Mar	4-5	767	2	4,550	0.4	-	-
	May	4-6	878	3	6,900	0.6	-	-
	May	27	508	1	1,400	0.1	-	-
	June	12	576	1	2,100	0.2	8	340
1977	Apr	2	627	1	2,800	0.2	9	-
	Apr	17	674	1	3,400	0.3	56	45
	June	14-15	657	2	3,200	0.3	136	-
	June	18-20	672	3	3,400	0.3	59	-
	Aug	13	524	1	1,600	0.1	-	-
	Dec	14-15	577	2	2,200	0.2	17	-
1978	Mar	30	503	1	1,300	0.1	-	22
	Apr	28-30	863	3	5,780	0.5	-	8
	May	1-2	814	3	5,100	0.4	-	5
	May	20	589	1	2,350	0.2	-	4
	June	26	772	2	4,600	0.4	41	5
	July	23-24	810	3	5,100	0.4	27	-
	July	17	612	1	2,650	0.2		
	Aug	8	553	1	1,900	0.2	-	-

/1: More than 500 m^3/s in peak discharge at Tanru Tedong

Table 3.2 (2) List of Past Floods

(2) Walanae River

Station	Year	Month	Date	Qmax/1 (m^3/s)	Duration (days)	Inundation Area (ha)	Inundation Depth (m)	2-Days Rainfall Maradda (mm)	2-Days Rainfall Watan Soppeng (mm)
Lakibong	1970	Aug	1-2	1,917	2	6,100	0.7	-	-
		Nov	21	1,026	1	1,650	0.2	-	-
			23	806	1	1,100	0.1	-	-
		Dec	4	931	1	1,400	0.2	-	-
			12	1,032	1	1,700	0.2	-	-
			16	992	1	1,600	0.2	-	-
Lakibong	1971	Mar	13-16	1,452	4	2,800	0.5	2	11
			19-20	1,069	2	1,800	0.3	-	9
		June	17-19	2,132	3	7,550	0.7	156	63
			22	1,696	1	4,500	0.6	31	36
			25-27	999	3	1,600	0.2	25	10
		July	6	1,429	1	2,700	0.5	19	57
		Sept	7	1,261	1	2,300	0.4	59	41
		Oct	2	925	1	1,400	0.2	57	49
		Dec	30-4	2,142	6	7,600	0.7	36	43
Lakibong	1972	Jan	6-15	3,068	10	13,700	1.0	44	62
		Feb	24	1,641	1	4,100	0.6	-	37
		Dec	18-19	1,131	2	1,950	0.3	-	-
Cabenge	1975	Apr	29	988	1	1,550	0.2	25	19
		May	7	898	1	1,300	0.2	117	27
			20	1,223	1	2,200	0.4	53	56
			29	1,213	1	2,150	0.4	80	10
		June	17	823	1	1,150	0.1	154	39
		July	23-25	1,139	3	2,000	0.3	52	46
		Aug	11-12	1,461	2	2,850	0.5	148	84
Cabenge	1977	Jan	9-11	1,004	3	1,600	0.2	44	27
			24-25	1,268	2	2,300	0.4	13	50
		Feb	15-18	1,506	4	3,150	0.5	20	34
		June	14-20	2,337	7	9,050	0.8	170	98
Cabenge	1978	Dec	29	801	1	1,100	0.1	-	-

/1: More than 800 m^3/s in daily discharge

Table 3.2 (3) List of Past Floods

(3) Lake Tempe

Year	Hmax	Month	Inundation					Monthly Rainfall /2
			Area	Depth (m) /1				
			(ha)	El.6m	El.7m	El.8m	El.9m	(mm)
1968	7.34	June-Sept	4,500	1.3	0.3	-	-	171
1969	7.62	May-July	5,500	1.6	0.6	-	-	230
1970	9.58	May-Aug	13,800	3.5	2.5	1.5	0.5	266
1971	7.20	Sept-Oct	3,200	1.1	0.1	-	-	150
1975	8.10	May-Nov	7,700	2.0	1.0	-	-	223
1976	6.79	July	1,100	0.8	-	-	-	175
1977	8.93	June-July	11,740	2.9	1.9	0.9	-	283
1978	7.51	May-Aug	5,000	1.5	0.5	-	-	268

(4) Cenranae River

Year	Month Date	Qmax /3 (m^3/s)	Duration (days)	Inundation	
				Area (ha)	Depth (m)
1975	May 29 - June 29	503	31	620	0.2
	July 26 - Aug 5	472	11	260	0.1
	Aug 12 - Aug 21	482	10	390	0.1
1976	——— no flood ———				
1977	June 16 - July 10	635	25	2,200	0.5
1978	May 17	405	1	-	-

/1: Average depth in inundation area during one-week

/2: Mean monthly rainfall of the basin at Sengkang during the period of high-water of Lake Tempe

/3: More than 400 m^3/s in daily discharge at Sengkang

Table 3.3 Rate of Decrease in Yield of Paddy due to Submergence

(Unit: %)

Submergence Depth	Duration (days)	Tillering Stage 0 - 7th day (0-54%)	Booting Stage 71-87th day (55-61%)	Handing Stage 88-100th day (68-77%)	Ripening Stage 101-130th day (78-100%)
Case (1)	1 - 2	10	70	30	5
Over	3 - 4	20	80	80	20
Plant	5 - 6	30	85	90	30
Height	over 7	35	95	100	30
Case (2)	1 - 2	6	40	10	4
70% of	3 - 4	9	46	23	15
Plant	5 - 6	14	49	26	13
Height	over 7	16	55	30	23
Case (3)	1 - 2	4	37	8	2
50% of	3 - 4	9	42	22	4
Plant	5 - 6	13	45	25	6
Height	over 7	15	50	28	6

Data Source: Study Report on Overall Ular River Improvement Project, January 1978, JICA.

Table 3.4 Flood Damages in Kec.Lilirilau due to Flood of June 1977

Item	Unit	Desa				
		Pajalesang	Lompulle	Baringeng	Ujung	Total
Paddy	ha	434	1,222	193	54	1,903
Tobacco	ha	315	504	-	28	846
Livestock						
Cow	nos	4	1	-	1	6
Buffalo	nos	-	-	-	-	-
Goat	nos	-	3	-	-	3
Chicken	nos	712	813	-	150	1,675
Duck	nos	506	1,112	-	-	1,618
Stored Goods						
Maise	bundle	-	-	-	650	650
Tobacco	bundle	2,200	-	-	-	2,200
Bamboo Case	nos	16,000	-	-	-	16,000
House	nos	17	3	-	8	28
Public Facilities						
Mosque	nos	1	-	-	-	1
School	nos	-	-	-	1	1
Road						
Prov. Road	km	1.5	-	-	0.5	2.0
Kab. Road	km	4.0	9.0	-	-	13.0
Desa Road	km	4.0	6.0	-	5.0	15.0
Damage Amount	10^6Rp.	304	692	77	33	1,106

Data Source: Kepala Pemerintahan Wilayah Kec.Lilirilau, Kab.Soppeng

Table 3.5 Percentage of Damage to Paddy and Other Damage

(Area in Kec.Lilirilau, Flood of June 1977)

Item	Unit	Paddy	Others	Total
Desa Pajalesang				
Damage Amount	10^6Rp	122	182	304
Percentage	%	40	60	100
Desa Lompulle				
Damage Amount	10^6Rp	342	350	692
Percentage	%	49	51	100
Desa Baringeng				
Damage Amount	10^6Rp	77	0	77
Percentage	%	100	0	100
Desa Ujung				
Damage Amount	10^6Rp	15	18	33
Percentage	%	45	55	100
Total				
Damage Amount	10^6Rp	556	550	1,106
Percentage	%	50	50	100

Table 3.6 (1) Estimated Damage to Paddy caused by Past Flood

Area around Lake Tempe

Item	Unit	Elevation less than 6m	6m - 7m	7m - 8m	8m - 9m	9m - 10m	Total
- Paddy Area							
Irrigated	ha	19	625	1,675	1,450	1,575	
Rainfed	ha	63	1,129	2,625	1,951	888	
- Paddy Production (if no flood)							
Irrigated	ton	89	2,938	7,873	6,815	7,403	
Rainfed	ton	170	3,048	7,088	5,268	2,398	
Total	ton	259	5,986	14,961	12,083	9,801	
1968							
Ratio of Damage to Paddy	%	100	80	35	-	-	
Decrease Production	ton	259	4,789	5,236	-	-	10,284
1969							
Ratio of Damage to Paddy	%	50	35	10	-	-	
Decrease Production	ton	130	2,095	1,496	-	-	3,721
1970							
Ratio of Damage to Paddy	%	100	50	35	35	15	
Decrease Production	ton	259	2,993	5,236	4,229	1,470	14,187
1971							
Ratio of Damage to Paddy	%	30	30	3	-	-	
Decrease Production	ton	78	1,796	449	-	-	2,323
1975							
Ratio of Damage to Paddy	%	100	100	95	-	-	
Decrease Production	ton	259	5,986	14,213	-	-	20,458
1976							
Ratio of Damage to Paddy	%	30	15	-	-	-	
Decrease Production	ton	78	898	-	-	-	976
1977							
Ratio of Damage to Paddy	%	100	100	45	35	-	
Decrease Production	ton	259	5,986	6,732	4,229	-	17,206
1978							
Ratio of Damage to Paddy	%	95	55	15	-	-	
Decrease Production	ton	246	3,292	2,244	-	-	5,782

Downstream Area of Bila River

Item	Unit	1974 Flood	1978 Flood
- Damaged Paddy Area			
Irrigated	ha	2,805	1,799
Rainfed	ha	4,211	2,490
- Paddy Production (if no flood)			
Irrigated	ton	16,830	10,794
Rainfed	ton	13,475	7,968
Total	ton	30,305	18,762
- Average Inundated Depth	m	0.7	0.5
- Duration of Inundation	days	5	3
- Growth Stage		Booting	Tillering
- Damage Ratio	%	30	25
- Decrease Paddy Production	ton	9,092	4,691

Table 3.6 (2) Estimated Damage to Paddy caused by Past Flood

Downstream Area of Walanae River

Item	Unit	1975 Flood	1977 Flood
- Damaged Paddy Area (Rainfed)	ha	1,875	5,081
- Paddy Production (if no flood)	ton	4,875	13,211
- Average Inundated Depth	m	0.5	0.8
- Duration of Inundation	days	3	8
- Growth Stage		Tilling	Booting
- Damage Ratio	%	70	95
- Decrease Paddy Production	ton	3,413	12,550

Area along Cenranae River (Sengkang - Solo)

Item	Unit	1977 Flood
- Downstream Paddy Area (Rainfed)	ha	1,475
- Paddy Production (if no flood)	ton	4,886
- Average Inundation Depth	m	0.5
- Duration of Inundation	days	25
- Growth Stage		Booting
- Damage Ratio	%	35
- Decrease Paddy Production	ton	1,710

Summarized Damage to Paddy

Flood	Return Period (yr)	Decrease Paddy Production (ton)		
		Mainstream	Tributaries	Total
Area around Lake Tempe				
1968	2.3	-	-	10,284
1969	1.5	-	-	3,721
1970	3.0	-	-	14,187
1971	1.3	-	-	2,323
1975	9.0	-	-	20,458
1976	1.1	-	-	976
1977	4.5	-	-	17,206
1978	1.8	-	-	5,782
Downstream Area of Bila River				
1974	6.0	6,364	2,728	9,092
1978	1.7	3,284	1,407	4,691
Downstream Area of Walanae River				
1975	1.7	2,696	717	3,413
1977	11.1	9,914	2,636	12,550
Area along Cenranae River				
1977	4.5	1,197	513	1,710

Table 3.7 Estimated Past Flood Damages

(Unit: 10^6Rp.)

Flood	Return Period (yr)	Damage Amount								
		Mainstream			Tributaries			Total		
		Paddy	Others	Total	Paddy	Others	Total	Paddy	Others	Total
Area around Lake Tempe										
1968	2.3			-			-	1,368	1,368	2,736
1969	1.5			-			-	495	495	990
1970	3.0			-			-	1,887	1,887	3,774
1971	1.3			-			-	309	309	618
1975	9.0			-			-	2,721	2,721	5,442
1976	1.1			-			-	129	129	258
1977	4.5			-			-	2,288	2,288	4,576
1978	1.8			-			-	769	769	1,538
Downstream Area of Bila River										
1974	6.0	847	363	1,210	363	156	519	1,209	520	1,729
1978	1.7	437	187	624	188	80	268	624	268	892
Downstream Area of Walanae River										
1975	1.7	359	358	717	96	95	191	454	454	908
1977	11.1	1,319	1,318	2,637	350	350	701	1,669	1,669	3,338
Area along Cenranae River										
1977	4.5	159	68	227	69	29	98/1	227	98	325

/1: Damages caused by inner water

Table 3.8 Estimated Average Annual Flood Damages

(under Present Conditions)

(Unit: 10^6Rp)

Item	Probability						
	1/1.1	1/2	1/5	1/10	1/20	1/50	1/100
Area around Lake Tempe							
- Damage amount	240	2,100	4,600	6,000	7,500	9,500	11,000
- Average Annual	240	708	1,713	2,243	2,581	2,806	2,910
Downstream Area of Bila River							
- Damage amount							
Mainstream	320	700	1,190	1,540	1,890	2,450	2,870
Tributaries	140	300	510	660	810	1,050	1,230
Total	460	1,000	1,700	2,200	2,700	3,500	4,100
- Average Annual							
Mainstream	322	526	810	946	1,033	1,098	1,124
Tributaries	138	226	347	406	442	470	482
Total	460	752	1,157	1,352	1,475	1,568	1,606
Downstream Area of Walanae River							
- Damage amount							
Mainstream	300	870	1,740	2,450	3,400	4,740	5,930
Tributaries	80	230	460	650	900	1,260	1,570
Total	380	1,100	2,200	3,100	4,300	6,000	7,500
- Average Annual							
Mainstream	300	534	925	1,134	1,280	1,403	1,456
Tributaries	80	142	246	302	341	373	387
Total	380	676	1,171	1,436	1,621	1,776	1,843
Area along Cenranae River (Sengkang - Solo)							
- Damage amount							
Mainstream	40	120	250	350	480	670	840
Inner water	20	50	100	150	200	290	360
Total	60	170	350	500	680	960	1,200
- Average Annual							
Mainstream	40	74	129	159	179	197	205
Inner water	20	32	55	68	77	84	87
Total	60	106	184	227	256	281	297

Table 3.9 (1) Estimated Potential Flood Damage to Paddy

Area around Lake Tempe

Item	Unit	Elevation less than 6m	6m - 7m	7m - 8m	8m - 9m	9m - 10m	Total
- Existing Swamp Area	ha	1,523	6,563	2,369	40	18	10,513
- Potentiality (if no flood)							
Paddy Area	ha	-	5,250	1,895	-	-	7,145
Production (rainfed)	ton	-	14,175	5,117	-	-	19,292
1968: Damage Ratio	%	-	80	35	-	-	
Decrease Production	ton	-	11,340	1,791	-	-	13,131
Amount of Damage	$10^6 R_p$						1,221
1969: Damage Ratio	%	-	35	10	-	-	
Decrease Production	ton	-	4,961	512	-	-	5,473
Amount of Damage	$10^6 R_p$						509
1970: Damage Ratio	%	-	50	35	-	-	
Decrease Production	ton	-	7,088	1,791	-	-	8,879
Amount of Damage	$10^6 R_p$						826
1971: Damage Ratio	%	-	30	3	-	-	
Decrease Production	ton	-	4,253	154	-	-	4,407
Amount of Damage	$10^6 R_p$						410
1975: Damage Ratio	%	-	100	95	-	-	
Decrease Production	ton	-	14,175	4,861	-	-	19,036
Amount of Damage	$10^6 R_p$						1,770
1976: Damage Ratio	%	-	15	-	-	-	
Decrease Production	ton	-	2,126	-	-	-	2,126
Amount of Damage	$10^6 R_p$						198
1977: Damage Ratio	%	-	100	45	-	-	
Decrease Production	ton	-	14,175	2,303	-	-	16,478
Amount of Damage	$10^6 R_p$						1,533
1978: Damage Ratio	%	-	55	15	-	-	
Decrease Production	ton	-	7,796	768	-	-	8,564
Amount of Damage	$10^6 R_p$						796

Downstream Area of the Bila and the Walanae River

Item	Unit	Quantity R.Bila	R.Walanae
- Existing Swamp Area	ha	730	369
- Potentiality (if no flood)			
Paddy Area	ha	490	369
Production (rainfed)	ton/yr	1,568	959
- Amount of Damage	$10^6 R_p$/yr	146	89

Table 3.10 Average Annual Potential Flood Damage to Paddy

(Unit: 10^6Rp)

Item	Probability						
	1/1.1	1/2	1/5	1/10	1/20	1/50	1/100
Area around Lake Tempe							
- Amount of Damage	200	730	1,450	1,800	2,150	2,550	2,900
- Average Annual Damage	200	386	713	876	974	1,045	1,072
Downstream Area of Bila River							
- Amount of Damage	146	146	146	146	146	146	146
- Average Annual Damage	16	74	118	133	140	145	146
Downstream Area of Walanae River							
- Amount of Damage	89	89	89	89	89	89	89
- Average Annual Damage	10	45	72	71	85	88	89

Table 3.11 Estimated Flood Damage to Paddy under the Condition of Proposed Irrigation Project

Downstream Area of Bila River

Item	Unit	1978-Flood	1974-Flood
- Damaged Paddy Area (irrigated)	ha	4,289	7,016
- Paddy Production (if no flood)	ton	25,734	42,096
- Average Inundation Depth	m	0.5	0.7
- Duration of Inundation	days	3	5
- Growth Stage		Tillering	Booting
- Damage Ratio	%	25	30
- Decrease Paddy Production	ton	6,434	12,629
- Amount of Paddy Damage	10^6Rp	856	1,680

Downstream Area of Walanae River

Item	Unit	Wet Season		Dry Season	
		1975	1977	1976/77	1971/72
- Damaged Paddy Area					
Irrigated Paddy	ha	1,226	4,386	1,264	4,386
Rainfed Paddy	ha	649	695	-	-
- Paddy Production (if no flood)					
Irrigated Paddy	ton	7,356	26,316	7,584	26,316
Rainfed Paddy	ton	1,687	1,807	-	-
Total	ton	9,043	28,123	7,584	26,316
- Average Inundation Depth	m	0.5	0.8	0.5	0.8
- Duration of Inundation	days	3	8	4	16
- Growth Stage		Tillering	Booting	Heading	Booting
- Damage Ratio	%	70	95	23	95
- Decrease Paddy Production	ton	6,330	26,717	1,744	25,000
- Amount of Paddy Damage	10^6Rp	842	3,553	232	3,325

Table 3.12 Damage to Paddy Area by Flood
(under Proposed Conditions)

Item	Unit	Probability 1/5	1/20	1/50
(1) Downstream Area of Bila River				
- Damage Area				
Inundated Paddy Area	ha	6,473	10,027	12,530
100% Damage Area /1	ha	1,942	3,008	3,759
Damage Ratio /2	%	30	30	30
- Average Annual				
Inundated Paddy Area	ha	4,746	5,930	6,270
100% Damage Area	ha	1,424	1,779	1,881
(2) Downstream Area of Walanae River				
(a) Wet Season				
- Damage Area				
Inundated Paddy Area	ha	4,117	6,332	9,102
100% Damage Area	ha	2,882	6,015	8,647
Damage Ratio	%	70	95	95
- Average Annual				
Inundated Paddy Area	ha	2,016	2,142	2,375
100% Damage Area	ha	1,411	2,035	2,256
(b) Dry Season				
- Damage Area				
Inundated Paddy Area	ha	4,117	6,322	9,102
100% Damage Area	ha	627	2,632	5,524
Damage Ratio	%	15	42	60
- Average Annual				
Inundated Paddy Area	ha	947	819	775
100% Damage Area	ha	142	344	465

/1: Damage area equivalent to 100% damage in paddy yield.

