It is absolutely necessary for the implement of the river improvement works that 850 houses in the area where the levees will be constructed, should be shifted to the outside of the project area before the commencement of river improvement works.

However, the method of shifting the remaining 1,450 houses is considered taking into consideration the social unrest which may occur due to a considerably large number of houses to be moved.

i) The high water channel area will be utilized actually as farmland even after the completion of the river improvement works. Such will make it possible to relocate the lots of existing houses in the proposed high water channel area to the farmland in the landside area. In such case the landholders who have lived in the landside area will be obliged to share their land with those whose houses are moved. It is also possible to realize the relocation of the houses in the high-water channel area to landside area step by step.

ii) The inundation in the high water channel area will be appreciably decreased with the progress of the river improvement works. The houses in the high water river channel area may not have to be moved for the time being if small levees to protect such houses against flood could be provided.

It is necessary to make the further study for the method of relocation of houses in the high water channel area.

3.8 CONSTRUCTION COST ESTIMATE

Estimated construction costs are shown in Tables 3.8.1 to 3.8.4. Total economic construction cost is estimated at US$32.9 million and fund requirement for construction is estimated at US$54.31 million in case of contract base and US$63.18 million in case of force account base respectively. In the estimate of the cost it is assumed that all the houses both on the levee area and the high water bed area are purchased, while only the land on the levee area is purchased. Additional cost for the resettlement is not included in the estimated cost. Operation and maintenance cost is estimated at US$180 thousand per year.

Fig. 3.6.1 Work Section

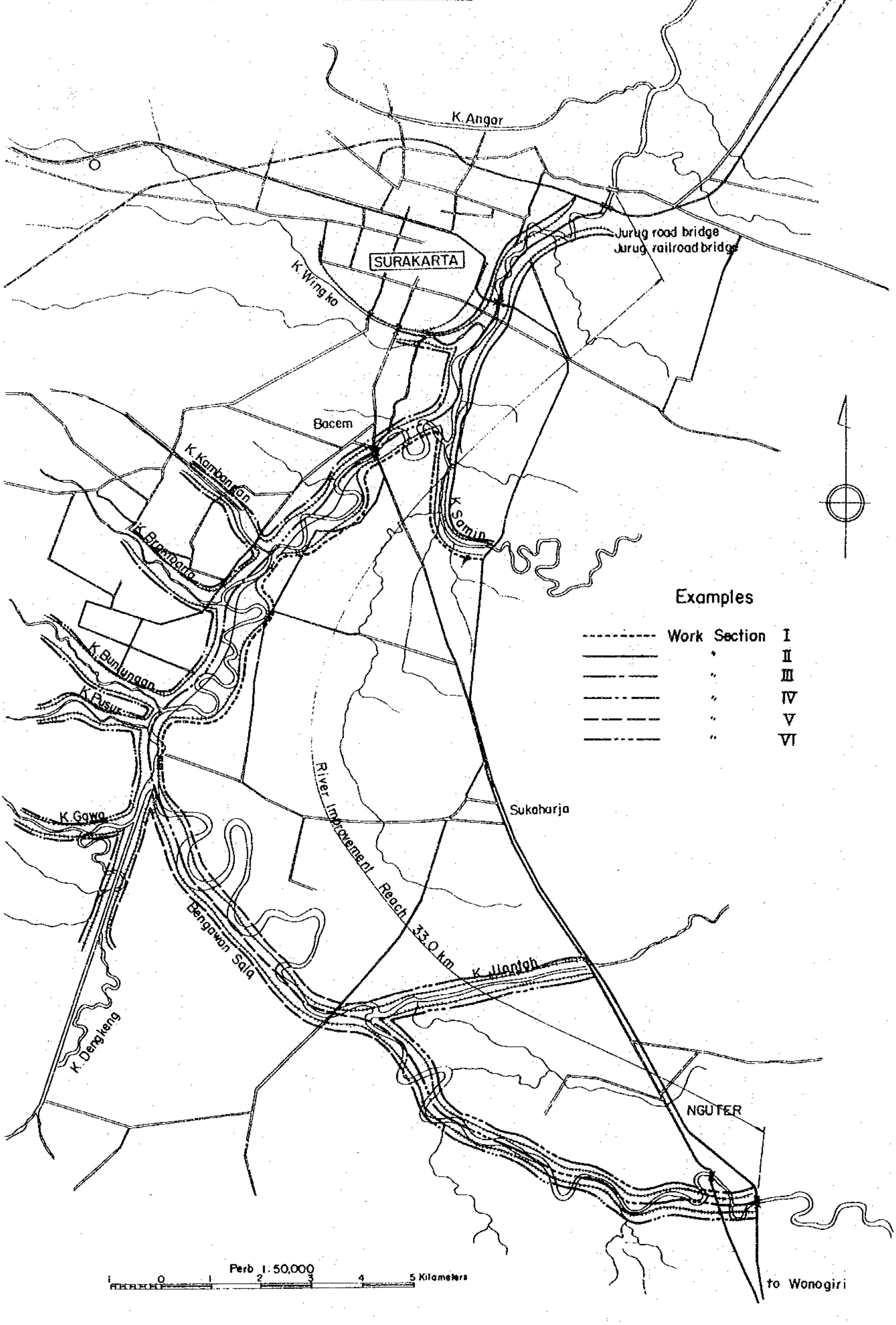
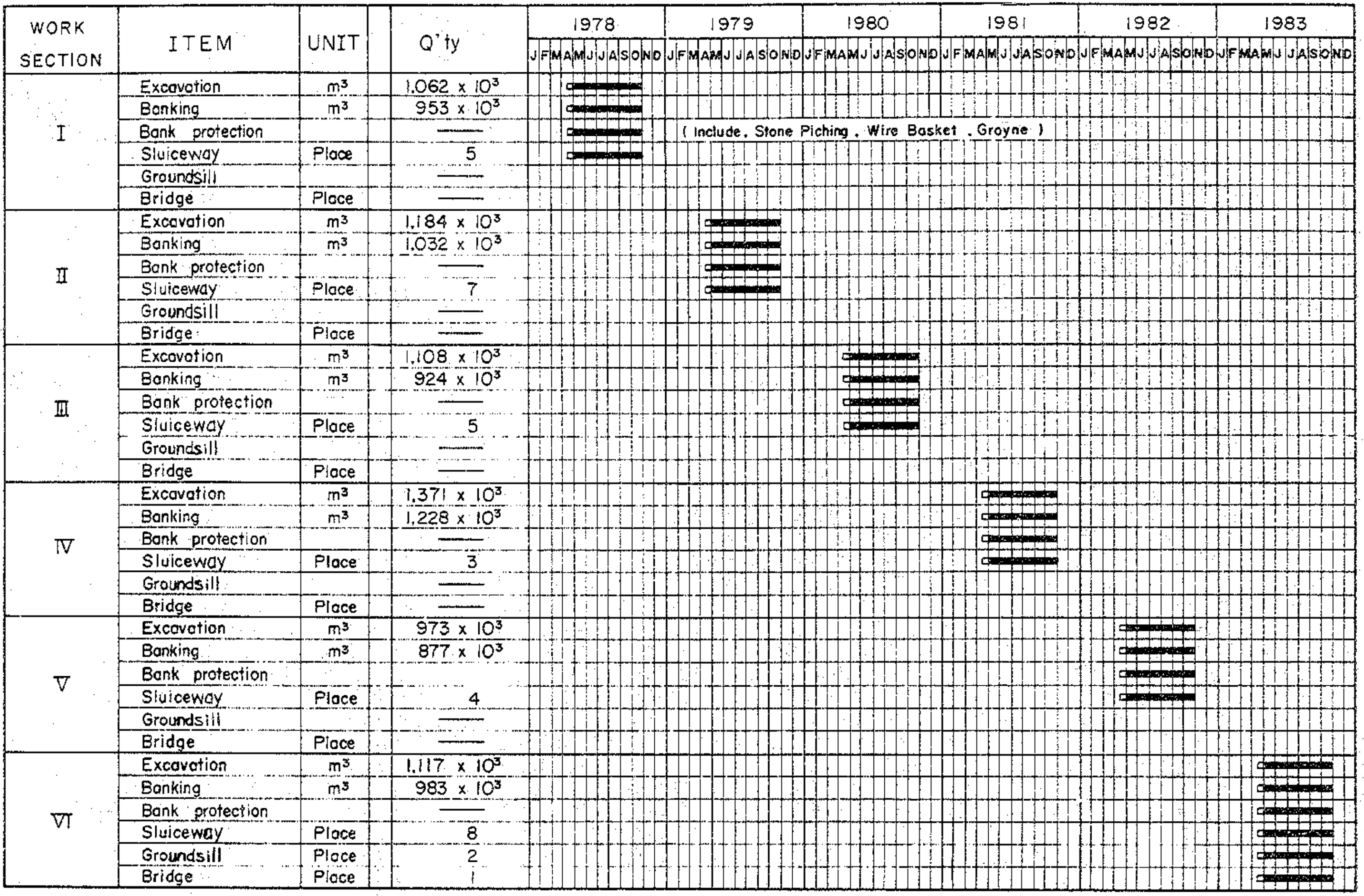


Fig.3.6.2 Proposed Construction Schedule



WORK SECTION	ITEM	UNIT	Q'ty
I	Excavation	m^3	$1,062 \times 10^3$
	Banking	m^3	953×10^3
	Bank protection		——
	Sluiceway	Place	5
	Groundsill		——
	Bridge	Place	——
II	Excavation	m^3	$1,184 \times 10^3$
	Banking	m^3	$1,032 \times 10^3$
	Bank protection		——
	Sluiceway	Place	7
	Groundsill		——
	Bridge	Place	——
III	Excavation	m^3	$1,108 \times 10^3$
	Banking	m^3	924×10^3
	Bank protection		——
	Sluiceway	Place	5
	Groundsill		——
	Bridge	Place	——
IV	Excavation	m^3	$1,371 \times 10^3$
	Banking	m^3	$1,228 \times 10^3$
	Bank protection		——
	Sluiceway	Place	3
	Groundsill		——
	Bridge	Place	——
V	Excavation	m^3	973×10^3
	Banking	m^3	877×10^3
	Bank protection		
	Sluiceway	Place	4
	Groundsill		——
	Bridge	Place	——
VI	Excavation	m^3	$1,117 \times 10^3$
	Banking	m^3	983×10^3
	Bank protection		——
	Sluiceway	Place	8
	Groundsill	Place	2
	Bridge	Place	1

(Include, Stone Piching, Wire Basket, Groyne)

※ ▫ : Preparation

Table 3.6.2 Construction Machineries and Equipments

No.	Equipment	Capacity	Unit
1	Bulldozer	21 ton	25
2	Bulldozer	8 ton	4
3	Drag shovel	1.2 m^3	10
4	Tractor shovel (Crawlar)	2.0 m^3	2
5	Tractor shovel (Wheel)	2.0 m^3	2
6	Dump truck	8 ton	70
7	Vibration roller	4.5 ton	2
8	Motor grader	3.7 m	2
9	Fuel tanker	8 ton	3
10	Water tanker	8 ton	3
11	Grease car	6 ton	3
12	Trailer truck	30 ton	1
13	Truck crane	30 ton	1
14	Cargo truck	6.0 ton	10
15	Back hoe shovel	0.3 m^3	1
16	Concrete mixer	0.3 m^3	2
17	Portable auger pile driver	2.2 ton	2
18	Submergible	6 inch	6
19	Submergible	4 inch	6
20	Diesel generator	50 kW	3
21	Ripper attachment	Bulldozer 21 ton	2
22	Dragline attachment	Shovel 1.2 m^3	3
23	Repair shop		L.S.
24	Miscellaneous		L.S.

