(b) Finite Difference Form of Equation of Continuity

$$\frac{(Bh)^{n}_{I,J} - (Bh)^{n-1}_{I,J}}{\Delta t} + \frac{Q^{n-1/2}_{I+1/2,J} - Q^{n-1/2}_{I-1/2,J}}{\Delta x} + \frac{Q^{n-1/2}_{I,J+1/2} - Q^{n-1/2}_{I,J-1/2}}{\Delta y} = 0$$

where,
suffix I, J : mesh number of x and y direction
suffix n : computative time step number

8.4 Initial Condition for Computation

The maximum inundation depth and the inundation area are examined under the probable flood discharge of 2-year, 5-year, 10-year, 20-year, 30-year, 50-year and 100-year return period. As the initial condition for computation, it is necessary to give the overflow discharge to the inundation area and the overflow section. Under this consideration, the following initial conditions are taken into account:

(a) The overflow sections are selected where the flow capacity is very poor compared with the adjacent stretches.

(b) It is assumed that in the probable flood hydrograph, the surplus discharge over the flow capacity overflows at the overflow section. The overflow discharge at the overflow section is given by the surplus discharge over the flow capacity in the flood hydrograph after subtracting the overflow discharge at the overflow section.

8.5 Computation Results

The probable inundation area and maximum water depth in each river, which correspond to the probable flood discharge of the master plan are shown in Fig. 8-2. Except the Ular River, the probable inundation area is estimated at about 500 km^2 in total for the six (6) other rivers.

Although the adequacy of the inundation model is not verified due to lack of hydrological records, this model seems to be applicable because the water depth between the actual flood of November 1990 as described in Section 5.5 and the computation results of a 10-year return period are similar, as shown in Fig. 8-3.

Table 2-1 DAILY RAINFALL RECORDS AVAILABLE AT PMG IN THE STUDY AREA

No	Name of Station	EL (m.MSL)	Location		Year of Record
			Longitude	Latitude	1950 55 60 65 70 75 80 85 90
1	Sampali	25	98° 47'	3° 47'	<---------->
2	Polonia	3	98° 42'	3° 48'	<---------->
3	Belawan	27	98° 44'	3° 34'	<----->
4	Tanjung Morawa				<---------->

Table 2-2 DAILY RAINFALL RECORDS AVAILABLE IN THE ULAR RIVER BASIN

No	Name of Station or Estates	EL (m.MSL)	Location		Year of Record
			Longitude	Latitude	1950 55 60 65 70 75 80 85 90
1	Perbaungan	15	98° 56'	3° 34'	BAABAAABAAAAAA
2	Kotarih	110	98° 52'	3° 20'	BAABABAABBAAAA
3	Gunung Meriah	680	98° 42'	3° 07'	BBBBA A AAAB
4	Negeri Dolok	250	98° 51'	3° 10'	BAABABAAABAAAB
5	Tiga Runggu	1310	98° 43'	3° 54'	BBABABABAB
6	Sarang Padang	1080	98° 42'	3° 03'	BAABBBAABBB
7	Silinda	200	98° 48'	3° 16'	BAAABB
8	Rumah Delang	210	98° 45'	3° 18'	BAABB
9	Tiga Juhar	310	98° 43'	3° 16'	BAABB
10	Negeri Kasihon	280	98° 50'	3° 10'	BAA BA
11	Paku	70	98° 53'	3° 21'	
12	Bah-Bah	540	98° 42'	3° 12'	
13	Sarang Ganjang	1400	98° 37'	2° 58'	
14	Pematang Raya	1010	98° 51'	2° 58'	BBBBBA
15	Siporkas	910	98° 51'	3° 01'	BABABAAAB
16	Sangai-sangai	950	98° 48'	3° 00'	BBABAB
17	Purba Etek	1400	98° 37'	2° 58'	BAAABA
18	Huta Raja	1200	98° 43'	2° 56'	BAAABB
19	Marubun Lokung	360	98° 45'	3° 12'	BAABB
20	Huta Silau	130	98° 54'	3° 15'	BABBBA
21	Purba Sinumbah	1300	98° 39'	2° 58'	BABBBB
22	Durian Tinggun	530	98° 32'	3° 12'	BAABBB
23	Bandar Pinang	80	98° 55'	3° 19'	BAABBB
24	Bandar Kuala	70	98° 54'	3° 22'	BAAABB
25	Serbajadi	70	98° 57'	3° 23'	

Note : A = complete data, B = incomplete with missing

TABLES

Table 2-3(1/3) DAILY RAINFALL RECORDS AVAILABLE AT ESTATE IN THE STUDY AREA

No	Name of Station or Estates	EL (m.MSL)	Location		Year of Record
			Longitude	Latitude	1950 55 60 65 70 75 80 85 90
1.01	Balai Penelitian	32	98° 41'	3° 33'	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
1.02	Bandar Baru	864	98° 30'	3° 16'	BAAA
1.03	Bandar Khalipah	16	98° 45'	3° 36'	AAAAAAAAAAAAAAAAAAAAAAABBBABAAAABAAAB
1.04	Belawan Estate	40	98° 36'	3° 32'	BAAAAAAA
1.05	Bulu Cina	11	98° 34'	3° 42'	AAAAAAAAAAAAAAAAAAAAAABBBAAAAAAABAAB
1.06	Glugur	80	98° 33'	3° 31'	AAAAAAAAAAAAAAAAAAAAAAAABB
1.07	Helvetia	15	98° 40'	3° 38'	AAAAAAAAAAAAAAAAAAAAAAAAAAAAAABABB BBB
1.08	Klambir Lima	17	98° 36'	3° 38'	BBAAAAAAAAAAAAAAAABBBBAAAAAAAAAAAAAB
1.09	Klumpang	14	98° 36'	3° 40'	BAAAAAAAAAAAAAAAAAAAAAAAAABBAAAABBAB
1.10	Mabar	12	98° 41'	3° 40'	BAABAAABAAAAAAABABBAB B
1.11	Mariendal	46	98° 42'	3° 31'	AAAAAAAAAAAAAAAAAAAAAAAAAAAABBAAA AAB
1.12	Medan Estate	21	98° 42'	3° 36'	AAAAAAAAAAAAAAAAAAAAAAAAABAAAAAAB
1.13	Medan Putri	20	98° 40'	3° 36'	AAAAAAAAAAAAAAAAAAAAABAAAAAAAAAA
1.14	Paya Bakong	14			BAAAAAAAAAAAAAAAAAABBBABBBAAAAA
1.15	Patumbak	89	98° 43'	3° 27'	AAAAAAAAAAAAAAAAAAAAAAAAAAABB AABAB
1.16	Sei Semayang A.	29	98° 34'	3° 35'	AAAAAAAAAAAAAAAAAAAABA BAAABABBABAB
1.17	Saentis	7	98° 45'	3° 40'	BAAAAAAAAAAAAAAAAAAAAAB BBAAAAAABAAAB
1.18	Sampali	12	98° 43'	3° 38'	AAAAAAAAAAAAAAAAAAAAAABAAAAAABAAB BBB
1.19	Seruwai	6	98° 42'	3° 44'	BAAAAAAAAAAAAAAAAAAAAAAAAAABAAAAAAAB
1.20	Sei Mencirim	50	98° 22'	3° 33'	BAAAB
1.21	Sei Sikambing	23	98° 38'	3° 35'	BAAAAAABBAAAAAAAAAAABB
1.22	Tandem	14	98° 31'	3° 38'	AAAAAAAAAAAAAAAAAAAABAA BBAAAAAABAABB
1.23	Tandem Hilir	12	98° 31'	3° 42'	AAAAAAAAAAAAAAAAAAAABA BBAAAAABAAAAB
1.24	Timbang Langkat	29	98° 31'	3° 35'	AAAAAAAAAAAAAAAAAAAAAABBBBBAAAAA
1.25	Tuntungan	79	98° 34'	3° 30'	AAAAAAAAAAB
1.26	Yayasan Karet	25	98° 42'	3° 34'	BAAAAA B BB
1.27	Sei Sikambing	25	98° 39'	3° 30'	
1.28	Mariendal Coklat	30	98° 42'	3° 32'	BB
1.29	Glugur Rimbun	127	98° 33'	3° 27'	BBAABAB
1.30	Bandar Baru(Sairy)	864	98° 33'	3° 17'	

Note : A = complete data, B = incomplete with missing

Table 2-3(2/3) DAILY RAINFALL RECORDS AVAILABLE AT ESTATE IN THE STUDY AREA

No	Name of Station or Estate	EL (m.MSL)	Location		Year of Record
			Longitude	Latitude	1950 55 60 65 70 75 80 85 90
3.01	Adolina Hilir	18	98° 57'	3° 32'	AAAAAAAAA B ABAAA
3.02	Adolina Hulu	30	98° 57'	3° 28'	B AAAAAAAAAAA
3.03	Aek Pancur	50	98° 47'	3° 28'	AAAAAAAAAAAAAAAAAAAAAAAAAAABAAAAAAAAAAAAAAA
3.04	Bandar Kwala	80	98° 53'	3° 22'	AAAAAAAAA AAAABBBAABB A
3.05	Bandar Negeri	110	98° 57'	3° 17'	AAAAAAAAAAAAAAAAAAA BABBAAAAAABB
3.06	Bandar Pinang	98	98° 55'	3° 19'	B AAAAAAAAAAAAAAAAAAAAABBBABAAAAAAAAB
3.07	Batang Kwis	9	98° 48'	3° 37'	AAAAAAAAAAAAAAAAAABAAAAAAA B BAABAAAB
3.08	Batu Gingging	118	98° 48'	3° 23'	AAAAAAAAAAAABBBB BB
3.09	Batu Rata	65	98° 50'	3° 25'	A AAAA AABB AA BBAAAABAAB
3.09 a	Bangun Purba	118	98° 48'	3° 21'	B AAAAAAB ABAB AB A AB B B
3.10	Bagerbang	64	98° 49'	3° 24'	AAAAAAAABBBAAAAAA BAAAABBA BB
3.11	Bengabing	18	98° 00'	3° 31'	AAAA AAAAAAAAAAA BBAAAAAABAB
3.12	Deli Muda	12	98° 01'	3° 34'	A AAAAAAAAAAAABBBBABAA BAAAAAABABBB
3.13	Greahan	137	98° 52'	3° 22'	AAAAAAAAAAAAAAAA BB A
3.14	Sei Karang	50	98° 52'	3° 25'	B AAAAAAAAAAAAAAAABABABBBABAAABABABB
3.15	Kwala Namu	12	98° 53'	3° 25'	AAAA AAAAAAAAAAAAAAAAABAB BABAB
3.16	Limau Mungkur	60	98° 47'	3° 26'	AAAA AAAAAAAAABAAAAAAAA BB BBBAA
3.17	Melati	16	98° 58'	3° 33'	AAAA AAAAAAAAAAAAAAAAAAABAABB
3.18	Pagar Merbau	24	98° 54'	3° 30'	AAAA AAAAAAAAAAAAAAAAAAA B BABBABAB
3.19	Ramunia	8	98° 54'	3° 37'	AA B
3.20	Serbajadi	58	98° 56'	3° 23'	BAAAAAAAAAAAB B
3.21	Sei Kari	109	98° 32'	3° 20'	AAAAAA AAAAAAAAAAAABBBABBABBABAAB
3.22	Sei Merah	16	98° 50'	3° 32'	BAAAB BAAAAAAAAAABBBABAAABABAAB
3.23	Sei Pancur	25	98° 48'	3° 30'	AAAAAA AAAAAAAAAAAAAAAAAABABAAABAAAAAAAAA
3.24	Sei Putih	54	98° 53'	3° 24'	B AAAAAAAAAAAAAAAAAAAAABAABBAAABBBAAB
3.25	Sei Tuan	4	98° 48'	3° 40'	AAAA B
3.26	Tanjung Garbus	14	98° 52'	3° 31'	AAAA AAAAAAAAAAAAAAAAAB BAB
3.27	Tanjung Morawa Kanan	20	98° 47'	3° 31'	AAAA AAAAAAAAAAAAAAAABAABA BBA BABAB
3.28	Tanjung Purba	60	98° 51'	3° 24'	B AAAAAAAAAAAAAAAAAAAABBBBBAABAB
3.29	Timbang Deli	36	98° 54'	3° 27'	B AAAAAAAAAAAAAAAABAAAAABBBABABAAAAAAB
3.30	Tanah Abang	27	98° 54'	3° 29'	AAA BAAAABBB
3.31	Hotari	121	98° 51'	3° 19'	AAAAAAAAAAAAABBBABAABBAAAAB
3.32	Silinda	207	98° 48'	3° 14'	AAAAAABBBBAAAAAAAAAAB

Note : A = complete data, B = incomplete with missing

Table 2-3(3/3) DAILY RAINFALL RECORDS AVAILABLE AT ESTATE IN THE STUDY AREA

No	Name of Station or Estate	EL (m.MSL.)	Location		Year of Record
			Longitude	Latitude	1950 55 60 65 70 75 80 85 90
4.01	Bahilang	30	99° 08'	3° 18'	BAAAAAAAAAAAAAAAB B BBBB
4.02	Bandar Bejambu	43	99° 05'	3° 17'	BAAAAAAAAAAAAAAAAAAAAAABBBABAABBABBBB
4.03	Bangun Bandar	60	99° 01'	3° 19'	AAAAAAAAAAAAAABAAAABBBABBAAAAABAAAAB
4.04	Sinar Kasih	23	99° 04'	3° 25'	BAAAAAAAAAAAAAAAAAAAAA BA
4.05	Gunung Monako	110	99° 00'	3° 13'	BAAAAAAAAAAAAAAAAAAA AABAAAABABAAABB
4.06	Gunung Pamela	76	99° 04'	3° 13'	BAAAAAAAABAAABABBB BAAAABABAABBB
4.07	Gunung Para	114	99° 06'	3° 10'	BAAAAAAAAAAAAAAAAAABAABBBBABAAABBABBB
4.08	Hevea Est.	43	99° 01'	3° 22'	AAAAAAAAAAAAAAAAAAAABBBBBAABB
4.09	Mata Poa	7	99° 05'	3° 22'	AAAAAAAAAAAAAAAAAAAAAABBBBABAAAAAAAAB
4.10	Naga Raja	153	99° 02'	3° 08'	BAAAAAAAAAAAAAAAAAAAABBA
4.11	Pabatu	30	99° 17'	3° 17'	BAAAAAAABAAAAAAAA BBBAAAABBABABA
4.12	Paya Mabar	5	99° 12'	3° 24'	BAAAAAAAAAAA ABAAAAA AAAABAABA ABAB
4.12 a	Sei Buluh	5	99° 11'	3° 26'	AAAAAAAAAAA ABA
4.13	Paya Pinang	36	99° 11'	3° 18'	BAAAAAAAAAAAAAAAAAAAABBBBBAAAAABAAB
4.14	Priok	5	99° 13'	3° 24'	BAAAAAAAAAAAAAAAAAB
4.15	Rambutan	13	99° 10'	3° 23'	BAAAAAAAAAAAAAAAAAABAABBABAABBBBBAAAA
4.15 a	Rambutan Acd.	13	99° 06'	3° 31'	BAAAAAAAA AA
4.16	Rambong Est.	20	99° 03'	3° 27'	BAAAAAAAAAAAAAAAAAAAAAAABBBBB
4.17	Rambong Sialang	30	99° 00'	3° 26'	BAAAAAAA BAAAAABAAABBBBABAAAABAAAB
4.17 b	Rambong Firdaus	7	99° 07'	3° 29'	BAAAAAAA B ABAAABAAABBB BB BBBAAB
4.18	Sarang Gining	76	99° 58'	3° 21'	AAAAAAAAABBAAAAB B BBBAABBBBBB BB
4.19	Sei Bamban	8	99° 10'	3° 26'	BAAAAAAAAAAAAAAAAAAB B BBABBBBBBAAAB
4.20	Sei Birung	7	99° 15'	3° 22'	BAAAAAAAAAAAAAAAAAABAAAAAAAAAAB
4.21	Sei Parit	2	99° 06'	3° 27'	AAAAAAAABBAAAAAAAAAAAAA AAAAABB
4.22	Sei Rampah	5	99° 10'	3° 17'	BAAAAAAA BBAA B BAAAAB
4.23	Sei Bulau	62	99° 10'	3° 15'	BAAAAAAAAAAAAAAAABAB BBBBABAAAAAAAAB
4.24	Silau Dunia	95	99° 58'	3° 16'	BAAAAAAAAABBAAAAAAAAAABBB ABABBABB
4.25	Tanah Besih	33	99° 13'	3° 19'	AAAAAAAAAAAAAAAAAAAAAAAAB
4.26	Tanjung Maria	40	99° 04'	3° 20'	AAAAAAAAAAAAAAAABB
4.27	Tanah Raja	14	99° 03'	3° 32'	BAAAAAA B AAAAABBAABAAABABBBB
4.28	Ratua (ex Mendaris)	30	99° 14'	3° 18'	BAAAAAAAAA B BBBBAAA
4.29	Mendaris A	30	99° 14'	3° 17'	AAAAAAAAABABAAAAAB BBB

Note : A = complete data, B = incomplete with missing

Table 2-4 CLIMATOLOGICAL DATA AT SAMPALI STATION (PMG) IN MEDAN

Item	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total / Average
Monthly Rainfall	mm	95	69	74	121	176	105	130	161	231	250	209	201	1,982
Mean Temparature	°c	25	26	26	27	27	27	26	26	26	26	26	26	26
Mean Max. Temp.	°c	31	32	33	33	33	33	32	32	31	31	31	31	32
Mean Min. Temp.	°c	21	21	21	22	23	22	22	22	22	22	22	22	22
Relative Humidity	%	85	84	84	84	85	84	83	84	86	87	87	86	85
Rainy Days	days	8	8	8	11	13	9	13	14	18	19	18	15	154
Sunshine Duration	%	49	54	59	57	57	60	59	58	49	45	43	47	53
Wind Velocity	m/sec	1.28	0.81	0.85	0.78	0.73	0.74	0.81	0.76	0.75	0.75	0.75	0.85	0.82
Evaporation	mm/day	3.8	4.5	4.5	4.7	4.6	4.7	4.5	4.8	4.1	4.0	3.9	3.4	4.29

Note : Data except rainfall and evaporation are the average of 1974-1984 (by PMG)

Table 3-1 WATER LEVEL STATIONS IN THE STUDY AREA

No.	Name of Station	River System	Recorded since	Gauge Type
1.	Kampung Lalang	Belawan	1974	Staff
2.	Asam Kumbang	- do -	1972	Staff/Automatic
3.	Helvetia	Deli	1974	Staff
4.	Simeme	- do -	1984	Automatic
5.	Tembung	Percut	1974	Staff/Automatic
6.	Kampung Serdang	Serdang	1984	Automatic
7.	Tanjung Morawa	- do -	1972	Staff
8.	Perbaungan	Ular	1972	Automatic
9.	Ular Bridge	- do -	1971	Staff
10.	Pulau Tagor	- do -	1972	Staff
11.	Serbajadi Bridge	- do -	1971	Staff
12.	Serbajadi	- do -	1977	Staff/Automatic
13.	Bandar Tiga	- do -	1972	Staff/Automatic
14.	Paku Bridge	- do -	1977	Staff/Automatic
15.	Siujan-Ujan	- do -	1977	Staff/Automatic
16.	Silau Dunia	Belutu	1984	Automatic
17.	Tebing Tinggi	Padang	1982	Automatic

Table 3-2 DAILY WATER LEVEL AND DISCHARGE RECORDS IN THE STUDY AREA

No	Name of Station	River System	Catchment Area(km2)	Start Year	Data Existence (1970 | 75 | 80 | 85 | 90)
1	Kampung Lalang	Belawan	254	1974.9	HHHHHHQQQQQQQQQ
2	Asam Kumbang	-do-	209	1972.1	HHHHHHHHHHQQQQQQQ
3	Helvetia	Deli	341	1974.9	HHHHHHQQQQQQQQQ
4	Simeme	-do-	158	1971.7	HQQHHHHHHQQQQQQQQQ
5	Tembung	Percut	171	1974.9	HHHHHHHHHHHHHHHH
7	Tanjung Morawa	Serdang	250	1972.1	QQQQQQQHHHHHHHHH
10	Pulau Tagor	-do-	1,031	1972.1	QQQQQQQHQQQQQQQQQ
17	Tebing Tinggi	Padang	919	1977.1	QQQQQQQQQQHHH

Note : H = Water Level Data (by Hydrology Section)
Q = Discharge Data (Prepared by IHE)

Table 3-3 HOURLY WATER LEVEL RECORDS IN THE STUDY AREA

No	Name of Station	River System	Catchment Area(km2)	Year of Record	(1975 | 80 | 85 | 90)
2	Asam Kumbang	Belawan	209	1982.1 - 1989.12	<------>
4	Simeme	Deli	158	1980.4 - 1989.10	<-------->
5	Tembung	Percut	171	1984.7 - 1990.1	<------>
6	Kampung Serdang	Serdang	671	1984.1 - 1988.3	<---->
16	Silau Dunia	Belutu	72	1984.9 - 1990.1	<------>
17	Tebing Tinggi	Padang	919	1985.1 - 1989.12	<---->

Note : Water Level Chart by Hydrology Section

Table 3-4(1/3) FLOW REGIME IN OBSERVED DISCHARGE

Station (Catchment Area)	River	Year	Flow Regime (m3/s)							Mean Discharge (m3/s)
			Daily Max	25%	50%	80%	95%	99%	Min	
Asam Kumbang (209 km2)	Belawan	1982	69.2	15.6	8.56	5.16	4.36	3.00	2.35	12.72 *
		1983	50.3	17.3	10.2	6.08	4.70	4.19	3.34	13.40 *
		1984	74.0	16.1	10.6	7.78	6.29	4.44	3.74	13.98 *
		1985	105.0	13.5	7.82	4.17	2.12	1.65	1.52	11.69 *
		1986	(107.0)	(18.8)	(9.53)	(4.34)	(2.65)	(1.81)	(1.72)	(13.94 *)
		1987	(90.5)	(20.4)	(11.6)	(6.73)	(4.88)	(4.38)	(4.62)	(16.73 *)
		1988	(252.0)	(15.0)	(11.6)	(8.48)	(7.03)	(5.89)	(5.30)	(20.26 *)
		Mean	74.6	15.6	9.30	5.80	4.37	3.32	2.74	12.9
		/km2	0.357	0.075	0.045	0.028	0.021	0.016	0.013	0.062
Kampung Lalang (254 km)	Belawan	1980	40.2	13.4	7.98	3.33	0.96	0.84	0.66	10.35 *
		1981	40.8	14.2	10.4	5.94	3.47	2.65	2.32	11.58 *
		1982	38.4	11.7	7.63	5.17	3.47	3.33	2.87	10.19 *
		1983	39.6	12.3	8.70	5.94	5.32	4.28	1.95	10.52 *
		1984	44.0	15.9	11.0	7.34	5.76	5.20	4.50	13.43 *
		1985	43.7	14.3	8.69	4.38	2.49	2.34	1.88	10.95 *
		1986	43.1	17.2	10.6	7.02	2.85	2.27	2.14	12.93 *
		1987	41.3	14.1	7.50	5.06	4.02	3.21	3.12	10.49 *
		1988	(128.0)	(21.0)	(16.9)	(11.9)	(8.88)	(6.78)	(6.44)	(20.45 *)
		Mean	41.6	14.1	9.06	5.52	3.54	3.02	2.43	11.3
		/km2	0.164	0.056	0.036	0.022	0.014	0.012	0.01	0.044
Simeme (158 km2)	Deli	1980	36.9	13.9	8.67	5.43	4.32	3.83	3.42	10.49 *
		1981	29.6	9.63	7.06	4.55	3.59	3.28	3.11	8.17 *
		1982	39.7	10.3	6.98	4.44	3.27	2.96	2.84	8.13 *
		1983	25.4	8.82	6.09	4.48	3.39	3.20	2.99	7.47 *
		1984	(30.6)	(15.9)	(12.8)	(9.55)	(7.30)	(7.08)	(6.70)	(13.54 *)
		1985	38.4	10.3	6.71	5.02	3.93	3.51	2.57	8.38 *
		1986	27.2	8.35	5.21	3.65	2.81	2.33	2.23	6.66
		1987	30.9	9.26	6.59	4.77	4.06	3.70	3.48	8.53 *
		1988	25.9	9.85	8.08	6.66	5.09	4.64	4.43	9.08 *
		Mean	31.8	10.1	6.92	4.88	3.81	3.43	3.14	8.36
		/km2	0.201	0.064	0.044	0.031	0.024	0.022	0.020	0.053

Note : * is including missing data
( ) is not used in calculation of mean value

Table 3-4(2/3) FLOW REGIME IN OBSERVED DISCHARGE

Station (Catchment Area)	River	Year	Flow Regime (m3/s)							Mean Discharge (m3/s)
			Daily Max	25%	50%	80%	95%	99%	Min	
Helvetia (341 km2)	Deli	1980	90.2	22.0	14.0	7.08	5.16	4.69	4.47	17.47 *
		1981	65.8	17.5	12.5	9.15	6.84	4.92	4.58	15.36
		1982	55.9	18.4	12.0	8.60	6.84	6.36	6.12	15.42 *
		1983	86.5	23.0	16.4	12.1	9.15	7.80	7.50	19.35 *
		1984	75.9	22.0	16.4	11.8	10.2	9.60	9.30	18.42
		1985	81.5	20.4	13.9	8.85	5.52	4.69	4.58	16.13
		1986	74.0	21.0	14.9	9.45	6.60	6.12	6.12	17.23
		1987	42.9	17.7	12.1	10.1	7.50	7.35	7.20	14.28 *
		1988	70.9	24.4	17.9	13.7	9.90	9.00	8.40	21.47 *
		Mean	71.5	20.7	14.5	10.1	7.52	6.73	6.47	17.2
		/km2	0.210	0.061	0.043	0.030	0.022	0.020	0.019	0.050
Tanjung Morawa (250 km)	Serdang	1972	89.5	14.1	9.22	6.90	6.02	5.80	5.80	13.13
		1973	142.0	17.5	11.6	6.99	5.50	4.60	4.45	17.26
		1974	(319.0)	(22.5)	(13.9)	(10.2)	(8.70)	(7.70)	(6.31)	(20.47)
		1975	93.0	15.0	11.1	8.00	6.30	5.55	4.80	13.14
		1976	174.0	13.5	10.6	8.19	6.47	5.55	5.25	15.03 *
		1977	116.0	21.7	13.3	9.14	6.00	4.54	4.15	17.51
		1978	43.0	15.7	10.4	6.64	5.10	4.54	3.76	12.05
		Mean	109.60	16.3	11.1	7.64	5.90	5.10	4.70	14.7
		/km2	0.438	0.065	0.044	0.031	0.024	0.020	0.019	0.059
Tebing Tinggi (919 km2)	Padang	1977	110.0	47.0	35.1	21.6	15.4	13.3	13.0	37.83
		1978	96.0	40.5	32.0	25.4	21.3	18.1	17.8	35.67
		1979	184.0	44.5	29.3	22.3	18.1	16.7	16.0	37.17
		1980	142.0	50.8	37.1	25.7	21.9	19.9	19.2	41.51 *
		1981	141.0	51.4	40.0	26.4	19.0	16.1	14.7	43.93 *
		1982	126.0	52.0	39.1	27.9	21.0	19.2	17.0	42.73 *
		1983	163.0	50.0	27.9	21.0	20.0	19.2	18.7	38.84 *
		1984	142.0	60.5	43.5	29.5	24.0	22.8	21.6	48.06 *
		1985	129.0	53.0	40.5	29.5	19.5	17.8	17.8	44.28 *
		1986	92.8	45.5	35.5	21.0	18.5	18.3	18.3	35.91 *
		Mean	132.6	49.5	36.0	25.0	19.9	18.1	17.4	40.6
		/km2	0.144	0.054	0.039	0.027	0.022	0.020	0.019	0.044

Note : * is including missing data
( ) is not used in calculation of mean value

Table 3-4(3/3) FLOW REGIME IN OBSERVED DISCHARGE

Station (Catchment Area)	River	Year	Flow Regime (m3/s)							Mean Discharge (m3/s)
			Daily Max	25%	50%	80%	95%	99%	Min	
		1972	123.0	55.8	49.6	43.0	32.4	29.2	26.8	51.12
		1973	189.0	60.4	50.8	44.7	40.7	36.3	35.0	56.31
Pulau		1974	172.0	57.2	50.8	44.1	41.3	39.0	38.6	53.20
Tagor	Ular	1975	110.0	51.5	45.3	38.6	35.9	34.2	33.5	46.40 *
(1031 km2)		1976	153.0	55.6	44.8	39.6	37.1	36.0	31.5	50.66
		1977	118.0	57.1	46.9	38.4	33.1	29.0	28.8	50.11
		1978	109.0	53.0	46.9	37.7	34.3	32.5	30.9	48.06 *
		1979	X	X	X	X	X	X	X	X
		1980	171.0	50.3	43.4	38.4	33.7	32.0	29.0	46.43 *
		1981	163.0	53.3	46.9	32.5	28.8	26.7	26.2	46.91 *
		1982	130.0	47.5	40.3	31.4	29.3	28.3	22.0	42.89 *
		1983	110.0	53.3	42.1	34.3	32.5	30.4	29.3	45.77 *
		1984	131.0	60.6	52.0	45.5	42.5	41.0	40.5	55.50 *
		1985	161.0	63.1	56.8	43.0	39.5	38.5	38.0	57.00 *
		1986	85.0	50.8	46.0	42.0	37.0	36.5	36.0	48.10 *
		1987	91.0	52.7	47.2	43.0	39.0	37.5	37.0	49.93 *
		1988	137.0	77.0	65.5	58.0	53.0	51.0	27.4	69.79 *
		Mean	134.6	56.2	48.5	40.9	36.9	34.9	31.9	51.1
		/km2	0.131	0.055	0.047	0.040	0.036	0.034	0.031	0.050

Note : * is including missing data
( ) is not used in calculation of mean value

Table 3-5(1/2) ANNUAL MAXIMUM DISCHARGE RECORDS (AUTOMATIC GAUGE)

Station		Asam Kumbang			Simeme			Tembung			Kampung Serdang			Silau Dunia			Tebing Tinggi		
Area		(209 km2)			(158 km2)			(171 km2)			(671 km2)			(72 km2)			(919 km2)		
River		Belawan			Deli			Percut			Serdang			Belutu			Padang		
H - Q		Q = from Table			Q = from Table			Q=6.87(H+0.42)^2			Q=22.47(H+0.34)^2			Q=6.01(H-0.38)^2			Q= from Table		
Year	Date	H (m)	Q (m3/s)	Date	H (m)	Q (m3/s)	Date	H (m)	Q (m3/s)	Date	H (m)	Q (m3/s)	Date	H (m)	Q (m3/s)	Date	H (m)	Q (m3/s)
1980	X	X	X	30/Oct	2.43	160	X	X	X	X	X	X	X	X	X	31/Dec	2.81	330
1981	X	X	X	16/Dec	2.42	158	X	X	X	X	X	X	X	X	X	6/May	2.84	336
1982	16/Sep	3.80	190	29/Dec	2.49	168	X	X	X	X	X	X	X	X	X	X	X	X
1983	8/Nov	2.46	87	30/Sep	2.53	174	X	X	X	X	X	X	X	X	X	X	X	X
1984	3/Dec	3.04	127	X	X	X	30/Oct	3.06	83	9/Feb	2.47	179	8/Nov	1.52	10	X	X	X
1985	21/May	3.59	171	6/Oct	2.90	235	21/May	3.49	105	19/Dec	2.34	163	19/Dec	1.73	16	17/Dec	2.47	262
1986	7/Dec	4.34	239	6/Dec	3.01	253	7/Dec	4.67	178	7/Dec	2.54	188	18/Apr	1.76	17	14/Apr	2.46	260
1987	7/May	3.05	128	16/Sep	2.43	160	10/Dec	4.45	163	26/Jul	3.24	292	10/Dec	2.49	49	8/Dec	1.83	159
1988	X	X	X	19/Sep	2.48	166	1/Apr	2.97	79	15/Feb	2.16	142	3/Sep	1.96	25	30/Sep	2.23	221
1989	23/Nov	4.46	250	24/Sep	2.12	119	19/Dec	4.24	149	X	X	X	11/Sep	1.88	22	24/Oct	1.83	159

X : No data available

Table 3-5(2/2) ANNUAL MAXIMUM DISCHARGE RECORDS
(STAFF GAUGE STATION)

Station		Kampung Lalang			Helvetia			Pulau Tagor	
Area		(254 km2)			(341 km2)			(1031 km2)	
River		Belawan			Deli			Ular	
H - Q		Q = from Table			Q = from Table			Q = from Table	
Year	Date	H (m)	Q (m3/s)	Date	H (m)	Q (m3/s)	Date	H (m)	Q (m3/s)
1980	10/Oct	4.00	225	6/Dec	3.90	158	21/Dec	2.68	659
1981	18/Nov	4.50	276	29/Oct	3.58	136	11/May	1.60	254
1982	17/Sep	2.45	100	X	X	X	2/Feb	1.80	297
1983	13/Oct	3.55	184	X	X	X	X	X	X
1984	X	X	X	27/Jul	4.35	199	24/Apr	1.97	334
1985	X	X	X	6/Nov	4.60	224	18/Dec	1.78	293
1986	X	X	X	3/Feb	4.75	240	8/Jan	1.22	184
1987	X	X	X	X	X	X	X	X	X
1988	X	X	X	X	X	X	X	X	X
1989	9/Aug	4.00	225	24/Nov	4.55	219	24/Sep	2.44	534

Table 4-1 MEAN MONTHLY RAINFALL AT REPRESENTATIVE STATION,1969-88

(Unit : mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Aug	Nov	Dec	Year
No. 1.01	103.2	108.4	107.8	141.3	188.1	151.3	149.5	182.4	248.6	299.1	251.6	223.5	2,154.4
No. 1.09	80.5	69.1	89.4	110.4	155.6	100.2	124.2	167.2	209.9	241.2	220.6	182.1	1,750.0
No. 1.16	95.2	91.6	96.2	142.8	195.4	134.0	169.9	197.4	259.1	289.9	241.2	190.9	2,103.6
No. 1.19	98.5	56.7	66.2	87.9	136.0	110.7	119.8	153.8	230.8	261.3	217.3	203.7	1,742.4
No. 1.23	85.6	60.8	88.2	129.6	186.0	150.4	153.9	180.5	231.5	272.2	241.8	201.7	1,982.1
No. 3.03	93.1	74.4	99.3	133.3	180.3	133.8	153.6	190.7	260.9	284.2	252.7	201.3	2,057.3
No. 3.06	151.3	141.5	100.1	176.0	242.5	199.4	216.5	250.0	292.9	330.6	275.1	232.4	2,608.3
No. 3.14	118.5	105.8	105.9	160.6	174.5	162.3	168.4	206.7	273.2	291.4	262.6	215.6	2,245.5
No. 3.22	68.9	57.0	84.6	95.3	131.8	106.2	138.7	136.2	184.8	198.5	186.6	172.6	1,561.0
No. 3.32	172.3	167.9	155.9	189.0	314.3	187.9	248.7	248.1	308.2	357.8	289.3	264.3	2,903.6
No. 4.02	123.9	109.4	130.8	214.8	299.1	172.2	225.1	217.4	349.6	361.9	273.4	217.6	2,695.1
No. 4.03	97.0	70.9	79.7	141.1	155.5	122.3	153.1	160.7	207.8	235.1	167.6	149.7	1,740.5
No. 4.05	121.0	121.7	107.0	207.8	227.4	157.8	195.8	185.2	290.1	273.4	250.9	204.8	2,342.9
No. 4.07	121.3	106.9	115.6	201.1	228.8	177.2	203.1	187.9	301.4	297.5	262.8	203.4	2,407.1
No. 4.17	81.6	69.9	91.8	126.8	138.6	107.7	127.9	148.7	213.5	227.7	177.0	150.6	1,661.9

Table 4-2 ANNUAL MAXIMUM DAILY RAINFALL IN EACH RIVER BASIN

(Unit : mm/day)

Year	Belawan	Deli	Percut	Serdang	Ular	Belutu	Padang
1954	57.2	57.5	84.3	78.4	144.4	127.3	97.0
1955	78.5	64.8	58.8	55.3	53.7	72.5	86.6
1956	172.3	165.6	109.1	111.8	82.4	87.8	77.2
1957	65.6	92.7	85.6	65.8	57.1	47.8	42.7
1958	70.2	77.8	68.2	60.5	53.3	50.6	63.3
1959	63.5	79.6	103.8	91.9	71.2	81.4	143.0
1960	88.1	77.1	72.6	65.3	59.3	56.6	98.7
1961	65.9	85.0	67.0	55.2	57.9	65.9	58.9
1962	70.5	78.3	55.6	51.8	78.6	68.2	109.7
1963	85.6	76.8	78.6	63.8	92.9	56.9	146.5
1964	78.0	69.4	50.2	53.1	91.5	52.9	113.2
1965	73.7	72.9	31.1	65.3	67.0	58.6	101.2
1966	56.4	58.6	54.9	46.8	51.0	47.8	62.6
1967	56.7	46.7	46.5	49.8	54.6	79.0	71.4
1968	64.8	57.4	50.8	47.2	86.6	47.1	138.6
1969	74.8	62.8	102.1	74.1	145.3	60.0	61.1
1970	69.9	65.0	61.7	61.6	81.9	53.3	58.3
1971	56.9	60.6	60.7	62.9	86.4	54.6	61.5
1972	46.6	55.6	54.4	64.1	67.9	37.6	48.4
1973	60.4	68.2	59.2	60.9	93.7	57.7	103.6
1974	68.7	49.6	60.5	53.9	103.1	42.2	98.8
1975	76.5	62.8	51.2	43.6	79.1	54.2	68.2
1976	76.0	46.8	83.4	63.9	120.4	93.7	95.4
1977	65.6	55.1	62.0	79.9	83.6	57.2	60.6
1978	77.4	76.1	78.4	63.6	79.3	55.4	62.0
1979	69.5	66.4	68.5	65.7	76.6	70.3	86.4
1980	67.1	78.7	77.8	54.8	126.4	46.8	58.8
1981	62.2	48.9	53.7	48.0	66.4	60.6	98.8
1982	69.8	65.3	69.9	49.4	112.8	58.6	66.7
1983	52.6	70.1	109.6	66.0	159.0	65.3	113.7
1984	57.8	57.6	63.9	47.8	94.0	55.8	76.4
1985	76.5	54.7	114.2	71.9	173.2	53.9	65.6
1986	67.4	65.4	61.4	67.8	95.4	52.9	82.5
1987	106.5	97.8	90.7	68.0	150.6	74.6	85.5
1988	72.5	62.0	82.1	54.5	105.1	71.2	72.1