/2: Damage ratio of decrease in paddy yield to inundated paddy area.

Table 3.13 Estimated Average Annual Flood Damages

(under Proposed Conditions)

(Unit: 10^6Rp)

Item	Probability						
	1/1.1	1/2	1/5	1/10	1/20	1/50	1/100
(1) Downstream Area of Bila River							
Damage to Paddy							
- Amount of Damage							
Mainstream Component	330	680	1,090	1,370	1,680	2,100	2,450
Tributary Component	140	290	460	580	720	900	1,050
Total	470	970	1,550	1,950	2,400	3,000	3,500
- Average Annual							
Mainstream Component	330	531	795	918	994	1,051	1,073
Tributary Component	140	227	341	393	426	450	460
Total	470	758	1,136	1,311	1,420	1,501	1,533
Other Damage (Average Annual)							
Mainstream Component	97	158	243	284	310	329	337
Tributary Component	41	68	104	122	133	141	145
Total	138	226	347	406	443	470	482
Total Damage (Average Annual)							
Mainstream Component	427	689	1,038	1,202	1,304	1,380	1,417
Tributary Component	181	295	443	515	559	591	605
Total	608	984	1,483	1,717	1,863	1,971	2,022
(2) Downstream Area of Walanae River							
Damage to Paddy during Wet Season							
- Amount of Damage							
Mainstream Component	240	830	1,740	2,610	3,630	5,290	6,720
Tributary Component	60	220	460	690	970	1,410	1,780
Sub-total	300	1,050	2,200	3,300	4,600	6,700	8,500
- Average Annual							
Mainstream Component	240	450	836	1,053	1,209	1,343	1,403
Tributary Component	60	120	222	280	321	357	373
Sub-total	300	570	1,058	1,333	1,530	1,700	1,776
Damage to Paddy during Dry Season							
- Amount of Damage							
Mainstream Component	0	30	240	630	1,110	2,530	4,270
Tributary Component	0	5	60	170	290	670	1,130
Sub-total	0	35	300	800	1,400	3,200	5,400
- Average Annual							
Mainstream Component	0	6	45	88	132	186	220
Tributary Component	0	1	12	24	35	50	59
Sub-total	0	7	57	112	167	236	279
Total Damage to Paddy (Average Annual)							
Mainstream Component	240	456	881	1,141	1,341	1,529	1,623
Tributary Component	60	121	234	304	356	407	432
Total	300	577	1,115	1,445	1,697	1,936	2,055
Other Damage (Average Annual)							
Mainstream Component	150	267	463	567	640	702	728
Tributary Component	40	71	123	151	171	187	194
Total	190	338	586	718	811	889	922
Total Damage (Average Annual)							
Mainstream Component	390	723	1,344	1,708	1,981	2,231	2,351
Tributary Component	100	192	357	455	527	594	626
Total	490	915	1,701	2,163	2,508	2,825	2,977

Table 4.1 Manning's Coefficient of Roughness for Design

River	Stretch	Manning's n Low-water channel	Manning's n High-water channel
- R.Cenranae	River mouth - Sengkang	0.021	0.040
- Mainstream of R.Bila	River mouth - Confluence of R.Boya	0.025	0.040
- Mainstream of R.Bila	Confluence of R.Boya - Bila AWLR	0.030	0.045
- R.Boya	Confluence of R.Bila - Bulu Cenrana AWLR	0.030	0.045
- Mainstream of R.Walanae	River mouth - 57 km	0.025	0.040
- Tributaries			
more than i = 1/200		0.040	-
i = 1/200 - 1/500		0.035	-
less than i = 1/500		0.030	-

Table 4.2 Design Criteria for Levee

Design Discharge (m^3/s)	Free Board (m)	Crest Width (m)	Side Slope
less than 200	0.6	4	1 : 2.0
200 - 500	0.8	4	1 : 2.0
500 - 2,000	1.0	4	1 : 2.0
2,000 - 5,000	1.2	4 - 5	1 : 2.0

Table 4.3 Probable Flood Discharge

(Unit: m^3/s)

Stretch	Catchment Area (km^2)	Probability 1/5	1/10	1/20	1/50	1/100
Bila River						
- Mainstream						
L.Tempe - R.Lancirang	1,368	1,453	1,615	1,843	2,057	2,223
R.Lancirang - R.Kalola	1,188	1,343	1,496	1,712	1,915	2,073
R.Kalola - R.Boya	956	1,190	1,331	1,527	1,716	1,862
Upstream of confluence of R.Boya	420	753	855	991	1,133	1,240
- Tributaries						
R.Boya	536	863	975	1,126	1,281	1,399
R.Lancirang	180	470	542	634	739	816
R.Kalola	167	451	521	610	711	787
Walanae River						
- Mainstream						
L.Tempe - R.Belo	3,190	2,326	2,546	2,878	3,154	3,377
R.Belo - R.Mario	2,859	2,189	2,400	2,716	2,984	3,199
Upstream of confluence of R.Mario	2,199	2,094	2,285	2,570	2,856	3,047
- Tributaries						
R.Mario	485	816	924	1,068	1,218	1,332
R.Belo	216	521	598	698	810	893
R.Lwo	88	316	369	435	515	573
Cenranae River						
- at Sengkang Bridge	-	646	744	849	1,105	1,367

Remarks: As the discharge of the Cenranae river depends on the water level of Lake Tempe, the discharges were calculated from the water level of Lake Tempe through a correlation curve between Lake Tempe and Sengkang.

Table 4.4 Economic Comparison of Design Flood

Item	Unit	Return Period of Flood			
		5-yr	10-yr	20-yr	50-yr
Bila River					
- Average annual benefit/1	10^6Rp	1,038	1,202	1,304	1,380
- Construction cost	10^6Rp	7,900	9,000	9,700	11,200
- Annual O/M cost	10^6Rp	36	41	44	50
- B/C ratio/3					
Discount rate 8%		1.29	1.31	1.32	1.21
Discount rate 10%		1.04	1.06	1.07	0.98
Discount rate 12%		0.87	0.89	0.89	0.82
Walanae River					
- Average annual benefit/1	10^6Rp	1,344	1,708	1,981	2,231
- Construction cost	10^6Rp	13,300	16,500	17,700	22,000
- Annual O/M cost	10^6Rp	60	74	80	99
- B/C ratio/3					
Discount rate 8%		0.99	1.01	1.10	0.99
Discount rate 10%		0.80	0.82	0.89	0.80
Discount rate 12%		0.67	0.69	0.74	0.67

/1: The benefits are estimated as effects of decrease in flood damages under the conditions of the proposed irrigation projects (refer to Table 3.13).

/2: The annual O/M cost is assumed at 0.5% of construction cost excluding engineering & administration cost.

/3: The B/C ratios are calculated only for comparative purpose taking up the improvement of the mainstream of the Bila and the Walanae Rivers. They would be different, if all the benefits and the construction costs including the improvement of tributaries would be taken into account.

Table 4.5 Design Flood Discharge of the Rivers in Indonesia

No.	Name of River	Province	Catchment Area (km^2)	Design Flood (m^3/s)	Return Period (yr)	Remarks
1	Sungai Cimanuk	West Jawa	3,006	1,440	25	
2	Kali Serang	Central Jawa	937	900	25	
3	Sungai Citanduy	West Jawa	3,680	1,900	25	
4	Sungai Ular	North Sumatera	1,080	800	25	
5	Kali Pemali	Central Jawa	1,228	1,300	25	
6	Sungai Cipanas	West Jawa	220	385	25	
7	Bengawan Solo	Central/East Jawa	3,400	1,500	10	1st stage
				2,000	40	2nd stage
8	Kali Madium	East Jawa	2,400	1,100	10	1st stage
				2,300	40	2nd stage
9	Sungai Wampu	North Sumatera	3,840	1,320	20	
10	Sungai Arakundo	Aceh	5,495	1,800	20	
11	Sungai Kring Aceh	Aceh	1,775	1,300	20	
12	Kali Brantas	East Jawa	10,000	1,350	10	1st stage
				1,500	50	2nd stage
13	Sungai Bah Bolon	North Sumatera	2,776	1,220	20	

Table 4.6 Flood Control Effect by Dam

Item	Unit	Probability						
		1/1.1	1/2	1/5	1/10	1/20	1/50	1/100
Discharge and Water Level								
(1) Without Dam (Present Condition)								
Discharge at Cabenge	m^3/s	900	1,700	2,200	2,400	2,700	3,000	3,200
W.L of L.Tempe	El.m	6.8	8.0	8.9	9.4	9.9	11.0	12.0
Discharge at Sengkang	m^3/s	310	490	650	750	850	1,110	1,370
(2) With Flood Regulation by Mong Dam (V = 50 million m^3)								
Walanae River								
Discharge at Cabenge	m^3/s	800	1,490	1,910	2,080	2,330	2,880	3,120
Discharge reduction	m^3/s	80	210	290	320	370	120	80
(3) With Flood Regulation by Walimpong Dam (V = 100 million m^3)								
Walanae River								
Discharge at Cabenge	m^3/s	760	1,320	1,690	1,820	2,040	2,740	3,020
Discharge reduction	m^3/s	140	380	510	580	660	260	180
Lake Tempe								
W.L of L.Tempe	El.m	6.78	7.96	8.84	9.33	9.82	10.90	11.89
W.L lowering	m	0.02	0.04	0.06	0.07	0.08	0.10	0.11
(4) With Flood Regulation by Walimpong Dam (V = 200 million m^3)								
Walanae River								
Discharge at Cabenge	m^3/s	640	1,050	1,310	1,410	1,570	2,540	2,900
Discharge reduction	m^3/s	260	650	890	990	1,130	460	300
Lake Tempe								
W.L of L.Tempe	El.m	6.75	7.92	8.80	9.28	9.77	10.85	11.84
W.L lowering	m	0.05	0.08	0.10	0.12	0.13	0.15	0.16
(5) With Flood Regulation by Walimpong Dam (V = 300 million m^3)								
Walanae River								
Discharge at Cabenge	m^3/s	580	880	1,140	1,230	1,360	2,500	2,860
Discharge reduction	m^3/s	320	820	1,060	1,170	1,340	500	340
Lake Tempe								
W.L of L.Tempe	El.m	6.75	7.91	8.79	9.27	9.75	10.83	11.81
W.L reduction	m	0.06	0.09	0.11	0.13	0.15	0.17	0.19

Table 4.7 Decrease in Flood Damages in Area around Lake Tempe by Means of Flood Regulation by Walimpong Dam

(Unit: 10^6Rp)

Item	Probability						
	1/1.1	1/2	1/5	1/10	1/20	1/50	1/100
1. Flood Control Capacity of Dam: V = 100 million m^3							
- Decrease in Damages							
Paddy & others	1	30	35	40	50	50	40
Potential damages/1	3	15	10	10	10	10	20
Sub-total	4	45	45	50	60	60	60
- Average Annual	4	17	30	35	37	39	40
2. Flood Control Capacity of Dam: V = 200 million m^3							
- Decrease in Damages							
Paddy & others	20	300	300	400	310	230	300
Potential damages/1	15	125	70	90	70	110	30
Sub-total	35	425	370	490	380	340	330
- Average Annual	35	150	269	312	334	345	348
3. Flood Control Capacity of Dam: V = 300 million m^3							
- Decrease in Damages							
Paddy & others	25	350	340	420	350	250	350
Potential damages/1	16	140	90	120	80	150	50
Sub-total	41	490	430	540	430	400	400
- Average Annual	41	174	312	360	385	397	401

/1: There are many swamps around Lake Tempe. Some of them will be utilized as paddy field due to lowering of high-water level by flood control measures. In this study, it is assumed that the net income with project obtained from the swamps is estimated at Rp. 93 per kg as production of rainfed paddy.

Table 4.8 (1) Effect by Dredging of Cenranae River

Discharge and Water Level

Item	Unit	Present Condition	Dredging Volume (10^3m^3) 500	2,000	18,800
1975					
- Water level of L.Tempe					
HWL	El.m	8.37	8.17	7.82	6.84
Reduction	m	-	0.20	0.55	1.53
- Discharge at Sengkang					
Peak	m^3/s	549	545	553	813
1977					
- Water level of L.Tempe					
HWL	El.m	8.97	8.82	8.67	7.89
Reduction	m	-	0.13	0.30	1.06
LWL	El.m	3.42	2.50	1.74	1.35
Reduction	m	-	0.92	1.68	2.07
- Discharge at Sengkang					
Peak	m^3/s	659	649	681	1,085
Lowest	m^3/s	25	25	25	25
1978					
- Water level of L.Tempe					
HWL	El.m	7.51	7.27	7.01	6.00
Reduction	m	-	0.24	0.50	1.51
LWL	El.m	4.08	3.02	2.15	1.58
Reduction	m	-	1.06	1.93	2.50
- Discharge at Sengkang					
Peak	m^3/s	409	418	442	619
Lowest	m^3/s	55	44	38	38

Table 4.8 (2) Effect by Dredging of Cenranae River

Flood Damage Reduction

Item	Unit	Probability						
		1/1.1	1/2	1/5	1/10	1/20	1/50	1/100
Dredging of V = 500,000 m^3								
- W.L of L.Tempe	El.m	6.47	7.82	8.78	9.30	9.81	10.93	11.94
- W.L reduction	m	0.33	0.18	0.12	0.10	0.09	0.07	0.06
- Flood damage reduction								
Present damage	10^6Rp	80	500	400	200	200	100	100
Potential damage	10^6Rp	40	150	50	50	30	30	20
Total	10^6Rp	120	650	450	250	230	130	120
- Annual average	10^6Rp	120	274	439	474	486	491	492
Dredging of V = 2,000,000 m^3								
- W.L of L.Tempe	El.m	6.16	7.58	8.57	9.11	9.65	10.78	11.79
- W.L reduction	m	0.64	0.42	0.33	0.29	0.25	0.22	0.21
- Flood damage reduction								
Present damage	10^6Rp	120	1,170	800	800	700	600	500
Potential damage	10^6Rp	80	350	200	200	170	150	100
Total	10^6Rp	200	1,520	1,000	1,000	870	750	600
- Annual average	10^6Rp	200	544	922	1,022	1,069	1,093	1,100
Dredging of V = 18,800,000 m^3								
- W.L of L.Tempe	El.m	5.00	6.70	7.80	8.44	9.01	10.20	11.25
- W.L reduction	m	1.80	1.30	1.10	0.96	0.89	0.80	0.75
- Flood damage reduction								
Present damage	10^6Rp	150	1,760	3,100	2,500	2,500	1,500	1,200
Potential damage	10^6Rp	130	540	950	600	600	350	200
Total	10^6Rp	280	2,300	4,050	3,100	3,100	1,850	1,400
- Annual average	10^6Rp	280	796	1,749	2,106	2,261	2,355	2,351

Table 4.9 (1) Economic Comparison of Dredging Scale of Cenranae River

Benefit - Cost Ratio

Item	Unit	Dredging Volume ($10^6 m^3$)		
		500	2,000	18,800
- Average annual benefit/1	10^6Rp	492	1,100	2,351
- Construction cost				
Dredging	10^6Rp	1,360	4,800	27,300
Construction of barrage	10^6Rp	1,870	1,870	1,870
Sub-total	10^6Rp	3,230	6,670	29,170
O/M cost (25% of above)	10^6Rp	808	1,668	7,368
Total	10^6Rp	4,038	8,338	36,538
- Annual cost				
discount rate 8%	10^6Rp	330	682	2,980
discount rate 10%	10^6Rp	407	841	3,678
discount rate 12%	10^6Rp	486	1,004	4,390
- B/C ratio				
discount rate 8%		1.49	1.61	0.79
discount rate 10%		1.21	1.31	0.64
discount rate 12%		1.01	1.10	0.54

/1: The benefit is included the reduction of present and potential damages.