Table 3.6.3 Work Section

Work Section	Item	Cross Section No.
I	Excavation	
	River Bed, Short Cut	No.20 - No.41+400,
	Low Water Channel	No.20 - No.41+400
	High water bed(Right Bank)	No.20 - No.43+ 50
	Banking	
	Right Bank	No.19+ 50 - No.49+ 50
II	Excavation	
	River Bed, Short Cut	No. 1 - No.20
	Low Water Channel	No. 1 - No.20
	High water bed	No. 1 - No.20
	Banking	
	Left Bank	No. 1 - No.16+ 50
	Right Bank	No. 1 - No.19+ 50
	K. Samin Right Bank	
III	Excavation	
	River Bed, Short Cut	No.20+150 - No.43+ 50
	Low Water Channel	No.20+150 - No.43+ 50
	High water bed (Left Bank)	No.20 - No.43+ 50
	Banking	
	Left Bank	No.16+ 50 - No.43+ 50
	K. Kembangan	
	K. Brambang	
IV	Excavation	
	River Bed, Short Cut	No.43+ 50 - No.53
	Low Water Channel	No.43+ 50 - No.53
	High water bed	No.43+ 50 - No.53
	Banking	
	Left Bank	No.43+ 50 - No.49+ 50
	K. Buntungan,	
	K. Pusur	
	K. Gawe	
V	Excavation	
	River Bed, Short Cut	No.53 - No.67+ 50
	Low Water Channel	No.53 - No.67+ 50
	High water bed	No.53 - No.67+ 50
	Banking	
	Left Bank	No.49+ 50 - No.67+ 50
	Right Bank	No.49+ 50 - No.65
	K. Dengkeng	
VI	Excavation	
	River Bed, Short Cut	No.67+ 50 - No.90
	Low Water Channel	No.67+ 50 - No.90
	High water bed	No.67+ 50 - No.90
	Banking	
	Left Bank	No.67+ 50 - No.90
	Right Bank	No.65 - No.90
	K. Jlantah	

Table 3.6-4 Work Section (Construction Quantity)

Item	Unit	1978	1979	1980	1981	1982	1983	Total
		I	II	III	IV	V	VI	
a. Excavation	m^3	1,062,200	1,183,600	1,108,200	1,370,000	973,000	1,117,000	6,814,000
b. Banking	m^3	953,000	1,032,400	924,400	1,228,000	876,700	983,500	5,998,000
c. Spoil Bank	m^3	117,200	117,200	117,200	117,200	117,200	117,200	703,200
d. Bank Protection								
Stone Piching	m^3	25,200	28,600	24,500	27,000	7,500	12,200	125,000
	(m)	(1,460)	(1,540)	(1,380)	(1,590)	(570)	(900)	(7,440)
Wire Basket	m^2	35,500	23,700	5,200	5,000	24,100	9,800	103,300
Groin (Wooden)	Place	15	16	18	2	34	174	259
Groin (Concrete)		19	20	21	3	39	34	136
Sodding	m^2	267,600	272,500	278,000	416,900	267,200	316,800	1,819,000
e. Ground Sill(I)	Place						2	2
" "(II)	Place		1		1		1	3
f. Sluice Way	Place	5	7	5	3	4	8	32
g. Intercepting Drainage Channel	m^3	42,330	42,330	42,330	42,330	42,330	42,350	254,000
h. Road for Construction Work	m	1,670	1,650	1,670	1,670	1,670	1,670	10,000
i. Bridge	Place						1	1

Table 3.8-1 Economic Construction Cost

Item	Quantity	Unit	Amount (10^3 US$)		
			Total	F/C	L/C
I Earthworks			25,938	12,168	13,770
a. Excavation	6,814,000	m^3	6,814	1,424	5,390
b. Banking	5,998,000	m^3	4,345	336	4,009
c. Spoil Bank	703,200	m^3	734	156	578
d. Bank Protection			4,206	1,636	2,570
Stone Piching	125,300	m^2	(1,950)	(637)	(1,313)
Wire Basket	103,300	m^2	(994)	(548)	(446)
Groin (Wooden)	259	Place	(222)	(121)	(101)
Groin (Concrete)	136	Place	(385)	(330)	(55)
Sodding	1,819,000	m^2	(655)	(-)	(655)
e. Groundsill (I)	2	Place	5	3	2
(II)	3	Place	9	4	5
f. Sluiceway	32	Place	2,580	1,747	833
g. Intercepting Drainage Channel	254,000	m^3	156	-	156
h. Road for Construction Work	10,000	m	200	100	100
i. Bridge	1	Place	539	412	127
j Construction Machinery	1	Set	6,350	6,350	-
II Land Acquisition			1,344	-	1,344
III Contingency			3,968	1,832	2,136
IV Engineering and Administrative Expenses			1,650	1,300	350
Total			32,900	15,300	17,600

Table 3.8-2 Disbursement Schedule of the Economic Construction Cost

(10^3 US$)

		1977	1978	1979	1980	1981	1982	1983	Total
			I	II	III	IV	V	VI	
I	Earthworks	-	4,280	4,700	3,940	4,550	3,580	4,900	25,950
	Construction Machinery	(-)	(1,000)	(1,100)	(1,010)	(1,290)	(920)	(1,040)	(6,360)
	Others	(-)	(3,280)	(3,600)	(2,930)	(3,260)	(2,660)	(3,860)	(19,590)
II	Land Acquisition	-	220	220	220	220	220	220	1,320
III	Contengency	-	630	720	610	680	580	750	3,970
IV	Engineering and Administrative Expenses	750	160	150	150	150	150	150	1,660
	Total	750	5,290	5,790	4,920	5,600	4,530	6,020	32,900
	Foreign	600	2,410	2,670	2,170	2,380	2,060	3,010	15,300
	Local	150	2,880	3,120	2,750	3,220	2,470	3,010	17,600

Table 3.8-3 Fund Requirement (Contract Base)

Item	Amount (10^3 US$)		
	Foreign	Local	Total
I Earthwork			
Excavation	1,020	9,520	10,540
Banking	270	7,080	7,350
Spoil Bank	110	1,020	1,130
Bank Protection	2,270	4,420	6,690
Groundsill	10	20	30
Sluiceway	2,440	1,470	3,910
Intercepting Drain. Channel	-	280	280
Construction Road	140	180	320
Bridge	690	270	960
Construction Machinery	8,190	-	8,190
(Sub-total)	(15,140)	(24,260)	(39,400)
II Land Acquisition	-	5,850	5,840
III Contingency	1,510	4,510	6,020
IV Engineering & Admin. Exp.	2,500	550	3,050
Total	19,150	35,160	54,310

Table 3.8-4 Fund Requirement (Force Account Base)

Item	Amount (10^3 US$) Foreign	Local	Total
I Earthwork			
Excavation	1,990	9,510	11,500
Banking	470	7,090	7,560
Spoil Bank	220	1,020	1,240
Bank Protection	2,270	4,420	6,690
Groundsill	10	20	30
Sluiceway	2,440	1,470	3,910
Intercepting Drain. Channel	-	280	280
Construction Road	140	180	320
Bridge	690	270	960
Construction Machinery	13,390	-	13,390
(Sub-total)	(21,620)	(24,260)	(45,880)
II Land Acquisition	-	5,840	5,840
III Contingency	2,980	4,590	7,570
IV Engineering & Admin. Exp.	3,100	790	3,890
Total	27,700	35,480	63,180

Table 3.8-5 Estimate of Operating & Maintenance Cost

Item	Quantity & Unit Cost	Amount (US$)
1. River improvement office personal expenses	10 men x 3,600 $/year	36,000
Others	15 x 1,200 $/year	18,000
2. Repair of reparian structure	1 L.S Groin (Wooden) 10%	22,000
3. Bank maintenance personal expenses	40 x 600 $/year	24,000
4. Drainage channel maintenance personal expenses	20 x 600 $/year	12,000
5. Control of sluice gate personal expenses	32 x 600 $/year	19,200
6. Clearance of groins personal expenses	10 x 600 $/year	6,000
7. Depreciation cost of O & M facilities (Office building & others)	L.S	42,800
Total		180,000

4. ANNEX II (RECONNAISSANCE OF THE KALI DENGKENG)

4.1 GENERAL

The Dengkeng river which is about 59 km long and having a drainage area of 833 km^2 rises from the Mt. Merapi (2,911 m above the sea level), runs downward through the steep mountain and reaches the open fields. The Dengkeng river has three major tributaries on its upper reaches such as Kali Kongklangan, the Kali Woro and the Kali Lusah.

These tributaries join the river, and the river changes its name to the Dengkeng river. After gathering such small tributaries as the Udjung, the Melase and other minor tributaries, it joins the Sala river at the point 16 km upstream from Surakarta as shown in Fig. 4.3.1.

Mt. Merapi is one of the most active volcanoes in the country. At present, it is still active and the cycle of its eruption is once every three to five years. Up to the present, immense amount of volcanic debris derived from Mt. Merapi has deposited over the foot of the mountain. The volcanic deposit is washed toward the vast and fertile plain in the downstream area at the time of heavy floods and cuases much damage.

The Sub Proyek Gunung Merapi, with the intention of reducing the damages, has constructed three large control pockets and several small ones on the upstream side of the highway running between Yokjakarta and Surakarta. However, almost all these sand control pockets have already been filled with debris.

The river bed of the Dengkeng river at its confluences with the said three tributaries is higher than the level of the surrounding farmland. The river causes extensive damages several times each year, breaking or overtopping the levee.

The river improvement of the Dengkeng river is urgently necessary for the purposes of reducing flood damages and of stabilizing the living of the people living in the area. However, the survey of the Dengkeng river in connection with the said river improvement should be made in due consideration of the unfavorable influence it may exert on the Sala river.

The reconnaissance survey of the Dengkeng river was recommended for the purpose of clarifying the existing conditions of the river and the causes of the damages to determine how the improvement of the river course should be carried out.

4.2 SCOPE OF SURVEY

4.2.1 Purpose of Survey

The purpose of the reconnaissance survey is to study the causes of damages necessary for formulating the plan of river improvement and to determine various types of surveys required for the desired improvement.

4.2.2 Territory of Survey

The Merapi Survey Team has been organized to carry out the investigation of the debris originating from the Mt. Merapi and those accumulated in the basin of the Dengkeng river. The team stayed in Indonesia for the period of 25 days from February 2 to February 26, 1976 to tackle the problem of sand debris control. The members of the Japan International Cooperation Agency Team had an opportunity to discuss with the members of the Merapi Survey Team the matters of common interest.

February 3, 1976	At Djakarta	Basic Policy and Assignment of the survey team.
February 10, 1976	At Yokjakarta	Report on the field survey.

After completing the reconnaissance survey of the 45-km section between the confluence of the Dengkeng river and the Sala river and the upstream sand control pocket, two survey teams exchanged their views in Tokyo.

The survey teams agreed the take charge of the respective survey territories. The Merapi Survey Team took charge of the study in one basin upstream of the confluence of the Dengkeng river with K. Lusah, and the JICA Team another basin downstream of the confluence.

4.3 EXISTING CONDITIONS

4.3.1 Hydrology

Rainfall

a) Annual rainfall

According to the data obtained at Deles, Jombor and Tawangsari, in and around the catchment basin (See Fig. 4.3.1 for location), annual mean rainfall, is approximately 2,600 mm at the Deles rain-gauge station, E.L. 1,500 m., located in the upper reach of basin. At Jombor and Tawangsari rain-gauge stations, both located in the plains, almost similar annual rainfall of about 1,500 mm was recorded. Annual rainfall observed at Jombor and Tawangsari was about a half of the precipitation recorded at Deles.

Annual rainfall in the plain areas is higher than that in the mountain areas. There is quite a difference in regional distribution of the annual rainfall in the catchment basin. The annual rainfall recorded at the above-mentioned three rain-gauge stations is at shown in Fig. 4.3.2.

b) Seasonal variations of rainfall

Seasonal variations of rainfall is quite noticeable. As shown in Fig. 4.3.3 the distinction between the dry and the rainy seasons is quite obvious --- rainy season is six monthe from November to April and dry season is also six months from May to October. While the average precipitation during the dry season is approximately 30 mm, it varies with the month and locality of observation stations in the rainy season. In the mountain area, the maximum monthly rainfall approximately 500 mm (1963 - 1972) was recorded, and approximately 300 mm in the plain area. Since rainfall is heavily concentrated in the rainy season, the magnitude of flood discharge can easily be imagined.

Water level and discharge

a) Water level and discharge observation

The Jurum observation station located at about 8 km upstream of the confluence of the Sala river and the Dengkeng river is the only station along the Dengkeng river. The records available are only for two years from 1974 to 1975. The float of the water-gauge did not seem to have worked properly probably due to the sinking of the river bed which occurred after the water-gauge was installed. Therefore, the available records at this observation station were considered inaccurate and were not incorporated in the plan for the improvement of the river course. The daily mean discharge and water level are as shown in Figs. 4.3.4 and 4.3.5. The rating curves (uniform flow computation) at the Jurum site are as shown in Fig. 4.3.6.

b) Design discharge

In the river improvement plan of the main Sala river, the design discharge of only the backwater influenced reach of the Dengkeng river was investigated, and it was estimated at 830 m^3/s or 1.0 $m^3/s/km^2$ in terms of specific discharge. However, for the calculation of the design discharge in case the entire length of the Dengkeng river is to be improved, more accurate hydrological data including water levels and discharges recorded over a long period of time would be necessary.

4.3.2 Sand debris

Mt. Merapi is an active volcano erupting at an interval of three to five years and produces each time tremendous amount of sand debris. The debris deposited over the foot of the mountain is washed away into the rivers by flood water during the rainy season. The rise of the river bed resulting from the washed-away debris is the cause of floods which cause heavy damages to the neighboring areas. Since it is not easy to estimate the quantity of debris coming from Mt. Merapi, the existing condition cannot be grasped. Around the foot of the volcano, there is, even now, a tremendous amount of sand debris, and it is likely to cause a heavy silt discharge at the time of large floods. However, the amount of silt discharge from the foot of the volcano running into the catchment basin of the Dengkeng river is getting less, and at present the volcanic silt deposit is not obvious. The recent progress of various Sabo works definitely contributes to holding back of a considerable sediment flowing into the river.

