Max. Hourly Rainfall of 1972 Flood

Sta. Cruz, Porac

Flood Hour	1972 June		1972 July		1972 Aug.	
	r (mm)	rt(mm/hr)	r (mm)	rt(mm/hr)	r (mm)	rt(mm/hr)
1 hr	42.5	42.5	37.4	374.4	24.0	24.0
2 hr	56.5	28.3	54.0	27.0	32.0	16.0
3 hr	60.0	20.0	62.2	22.4	43.0	14.3
6 hr	60.0	10.0	93.0	31.0	51.0	8.5

Therefore, the cause for the damage is attributed not to the flood caused by floods with a high intensity if hourly rainfall but to gradual increase of inundation to lowlands due to deficiency of discharge capacity of the Pasig-Potreo River channel at the stream together with successive in flow by long-term rainfall.

4-4 Area Mean Rainfall

Generally, the area mean rainfall is obtained by Tissen's method or Isohyetal method.

However, the good correlation if rainfall studied in Item 4-2 can conclude that the observed rainfall at the Porac station can presents the mean rainfall over the Pasig Potrero basin correctly.

4-5 Flood Records and Reports

Daily mean water level records at Cabetican Bacolor and daily rainfall records at Porac during five noticeable floods experienced in May of 1966, September of 1970, July of 1972, August of 1974 and May of 1976 are summarized in FIGURE I-18 as a hydrograph and hyetgraph.

The figures show that the hydrograph and the hyetograph in each flood correspond well to each other and their time lags between peak in the hydrograph and that in the hyetograph take place within a day in most cases. Futhermore, sharp depletion curves of hydrographs after the peak discharge is characterized as a nature of this river.

Other flood records in the Pasig Potrero River are also collected from flood reports at the Apalit office and shown in the Reference Material attached to the end of this report.

4-6 Water Balance

The water balance between annual discharge and annual rainfall is studied to check the reliability of discharge records at 4 stations Sachas Der Carmen, Valdez, HDA Dolores and Cabetican Bacolor.

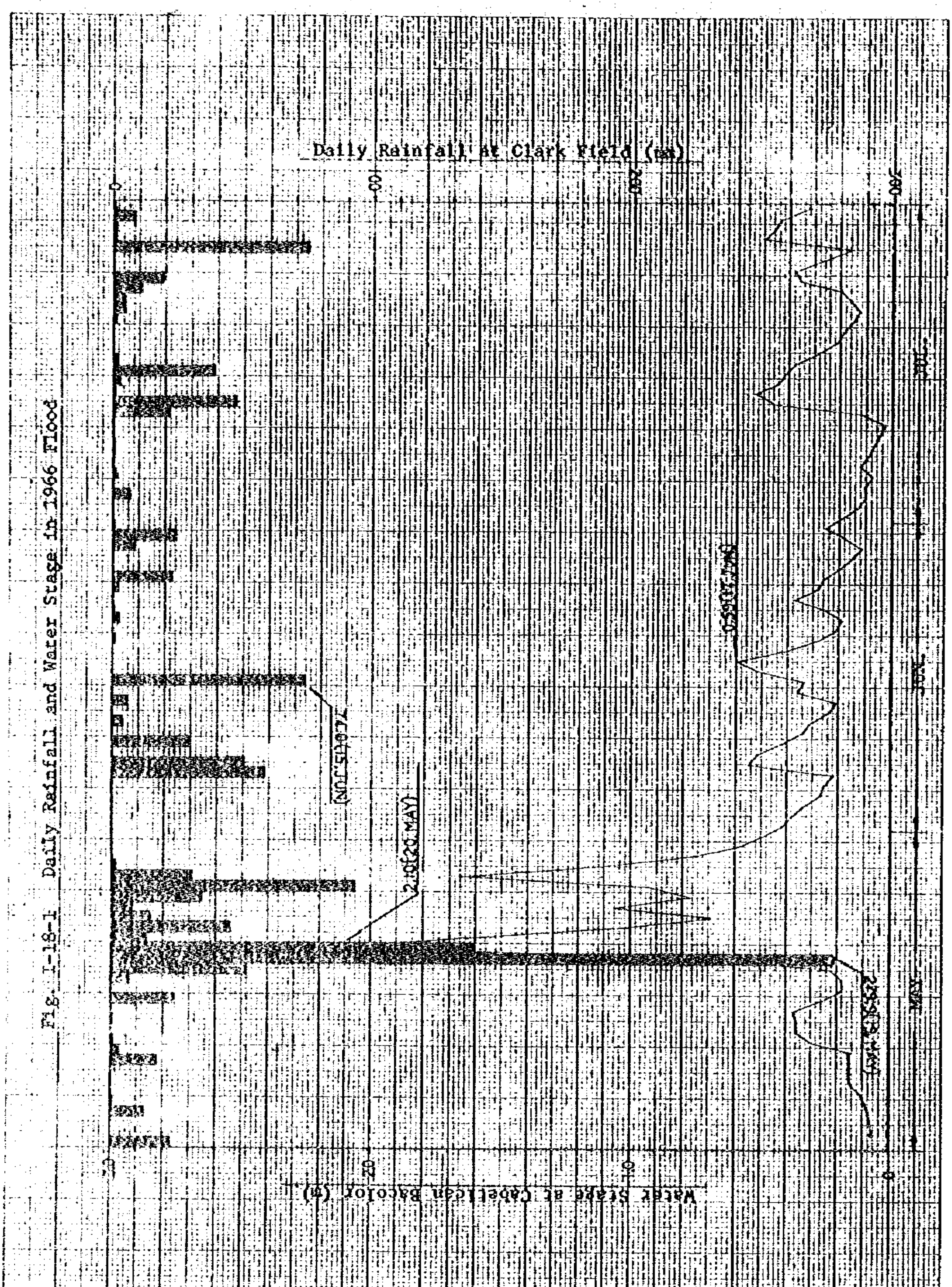
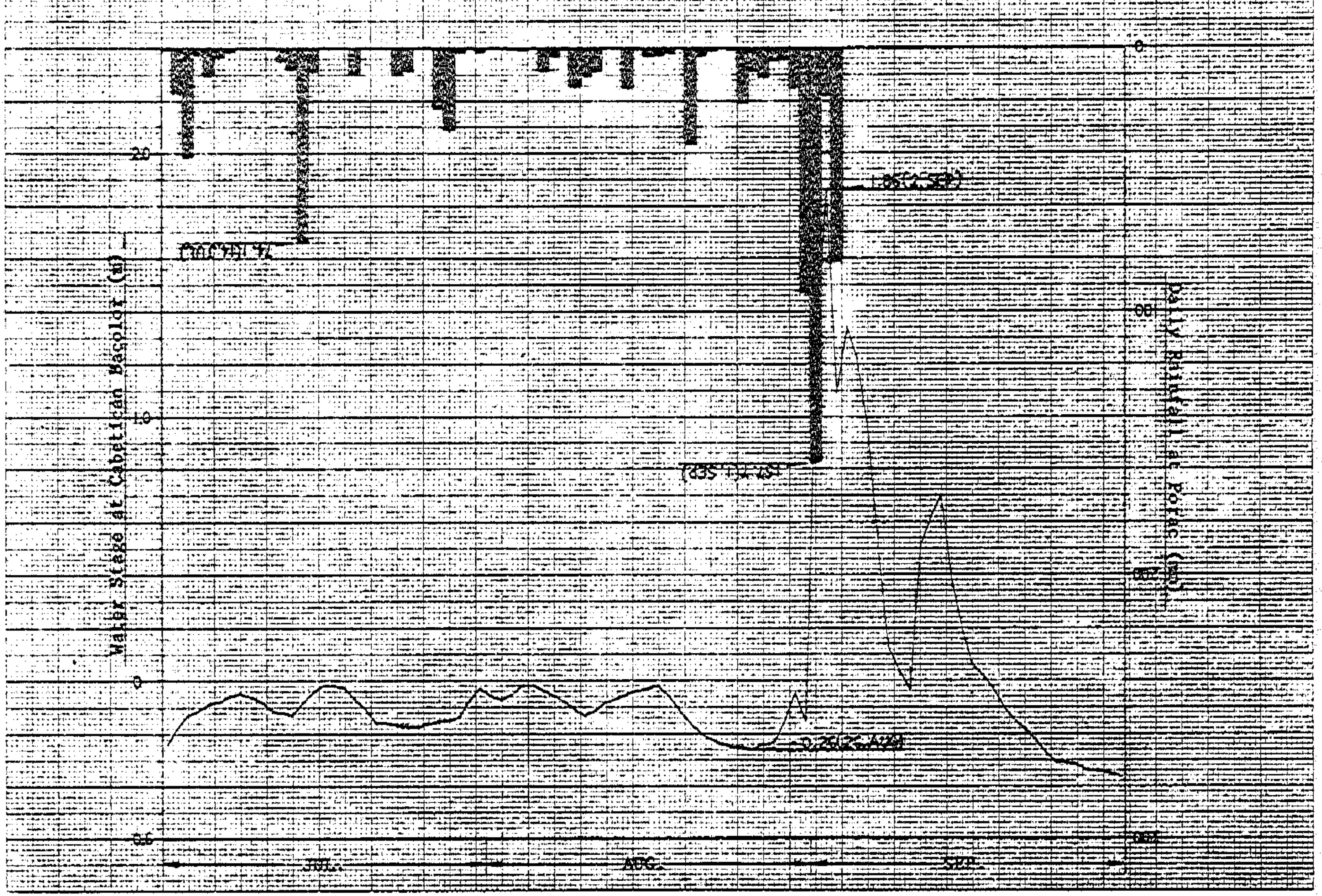