Table 4.9 (2) Economic Comparison of Dredging Scale of Cenranae River

Construction Cost

Item	Unit	Q'ty	Unit Price (Rp)	Amount	
				10^6Rp	10^3US$
Dredging Volume: 500,000 m^3					
- Civil works					
Preparation	LS	-	-	72	
Dredging	10^3m^3	500	1,800	900	
Miscellaneous	LS	-	-	48	
Sub-total				1,020	
- Land acquisition	ha	10	500,000	5	
- Contingency	LS	-	-	205	
- Engineering & administration		-	-	130	
- Total				1,360	2,176
Dredging Volume: 2,000,000 m^3					
- Civil works					
Preparation	LS	-	-	256	
Dredging	10^3m^3	2,000	1,600	3,200	
Miscellaneous	LS	-	-	174	
Sub-total				3,630	
- Land acquisition	ha	10	500,000	5	
- Contingency	LS	-	-	725	
- Engineering & administration		-	-	440	
- Total				4,800	7,680
Dredging Volume: 18,800,000 m^3					
- Civil works					
Preparation	LS	-	-	1,430	
Dredging	10^3m^3	18,800	950	17,860	
Miscellaneous	LS	-	-	980	
Sub-total				20,270	
- Land acquisition & compensation					
Land	ha	100	500,000	50	
House	nos	800	500,000	400	
Sub-total				450	
- Contingency	LS	-	-	4,140	
- Engineering & administration		-	-	2,440	
- Total				27,300	43,680

Table 4.10 Present Land Use in the Planned Polders

(Unit: ha)

Elevation (m)	Area					
	Irrigated	Rainfed	Sub-total	Swamp	Others	Total
Teteaji						
less than 7	-	-	-	-	-	-
7 - 8	214	-	214	-	1	215
8 - 9	552	-	552	-	21	573
9 - 10	943	-	943	-	10	953
Total	1,709	-	1,709	-	32	1,741
Belawa						
less than 7	-	346	346	503	34	883
7 - 8	-	1,308	1,308	1,250	413	2,971
8 - 9	-	1,471	1,471	63	688	2,222
9 - 10	-	134	134	13	466	613
Total	-	3,259	3,259	1,829	1,601	6,689
Wele						
less than 7	-	-	-	-	-	-
7 - 8	-	42	42	128	103	273
8 - 9	-	306	306	66	27	399
9 - 10	-	396	396	16	8	420
Total	-	744	744	210	138	1,092
Ugi						
less than 7	-	11	11	-	3	14
7 - 8	44	530	574	-	53	627
8 - 9	64	769	833	-	537	1,370
9 - 10	29	480	509	-	382	891
Total	137	1,790	1,927	-	975	2,902
Total						
less than 7	-	357	357	503	37	897
7 - 8	258	1,880	2,138	1,378	570	4,086
8 - 9	616	2,546	3,162	129	1,273	4,564
9 - 10	972	1,010	1,982	29	866	2,877
Total	1,846	5,793	7,639	2,039	2,746	12,424

Table 4.11 Possible Area for Paddy in the Planned Polder

(Unit: ha)

Item	Elevation			
	7.7m - 8m	8m - 9m	9m - 10m	Total
- Paddy area at present				
irrigated	77	616	972	1,665
rainfed	564	2,546	1,010	4,120
- Potential paddy area (swamp area at present)				
rainfed	441	129	-	570
- Total paddy area	1,082	3,291	1,982	6,355

Table 4.12 Benefit - Cost Ratio for Planned Polder

(Design Flood: 20yr)

Item	Amount
	(10^6Rp)
Average Annual Benefit	464
Construction Cost	
- Dredging of Cenranae river	3,300
- Construction of barrage	1,870
- Embankment of levee (including drainage facility)	
Teteaji polder	990
Belawa polder	3,360
Wele polder	650
Ugi polder	1,520
- Sub-total	11,690
- O/M cost (25% of above)	2,923
- Total	14,613
Annual Cost	
discount rate 8%	1,223
10%	1,508
12%	1,801
B/C Ratio	
discount rate 8%	0.38
10%	0.31
12%	0.26

Table 4.13 B/C Ratio for Flood Control Method of Separation of L.Sidenreng from L.Tempe

Item		Amount (10^6Rp)
Annual Average Benefit		156
Construction Cost		
- Civil works		
Embankment of levee		376
Construction of barrage		1,000
Others		184
Sub-total		1,560
- Land acquisition		5
- Contingency		315
- Engineering & administration		190
- Total		2,070
- O/M cost (25% of above)		518
- Total construction cost		2,588
Annual Cost		
discount rate	8%	216
	10%	261
	12%	312
B/C Ratio		
discount rate	8%	0.72
	10%	0.62
	12%	0.50

Remarks: Average annual benefit is assumed at Rp.73,000/ha using the value of the proposed polder.

Table 4.14 Cost Comparison of Improvement Plan of Bila River

Item	Unit	Improvement Method: Present Channel Improvement	Improvement Method: Flood Way
Construction Quantities			
- Embankment	10^3m^3	942	984
- Excavation	10^3m^3	4,585	3,438
- Land acquisition	ha	370	260
- House compensation	nos	420	100
Construction Cost			
- Civil works			
Preparation	10^6Rp	610	510
Embankment	10^6Rp	754	788
Excavation	10^6Rp	6,311	4,706
Others	10^6Rp	975	1,136
Sub-total	10^6Rp	8,650	7,140
- Land Acquisition & Compensation			
Land acquisition	10^6Rp	185	130
House compensation	10^6Rp	210	50
Sub-total	10^6Rp	395	180
- Contingency (20%)	10^6Rp	1,805	1,480
- Eng. & administration	10^6Rp	1,050	900
- Total cost	10^6Rp	11,900	9,700

Table 4.15 Benefit - Cost Ratio for Improvement of the Leceleceng River

(Design Scale: 5-yr Flood)

Item	Unit	Q'ty	Unit Price (Rp)	Amount (10^6Rp)
Construction Cost				
- Civil works				
Preparation	LS			720
Excavation	10^3m^3	7,300	1,200	8,760
Bridge	nos	2		120
Miscellaneous	LS			500
Sub-total				10,100
- Land acquisition	ha	90	500,000	45
- Contingency	LS			2,045
- Eng. & administration				1,210
- Total				13,400
- O/M cost (25% of Total cost)				3,350
Total Cost				16,750
Annual Cost				
discount rate 8%	10^6Rp			1,369
10%	10^6Rp			1,689
12%	10^6Rp			2,017
Annual Average Benefit	10^6Rp			204
B/C Ratio				
discount rate 8%				0.15
10%				0.12
12%				0.10

Table 4.16 Unit Cost for Civil Works and Land Acquisition

Item	Unit	Cost (Rp)
1. Dredging		
a. Amp. excavator & Back hoe (to Emb. by Dump T - 3 km)	m^3	1,700
b. Dredger (1,000 Ps)	m^3	1,600
c. Dredger (2,000 Ps)	m^3	950
2. Excavation		
a. Bulldozer (S) 13 t & Back hoe (to Emb. by Dump T - 50 m)	m^3	800
b. Bulldozer (S) 13 t & Back hoe (to Emb. by Dump T - 1 km)	m^3	1,200
c. Bulldozer (S) 13 t & Back hoe (to Emb. by Dump T - 3 km)	m^3	1,600
3. Embankment		
Com. by vib. roller, vib. tumper, Bulldozer 13 t and sodding	m^3	800
4. Bank Protection	m	50,000
5. Bridge (B = 5)	m	1,000,000
6. Ground - sill		
(for river bed protection, h = 3m)	m	3,000,000
7. Land Acquisition and Compensation		
- Land acquisition	ha	500,000
- House compensation	house	500,000

Remarks:

a, b, c	:	type of work
Amp.excavator	:	Amphibious excavator
Emb.	:	embankment or reclamation
Dump T - 3 km	:	Dump truck, distance 3 km
Bulldozer (S)	:	Bulldozer swamp
vib. roller	:	vibration roller
vib. tumper	:	vibration tumper

Table 4.17 Wages of Laborers and Units Prices of Construction Materials, Fuel and Oil at the 1979 Price

Item	Unit	Wage or Price (Rp)
1. Wages of Laborer		
- Forman	day	650
- Skill laborer	day	1,000
- Semi skill laborer	day	850
- Common laborer	day	500
- Operator	day	2,500
- Mechanic	day	2,500
- Driver	day	2,500
- Carpenter	day	800
2. Prices of Construction Materials		
- Cement	ton	40,000
- Steel bar, ø 9 - 25	ton	107,500
- Iron wire, ø 18	ton	500,000
- Log, ø 90.1 = 5 m	m^3	85,000
- Square timber, 1st class	m^3	75,000
- Boad, 1st class 150 mm x 10 mm x 4 m	m^3	100,000
3. Prices of Fuel and Oil		
- Petrol (Gasoline)	l	70
- Engine oil	l	650
- Light oil	l	25
- Grease	kg	750
- Gear oil	l	750

Table 4.18 Construction Cost for Improvement of Bila River

Design Discharge: 1,900 m^3/s
Probability : 1/20

Item	Unit	Q'ty	Unit Price (Rp)	Amount 10^6Rp	Amount 10^3US$
Main Civil Works					
- Preparation	LS	-	-	641	
- Embankment					
Mainstream					
0.0 k - 13.2 k	10^3m^3	421	800	337	
13.2 k -	10^3m^3	180	800	144	
Flood way	10^3m^3	327	800	262	
R.Boya	10^3m^3	56	800	45	
R.Lancirang	10^3m^3	225	800	180	
R.Kalola	10^3m^3	162	800	130	
Sub-total	10^3m^3	1,371		1,098	
- Excavation					
Mainstream					
-9.0 k - 0.0 k	10^3m^3	768	1,700	1,306	
0.0 k - 13.2 k	10^3m^3	421	800	337	
13.2 k -	10^3m^3	180	800	144	
13.2 k -	10^3m^3	160	1,600	256	
Flood way	10^3m^3	327	800	262	
Flood way	10^3m^3	1,312	1,600	2,099	
R.Boya	10^3m^3	56	800	45	
R.Boya	10^3m^3	214	1,200	257	
R.Lancirang	10^3m^3	225	800	180	
R.Lancirang	10^3m^3	620	1,600	992	
R.Kalola	10^3m^3	162	800	130	
R.Kalola	10^3m^3	227	1,600	363	
Sub-total	10^3m^3	4,672		6,371	
- Bank Protection	m	800	50,000	40	
- Outlet Structures	LS	-	-	150	
- Bridge	nos	2		120	
- Ground Sill	place	2		255	
- Miscellaneous	LS	-	-	445	
- Sub-total				9,120	14,592
Acquisition & Compensation					
- Land Acquisition	ha	260	500,000	130	
- House Compensation	nos	100	500,000	50	
- Sub-total				180	288
Contingency (20% of above)				1,860	2,976
Engineering & Administration (10% of above)				1,140	1,824
Total				12,300	19,680

Table 4.19 Construction Cost for Improvement of Walanae River

Case : Without Dam
Design Discharge: 2,900 m^3/s
Probability : 1/20

Item	Unit	Q'ty	Unit Price (Rp)	Amount 10^6Rp	Amount 10^3US$
Main Civil Works					
- Preparation	LS			1,030	
- Embankment					
Mainstream					
9.2 k - 30.0 k	10^3m^3	2,530	800	2,024	
R.Belo (including R.Lawo)	10^3m^3	490	800	392	
Sub-total	10^3m^3	3,020		2,416	
- Excavation					
Mainstream					
0.0 k - 9.2 k	10^3m^3	2,050	1,600	3,280	
9.2 k - 30.0 k	10^3m^3	2,100	1,600	3,360	
9.2 k - 30.0 k	10^3m^3	2,530	800	2,024	
R.Belo (including R.Lawo)	10^3m^3	490	800	392	
R.Belo	10^3m^3	455	1,600	728	
Sub-total	10^3m^3	7,630		9,792	
- Bank Protection	m	1,400	50,000	70	
- Outlet Structures	LS			500	
- Bridge	nos	1		90	
- Ground Sill	place	2		240	
- Miscellaneous	LS			452	
- Sub-Total				14,590	23,344
Acquisition & Compensation					
- Land Acquisition	ha	390	500,000	195	
- House Compensation	nos	330	500,000	165	
- Sub-Total				360	576
Contingency (20% of above)				3,000	4,800
Engineering & Administration (10% of above)				1,850	2,960
Total				19,800	31,680

Table 4.20 Construction Cost for Improvement of Walanae River

Case : With Mong Dam
Design Discharge: 2,600 m^3/s
Probability : 1/20

Item	Unit	Q'ty	Unit Price (Rp)	Amount 10^6Rp	Amount 10^3US$
Main Civil Works					
- Preparation	LS			970	
- Embankment					
Mainstream					
9.2 k - 30.0 k	10^3m^3	2,240	800	1,792	
R.Belo & R.Lawo	10^3m^3	490	800	392	
Sub-total	10^3m^3	2,730		2,184	
- Excavation					
Mainstream					
0.0 k - 9.2 k	10^3m^3	1,850	1,600	2,960	
9.2 k - 30.0 k	10^3m^3	1,990	1,600	3,184	
9.2 k - 30.0 k	10^3m^3	2,240	800	1,792	
R.Belo & R.Lawo	10^3m^3	460	1,600	738	
R.Belo & R.Lawo	10^3m^3	490	800	392	
Sub-total	10^3m^3	7,030		9,064	
- Bank Protection	m	1,400	50,000	70	
- Outlet Structures	LS			500	
- Bridge	nos	1		90	
- Ground Sill	place	2		240	
- Miscellaneous	LS			602	
- Sub-Total				13,720	21,952
Acquisition & Conpensation					
- Land Acquisition	ha	380	500,000	190	
- House Compensation	nos	320	500,000	160	
- Sub-Total				350	560
Contingency (20% of above)				2,830	4,528
Engineering & Administration (10% of above)				1,700	2,720
Total				16,800	29,760

Table 4.21 Construction Cost for Improvement of Walanae River

Case : With Walimpong Dam
Design Discharge: 1,800 m^3/s
Probability : 1/20

Item	Unit	Q'ty	Unit Price (Rp)	Amount 10^6Rp	Amount 10^3US$
Main Civil Works					
- Preparation	Ls			720	
- Embankment					
Mainstream 9.2 k - 30.0 k	10^3m^3	1,360	800	1,088	
R.Belo & R.Lawo	10^3m^3	490	800	392	
Sub-total	10^3m^3	1,850		1,480	
- Excavation					
Mainstream 0.0 k - 9.2 k	10^3m^3	1,550	1,600	2,480	
9.2 k - 30.0 k	10^3m^3	1,270	1,600	2,032	
9.2 k - 30.0 k	10^3m^3	1,360	800	1,088	
R.Belo & R.Lawo	10^3m^3	460	1,600	736	
R.Belo & R.Lawo	10^3m^3	490	800	392	
Sub-total	10^3m^3	5,130		6,728	
- Bank Protection	m	1,200	50,000	60	
- Outlet Structures	Ls			500	
- Bridge	nos	1		90	
- Ground Sill	place	2		240	
- Miscellaneous	Ls			362	
- Sub-Total				10,180	16,288
Acquisition & Compensation					
- Land Acquisition	ha	340	500,000	170	
- House Compensation	nos	300	500,000	150	
- Sub-Total				320	512
Contingency (20% of above)				2,080	3,328
Engineering & Administration (10% of above)				1,220	1,952
Total				13,800	22,080

Table 4.22 Construction Cost for Improvement of Cenranae River

Design Discharge: 850 m^3/s
Probability : 1/20

Item	Unit	Q'ty	Unit Price (Rp)	Amount 10^6Rp	Amount 10^3US$
Improvement of Mainstream Channel					
- Civil works					
Preparation	Ls	-	-	414	
Embankment	10^3m^3	1,250	800	1,000	
Excavation	10^3m^3	1,250	800	1,000	
Dredging	10^3m^3	2,000	1,600	3,200	
Miscellaneous	Ls	-	-	286	
Sub-total				5,900	9,440
- Land acquisition & compensation					
Land	ha	140	500,000	70	
House	nos	160	500,000	80	
Sub-total				150	240
- Contingency (20%)	Ls			1,210	1,936
- Engineering service & administration (10%)	Ls			740	1,184
- Total				8,000	12,800
Construction of Tempe Barrage					
- Civil works					
Preparation	Ls			80	
Excavation	10^3m^3	182	1,200	219	
Banking	10^3m^3	30	800	24	
R.C pile	nos	750	210,000	158	
Sheet pile	ton	120	220,000	27	
Bank protection	m^2	2,000	22,000	44	
Concrete	m^3	4,600	100,000	460	
Gate	ton	90	3,920,000	353	
Miscellaneous	Ls			50	
Sub-total				1,415	2,264
- Land acquisition	ha	4	500,000	2	3
- Contingency (20%)	Ls			283	453
- Engineering service & administration	Ls			170	272
- Total				1,870	2,992
Grand Total				9,870	15,792