Table 4-3 CALCULATION RESULT OF PROBABLE RAINFALL

(Unit : mm/day)

Year	Belawan	Deli	Percut	Serdang	Ular	Belutu	Padang
2	68.9	66.3	67.9	60.4	86.6	59.6	79.9
3	78.6	76.0	77.2	66.7	101.7	67.5	92.2
5	89.4	86.8	87.6	73.8	118.6	76.3	105.9
8	98.7	96.1	96.5	79.9	133.2	83.9	117.7
10	103.0	100.4	100.6	82.7	139.9	87.4	123.2
20	116.0	113.5	113.1	91.3	160.2	98.0	139.7
30	123.5	121.0	120.3	96.2	172.0	104.1	149.2
50	132.8	130.4	129.2	102.4	186.6	111.8	161.1
60	136.2	133.7	132.4	104.6	191.8	114.5	165.4
80	141.4	139.0	137.5	108.0	200.0	118.7	172.0
100	145.4	143.0	141.4	110.7	206.4	122.0	177.2
150	152.8	150.4	148.4	115.5	217.9	128.0	186.5
200	158.0	155.6	153.4	118.9	226.0	132.3	193.2

Table 4-4 ACCUMULATED RATES OF THE BIGGEST 20 DAILY RAINFALLS AT SAMPALI (1977-1989)

Hour	1977 Jan 12	1977 Sep 25	1977 Dec 8	1978 Dec 3	1979 Apr 24	1979 Jul 11	1979 Nov 13	1980 Dec 6	1982 Mar 27	1982 Oct 31	1982 Dec 31	1983 Oct 13	1984 Jul 30	1986 Jan 5	1986 Sep 10	1987 Sep 16	1987 Dec 10	1988 Jul 1	1988 Sep 16	1989 Jul 31
8														0.01						
9														0.08						
10														0.13						
11														0.14						
12	0													0.14		0				
13	0.46 *			0										0.14		0.01				
14	0.46			0.04				0		0				0.14		0.01				
15	0.46		0	0.04				0.02		0.00				0.14		0.01		0		
16	0.46		0.07	0.04				0.02		0.00			0	0.32		0.01		0.07		
17	0.56		0.31 *	0.04				0.03		0.00			0.09	0.40		0.12		0.28	0	
18	0.56		0.33	0.04				0.07		0.00			0.92 *	0.40		0.40		0.29	0.04	
19	0.56	0	0.55	0.04			0	0.24		0.00		0	0.97	0.40		0.40		0.29	0.53 *	
20	0.56	0.18	0.55	0.06			0.32 *	0.35	0	0.00		0.10	1.00	0.40		0.40		0.29	0.80	
21	0.96	0.49	0.63	0.06			0.58	0.36	0.13	0.00		0.31		0.40		0.44		0.29	0.85	0
22	0.98	0.88 *	0.63	0.11		0	0.71	0.55 *	0.85 *	0.00		0.61		0.40	0	0.90 *		0.29	0.92	0.27
23	1.00	0.91	0.63	0.12		0.33	0.77	0.69	1.00	0.00	0	1.00 *		0.41	0.60 *	0.92	0	0.63 *	0.97	0.94 *
0	1.00	0.93	0.63	0.14	0	0.85 *	0.77	0.76	1.00	0.01	0.50 *			0.51	0.98	0.97	0.01	0.96	0.98	0.99
1		0.97	0.64	0.15	0.44 *	0.90	0.94	0.91		0.02	0.73			0.77 *	1.00	0.99	0.37 *	0.96	0.99	1.00
2		0.99	0.64	0.20	0.76	0.93	0.98	0.96		0.02	0.79			0.77		1.00	0.61	0.98	1.00	1.00
3		1.00	0.68	0.52	0.84	0.97	1.00	0.97		0.07	0.87			0.78		1.00	0.78	1.00		
4		1.00	0.80	0.92 *	0.91	0.98	1.00	0.98		0.93 *	0.92			0.85			0.92	1.00		
5			0.99	0.95	0.98	1.00		0.99		0.96	0.98			0.88			1.00			
6			0.99	0.97	0.99	1.00		1.00		0.99	1.00			1.00			1.00			
7			1.00	1.00	1.00			1.00		1.00	1.00									
Total Rainfall (mm)	112.2	96.0	90.0	154.4	85.8	104.0	113.0	87.0	101.6	83.8	85.6	104.4	109.4	92.9	102.5	135.6	117.2	82.7	80.5	79.0

Note : * is hourly rainfall peak

Table 5-1 LAG TIME OF BASIN BY RZIHA EQUATION

River	Catchment Area (km2)	Elevation Maximum (m)	Elevation Minimum (m)	Altitude Difference (m)	River Length (km)	Average Gradient	Velocity (km/hr)	Lag Time (hr)
Belawan	647	1,100	0	1,100	76	0.0145	5.68	13.4
Deli	358	1,500	1	1,499	82	0.0183	6.53	12.6
Percut	186	1,520	8	1,512	64	0.0236	7.60	8.4
Serdang	671	1,450	4	1,446	63	0.0230	7.49	8.4
Ular	1,081	1,330	30	1,300	91	0.0143	5.63	16.2
Belutu	500	1,000	4	996	76	0.0131	5.34	14.2
Padang	919	1,020	6	1,014	82	0.0124	5.17	15.9

Table 5-2 LAG TIME OF SUBBASIN

River (R.Length) (Tl)	Subbasin	Channel Length (km)	Lag Time (hr)	River (R.Length) (Tl)	Subbasin	Channel Length (km)	Lag Time (hr)
Belawan	B 1	22	1.9	Ular	U 1	45	4.0
(76km)	B 2	19	1.7	(91km)	U 2	39	3.5
(13.4hr)	B 3	29	2.6	(16.2hr)	U 3	24	2.1
	B 4	14	1.2		U 4	2	0.2
	B 5	1	0.1		U 5	26	2.3
	B 6	24	2.1		U 6	7	0.6
	B 7	39	3.4		U 7	35	3.1
	B 8	10	0.9		U 8	1	0.1
					U 9	16	1.4
Deli	D 1	28	2.2	Belutu	Bt1	27	2.5
(82km)	D 2	19	1.5	(76km)	Bt2	1	0.1
(12.6hr)	D 3	5	0.4	(14.2hr)	Bt3	9	0.8
	D 4	30	2.3		Bt4	33	3.1
	D 5	12	0.9		Bt5	5	0.5
	D 6	1	0.1		Bt6	32	3.0
					Bt7	14	1.3
Percut	Pr1	22	1.4	Padang	P 1	41	4.0
(64km)	Pr2	4	0.3	(82km)	P 2	25	2.4
(8.4hr)	Pr3	2	0.1	(15.9hr)	P 3	6	0.6
Serdang	S 1	23	1.5		P 4	32	3.1
(63km)	S 2	7	0.5		P 5	36	3.5
(8.4hr)	S 3	29	1.9		P 6	6	0.6
	S 4	37	2.5		P 7	24	2.3
	S 5	27	1.8		P 8	38	3.7
	S 6	22	1.5				

Table 5-3 CHARACTERISTIC FEATURES OF RIVER CHANNEL

River	Channel No.	Upstream Elevation (m)	Downstream Elevation (m)	Relative Elevation (m)	Channel Length (km)	Average Gradient	Average Width (m)	Storage coefficient	
								K	Tl
Belawan	1	89	68	21	5	0.0042	10	2.4	0.06
	2	68	24	44	11	0.0040	20	7.0	0.13
	3	24	13	11	5	0.0022	20	4.8	0.11
	4	13	1	12	29	0.0004	20	37.4	1.07
Deli	1	186	50	136	15	0.0091	10	5.7	0.12
	2	50	12	38	18	0.0021	20	14.1	0.29
	3	12	1	11	21	0.0005	20	25.3	0.69
Percut	1	233	12	221	37	0.0060	15	18.9	0.35
	2	12	8	4	5	0.0008	15	4.7	0.13
Serdang	1	145	11	134	34	0.0039	5	12.7	0.40
	2	11	5	6	6	0.0010	20	5.9	0.14
	3	11	5	6	7	0.0009	20	7.1	0.17
Ular	1	245	58	187	24	0.0078	50	18.3	0.20
	2	58	45	13	5	0.0026	60	5.7	0.07
	3	400	68	332	25	0.0133	50	16.2	0.16
	4	68	45	23	6	0.0038	60	6.1	0.07
	5	45	30	15	17	0.0009	80	29.9	0.42
Belutu	1	119	95	24	7	0.0034	10	3.6	0.09
	2	95	26	69	21	0.0033	20	14.4	0.27
	3	26	7	19	15	0.0013	20	13.6	0.31
	4	7	4	3	6	0.0005	30	9.1	0.22
Padang	1	42	21	21	16	0.0013	20	14.5	0.33
	2	21	14	7	15	0.0005	50	26.1	0.49
	3	104	14	90	38	0.0024	20	28.6	0.57

Note : K is constant of Storage Function Model
Tl is lag time

Table 5-4(1/2) SUMMARY OF PARAMETERS OF STORAGE FUNCTION MODEL

River	Subbasin /Channel	Catchment Area(km2)	Parameter in Storage Function K	p	Tl	f1	Rsa
	(Subbasins)						
Belawan	B1	76	3.5	0.8	1.9	0.3	300
	B2	65	3.5	0.8	1.7	0.3	300
	B3	68	3.5	0.8	2.6	0.3	300
	B1	45	3.5	0.8	1.2	0.3	300
	B4	15	7.0	0.8	0.1	0.3	300
	B5	126	7.0	0.8	2.1	0.3	300
	B6	223	7.0	0.8	3.4	0.3	300
	B7	29	7.0	0.8	0.9	0.3	300
	(Channels)						
	1		2.4	0.6	0.1		
	2		7.0	0.6	0.1		
	3		4.8	0.6	0.1		
	4		37.4	0.6	1.1		
	(Subbasins)						
Deli	D1	93	3.5	0.8	2.2	0.3	300
	D2	65	3.5	0.8	1.5	0.3	300
	D3	44	3.5	0.8	0.4	0.3	300
	D4	99	3.5	0.8	2.3	0.3	300
	D5	40	3.5	0.8	0.9	0.3	300
	D6	17	3.5	0.8	0.1	0.3	300
	(Channels)						
	1		5.7	0.6	0.1		
	2		14.1	0.6	0.3		
	3		25.3	0.6	0.7		
	(Subbasins)						
Percut	P1	105	3.5	0.8	1.4	0.3	300
	P2	66	3.5	0.8	0.3	0.3	300
	P3	15	3.5	0.8	0.1	0.3	300
	(Channels)						
	1		18.9	0.6	0.4		
	2		4.7	0.6	0.1		
	(Subbasins)						
Serdang	S1	159	4.0	0.9	1.5	0.3	300
	S2	103	4.0	0.9	0.5	0.3	300
	S3	83	4.0	0.9	1.9	0.3	300
	S4	189	4.0	0.9	2.5	0.3	300
	S5	71	4.0	0.9	1.8	0.3	300
	S6	66	4.0	0.9	1.5	0.3	300
	(Channels)						
	1		12.7	0.6	0.4		
	2		5.9	0.6	0.1		
	3		7.1	0.6	0.2		

Table 5-4(2/2) SUMMARY OF PARAMETERS OF STORAGE FUNCTION MODEL

River	Subbasin /Channel	Catchment Area(km2)	Parameter in Storage Function				
			K	p	Tl	fl	Rsa
	(Subbasins)						
Ular	U1	292	13.7	0.9	4.0	0.3	300
	U2	154	13.7	0.9	3.5	0.3	300
	U3	54	13.7	0.9	2.1	0.3	300
	U4	73	13.7	0.9	0.2	0.3	300
	U5	190	13.7	0.9	2.3	0.3	300
	U6	104	13.7	0.9	0.6	0.3	300
	U7	134	13.7	0.9	3.1	0.3	300
	U8	12	13.7	0.9	0.1	0.3	300
	U9	68	13.7	0.9	1.4	0.3	300
	(Channels)						
	1		18.3	0.6	0.2		
	2		5.7	0.6	0.1		
	3		16.2	0.6	0.2		
	4		6.1	0.6	0.1		
	5		29.9	0.6	0.4		
	(Subbasins)						
Belutu	Bt1	64	8.0	0.9	2.5	0.3	300
	Bt2	8	8.0	0.9	0.1	0.3	300
	Bt3	56	8.0	0.9	0.8	0.3	300
	Bt4	96	8.0	0.9	3.1	0.3	300
	Bt5	33	8.0	0.9	0.5	0.3	300
	Bt6	166	8.0	0.9	3.0	0.3	300
	Bt7	77	8.0	0.9	1.3	0.3	300
	(Channels)						
	1		3.6	0.6	0.1		
	2		14.4	0.6	0.3		
	3		13.6	0.6	0.3		
	4		9.1	0.6	0.2		
	(Subbasins)						
Padang	P1	241	8.5	0.9	4.0	0.3	300
	P2	129	8.5	0.9	2.4	0.3	300
	P3	44	8.5	0.9	0.6	0.3	300
	P4	110	8.5	0.9	3.1	0.3	300
	P5	121	8.5	0.9	3.5	0.3	300
	P6	114	8.5	0.9	0.6	0.3	300
	P7	61	8.5	0.9	2.3	0.3	300
	P8	99	8.5	0.9	3.7	0.3	300
	(Channels)						
	1		14.5	0.6	0.3		
	2		26.1	0.6	0.5		
	3		28.6	0.6	0.6		

Table 5-5 PERIOD OF AVAILABLE RECORDS OF NEW HYDROLOGICAL STATION

Kind	Station	River System	Catchment Area(km2)	Period of Record
Rainfall Station	T.Morawa	Serdang		Sep 1990 - Jan 1991 Apr 1991 - continue
	Kutajurung	-do-		Sep 1990 - Apr 1991 Apr 1991 - continue
	Sinan Kasih	Belutu		Sep 1990 - Jan 1991 Apr 1991 - continue
	Bandar Negiri	-do-		Sep 1990 - Mar 1991 Mar 1991 - continue
	Pabatu	Padang		Sep 1990 - Apr 1991 Apr 1991 - continue
	Sindar Raya	-do-		Sep 1990 - Apr 1991 Apr 1991 - continue
Water Level Station	Bedimbar	Belumai (Serdang)	262	Sep 1990 - Oct 1990 Feb 1991 - continue
	Pekapahan	Batu Ginnging (Serdang)	272	Sep 1990 - Apr 1991 Apr 1991 - continue
	Rampah	Belutu	423	Sep 1990 - Jan 1991 Apr 1991 - continue
	Simpang	-do-	224	Sep 1990 - Apr 1991 Apr 1991 - continue
	Basumbu	Padang	524	Sep 1990 - Apr 1991 Apr 1991 - continue
	Brohol	-do-	820	Sep 1990 - Apr 1991 Apr 1991 - continue

Table 5-6 ZERO GAUGE ELEVATION OF NEW WATER LEVEL STATIONS

Station	River System	Catchment Area(km2)	Floor Elevation	Zero Gauge Elevation
Bedimbar	Serdang	262	22.39m	14.00m
Pekapahan	-do-	272	14.99m	8.41m
Rampah	Belutu	423	4.90m	-0.67m
Simpang	-do-	224	30.19m	25.14m
Basumbu	Padang	524	27.12m	20.65m
Brohol	-do-	820	20.45m	14.32m

Note : Elevation are based on the National Bench Mark (TTG).

Table 5-7 RESULTS OF PARAMETER ANALYSIS FOR NEW HYDROLOGICAL STATIONS

River	Station	Catchment Area(km2)	Date of Flood	(Parameters in Storage Function) Storage Coefficient K	P	Runoff Ratio f	Time Lag Tl (hr)
Serdang River	Bedimbar	262	16~18 Sep 1990	4.78	0.9	0.272	6
			2~ 6 Oct 1990	4.20	0.9	0.485	8
			Mean(Belumai)	k= 4.5			
	Pekapahan	272	14~18 Dec 1990	16.83	1.0	0.172	16
Belutu River	Rampah	423	18~25 Oct 1990	26.00	1.0	0.467	10
	Simpang	224	1~ 3 Nov 1990	6.87	1.0	0.477	12
Padang River	Basumbu	524	25~29 Sep 1990	8.49	0.9	0.152	7
			5~ 8 Oct 1990	6.74	0.9	0.127	6
			16~21 Oct 1990	(15.92)	0.9	0.193	5
			11~15 Dec 1990	10.24	0.9	0.261	6
			Mean(Basumbu)	k= 8.5			
	Brohol	820	25~29 Sep 1990	11.17	0.9	0.170	11
			5~ 8 Oct 1990	8.61	0.9	0.116	8
			16~21 Oct 1990	(21.27)	0.9	0.231	9
			11~15 Dec 1990	10.80	0.9	0.272	11
			Mean(Brohol)	k=10.2			
Mean(All Station)					Runoff Ratio	f= 0.26	

note : ( ) is not included at calculation of mean value

Table 5-8 DAILY RAINFALL IN NOVEMBER 1990 FLOOD

Kind	Station	Daily Rainfall (mm) Nov.24	Nov.25	Nov.26	Nov.27
Mannual Gauge	NO 1.01	47.0	0.0	60.0	0.0
	NO 1.03	16.0	1.0	88.0	3.0
(by RISPA)	NO 1.05	28.0	0.0	26.0	0.0
	NO 1.07	78.0	6.0	62.0	1.0
	NO 1.08	15.0	5.0	26.0	0.0
	NO 1.09	30.0	3.0	51.0	0.0
	NO 1.11	55.0	0.0	58.0	0.0
	NO 1.15	0.0	135.0	0.0	0.0
	NO 1.16	23.0	0.0	17.0	0.0
	NO 1.17	98.0	5.0	23.0	0.0
	NO 1.18	13.0	20.0	0.0	0.0
	NO 1.23	16.0	9.0	16.0	13.0
	NO 3.03	16.0	1.0	88.0	3.0
	NO 3.06	0.0	3.0	22.0	1.0
	NO 3.07	40.0	4.0	25.0	0.0
	NO 3.08	2.0	10.0	0.0	0.0
	NO 3.09	0.0	0.0	18.0	0.0
	NO 3.10	0.0	31.0	0.0	0.0
	NO 3.11	0.0	0.0	0.0	7.0
	NO 3.12	21.0	15.0	8.0	0.0
	NO 3.15	6.0	2.0	15.0	0.0
	NO 3.18	17.0	2.0	50.0	0.0
	NO 3.21	0.0	7.0	0.0	0.0
	NO 3.22	5.0	41.0	0.0	0.0
	NO 3.23	0.0	82.0	28.0	0.0
	NO 3.24	5.0	0.0	11.0	0.0
	NO 3.27	36.0	0.0	30.0	0.0
	NO 3.29	7.0	0.0	30.0	0.0
	NO 3.31	0.0	40.0	0.0	0.0
	NO 3.32	0.0	25.0	0.0	0.0
Automatic Gauge					
(by PMG)	Sampali	72.5	6.0	26.2	0.0
(by JICA)	T.Morawa	2.0	51.5	26.2	1.0
(-do-)	Kutajurung	0.5	41.5	5.5	15.0

Note : 1 day = 7:00 to next 7:00

Table 5-9 RESULTS OF PARAMETER ANALYSIS ON NOVEMBER 1990 FLOOD

River	Station	Catchment Area(km2)	Date of Flood	(Parameters in Storage Function) Storage Coefficient K	P	Runoff Ratio f	Time Lag Tl (hr)
Deli River	Simeme	158	24~27 Nov 1990	3.51	0.8	0.355	22
Percut River	Tembung	171	24~27 Nov 1990	10.75	1.0	1.0	28

Table 6-1(1/3) FLOW REGIME AND BALANCE IN OBSERVED DISCHARGE

Station (Catchment Area)	River	Year	Flow Regime (m3/s)							Mean Discharge (1) (m3/s)	Annual Run-Off (2) (mm/y)	Annual Rainfall (3) (mm/y)	Annual Loss (4)= (3)-(2) (mm/y)	Run Off Ratio (5)= (2)/(3)
			Daily Max	25%	50%	80%	95%	99%	Min					
Asam Kumbang (209 km2)	Belawan	1982	69.2	15.6	8.56	5.16	4.36	3.00	2.35	12.72 *	1,919	2,140	221	0.90
		1983	50.3	17.3	10.2	6.08	4.70	4.19	3.34	13.40 *	2,022	2,046	24	0.99
		1984	74.0	16.1	10.6	7.78	6.29	4.44	3.74	13.98 *	2,115	2,213	98	0.96
		1985	105.0	13.5	7.82	4.17	2.12	1.65	1.52	11.69 *	1,764	2,095	331	0.84
		1986	(107.0)	(18.8)	(9.53)	(4.34)	(2.65)	(1.81)	(1.72)	(13.94 *)	(2,103)	(1,776)	(-327)	(1.18)
		1987	(90.5)	(20.4)	(11.6)	(6.73)	(4.88)	(4.38)	(4.62)	(16.73 *)	(2,524)	(2,202)	(-322)	(1.15)
		1988	(252.0)	(15.0)	(11.6)	(8.48)	(7.03)	(5.89)	(5.30)	(20.26 *)	(3,065)	(1,722)	(-1,343)	(1.78)
		Mean	74.6	15.6	9.30	5.80	4.37	3.32	2.74	12.9	1,955	2,124	169	0.92
		/km2	0.357	0.075	0.045	0.028	0.021	0.016	0.013	0.062				
Kampung Lalang (254 km)	Belawan	1980	40.2	13.4	7.98	3.33	0.96	0.84	0.66	10.35 *	1,285	2,522	1,237	0.51
		1981	40.8	14.2	10.4	5.94	3.47	2.65	2.32	11.58 *	1,438	2,382	944	0.60
		1982	38.4	11.7	7.63	5.17	3.47	3.33	2.87	10.19 *	1,265	2,139	874	0.59
		1983	39.6	12.3	8.70	5.94	5.32	4.28	1.95	10.52 *	1,306	2,048	742	0.64
		1984	44.0	15.9	11.0	7.34	5.76	5.20	4.50	13.43 *	1,672	2,209	537	0.76
		1985	43.7	14.3	8.69	4.38	2.49	2.34	1.88	10.95 *	1,360	2,088	728	0.65
		1986	43.1	17.2	10.6	7.02	2.85	2.27	2.14	12.93 *	1,605	1,757	152	0.91
		1987	41.3	14.1	7.50	5.06	4.02	3.21	3.12	10.49 *	1,302	2,191	889	0.59
		1988	(128.0)	(21.0)	(16.9)	(11.9)	(8.88)	(6.78)	(6.44)	(20.45 *)	(2,546)	(1,686)	(-860)	(1.51)
		Mean	41.6	14.1	9.06	5.52	3.54	3.02	2.43	11.3	1,404	2,167	763	0.66
		/km2	0.164	0.056	0.036	0.022	0.014	0.012	0.01	0.044				
Simeme (158 km2)	Deli	1980	36.9	13.9	8.67	5.43	4.32	3.83	3.42	10.49 *	2,094	3,012	919	0.70
		1981	29.6	9.63	7.06	4.55	3.59	3.28	3.11	8.17 *	1,631	2,263	632	0.72
		1982	39.7	10.3	6.98	4.44	3.27	2.96	2.84	8.13 *	1,623	2,340	717	0.69
		1983	25.4	8.82	6.09	4.48	3.39	3.20	2.99	7.47 *	1,491	2,298	807	0.65
		1984	(30.6)	(15.9)	(12.8)	(9.55)	(7.30)	(7.08)	(6.70)	(13.54 *)	(2,710)	(2,676)	(-34)	(1.01)
		1985	38.4	10.3	6.71	5.02	3.93	3.51	2.57	8.38 *	1,673	2,555	882	0.65
		1986	27.2	8.35	5.21	3.65	2.81	2.33	2.23	6.66	1,329	2,239	910	0.59
		1987	30.9	9.26	6.59	4.77	4.06	3.70	3.48	8.53 *	1,703	2,655	952	0.64
		1988	25.9	9.85	8.08	6.66	5.09	4.64	4.43	9.08 *	1,817	2,879	1,062	0.63
		Mean	31.8	10.1	6.92	4.88	3.81	3.43	3.14	8.36	1,670	2,530	860	0.66
		/km2	0.201	0.064	0.044	0.031	0.024	0.022	0.020	0.053				

Note : (2) = (1) x (365 or 366) days x 86,400 sec/A km2/1,000
* is including missing data
( ) is not used in calculation of mean value

Table 6-1(2/3) FLOW REGIME AND BALANCE IN OBSERVED DISCHARGE

Station (Catchment Area)	River	Year	Flow Regime (m3/s)							Mean Discharge (1) (m3/s)	Annual Run-Off (2) (mm/y)	Basin Rainfall (3) (mm/y)	Annual Loss (4)= (3)-(2) (mm/y)	Run Off Ratio (5)= (2)/(3)
			Daily Max	25%	50%	80%	95%	99%	Min					
Helvetia (341 km2)	Deli	1980	90.2	22.0	14.0	7.08	5.16	4.69	4.47	17.47 *	1,616	2,635	1,019	0.61
		1981	65.8	17.5	12.5	9.15	6.84	4.92	4.58	15.36	1,421	2,043	622	0.70
		1982	55.9	18.4	12.0	8.60	6.84	6.36	6.12	15.42 *	1,426	2,191	765	0.65
		1983	86.5	23.0	16.4	12.1	9.15	7.80	7.50	19.35 *	1,790	2,026	236	0.88
		1984	75.9	22.0	16.4	11.8	10.2	9.60	9.30	18.42	1,708	2,287	579	0.75
		1985	81.5	20.4	13.9	8.85	5.52	4.69	4.58	16.13	1,492	2,286	794	0.65
		1986	74.0	21.0	14.9	9.45	6.60	6.12	6.12	17.23	1,593	2,261	668	0.70
		1987	42.9	17.7	12.1	10.1	7.50	7.35	7.20	14.28 *	1,321	2,433	1,112	0.54
		1988	70.9	24.4	17.9	13.7	9.90	9.00	8.40	21.47 *	1,991	2,643	652	0.75
		Mean	71.5	20.7	14.5	10.1	7.52	6.73	6.47	17.2	1,595	2,311	716	0.69
		/km2	0.210	0.061	0.043	0.030	0.022	0.020	0.019	0.050				
Tanjung Morawa (250 km)	Serdang	1972	89.5	14.1	9.22	6.90	6.02	5.80	5.80	13.13	1,661	1,986	325	0.84
		1973	142.0	17.5	11.6	6.99	5.50	4.60	4.45	17.26	2,177	2,362	185	0.92
		1974	(319.0)	(22.5)	(13.9)	(10.2)	(8.70)	(7.70)	(6.31)	(20.47)	(2,582)	(1,909)	(-673)	(1.35)
		1975	93.0	15.0	11.1	8.00	6.30	5.55	4.80	13.14	1,658	2,197	539	0.75
		1976	174.0	13.5	10.6	8.19	6.47	5.55	5.25	15.03 *	2,215	2,768	553	0.80
		1977	116.0	21.7	13.3	9.14	6.00	4.54	4.15	17.51	2,209	2,307	98	0.96
		1978	43.0	15.7	10.4	6.64	5.10	4.54	3.76	12.05	1520	2,470	950	0.62
		Mean	109.60	16.3	11.1	7.64	5.90	5.10	4.70	14.7	1,906	2,348	442	0.82
		/km2	0.438	0.065	0.044	0.031	0.024	0.020	0.019	0.059				
Tebing Tinggi (919 km2)	Padang	1977	110.0	47.0	35.1	21.6	15.4	13.3	13.0	37.83	1,298	2,155	857	0.60
		1978	96.0	40.5	32.0	25.4	21.3	18.1	17.8	35.67	1,224	2,271	1,047	0.54
		1979	184.0	44.5	29.3	22.3	18.1	16.7	16.0	37.17	1,276	2,589	1,313	0.49
		1980	142.0	50.8	37.1	25.7	21.9	19.9	19.2	41.51 *	1,428	2,593	1,165	0.55
		1981	141.0	51.4	40.0	26.4	19.0	16.1	14.7	43.93 *	1,507	2,488	981	0.61
		1982	126.0	52.0	39.1	27.9	21.0	19.2	17.0	42.73 *	1,466	2,583	1,117	0.57
		1983	163.0	50.0	27.9	21.0	20.0	19.2	18.7	38.84 *	1,333	2,408	1,075	0.55
		1984	142.0	60.5	43.5	29.5	24.0	22.8	21.6	48.06 *	1,654	2,455	801	0.67
		1985	129.0	53.0	40.5	29.5	19.5	17.8	17.8	44.28 *	1,519	2,387	868	0.64
		1986	92.8	45.5	35.5	21.0	18.5	18.3	18.3	35.91 *	1,232	2,708	1,476	0.45
		Mean	132.6	49.5	36.0	25.0	19.9	18.1	17.4	40.6	1,394	2,464	1,070	0.57
		/km2	0.144	0.054	0.039	0.027	0.022	0.020	0.019	0.044				

Note : (2) = (1) x (365 or 366) days x 86,400 sec/A km2/1,000
* is including missing data
( ) is not used in calculation of mean value

Table 6-1(3/3) FLOW REGIME AND BALANCE IN OBSERVED DISCHARGE

Station (Catchment Area)	River	Year	Flow Regime (m3/s)							Mean Discharge (1) (m3/s)	Annual Run-Off (2) (mm/y)	Basin Rainfall (3) (mm/y)	Annual Loss (4)=(3)-(2) (mm/y)	Run Off Ratio (5)=(2)/(3)
			Daily Max	25%	50%	80%	95%	99%	Min					
Pulau Tagor (1031 km2)	Ular	1972	123.0	55.8	49.6	43.0	32.4	29.2	26.8	51.12	1,568	2,032	464	0.77
		1973	189.0	60.4	50.8	44.7	40.7	36.3	35.0	56.31	1,722	2,535	813	0.68
		1974	172.0	57.2	50.8	44.1	41.3	39.0	38.6	53.20	1,627	2,075	448	0.78
		1975	110.0	51.5	45.3	38.6	35.9	34.2	33.5	46.40 *	1,419	2,260	841	0.63
		1976	153.0	55.6	44.8	39.6	37.1	36.0	31.5	50.66	1,554	3,208	1,654	0.48
		1977	118.0	57.1	46.9	38.4	33.1	29.0	28.8	50.11	1,533	2,644	1,111	0.58
		1978	109.0	53.0	46.9	37.7	34.3	32.5	30.9	48.06 *	1,470	2,654	1,184	0.55
		1979	X	X	X	X	X	X	X	X	X	X	X	X
		1980	171.0	50.3	43.4	38.4	33.7	32.0	29.0	46.43 *	1,424	3,550	2,126	0.40
		1981	163.0	53.3	46.9	32.5	28.8	26.7	26.2	46.91 *	1,435	2,571	1,136	0.56
		1982	130.0	47.5	40.3	31.4	29.3	28.3	22.0	42.89 *	1,312	2,486	1,174	0.53
		1983	110.0	53.3	42.1	34.3	32.5	30.4	29.3	45.77 *	1,400	2,546	1,146	0.55
		1984	131.0	60.6	52.0	45.5	42.5	41.0	40.5	55.50 *	1,702	3,103	1,401	0.55
		1985	161.0	63.1	56.8	43.0	39.5	38.5	38.0	57.00 *	1,744	2,905	1,161	0.60
		1986	85.0	50.8	46.0	42.0	37.0	36.5	36.0	48.10 *	1,471	2,338	867	0.63
		1987	91.0	52.7	47.2	43.0	39.0	37.5	37.0	49.93 *	1,527	3,188	1,661	0.48
		1988	137.0	77.0	65.5	58.0	53.0	51.0	27.4	69.79 *	2,141	3,181	1,040	0.67
		Mean	134.6	56.2	48.5	40.9	36.9	34.9	31.9	51.1	1,565	2,705	1,140	0.59
		/km2	0.131	0.055	0.047	0.040	0.036	0.034	0.031	0.050				

Note : (2) = (1) x (365 or 366) days x 86,400 sec/A km2/1,000
* is including missing data
( ) is not used in calculation of mean value

Table 6-2 EVAPORATION LOSS

Month		(1) Pan Evaporation (mm/day)	(2) Modified Evaporation (mm/day)
1	Jan.	3.8	2.66
2	Feb.	4.5	3.15
3	Mar.	4.5	3.15
4	Apr.	4.7	3.29
5	May	4.6	3.22
6	Jun.	4.7	3.29
7	Jul.	4.5	3.15
8	Aug.	4.8	3.36
9	Sep.	4.1	2.87
10	Oct.	4.0	2.80
11	Nov.	3.9	2.73
12	Dec.	3.4	2.38
	T o t a l	1,566 mm/year	1,100 mm/year

Note : (1) = Mean value of recent 10 years at Sampali
(2) = (1) x 70%

Table 6-3 PARAMETERS IN TANK MODEL

	Symbol	Unit	Kampung Lalang	Simeme	Helvetia	Tanjung Morawa	Tebing Tinggi	Pulau Tagor
	a0		0.30	0.30		0.30	0.30	0.40
Upper	a1		0.20	0.20	same as	0.20	0.20	0.10
Tank	a2		0.10	0.20		0.25	0.10	0.05
	A1	mm	100	100	Simeme	100	100	150
	A2	mm	10	10		10	20	50
	initial X1	mm	0	0		0	0	0
	b0		0.15	0.15		0.20	0.08	0.10
Middle	b1		0.05	0.05	same as	0.05	0.05	0.05
Tank	b2		0.03	0.02		0.03	0.02	0.03
	B1	mm	100	100	Simeme	100	100	100
	B2	mm	0	0		0	0	0
	initial X2	mm	0	0		0	0	0
	c0		0	0		0	0	0
Lower	c1		0	0	same as	0	0	0
Tank	c2		0.002	0.002		0.002	0.002	0.003
	C1	mm	0	0	Simeme	0	0	0
	C2	mm	0	0		0	0	0
	initial X3	mm	1000	1500		1500	1000	1500

Table 6-4 COMPARISON OF FLOW REGIME BY CALCULATION AND OBSERVATION

Station (Catchment Area)	Kind of Data	Period	Flow Regime (m3/s)							
			Max	25%	50%	80%	95%	99%	Min	Mean
Kampung Lalang (254 km2)	Observation	1980 - 87	41.60	14.10	9.06	5.52	3.54	3.02	2.43	11.30
	Calculation	-do-	47.70	9.84	6.57	5.38	4.86	4.60	4.51	8.76
	-do-	1969 - 88	41.50	9.60	6.51	5.28	4.75	4.50	4.40	8.59
	m3/s/km2	-do-	0.163	0.038	0.026	0.021	0.019	0.018	0.017	0.035
Simeme (158 km2)	Observation	1980 - 88	31.80	10.10	6.92	4.88	3.81	3.43	3.14	8.36
	Calculation	-do-	35.30	8.21	5.21	4.27	3.86	3.69	3.62	7.10
	-do-	1969 - 88	33.60	8.07	5.30	4.34	3.91	3.75	3.68	7.13
	m3/s/km2	-do-	0.213	0.051	0.034	0.027	0.025	0.024	0.023	0.045
Helvetia (341 km2)	Observation	1980 - 88	71.50	20.70	14.50	10.10	7.52	6.73	6.47	17.20
	Calculation	-do-	74.30	13.90	9.19	7.50	6.75	6.45	6.32	12.80
	-do-	1969 - 88	67.50	14.30	9.71	8.02	7.23	6.92	6.78	13.30
	m3/s/km2	-do-	0.198	0.042	0.028	0.024	0.021	0.020	0.020	0.039
Tanjung Morawa (250 km2)	Observation	1972 - 78	109.60	16.30	11.10	7.64	5.90	5.10	4.70	14.70
	Calculation	-do-	64.90	10.60	6.68	5.53	5.04	4.03	4.74	10.30
	m3/s/km2	1969 - 88	75.80	13.50	8.01	6.53	5.93	5.71	5.61	12.20
		-do-	0.303	0.054	0.032	0.026	0.024	0.023	0.022	0.049
Tebing Tinggi (919 km2)	Observation	1977 - 86	132.60	49.50	36.00	25.00	19.90	18.10	17.40	40.60
	Calculation	-do-	145.60	43.60	34.40	28.40	25.70	24.50	24.10	39.80
	-do-	1969 - 88	136.00	43.50	34.80	28.60	25.90	24.70	24.20	39.70
	m3/s/km2	-do-	0.148	0.047	0.038	0.031	0.028	0.027	0.026	0.043
Pulau Tagor (1031 km2)	Observation	1972 - 88	134.60	56.20	48.50	40.90	36.90	34.90	31.90	51.10
	Calculation	-do-	130.80	61.20	50.60	41.20	36.00	34.00	33.20	53.60
	-do-	1969 - 88	140.50	65.50	54.20	44.70	38.70	36.50	35.70	57.80
	m3/s/km2	-do-	0.136	0.064	0.053	0.043	0.038	0.035	0.035	0.056

Table 6-5(1/3) ESTIMATED MEAN MONTHLY DISCHARGE

(Unit : m3/s)