Fig. I-18-1 Daily Rainfall and Water Stage in 1966 Flood

Fig. II-18-2 Daily Rainfall and Water Stage in 1970 Flood



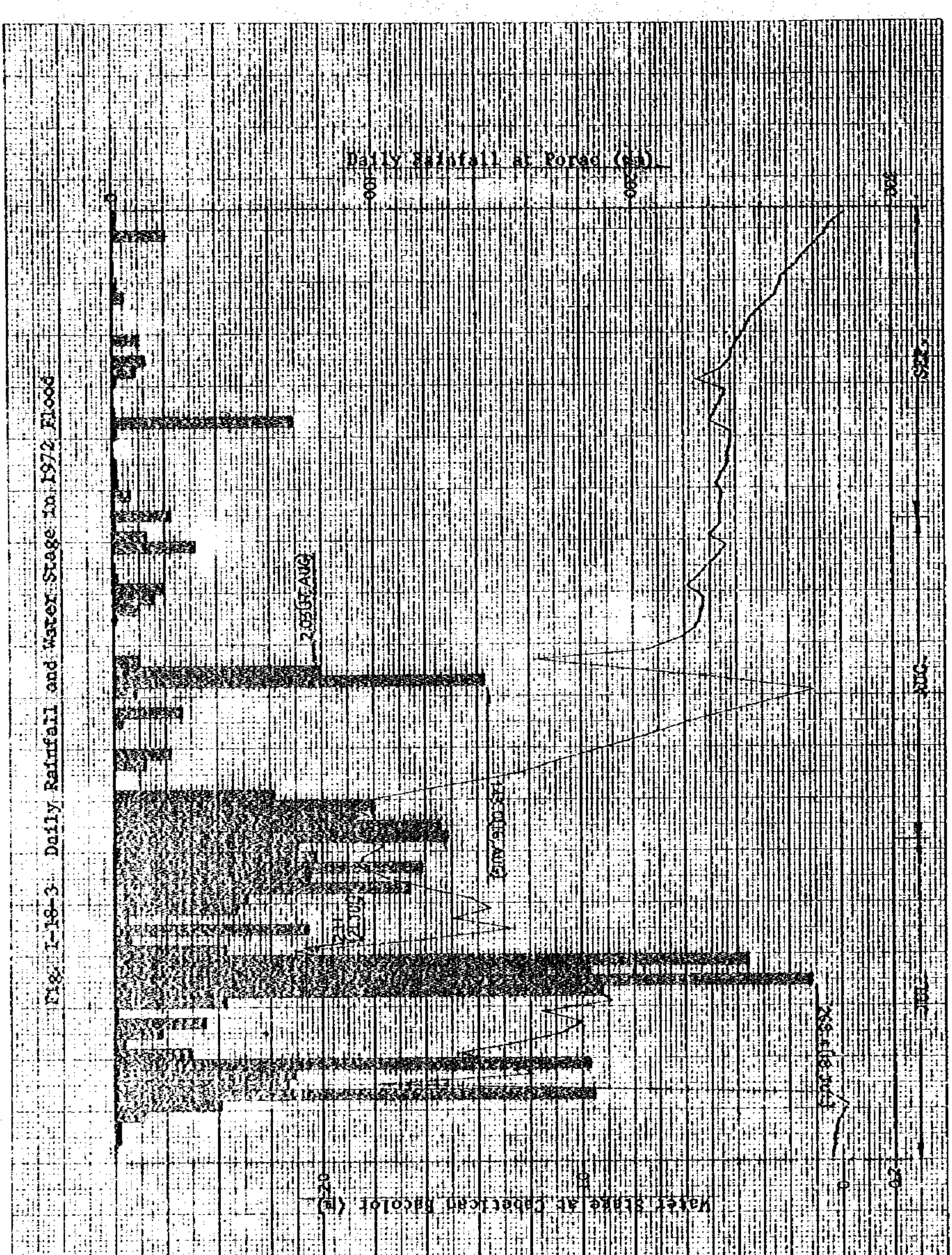


Fig. I-18-3 Daily Rainfall and Water Stage in 1972 Flood

Fig. I-18-4 Daily Rainfall and Water Stage in 1974 Flood

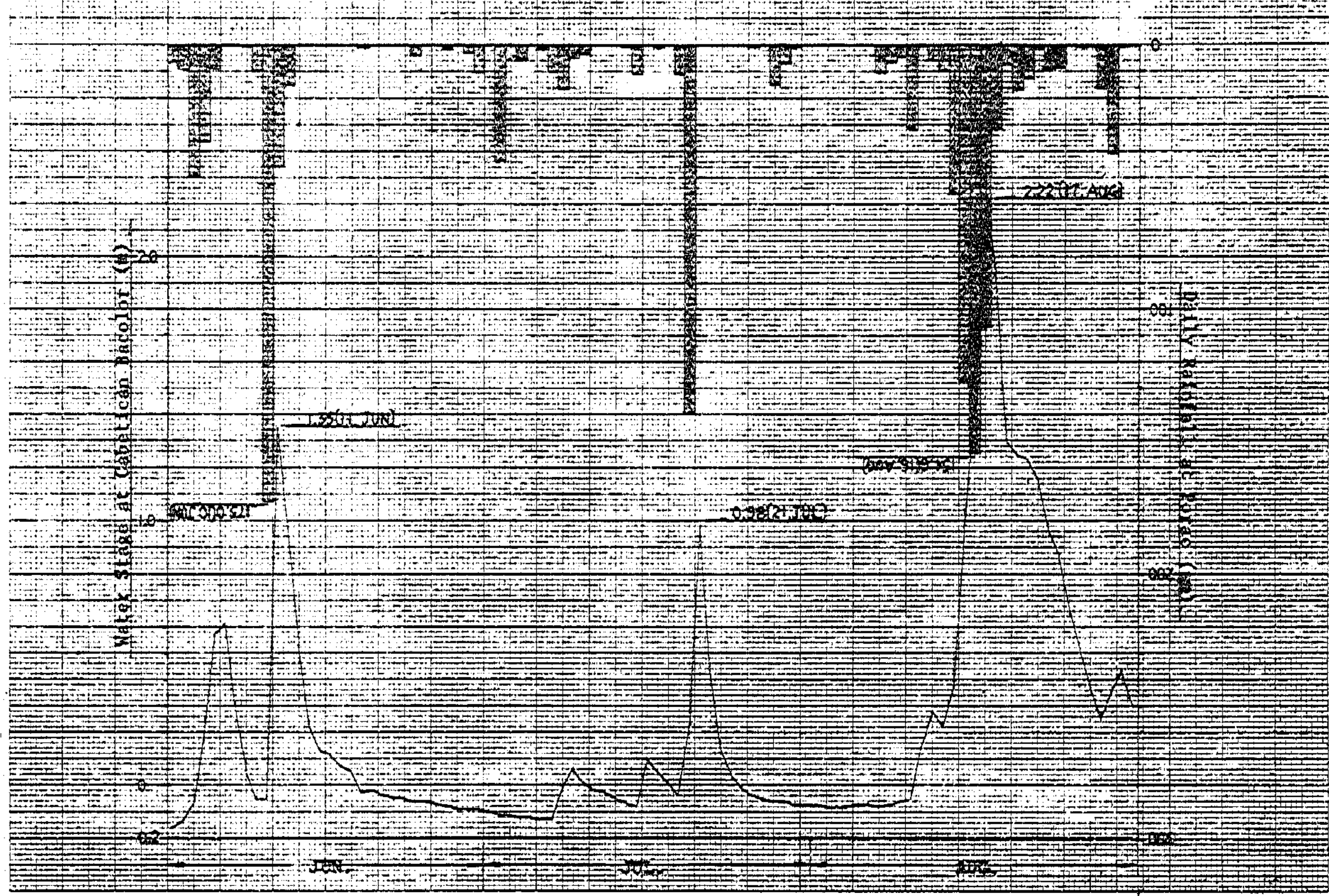


Fig. I-18-5 Daily Rainfall and Water Stage in 1976 Flood

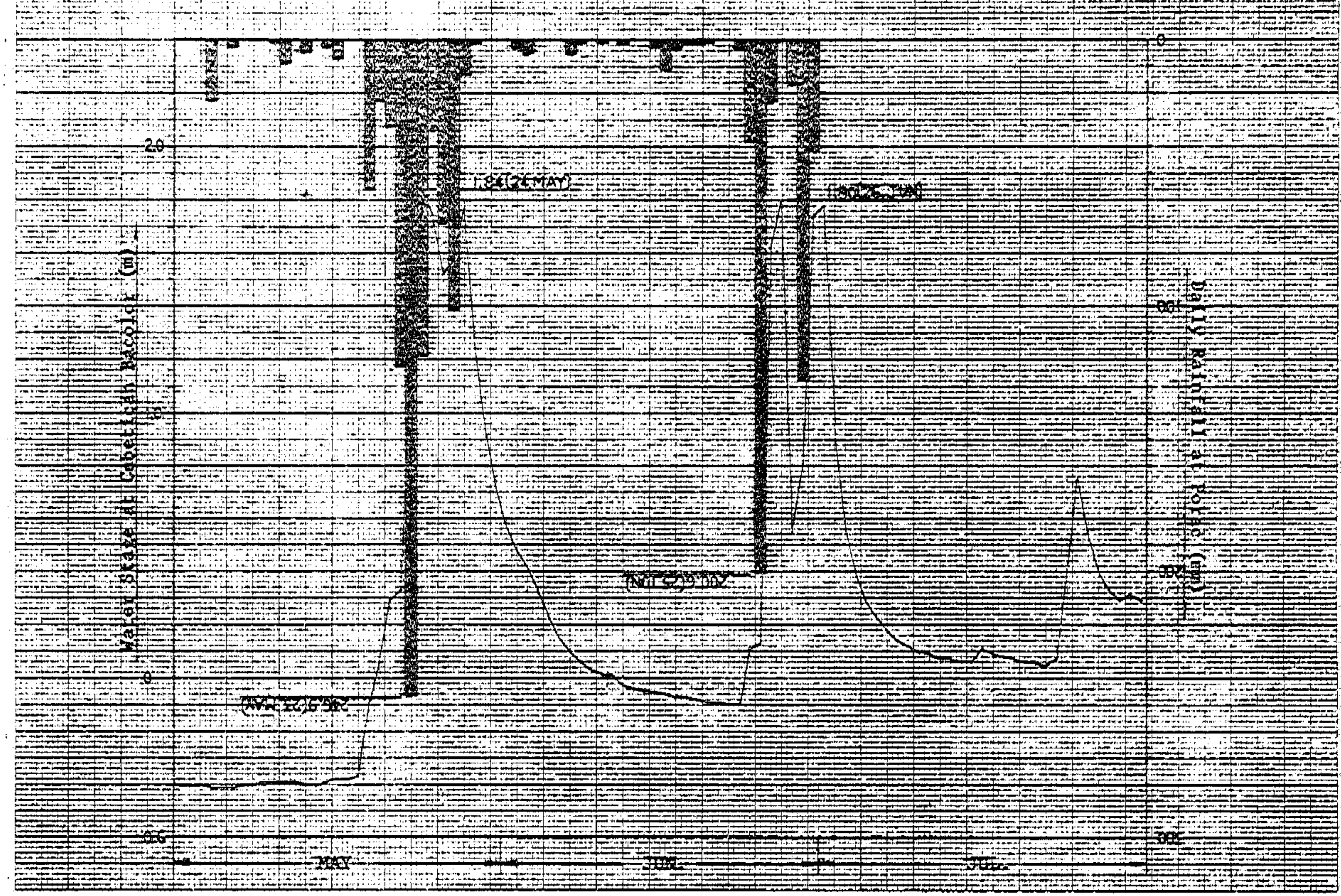


TABLE I-14 ANNUAL MAXIMUM WATER STAGE AND DISCHARGE

Item / Year	Porac River								Pasig - Potrero River							
	Der Carmen				Valdez				HDA Bdores				Cabetican Bacolor			
	Date	Time	Hmax	Qmax	Date	Time	Hmax	Qmax	Date	Time	Hmax	Qmax	Date	Time	Hmax	Qmax
1977																
76													May 24		1.84	
75													Aug. 10	17:00	1.42	
74					Aug. 17	7:00	4.00	132.300					Aug. 17	17:00	2.24	
73					Oct. 17	7:00	2.55	21.750					Oct. 16	17:00	1.88	
72	May 31	12:00	3.44	(12.400)	Jul. 9	17:00	6.30	366.900	Jul. 25	7:00	2.00	8.860	Jul. 21	7:00	2.20	
71	May 22	18:00	3.98	43.380	Jul. 26	7:00	3.15	56.000	Jul. 26	17:00	1.98	8.630	Jul. 24	17:00	1.54	
70	Sep. 2	12:00	5.00	146.000	Sep. 2	12:00	3.50	82.600	Aug. 31	7:00	1.32	2.220	Sep. 2	7:00	2.00	
1969	Sep. 6	6:00	4.28	224.600	Aug. 6	5:00	2.98	44.640	Aug. 6	7:00	1.75	6.010	Aug. 7		1.34	32.090