Table 4.23 (1) Construction Quantity and Costs for Flood Control Works

Item	Quantity	Cost (US$1,000)
1. Improvement of Bila River		
- Main Civil Works		14,592
Embankment (L = 72 km)	1,371,000 m^3	
Excavation	4,672,000 m^3	
- Acquisition & Compensation		288
Land	260 ha	
House	100 houses	
- Contingency		2,976
- Engineering & Administration		1,824
- Total		19,680
2. Improvement of Walanae River		
Without Dam		
- Main Civil Works		23,344
Embankment (L = 84 km)	3,020,000 m^3	
Excavation	7,630,000 m^3	
- Acquisition & Compensation		576
Land	390 ha	
House	330 houses	
- Contingency		4,800
- Engineering & Administration		2,960
- Total		31,680
With Mong Dam		
- Main Civil Works		21,952
Embankment (L = 84 km)	2,730,000 m^3	
Excavation	7,030,000 m^3	
- Acquisition & Compensation		560
Land	380 ha	
House	320 houses	
- Contingency		4,528
- Engineering & Administration		2,720
- Total		29,760

Table 4.23 (2) Construction Quantity and Costs for Flood Control Works

Item	Quantity	Cost (US$1,000)
With Walimpong Dam (V = 100 million m^3)		
- Main Civil Works		19,768
Embankment (L = 82 km)	2,410,000 m^3	
Excavation	6,270,000 m^3	
- Acquisition & Compensation		536
Land	360 ha	
House	310 houses	
- Contingency		4,064
- Engineering & Administration		2,432
- Total		26,800
With Walimpong Dam (V = 200 million m^3)		
- Main Civil Works		16,288
Embankment (L = 80 km)	1,850,000 m^3	
Excavation	5,130,000 m^3	
- Acquisition & Compensation		512
Land	340 ha	
House	300 houses	
- Contingency		3,328
- Engineering & Administration		1,952
- Total		22,080
With Walimpong Dam (V = 300 million m^3)		
- Main Civil Works		15,696
Embankment (L = 78 km)	1,790,000 m^3	
Excavation	4,120,000 m^3	
- Acquisition & Compensation		512
Land	340 ha	
House	300 houses	
- Contingency		3,248
- Engineering & Administration		1,944
- Total		21,400

Table 4.23 (3) Construction Quantity and Costs for Flood Control Works

Item	Quantity	Cost (US$1,000)
3. Improvement of Cenranae River		
- Main Civil Works		11,704
Embankment (L = 37 km)	1,250,000 m^3	
Excavation	1,250,000 m^3	
Dredging	2,000,000 m^3	
Barrage (11 m x 3 gates)	1 site	
- Acquisition & Compensation		243
Land	144 ha	
House	160 houses	
- Contingency		2,389
- Engineering & Administration		1,456
- Total		15,792

Table 5.1 Summarized Construction Cost, Operation & Maintenance Cost and Benefit for Proposed Flood Control Plans

(Unit: US$1,000)

Plan	Const. Cost for River Improvement	Annual O/M Cost	Annual Benefit Existing Condition	Annual Benefit Proposed /1 Condition
1. Bila River Improvement Plan	19,680	89	2,397	2,987
2. Walanae River Flood Control Plan				
- Without Dam	31,680	144	2,557	-
- With Mong Dam	29,760	134	-	3,856
- With Walimpong Dam (V = 100 million m^3)	26,800	121	-	3,920
- With Walimpong Dam (V = 200 million m^3)	22,080	99	-	4,413
- With Walimpong Dam (V = 300 million m^3)	21,400	96	-	4,497
3. Cenranae River Improvement Plan	15,792	72	2,046	-

/1: Under the condition of the proposed irrigation project.

Table 5.2 Annual Allotment of Construction Cost for Flood Control Works

(Unit: US$1,000)

Works	1st-yr	2nd-yr	3rd-yr	4th-yr	5th-yr	Total
1. Improvement of R.Bila	984	1,968	5,904	5,904	4,920	19,680
2. Flood Control of R.Walanae (Channel Improvement)						
- Without Dam	1,584	3,168	9,504	9,504	7,920	31,680
- With Mong Dam	1,488	2,976	8,928	8,928	7,440	29,760
- With Walimpong Dam (V = 100 million m^3)	1,340	2,680	8,040	8,040	6,700	26,800
- With Walimpong Dam (V = 200 million m^3)	1,104	2,208	6,624	6,624	5,520	22,080
- With Walimpong Dam (V = 300 million m^3)	1,070	2,140	6,420	6,420	5,350	21,400
3. Improvement of R.Cenranae	789	1,579	4,738	4,738	3,948	15,792

Table 5.3 Construction Quantity and Cost for First-Phase Flood Control Plan

Item	Quantity	Cost (US$1,000)
1. Improvement of Bila River		
- Main Civil Works		12,576
Embankment (L = 72 km)	1,248,000 m^3	
Excavation	3,976,000 m^3	
- Aquisition & Compensation		192
Land	210 ha	
House	30 houses	
- Contingency		2,560
- Engineering & Administration		1,632
- Total		16,960

Table 5.4 Economic Cost and Benefit for First-Phase Flood Control Plan

(Unit: US$1,000)

Year	Construction Costs					O/M Cost	Benefits	
	Allocated Cost	Discount Rate 8%	10%	12%	15%		Existing Condition	Proposed/1 Condition
Bila River Improvement Plan								
1st yr	848	785	771	757	738			
2nd yr	1,696	1,453	1,401	1,352	1,282			
3rd yr	5,088	4,040	3,821	3,622	3,348			
4th yr	5,088	3,740	3,475	3,236	2,910			
5th yr	4,240	2,887	2,633	2,404	2,107			
6th yr						77	1,851	1,953
7th yr						77	1,851	2,207
8th yr						.	.	2,460
9th yr						.	.	2,562
10th yr						.	.	2,562
.						.	.	.
.						.	.	.
.						.	.	.
50th yr						77	1,851	2,562
Total	16,960	12,905	12,101	11,371	10,385	3,465	83,295	114,224
IRR							9.1	12.0