4.3.3 Characteristics of the Existing River Channel

Discharge Capacity of River Channel

The field reconnaissance of the Dengkeng river basin, especially of the river, was performed over the reaches from the confluence with the Sala river to the sand control pockets located along the K. Simpin. The following shows the findings on the river regime and the cross sections of the rivers.

a) There is a short cut with levees, 7 km in the river length and about 300 m^3/sec in discharge capacity, constructed by local Government, in the reach between the Sala river confluence and near the Jurum bridge.

b) In the section between the Jurum bridge and the Paseban bridge, the cross sections of the river are practically the same and the discharge capacity is approximately 250 m^3/sec.

c) The river becomes narrow at the Paseban bridge as there is a stretch of hills on the right bank and low mountains on the left.

The upstream area of the bridge forms a flat plane, but towards the upstream the river bed rises gradually and at Kali Banding, the level of the river bed and that of the surrounding farmland are almost the same.

In the area further upstream, the river bed is located at an elevation higher than the level of the surrounding farmland. The Dengkeng river divided into three tributaries near Jember, namely, the Kali Kongklangan, the Kali Woro and the Kali Lusah.

In these tributaries, the river bed is 3 to 5 m above the neighbouring farmland and the continuous levee is 5 to 8 m. The discharge capacity of the Kali Kongklangan, the Kali Woro and the Kali Lusah, is 100 m^3/s, 120 m^3/s, and 50 m^3/s, respectively. The sum of the discharge capacity of the above three rivers is larger than the discharge capacity of 170 m^3/s of the Dengkeng river at the downstream reach of the confluence of the three tributaries.

This shows that there is an unbalance in the discharge capacity of the river channel.

Fig. 4.3.7 shows the closs sections of the confluence of the Dengkeng river with the three tributaries.

d) While the Kali Woro, with tremendous sand deposit, forms an elevated-river bed at the crossing with highway, the Kongklangan and the Lusah have scoured river channels, holding elatively large boulders scattered over the channels, and have large discharge capacities. In particular, the discharge capacity of the Lusah is considerably large, and is estimated at approximately 750 m^3/s.

e) There are three large sand control pockets and several small ones along the upstream reach from the highway on the Woro, and they block and regulate sediment load coming from Mt. Merapi at the time of floods.

Since the sand control pockets have already been filled in the sand to almost their full capacities, the regulating function of these pockets is quite limited.

Variation of River Bed

Since 1963 to date, as shown in Fig. 4.3.8, a survey of the river bed elevation was carried out at 25 points along the Dengkeng river between Yokjakarta-Sala Highway and the confluence of the Sala River. The survey record of the river bed elevation, 1963 - 1974, is as shown in Fig. 4.3.9. The results show that there was a tendency of rise in elevation of the river bed of the Kali Simpin (Kali Woro) (about 50 cm rise of the river bed between 1963 and 1974), and some scouring of the river bed was observed in other rivers. Especially, the Kali Ujung at Raya bridge, though a considerable amount of silt is observed even now, has its bed of silt scoured to about 1.5 m deeper than the elevation of the river bed in 1963. Along the river course upper reach of the Sala river confluence, a noticeable scour is observed. Since a silt discharge coming from Mt. Merapi forms a deposit in the upstream side of the sand control pockets and the upstream rivercourse, it is considered that the tractive force is greater than the amount of the silt transferred to the area. At any rate, it may reasonably be concluded that no noticeable change of the river bed had taken place between 1963 and 1974 and the silt discharge from Mt. Merapi has no substantial effects on the main Sala river.

4.3.4 River Structure and River Utilization

There are a number of ripariam structures along the river course of the Dengkeng river. Along the upper reach of river course, there are many sand control pockets and Sabo dams to deposit sediment. Farmlands on both banks are fertile and irrigation intakes are found along the river course. Drainage sluices are found at the confluences of the Dengkeng river with the secondary tributaries to check the backwater flowing in from the main river. The Dengkeng river is located between Surakarta City and Yokjakarta City. A national highway bridge and a railroad bridge linking the two cities and also many small bridges linking the villages cross the river.

The river is under the administration of the local government.

Levees are constructed partially along the 7-km downstream lower-reach of river (upper reach of the Sala river confluence), in the neighbourhood of the confluence of the three tributaries and their secondary tributaries.

The Dengkeng river may be regarded as a considerably improved river compared with other tributaries.

4.3.5 Cause of Damage

In the area along the Dengkeng river, is heavy damage, caused by insufficient cross section of the river and the adverse effects of the backwater, is repeated annually. Causes of flood damage were investigated with regard to the 1975 flood, the worst in recent years, which caused a considerable damage. At the time of 1975 flood, the heaviest flood so far known, the inundation area was divided into two parts as shown in Fig. 4.3.10.

At any rate, the discharge capacity of the entire river channel of the Dengkeng river including the tributaries is not large enough to flow down safely its own discharge.

4.4 COUNTERMEASURE FOR FLOOD DAMAGE

The inundated area along the Dengkeng river at the time of 1975 flood was divided into two separate areas: the up and downstream areas as shown in Fig. 4.3.10

The upstream inundation area functions as a sand control pocket for trapping the sediments from Mt. Merapi. In the downstream inundated area, therefore, there is no substantial damage directly caused by the sediment.

In case the river improvement of the Dengkeng river for reducing the upstream inundation area would be implemented, the discharge in the channel will be increased and more sediment load will also flow down into the Sala river with the increased discharge.

The sediments flowing into the Sala river will be deposited on the main river channel near the confluence of the Dengkeng river with the Sala river, and will exert unfavorable influence upon the discharge capacity of the Sala river. Even when the tractive force enough to flush the sediment is allowed to the proposed (improved) channel of the Sala river, the sediment would be accumulated on the unimproved river downstream of Surakarta. At any rate, the sediment, which originates in Mt. Merapi, deposits in the Sala river channel and becomes the cause of inundation.

If the river improvement plan of the Dengkeng river shall be worked out from the viewpoint of increasing its discharge capacity, the design discharge of the Sala river at Surakarta shall naturally be over 2,000 m^3/sec.L[1] The 1966 flood was taken up for the purpose of determining the design discharge of the Sala river at Surakarta. It is so decided as to make up a reasonable design discharge distribution to the tributary which are left unimproved.

As to the river improvement plan of the Dengkeng river, a long-term river improvement plan should be worked out after the control plan of the volcanic products from the Mt. Merapi is envisaged.

For the time being a temporary river improvement plan shall carefully be formulated for the reduction of the damage in the area along the Dengkeng river so as not to exert unfavorable influence upon the Sala river.

a) Downstream inundation area

It is generally considered that the inundation in the downstream area from the Jurum bridge to the confluence with the Sala river is caused by the backwater from the Sala river, but the flood flow of the Dengkeng river itself due to the insufficient discharge capacity the cause of the inundation.

As regards this inundation area, it is considered that the river improvement works on the Sala river will reduce the degree of the inundation caused by the backwater.

However, even on completion of the river improvement works including the construction of the back levees along the Dengkeng river, some inundation area caused by the landside water of the Dengkeng river will still remain.

L[1] The 1966 flood was taken up for the purpose of determining the design discharge of the Sala river at Surakarta.

b) Upstream inundation area

In the inundation area upstream of the Paseban bridge, the discharge from the upstream is flooded in the upstream area near the Paseban bridge because there is a difference in the discharge capacities between the Dengkeng and the upstream three tributaries such as the Kali Kongklangan, the Kali Woro, and the Kali Lusah (the discharge capacity of the downstream channel is smaller than that of the upstream and as the result the levees are damaged).

As the river bed upstream of Kalibandung is at a higher elevation than the level of the farmland surrounding the river, the river fails to perform the function of draining landside water.

The landside water thus confined in the farmland also induces flood. Of course, the drainage systems to reduce the landside water are functioning, but their drainage capacity is insufficient. Furthermore, as the sand control pockets located in the upstream from the highway are already near full, further sand regulation cannot be expected. Therefore, at the time of large floods, the sand control pockets will release a large amount of sediment load to the K. Woro.

As mentioned above, in case that the levee is broken, the discharge in the downstream reach from the spot where the levee is broken is much decreased and the tractive force also is decreased, and as the result, a large amount of sediment is left behind and deposited in the river. This is the cause of a further rise of the river bed which is already considerably higher than the level of the surrounding farmland.

As it stands at present, it is considered that the inundated area near the confluence with the three tributaries plays the role of a sand control pocket. Since the levees are very high. It is also considered that the damage potential is large and the damage by flood from the broken levee is gravely serious. High levees are dangerous.

4.4.1 Overall River Improvement

It is still not practical to work out the general river improvement plan since the volume of the sediment in the flow and of the sediment product in the basin cannot be reasonably determined. It is recommended that the overall river improvement plan should be formulated in accordance with the progress of the sabo works and at the same time taking into consideration the effects on the main course of the Sala River and the economic factors.

4.4.2 Tentative River Improvement

Since the volume of the sediment in the flow and of the sediment product in the basin cannot be reasonably determined at the moment, a tentative river improvement plan is recommended as the plan most effective for reducing the flood damage.

Downstream River Course Improvement Plan

There are a good number of agricultural facilities for irrigation and drainage along the lower reach of river. Though inundation along the 12-km reach upstream of the confluence of the Sala river is directly caused by the backwater from the Sala river as well as the insufficient discharge capacity of the river, an increase of the discharge capacity is absolutely necessary. To increase the discharge capacity, an increase of cross section of the river, relocation of the existing heavily meandering river to more gentle alignment by short cutting, and introduction of a steeper river bed profile are recommended. For the purpose of the cross section increase, banking is considered as more practical than the enlargement of the low water channel for the following reasons.

a) Along the river, there are a good number of agricultural facilities for irrigation and drainage. To continue maintain full utilization of the above-mentioned facilities, the existing low water channel should be preserved as it is.

b) As there are considerable variation in the discharge in the rainy and dry seasons, especially in the dry season, it is said that the surface water changes infiltration water. To make the low water channel steady, the channel should be maintained as it is. Since almost no hydraulic data are available at present, it is rather difficult to investigate appropriate low water channel from the view point of stability. Therefore, it is recommended to investigate the scope of the low water channel only after ample volume of hydraulic and hydrological data is made available.

Upstream River Course Improvement Plan

A lack of balance in discharge capacity between the three tributaries namely, K. Kongklangan, K. Simpin and K. Lusah, and the Dengkeng river, and the insufficient flow discharge capacity of the river course, are the real causes of inundation. Because the river bed is higher than the surrounding ground level, damages from flood caused by the above-mentioned unbalance will become even heavier. Therefore, the following is recommended to reduce damages over the area resulting from inundation.

1) to increase the discharge capacity of the overall river to balance the discharge capacity

2) to adjust discharge capacity of the three tributaries suitable for the discharge capacity of the Dengkeng river

3) to lower the elevation of the river bed to below the surrounding ground level

4) to increase discharge capacity of the drainage channels through improvement of drainage channels

Based on the above recommendation, the following river improvement plan is proposed.

1) to carry out a change in the river cross sections, from the existing single to composite cross section, of K. Konglangan, K. Simpin and K. Dengkeng, by the excavation of low water channels in accordance with the increased discharge capacity to reduce flood damages.

2) Presently, almost no sediment from landside area is observed in the K. Lusah as the sand control pockets on the upstream are functioning properly.

   However, because of a back sand from the Dengkeng river, the elevation of the river bed of the K. Lusah in the neighbourhood of the confluence with the Dengkeng river, is higher than the surrounding ground level. By improving the cross section of the river (by excavation) to make the K. Birin join the K. Lusah, and perform river improvement on the portion of the K. Birin upstream of the confluence.

3) By performing improvement of drainage networks, and of drainage of the inner basin to reduce damage caused by landside water.

Since the hydrological and hydraulic data collected so far are not satisfactory, it is difficult to work out a comprehensive river improvement plan, even tentatively. Therefore, further observation and collection of more data will be necessary for the formulation of an appropriate river improvement plan. It is also necessary to take into consideration the enonomic aspects.

The downstream area, i.e., the downstream inundation area and the main Sala river, will be seriously affected by the river improvement of the above-mentioned reach, therefore, it is recommended to take the existing conditions of the downstream river and of the Dengkeng river the Sala River into consideration.

4.5 RECOMMENDATION

It is recommended to make the following surveys for the purpose of the river improvement of the Dengkeng river and its tributaries.

Hydraulics and Hydrology

Rainfall Observation

In the catchment basin, there are a number of rain-gauge stations but not all of them are under the control of the Sala River Office. Therefore, it is necessary to collect as much rainfall data as possible and to put them in order. Also, it is necessary to perform a rain-gauge station in the upstream area near Mt. Merapi as the observation network density is low in the area.

For the determination of the design discharge and hydraulic conditions of the river, it is necessary to establish, at least at points mentioned below, water-gauge stations.

a) Raja Bridge point on the K. Kongklangan
b) " " " on the K. Simpin
c) " " " on the K. Lusah
d) The Paseban Bridge

As the water-gauge instrument of installed at the Juram water-gauge station is not good at all for observation of the low water discharge, it must be improved.

Topographic Maps, Plans and Longitudinal and Cross-sections

Topographic Maps

It is recommended to prepare a 1 : 5,000 topographic map of the entire catchment area with 1-meter contour lines.

Plans

It is recommended to prepare 1 : 2,500 plans covering the river basin.