Station	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Kampung Lalang A= 254 km2	1969	8.51	5.72	5.41	5.40	5.80	7.47	7.31	10.21	10.03	14.78	15.78	9.64	8.84
	1970	7.71	6.34	6.12	6.28	6.18	6.21	5.60	10.03	8.92	11.53	12.40	11.45	8.23
	1971	11.06	11.32	9.89	6.36	13.08	7.55	9.82	13.11	9.37	12.41	7.24	9.85	10.09
	1972	6.17	8.08	5.99	5.57	6.70	7.80	4.98	6.09	11.36	10.33	9.23	10.64	7.75
	1973	7.86	6.35	6.09	4.87	7.38	6.22	4.39	6.94	6.31	6.96	9.84	15.90	7.43
	1974	6.90	9.96	5.09	8.42	10.31	11.47	5.80	7.43	5.85	9.47	14.53	5.94	8.43
	1975	8.41	7.42	6.06	7.20	6.74	6.52	7.66	8.05	9.16	7.07	10.34	13.01	8.14
	1976	8.32	5.75	6.12	5.19	7.71	7.36	11.02	7.10	10.53	7.94	10.93	8.89	8.07
	1977	5.76	7.66	6.43	4.88	4.50	5.00	3.59	9.90	8.80	20.02	13.35	10.01	8.33
	1978	11.88	6.29	5.87	10.40	7.41	6.22	8.68	7.58	21.94	18.26	14.92	14.14	11.13
	1979	9.61	8.21	7.06	10.99	10.38	7.75	7.38	8.69	9.28	11.26	15.95	6.70	9.44
	1980	6.51	5.62	5.45	6.75	8.69	5.48	5.63	9.11	11.28	15.11	13.70	17.66	9.25
	1981	9.62	6.97	6.62	10.16	10.86	7.39	6.87	7.50	14.10	15.70	15.03	13.92	10.40
	1982	7.16	6.31	8.70	10.39	7.64	7.95	7.97	7.62	6.33	12.72	10.43	13.16	8.87
	1983	10.99	6.39	6.29	7.82	7.87	12.26	8.62	7.14	12.22	11.37	10.23	7.52	9.06
	1984	7.11	12.07	7.80	6.80	11.63	7.12	16.21	7.61	9.00	11.00	9.00	6.77	9.34
	1985	5.70	5.18	6.76	8.05	11.74	4.82	5.78	5.28	10.23	11.13	12.46	10.33	8.12
	1986	7.18	10.27	7.29	7.21	7.97	6.74	6.10	4.59	12.66	11.14	5.05	4.53	7.56
	1987	5.92	3.62	5.10	3.76	7.23	5.30	6.07	9.61	15.71	10.97	6.81	8.23	7.36
	1988	5.24	5.84	4.50	3.85	4.66	4.18	9.74	5.24	6.80	5.89	7.45	6.97	5.86
	Mean	7.88	7.27	6.43	7.02	8.22	7.04	7.46	7.94	10.49	11.75	11.23	10.26	8.58
Simeme A= 158 km2	1969	10.11	7.16	6.15	5.91	7.87	8.46	6.77	10.57	9.44	16.78	14.60	10.36	9.52
	1970	10.07	6.58	5.85	7.15	6.07	5.76	8.44	10.32	7.66	11.91	13.03	10.97	8.65
	1971	11.57	10.55	10.59	7.13	14.07	12.05	10.01	12.21	11.38	8.76	9.22	13.53	10.92
	1972	6.74	7.17	6.29	7.27	7.00	7.55	4.97	5.00	9.17	7.90	7.08	7.14	6.94
	1973	5.84	5.86	6.91	4.34	4.53	5.23	4.65	3.93	4.91	9.79	7.68	13.08	6.40
	1974	5.11	8.43	4.73	4.92	6.80	6.22	5.63	4.38	5.76	4.91	7.34	4.54	5.73
	1975	4.59	3.83	3.58	3.60	5.74	3.25	3.31	3.14	6.18	7.62	7.56	8.35	5.06
	1976	4.93	6.29	4.83	4.11	4.48	4.44	6.32	6.37	8.21	6.76	11.83	8.24	6.40
	1977	5.14	4.44	3.78	4.21	3.51	5.29	3.03	7.92	6.89	9.29	9.03	9.24	5.98
	1978	5.74	4.14	3.72	6.14	8.74	5.11	6.65	4.62	7.02	9.77	7.98	7.95	6.47
	1979	4.62	4.63	3.64	7.47	5.58	5.78	7.89	6.32	6.70	11.58	10.86	4.95	6.67
	1980	5.47	6.32	6.41	4.43	6.95	4.39	4.73	9.20	10.80	11.07	10.28	13.98	7.84
	1981	6.69	6.65	5.27	7.26	10.90	5.51	5.66	5.17	8.54	9.30	9.63	6.41	7.25
	1982	4.36	4.13	4.80	8.33	8.08	6.17	5.76	5.84	5.55	8.62	7.24	6.71	6.30
	1983	5.25	4.32	3.58	3.14	5.61	3.89	6.73	5.75	8.04	11.94	8.90	6.42	6.13
	1984	7.06	9.14	7.66	5.72	11.21	5.42	10.16	7.23	5.51	7.89	6.39	7.46	7.57
	1985	6.92	5.67	5.82	7.80	10.62	4.43	6.15	5.10	9.49	11.74	6.71	7.56	7.33
	1986	7.04	5.53	5.60	5.62	6.17	7.04	4.03	3.59	9.73	7.92	6.39	8.12	6.40
	1987	5.87	3.87	7.43	7.10	6.52	6.50	5.25	5.43	10.42	10.51	8.64	7.97	7.13
	1988	5.07	5.92	5.97	4.86	5.51	5.43	10.29	10.24	12.10	9.22	11.05	8.68	7.86
	Mean	6.41	6.03	5.63	5.83	7.30	5.90	6.32	6.62	8.18	9.66	9.07	8.58	7.13

Table 6-5(2/3) ESTIMATED MEAN MONTHLY DISCHARGE

(Unit : m3/s)

Station	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Helvetia A= 341 km2	1969	19.22	16.06	12.91	12.21	13.75	16.85	12.33	18.12	16.98	30.31	27.60	17.62	17.83
	1970	18.01	11.86	11.19	12.11	10.10	10.37	10.30	17.89	14.91	24.95	25.56	20.67	15.66
	1971	20.68	15.38	17.26	11.39	22.88	20.64	18.04	22.89	16.91	16.80	15.53	22.91	18.44
	1972	12.08	12.99	11.18	11.71	12.37	13.56	9.20	8.16	20.69	15.91	14.28	15.01	13.10
	1973	11.34	9.68	10.52	9.21	10.79	9.06	7.80	7.75	10.22	18.75	17.51	33.17	12.98
	1974	11.05	20.69	9.45	11.82	17.14	13.09	9.56	10.90	10.87	13.14	18.74	9.15	12.97
	1975	11.23	8.58	7.24	10.54	10.56	8.29	7.14	7.86	14.30	15.01	14.92	22.14	11.48
	1976	11.43	9.58	9.46	7.66	10.29	9.88	14.63	11.01	15.75	12.03	19.12	14.12	12.08
	1977	8.76	9.72	7.87	6.91	6.08	7.79	5.02	14.50	13.14	23.88	18.25	15.88	11.48
	1978	14.45	7.99	8.16	12.97	12.09	8.40	12.07	8.92	15.51	23.53	15.70	15.63	12.95
	1979	10.87	9.23	7.38	13.73	9.77	9.18	13.57	10.44	10.83	21.22	21.54	8.77	12.21
	1980	9.10	9.66	10.14	6.97	12.44	8.15	6.37	16.24	19.50	18.70	19.05	26.65	13.58
	1981	11.12	9.61	8.58	15.11	17.67	8.90	8.34	8.64	15.46	17.03	18.48	12.94	12.66
	1982	7.81	6.82	10.41	13.67	10.61	10.50	11.55	9.72	8.47	16.95	13.96	15.62	11.34
	1983	11.23	8.34	7.49	5.93	10.17	10.28	12.22	8.99	14.74	20.41	12.05	10.49	11.03
	1984	10.91	17.46	12.45	8.80	17.49	8.36	18.63	11.01	8.96	15.46	11.83	10.64	12.67
	1985	9.21	7.87	10.08	15.96	19.51	7.56	9.15	9.39	16.13	19.53	12.92	13.56	12.57
	1986	10.76	14.19	10.24	10.96	11.61	16.26	8.14	6.95	21.80	13.89	14.37	14.18	12.78
	1987	10.75	7.41	13.46	11.45	12.72	10.89	8.32	11.84	20.05	19.57	17.81	15.88	13.35
	1988	10.36	14.35	11.33	8.44	11.02	10.16	18.63	15.90	22.98	16.45	20.66	18.48	14.90
	Mean	12.02	11.37	10.34	10.88	12.95	10.91	11.05	11.86	15.41	18.68	17.49	16.68	13.30
Tanjung Morawa A= 250 km2	1969	16.67	9.83	8.77	8.51	13.84	13.55	10.83	19.33	15.78	30.42	24.31	17.55	15.78
	1970	16.26	10.13	8.67	12.19	10.54	9.68	17.17	18.61	12.39	19.49	22.18	18.44	14.65
	1971	19.84	20.23	18.83	11.84	26.69	21.89	16.67	20.77	21.08	14.21	15.84	24.71	19.38
	1972	10.42	12.11	10.29	12.99	12.46	13.56	7.97	8.93	15.34	13.09	11.60	11.45	11.68
	1973	9.42	10.65	13.32	6.90	6.99	9.65	8.70	6.50	8.28	18.11	12.02	19.86	10.87
	1974	7.38	13.56	7.51	7.59	10.56	10.08	10.21	6.21	10.61	6.68	11.22	7.33	9.08
	1975	6.64	6.09	6.25	5.21	10.74	4.47	5.53	4.97	9.83	13.35	12.78	12.09	8.16
	1976	6.94	12.21	8.14	6.90	6.97	6.96	11.04	11.56	14.50	11.80	22.36	14.33	11.14
	1977	7.96	6.64	5.62	7.39	6.11	10.33	5.24	14.90	12.20	14.23	15.13	16.34	10.17
	1978	7.93	6.51	5.44	10.14	17.78	8.90	11.69	7.71	10.94	15.48	13.20	12.94	10.72
	1979	6.48	7.00	5.33	13.42	9.64	10.60	14.28	11.53	11.68	20.76	18.05	7.77	11.38
	1980	9.43	12.16	11.09	7.64	12.46	7.36	9.07	16.92	18.83	19.87	17.32	24.48	13.89
	1981	10.77	12.07	8.45	12.06	20.27	8.96	10.25	8.75	14.77	16.10	16.39	9.90	12.40
	1982	6.84	7.11	7.86	15.42	16.29	10.18	9.45	10.39	10.13	14.69	12.08	10.06	10.88
	1983	7.93	7.11	5.58	5.14	10.59	5.93	12.13	10.92	14.55	22.14	16.39	10.72	10.76
	1984	12.86	15.32	13.41	10.35	21.12	9.07	18.13	12.75	9.19	12.84	10.26	14.00	13.28
	1985	13.46	10.23	9.54	13.23	19.25	6.92	11.67	8.77	17.91	20.99	10.91	12.86	12.98
	1986	13.27	7.60	9.26	9.50	10.26	10.93	6.24	5.66	16.63	14.28	10.24	14.41	10.69
	1987	10.31	5.83	13.64	13.49	12.09	11.44	9.70	8.68	18.94	18.45	13.98	12.70	12.44
	1988	7.70	8.75	9.85	7.97	9.13	9.77	18.91	19.07	20.89	15.49	18.67	13.29	13.29
	Mean	10.43	10.06	9.34	9.89	13.19	10.01	11.24	11.65	14.22	16.62	15.25	14.26	12.18

Table 6-5(3/3) ESTIMATED MEAN MONTHLY DISCHARGE

(Unit : m3/s)

Station	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Tebing Tinggi A= 919 km2	1969	26.78	20.38	20.41	22.26	29.10	38.55	36.34	31.44	37.69	75.77	88.91	49.26	39.74
	1970	39.30	30.02	29.04	30.39	25.67	28.02	32.82	34.78	38.54	46.80	56.98	35.16	35.63
	1971	53.43	37.85	36.66	33.85	45.34	43.06	43.13	46.45	52.75	40.73	39.66	56.46	44.11
	1972	35.81	32.98	28.03	29.00	29.43	31.63	23.98	27.99	41.09	31.28	42.21	38.24	32.64
	1973	38.90	26.57	28.27	26.77	27.54	29.13	23.50	27.55	36.78	41.00	49.40	73.27	35.72
	1974	42.04	53.21	32.89	45.23	36.57	44.65	35.30	33.69	44.01	39.31	46.69	32.52	40.51
	1975	33.66	28.83	35.64	35.68	34.64	29.57	29.51	26.98	42.21	45.46	38.50	43.86	35.38
	1976	33.18	36.37	33.37	32.57	39.42	27.06	35.61	39.63	40.84	38.70	58.68	45.83	38.44
	1977	45.27	28.99	26.27	28.35	25.62	26.42	22.92	29.71	35.41	55.31	45.29	39.46	34.09
	1978	37.60	31.03	27.69	34.16	52.98	38.07	37.00	30.01	30.89	44.24	46.29	34.88	37.07
	1979	26.09	26.21	22.74	41.38	41.37	27.82	40.44	33.33	41.19	51.86	78.09	38.70	39.10
	1980	29.84	32.79	29.08	25.95	33.23	24.89	26.07	50.93	45.11	61.39	48.76	58.17	38.85
	1981	36.91	32.48	29.59	39.54	80.12	37.14	38.84	31.63	64.55	52.41	50.09	35.10	44.03
	1982	30.56	27.34	27.87	46.58	47.68	38.00	40.90	37.61	44.24	57.20	51.12	39.37	40.71
	1983	38.61	30.94	27.27	25.10	32.64	31.91	29.99	40.46	74.35	61.85	49.47	36.98	39.96
	1984	41.46	45.35	44.37	37.53	58.19	39.03	53.01	38.75	36.28	38.62	35.73	37.38	42.14
	1985	32.12	40.78	32.77	42.25	47.91	29.29	30.81	26.34	42.00	55.92	32.60	48.51	38.44
	1986	34.51	32.39	34.60	41.53	50.01	45.43	32.25	30.48	55.87	58.70	48.71	48.82	42.78
	1987	33.54	28.71	37.78	46.94	42.52	52.23	50.81	44.55	58.25	70.71	54.86	52.59	47.79
	1988	38.00	44.75	38.81	40.39	34.03	42.41	55.96	48.31	64.38	52.83	48.99	51.74	46.72
	Mean	36.38	33.40	31.16	35.27	40.70	35.22	35.96	35.53	46.32	51.00	50.55	44.82	39.69
Pulau Tagor A= 1031 km2	1969	80.29	59.96	53.06	47.70	58.56	70.13	55.71	67.97	75.88	124.61	112.89	87.37	74.51
	1970	85.00	63.67	57.30	60.33	57.24	54.18	70.75	87.62	60.86	79.95	96.06	75.31	70.69
	1971	102.93	90.28	94.27	73.67	117.54	104.75	101.15	101.85	104.38	90.63	89.70	118.49	99.14
	1972	77.67	72.97	62.60	64.31	67.28	65.35	50.09	47.63	61.21	58.69	56.15	57.10	61.75
	1973	44.36	44.42	55.24	41.97	37.01	45.50	38.80	32.24	41.16	56.03	55.21	67.83	46.65
	1974	50.17	60.41	42.41	42.91	44.68	45.32	45.11	34.76	41.15	38.99	43.67	36.12	43.81
	1975	39.40	29.46	30.76	28.83	43.49	29.53	30.65	26.97	31.37	46.34	45.58	44.77	35.60
	1976	41.05	55.41	41.03	39.85	36.02	37.14	45.37	55.38	57.92	59.04	85.26	69.99	51.96
	1977	58.33	46.88	39.70	39.22	38.75	48.16	38.45	56.05	58.55	73.24	70.92	68.68	53.08
	1978	58.21	46.90	42.34	47.53	69.66	58.84	58.17	49.01	54.22	62.52	59.22	59.44	55.51
	1979	44.04	39.10	34.19	48.27	45.65	43.64	55.93	54.48	56.57	76.91	73.72	50.59	51.92
	1980	46.56	57.04	57.97	45.13	55.93	46.77	45.44	69.35	73.69	76.89	81.08	95.33	62.60
	1981	74.41	64.82	59.33	62.33	82.77	60.99	58.26	50.14	60.38	58.49	72.30	55.86	63.34
	1982	42.68	41.51	39.36	55.78	61.85	53.41	46.00	47.11	51.12	61.39	54.81	44.75	49.98
	1983	43.38	37.00	31.01	26.16	36.98	34.82	36.89	50.45	49.65	74.49	72.55	53.88	45.61
	1984	55.69	64.53	60.99	50.54	83.04	60.58	71.89	72.44	51.73	56.95	52.50	61.69	61.88
	1985	59.86	58.41	46.94	54.72	80.88	45.52	52.74	42.48	57.71	81.59	61.33	62.60	58.73
	1986	60.30	52.17	48.29	45.24	42.47	49.66	35.51	29.71	52.13	62.38	46.88	57.81	48.55
	1987	47.63	39.02	56.82	61.82	51.27	57.45	51.44	50.11	77.20	75.72	69.73	65.55	58.65
	1988	51.14	52.46	50.87	43.06	45.55	45.16	69.84	77.87	79.61	76.73	80.86	67.01	61.68
	Mean	58.16	53.82	50.22	48.97	57.83	52.85	52.91	55.18	59.82	69.58	69.02	65.01	57.78

Table 6-6(1/3) FLOW REGIME BY RUNOFF ANALYSIS

Station	Year	Flow Regime by Tank-Model Calculation (m3/s)								Annual Rainfall (mm)
		Max	25%	50%	80%	95%	99%	Min	Mean	
	1969	35.03	11.05	6.74	5.13	4.44	4.28	4.24	8.85	2,386.3
	1970	27.66	8.84	6.63	5.53	4.86	4.63	4.54	8.24	2,059.5
	1971	37.82	11.40	8.02	6.68	6.29	6.01	5.87	10.10	2,339.8
	1972	29.77	8.25	6.17	4.96	4.43	4.20	4.12	7.73	1,918.2
	1973	35.53	8.47	5.66	4.55	3.96	3.77	3.69	7.44	2,051.6
	1974	32.93	8.82	6.25	5.44	5.00	4.77	4.66	8.40	2,042.2
	1975	32.82	8.84	6.00	4.84	4.50	4.22	4.12	8.14	2,236.4
Kampung	1976	32.38	9.12	6.15	5.03	4.50	4.23	4.17	8.08	2,066.0
Lalang	1977	49.35	9.08	5.75	4.39	3.60	3.23	3.13	8.33	2,209.3
A=254 km2	1978	52.28	13.08	7.83	5.75	5.20	4.94	4.83	11.15	2,780.9
	1979	37.73	10.01	7.44	6.33	5.74	5.55	5.46	9.43	1,920.3
	1980	39.51	11.09	6.50	5.25	4.58	4.32	4.23	9.27	2,521.5
	1981	41.61	12.15	7.82	6.26	5.68	5.33	5.21	10.41	2,381.7
	1982	48.31	9.60	7.20	6.13	5.75	5.52	5.40	8.89	2,139.4
	1983	29.92	10.08	7.13	6.05	5.41	5.12	5.03	9.06	2,048.2
	1984	33.70	10.49	6.96	6.14	5.78	5.48	5.38	9.34	2,208.9
	1985	36.34	9.31	5.88	4.82	4.22	3.92	3.83	8.14	2,087.6
	1986	39.17	7.83	5.68	4.89	4.34	4.09	3.98	7.54	1,757.3
	1987	112.79	8.19	5.41	3.49	3.13	3.05	3.00	7.39	2,190.5
	1988	45.32	6.24	4.93	4.00	3.49	3.25	3.16	5.87	1,685.6
	Mean	41.50	9.60	6.51	5.28	4.75	4.50	4.40	8.59	2,151.6
	1969	40.22	11.46	7.07	5.72	5.20	5.01	4.92	9.53	2,971.8
	1970	33.84	9.90	6.48	5.50	4.96	4.82	4.69	8.67	2,698.6
	1971	33.55	13.27	9.13	7.08	6.08	5.93	5.83	10.94	3,476.4
	1972	27.12	6.72	5.84	5.16	4.71	4.45	4.37	6.93	1,996.6
	1973	28.58	6.92	4.56	3.80	3.33	3.18	3.11	6.41	2,379.8
Simeme	1974	29.99	5.60	4.46	3.83	3.53	3.43	3.36	5.70	1,941.1
A=158 km2	1975	22.06	5.47	3.47	2.87	2.66	2.58	2.49	5.07	2,212.3
	1976	37.63	7.03	4.32	3.44	3.14	3.06	3.00	6.39	2,547.1
	1977	27.12	6.98	4.29	3.14	2.74	2.49	2.43	5.99	2,223.3
	1978	36.26	6.90	4.74	3.99	3.65	3.43	3.34	6.48	2,413.1
	1979	37.56	7.22	4.66	3.89	3.52	3.46	3.40	6.67	2,400.4
	1980	38.48	10.06	5.57	4.13	3.74	3.60	3.50	7.85	3,011.8
	1981	27.43	7.91	5.64	4.89	4.43	4.27	4.16	7.25	2,262.9
	1982	29.53	6.87	4.68	4.10	3.77	3.67	3.60	6.31	2,340.2
	1983	36.87	6.50	4.41	3.35	3.03	2.93	2.88	6.12	2,298.3
	1984	28.74	8.84	5.63	4.91	4.74	4.55	4.48	7.58	2,675.8
	1985	49.90	8.28	5.30	4.55	4.08	3.91	3.87	7.35	2,554.5
	1986	27.64	7.43	4.77	4.08	3.45	3.12	3.06	6.40	2,238.8
	1987	46.18	8.09	4.86	3.87	3.55	3.42	3.37	7.14	2,654.9
	1988	33.33	9.93	6.05	4.52	3.98	3.73	3.64	7.87	2,878.8
	Mean	33.60	8.07	5.30	4.34	3.91	3.75	3.68	7.13	2,508.0

Table 6-6(2/3) FLOW REGIME BY RUNOFF ANALYSIS

Station	Year	Flow Regime by Tank-Model Calculation (m3/s)								Annual Rainfall (mm)
		Max	25%	50%	80%	95%	99%	Min	Mean	
	1969	62.40	19.52	14.15	11.40	10.24	9.90	9.62	17.84	2,538.9
	1970	67.35	17.31	11.71	9.61	8.76	8.40	8.17	15.69	2,428.2
	1971	57.23	22.23	14.13	12.13	10.75	10.38	10.12	18.49	2,898.4
	1972	49.32	13.20	10.72	9.29	8.12	7.69	7.55	13.07	1,992.1
	1973	71.40	14.19	8.81	7.38	6.62	6.23	6.14	13.03	2,416.3
	1974	52.15	12.98	9.72	8.65	8.24	7.96	7.88	12.90	2,035.8
	1975	62.65	12.73	7.81	6.59	5.93	5.68	5.61	11.50	2,265.5
Helvetia	1976	49.24	12.52	8.54	7.20	6.56	6.37	6.30	12.08	2,197.4
A=341 km2	1977	60.40	12.00	8.03	5.90	4.86	4.38	4.25	11.50	2,137.3
	1978	77.36	13.19	9.12	7.46	6.91	6.77	6.62	12.99	2,356.3
	1979	72.21	11.85	8.65	7.34	6.82	6.60	6.42	12.22	2,105.3
	1980	89.28	16.06	8.87	6.75	6.25	6.05	5.90	13.60	2,634.9
	1981	59.66	12.78	9.65	8.21	7.25	6.85	6.66	12.66	2,042.7
	1982	65.91	11.58	8.16	6.90	6.22	6.08	6.00	11.37	2,191.1
	1983	66.83	11.56	8.32	6.39	5.78	5.48	5.35	11.05	2,025.8
	1984	68.92	13.71	9.36	8.23	7.87	7.70	7.57	12.67	2,287.4
	1985	69.28	13.42	8.83	7.39	6.66	6.37	6.24	12.60	2,286.2
	1986	66.44	14.08	9.29	7.81	6.63	5.95	5.84	12.73	2,260.6
	1987	112.72	14.33	9.21	7.19	6.63	6.46	6.40	13.37	2,432.6
	1988	69.53	17.09	11.04	8.67	7.49	7.08	6.93	14.89	2,642.5
	Mean	67.51	14.32	9.71	8.02	7.23	6.92	6.78	13.31	2,308.0
	1969	101.22	19.25	9.94	7.81	7.12	6.95	6.83	15.83	3,231.5
	1970	69.59	15.93	9.52	8.33	7.54	7.24	7.14	14.69	2,853.2
	1971	71.01	24.90	14.60	10.63	9.15	8.92	8.80	19.39	3,855.8
	1972	63.40	10.58	9.25	8.09	7.51	7.22	7.09	11.66	1,985.9
	1973	53.29	11.66	7.02	5.91	5.14	5.00	4.94	10.89	2,361.9
Tanjung	1974	70.29	7.75	6.25	5.29	4.86	4.70	4.61	9.03	1,909.3
Morawa	1975	48.55	8.71	4.92	4.07	3.79	3.64	3.59	8.18	2,197.0
A=250 km2	1976	92.75	12.00	6.17	4.80	4.42	4.28	4.18	11.12	2,767.5
	1977	57.06	11.53	6.26	4.77	4.26	3.97	3.88	10.19	2,306.6
	1978	68.76	11.63	6.92	5.80	5.33	5.01	4.91	10.76	2,469.8
	1979	73.44	12.05	7.05	5.76	5.27	5.16	5.02	11.39	2,551.3
	1980	80.56	18.30	8.87	6.34	5.86	5.60	5.50	13.91	3,234.5
	1981	50.38	13.99	8.52	7.62	7.02	6.82	6.72	12.39	2,397.0
	1982	73.12	10.61	7.35	6.48	6.11	5.94	5.84	10.89	2,420.2
	1983	100.58	11.30	6.84	5.33	4.76	4.63	4.56	10.79	2,442.5
	1984	63.86	15.04	8.84	7.62	7.19	6.90	6.81	13.30	2,892.7
	1985	139.59	13.90	8.35	7.17	6.54	6.23	6.12	13.01	2,711.1
	1986	67.95	10.42	7.05	6.17	5.32	4.92	4.84	10.70	2,239.0
	1987	97.71	13.58	7.27	5.82	5.47	5.27	5.20	12.47	2,814.1
	1988	72.55	17.49	9.12	6.86	6.00	5.70	5.61	13.30	3,011.4
	Mean	75.78	13.53	8.01	6.53	5.93	5.71	5.61	12.19	2,632.6

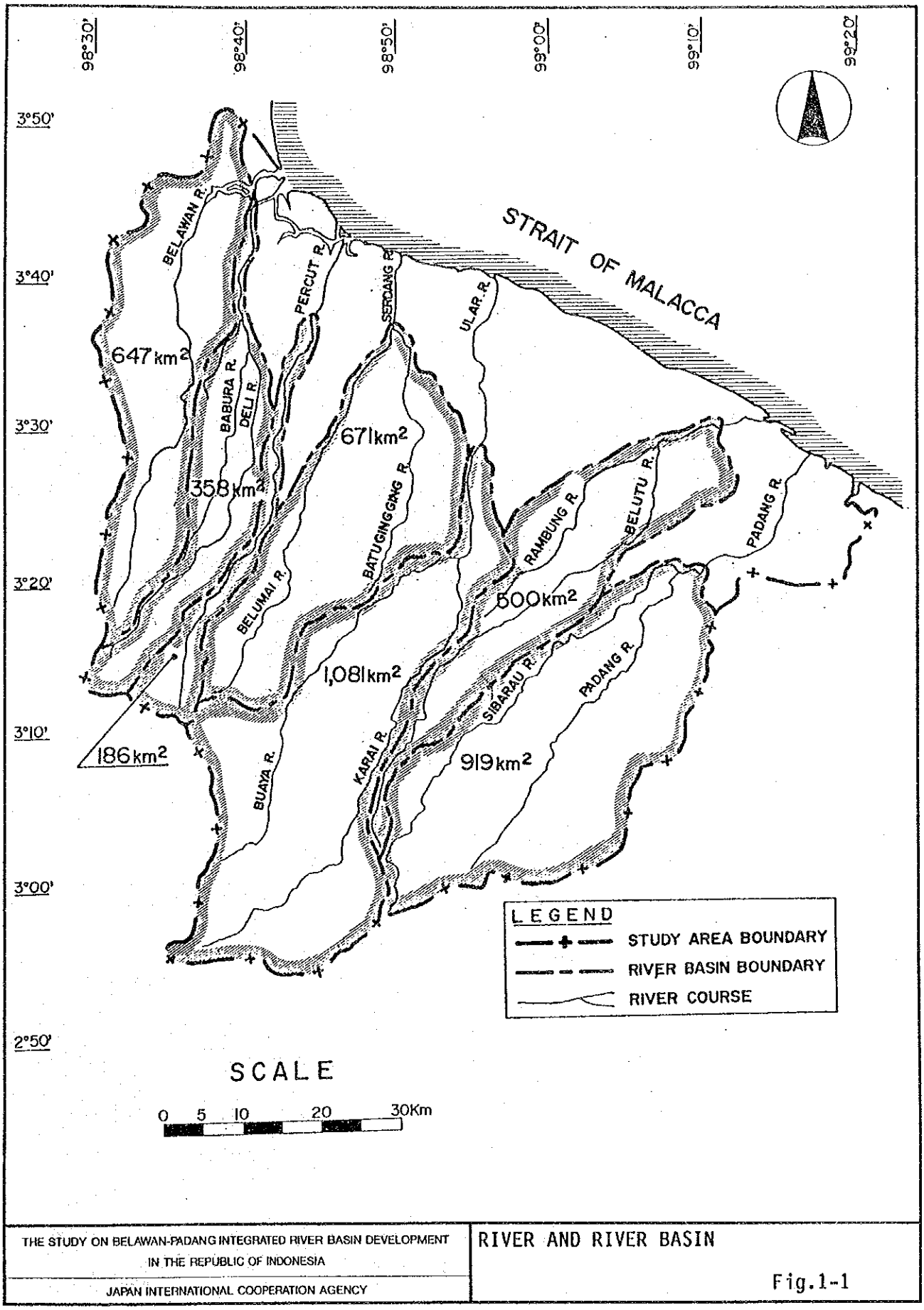
Table 6-6(3/3) FLOW REGIME BY RUNOFF ANALYSIS

Station	Year	Flow Regime by Tank-Model Calculation (m3/s)								Annual Rainfall (mm)
		Max	25%	50%	80%	95%	99%	Min	Mean	
	1969	161.71	47.06	31.64	21.41	18.81	17.41	17.11	39.82	2,996.1
	1970	132.90	38.46	31.82	26.79	25.07	23.73	23.41	35.64	2,123.6
	1971	103.62	46.41	39.80	35.11	31.65	29.40	27.96	44.18	2,882.8
	1972	84.41	35.59	30.55	26.01	23.18	22.63	21.87	32.60	1,820.3
	1973	139.23	39.95	29.28	24.69	22.73	21.32	20.89	35.80	2,587.2
	1974	128.36	42.73	36.13	31.21	28.81	27.77	27.39	40.35	2,324.4
	1975	81.29	38.76	32.66	27.86	25.65	24.03	23.55	35.42	2,372.4
Tebing	1976	147.72	40.50	33.97	27.25	24.99	23.87	23.41	38.43	2,520.4
Tinggi	1977	135.28	36.61	28.96	25.65	22.82	21.22	20.81	34.13	2,155.3
A=919 km2	1978	101.80	40.98	32.87	27.77	25.61	24.18	23.73	37.12	2,271.4
	1979	220.48	42.84	31.71	25.28	22.67	21.79	21.60	39.12	2,588.8
	1980	146.72	46.30	33.06	25.98	22.91	21.50	21.18	38.91	2,593.4
	1981	197.76	47.24	36.51	30.89	28.48	27.83	27.50	44.09	2,488.1
	1982	114.99	45.44	36.82	28.71	26.21	24.93	24.17	40.77	2,583.3
	1983	156.94	43.34	33.51	27.41	24.42	23.25	22.96	39.98	2,407.5
	1984	126.72	45.01	37.25	33.72	30.98	29.40	28.82	42.18	2,455.3
	1985	129.00	41.59	33.85	28.11	25.90	24.14	23.86	38.44	2,387.2
	1986	125.82	46.26	38.94	30.19	27.25	26.43	25.86	42.80	2,707.9
	1987	170.11	52.86	43.22	32.81	27.65	26.91	26.25	47.89	2,948.5
	1988	115.62	51.17	43.10	36.04	32.94	31.62	30.60	46.70	2,733.8
	Mean	136.02	43.46	34.78	28.64	25.94	24.67	24.15	39.72	2,497.4
	1969	219.14	86.69	63.08	52.20	46.28	43.67	43.19	74.61	3,714.6
	1970	172.87	78.90	64.99	57.21	50.30	47.09	46.06	70.78	3,134.8
	1971	193.23	104.34	95.25	83.58	65.68	61.27	59.91	99.28	4,601.0
	1972	107.83	68.49	60.99	51.41	46.75	44.46	43.98	61.69	2,031.8
	1973	117.60	52.87	43.42	36.16	30.94	28.87	28.29	46.67	2,535.2
Pulau	1974	108.51	49.79	41.64	34.07	30.37	29.06	28.38	43.68	2,075.4
Tagor	1975	71.92	40.88	33.08	26.79	24.53	23.26	22.60	35.67	2,260.3
A= 1,031 km2	1976	146.41	61.60	46.42	34.59	30.63	29.27	28.65	51.90	3,207.9
	1977	117.06	65.08	48.31	37.43	32.50	30.73	30.35	53.12	2,643.6
	1978	120.30	60.89	53.55	46.10	40.77	37.33	36.42	55.58	2,653.7
	1979	137.79	58.63	48.97	38.64	33.61	32.27	31.80	51.99	2,649.2
	1980	151.07	72.92	60.35	44.92	39.60	37.38	36.56	62.64	3,550.0
	1981	108.47	71.09	60.33	53.34	46.87	45.29	44.18	63.32	2,570.8
	1982	137.76	55.56	46.43	41.44	38.10	35.92	34.78	50.01	2,485.5
	1983	150.39	55.47	41.42	30.78	25.51	24.61	23.85	45.67	2,546.3
	1984	135.97	67.86	58.34	50.97	46.38	43.72	41.90	61.95	3,103.4
	1985	211.70	62.53	55.72	45.52	41.29	39.14	38.16	58.78	2,904.7
	1986	120.11	55.88	46.16	38.02	30.40	27.95	27.14	48.52	2,337.6
	1987	153.80	68.06	53.99	43.76	34.76	32.94	32.23	58.72	3,187.8
	1988	127.48	73.26	60.61	46.38	38.90	36.45	35.47	61.72	3,180.6
	Mean	140.47	65.54	54.15	44.67	38.71	36.53	35.70	57.82	2,868.7

Table 7-1 PROBABLE FLOOD DISCHARGES AT SPECIFIC RIVER POINTS

River	Divided Basin	Catchment Area (km2)	Point Number in Model	Calculated Peak Discharge (m3/s)						
				2-yr.	5-yr.	10-yr.	20-yr.	30-yr.	50-yr.	100-yr.
Belawan	B1	76	2	101	135	159	182	196	212	234
	B1-B2	141	8	154	210	249	286	309	335	370
	B1-B3	209	11	239	322	382	437	472	510	562
	B1-B4	254	15	245	333	401	464	503	548	607
	B5	15	17	11	15	18	20	22	23	26
	B6	126	21	95	126	148	169	182	197	217
	B7	223	24	167	223	262	300	324	350	387
	B8	29	27	22	29	34	39	42	46	51
	B1-B8	647	28	245	333	401	464	503	548	607
Deli	D1	93	2	102	139	163	189	202	219	244
	D1-D2	158	7	154	211	247	287	307	332	369
	D1-D3	202	11	159	219	256	295	315	340	379
	D4	99	13	111	149	172	198	211	228	252
	D1-D4	301	14	249	348	412	482	518	564	632
	D5	40	16	51	69	81	94	100	109	121
	D1-D5	341	17	277	384	453	529	567	617	689
	D6	17	19	20	28	33	37	40	44	49
	D1-D6	358	21	246	350	414	482	515	565	646
Percut	Pr1	105	2	124	164	190	214	228	247	272
	Pr1-Pr3	186	11	141	187	223	258	279	300	340
Serdang	S1	159	2	130	161	182	200	211	225	246
	S1-S2	262	7	183	230	261	289	306	326	357
	S3	83	10	69	86	97	107	113	121	132
	S4	189	12	155	192	216	238	251	267	292
	S3-S4	272	13	219	272	306	336	355	378	413
	S5	71	15	59	73	83	91	96	103	112
	S3-S5	343	16	274	339	381	419	443	471	514
	S6	66	19	54	67	75	83	88	93	102
	S3-S6	409	20	299	377	428	473	502	536	588
	S1-S6	671	21	469	589	672	746	793	849	934
Ular	U1-U2	446	5	209	287	340	391	422	461	510
	U1-U3	500	9	219	303	361	417	450	492	546
	U4	73	13	34	47	55	63	68	74	82
	U1-U4	573	14	219	337	401	464	502	549	610
	U5-U6	294	20	126	176	208	239	259	283	315
	U7	134	22	62	86	101	117	126	137	152
	U5-U7	428	23	187	258	307	355	383	420	466
	U5-U8	440	28	191	265	315	362	391	427	474
	U1-U8	1013	29	430	597	710	818	883	964	1067
	U9	68	31	31	43	51	59	64	69	77
	U1-U9	1081	33	430	597	710	818	883	964	1067
Belutu	Bt1	64	2	31	39	45	51	55	59	65
	Bt1-Bt2	72	7	34	44	50	57	61	66	72
	Bt1-Bt3	128	11	51	66	76	86	92	99	109
	Bt4	96	13	48	61	70	79	84	91	99
	Bt1-Bt4	224	14	93	120	139	158	169	183	201
	Bt1-Bt5	257	18	102	131	151	172	184	201	221
	Bt6	166	20	83	106	122	138	146	158	173
	Bt1-Bt6	423	21	170	220	254	289	308	334	368
	Bt7	77	24	38	48	55	63	67	72	79
	Bt1-Bt7	500	25	170	220	254	289	308	334	368
Padang	P1-P2	370	5	229	305	355	407	434	470	519
	P1-P3	414	10	240	323	378	433	463	502	554
	P4	110	12	70	94	109	126	134	145	160
	P1-P4	524	13	301	405	473	542	578	627	691
	P5	121	16	75	100	117	134	143	155	172
	P5-P6	235	20	112	153	181	209	224	244	271
	P1-P6	759	21	385	525	616	712	766	838	933
	P7	61	23	38	51	60	68	73	79	88
	P8	99	26	62	83	97	111	118	128	142
	P1-P8	919	27	385	525	616	712	766	838	933