/1: Proposed condition of irrigation project

Fig. 2·1 River System of the Objective Area

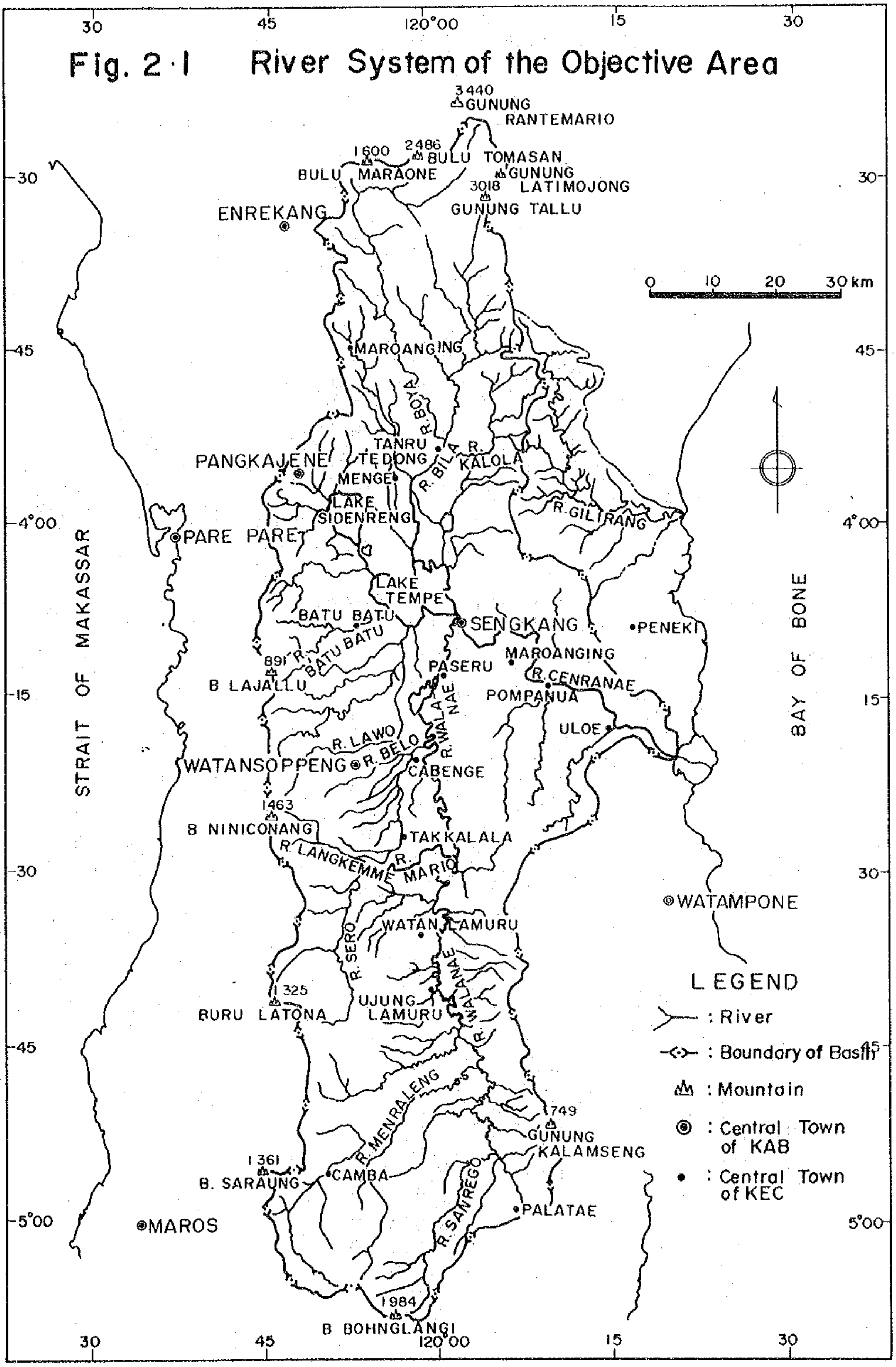

Fig. 2·2 Profiles of Rivers

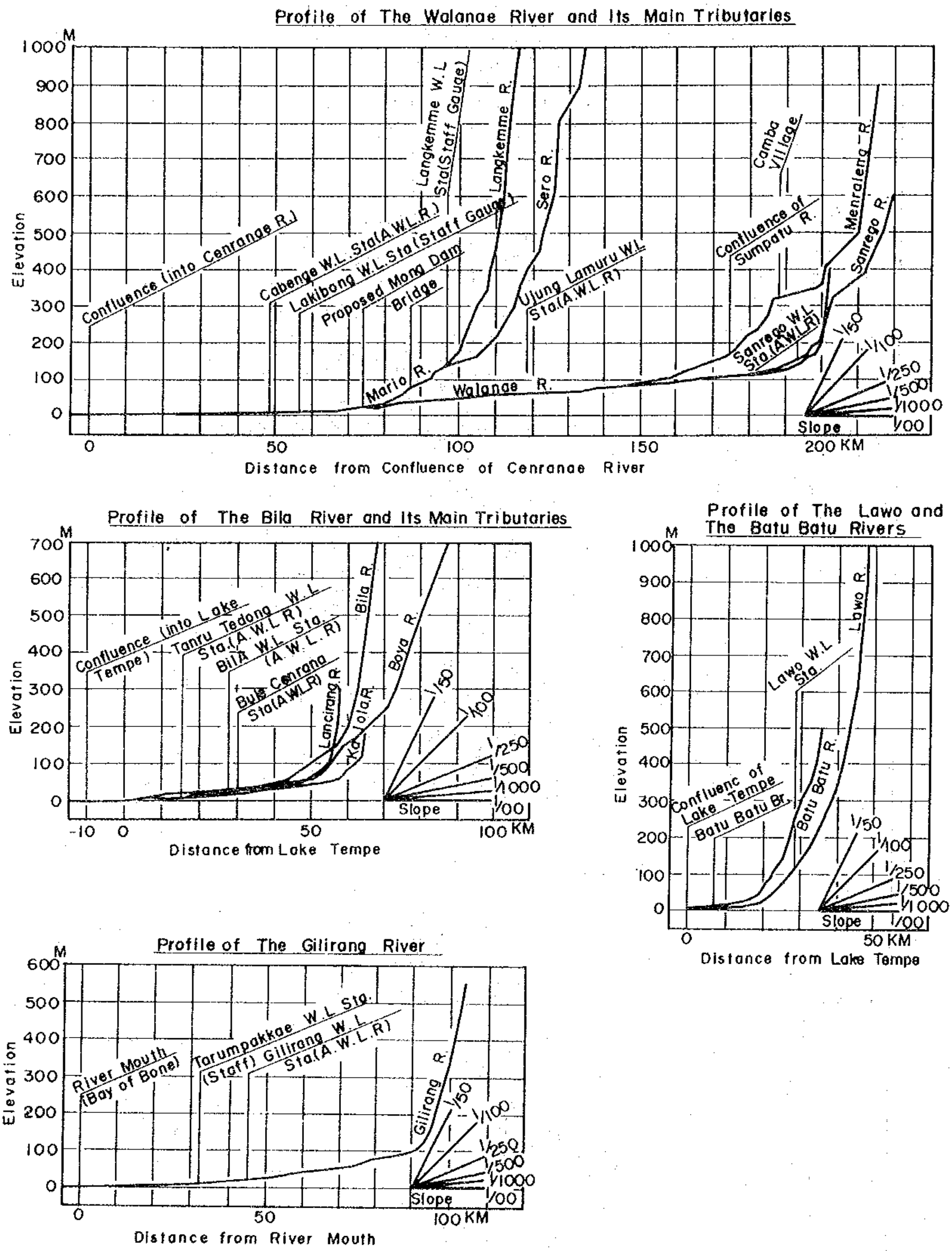

Fig. 2·3 River Mouth of Cenranae River

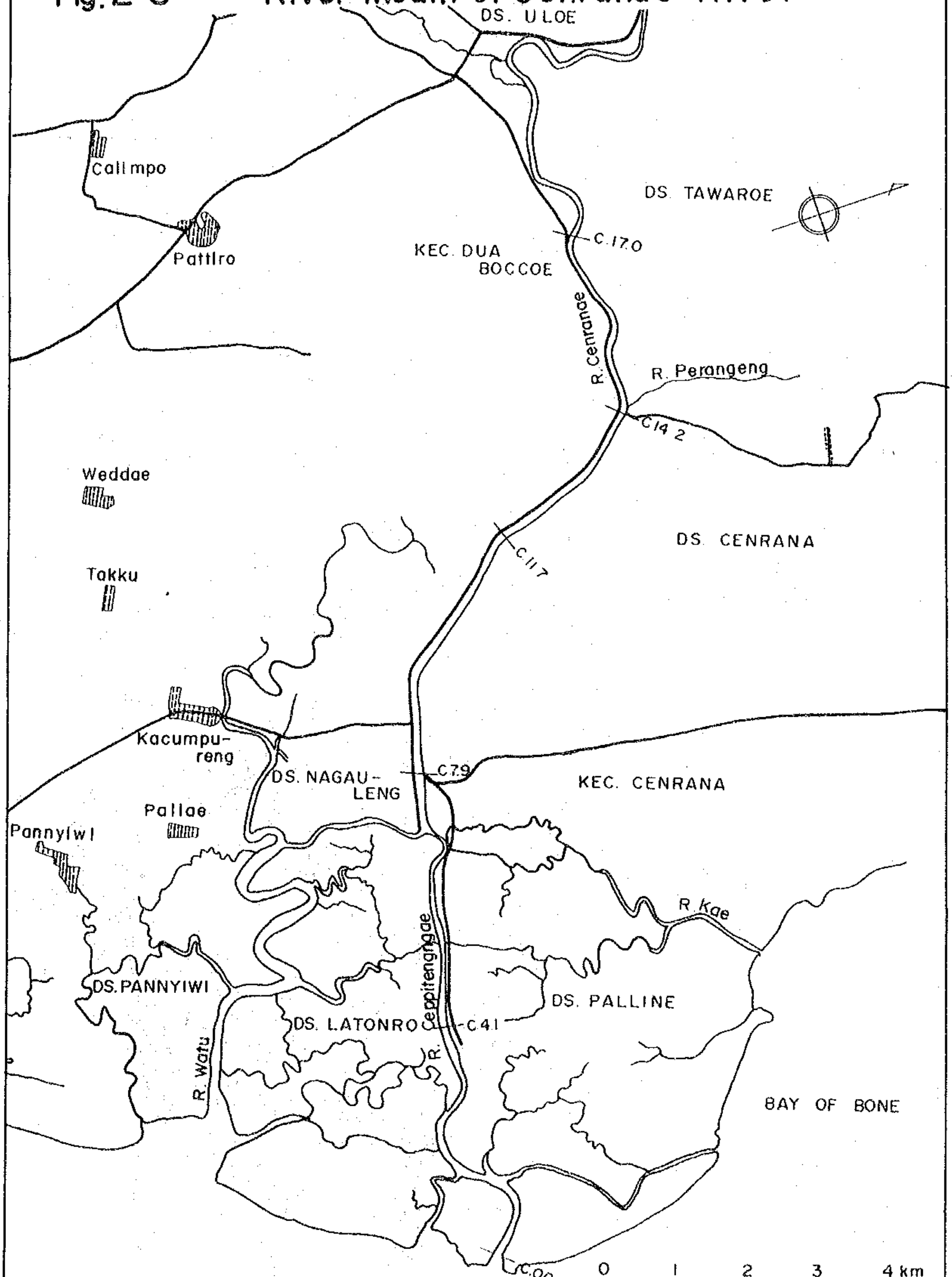

Fig. 2·4 Contour Map of Lake Tempe

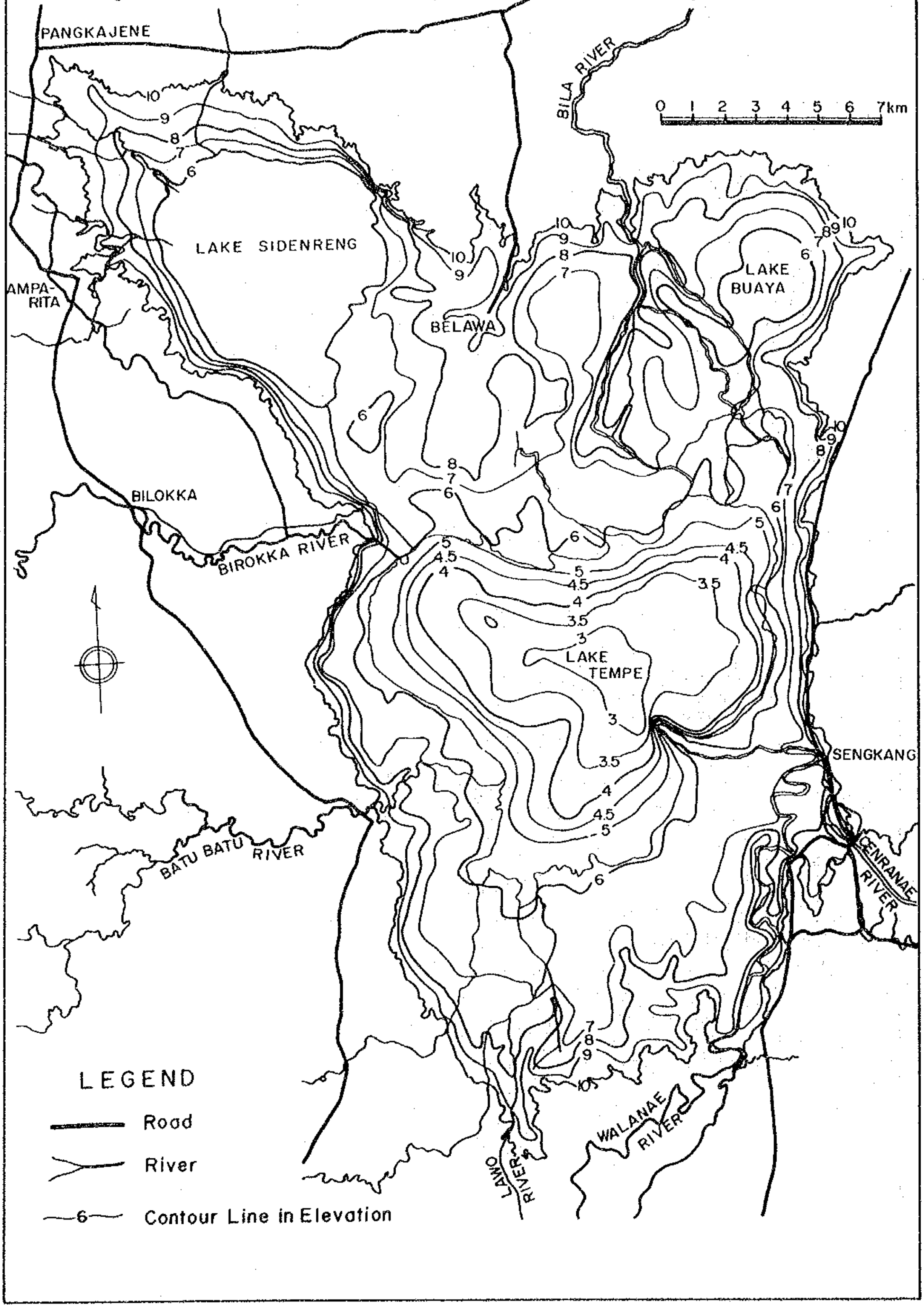

Fig 2·5 Surveyed River Cross-section Sites

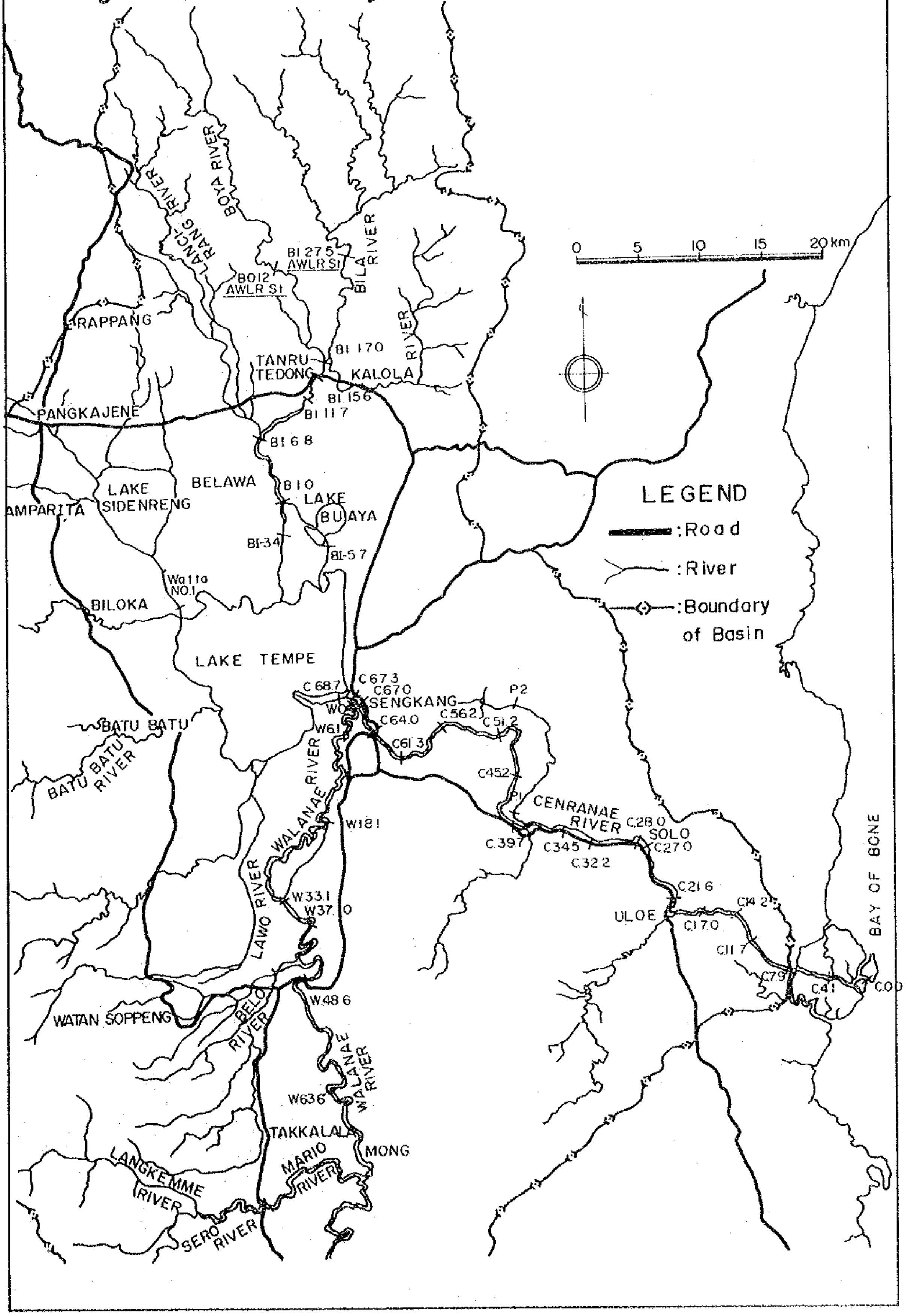

Fig. 2·6 (1) Cross-Section of Existing River Channel

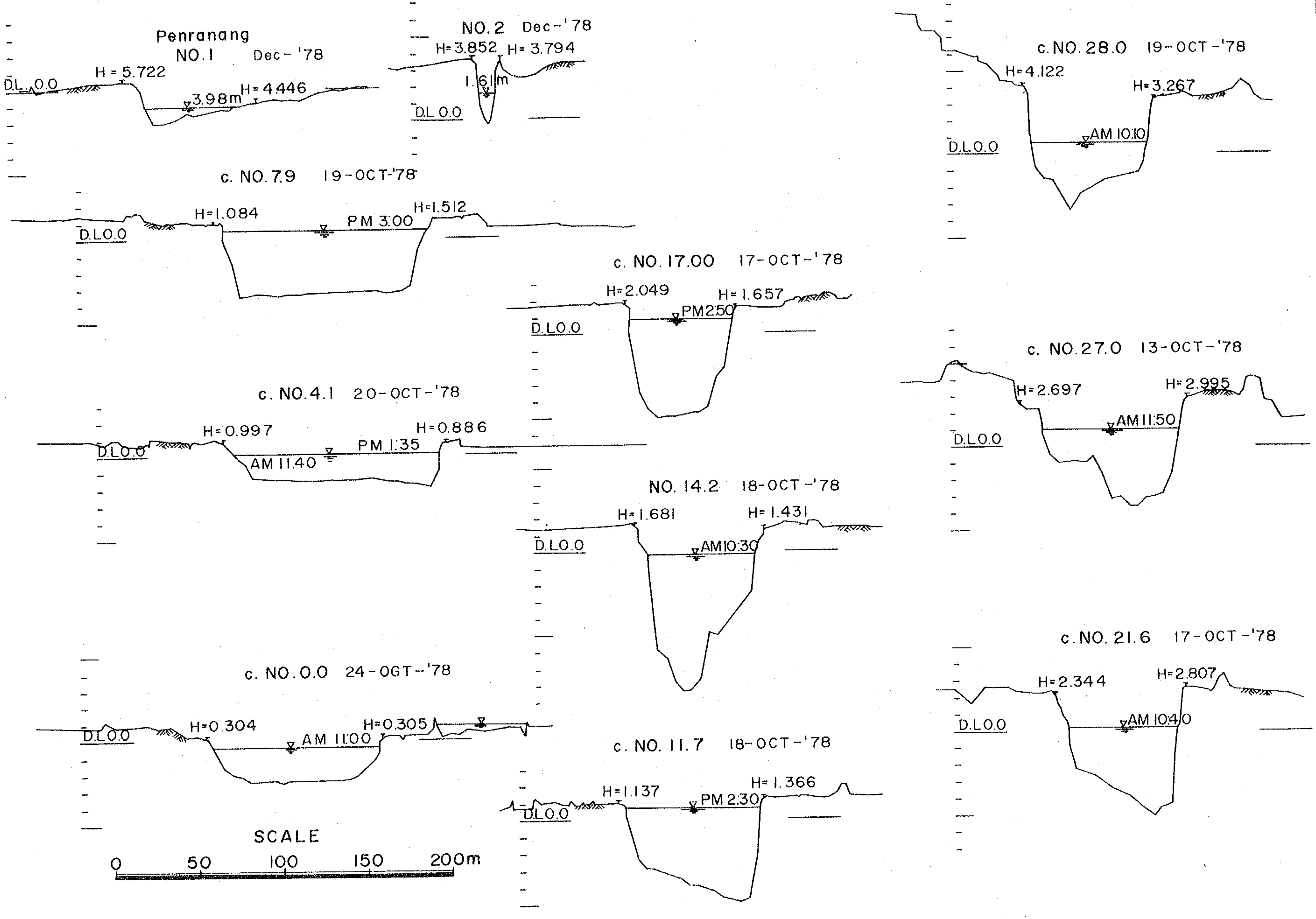