Longitudinal and Cross-sections

Although the cross-sectional survey is being conducted under the vision of the Sala River Office, the river changes its course frequenthy at each flood. Therefore, it is recommended to prepare a longitudinal and cross-sectional servey maps by performing cross-sectional survey at 200-meter intervals over the section between the Sala River confluence and the sand control pockets.

Inundation Records

It is recommended to study the inundation characteristics and the damage records of the past floods.

Survey of Assets

It is necessary to perform a survey of the assets and make out an itemized list of the assets, and to perform a survey of land utilization by items as well as by seasons.

Survey of Rivers and River Water Utilization

It is necessary to perform a survey of rivers and river water utilization and also of river structures.

On the basis of the aforementioned hydraulic and hydrological data, it is recommended to formulate a sound river improvement plan which can be justified both technically and economically.

FIG. 4.3.1 GENERAL MAP OF THE DENGKENG RIVER BASIN

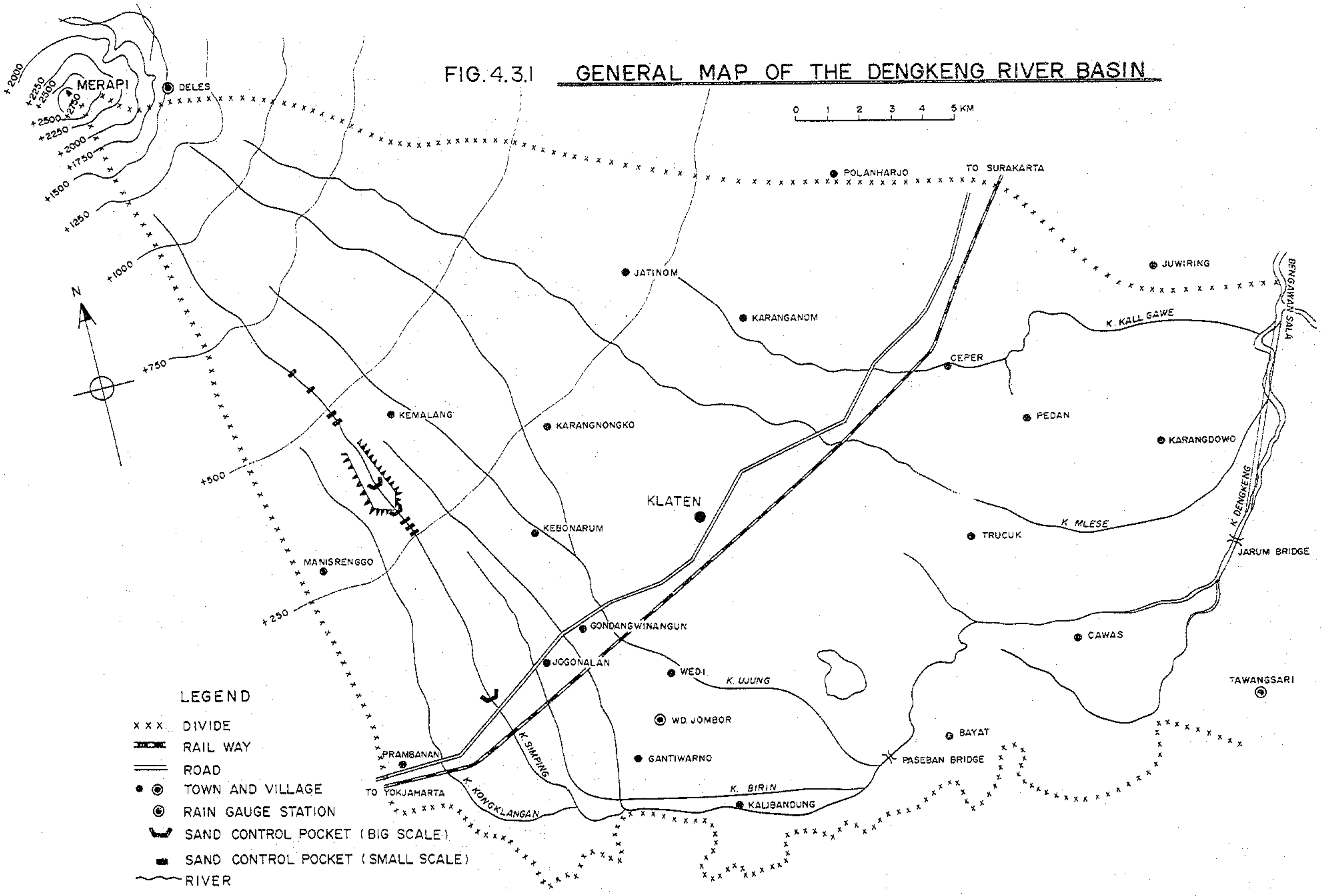


FIG. 4.3.2 ANNUAL RAINFALL

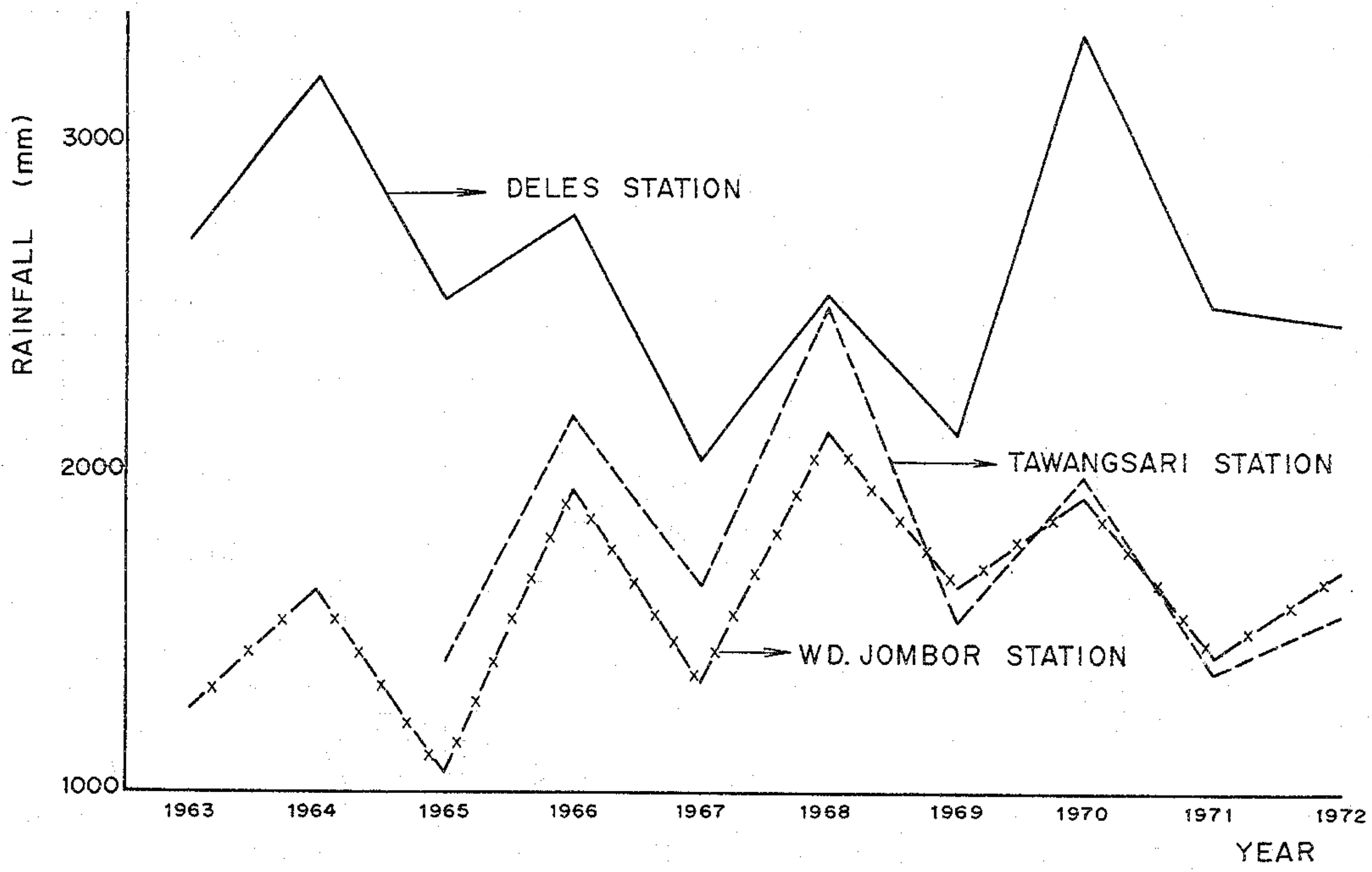


FIG. 4.3.3 MEAN MONTHLY RAINFALL IN THE DENGKENG RIVER BASIN

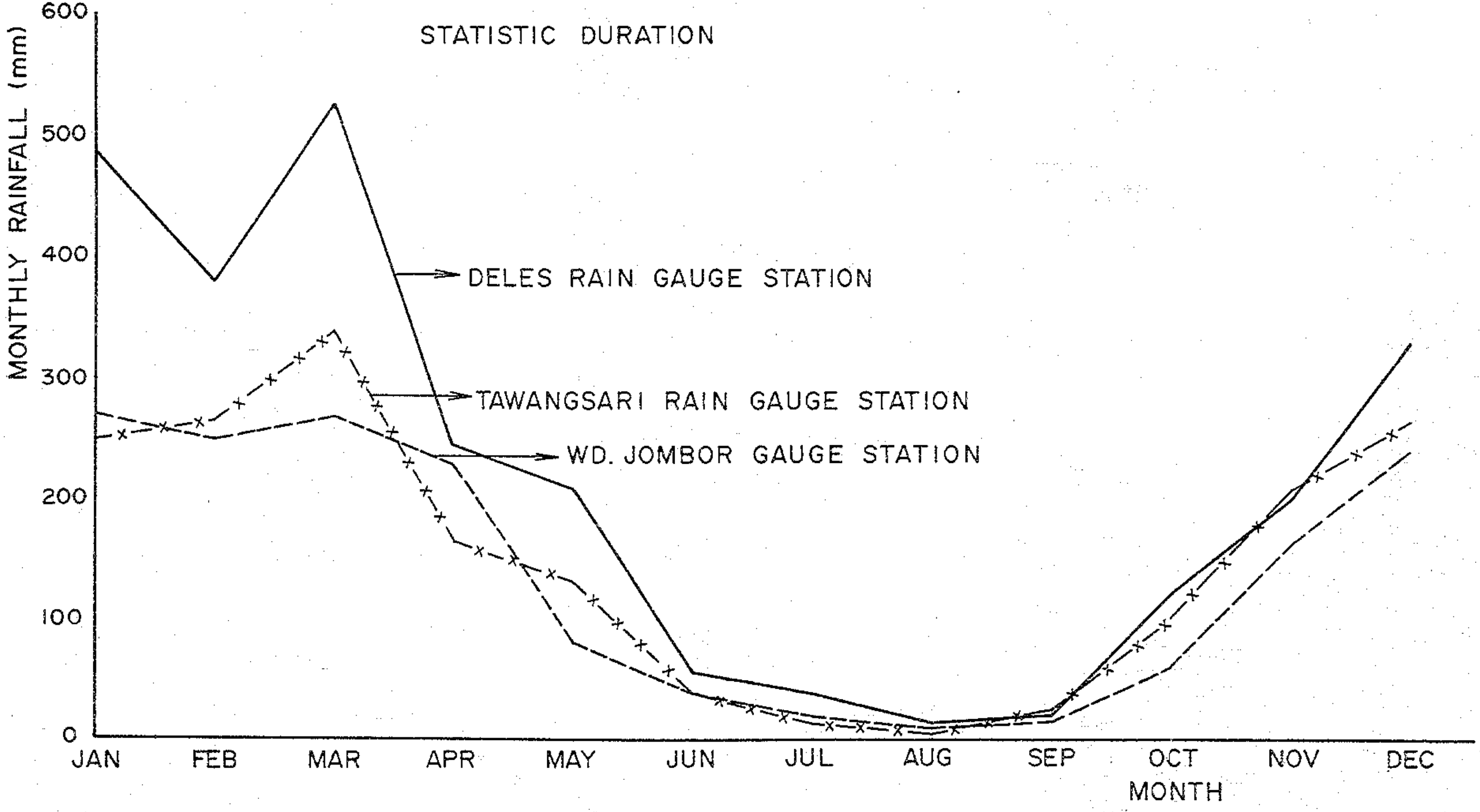
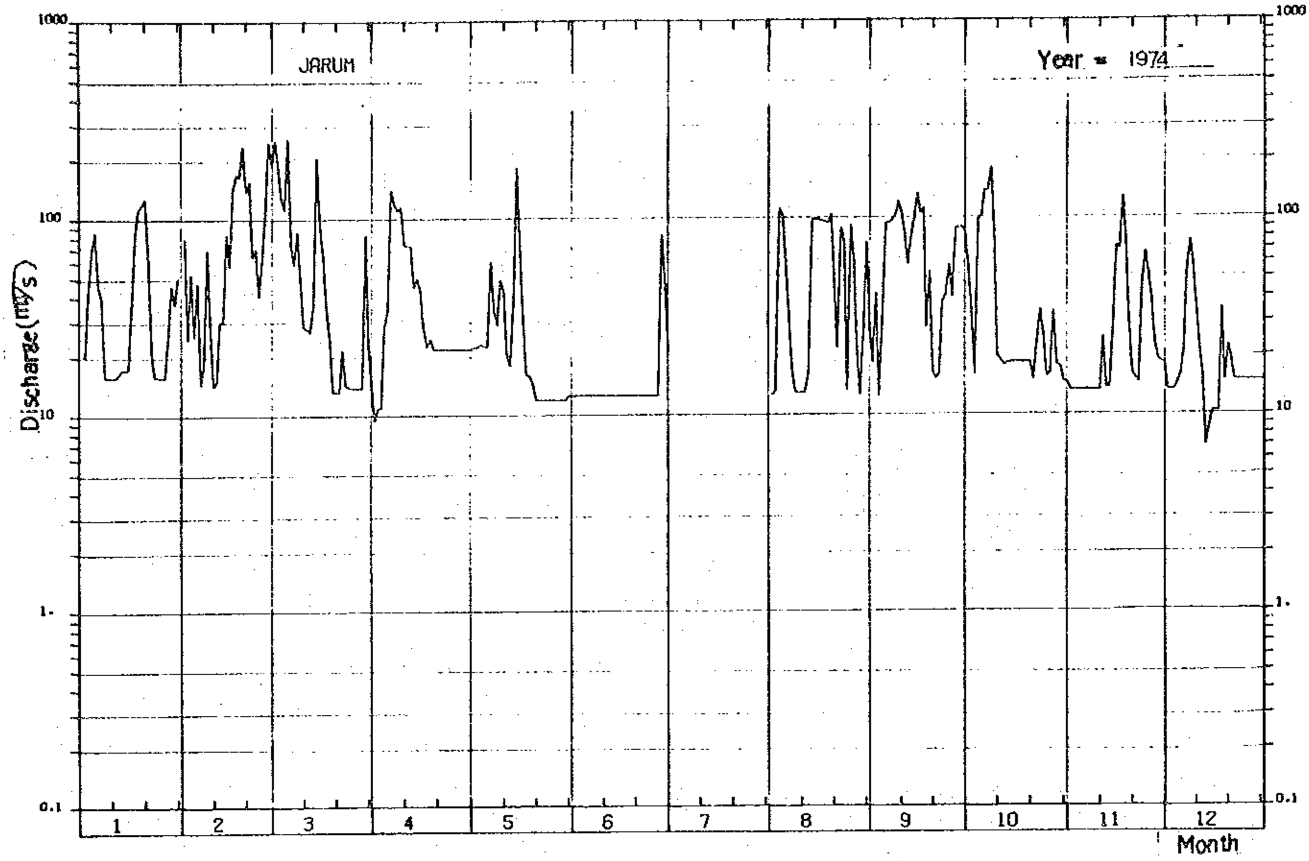