FIGURES

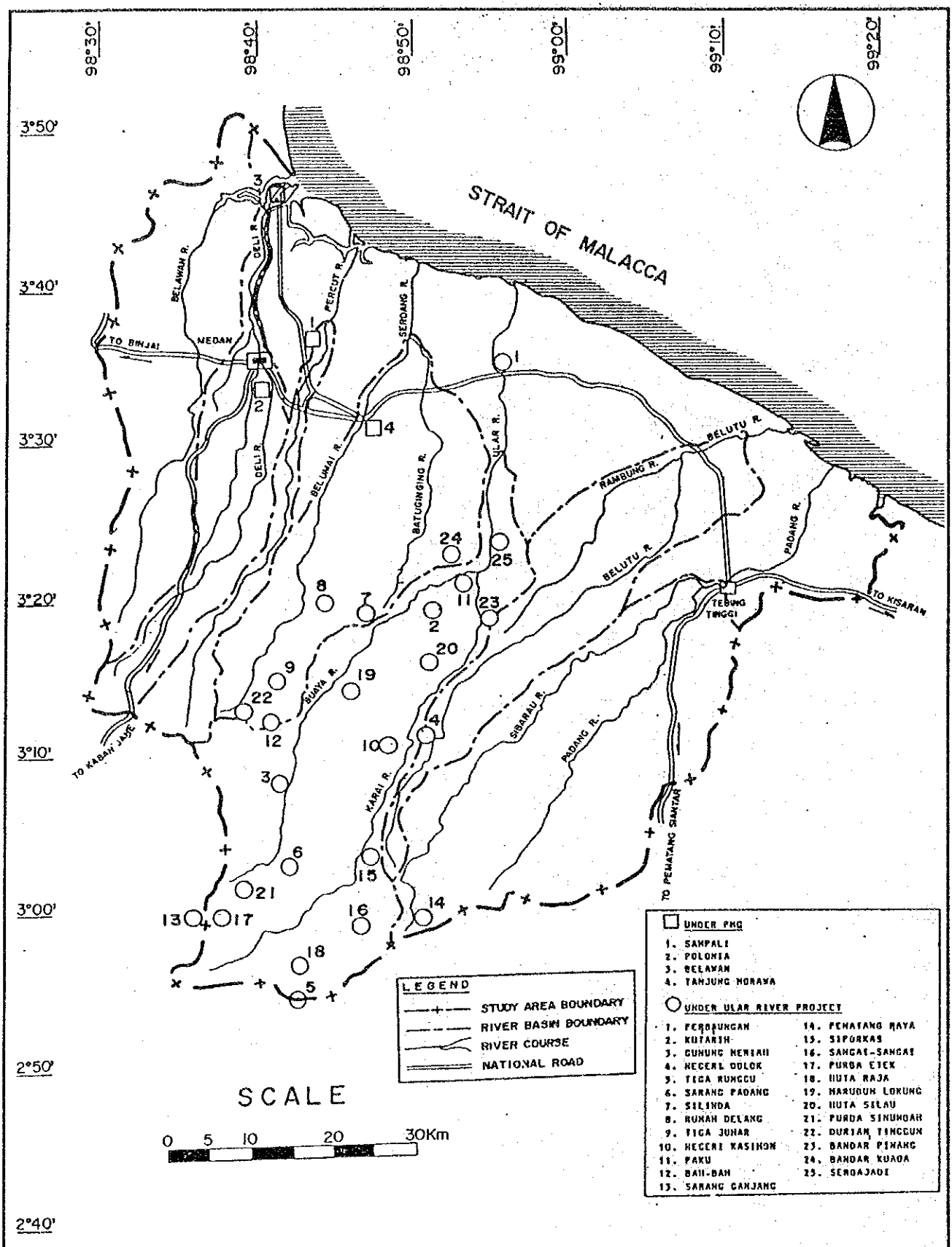


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

RIVER AND RIVER BASIN

Fig.1-1

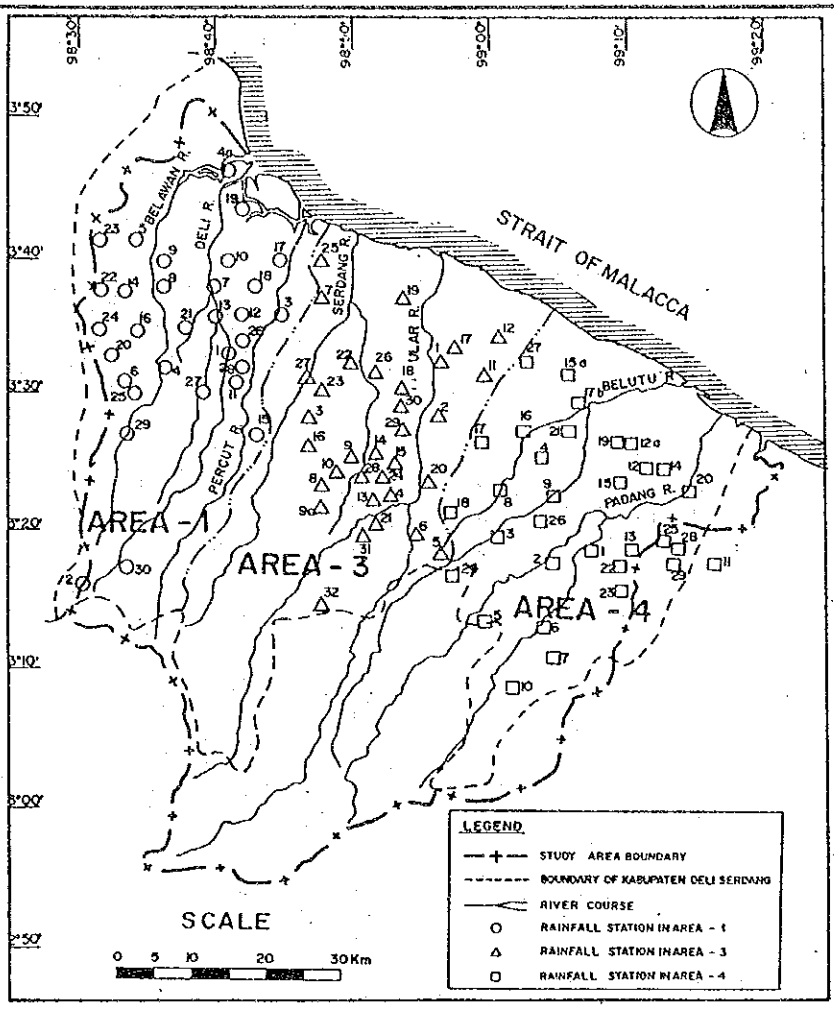


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

LOCATION OF RAINFALL STATIONS UNDER PMG AND ULAR RIVER PROJECT

Fig.2-1



AREA - 1

1. B.P.P.H /1
2. BANDAR BARU /4
3. BANDAR KLIPPA
4. BELAWAN ESTATE /4
4a. BELAWAN (PORT.) /4
5. BULU CINA
6. CELUCUR
7. HELVETIA
8. KLAMBIR LIMA
9. KLUMPANG
10. MADAN
11. MARIENDAL
12. MEDAN ESTATE
13. MEDAN PUTRI /2
14. PAYA DAKONG
15. PATUMBAK
16. SEI SEMAYANG A.
17. SAENTIS
18. SAMPALI
19. SERUWAI
20. SEI MENCIRIH /4
21. SEI SIKAMBING DINAS TRACTOR
22. TANDEM
23. TANDEM HILIR
24. TIKUNG LANGKAT
25. TUNTUNGAN /4 RAKYAT MEDAN
27. SEI SIKAMBING KIR. PNP. III
28. MARIENDAL COKLAT
29. CELUCUR RITHOUN
30. BANDAR BARU /3 (DAIRY)

AREA - 3

1. ADOLINA ILIR /3
2. ADOLINA ULU
3. AEK PANCUR
4. BANDAR KWALA
5. BANDAR NEGERI
6. BANDAR PINANG
6. BATANG KWIS
8. BATU GINGGING
9. BATU RATA
9a. BANGUN PURBA
10. DEGERPANG
11. DENGADING
12. DELI TUDA
13. GREANAH
14. SEI KARANG
15. KWALA NAMU
16. LIMAU MUNGKUR
17. NELATI
18. PAGAR MERBAU
19. RAHUNIA /4
20. SERDANGJADI
21. SEI KARI
22. SEI MERAH
23. SEI PANCUR /4
24. SEI PUTIH
25. SEI TUAN /4
26. TANJONG GARBUS
27. TANJONG MERANA KANAN
28. TANJONG PURBA
29. TIKUANG DELI
30. TANAH ALANG
31. KOTARI
32. SILINDA

AREA - 4

1. BAHILANG
2. BANDAR DEJAHOU
3. BANGUN BANDAR /3
4. SINA KASIH
5. GUNUNG MONAKO
6. GUNUNG PAHELA
7. GUNUNG PARA
8. HEVEA EST.
9. HAJA PAO
10. NAGA RAJA
11. PADANG /2
12. PAYA MADAR
12a. SEI BULUH
13. PAYA PINANG
14. PRIOK
15. RAHOJIAN
15a. RAHOJIAN AFD.V LINDERIA
16. RAHOONG EST.
17. RAHOONG SIALANG
17b. RAHOONG SIALANG DIV.V FIRDAUS
18. SARANG GINTING
19. SEI BAHDAR
20. SEI BIHUNG
21. SEI PARIT
22. SEI RAHPAH
23. SEI DIRIAN
24. SILAU DUNIA
25. TANAH DESIH
26. TANJUNG HARIA
27. TAHAH RAJA
28. RATNA (EX HENDARIS B)
29. HENDARIS A

NOTE : /1 With observation of solar radiation and temperature

/2 With observation of solar radiation

/3 With observation of temperature

/4 Observation of rainfall being interrupted

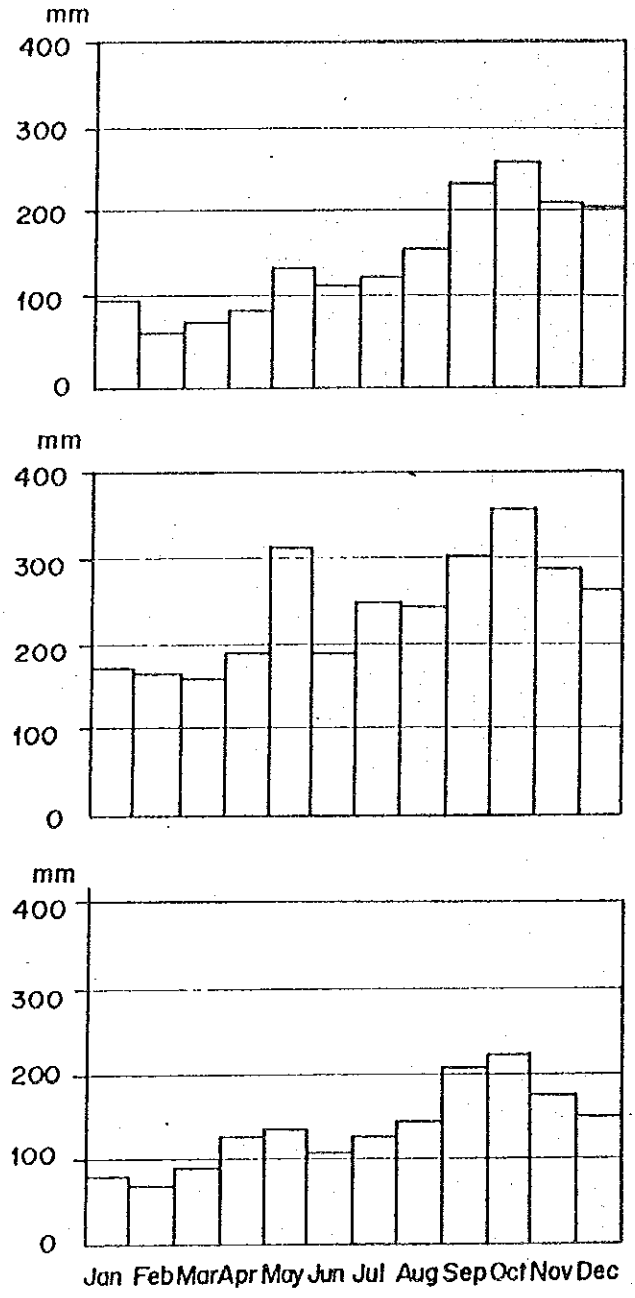
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

LOCATION OF RAINFALL STATIONS UNDER RISPA

Fig.2-2

MONTHLY
Rainfall



NO. 1.19
Seruway
(EL = 6m)

1742 mm/year

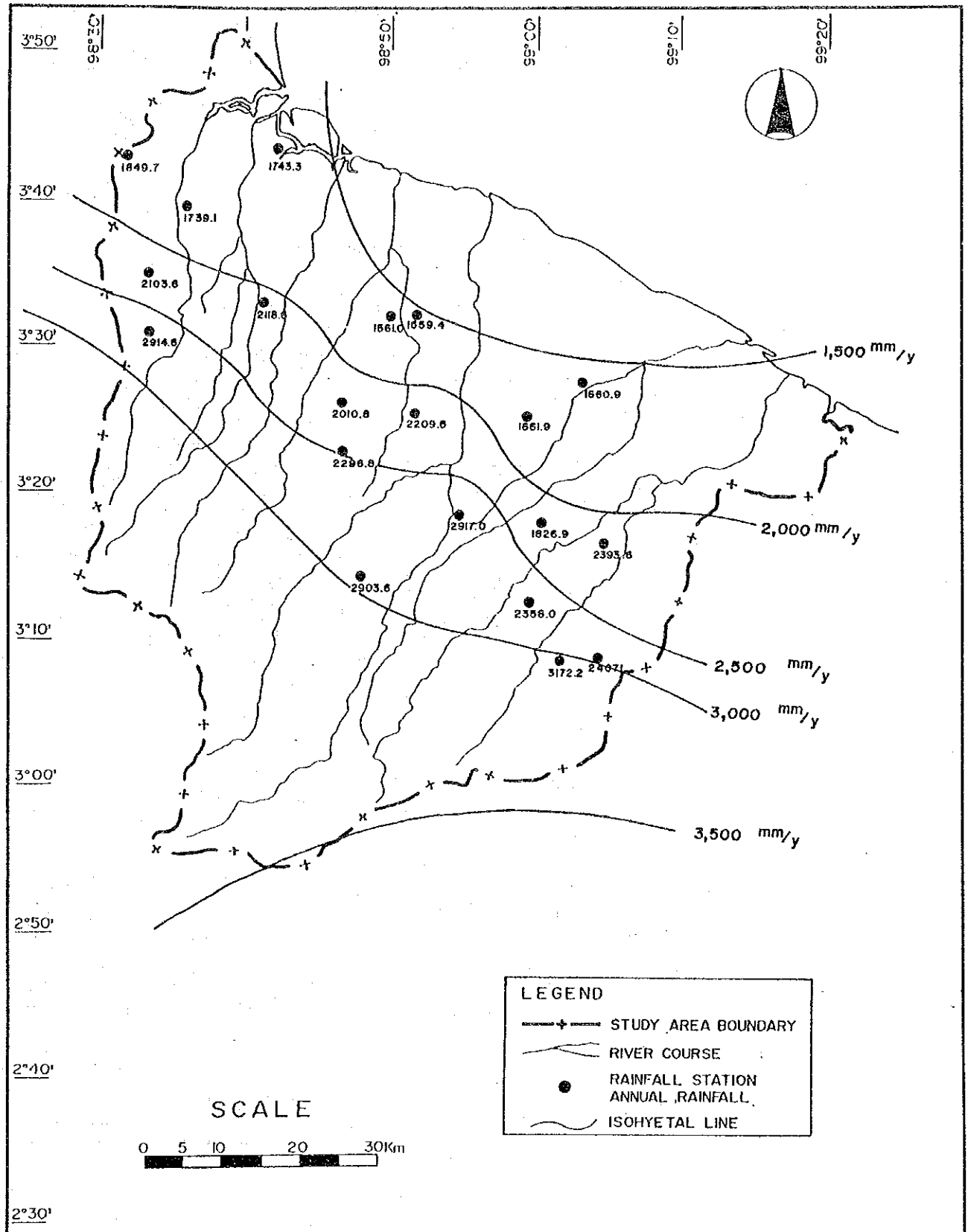
NO. 3.32
Silinda
(EL = 207m)

2904 mm/year

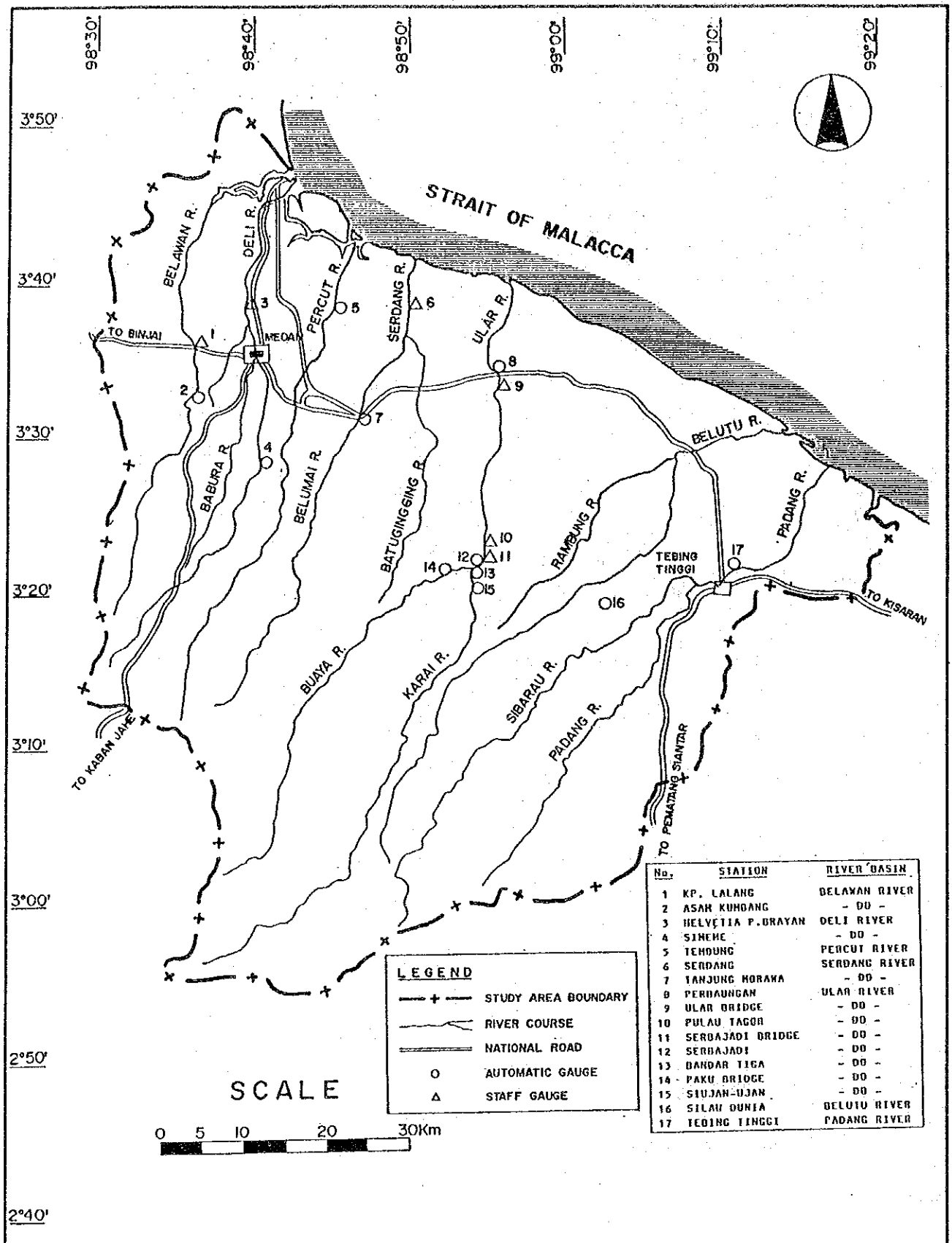
NO. 4.17
Rambung Si alang
(EL = 30m)

1662 mm/year

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	MONTHLY RAINFALL PATTERNS Fig.2-3



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	ISOHYETAL MAP OF ANNUAL RAINFALL IN 1969-1988 Fig.2-4



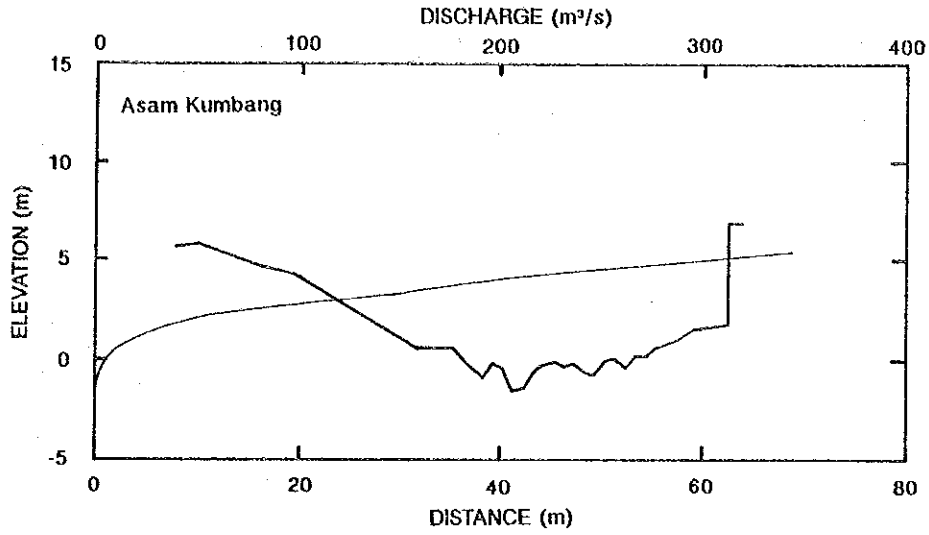
No.	STATION	RIVER BASIN
1	KP. LALANG	BELAWAN RIVER
2	ASAM KUMBANG	- DO -
3	HELVETIA P.BRAYAN	DELI RIVER
4	SINEMBE	- DO -
5	TEMBUNG	PERCUT RIVER
6	SERDANG	SERDANG RIVER
7	TANJUNG MORAWA	- DO -
8	PERDAUNGAN	ULAR RIVER
9	ULAR BRIDGE	- DO -
10	PULAU TAGOR	- DO -
11	SERBAJADI BRIDGE	- DO -
12	SERBAJADI	- DO -
13	BANDAR TIGA	- DO -
14	PAKU BRIDGE	- DO -
15	SIUJAN-UJAN	- DO -
16	SILAU DUNIA	BELUTU RIVER
17	TEBING TINGGI	PADANG RIVER

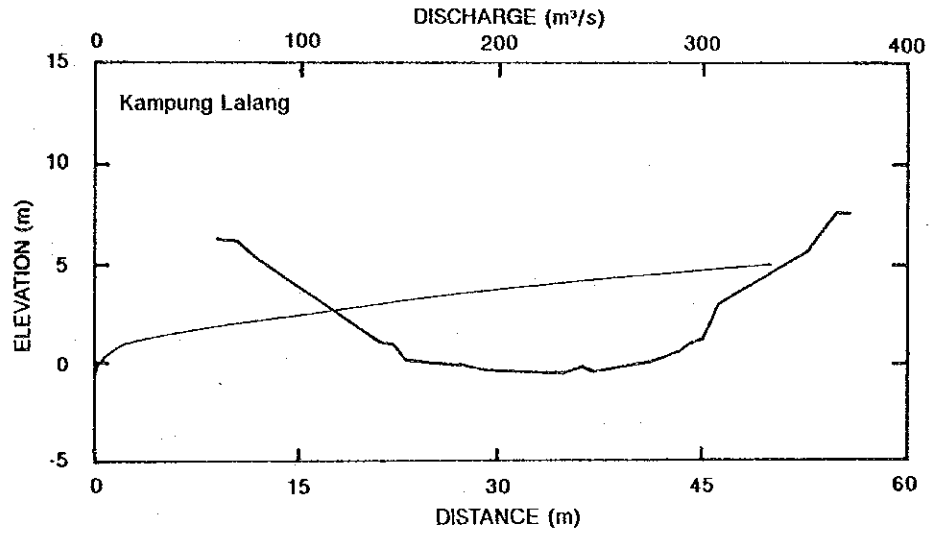
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

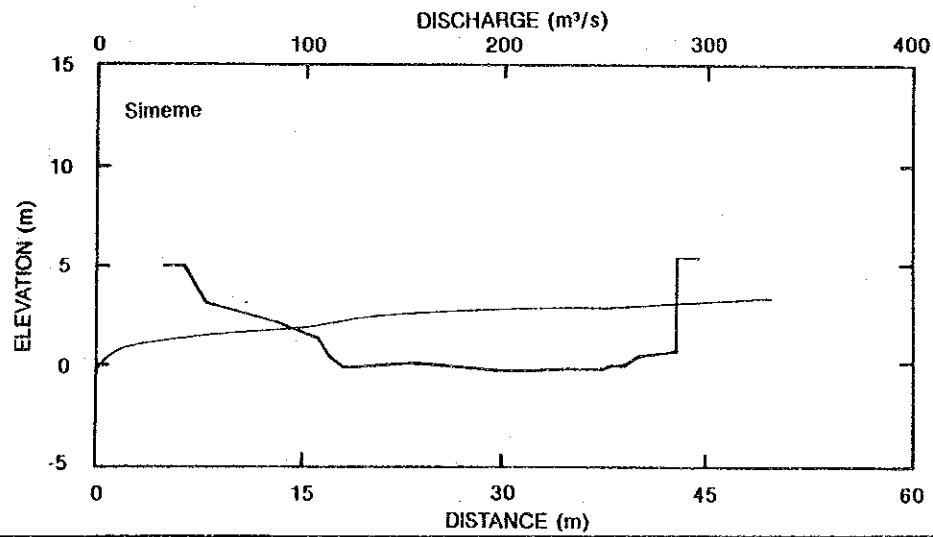
JAPAN INTERNATIONAL COOPERATION AGENCY

LOCATION OF WATER LEVEL STATIONS

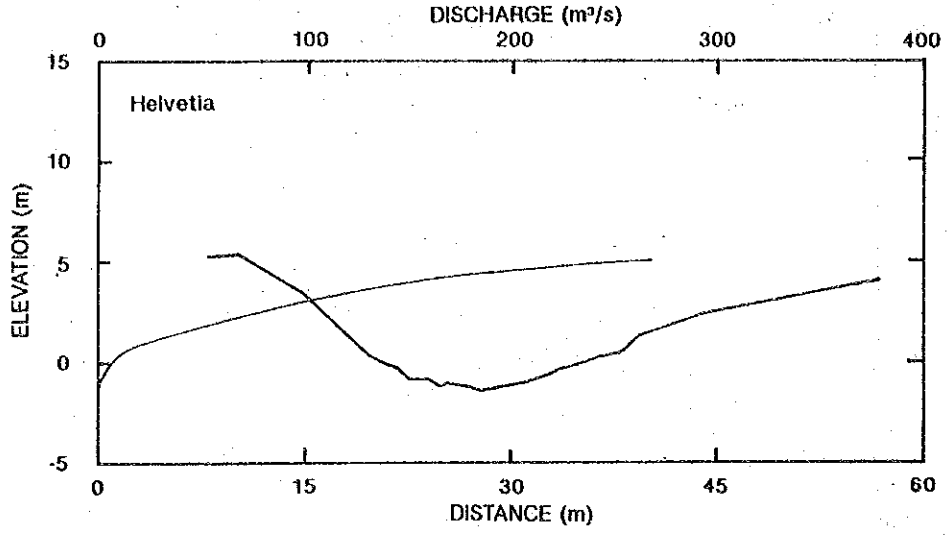
Fig.3-1

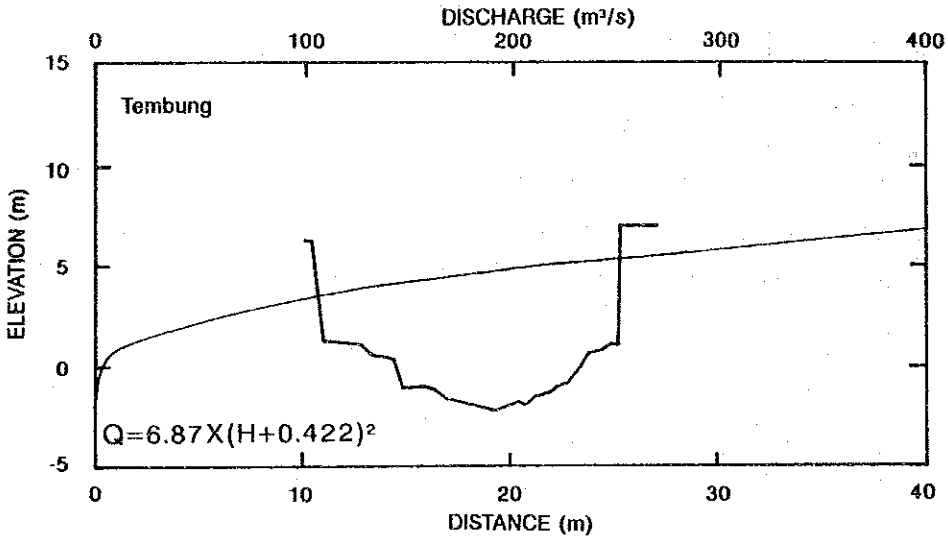


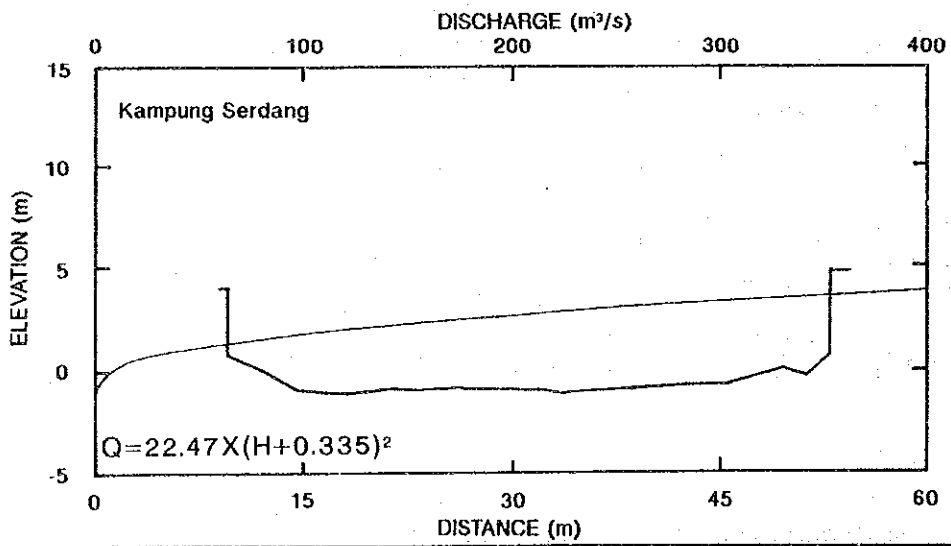




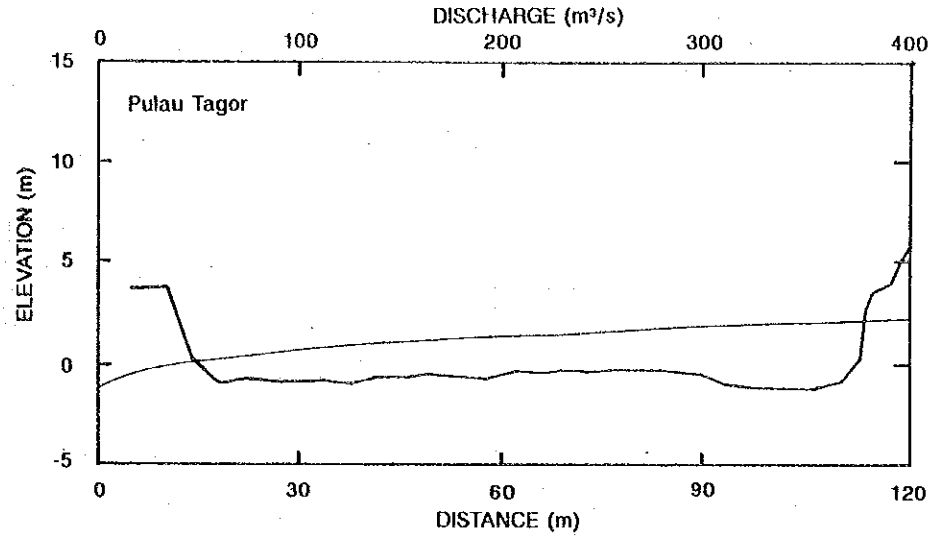
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	CROSS SECTION AND RATING CURVE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.3-2(1/3)

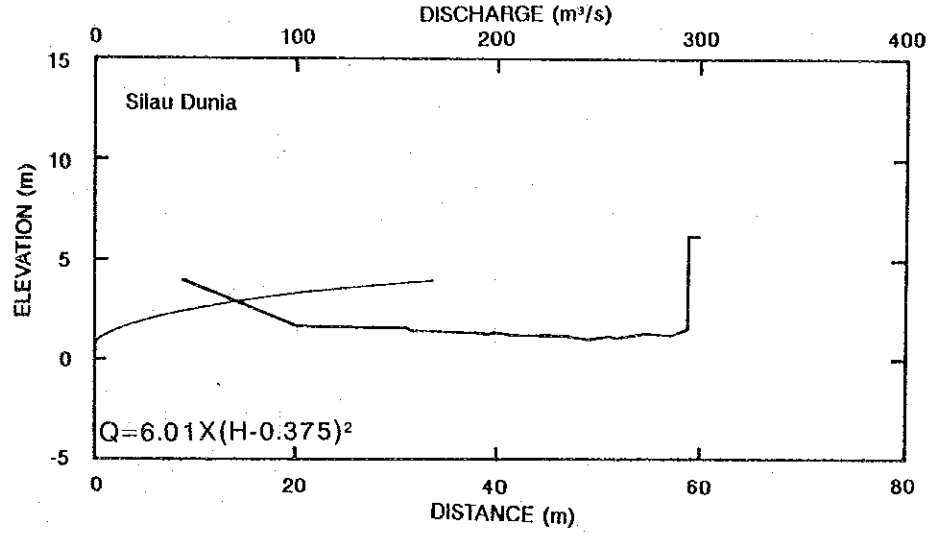


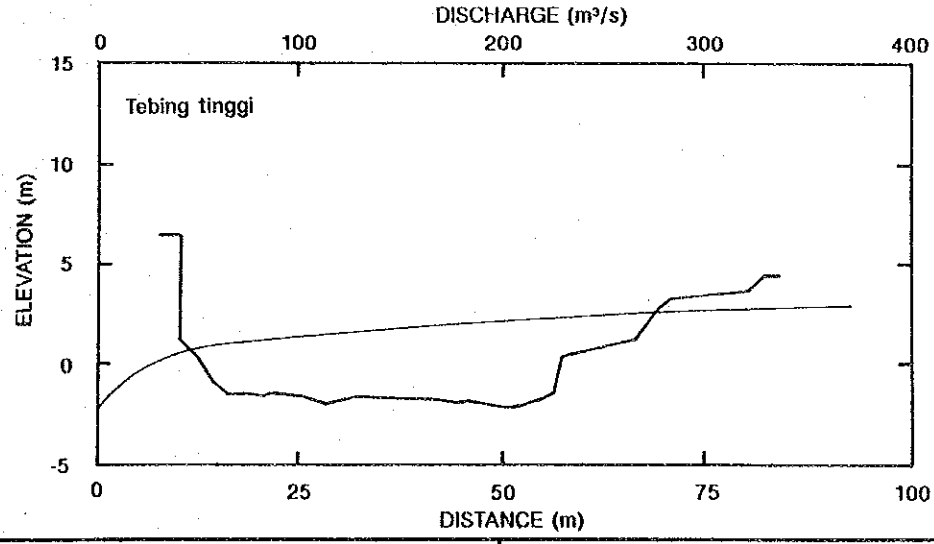




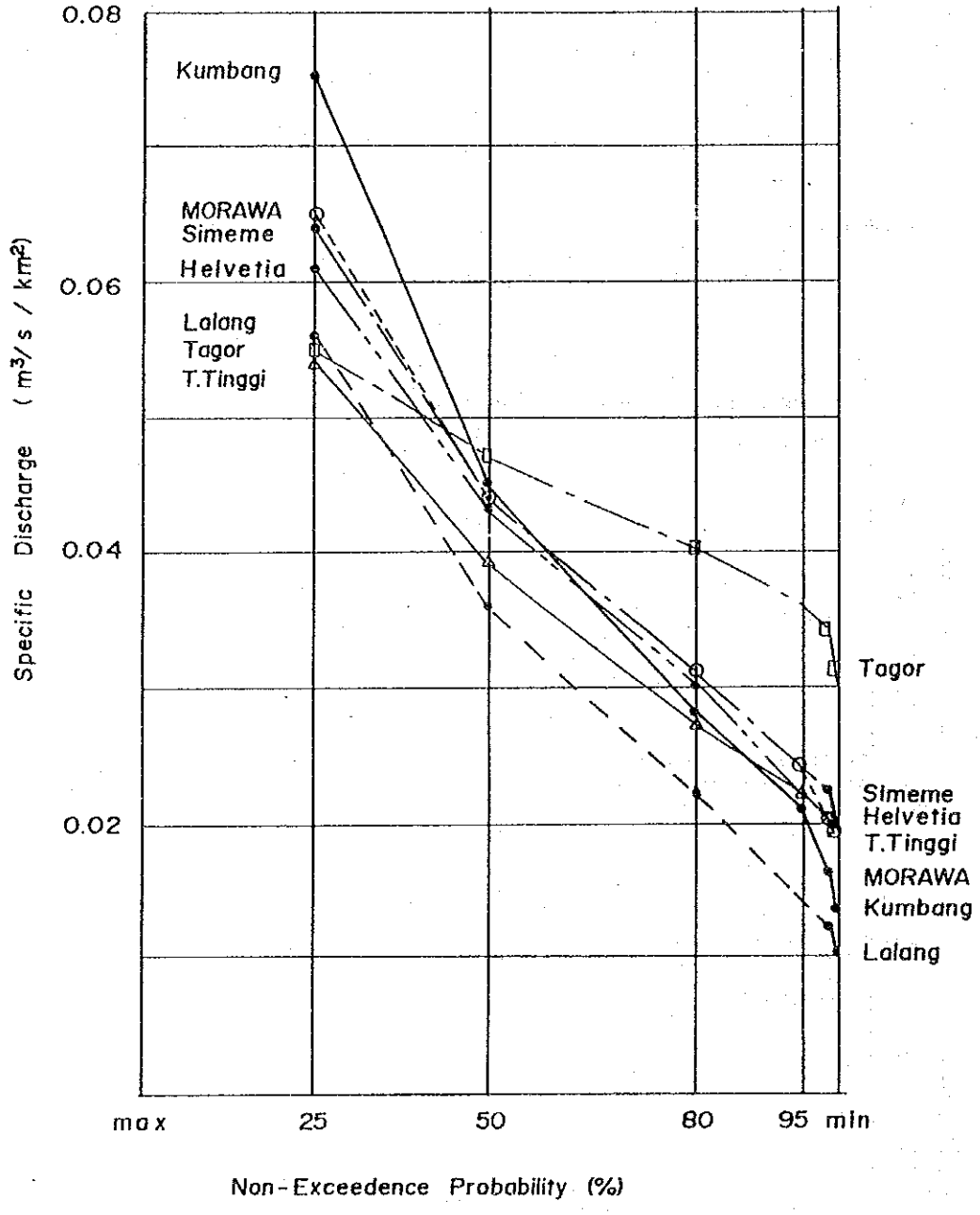
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	CROSS SECTION AND RATING CURVE Fig.3-2(2/3)





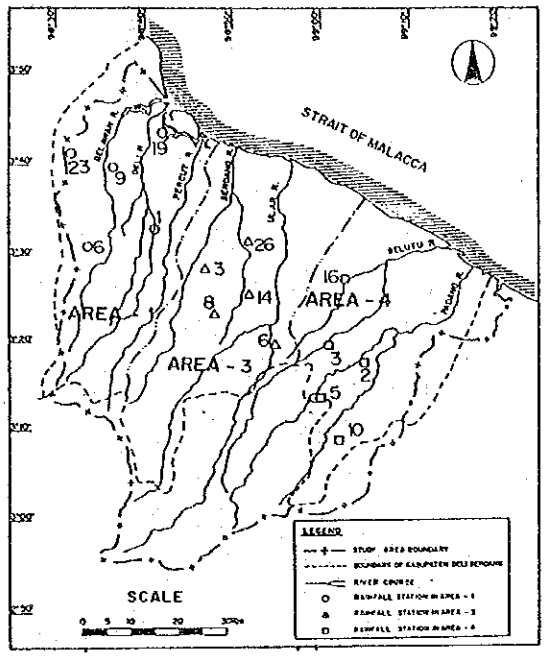


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	CROSS SECTION AND RATING CURVE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.3-2(3/3)



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	SPECIFIC DISCHARGE AND NON-EXCEEDANCE PROBABILITY Fig.3-3

1954 - 1968 (15 STATION)

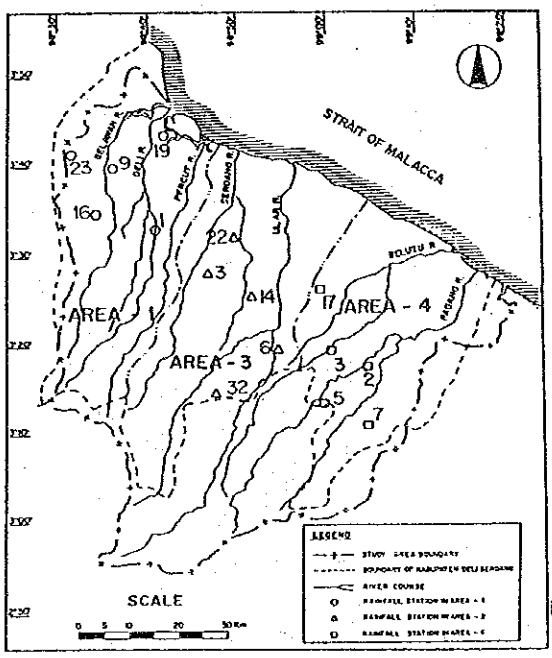


AREA - 1		AREA - 3	
1.	B.P.P.M /1	3.	AEK PANCUR
6.	GLUGUR	6.	BANDAR PINANG
9.	KLUMPANG	8.	BATU GINGGING
19.	SERUWAI	14.	SEI KARANG
23.	TANDEM HILIR	26.	TANJONG GARBUS

AREA - 4	
2.	BANDAR BEJAMBU
3.	BANGUN BANDAR /2
5.	GUNUNG MONAKO
10.	NAGA RAJA
16.	RAMBONG EST.