Fig. 2·6 (2) Cross-Section of Existing River Channel

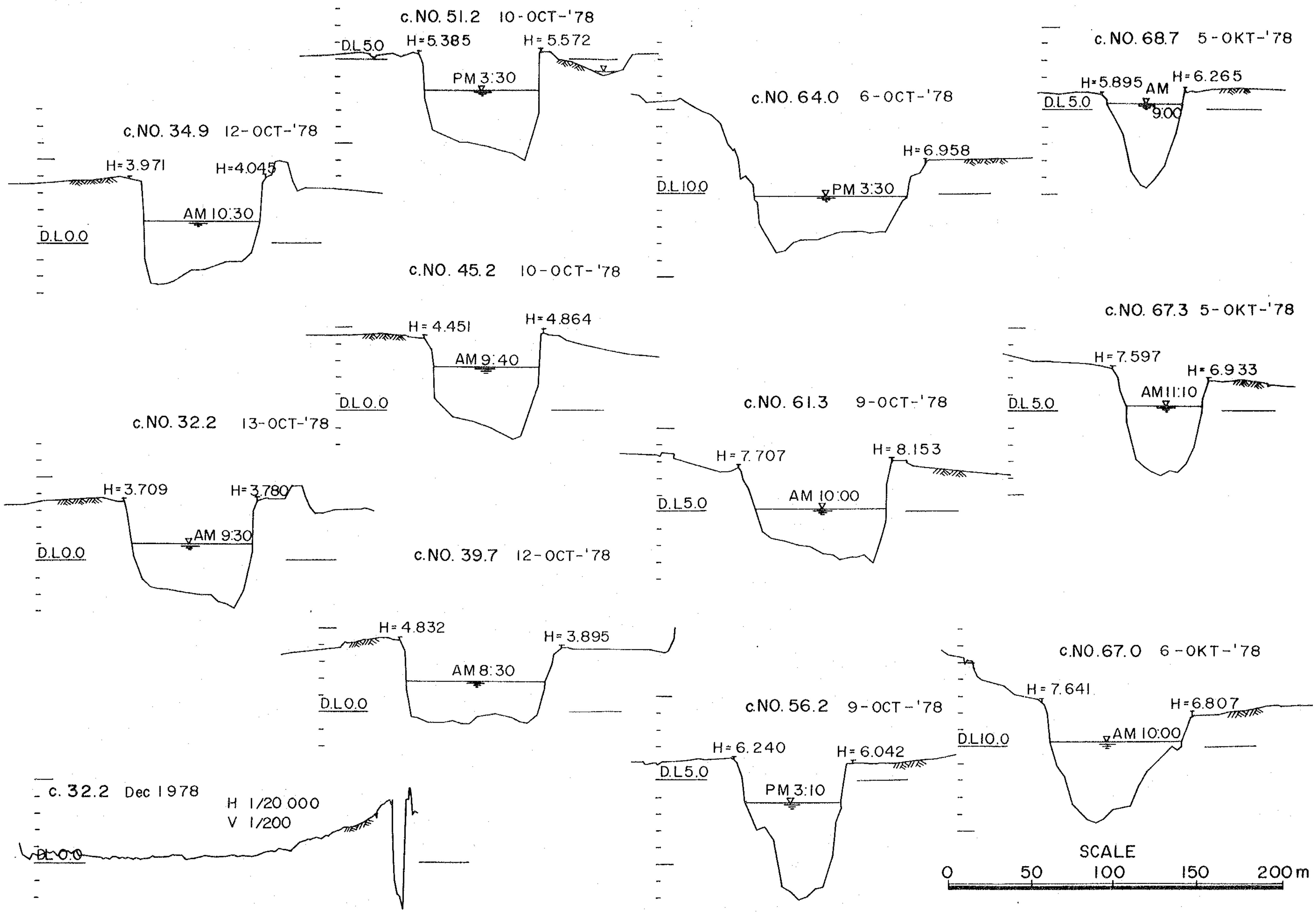

Fig. 2·6 (3) Cross-Section of Existing River Channel

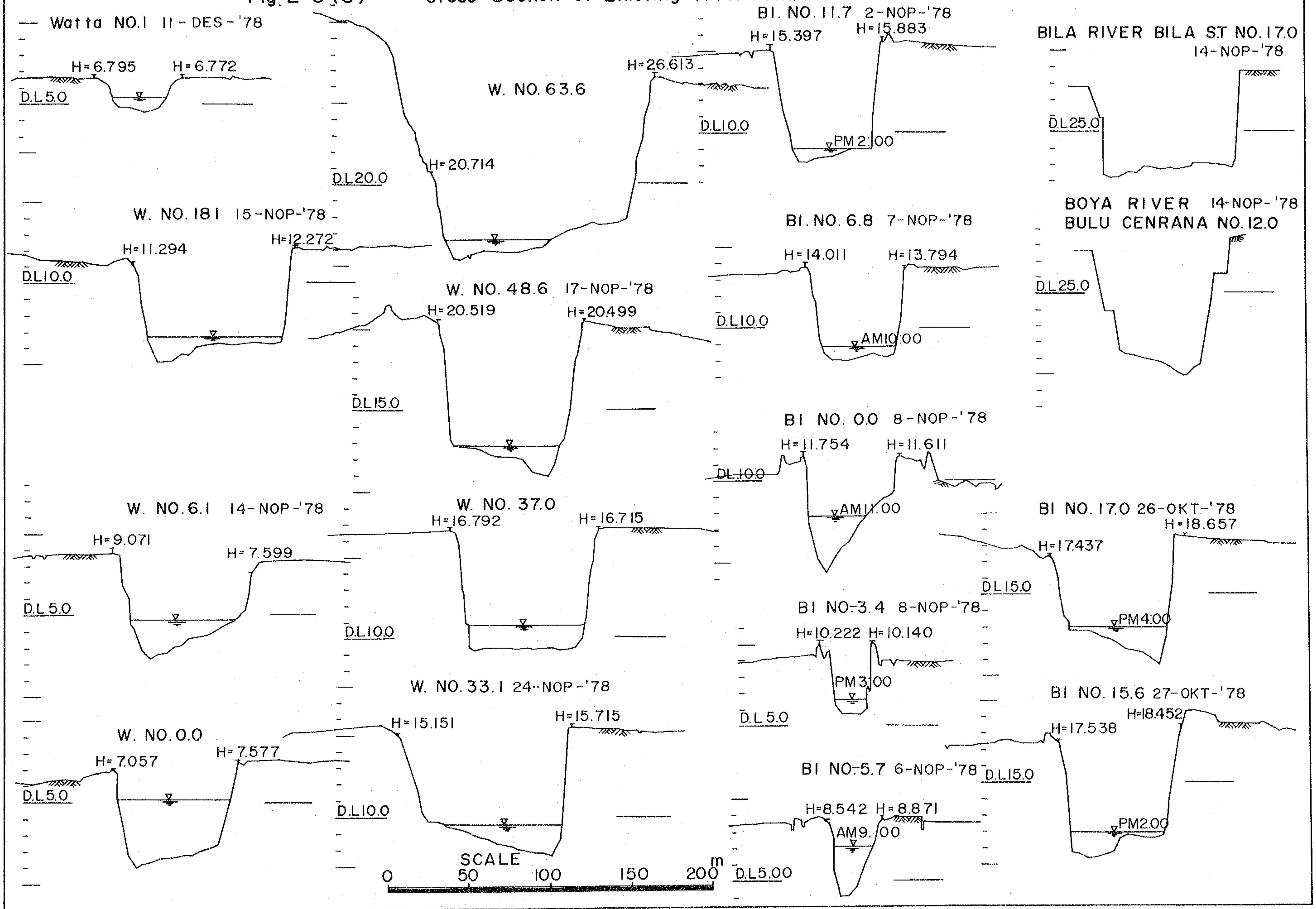

Fig 2·7 (1)　　Longitudinal Profile of the Existing River Channel

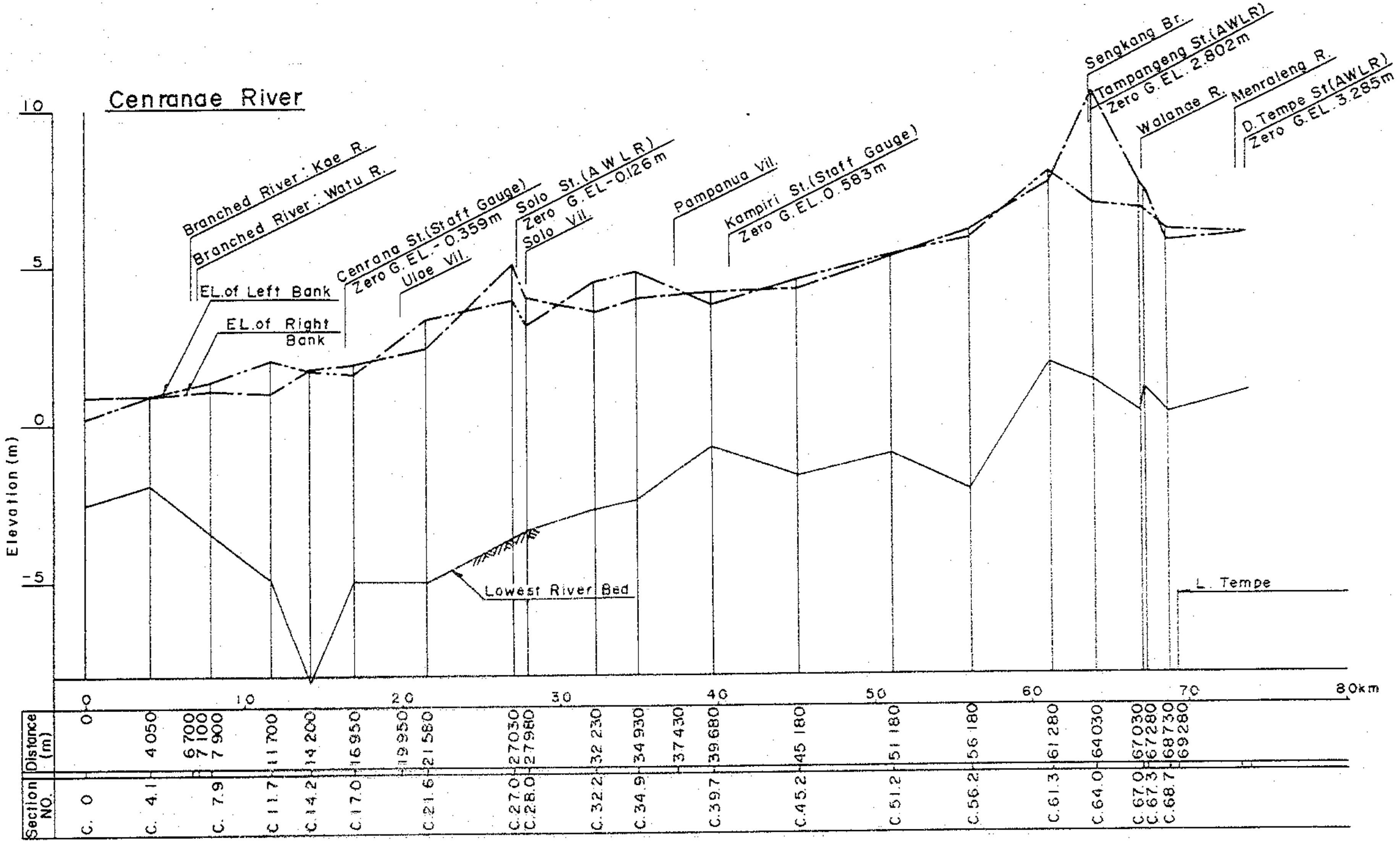

Fig 2·7(2) Longitudinal Profile of the Existing River Channel

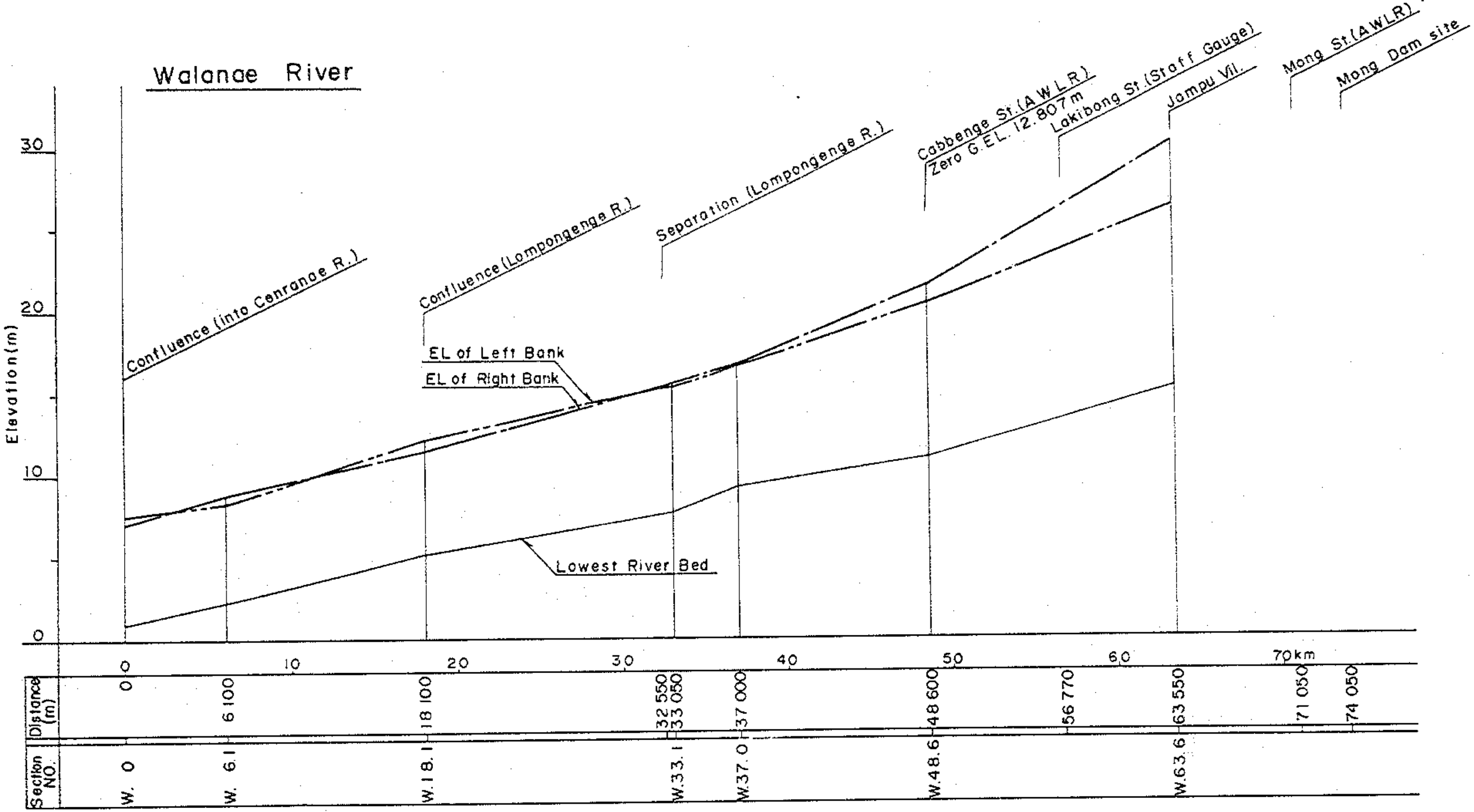

Fig 2·7 (3) Longitudinal Profile of the Existing River Channel

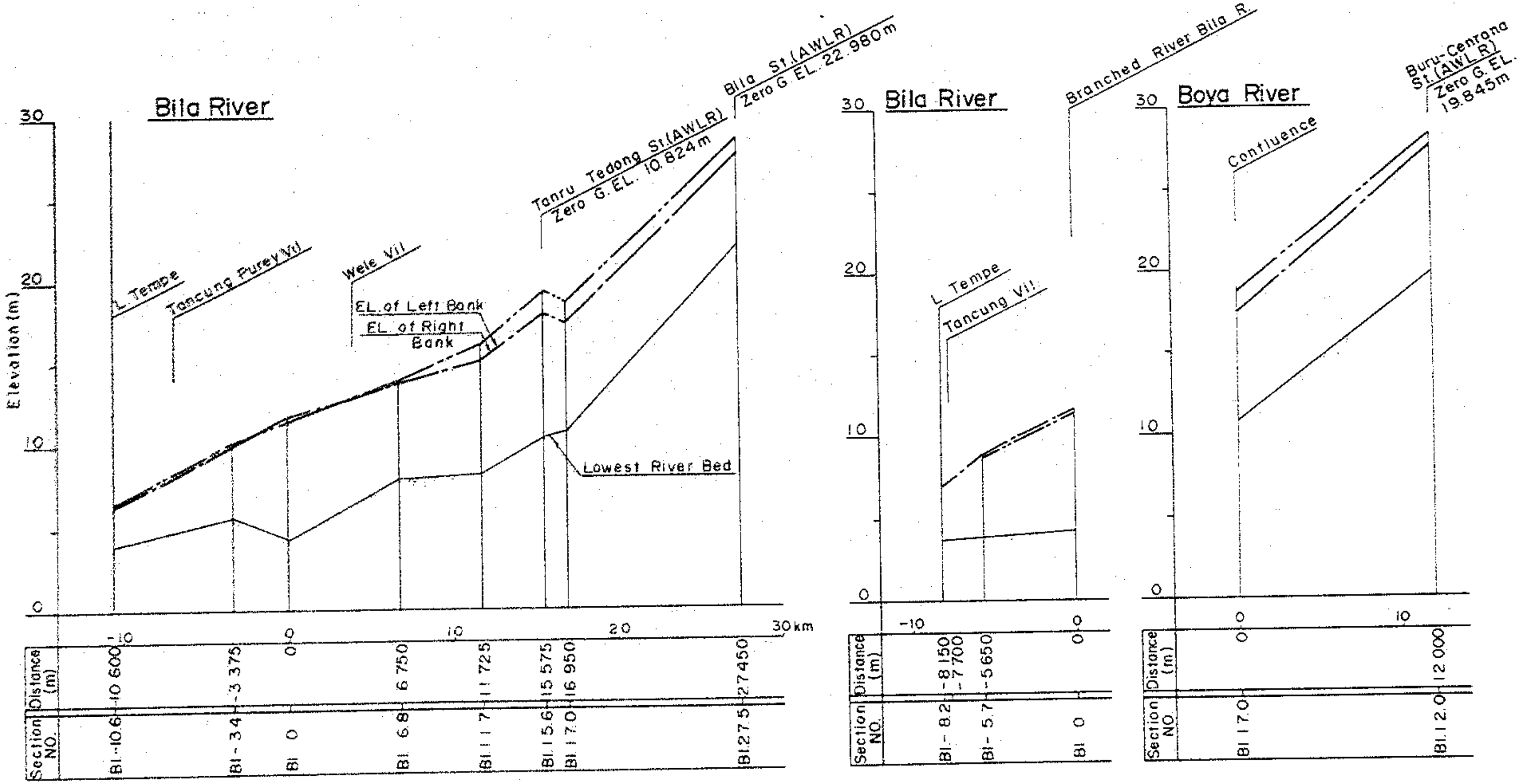