Fig.4.3.4 Daily mean discharge



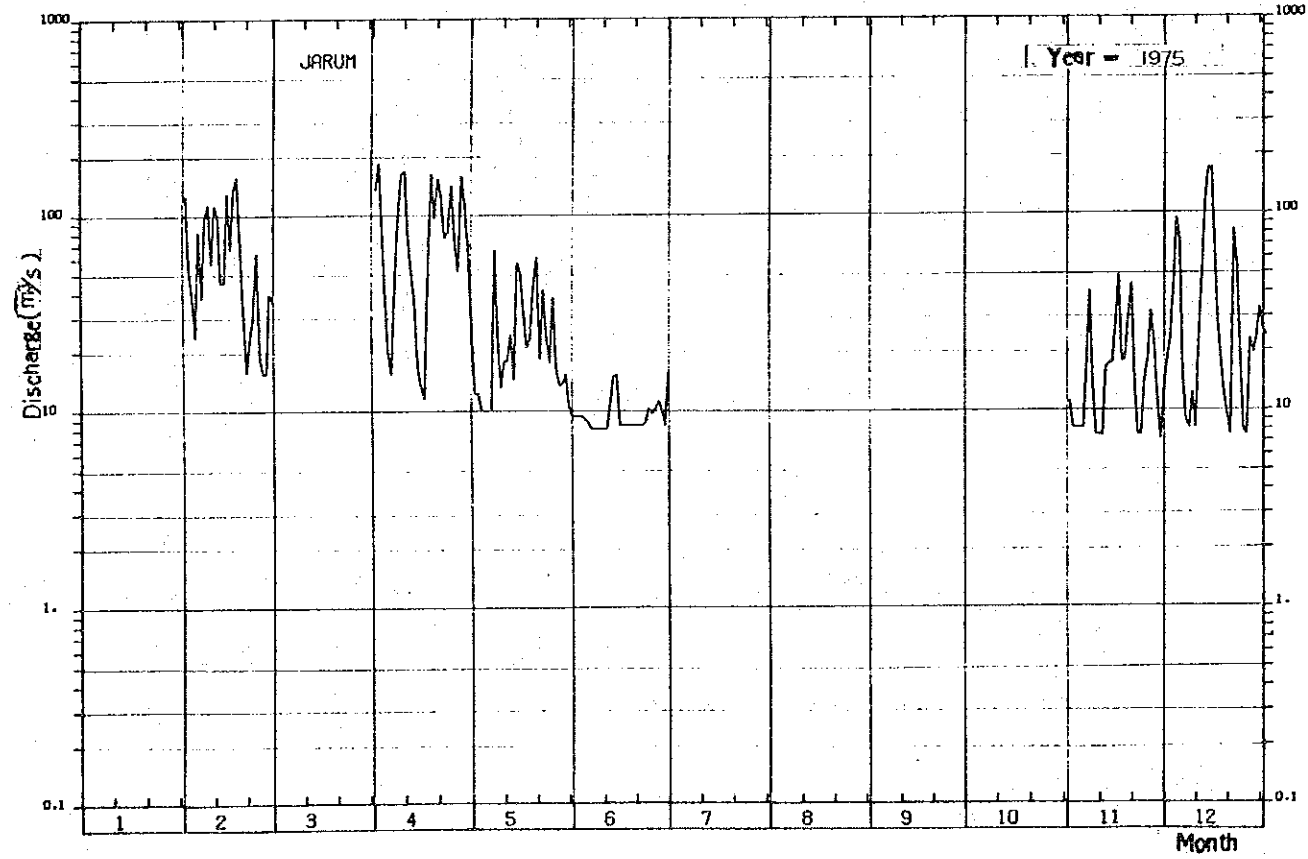


Fig. 4.3.5(a) Daily mean stage

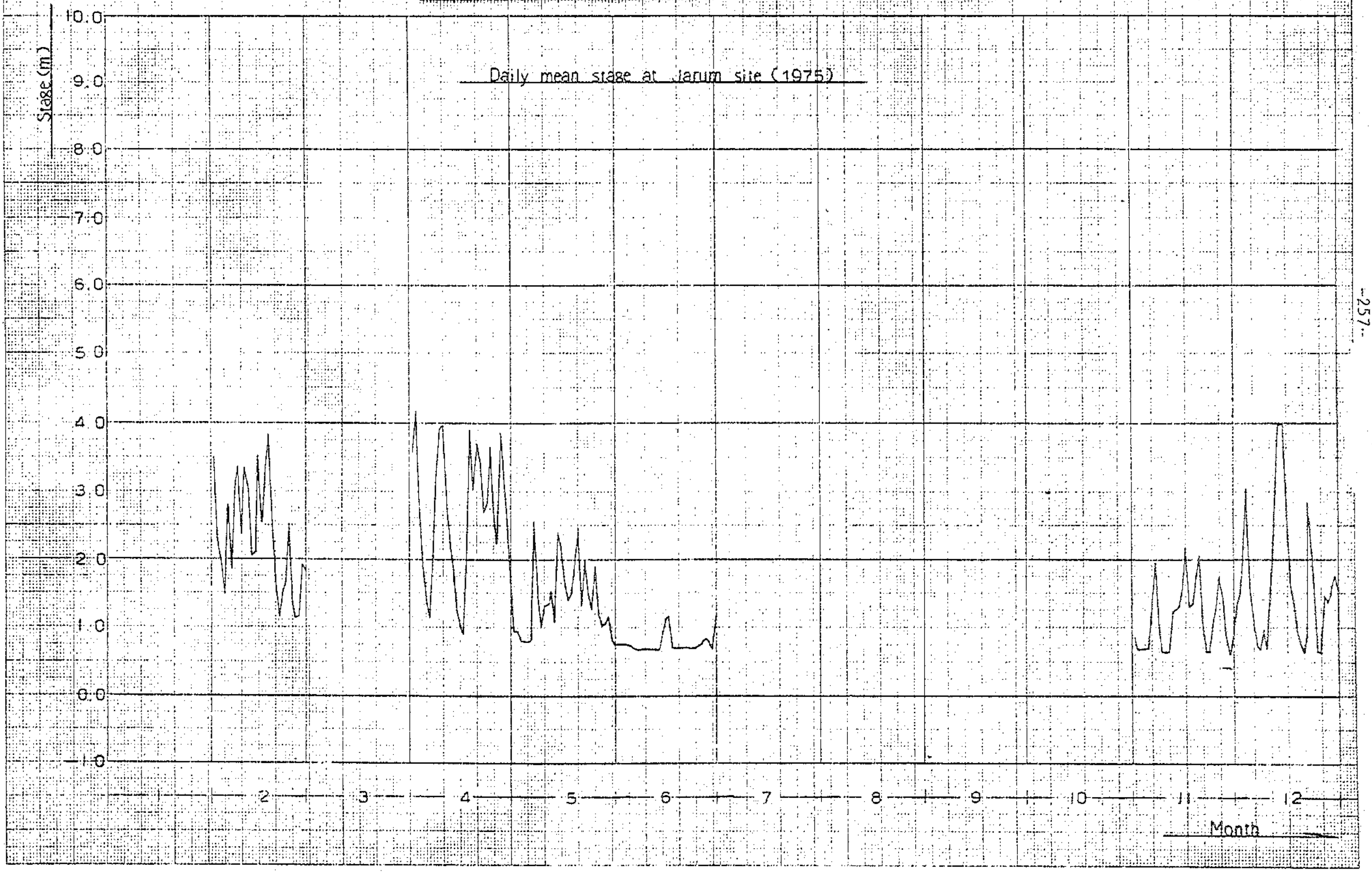


Fig. 4.3.5(b) Daily mean stage

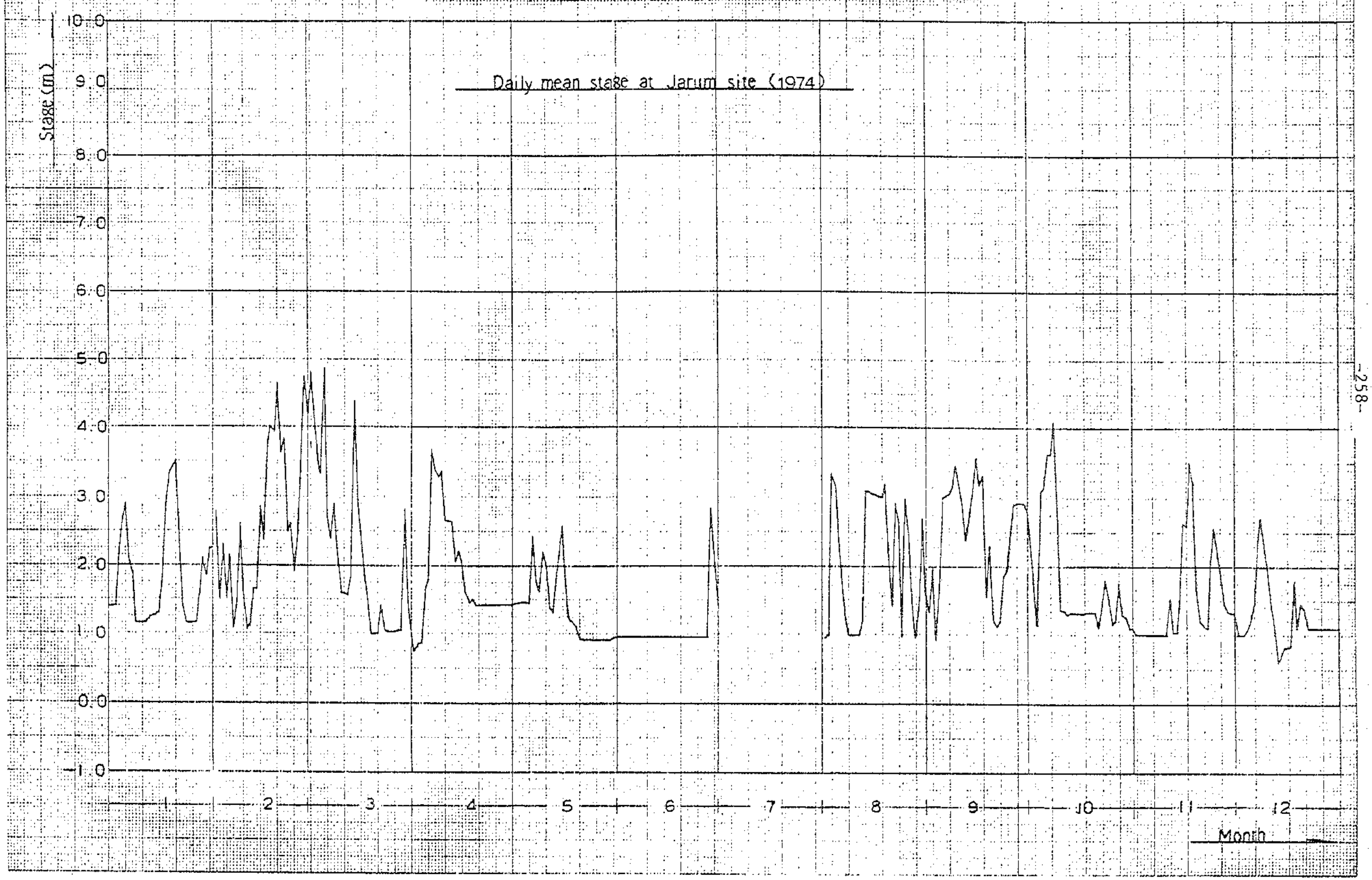
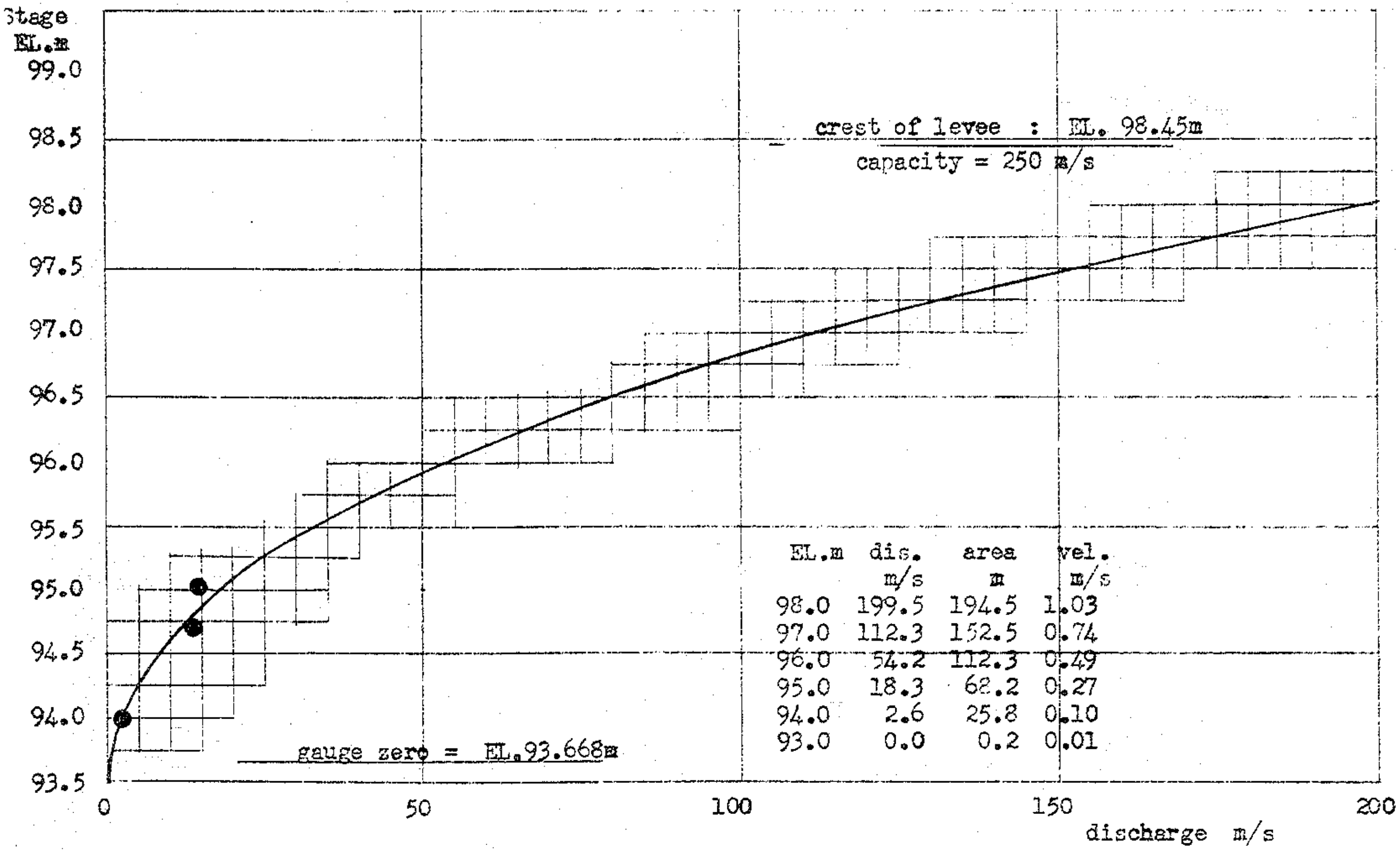


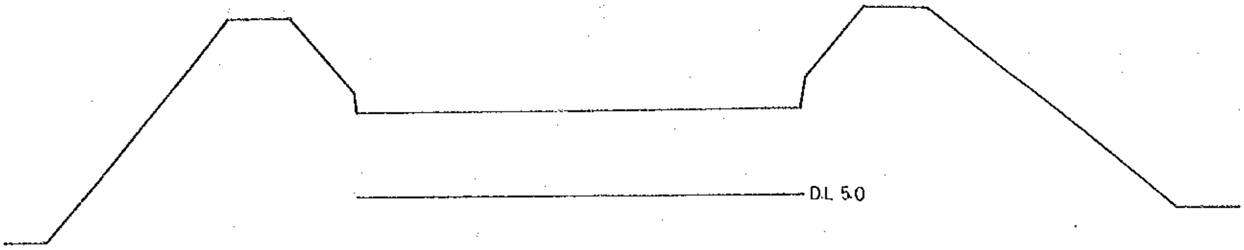
Fig. 4.3.6 Rating curve at Jarum site in K. Dengkeng



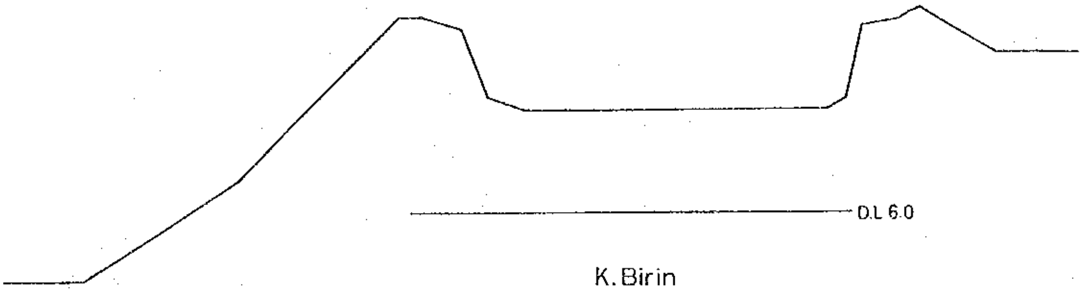
EL.m	dis. m/s	area m	vel. m/s
98.0	199.5	194.5	1.03