68	Aug. 31	13:00	3.90	35.900	Aug. 28	17:00	2.86	37.360	Aug. 29	17:00	2.00	8.860	Aug. 29	18:00	1.92	60.740
67	Aug. 2	6:00	5.59	224.600	Jul. 30	7:00	4.20	152.700	Nov. 5	7:00	1.85	7.150	Jun. 8	18:00	2.12	71.140
66	Sep. 9	18:00	5.62	227.400	May. 20	7:00	5.85	321.000	Nov. 21	17:00	1.60	4.300	May. 20	12:00	2.16	73.220
65	Jul. 28	17:00	4.30	134.000	Jul. 14	3:00	5.20	254.700					Jul. 14	17:00	1.66	48.260
64	Jul. 1	12:00	4.81	124.100	Jun. 30	7:00	5.94	330.180								
63	Aug. 15	18:00	4.06	54.800	Jun. 28	17:00	5.97	333.240								
62	Jul. 24	18:00	6.80	400.000	Sep. 19	12:00	3.00	30.300								
61	Jul. 7	18:00	3.99	67.600	Jul. 7		4.22	141.480								
60	Aug. 13	17:00	3.86	128.500	Aug. 9	17:00	4.35	168.000								
1959	Aug. 30	5:00	5.36	21.300	Aug. 6	12:00	2.93	23.160								
58	Jul. 14	7:00	4.70	6.930												
57	Aug. 16	5:00	4.30	5.450												

Hmax : Maximum Water Stage.
Qmax : Maximum Discharge.

Drainage Area : Der Carmen A = 111 Km, Valdez A = 118 Km²
HDA Dolores A = 28 Km, Ca. Bacolor A = 242 Km²

Fig. I-19 MONTHLY MEAN DISCHARGE

	Station	River	A(km²)
1	Der Carmen	Porac	111.0
2	Valdez	Porac	118.0
3	HDA Dolores	Pasig-Potrero	28.0
4	Ca. Bacolor	Pasig-Potrero	242.0