Fig. 2·8 Sampling Sites of River Bed Material

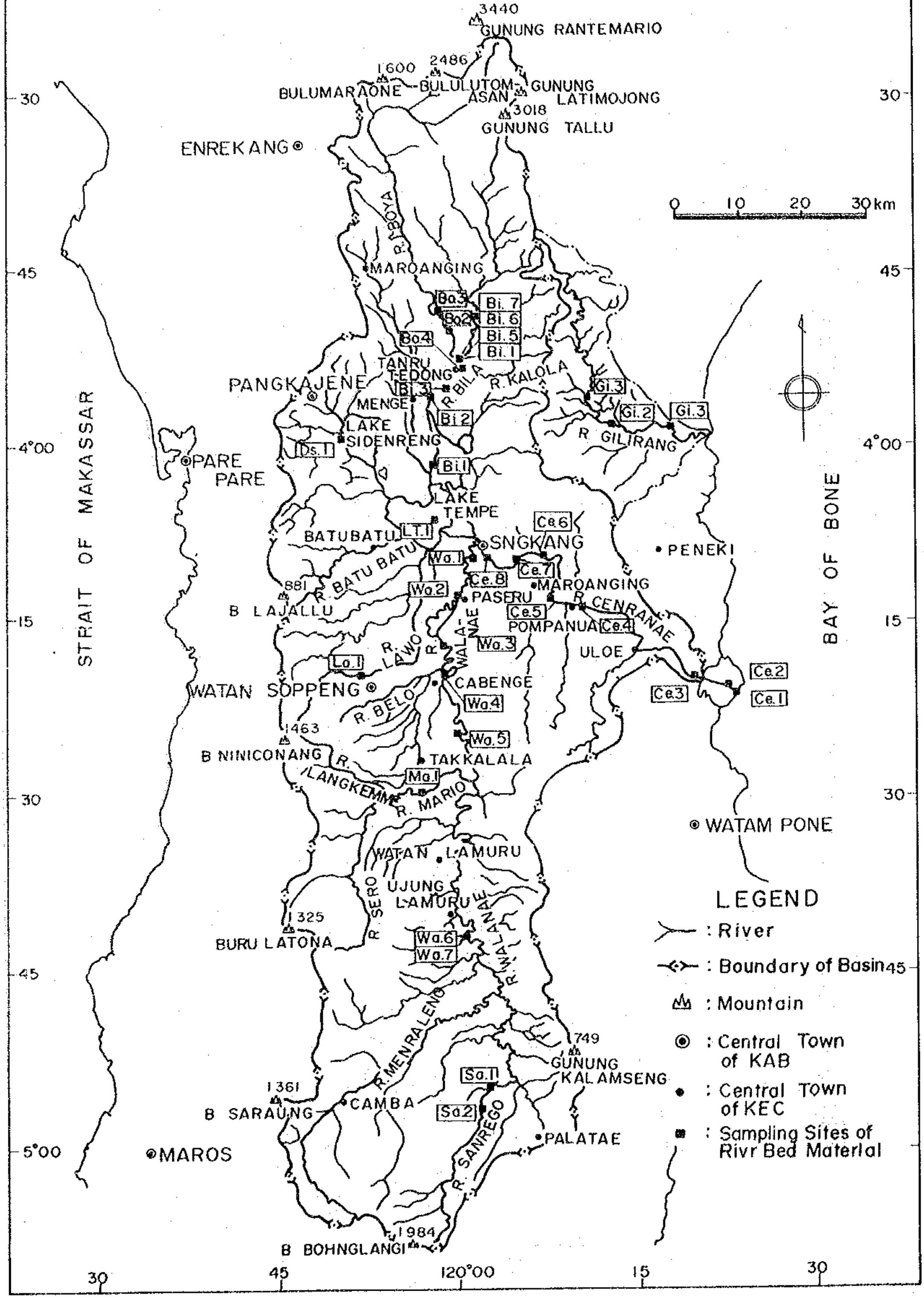

Fig. 2.9 Relationship between Sediment Discharge and Water Discharge

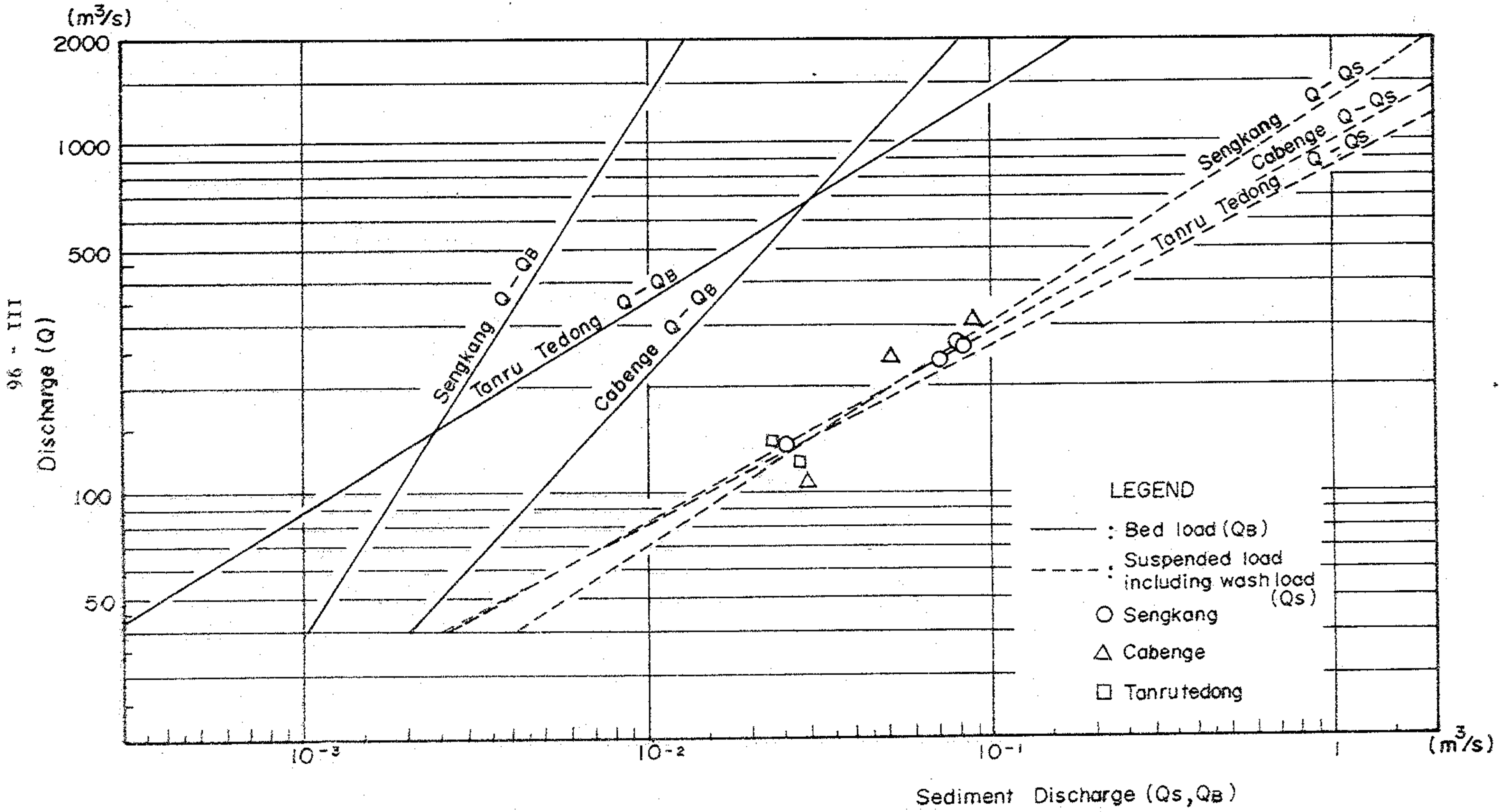

Fig. 2·10 Relation between Elevation and Water Surface Area or Storage Volume

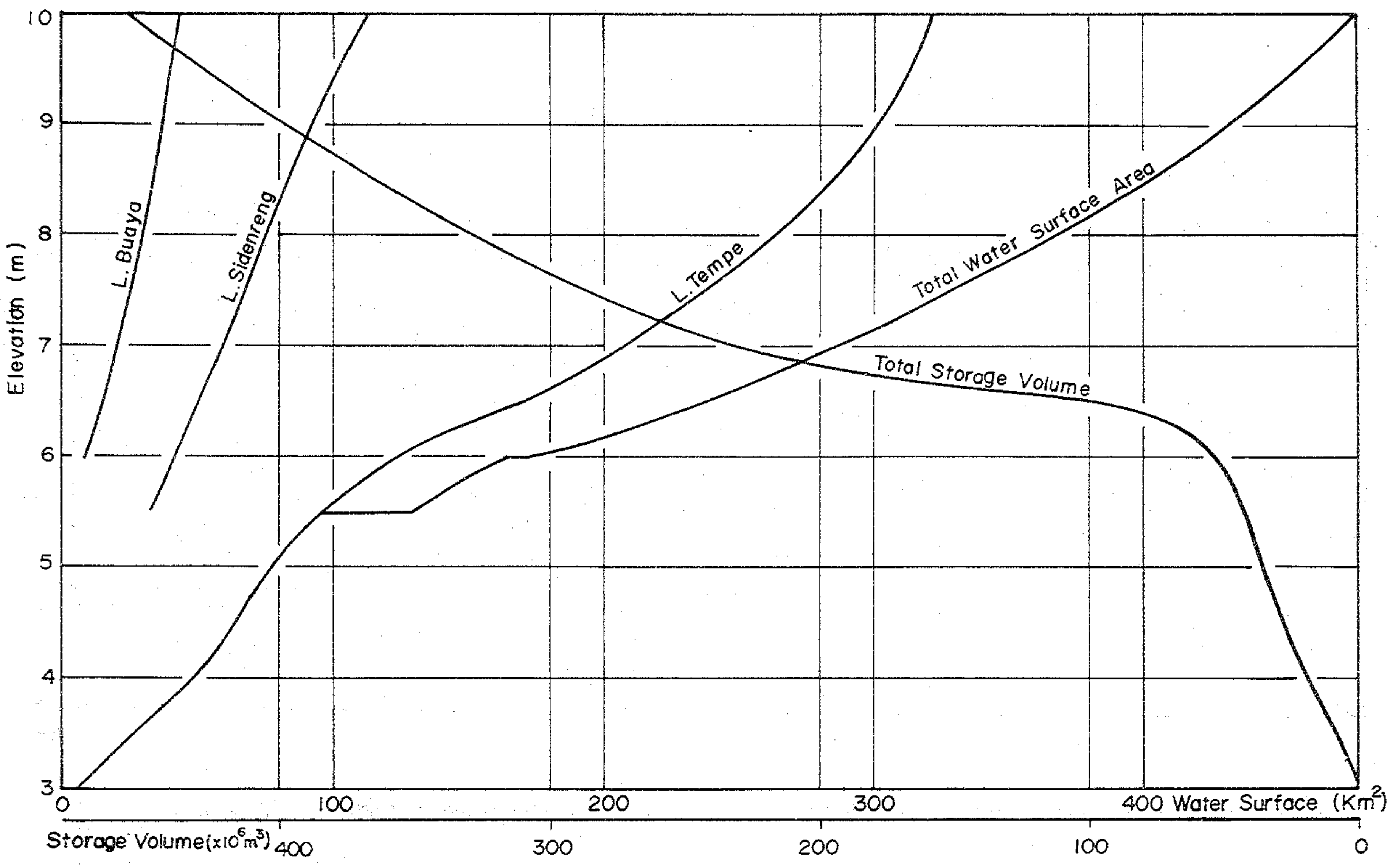

Fig 2.11 Water Level Hydrograph of Lake Tempe

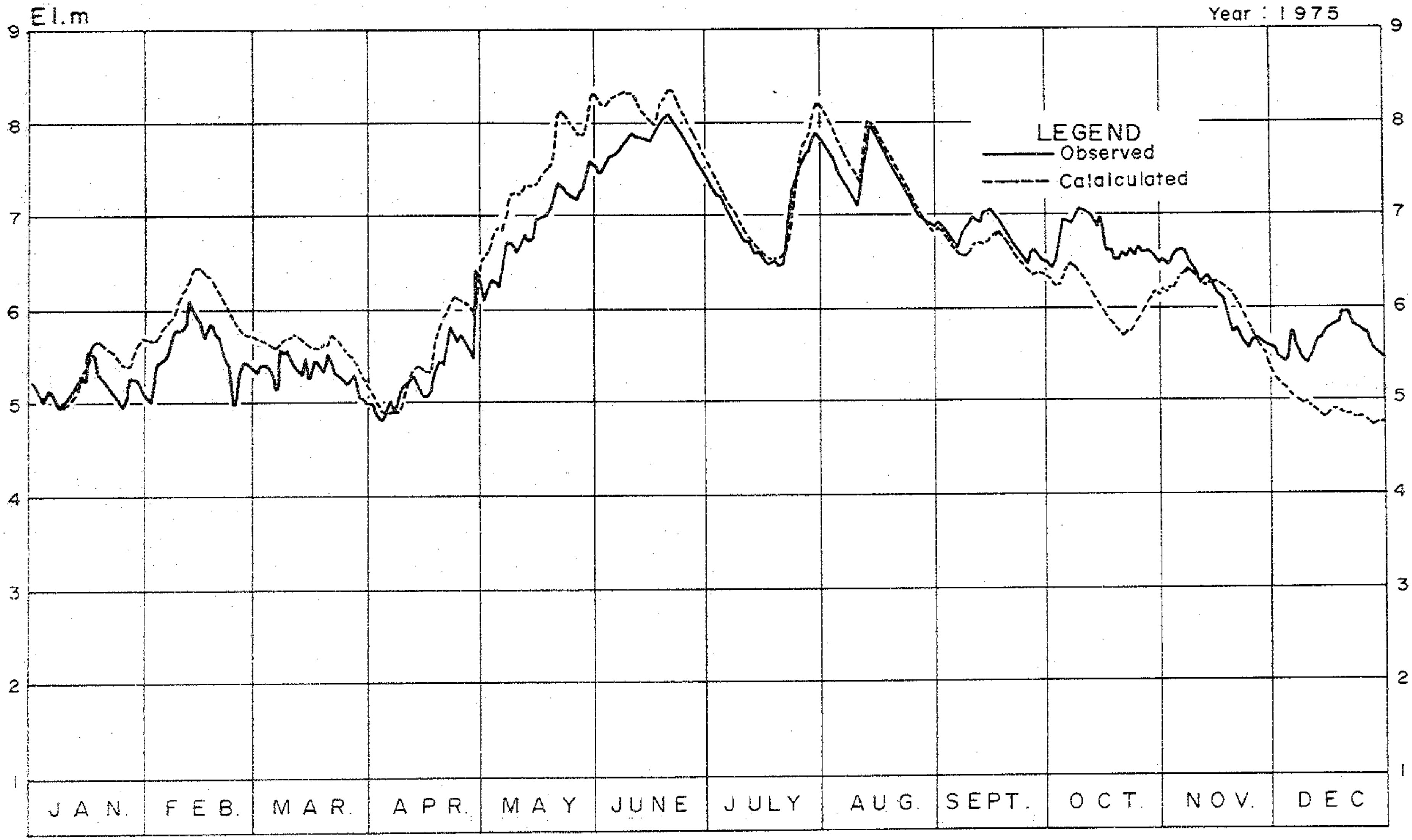

Fig 2·12 Water Level Hydrograph of Lake Tempe

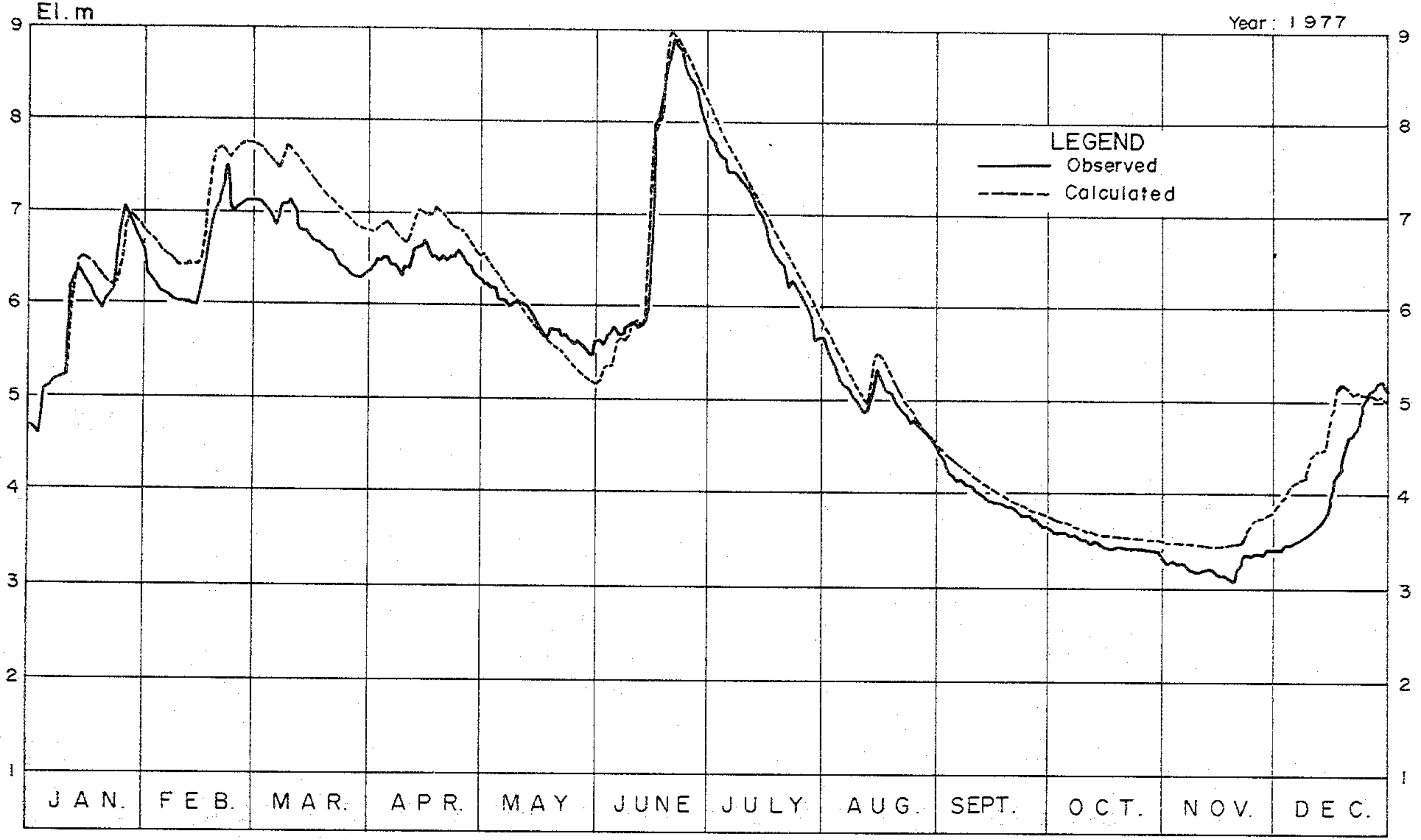

Fig 2-13 Water Level Hydrograph of Lake Tempe