NOTE : /1 WITH OBSERVATION OF SOLAR RADIATION AND TEMPERATURE
/2 WITH OBSERVATION OF TEMPERATURE

1969 - 1988 (15 STATION)

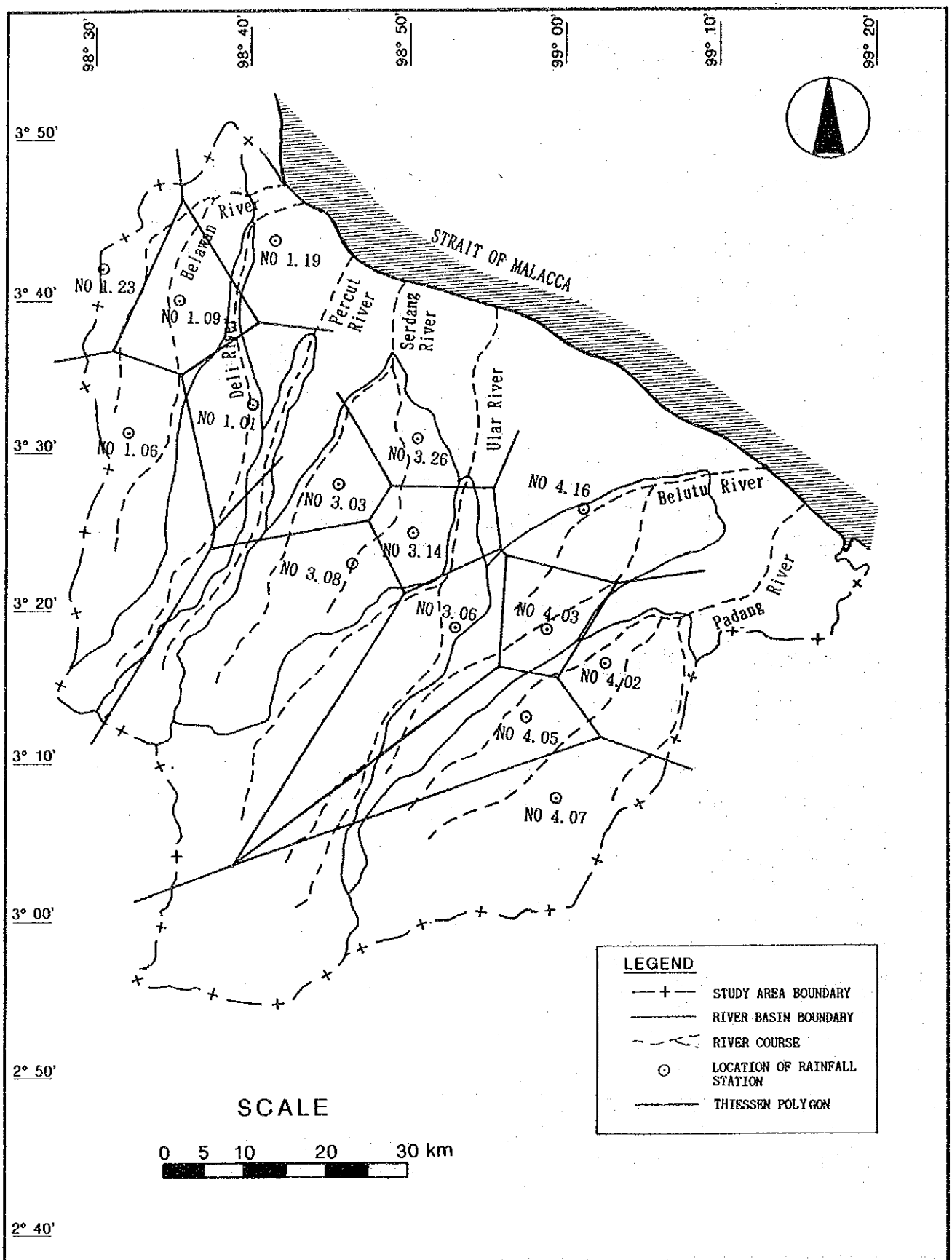


AREA - 1		AREA - 3	
1.	B.P.P.M /1	3.	AEK PANCUR
9.	KLUMPANG	6.	BANDAR PINANG
16.	SEI SEMAYANG A.	14.	SEI KARANG
19.	SERUWAI	22.	SEI MERAH
23.	TANDEM HILIR	32.	SILINDA

AREA - 4	
2.	BANDAR BEJAMBU
3.	BANGUN BANDAR /2
5.	GUNUNG MONAKO
7.	GUNUNG PARA
17.	RAMBONG SIALANG

NOTE : /1 WITH OBSERVATION OF SOLAR RADIATION AND TEMPERATURE
/2 WITH OBSERVATION OF TEMPERATURE

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	LOCATION OF REPRESENTATIVE RAINFALL STATION Fig.4-1

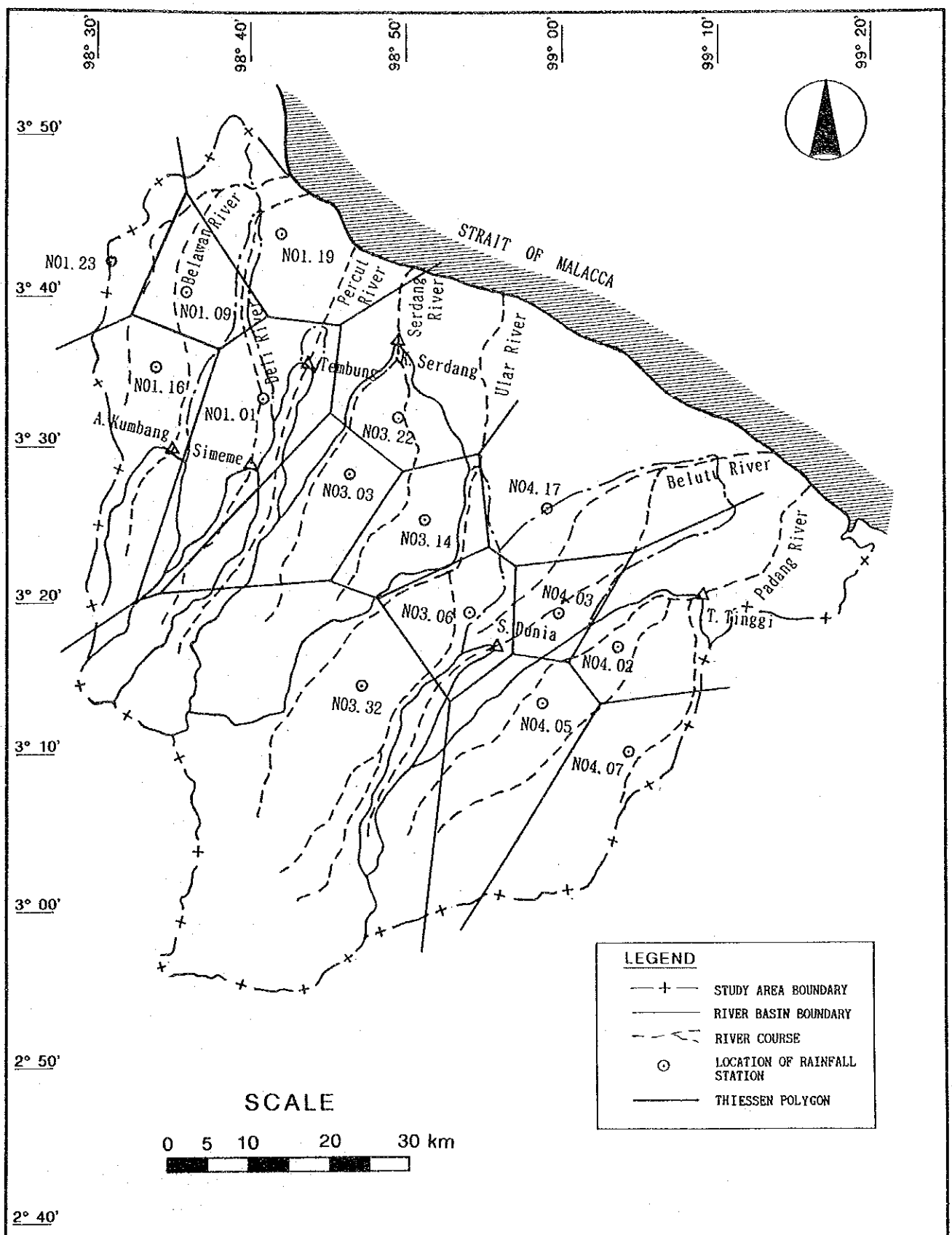


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

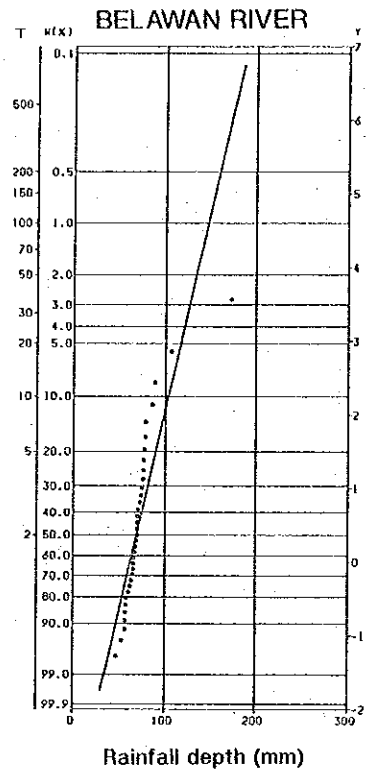
JAPAN INTERNATIONAL COOPERATION AGENCY

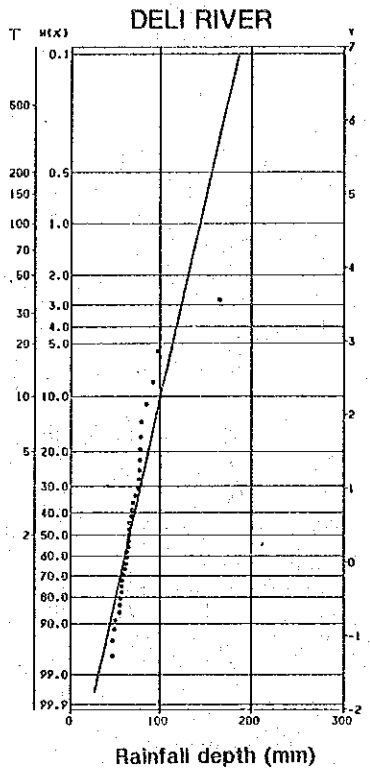
THIESSEN POLYGON (1954-1968)

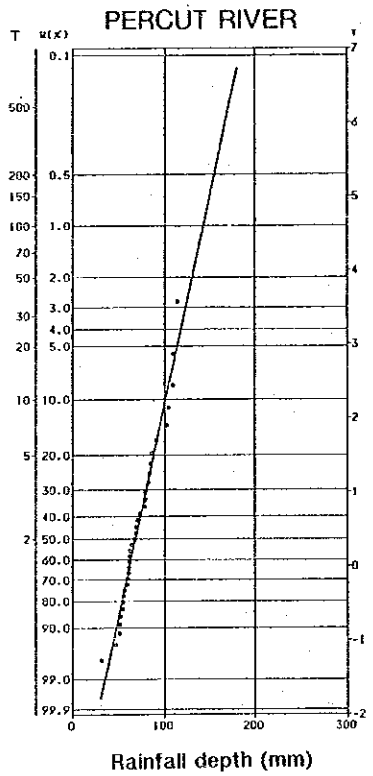
Fig.4-2(1/2)

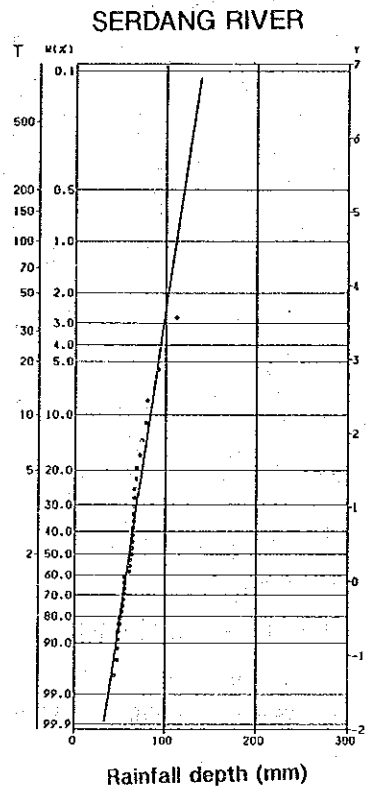


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	THIESSEN POLYGON (1969-1988) Fig.4-2(2/2)



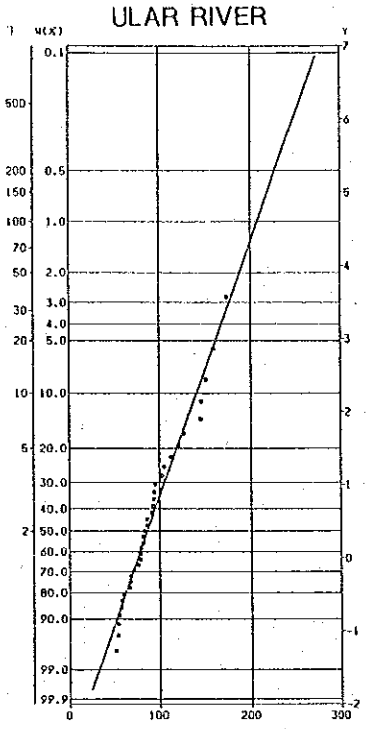






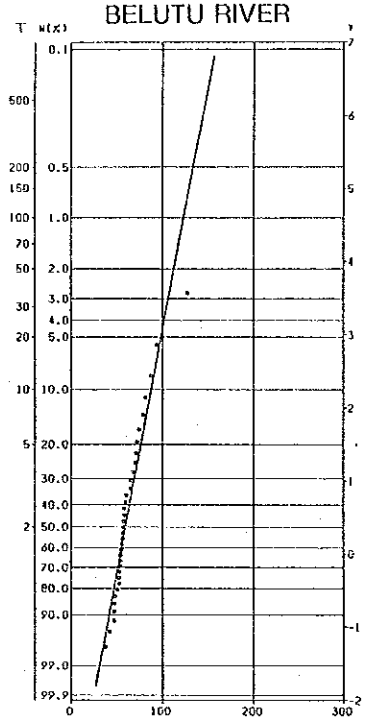
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	PROBABILITY GRAPH OF EXCEEDANCE Fig.4-3(1/2)

ULAR RIVER



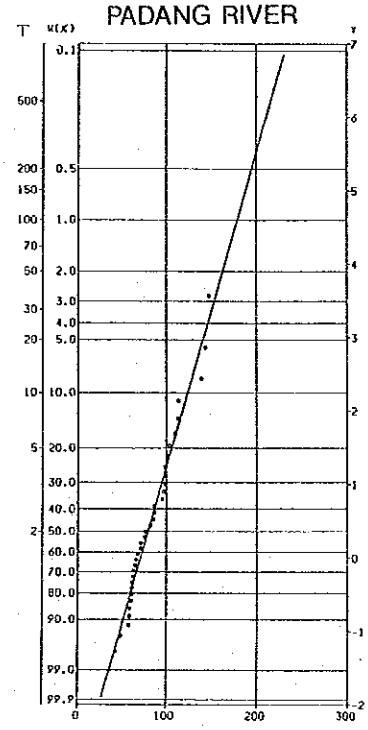
Rainfall depth (mm)

BELUTU RIVER



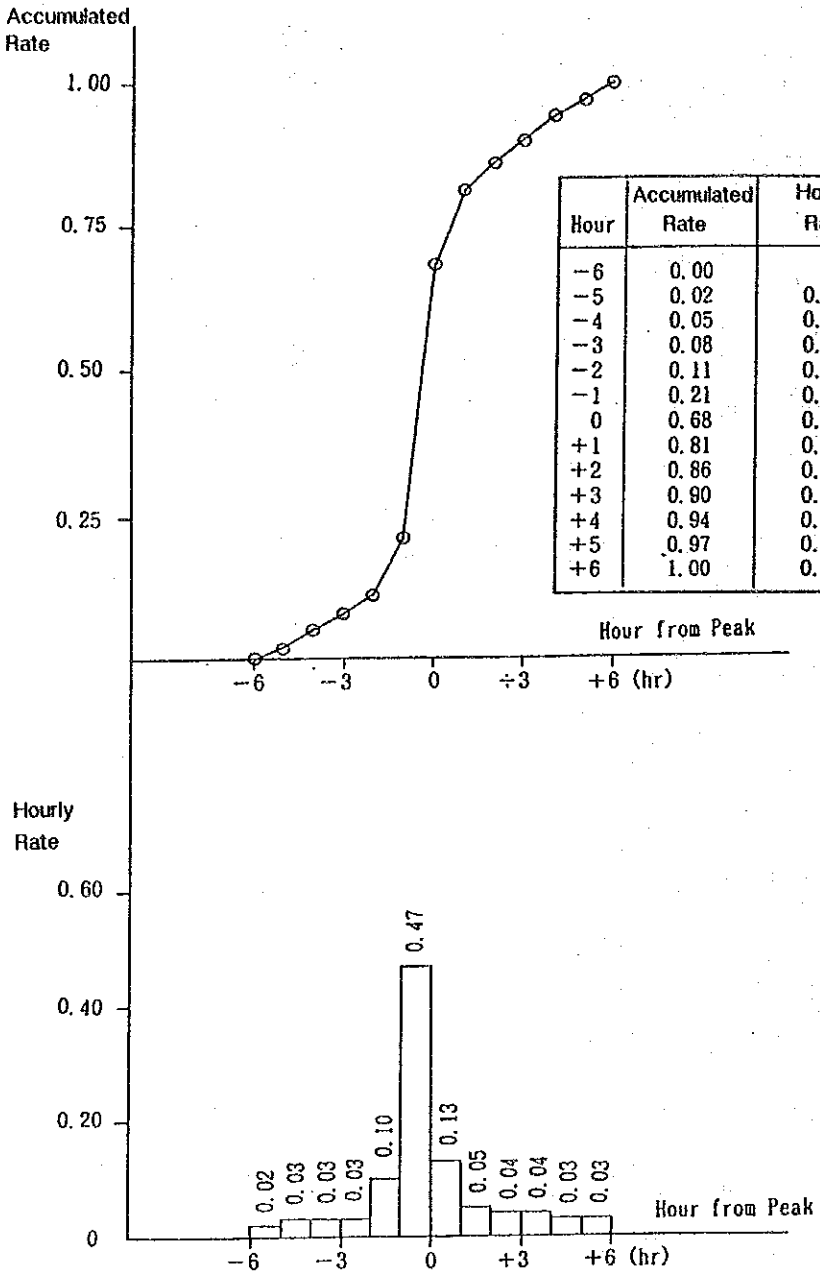
Rainfall depth (mm)

PADANG RIVER



Rainfall depth (mm)

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	PROBABILITY GRAPH OF EXCEEDANCE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.4-3(2/2)



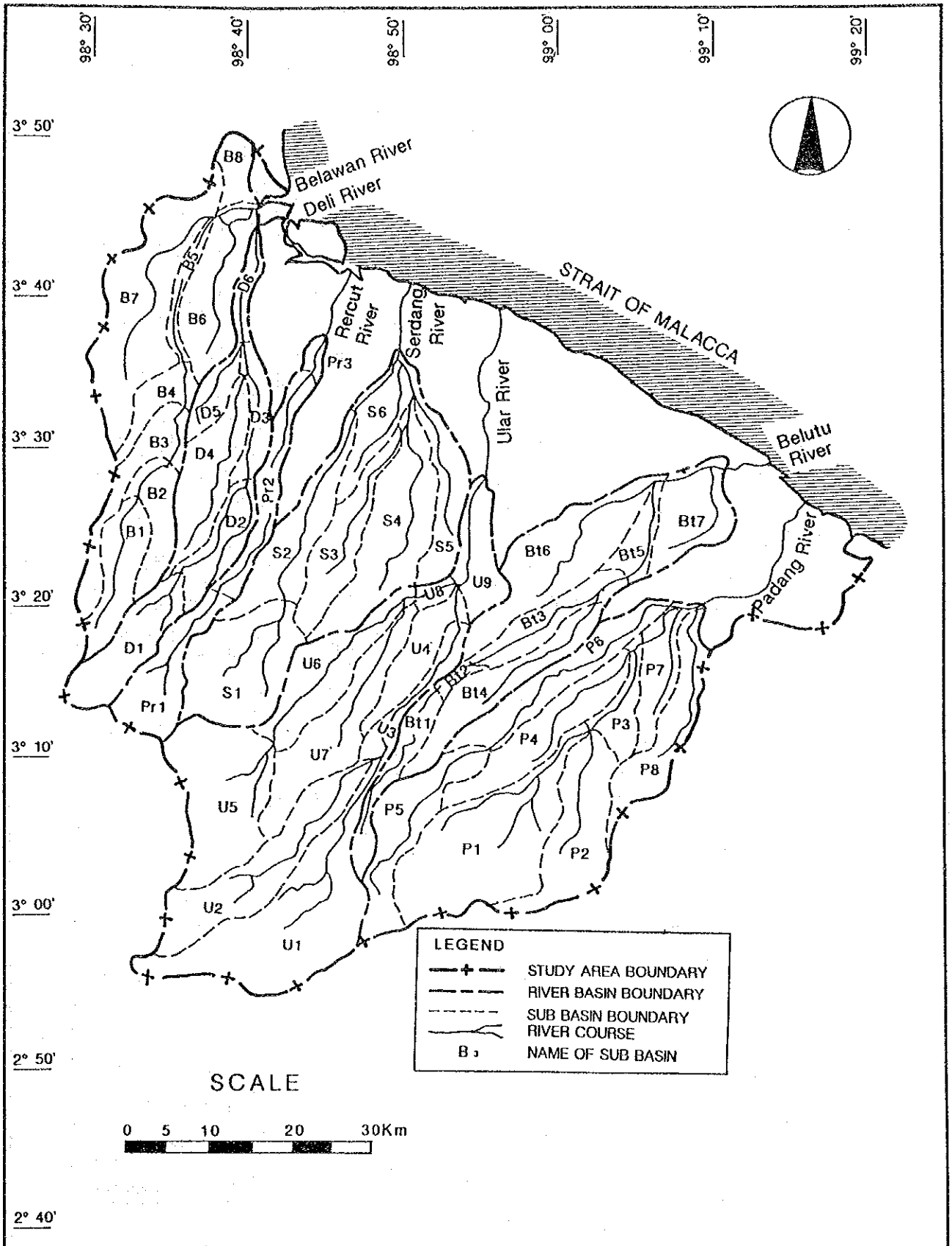
Hour	Accumulated Rate	Hourly Rate
−6	0.00	
−5	0.02	0.02
−4	0.05	0.03
−3	0.08	0.03
−2	0.11	0.03
−1	0.21	0.10
0	0.68	0.47
+1	0.81	0.13
+2	0.86	0.05
+3	0.90	0.04
+4	0.94	0.04
+5	0.97	0.03
+6	1.00	0.03

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

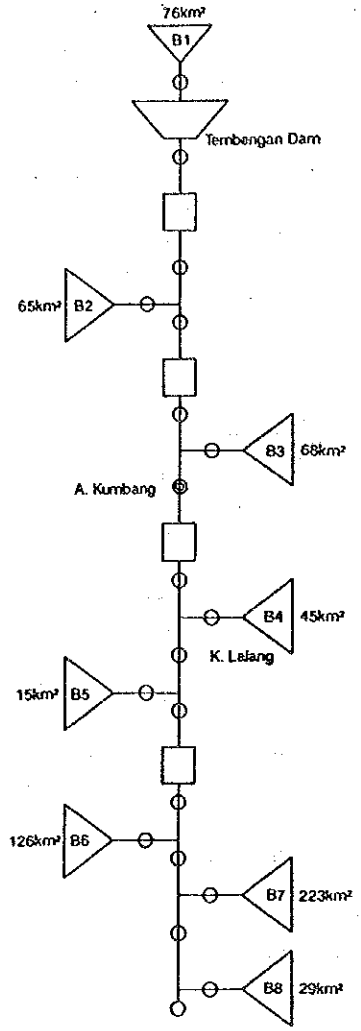
JAPAN INTERNATIONAL COOPERATION AGENCY

DESIGN STORM PATTERN

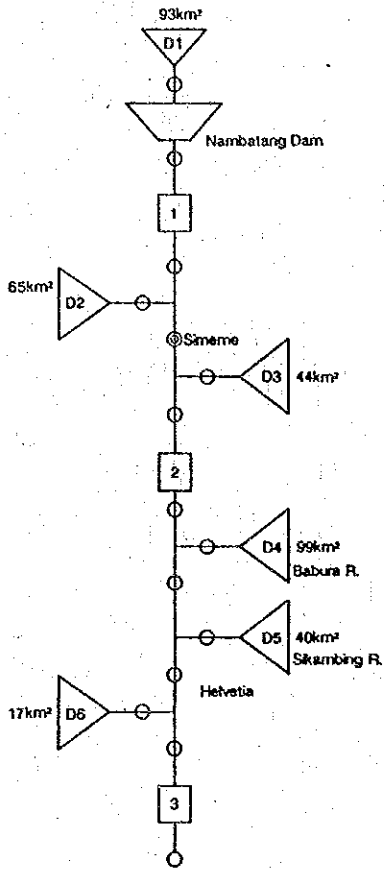
Fig.4-4



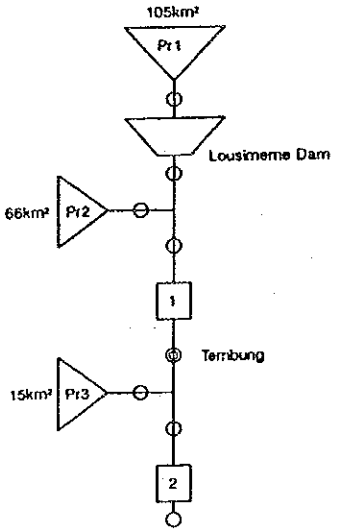
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	SUBBASIN DIVISION Fig.5-1



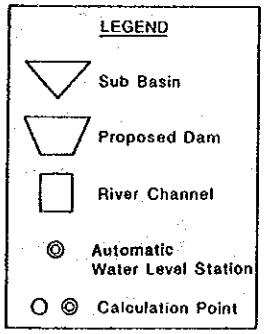
BELAWAN R. MODEL



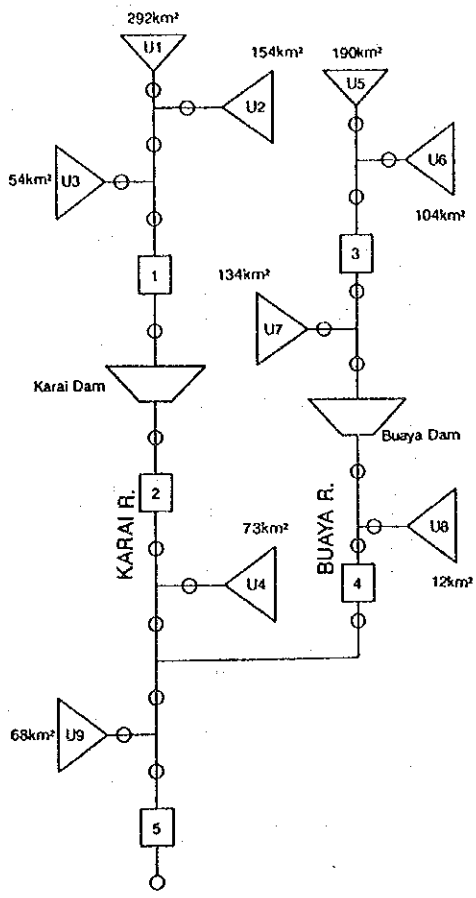
DELI R. MODEL



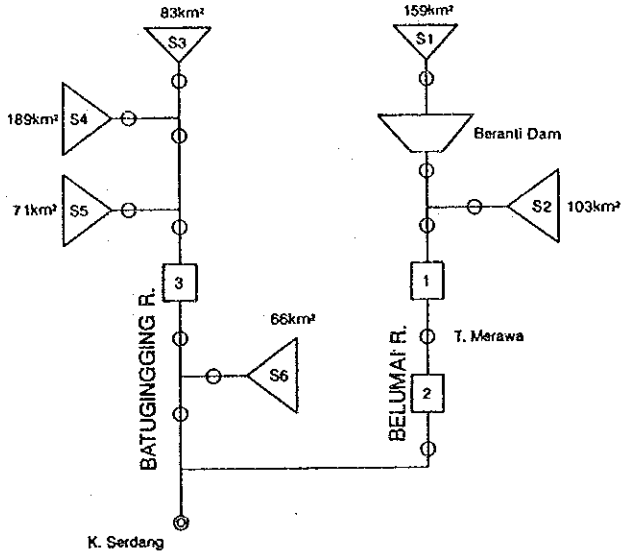
PERCUT R. MODEL



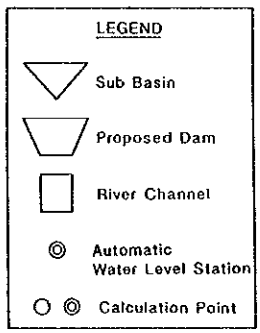
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	BASIN RUNOFF MODEL
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.5-2(1/3)



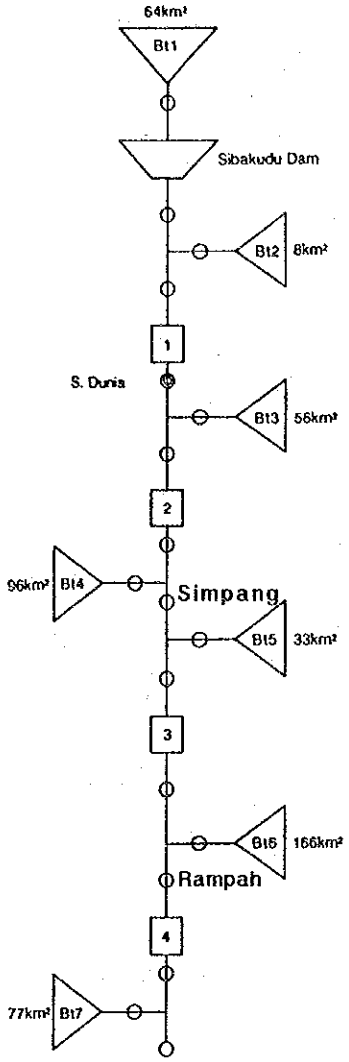
ULAR R. MODEL



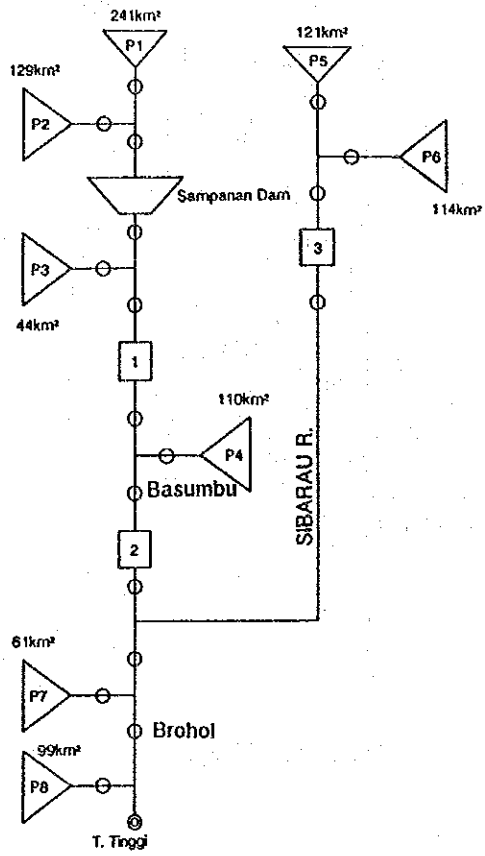
SERDANG R. MODEL



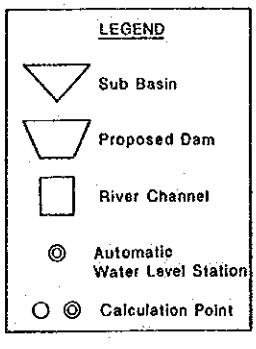
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	BASIN RUNOFF MODEL Fig.5-2(2/3)