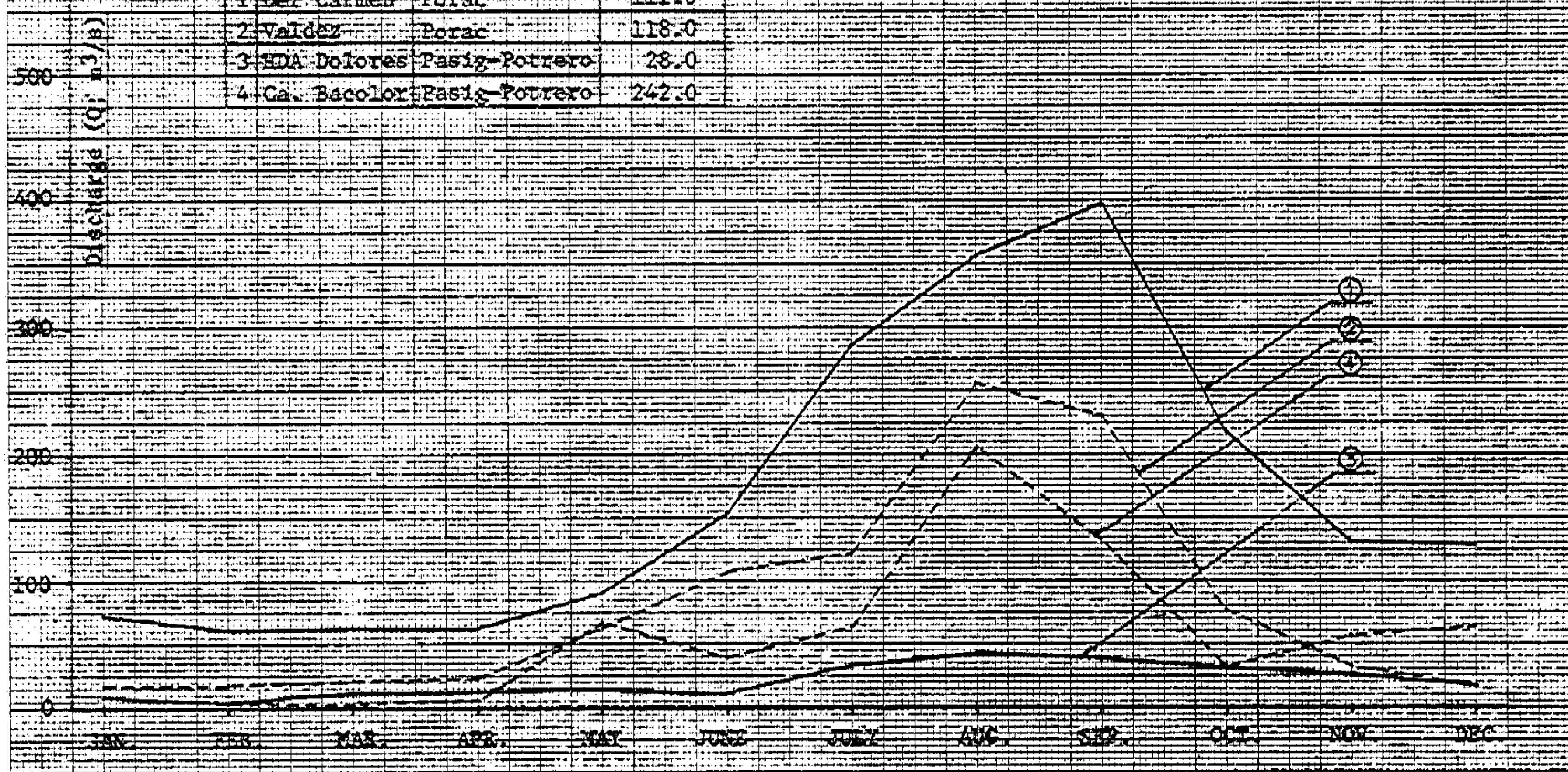


TABLE - I-15-1 ANNUAL MONTHLY TOTAL RUNOFF DISCHARGE (I)

DER CARMEN, PORAC

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977													
6													
5													
4													
3													
2	151.25	106.60	137.20	161.45	25.80								—
1	0.78	10.30	36.80	37.30	76.18	40.60	141.50	7.40	63.50	226.15	[illegible]	320.90	1250.21
0	91.50	26.75	25.45	68.80	47.70	23.29	260.55	314.07	867.86	382.88	247.20	537.40	2893.45
1969	68.50	122.75	127.00	177.90	167.30	206.60	463.96	592.63	564.88	388.69	20.10	16.45	2916.76
8	183.90	179.52	191.50	145.30	314.32	110.40	121.95	487.84	904.28	332.99	36.90	96.20	3106.10
7	57.25	28.15	28.35	23.90	27.20	564.61	266.40	1034.54	196.37	168.30	178.63	53.65	2627.35
6	76.60	67.45	73.15	69.60	399.25	265.55	216.40	390.20	1334.22	146.28	266.57	111.60	3416.87
5	73.45	58.75	55.56	38.08	50.75	134.95	521.80	174.05	148.75	212.30	131.50	91.50	1691.44
4	64.05	71.20	62.32	39.33	42.83	185.09	240.51	354.00	205.30	239.15	148.05	125.35	1777.18
3	66.65	48.50	44.22	34.57	33.78	198.99	170.05	234.93	244.11	154.95	77.10	84.80	1392.65
2	41.70	38.69	49.16	43.85	43.12	52.48	1128.91	95.15	292.55	92.50	82.40	77.37	2037.88
1	38.78	78.04	27.62	23.50	25.91	129.33	302.47	159.28	201.35	105.20	83.92	69.41	1244.81
0		23.65	25.13	30.97	27.41	150.35	48.15	979.59	328.30	437.35	126.46	90.25	(2267.61)
1959	47.36	27.70	30.30	23.06	52.76	44.84	52.66	121.98	153.17	104.26	89.68	82.60	830.37
8	54.03	14.36	23.96	14.77	16.14	39.92	63.61	49.71	53.91	69.97	57.32	58.90	516.60
TOTAL	1015.80	902.41	937.72	932.38	1350.45	2147.0	3998.92	4995.37	5559.55	3060.97	1834.63	1816.38	28551.68
MEAN	72.56	60.16	62.51	62.16	90.03	153.35	285.63	356.8	397.11	218.64	131.05	129.74	2019.74

UNIT ; m^3/s

TABLE I-15-2 ANNUAL MONTHLY TOTAL RUNOFF DISCHARGE (2)