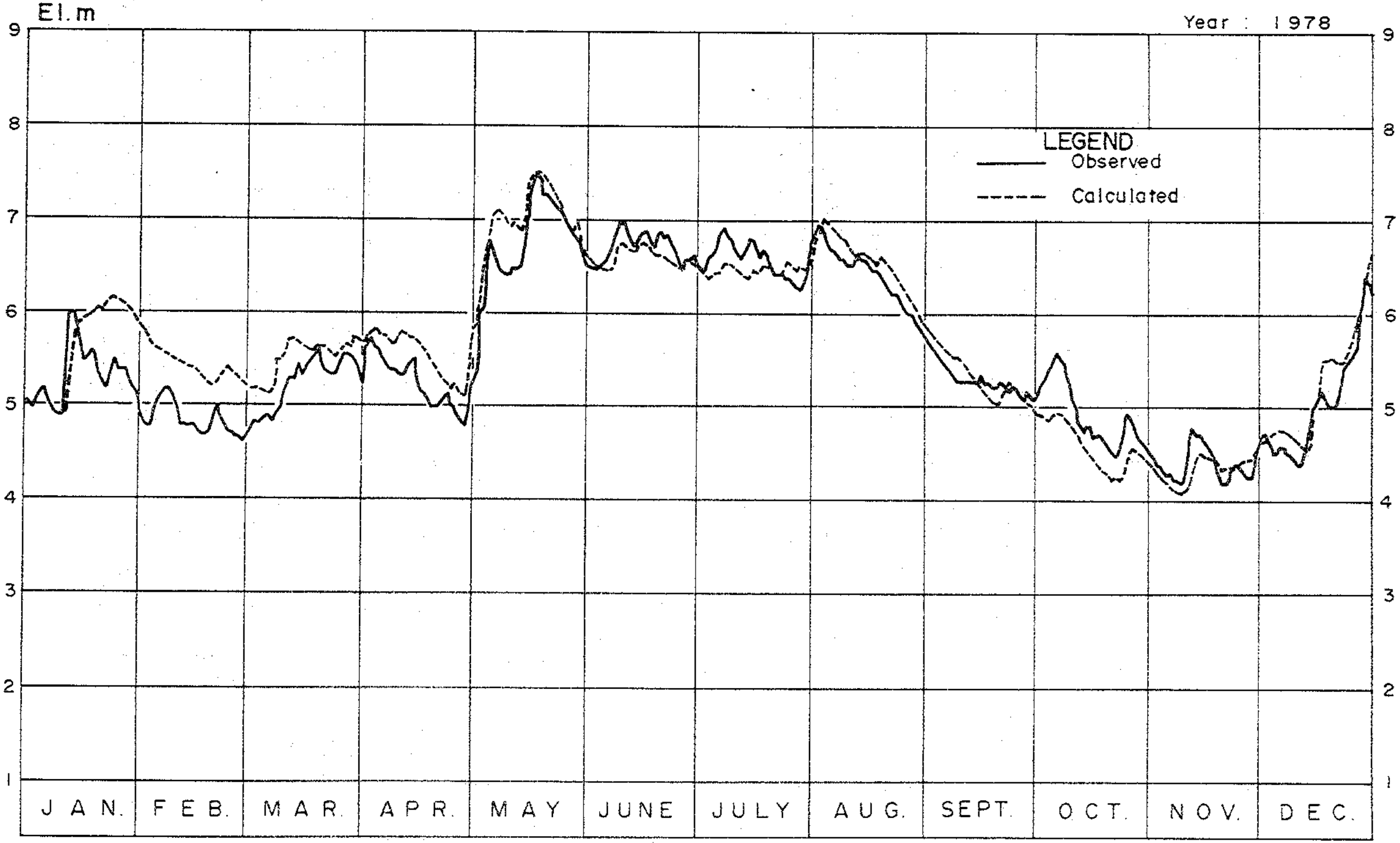

Fig. 2·14 Flood Hydrograph of Lake Tempe

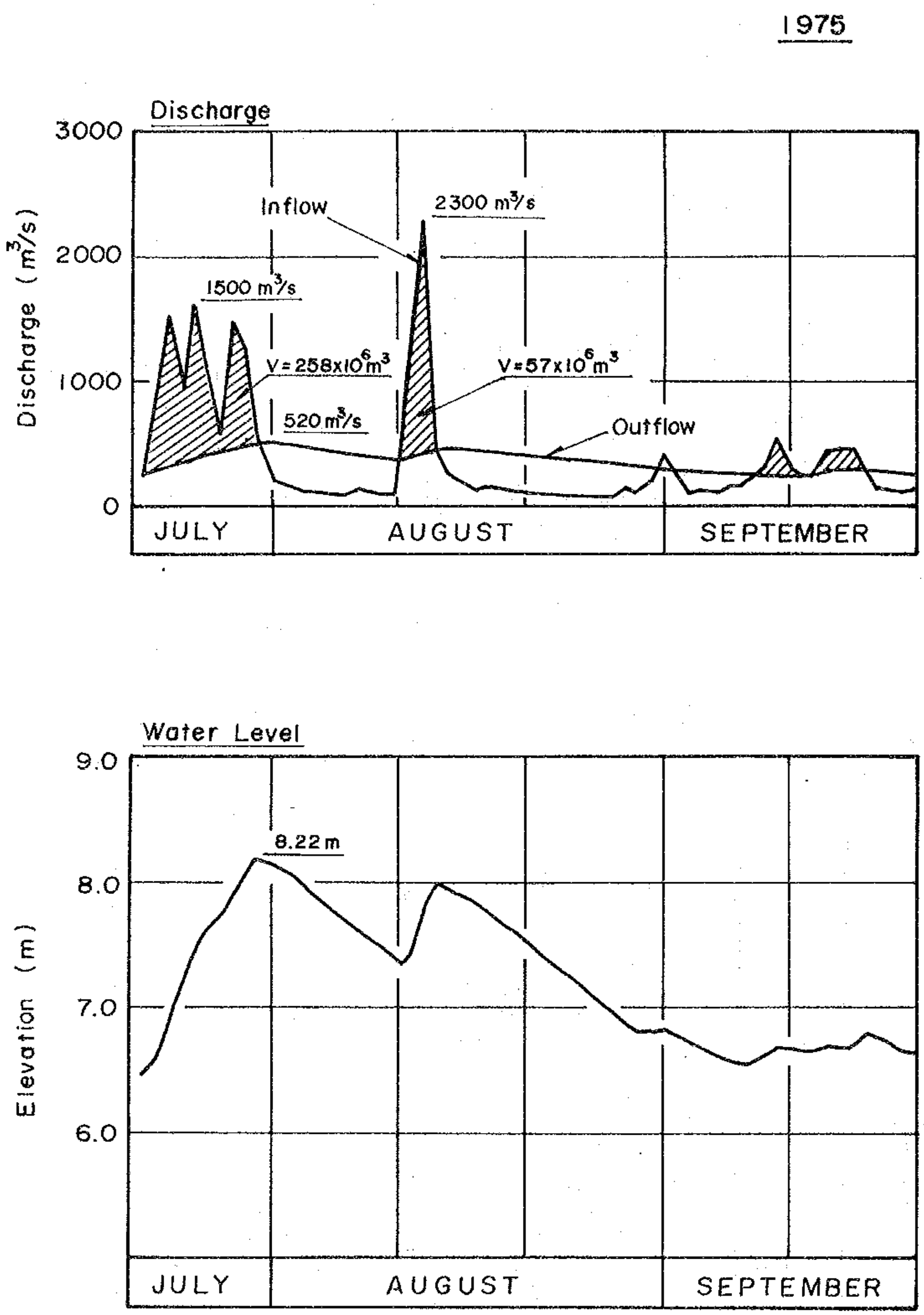

Fig. 2.15 Flood Hydrograph of Lake Tempe

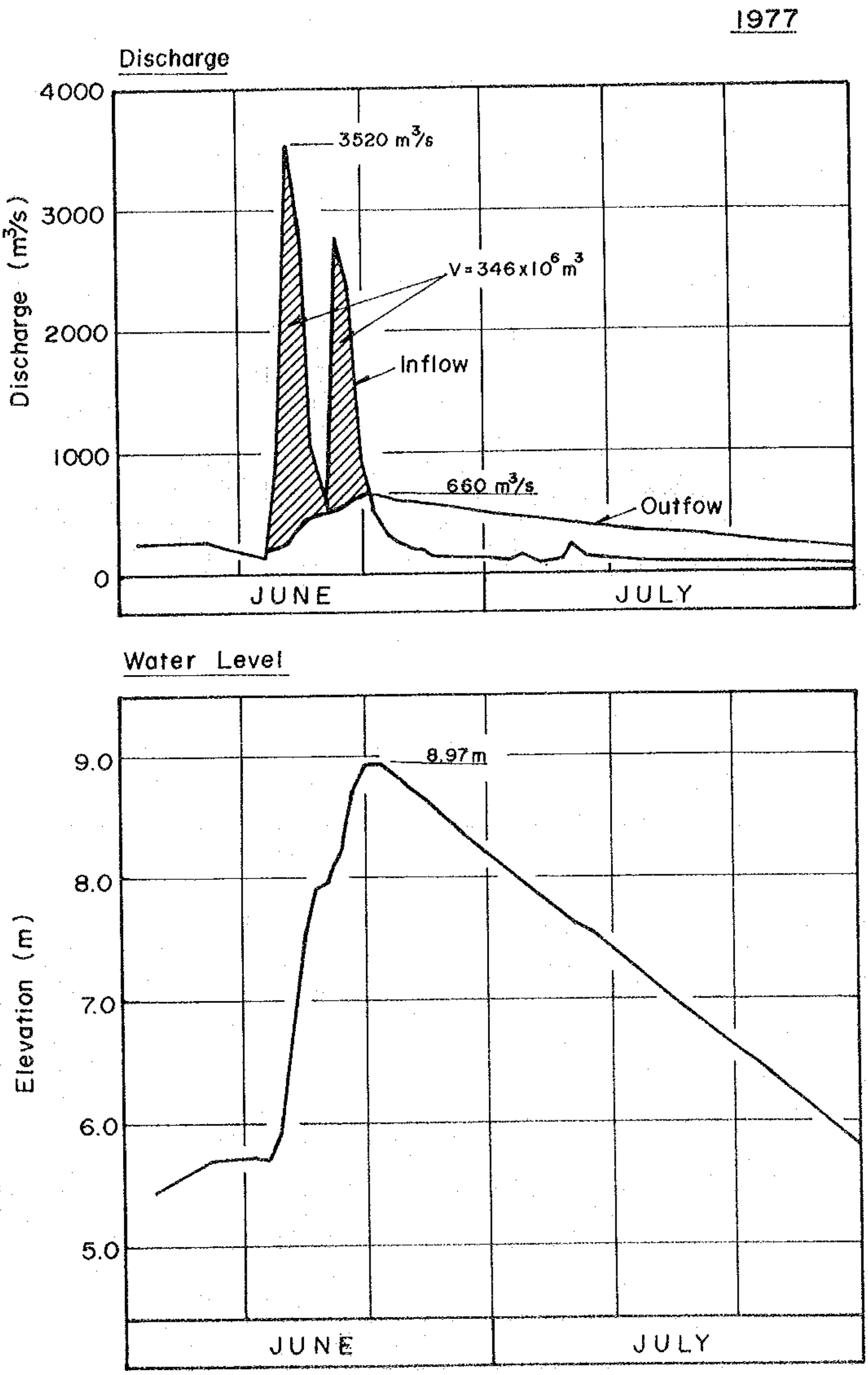

Fig.2.16 Flood Hydrograph of Lake Tempe

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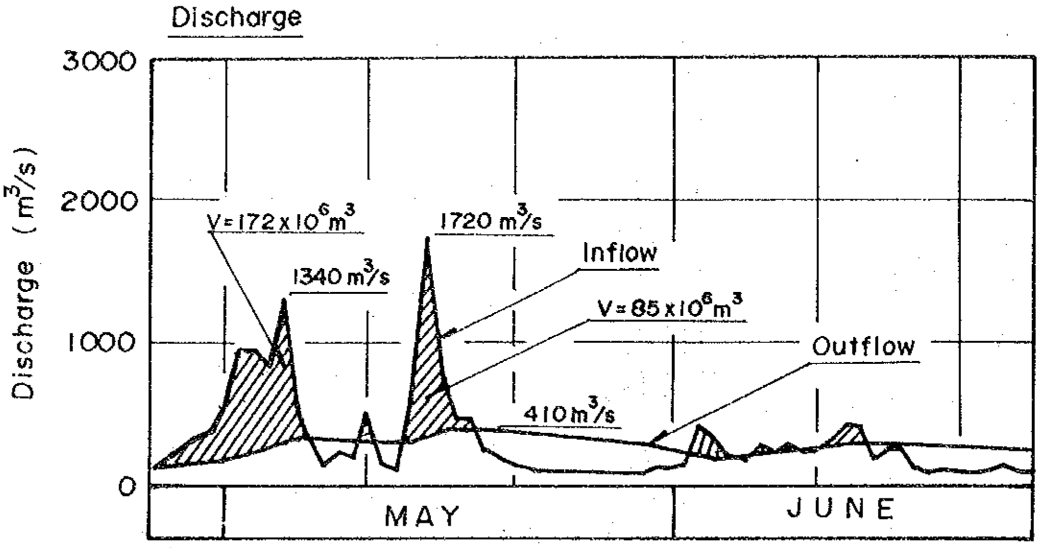

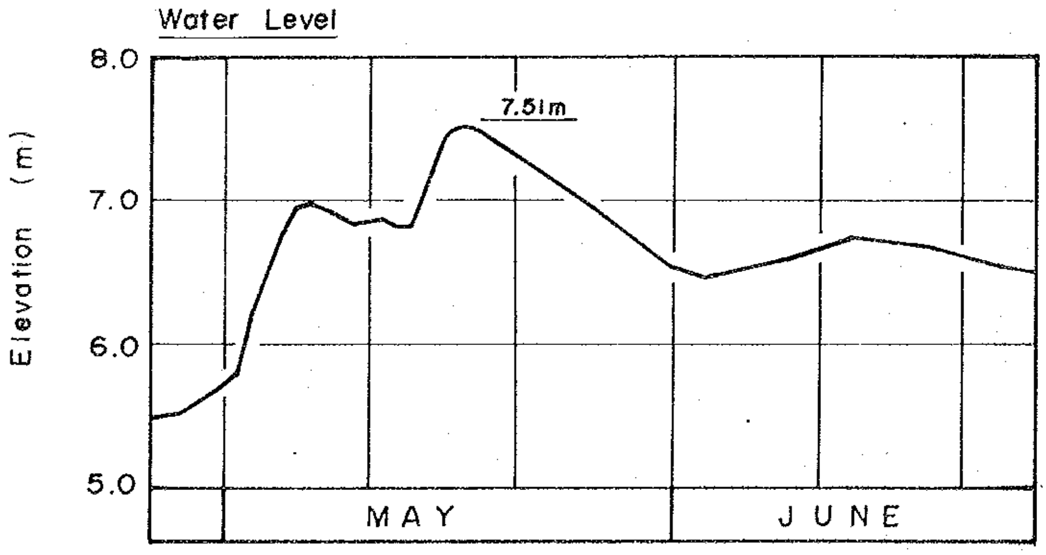

Fig. 3·1 Inundated Areas by Floods

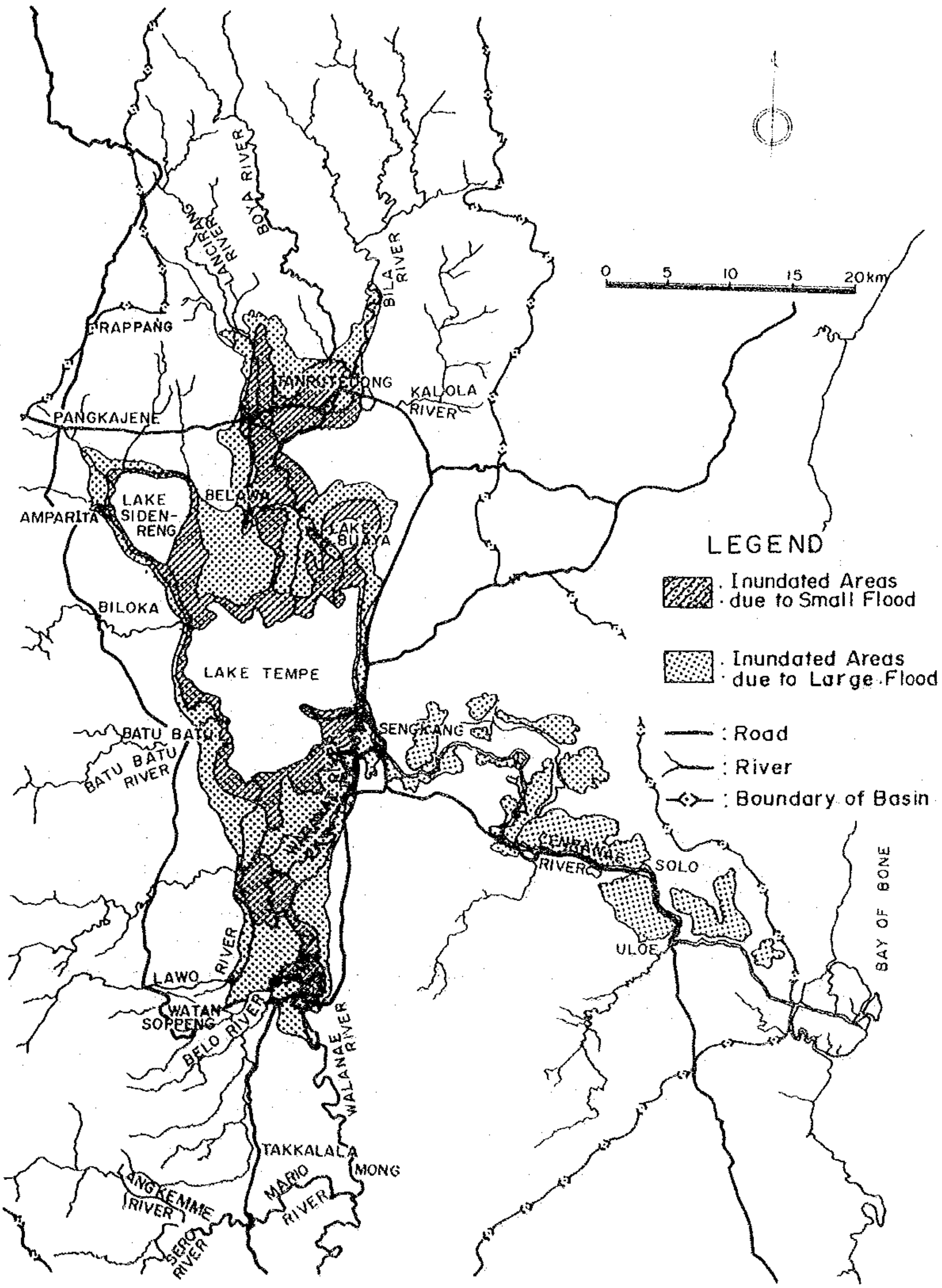

Fig.3·2 Relation Between Plant Height and Period of Growth of Paddy