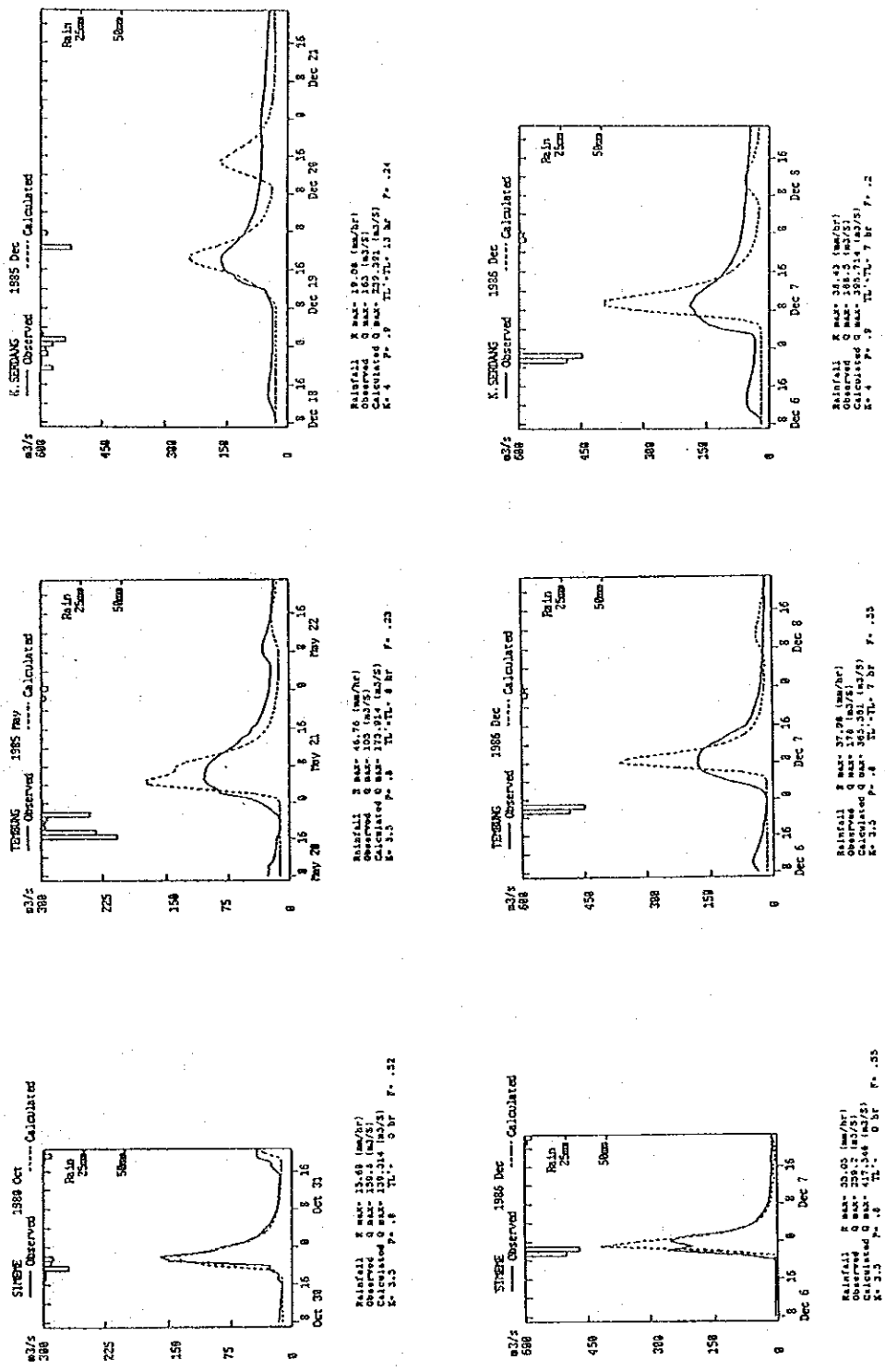
BELUTU R. MODEL



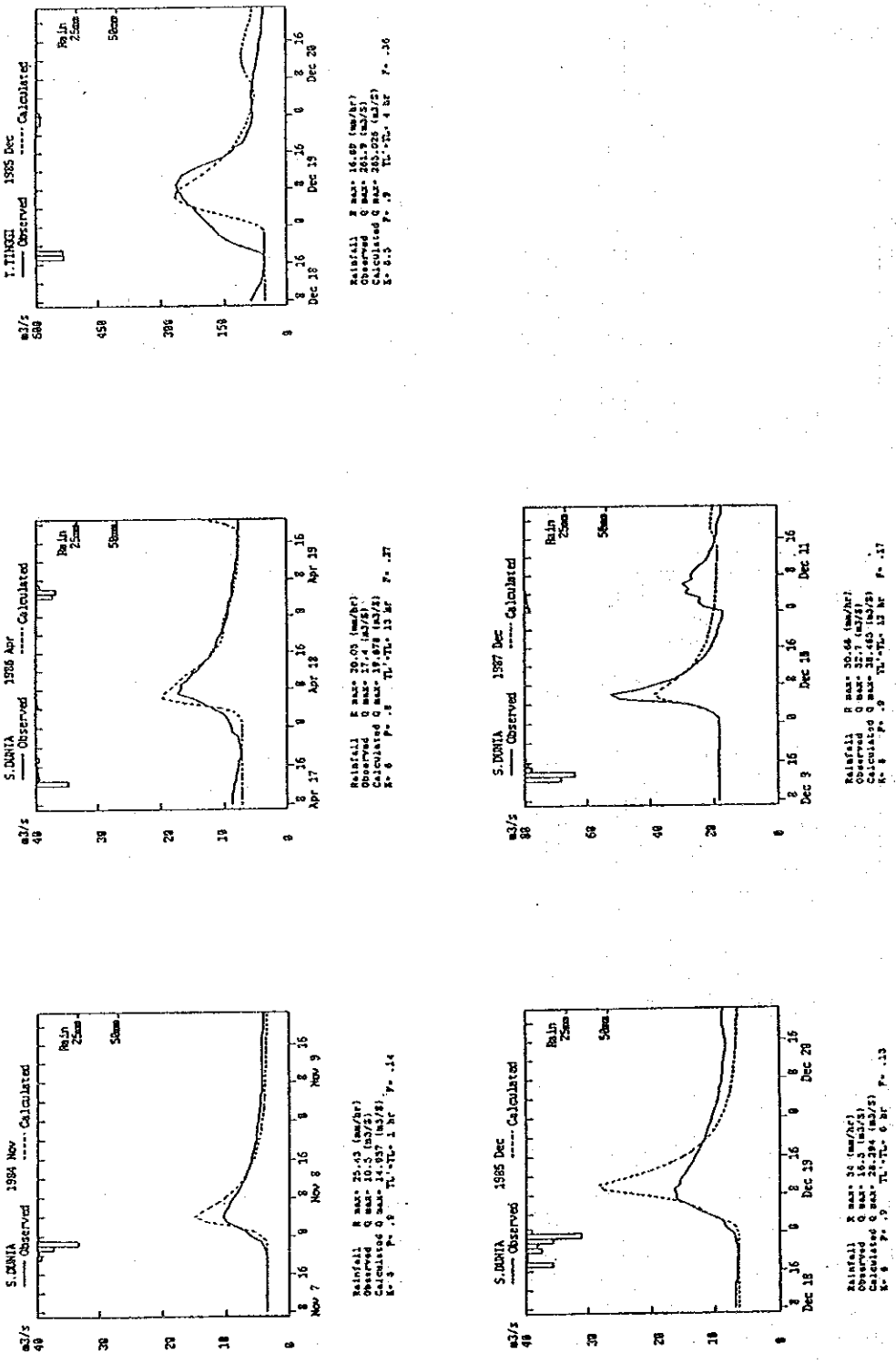
PADANG R. MODEL



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	BASIN RUNOFF MODEL Fig.5-2(3/3)



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	RESULTS OF MODEL CALIBRATION
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.5-3(1/2)

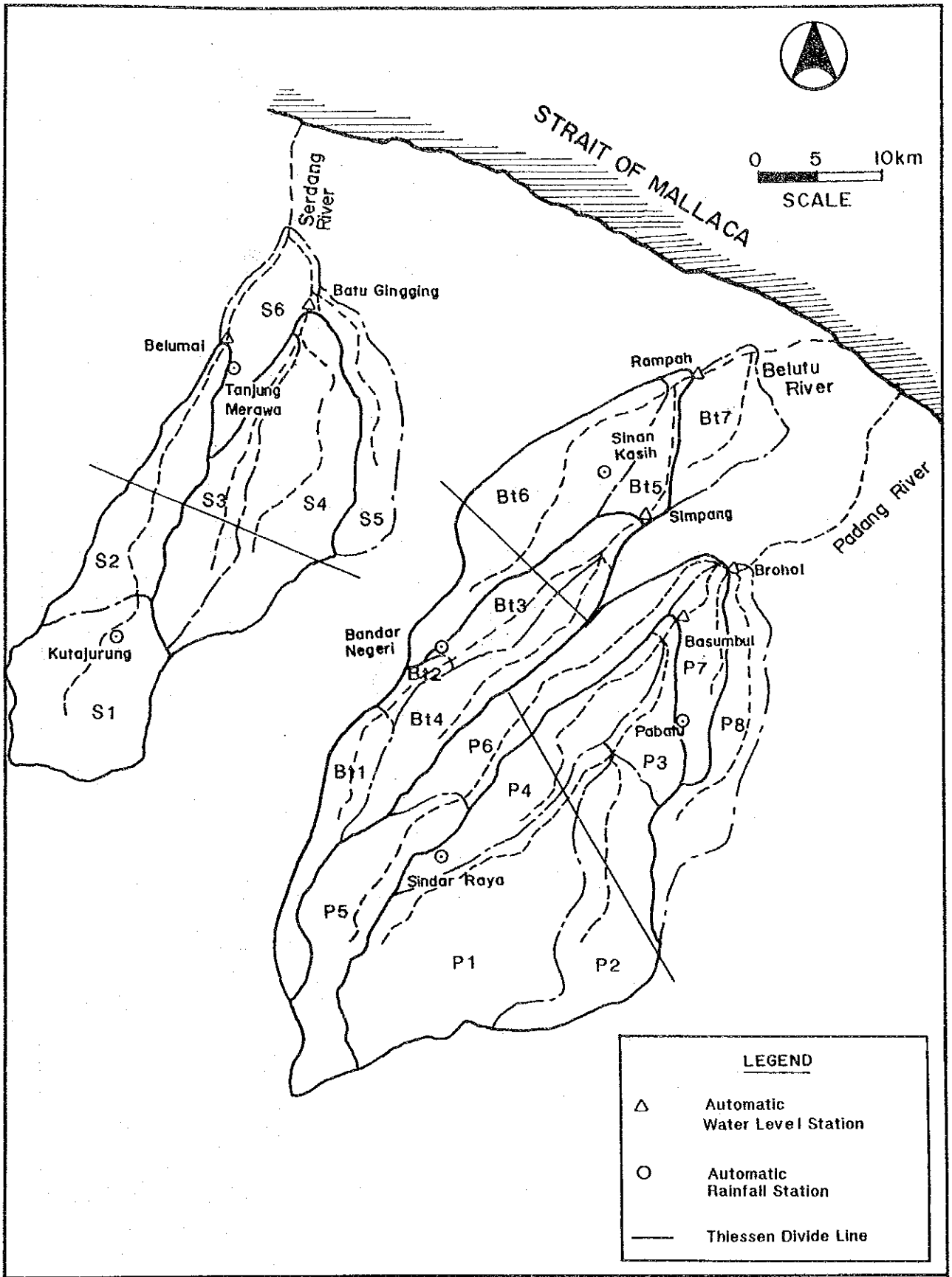


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

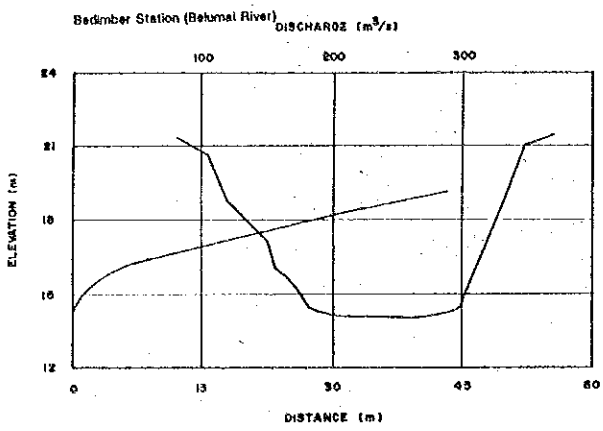
JAPAN INTERNATIONAL COOPERATION AGENCY

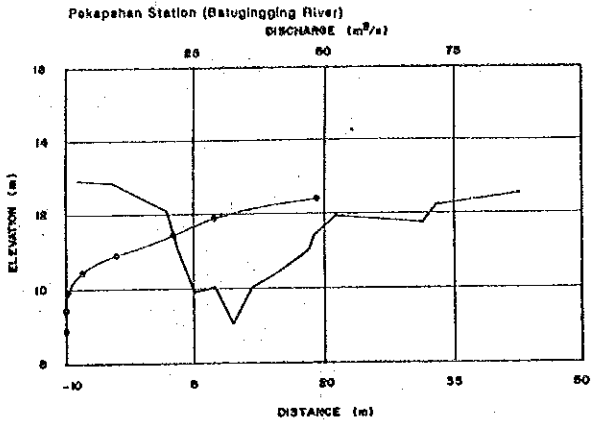
RESULTS OF MODEL CALIBRATION

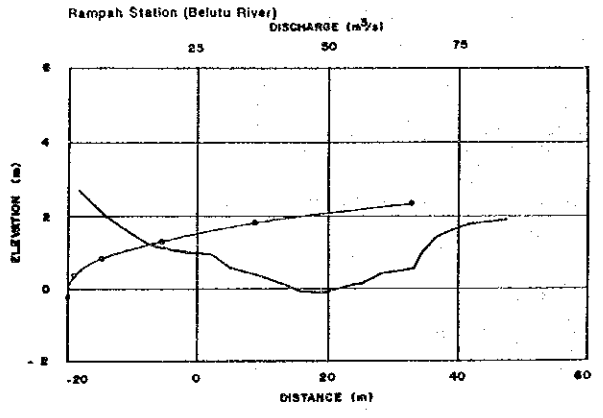
Fig.5-3(2/2)

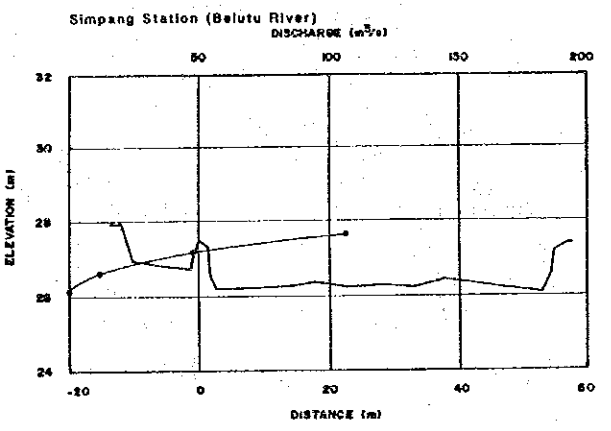


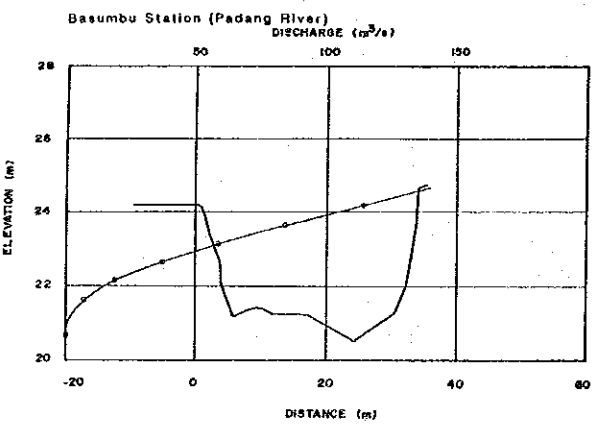
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	LOCATIONS OF NEW HYDROLOGICAL STATIONS Fig.5-4

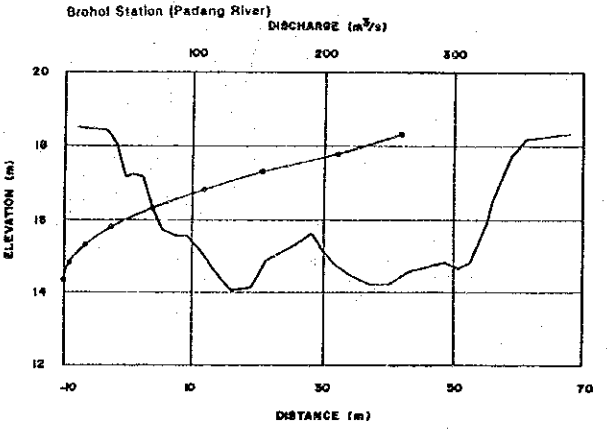






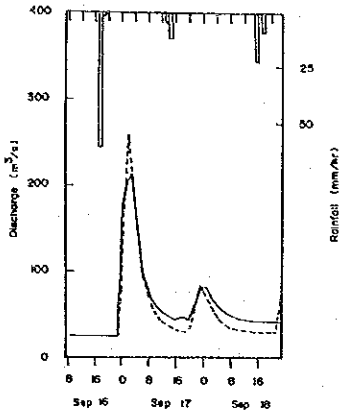




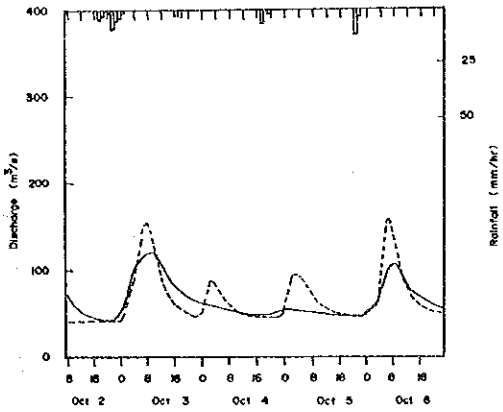


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	CROSS SECTION AND RATING CURVE OF NEW HYDROLOGICAL STATIONS Fig.5-5

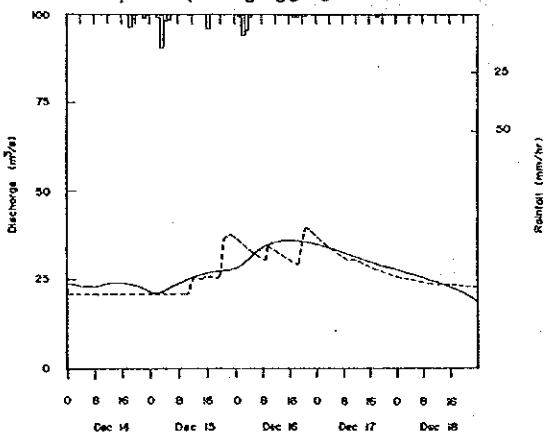
Bedimbar(Belumai River)



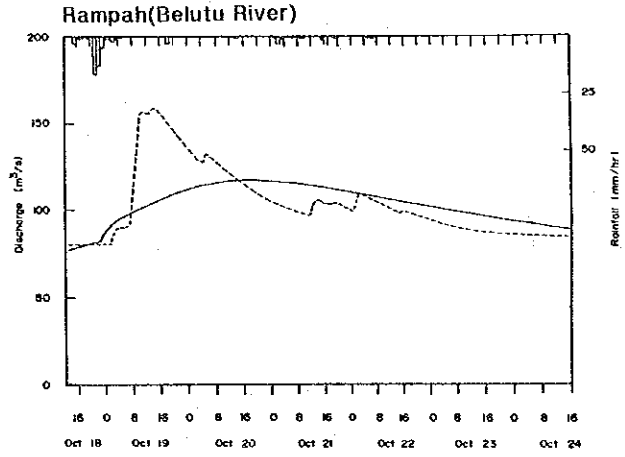
Bedimbar(Belumai River)



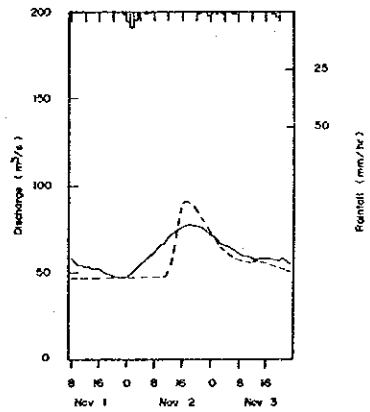
Pekapahan(Batugingging River)



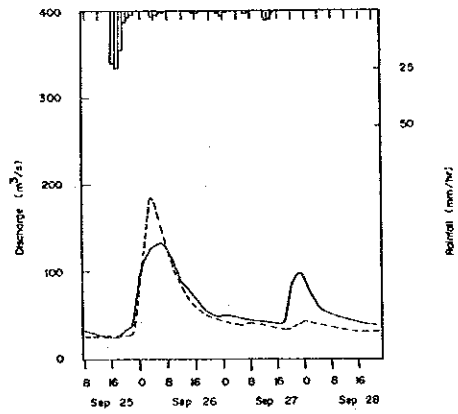
Rampah(Belutu River)



Simpang(Belutu River)

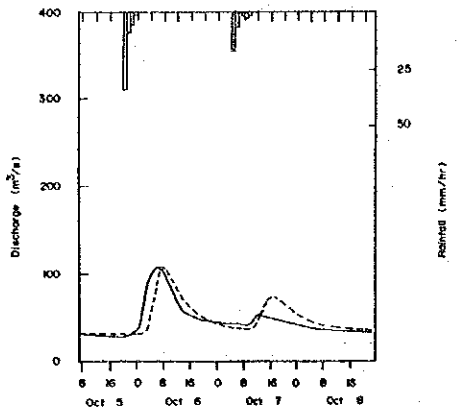


Basumbu(Padang River)

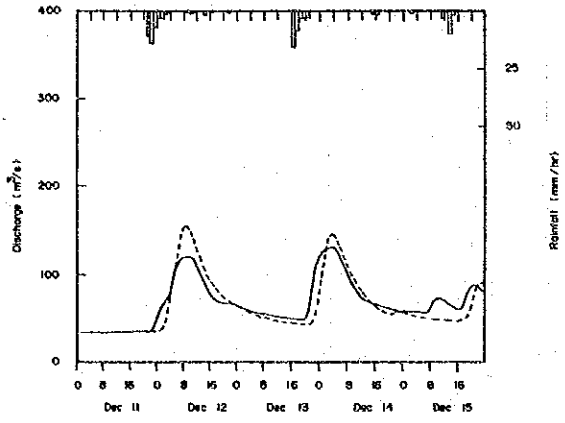


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	RUNOFF SIMULATION FOR NEW HYDROLOGICAL STATIONS
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.5-6(1/2)

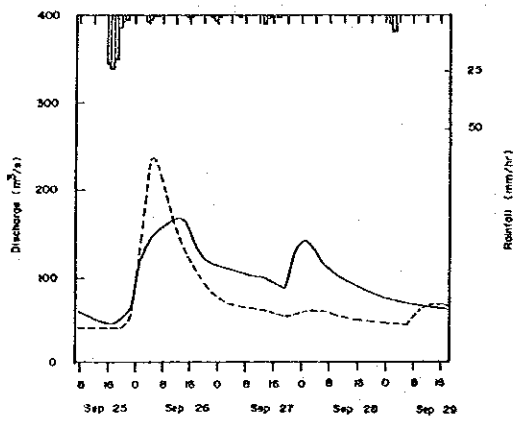
Basumbu(Padang River)



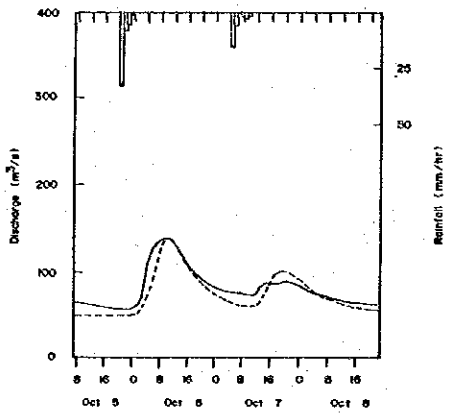
Basumbu(Padang River)



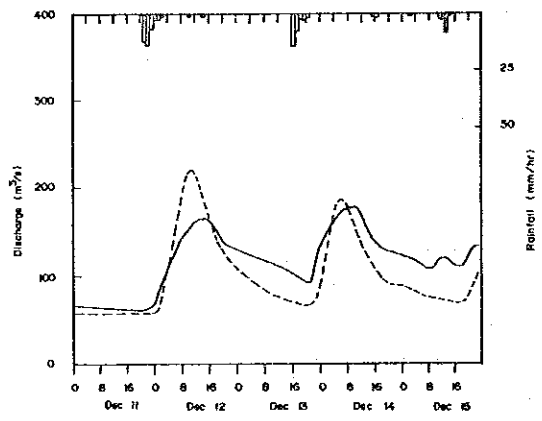
Brohol(Padang River)



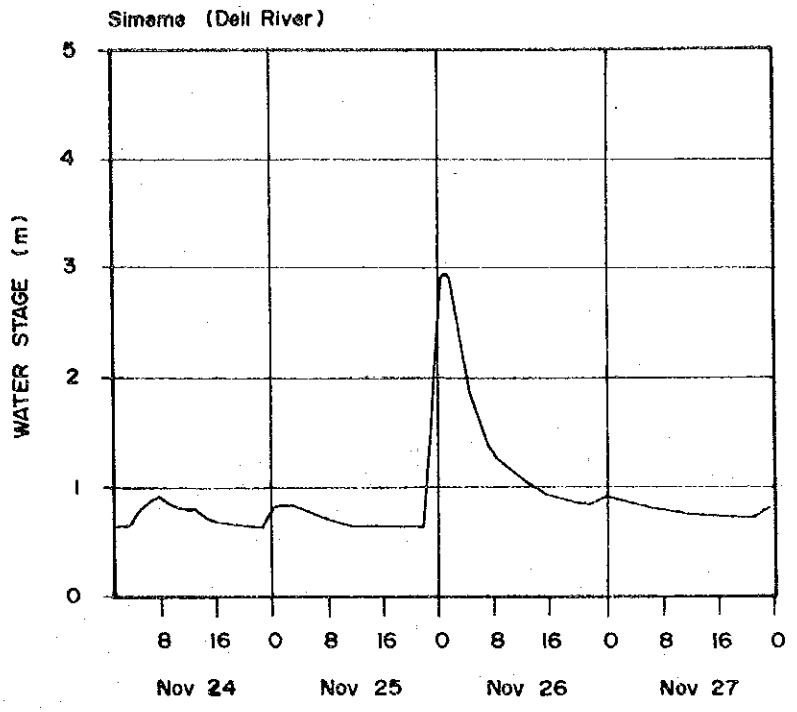
Brohol(Padang River)

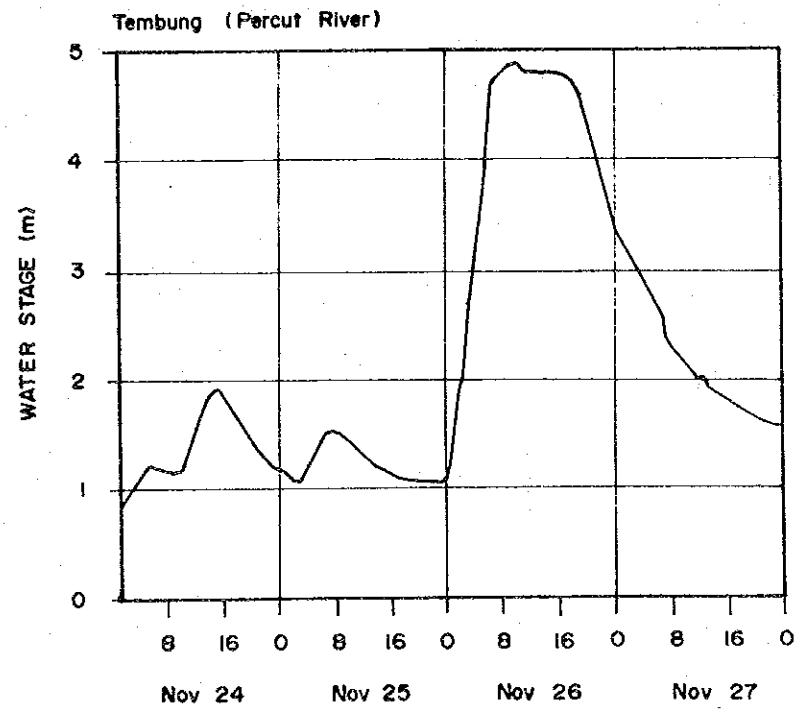


Brohol(Padang River)

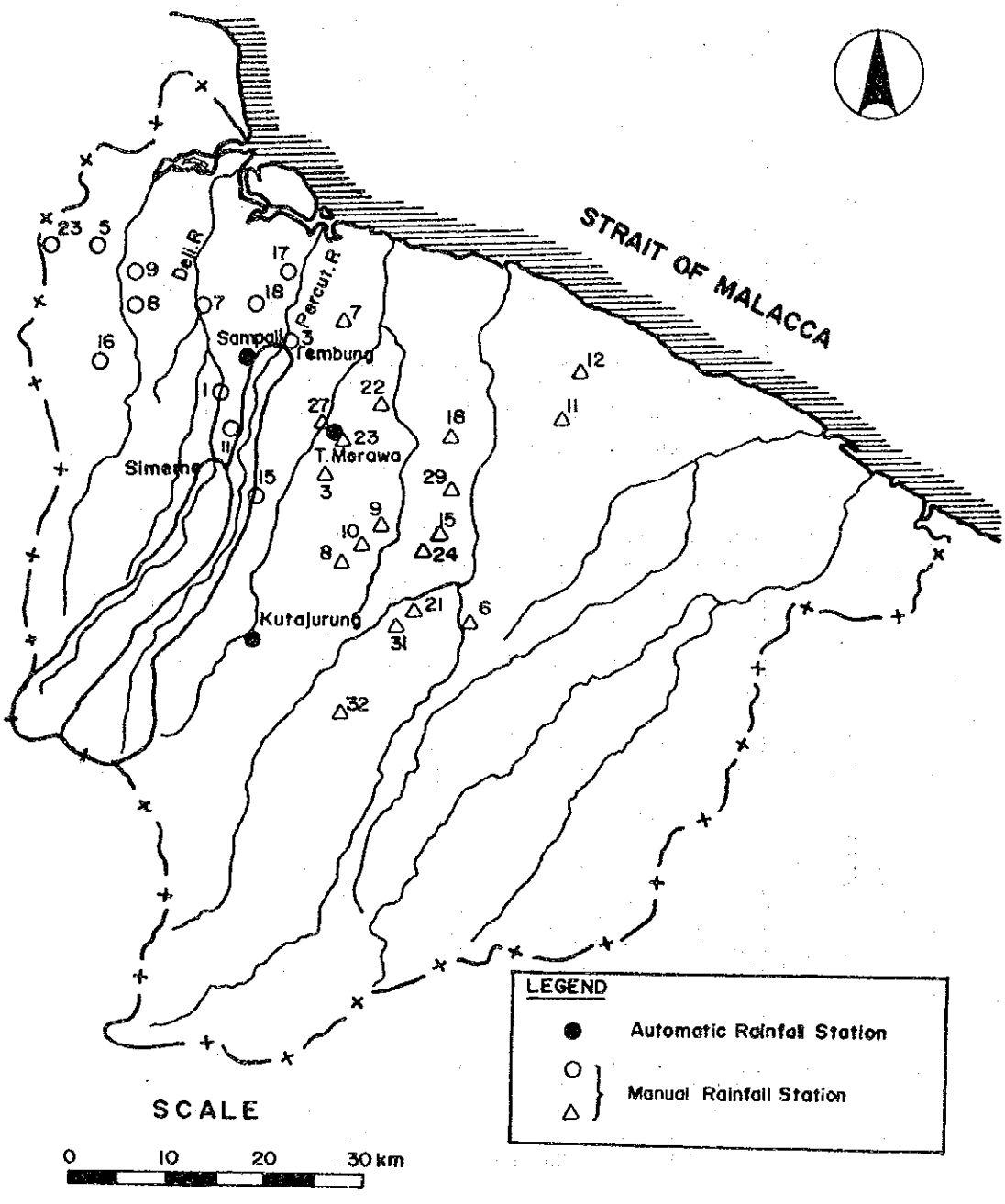


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	RUNOFF SIMULATION FOR NEW HYDROLOGICAL STATIONS Fig.5-6(2/2)





THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	HOURLY WATER LEVEL RECORDS IN NOVEMBER 1990 FLOOD Fig.5-7

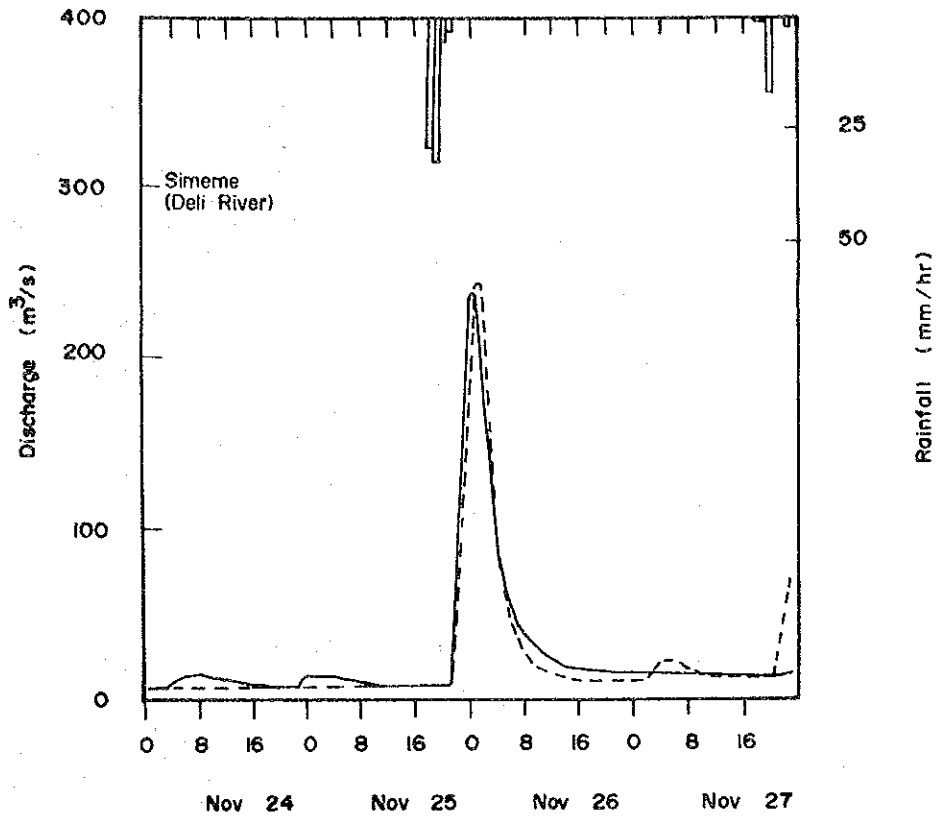


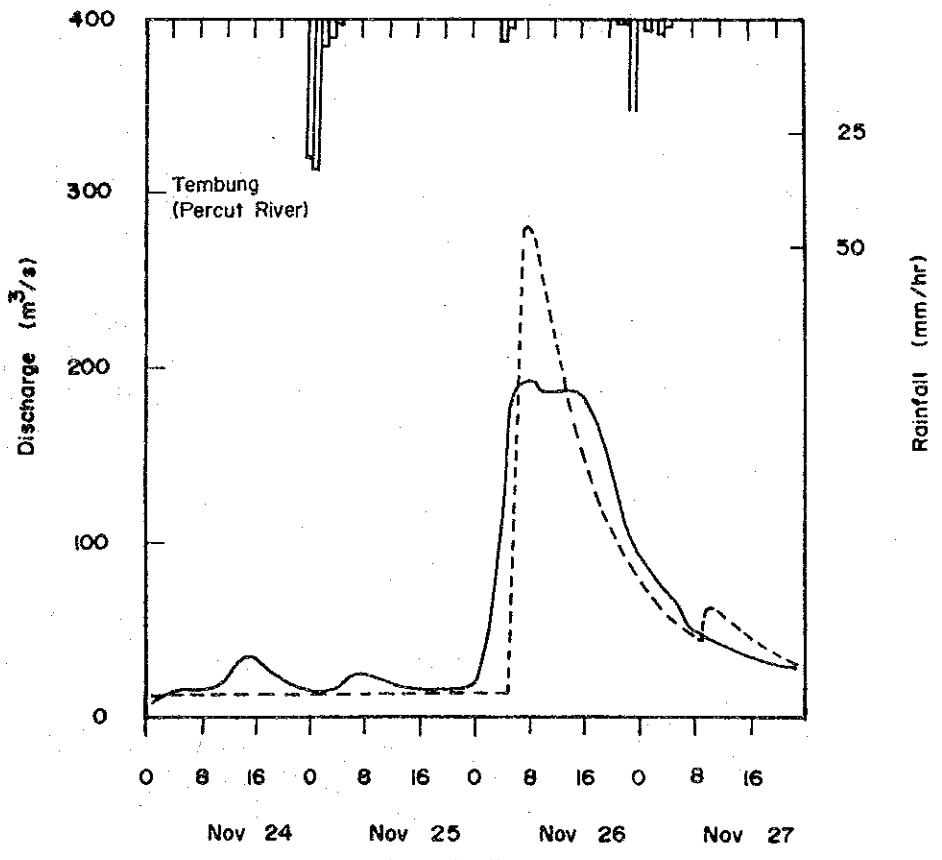
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