VALDEZ, PORAC

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977													
6													
5	9.42	3.64	8.97	8.14	8.38	95.75	12.67	61.95	86.30	68.55	59.20	11.60	434.57
4	10.00	2.46	4.57	7.24	10.88	71.76	12.04	196.15	10.00	34.82	26.60	11.00	397.60
3	9.10	7.56			5.38	4.95	6.53	8.25	6.43	59.18	7.58	7.29	(122.17)
2	7.31	8.03	9.37	9.29	11.28	9.56	128.68	240.69	42.89	7.20	7.55	7.69	489.54
1	75.22	19.68	28.50	21.29	23.18	26.81	104.04	12.19	12.66	79.77	25.20	29.73	458.27
0	30.72	38.50	31.20	26.24	25.39	31.87	30.05	28.32	123.50	23.72	38.42	40.00	465.92
1969	7.76	10.43	11.50	47.70	40.50	4.37	20.47	99.92	26.53	25.73	27.27	34.19	356.37
8	25.47	39.50	37.37	21.85	15.63	15.24	18.84	116.60	196.24	15.25	9.08	5.37	516.24
7	4.28	13.81	15.63	18.73	11.83	183.15	258.73	431.29	371.88	276.76	178.34	22.45	1786.88
6	42.18	51.67	54.75	44.39	802.74			531.32	670.90	26.28	38.39	11.11	(2273.73)
5	17.13	18.04	24.86	20.57	11.42	20.58	431.90	128.91	137.28	90.43	37.79	27.85	966.76
4	11.21	21.41	21.13	18.39	8.97	334.95	231.89	481.56	172.87	177.09	9.66	20.99	1510.06
3	17.71	18.39	19.23	19.74	21.32	693.14	179.03	364.29	1170.48	55.31	17.80	6.31	2582.75
2	18.62	19.56	25.83	37.85	35.70	25.22				39.63	28.60	18.33	(249.34)
1	17.85	20.11	20.24	19.85	18.69	81.68	634.51	354.57	255.78	95.84	12.23	16.99	1548.34
0	6.20	12.67	15.74	14.28	8.34	91.89	64.72	981.68	298.03	192.91	26.60	13.37	1721.43
1959	6.61	9.35	8.83	9.24	6.97	3.80	5.91	49.52	119.36	33.46	20.20	6.13	279.38
8											11.62	4.19	—
TOTAL	316.87	312.76	337.72	344.79	1066.56	1694.72	2139.81	4087.21	3696.13	1301.93	582.07	294.59	16175.16
MEAN	18.64	18.40	21.11	21.55	62.74	105.92	142.65	255.45	231.01	76.58	32.34	16.37	1002.76

UNIT ; m^3/s

TABLE I-15-3 ANNUAL MONTHLY TOTAL RUNOFF DISCHARGE (3)

HDA DOLORES , PASIG—POTRERO

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977													
6													
5													
4													
3													
2	8.50	7.09	7.45	6.88	8.67	11.60	25.35						—
1	1.15	1.29	1.87	2.52	6.02	6.02	89.10	0.8	36.07	68.45	31.39	43.43	286.58
0	1.08	0.73	1.43	2.35	3.81	3.81	23.01	40.50	14.06	0.95	0.92	0.84	114.20
1969	5.02	2.22	2.36	2.47	3.64	3.64	13.85	28.22	9.22	2.47	1.14	1.01	74.73
8	11.62	9.04	16.03	25.49	36.63		17.23	55.87	96.94	41.52	27.77	4.86	(348.00)
7	26.31		31.68	29.53	28.29	28.29		85.12	38.98	38.40	54.68	29.37	(362.36)
6										23.74	38.75	25.19	—
5													
4													
3													
2													
1													
0													
1959													
8													
TOTAL	53.68	20.37	60.82	69.24	87.06	43.72	168.54	210.51	195.27	180.53	154.15	104.7	1345.59
MEAN	8.95	4.07	10.14	11.54	14.51	10.93	33.71	42.10	39.05	30.09	25.77	17.45	248.31

UNIT ; m^3/s

TABLE I-15-4 ANNUAL MONTHLY TOTAL RUNOFF DISCHARGE (4)

CABETICAN BACOLOR, PASIG—POTRERO

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977													
6													
5													
4													
3													
2													
1													
0													
1969	5.50	2.42	0.60	0.46	2.95	1.84	77.92	164.5	60.32	28.47	12.20	5.66	362.84
8	16.95	7.46	4.44	14.33	7.91	7.44	36.82	200.69	145.84	56.48	2.78	1.56	502.70
7	1.33	1.40	2.53	2.60	7.88	119.72	65.96	521.04		30.01	126.45	21.49	(900.41)
6	6.12				287.24	40.58	30.48	104.19	273.43	9.78	90.45	60.77	(903.04)
5					26.27	27.77	104.98	35.78	58.13	34.74	52.11	106.12	(445.90)
4													
3													
2													
1													
0													
1959													
8													
TOTAL	29.9	11.28	7.57	17.39	332.25	197.35	316.16	1026.2	537.72	159.48	283.99	195.6	3114.89
MEAN	7.48	3.76	2.52	5.80	66.45	39.47	63.23	205.24	134.43	31.90	56.80	39.12	656.20

UNIT ; m^3/s

TENTATIVE WATER BALANCE OF THE UPPER PAMPANGA RIVER
ENTERING PROJECT AREA NEAR ARAYAT MT.

	Q_n-CUSE ($10^9 m^3$)	CUSE ($10^9 m^3$)	Qnat ($10^9 m^3$)	Qbase ($10^9 m^3$)	Qflood ($10^9 m^3$)	Qb/Qf (%)	Precip. (M.M.)	R.O (M.M.)	$f = \frac{RO}{Prec.}$
1960	9.94	0.98	10.92	4.07	6.85	0.59	2277.	1960	0.74
1961	8.69	1.28	9.97	3.94	6.03	0.65	2175.	1540	0.71
1962	9.16	1.27	8.43	3.78	4.65	0.81	1781.	1303	0.73
1963	7.96	0.91	8.87	3.85	5.02	0.64	1755.	1371	0.78
1964	8.92	0.99	9.91	4.05	5.86	0.70	2369.	1531	0.65
1965	7.69	0.83	8.52	3.32	5.20	0.64	2024.	1318	0.65
1966	8.96	0.70	9.66	3.71	5.95	0.62	2564.	1497	0.58
1967	9.77	1.08	10.	3.97	6.88	0.58	1836.(?)	1680	0.92(?)
1968	6.40	1.40	7.80	3.06	4.74	0.64	1628.	1208	0.74
1969	4.92	0.81	5.73	3.10	2.33	1.52	1501.	885	0.59
1970	7.80	0.93	8.73	3.47	4.26	0.82	1305(?)	1350(?)	(?)
1971	10.45	0.60	11.05	1.23	6.82	0.62	2006.	1703	0.85
1972	12.61	0.94	13.55	5.35	8.20	0.65	2326(?)	2090(?)	0.90(?)
Average	8.47	0.98	9.45	3.86	5.59	0.69	2069.	1470	(?)