97.0	112.3	152.5	0.74
96.0	54.2	112.3	0.49
95.0	18.3	62.2	0.27
94.0	2.6	25.8	0.10
93.0	0.0	0.2	0.01

Fig. 4.3.7 Cross Section

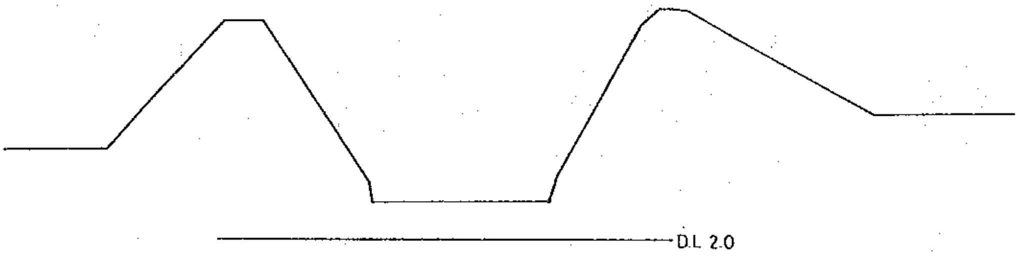
K. Dengkeng



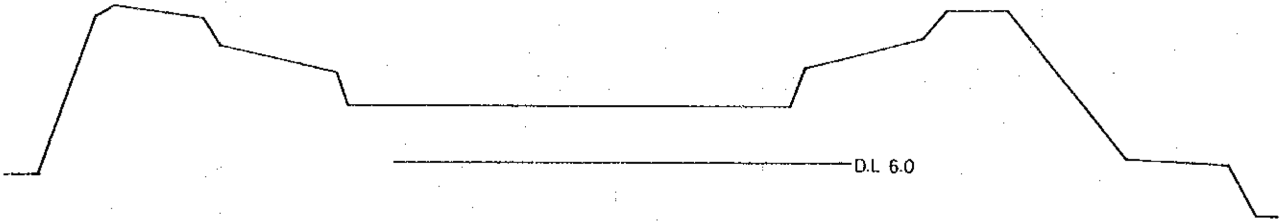
K. Lusah



K. Birin



K. Kongklangan



K. Simping

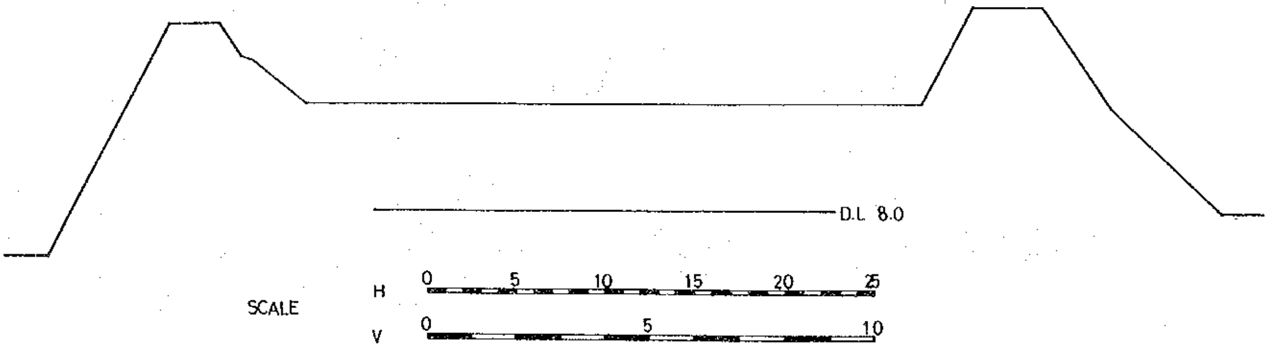


FIG.4.38 LOCATION OF RIVER BED MEASUREMENT SITE

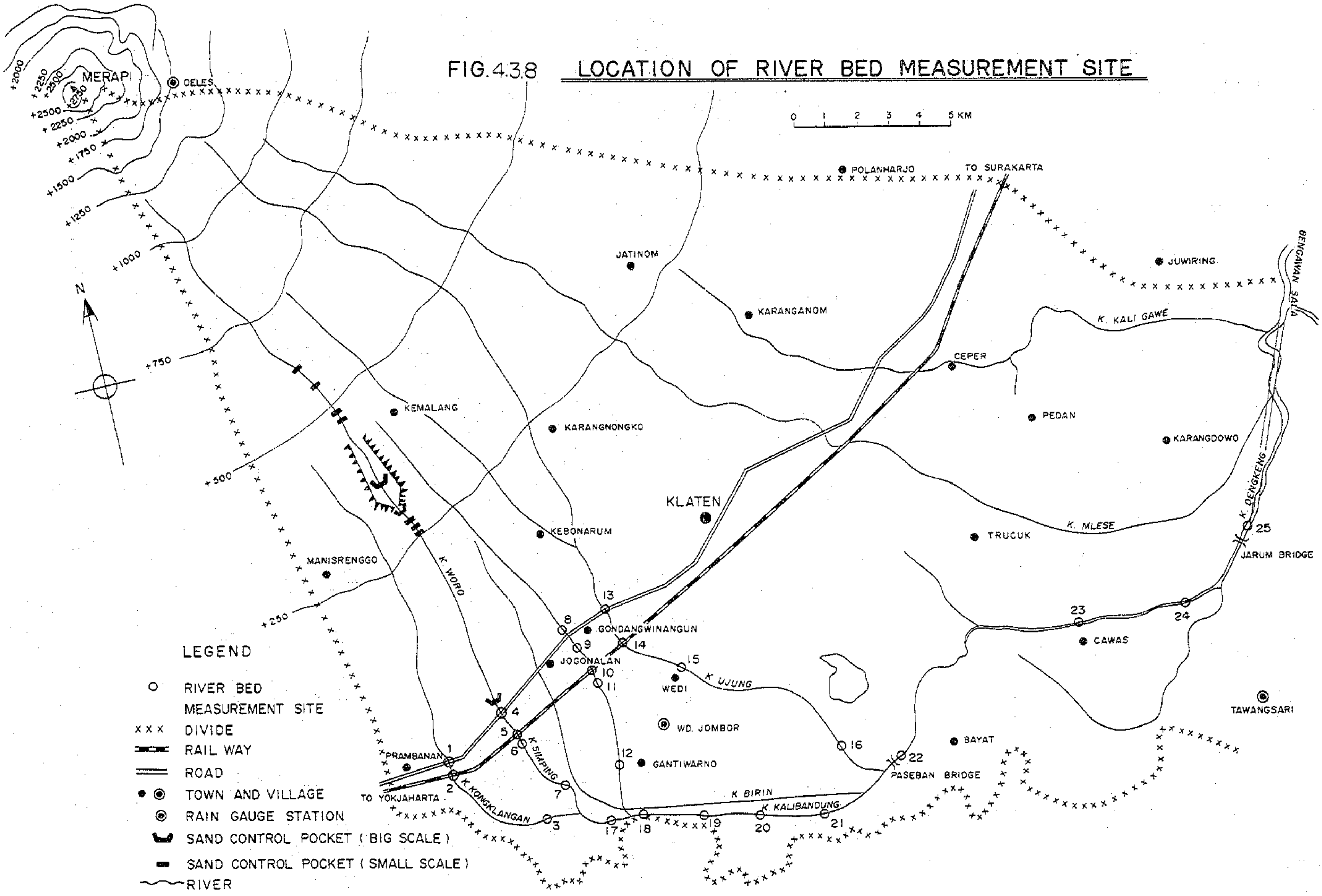


FIG.4.39(a) ANNUAL VARIATION OF RIVER BED
(K.KONGKLANGAN)