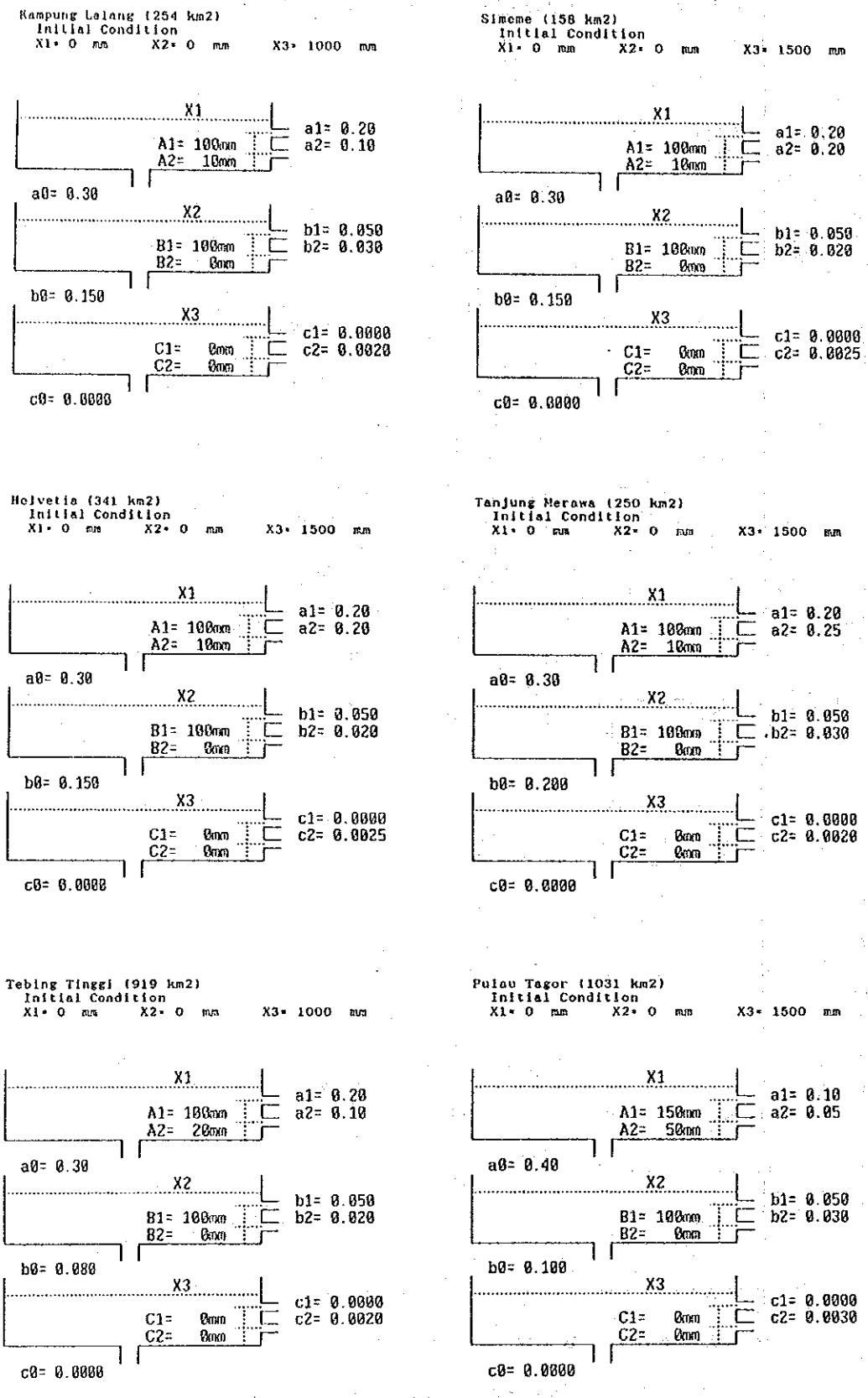
RAINFALL STATIONS IN AND AROUND DELI AND PERCUT RIVERS

Fig.5-8





THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	RUNOFF SIMULATION FOR 1990 FLOOD Fig.5-9

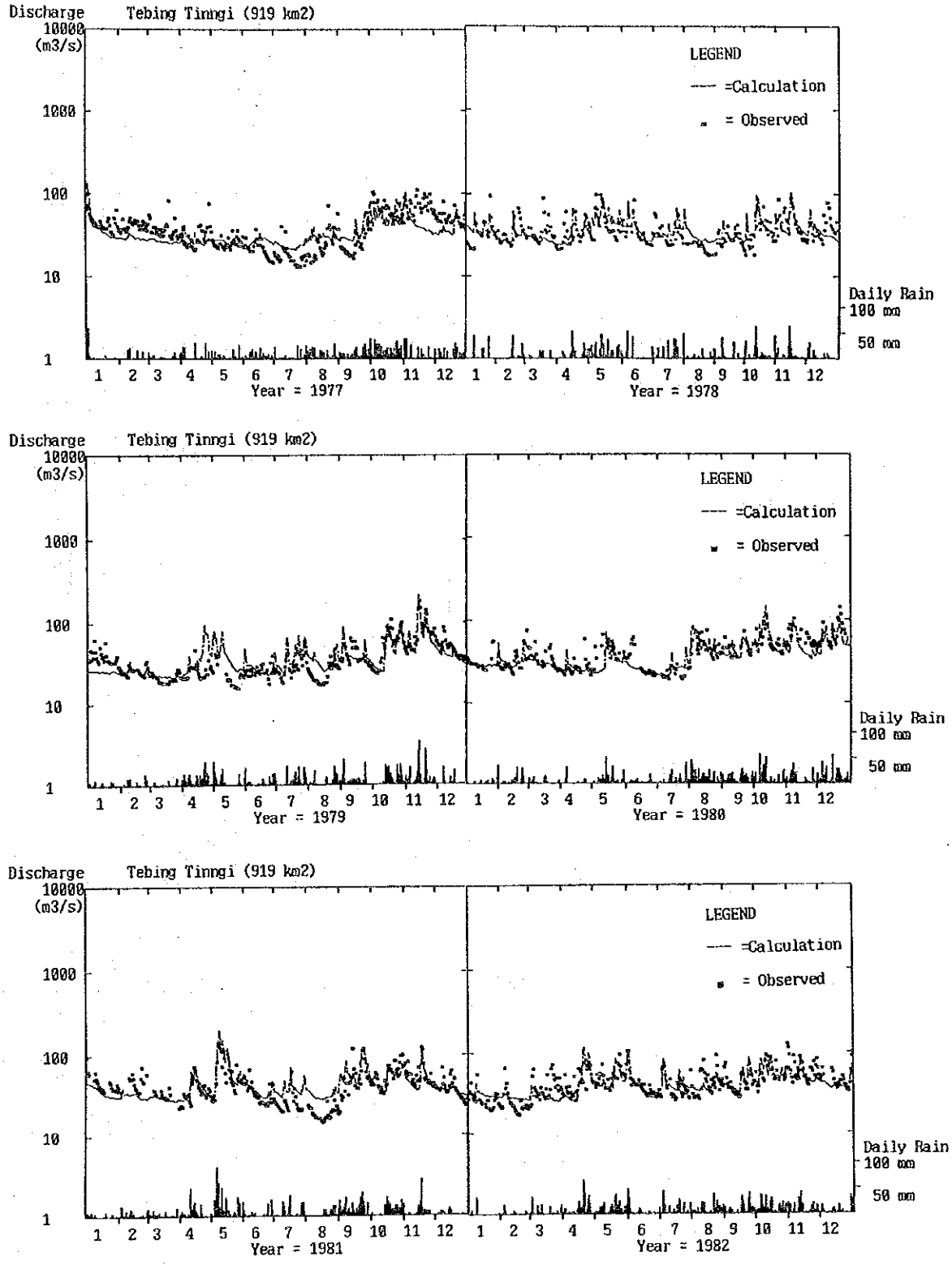


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

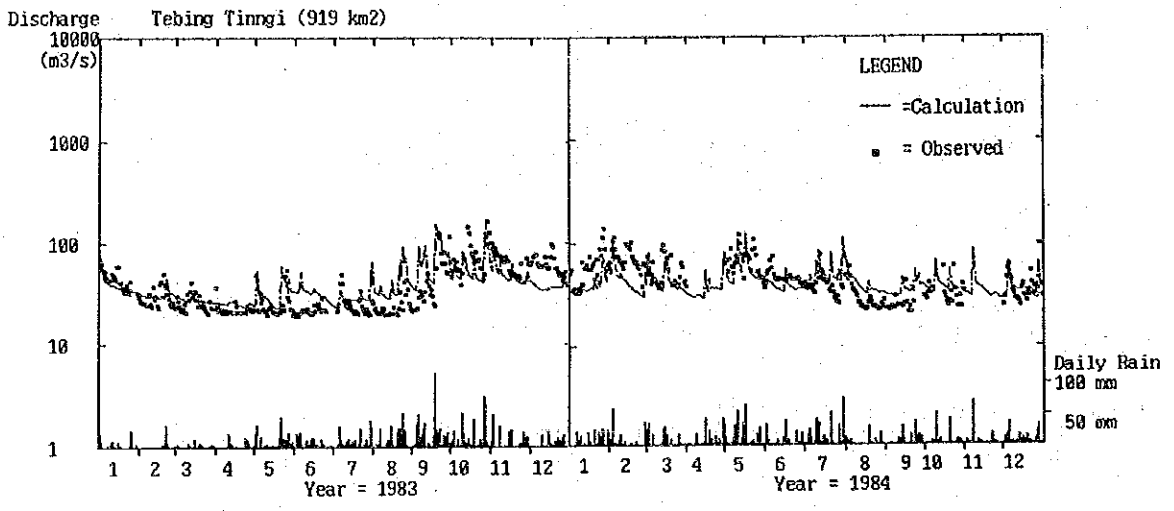
JAPAN INTERNATIONAL COOPERATION AGENCY

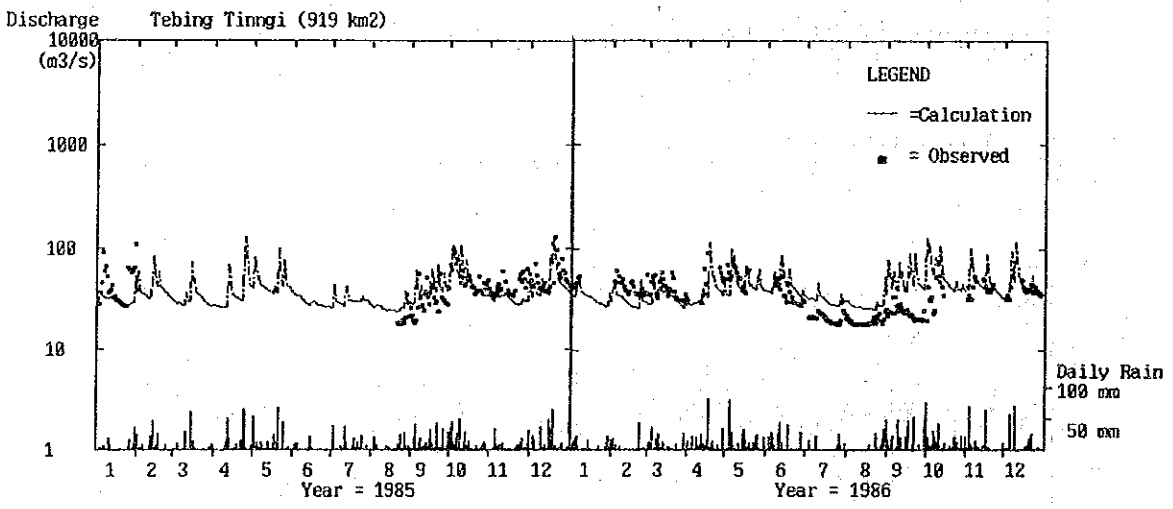
SCHEMATIC TANK MODEL

Fig.6-1

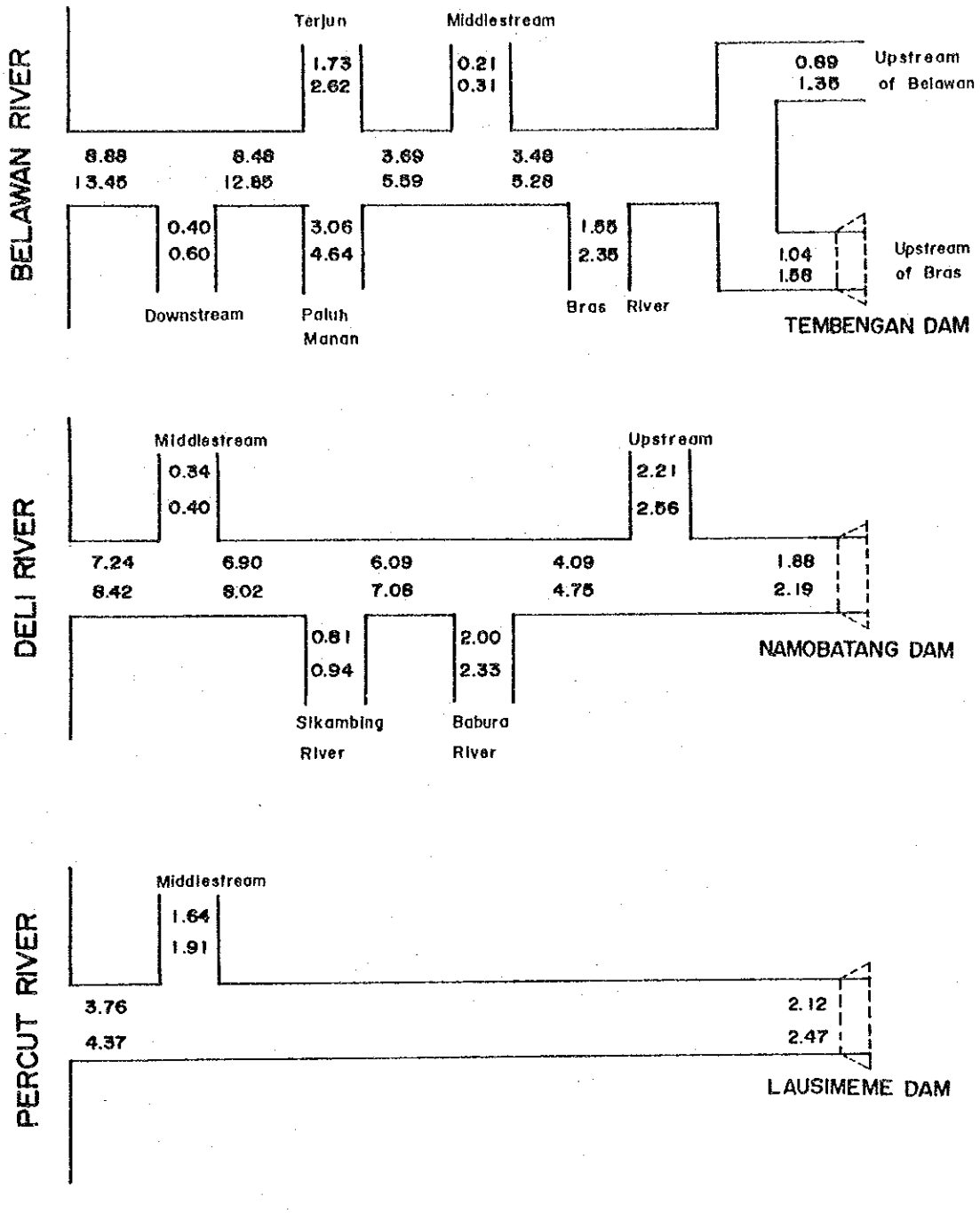


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	COMPARISON OF FLOW REGIME BY CALCULATION AND OBSERVATION Fig.6-2(1/2)

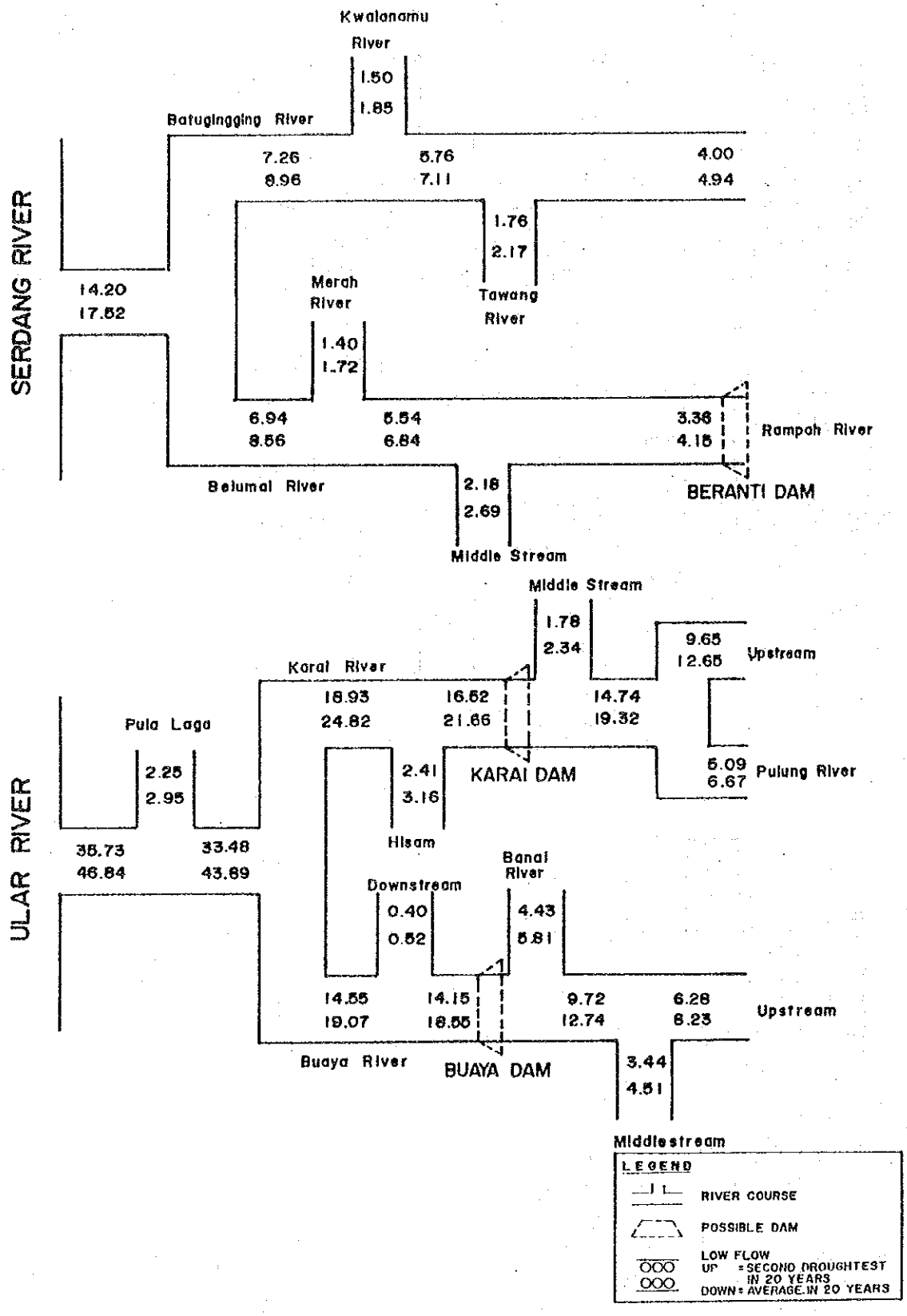




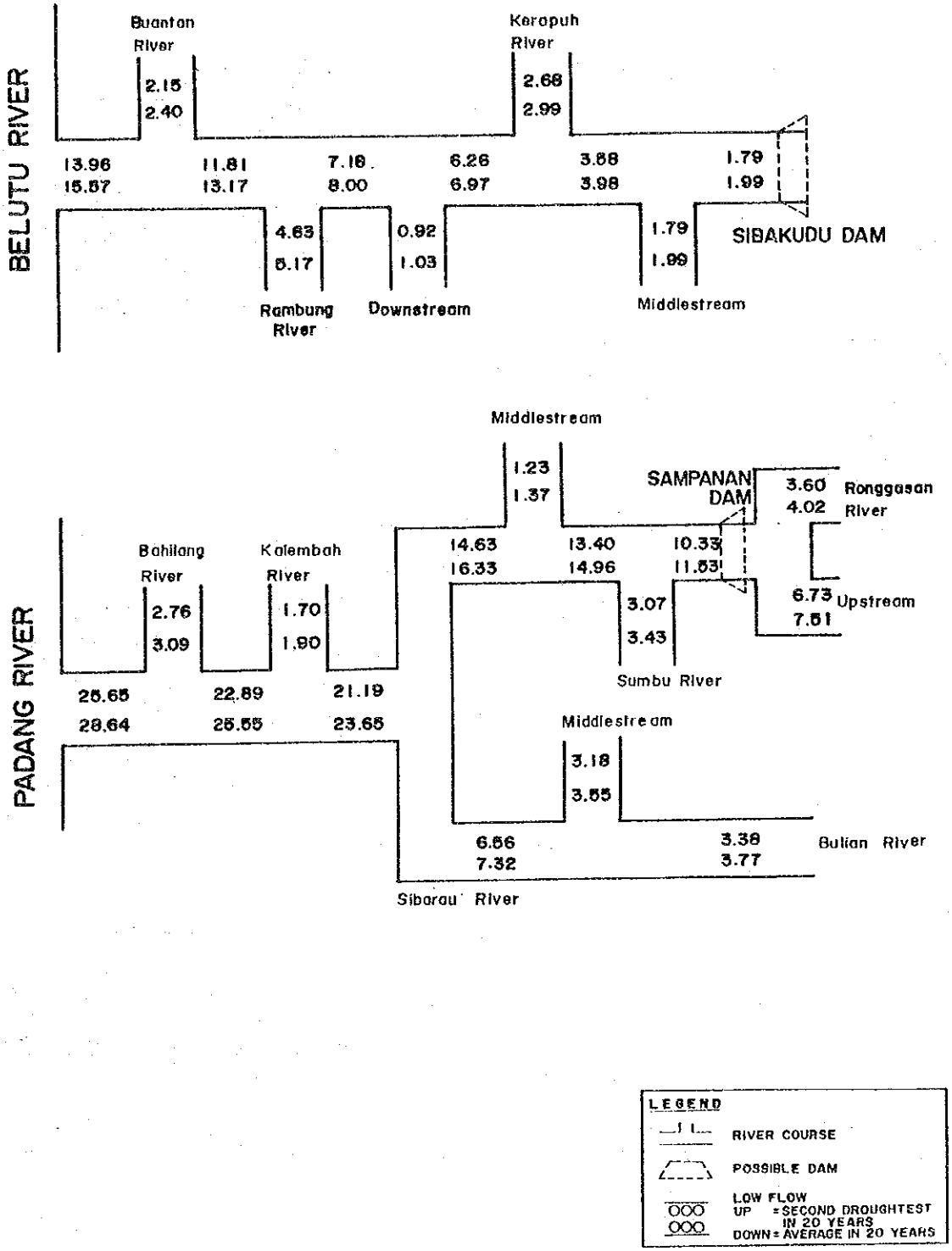
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	COMPARISON OF FLOW REGIME BY CALCULATION AND OBSERVATION Fig.6-2(2/2)



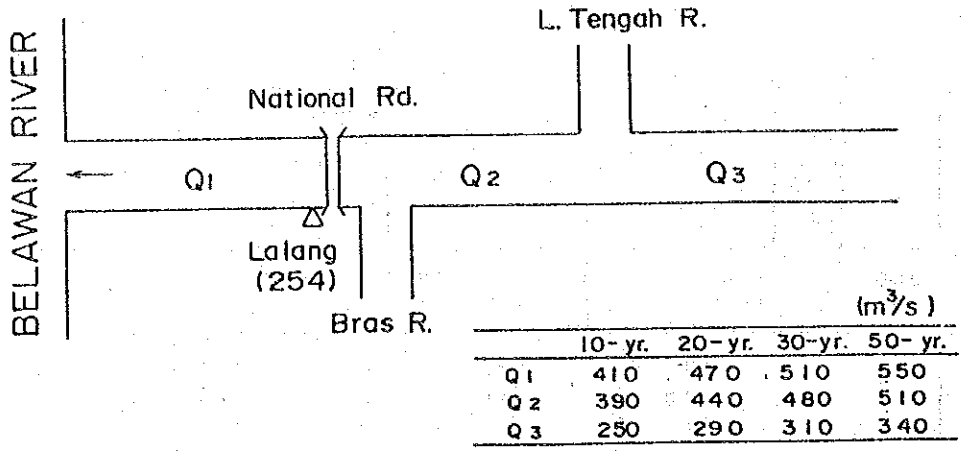
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	LOW FLOW DISCHARGE DISTRIBUTION Fig.6-3(1/3)



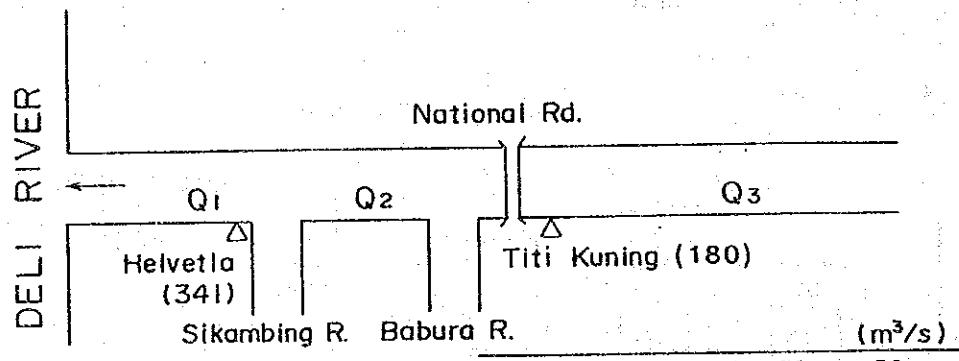
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	LOW FLOW DISCHARGE DISTRIBUTION Fig.6-3(2/3)



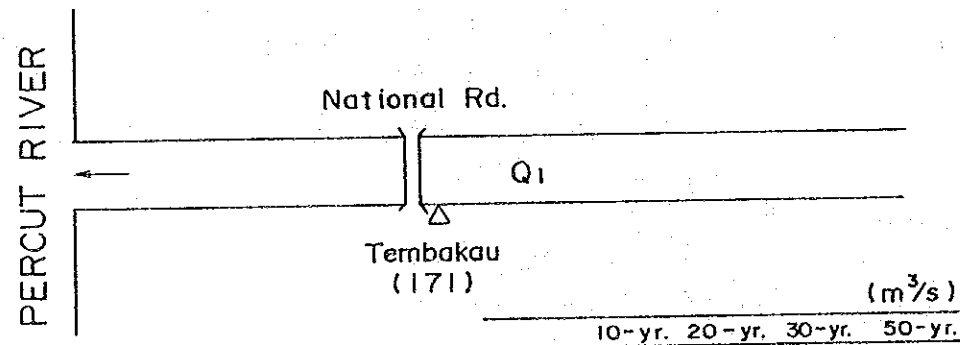
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	LOW FLOW DISCHARGE DISTRIBUTION Fig.6-3(3/3)



	10-yr.	20-yr.	30-yr.	50-yr.
	(m³/s)			
Q1	410	470	510	550
Q2	390	440	480	510
Q3	250	290	310	340



	10-yr.	20-yr.	30-yr.	50-yr.	100-yr.
	(m³/s)				
Q1	460	530	570	620	690
Q2	420	490	520	570	640
Q3	260	300	320	340	380

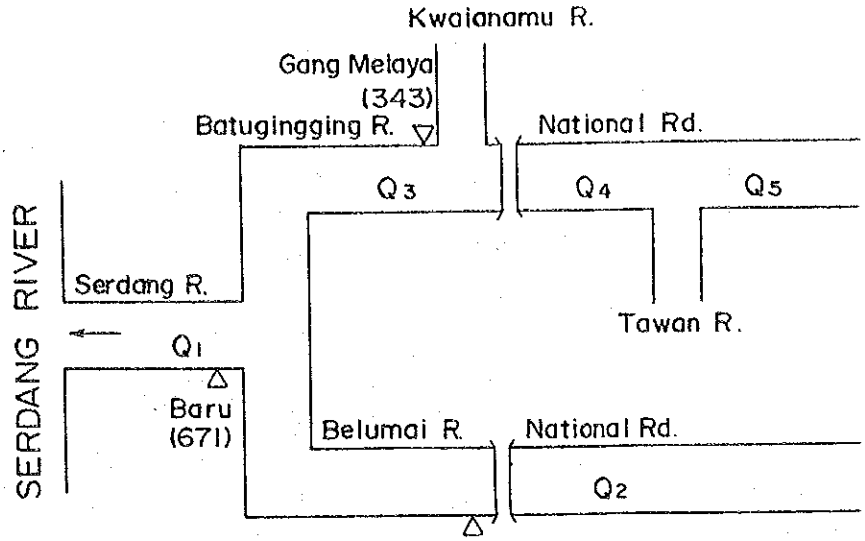


	10-yr.	20-yr.	30-yr.	50-yr.	100-yr.
	(m³/s)				
Q1	230	260	280	300	340

LEGEND

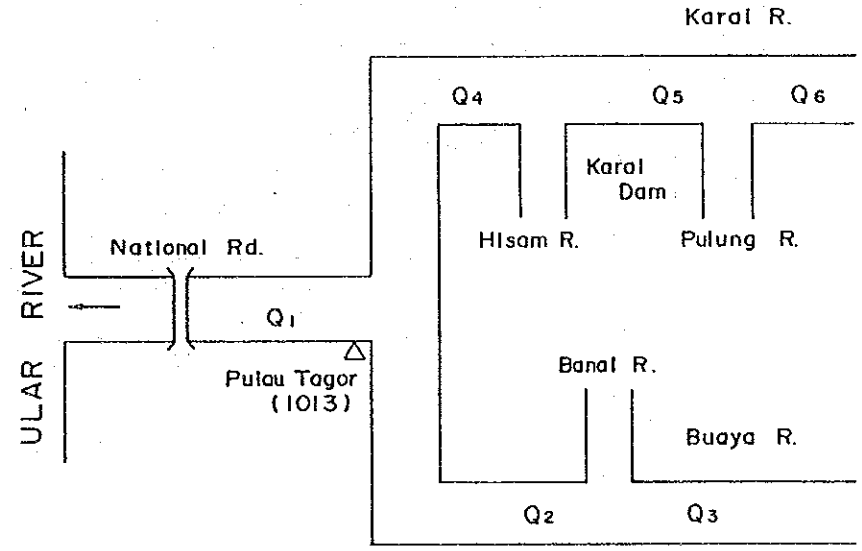
- River Course
- △ Reference Point
- (000) Catchment Area (km²)

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	PROBABLE FLOOD DISCHARGE DISTRIBUTION
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.7-1(1/3)



(m³/s)

	10-yr.	20-yr.	30-yr.	50-yr.
Q1	680	750	800	850
Q2	270	290	310	330
Q3	390	420	450	480
Q4	310	340	360	380
Q5	100	110	120	130



(m³/s)

	10-yr.	20-yr.	30-yr.	50-yr.
Q1	710	820	890	970
Q2	310	360	390	420
Q3	210	240	260	290
Q4	410	470	510	550
Q5	370	420	450	500
Q6	230	260	280	310

LEGEND

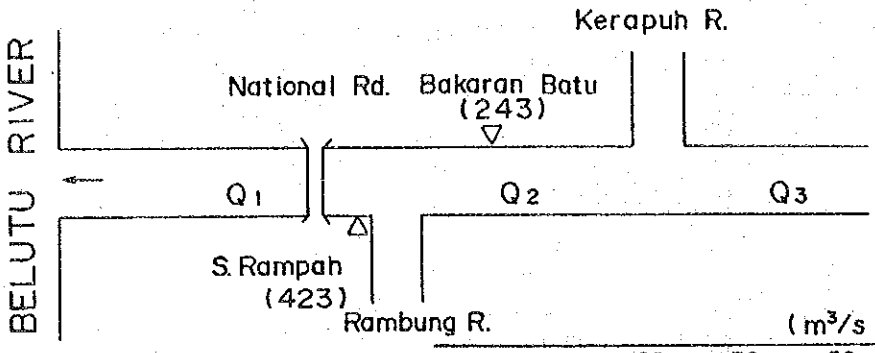
- River Course
- △ Reference Point
- (000) Catchment Area (km²)

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

JAPAN INTERNATIONAL COOPERATION AGENCY

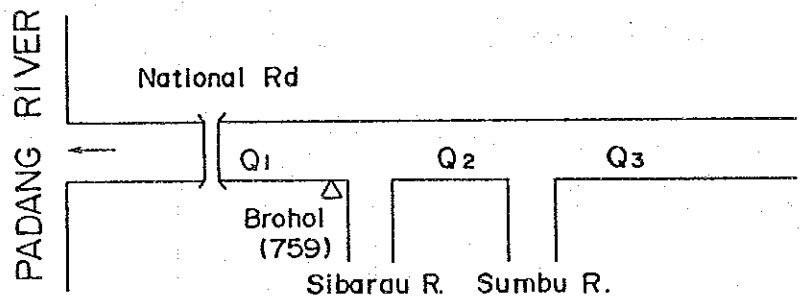
PROBABLE FLOOD DISCHARGE DISTRIBUTION

Fig.7-1(2/3)



(m³/s)

	10-yr.	20-yr.	30-yr.	50-yr
Q1	260	290	310	340
Q2	160	180	190	210
Q3	80	90	95	100



(m³/s)

	10-yr.	20-yr.	30-yr.	50-yr.
Q1	620	720	770	840
Q2	480	550	580	630
Q3	380	440	470	510

LEGEND

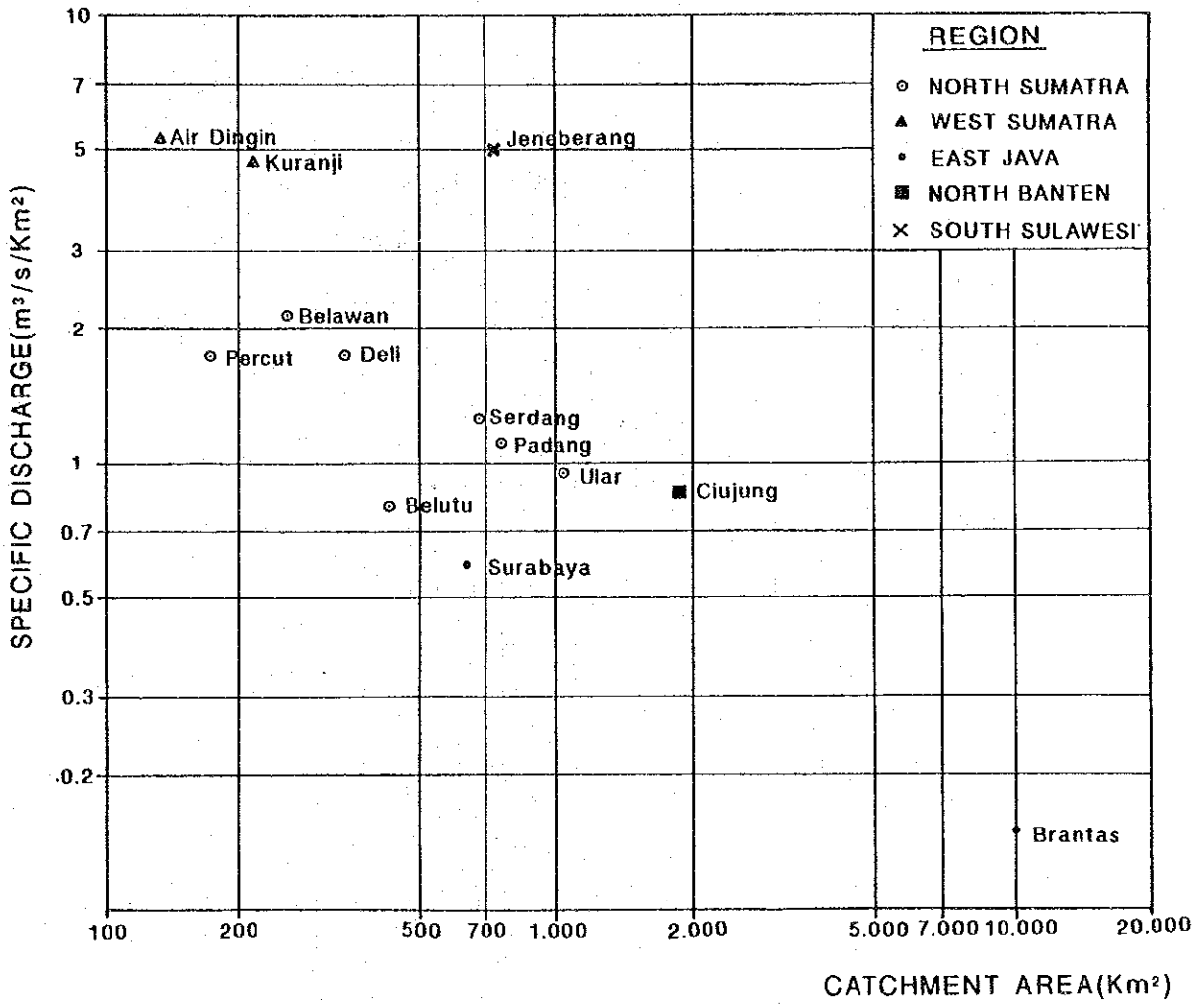
- River Course
- △ Reference Point
- (000) Catchment Area (km²)