TABLE I-16-1 ANNUAL WATER BALANCE (I)

RIVER : PORAC

Q : VALDEX , R : PORAC

	① RUN OFF DISCHARGE ΣQ (m³/s)	② RUN OFF VOLUME 86 400 ΣQ (m³)	③ RAINFALL ΣR (mm)	④ DRAINAGE AREA A (km²)	⑤ RAINFALL VOLUME AΣR (m³)	⑥ RUN OFF COEFFICIENT F = ②/⑤	REMARKS
1977				111			
76			(2345. 0)	〃	260.3 X10⁶		
75			1417. 3	〃	157.3		
74			(2408. 3)	〃	267.3		
73			(1452. 2)	〃	161.1		
72			4092.0	〃	454.2		
71	1250. 21	108.0 X10⁶	(1914. 0)	〃	212.5	(0.508)	
1970	2893. 45	250.0	—	〃			
69	2916. 76	252.0	—	〃			
68	3106. 10	268.3		〃			
67	2627. 44	227.0		〃			
66	3416. 87	295.2		〃			
65	1691. 44	146.1		〃			
64	1777. 18	153.5		〃			
63	1392. 65	120.3		〃			
62	2037. 88	176.1		〃			
61	1244. 81	107.6		〃			
1960	2267. 61	195.9		〃			
59	830. 37	71.7		〃			
58	516. 60	44.6		〃			
MEAN	2019. 74	174.5 X10⁶	2271.5		252.1 X10⁶	0. 69	

* Q AND R ARE THE DISCHARGE OBSERVATION STATION AND THE RAINFALL OBSERVATION STATION.

** MEAN VALUE WAS ADOPTED FROM ANNUAL MONTHLY RUN-OFF DISCHARGE (TABLE I-15) AND ANNUAL MONTHLY RAINFALL (FIGURE I-15).

TABLE I-16-2 ANNUAL WATER BALANCE (2)

RIVER ; PORAC | Q : VALDEX ; R : PORAC

	① RUN OFF DISCHARGE ΣQ (m^3/s)	② RUN OFF VOlUME $86400 \Sigma Q$ (m^3)	③ RAINFALL ΣR (mm)	④ DRAINAGE AREA A (km)	⑤ RAINFALL VOlUME $A \Sigma R$ (m^3)	⑥ RUN-OFF COEFFICIEUT $F = ②/⑤$	REMARKS
1977				118			
76			(2345.0)	〃	276.7 ×10⁶		
75	434.57	37.5 ×10⁶	1417.3	〃	167.2	0.22	
74	397.58	34.3	(7408.3)	〃	284.2	0.12	
73	(122.17)	10.6	(1452.2)	〃	171.4	0.06	
72	489.54	42.2	(4092.0)	〃	482.9	0.19	
71	458.27	39.6	(1914.0)	〃	225.9	0.18	
1970	465.92	40.2	—	〃			
69	356.37	30.7	—	〃			
68	516.24	44.6		〃			
67	1766.88	152.7		〃			
66	(2273.73)	196.5		〃			
65	966.76	83.5		〃			
64	1510.06	130.5		〃			
63	2564.36	221.6		〃			
62	(249.34)	21.5		〃			
61	1548.34	133.7		〃			
1960	1721.43	148.7		〃			
59	279.38	24.1		〃			
58	—			〃			
MEAN.	1002.76	86.6 ×10⁶	2271.5		268.0 ×10⁶	0.32	

* Q AND R ARE THE DISCHARGE OBSERVATION STATION AND THE RAINFALL OBSERVATION STATION

** MEAN VALUE WAS ADOPTED FROM ANNUAL MONTHLY RUN-OFF DISCHARGE (TABLE I-15) AND ANNUAL MONTHLY RAINFALL (FIGURE I-15).

TABLE I-16-3 ANNUAL WATER BALANCE (3)

RIVER; PASIG-POTORERO

Q; HDA DOLORES, R; PORAC

	① RUN OFF DISCHARGE ΣQ (m^3/s)	② RUN OFF VOLUME $86400 \cdot \Sigma Q$ (m^3)	③ RAINFALL ΣR (mm)	④ DRAINAGE AREA A (km^2)	⑤ RAINFALL VOLUME $A \cdot \Sigma R$ (m^3)	⑥ RUN OFF COEFFICIENT F=③/⑤	REMARKS
1977				28			
76			(2345. 0)	〃	65.7 X10[6]		
75			1417. 3	〃	39.7		
74			(2408. 3)	〃	67.4		
73			(1452. 2)	〃	40.7		
72			4092. 0	〃	114.6		
71	286. 58	24. 8 X10[6]	(1914. 0)	〃	53.6	0.46	
1970	114.20	9.9		〃			
69	74. 73	6.5		〃			
68	(348. 00)	30.1		〃			
67	(362. 36)	31. 3		〃			
66				〃			
65				〃			
64				〃			
63				〃			
62				〃			
61				〃			
1960				〃			
59				〃			
58				〃			
MEAN	248.31	21.5 X10[6]	2271.5		63.6 X10[6]	0. 34	

* Q AND R ARE THE DISCHARGE OBSERVATION STATION AND THE RAINFALL OBSERVATION STATION.

** MEAN VALUE WAS ADOPTED FROM ANNUAL MONTHLY RUN-OFF DISCHARGE (TABLE I-15) AND ANNUAL MONTHLY RAINFALL (FIGURE I-15).

TABLE I-15-4 ANNUAL WATER BALANCE (4)

RIVER: PASIG - POTORERO

Q: CABETICAN BACOLOR R: PORAC

	① RUN OFF DISCHARGE ΣQ (m^3/s)	② RUN OFF VOLUME 86400 ΣQ (m^3)	③ RAINFALL ΣR (mm)	④ DRAINAGE AREA A (km)	⑤ RAINFALL VOLUME AΣR (m^3)	⑥ RUN OFF COEFFICIENT F = ③/⑤	REMARKS
1977				242			
76			(2345.0)	〃	567.5 X10^6		
75			1417.3	〃	343.0		
74			(2408.3)	〃	582.7		
73			(1452.2)	〃	351.4		
72			4092.0	〃	990.3		
71			(1914.0)	〃	463.2		
1970				〃			
69	362.84	31.3 X10^6		〃			
68	502.70	44.3		〃			
67	(900.04)	77.8		〃			
66	(445.90)	38.5		〃			
65				〃			
64				〃			
63				〃			
62				〃			
61				〃			
1960				〃			
59				〃			
58				〃			
MEAN	656.20	56.7	2271.5		549.7 X10	0.10	

* Q AND R ARE THE DISCHARGE OBSERVATION STATION AND THE RAINFALL OBSERVATION STATION.