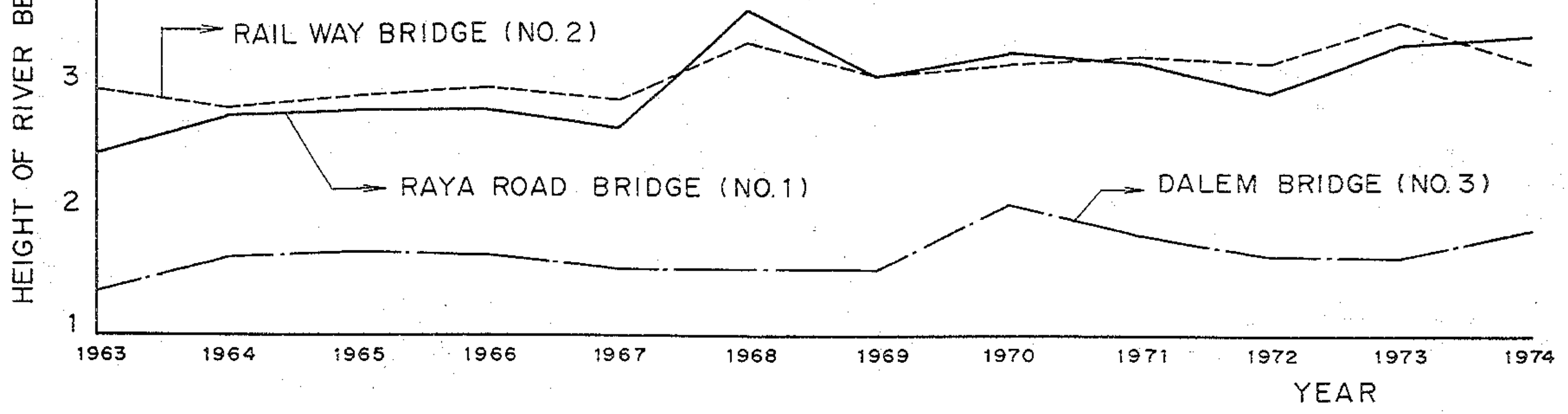


FIG. ANNUAL VARIATION OF RIVER BED
(KALI SIMPING)

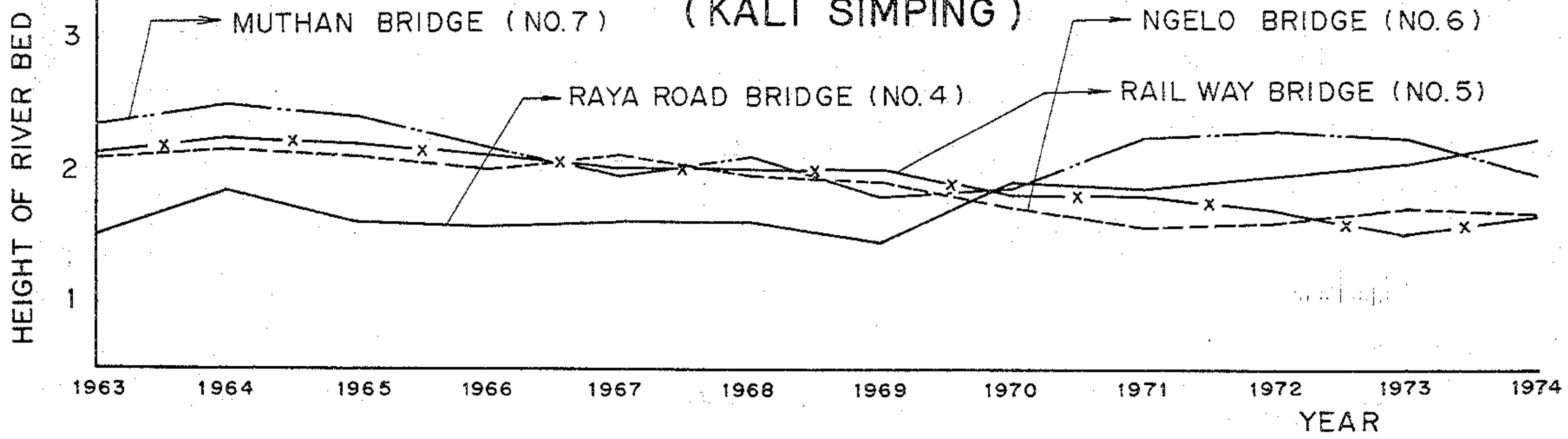
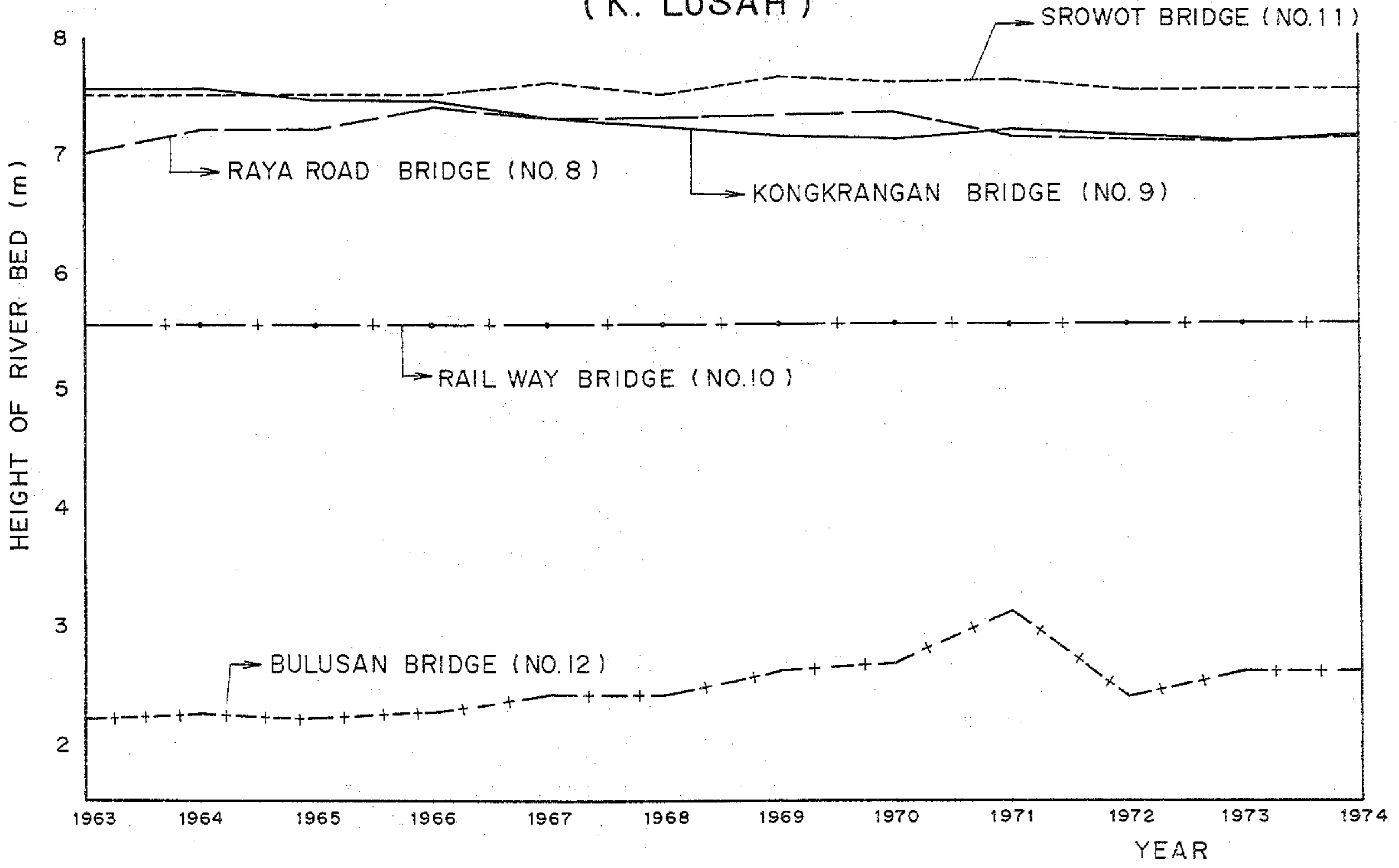


FIG. 4.39(b) ANNUAL VARIATION OF RIVER BED

(K. LUSAH)



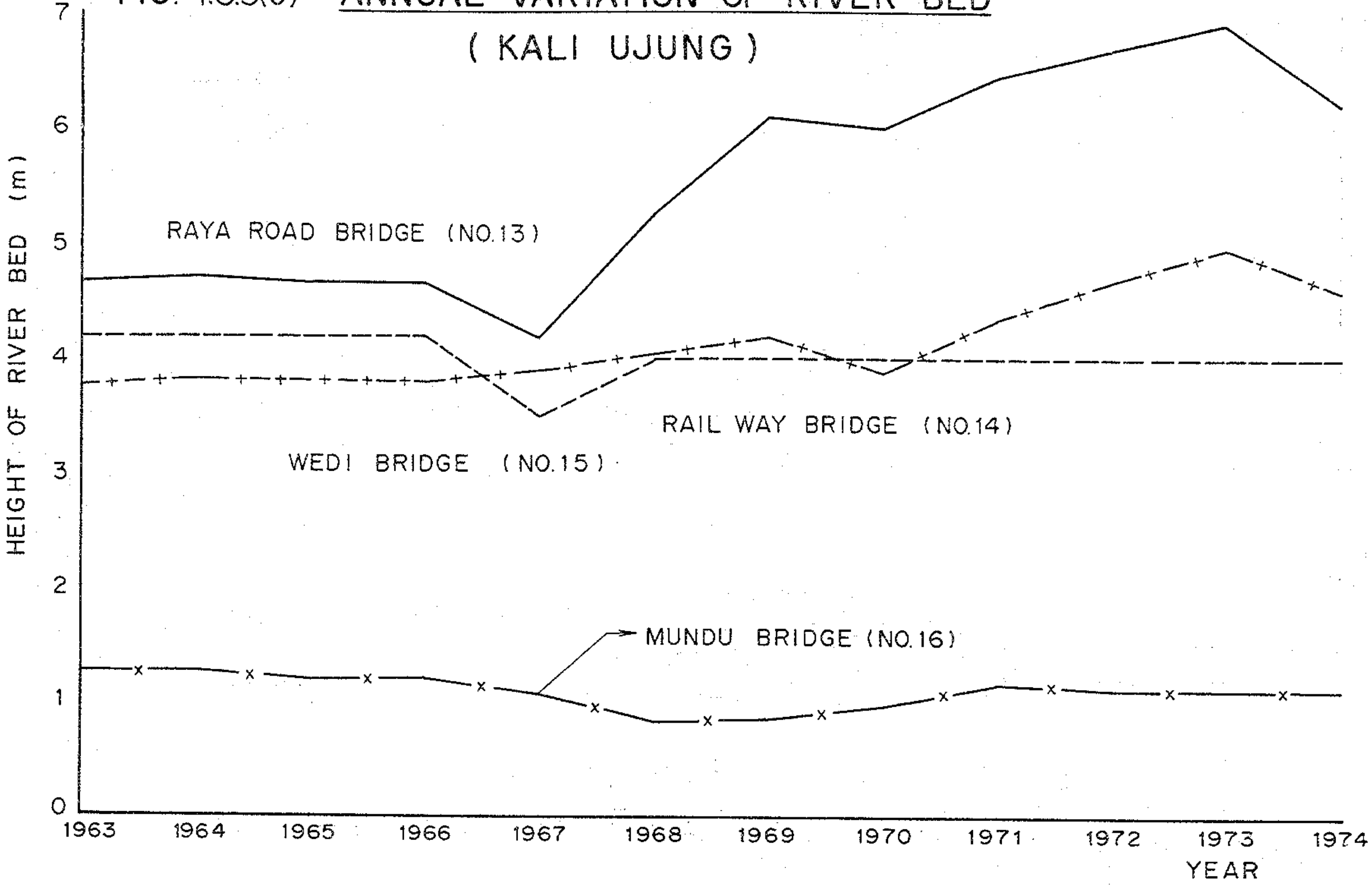


FIG. 4.39(c) ANNUAL VARIATION OF RIVER BED
(KALI UJUNG)