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA

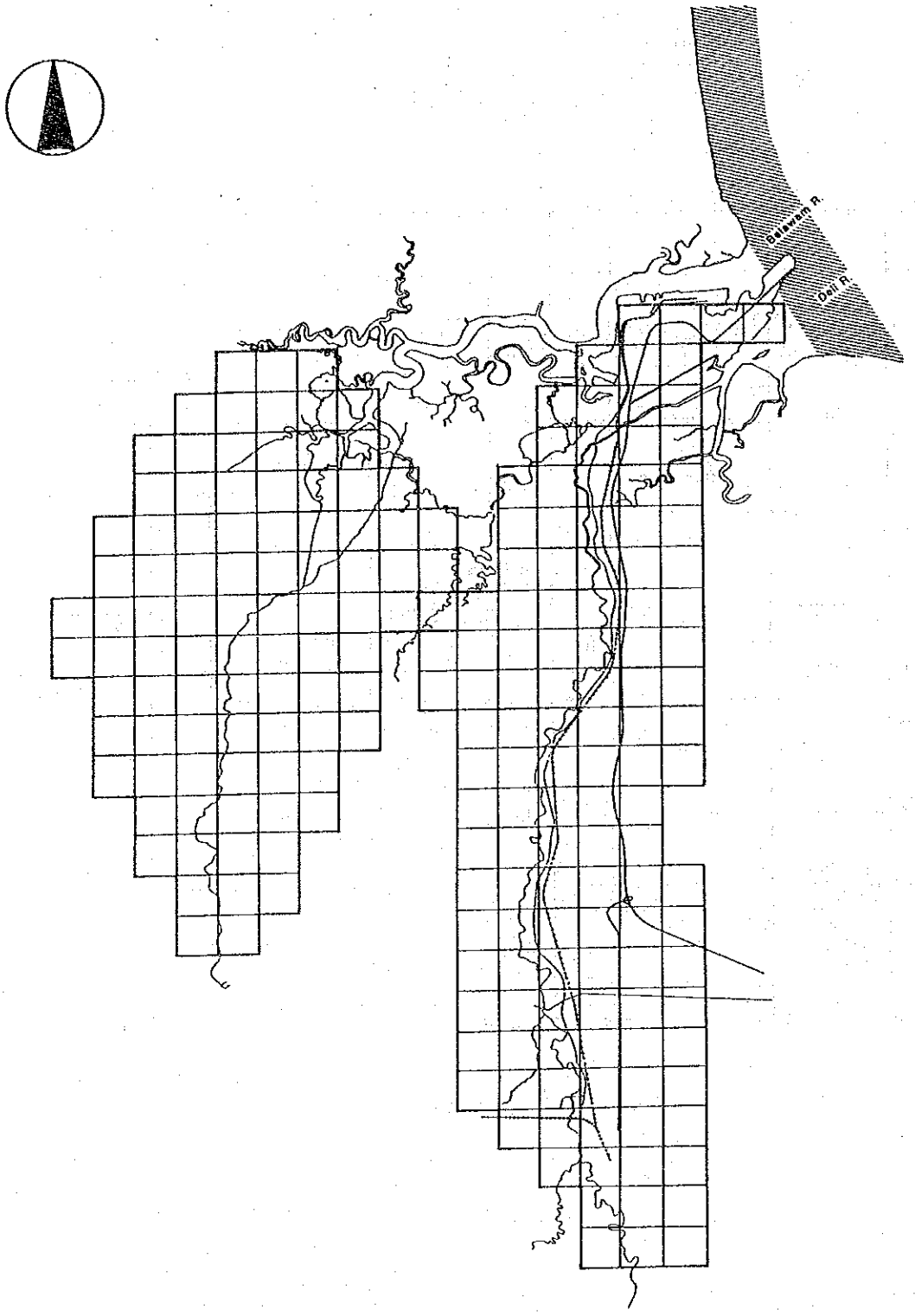
JAPAN INTERNATIONAL COOPERATION AGENCY

PROBABLE FLOOD DISCHARGE DISTRIBUTION

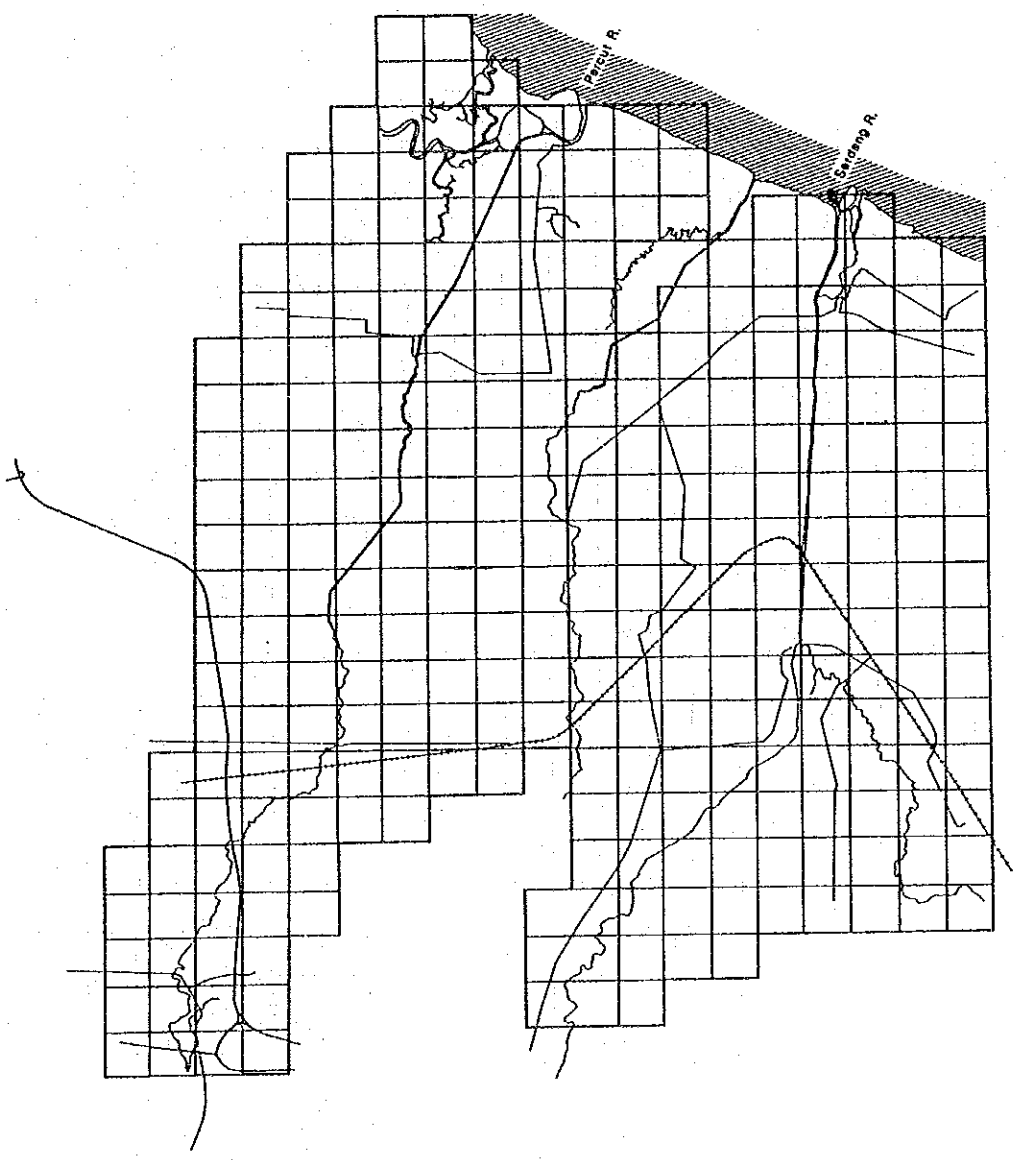
Fig.7-1(3/3)



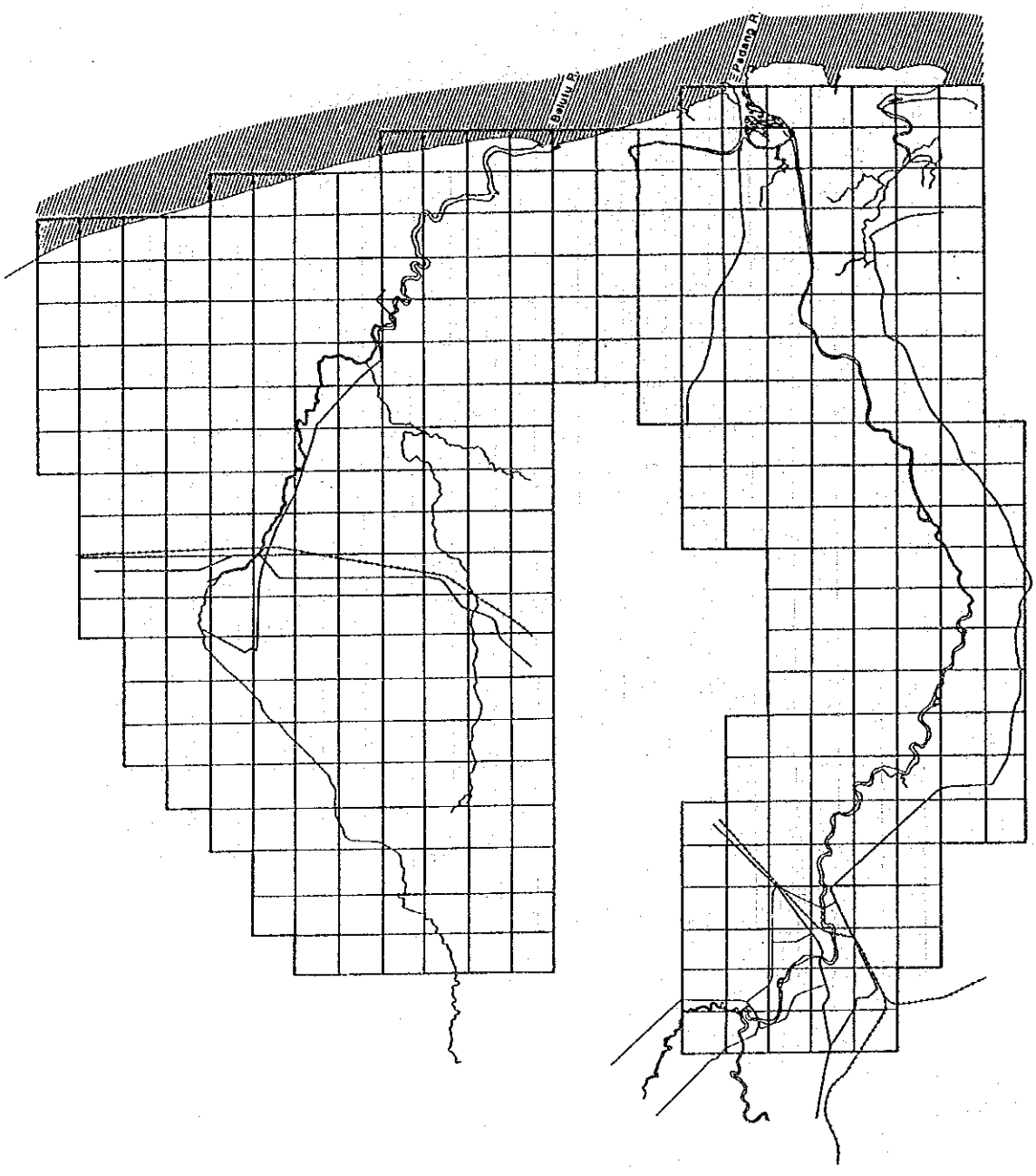
THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	SPECIFIC DISCHARGE PLOT FOR 50-YEAR RETURN PERIOD FLOOD Fig.7-2



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	MESH MAP OF INUNDATION AREA Fig.8-1(1/3)

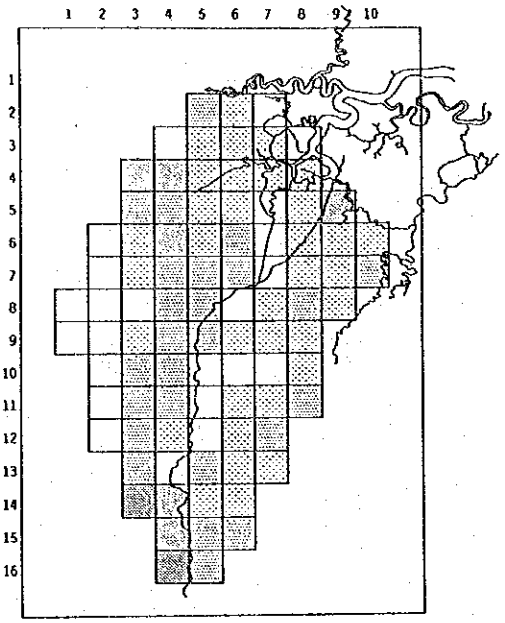


THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	MESH MAP OF INUNDATION AREA Fig.8-1(2/3)



THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	MESH MAP OF INUNDATION AREA Fig.8-1(3/3)

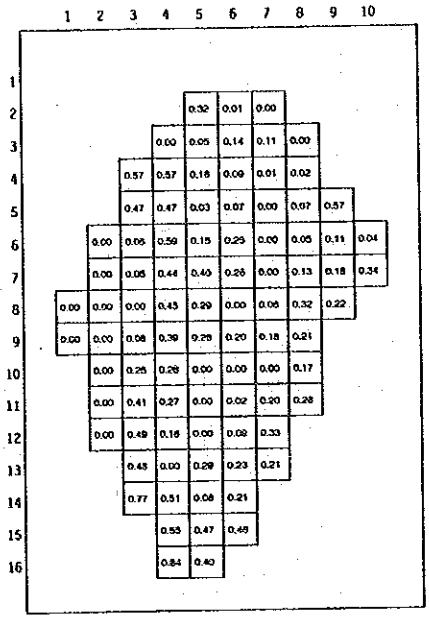
50 -year Return Period Flood



LEGEND

- : No inundation
- : 0.00 - 0.25 m
- : 0.25 - 0.50 m
- : 0.50 - 0.75 m
- : 0.75 - 1.00 m
- : 1.00 - 1.25 m
- : 1.25 - 1.50 m
- : > 1.50 m

50 -year Return Period Flood



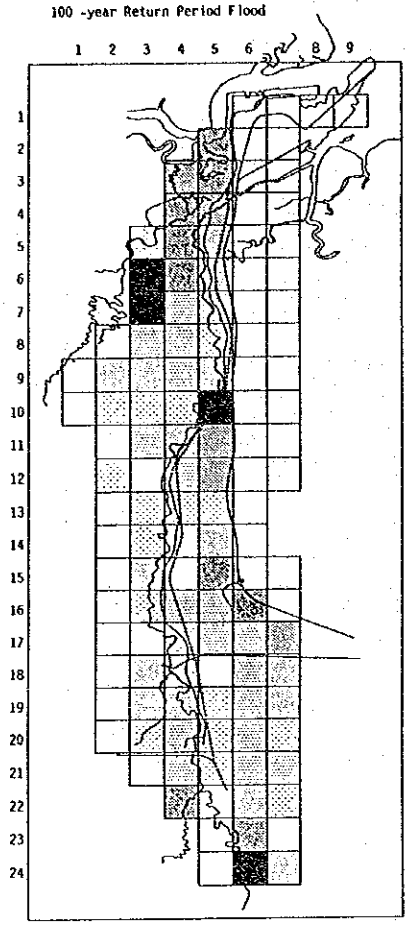
NOTE

: Mesh unit (1.0 km x 1.0 km).
Figures in meshes present inundation depth in meter.

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	INUNDATION AREA AND MAXIMUM WATER DEPTH Fig.8-2(1/6)

Deli River

100 -year Return Period Flood



LEGEND

- : No Inundation
- : 0.00 - 0.25 m
- : 0.25 - 0.50 m
- : 0.50 - 0.75 m
- : 0.75 - 1.00 m
- : 1.00 - 1.25 m
- : 1.25 - 1.50 m
- : > 1.50 m

100 -year Return Period Flood

	1	2	3	4	5	6	7	8	9
1						0.00	0.00	0.00	0.00
2					1.01	0.00	0.00		
3				0.91	1.91	0.00	0.00		
4				1.11	0.81	0.00	0.00		
5			0.02	1.11	0.01	0.00	0.00		
6			1.91	1.01	0.41	0.00	0.00		
7			1.81	0.49	0.14	0.00	0.00		
8		0.00	0.91	0.45	0.04	0.00	0.00		
9	0.00	0.52	0.62	0.29	0.07	0.00	0.00		
10	0.00	0.12	0.23	0.07	1.53	0.00	0.00		
11		0.00	0.45	0.66	0.75	0.00	0.00		
12		0.01	0.00	0.27	0.99	0.00	0.00		
13		0.03	0.22	0.24	0.07	0.00			
14		0.00	0.17	0.00	0.71	0.00			
15		0.00	0.65	0.00	1.17	0.00	0.00		
16		0.00	0.04	0.27	0.68	1.03	0.00		
17		0.00	0.00	0.22	0.25	0.38	0.87		
18		0.00	0.81	0.80	0.00	0.33	0.57		
19		0.00	0.38	0.37	0.05	0.42	0.59		
20		0.00	0.15	0.46	0.17	0.35	0.23		
21			0.00	0.42	0.07	0.49	0.38		
22				1.00	0.00	0.68	0.13		
23					0.00	1.24	0.00		
24					0.00	2.13	0.83		

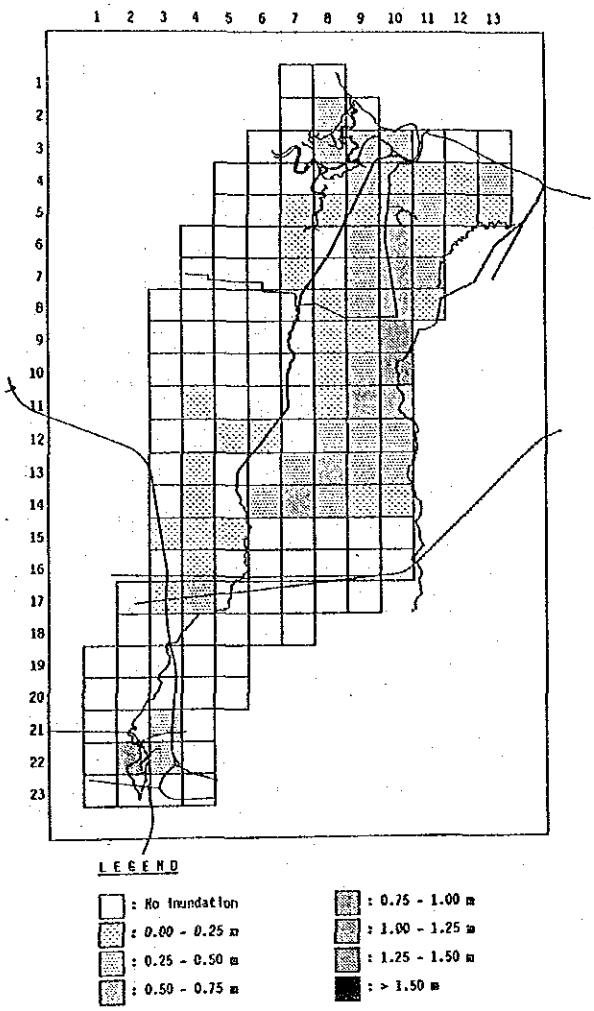
NOTE

: Mesh unit (1.0 km x 1.0 km).
Figures in meshes present inundation depth in meter.

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	INUNDATION AREA AND MAXIMUM WATER DEPTH Fig.8-2(2/6)

Percut River

100 -year Return Period Flood



LEGEND

- : No Inundation
- : 0.00 - 0.25 m
- : 0.25 - 0.50 m
- : 0.50 - 0.75 m
- : 0.75 - 1.00 m
- : 1.00 - 1.25 m
- : 1.25 - 1.50 m
- : > 1.50 m

100 -year Return Period Flood

	1	2	3	4	5	6	7	8	9	10	11	12	13
1							0.00	0.00					
2							0.00	0.31	0.00				
3						0.00	0.00	0.31	0.31	0.30	0.00	0.00	0.00
4					0.00	0.00	0.00	0.00	0.33	0.02	0.12	0.08	0.43
5					0.00	0.00	0.02	0.14	0.23	0.27	0.29	0.11	0.09
6				0.00	0.00	0.00	0.08	0.00	0.42	0.53	0.23		
7				0.00	0.00	0.00	0.15	0.00	0.38	0.58	0.28		
8			0.00	0.00	0.00	0.00	0.00	0.01	0.38	0.59	0.24		
9			0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.98			
10			0.00	0.00	0.00	0.00	0.00	0.07	0.33	1.01			
11			0.00	0.01	0.00	0.00	0.00	0.19	0.53	0.59			
12			0.00	0.00	0.01	0.08	0.00	0.33	0.43	0.38			
13			0.00	0.04	0.00	0.00	0.42	0.60	0.45	0.48			
14			0.00	0.08	0.00	0.43	0.73	0.30	0.15	0.00			
15			0.03	0.09	0.07	0.00	0.00	0.00	0.00	0.00			
16			0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00			
17		0.00	0.02	0.30	0.00	0.00	0.00	0.00	0.00				
18		0.00	0.00	0.00	0.00	0.00	0.00						
19	0.00	0.00	0.00	0.00	0.00								
20	0.00	0.00	0.00	0.00	0.00								
21	0.00	0.00	0.27	0.00									
22	0.00	0.96	0.28	0.00									
23	0.00	0.00	0.00	0.00									

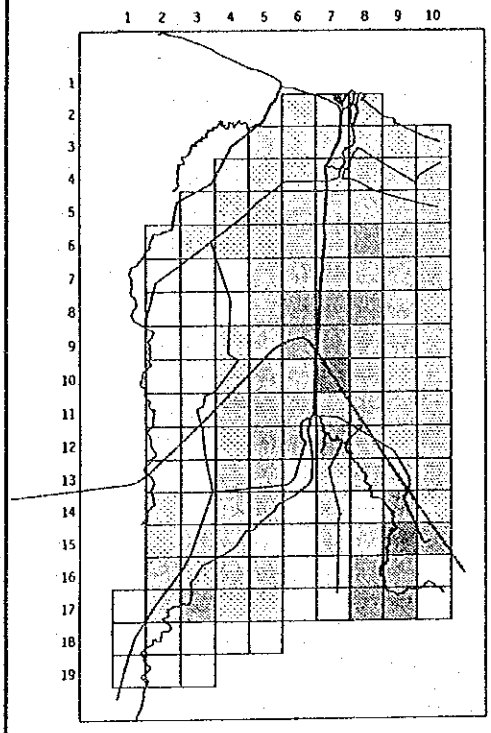
NOTE

: Mesh unit (1.0 km x 1.0 km).
Figures in meshes present inundation depth in meter.

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	INUNDATION AREA AND MAXIMUM WATER DEPTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.8-2(3/6)

Serdang River

50 -year Return Period Flood



LEGEND

- : No inundation
- : 0.00 - 0.25 m
- : 0.25 - 0.50 m
- : 0.50 - 0.75 m
- : 0.75 - 1.00 m
- : 1.00 - 1.25 m
- : 1.25 - 1.50 m
- : > 1.50 m

50 -year Return Period Flood

	1	2	3	4	5	6	7	8	9	10
1										
2						0.02	0.00	0.14		
3					0.31	0.00	0.18	0.15	0.22	0.53
4				0.00	0.21	0.15	0.23	0.32	0.53	0.43
5			0.00	0.15	0.09	0.38	0.45	0.58	0.34	0.25
6		0.00	0.02	0.07	0.21	0.47	0.25	0.75	0.27	0.31
7		0.00	0.00	0.00	0.42	0.52	0.33	0.61	0.59	0.46
8		0.00	0.00	0.00	0.27	0.78	0.77	0.52	0.52	0.07
9		0.00	0.00	0.06	0.58	0.79	0.99	0.48	0.32	0.29
10		0.00	0.00	0.08	0.74	0.51	1.43	0.29	0.23	0.31
11		0.00	0.00	0.27	0.42	0.42	0.32	0.80	0.45	0.48
12		0.00	0.00	0.23	0.81	0.70	0.83	0.42	0.20	0.28
13		0.00	0.00	0.32	0.52	0.00	0.03	0.37	0.50	0.40
14		0.03	0.00	0.72	0.48	0.00	0.26	0.00	1.02	0.08
15		0.18	0.26	0.42	0.00	0.00	0.26	0.54	1.20	0.84
16		0.57	0.08	0.28	0.29	0.00	0.00	0.96	0.78	0.00
17	0.00	0.49	0.92	0.24	0.07	0.00	0.00	1.07	1.02	0.00
18	0.00	0.00	0.00	0.00	0.00					
19	0.00	0.00	0.00							

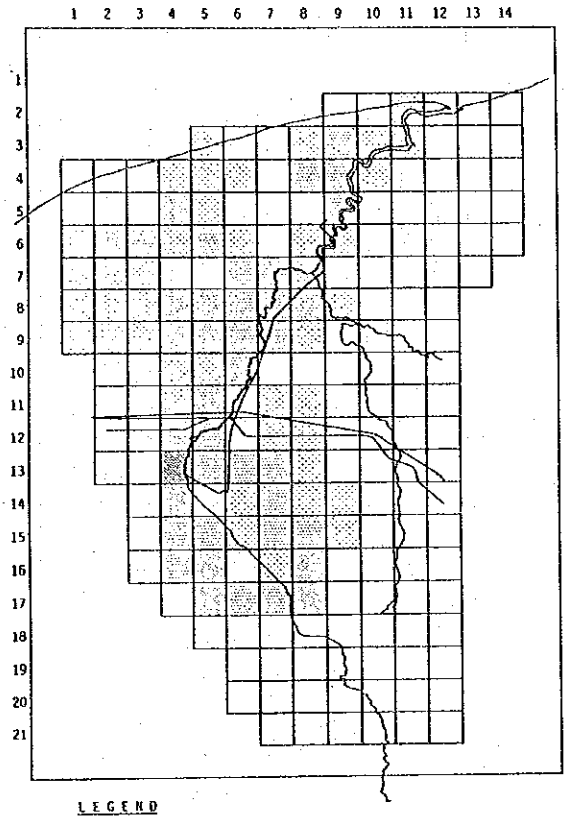
NOTE

: Mesh unit (1.0 km x 1.0 km).
Figures in meshes present inundation depth in meter.

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	INUNDATION AREA AND MAXIMUM WATER DEPTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.8-2(4/6)

Belutu River

50 -year Return Period Flood



LEGEND

- : No inundation
- : 0.00 - 0.25 m
- : 0.25 - 0.50 m
- : 0.50 - 0.75 m
- : 0.75 - 1.00 m
- : 1.00 - 1.25 m
- : 1.25 - 1.50 m
- : > 1.50 m

50 -year Return Period Flood

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1									0.00	0.00	0.04	0.00	0.00	0.00
2									0.00	0.00	0.00	0.00	0.00	0.00
3					0.01	0.00	0.00	0.00	0.27	0.23	0.11	0.00	0.00	0.00
4	0.00	0.00	0.00	0.03	0.13	0.10	0.00	0.00	0.38	0.18	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.28	0.07	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
6	0.11	0.51	0.31	0.09	0.25	0.22	0.00	0.14	0.15	0.00	0.00	0.00	0.00	0.00
7	0.04	0.14	0.07	0.00	0.00	0.38	0.36	0.21	0.00	0.00	0.00	0.00	0.00	
8	0.08	0.07	0.18	0.25	0.37	0.36	0.45	0.29	0.18	0.00	0.00	0.00		
9	0.05	0.11	0.19	0.26	0.30	0.38	0.47	0.22	0.00	0.00	0.00	0.00		
10		0.00	0.00	0.05	0.07	0.30	0.00	0.00	0.00	0.00	0.00	0.00		
11		0.00	0.00	0.12	0.28	0.00	0.15	0.13	0.00	0.00	0.00	0.00		
12		0.00	0.00	0.08	0.36	0.00	0.21	0.02	0.00	0.00	0.00	0.00		
13		0.00	0.00	1.07	0.47	0.26	0.28	0.09	0.00	0.00	0.00	0.00		
14			0.00	0.83	0.00	0.21	0.42	0.18	0.03	0.00	0.00	0.00		
15			0.00	0.47	0.26	0.01	0.30	0.29	0.07	0.00	0.00	0.00		
16			0.00	0.41	0.57	0.00	0.06	0.53	0.00	0.00	0.00	0.00		
17				0.00	0.84	0.29	0.40	0.82	0.00	0.00	0.00	0.00		
18					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
19						0.00	0.00	0.00	0.00	0.00	0.00	0.00		
20						0.00	0.00	0.00	0.00	0.00	0.00	0.00		
21							0.00	0.00	0.00	0.00	0.00	0.00		

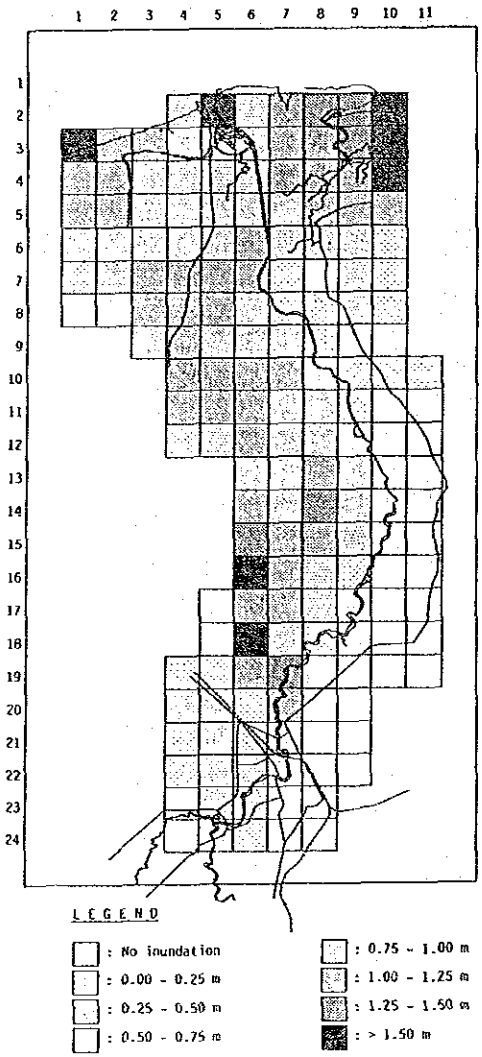
NOTE

: Mesh unit (1.0 km x 1.0 km).
Figures in meshes present inundation depth in meter.

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA	INUNDATION AREA AND MAXIMUM WATER DEPTH
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.8-2(5/6)

Padang River

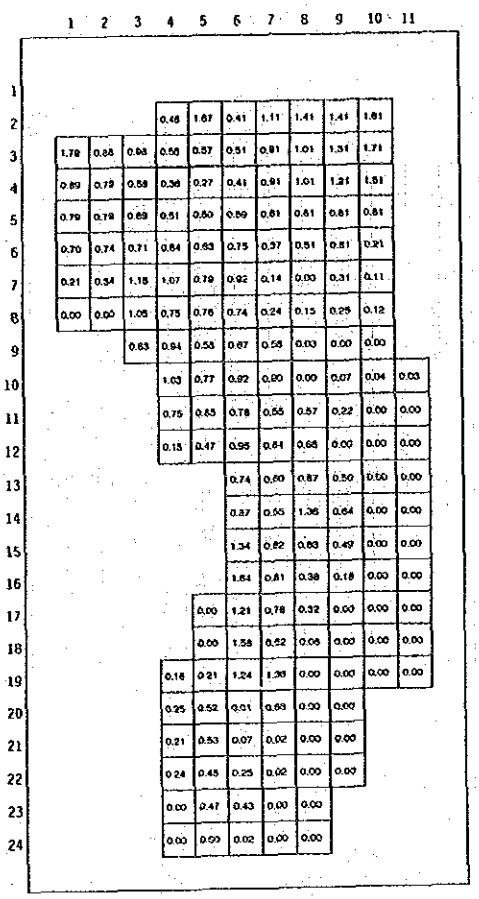
50 -year Return Period Flood



LEGEND

- : No Inundation
- : 0.00 - 0.25 m
- : 0.25 - 0.50 m
- : 0.50 - 0.75 m
- : 0.75 - 1.00 m
- : 1.00 - 1.25 m
- : 1.25 - 1.50 m
- : > 1.50 m

50 -year Return Period Flood

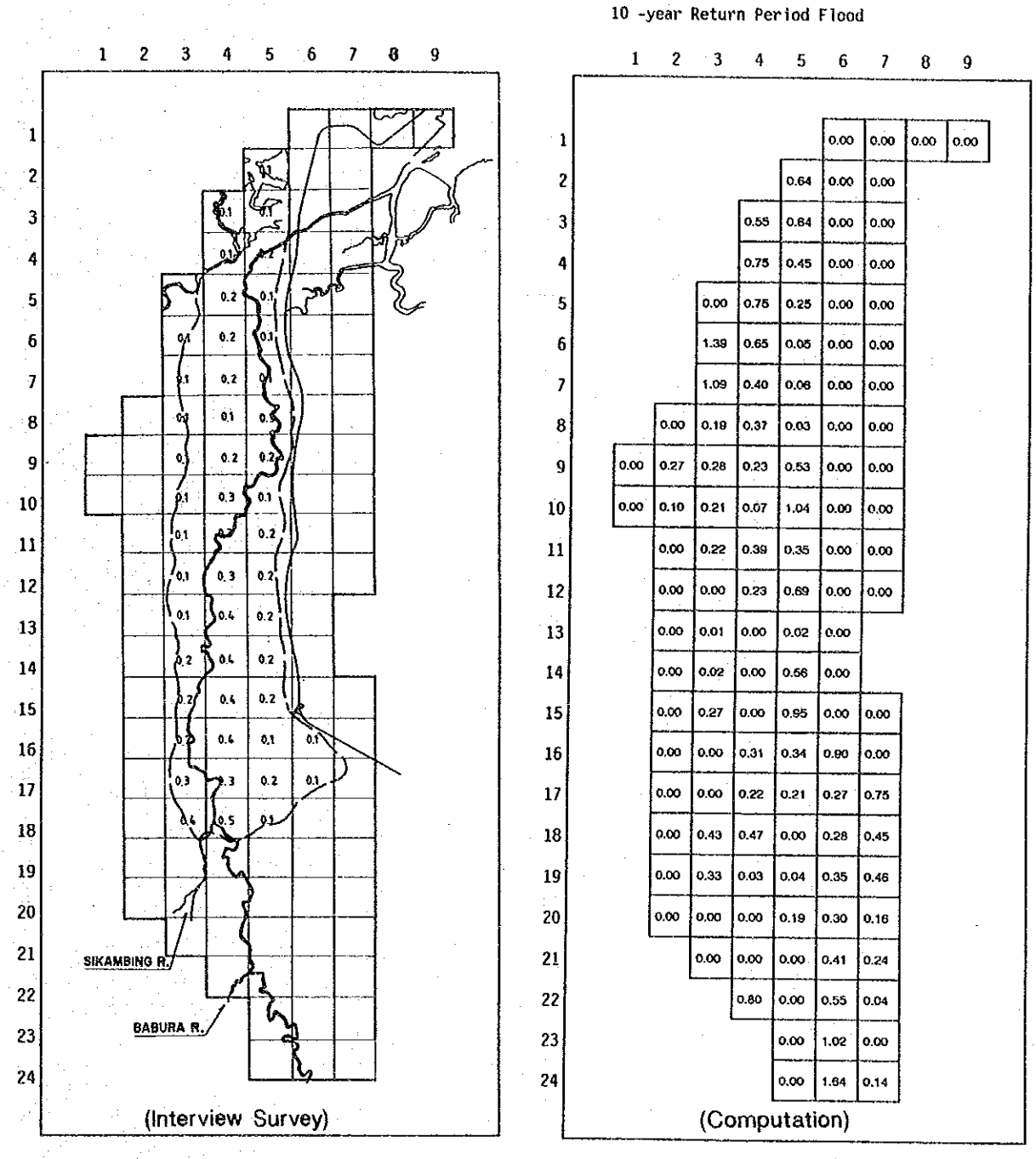


NOTE

: Mesh unit (1.0 km x 1.0 km).
Figures in meshes present inundation depth in meter.

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	INUNDATION AREA AND MAXIMUM WATER DEPTH Fig.8-2(6/6)

Deil River



NOTE

: Mesh unit (1.0 km x 1.0 km).
Figures in meshes present inundation depth in meter.

THE STUDY ON BELAWAN-PADANG INTEGRATED RIVER BASIN DEVELOPMENT IN THE REPUBLIC OF INDONESIA JAPAN INTERNATIONAL COOPERATION AGENCY	COMPARISON OF INUNDATION WATER DEPTH BY COMPUTATION AND INTERVIEW SURVEY Fig.8-3

GE

GEOLOGY

STUDY ON BELAWAN-PADANG
INTEGRATED RIVER BASIN DEVELOPMENT

SUPPORTING REPORT

GEOLOGY

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SUPPORTING REPORT

GEOLOGY

1. INTRODUCTION

The geological study is carried out in two investigation stages to know the topographical and geological conditions of the study area and the possible sites for structures.

The first stage mainly consists of surface exploration in the whole study area and in places related to structural measures for flood control and water supply plans, using published topographic maps of 1/50,000 scale and geological maps of 1/200,000 scale.

The second stage consists of detailed geotechnical investigation with drilling and laboratory tests. Priority areas for urgent project sites such as the Lausimeme dam site, Medan floodway and river improvement courses are studied from the geotechnical point of view.

The results of the geological study are presented in this report in the following order, inclusive of data of drilling logs:

(a) Geological Condition in the Study Area
(b) Geological Condition of Possible Structure Sites
(c) Geological Condition of Proposed Structure Sites

2. GEOGRAPHY OF THE STUDY AREA

2.1 Topography

Topography along the upper reaches of the Ular River consists of a plateau (Toba Plateau) at an elevation of 1,000 to 1,300 m, while that along the upper reaches of the other rivers in the study area stems from a volcano at an elevation of 1,500 to 1,900 m which erupted before the formation of Toba Plateau. Toba Plateau and the piedmont of the volcano are at an elevation of about 1,000 m. The areas between this elevation and eastern lowlands are hilly lands with a gentle slope of about 5° and a still gentler slope of about 1°.

Among these topography, the hills which account for a major part of the study area were formed by accumulated pyroclastic flow during the transformation of Toba Caldera from the old geological formation consisting of a Paleozoic system, a Mesozoic system and a Tertiary system. Some volcanoes that erupted after the formation of Toba Caldera are observed in the steep mountains on the west side of Toba Plateau.

The area in the sea side at an elevation of up to 50 m is flat land called eastern lowlands, which is an alluvial plain formed through sedimentation from rivers. Near Medan City, however, there is a diluvial upland composed of sand and gravel. Topography of the study area described above is shown in Figs. 2-1 and 2-2.

2.2 Geology

A major part of the study area is covered with volcanic soils. These volcanic soils came from, in chronological order, the Takur-Takur- Simbolon Centre, the Toba Centre and the Sibayak Centre, and were formed during the Plio-Pleistocene and Pleistocene-Holocene. The major component of volcanic soils is Toba tuff consisting of pyroclastic flow deposits during the formation of the Toba Caldera.

At some places on the west side of the steep mountains, Bruksah Formation is observed. Distributed next to Bruksah Formation is Mendem Microdiorite, intrusive. The area around Medan City is diluvial upland consisting of the Pleistocene Medan Formation, while the eastern lowlands facing the Strait of Malacca is composed of Holocene alluvium. The formation of these layers is shown in Fig. 2-3.

Alluvium and Medan Formation are composed of gravel, sand and clay. Unlike Alluvium, Medan Formation also contains boulder gravels and has been slightly consolidated. This formation is about 30 m deep.

Bruksah Formation, which is a group of layers of sediment, has been consolidated and is composed mainly of micaceous sand stones and basal conglomerates. Among the volcanic soils mentioned above, Sibayak Volcanics and Takur-Takur-Simbolon Volcanics are composed mainly of andesite, andesitic pyroclastics, dacite and dacitic pumiceous pyroclastics, while Toba tuffs are pyroclastic flow deposits produced during the formation of Toba Caldera and are composed of

unwelded and welded tuffs. The layer of this welded tuff is roughly 50 m deep. The lower part of the layer has been welded, and columnar joints which have developed as cooling joints are observed there.

These layers overlie Tertiary, Mesozoic and Paleozoic sediments, metasediments and intrusives. This region, however, is largely covered with volcanics, and therefore distribution of the above formation cannot be confirmed.

The geological formation of the study area is shown in Table 2-1 and Fig. 2-4.