FIG.4.39(d) ANNUAL VARIATION OF RIVER BED
(KALI DENGKENG)

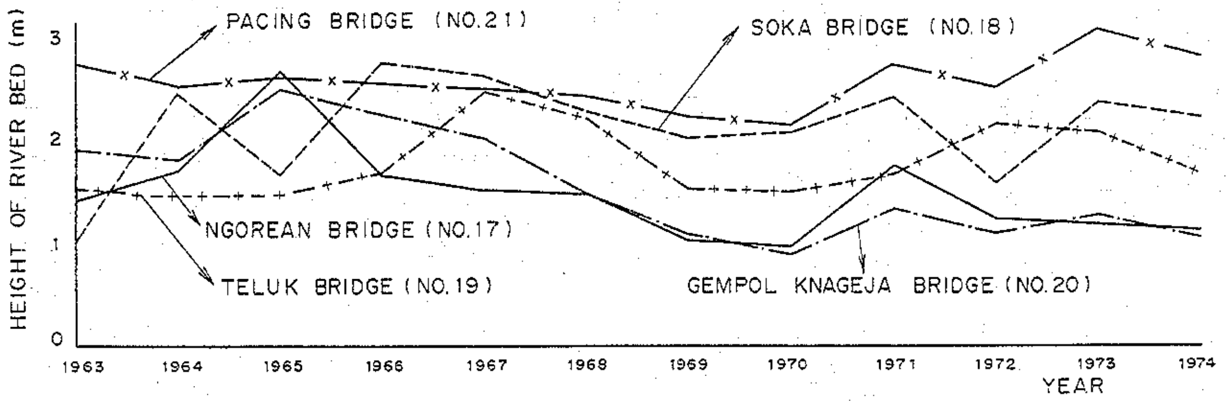


FIG. 4.39(e) ANNUAL VARIATION OF RIVER BED

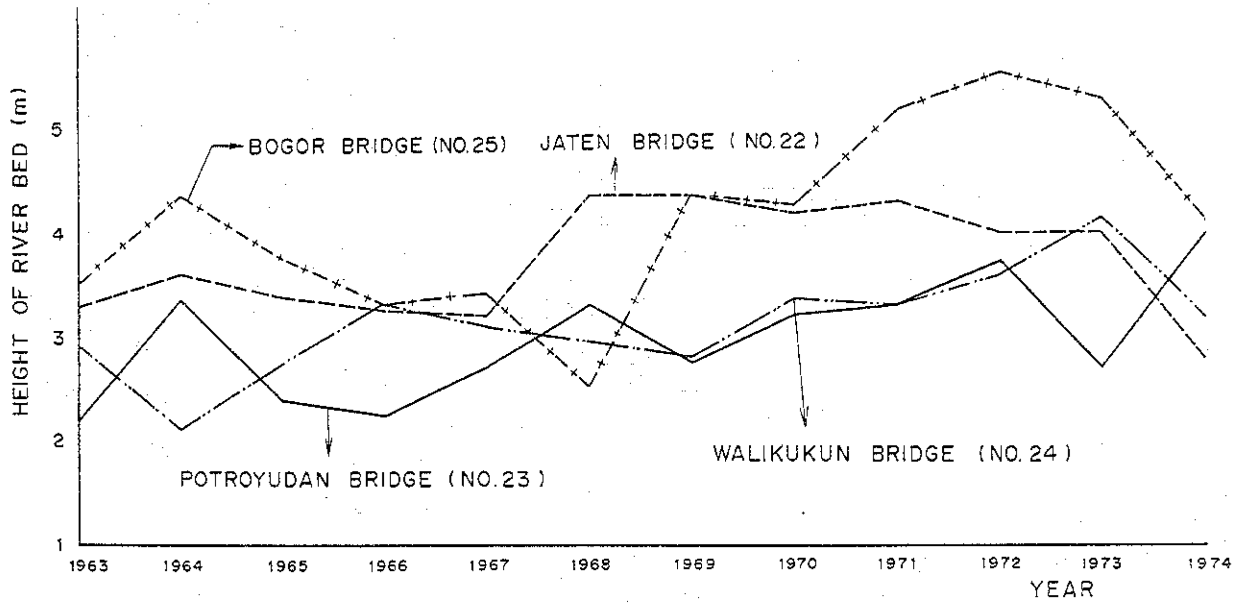
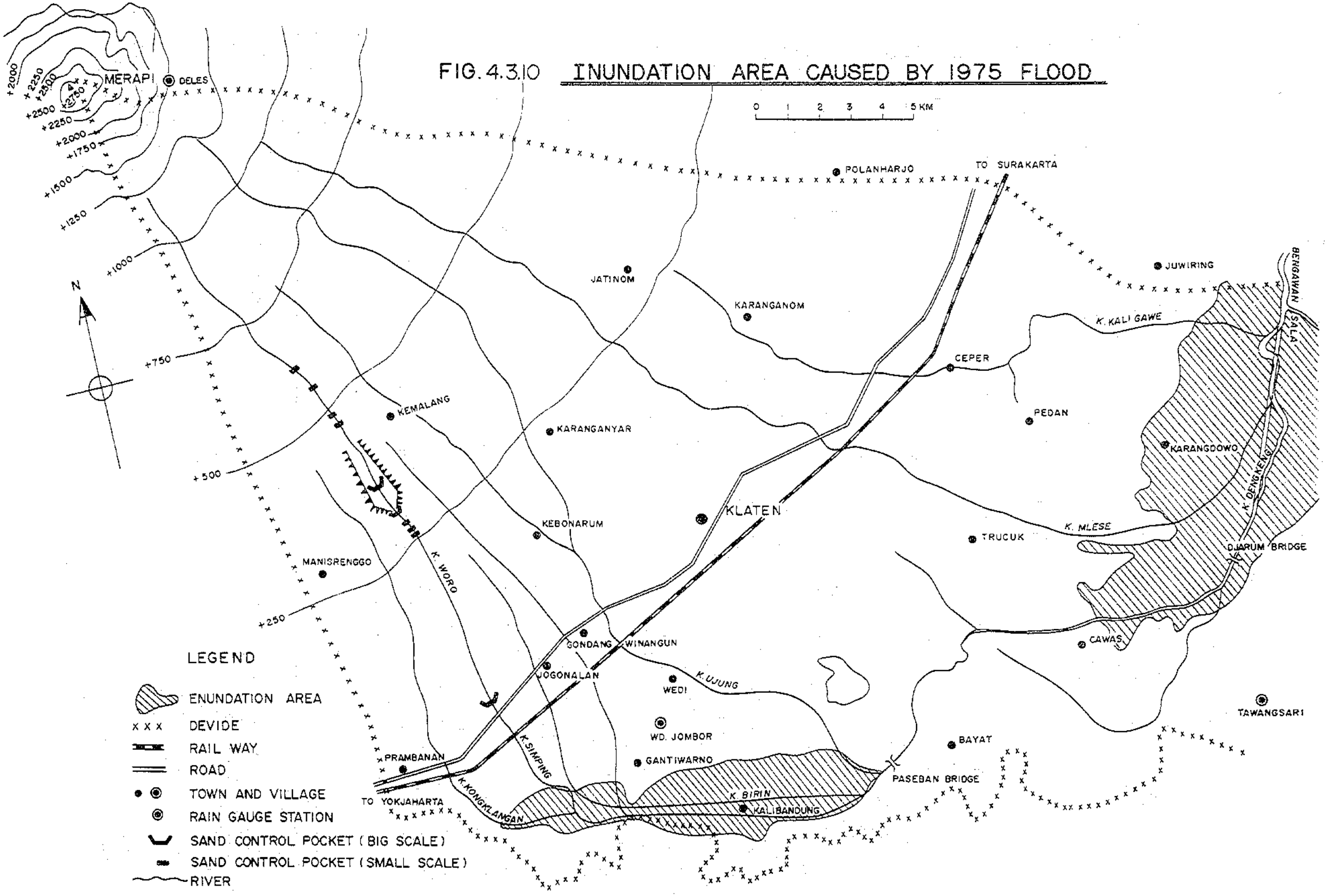


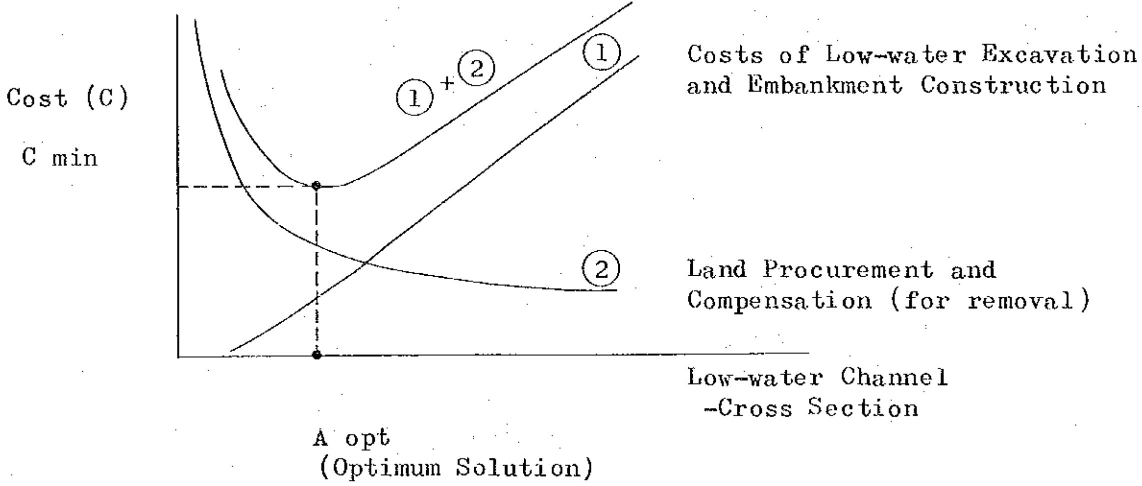
FIG. 4.3.10 INUNDATION AREA CAUSED BY 1975 FLOOD



5. ANNEX III (FUNDAMENTAL CONCEPTION OF RIVER CHANNEL DESIGN)

5.1 GENERAL

Generally, it is economical to perform the excavation of low water channels and banking of levees by taking into consideration the earthwork balance. A method based on the earthwork balance, as shown below, to obtain the most economical cross section may also be considered.



However, this method is merely for the economy of the construction costs and has the disadvantage that the low-water channel cross sections, proposed high-water level, high-water channel width are determined regardless of the river engineering viewpoints. In planning a river improvement, there are several basic considerations, and needless to say, such basic considerations must be duly respected besides the construction cost.

5.2 FUNDAMENTALS OF RIVER IMPROVEMENTS

Fundamentals of river improvements are as below.

1) Maintain the proposed high-water level at as low as practically possible.

2) For cross sections, use composite cross sections as much as possible moreover,

   a) Low- water channel sections should be stabilized.

   b) Design width of high-water channel should be wide enough.

3) For river channel alignment use curves of the easiest curve as much as possible or straight line.

4) Use "levee ended in the mountain" [1/] as far as is practically possible (or similar kind by utilizing roads, where the road surface is higher than the crest of levee, instead of mountains).

5) Avoid abrupt change of profile

6) Others

A further description of the proposed high-water level and cross section contours is as given below.

5.3 PROPOSED HIGH-WATER LEVEL

Floods are natural phenomend and they are in countless varieties in magnitude. The proposed river improvement plan to be formulated here is first to determine a design discharge of a certain magnitude out of a wide range of flood discharge and work out a plan to flow down safely the design discharge. Therefore, floods above the design high-water discharge (extraordinary floods) may have to be expected, so some highly effective counter-measure must be prepared against extraordinary floods especially when the degree of safety of the proposed river channel, namely, the design discharge probability for the river channel design.

The design safety factor of the Sala River which will withstand a flood with the probability of occurrence of once in forty years is not too high. Large rivers in Japan are supposed to withstand floods of 100-year to 200-year recurrence periods. In case of Brantas River, it withstands floods of 50-year recurrence period.

Furthermore, the design high-water discharge of the respective tributaries in this study is fixed using the specific discharge charts as the basis.

Study has not been fully performed yet in regard to the probable variation in the discharge of the main channel of the Sala River in the case of a concentrated rainfall in the remaining basins, contrary to the case of the regional distribution of rainfall in the 1966 flood.

Since hydraulic data required for the study are not available at this stage, there is no other way except to make a macroscopic estimate.

[1/] by connecting levee to a higher land to block or separate inundation area to reduce damage