** MEAN VALUE WAS ADOPTED FROM ANNUAL MONTHLY RUN-OFF DISCHARGE (TABLE I-15) AND ANNUAL MONTHLY RAINFALL (FIGURE I-15).

Conversion from water stage records into discharge is done not by the method that water stage-discharge curves are adjusted according to the variation of a river-bed but by the method that the rating curve established initially is utilized as it is if the difference between the observed discharge and the calculated value from a rating curve is confined within ±5% (Area-Velocity Method).

The annual highest water stage and the annual maximum discharge thus calculated are given in TABLE I-14. However, conversion into discharge for this river with a high permeability and a serious variation of stream should be re-studied because the data observed at 7 A.M. on July 25, 1972, show Hmax=2.00 m and Qmax=8.86 m^3/s.

The monthly mean discharge duration curves at Der Darmen ($A = 111\ km^3$) Valdez ($A = 118\ km^3$), along the Porac River, HDA Dolores ($A = 28\ km^3$) and Cabetican Bacolor ($A = 242\ km^2$) along the Pasig-Potrero River show an adverse tendency that the discharge in the up-stream surpasses that in the down-stream. Balance between the annual total rainfall and run-off discharge is presented in the following table to clear up this tendency.

	① Runoff Volume 86400 Q (m^3)	② Rainfall Volume A R (m^3)	f ①/②	Remarks
Der Carmen	174.5×10^6	252.1×10^6	0.69	
Valdez	86.6×10^6	268.0×10^6	0.32	
HDA Dolores	21.5×10^6	63.6×10^6	0.34	
Cabetican Bacolor	56.7×10^6	549.7×10^6	0.10	

It is concluded that this tendency is caused by the higher permeability in the down reaches. Therefore, studies are carried out in Chapter II Hydrology, based on rainfall data, not water stage and discharge records.

4-7 Return Period of Rainfall

Annual maximum daily rainfall records (N days, N = 1 - 7) collected at seven stations are summarized in TABLE I-17. Based upon the records at Clark Field, Sta. Cruz Porac, San Agustin Arayat and Casinala Apalit stations, daily rainfall probability (Return Period of N-Day Rainfall, N = 1, 3, 5) has been estimated as given in the following table.

Return Period of N-Day Rainfall

Station	N-Days Rainfall	Return Period (T: Year) 2	5	10	20	50	100
Clark Air Base	R	140	220	275	330	410	470
	3R	240	410	540	690	900	1,050
	5R	300	520	700	890	1,180	1,400
Sta. Cruz Porac	R	150	230	280	340	410	470
	3R	270	430	560	700	900	1,050
	5R	320	550	720	920	1,200	1,400
Casinala Apalit	R	130	210	270	330	420	480
	3R	200	360	500	660	900	1,080
	5R	250	460	650	860	1,200	1,450
San Augstin Arayat	R	135	210	265	320	400	460
	3R	220	375	500	640	850	1,000
	5R	260	380	600	770	1,000	1,200

According to the table, rainfall values (especially 3-day rainfall and 5-day rainfall) at Clark Air Base fall below those at other three stations. Distribution of rainfall values plotted on the logarithmic probability paper shows that 5-day rainfall values do not exist in one line, though 3-day and 5-day rainfall values do (normal distribution), which indicates the following matters.

i) The data have been collected at Clark Air Base for 16 years while less than 10 years at other stations. It is reasonable that rainfall probability based on the small number of statistical years be high.

ii) 1-day and 3-day rainfall data present normal distribution while 5-day rainfall data do no. This phenomenon corresponds to the rainfall duration of less than 3 days mentioned in 4-3) Hourly Rainfall Distribution.

On the other hand, N-day maximum rainfall data during floods are listed up in the table below to study main floods statistically these years.

Maximum N-Day Rainfall in Main Floods

Flood	Rain	Clark Air Base Date	Clark Air Base (mm)	Sta. Cruz Porac Date	Sta. Cruz Porac (mm)	Casirala Apalit Date	Casirala Apalit (mm)	San Augstin Arayat Date	San Augstin Arayat (mm)
1966 May	R	5/19	279.9						
	3R	5/18-5/20	472.4						
	5R	5/18-5/22	533.4						
	7R	5/18-5/24	557.8						
1970 Sept.	R	9/1	222.0	9/1	157.7			9/1	312.4
	3R	8/31-9/2	356.4	8/31-9/2	269.1			8/30-9/1	617.6
	5R	8/21-9/4	511.3	8/30-9/3	284.6			8/30-9/3	696.7
	7R	8/30-9/5	528.1	8/28-9/3	376.1			8/30-9/5	747.7
1972 July	R	7/19	291.6	7/18	269.4	7/18	282.0	7/17	337.7
	3R	7/18-7/20	734.1	7/18-7/20	697.2	7/17-7/19	649.3	7/17-7/19	833.0
	5R	7/17-7/21	912.9	7/17-7/21	927.2	7/16-7/20	814.3	7/16-7/20	1160.5
	7R	7/17-7/23	938.8	7/17-7/23	1007.7	7/17-7/23	910.8	7/17-7/23	1254.1
1974 Aug.	R			8/16	154.6	8/16	205.6	8/16	704.9
	3R			8/15-8/17	389.1	8/15-8/17	437.5	8/15-8/17	1211.3
	5R			8/14-8/18	477.8	8/13-8/17	505.0	8/13-8/17	1380.9
	7R			8/14-8/20	502.8	8/13-8/19	532.0	8/11-8/17	1484.8
1976 May	R			5/23	246.9	5/22	212.0	5/23	167.9
	3R			5/22-5/24	488.6	5/21-5/23	413.0	5/22-5/24	303.9
	5R			5/22-5/26	591.1	5/20-5/24	491.6	5/22-5/26	427.0
	7R			5/21-5/27	725.6	5/20-5/26	597.6	5/21-5/27	544.2

Since one continuous rainfall can be represented by 3-day rainfall, according to the study in 4-3), 3-day rainfall data at Clark Air Base with many statistical years are studied herein. The study of those data indicates that the flood in May of 1966 is 6.7-year probability, that in September of 1970 3.6-year probability and that is July of 1972 25-year probability.

A4 NO. 349 C

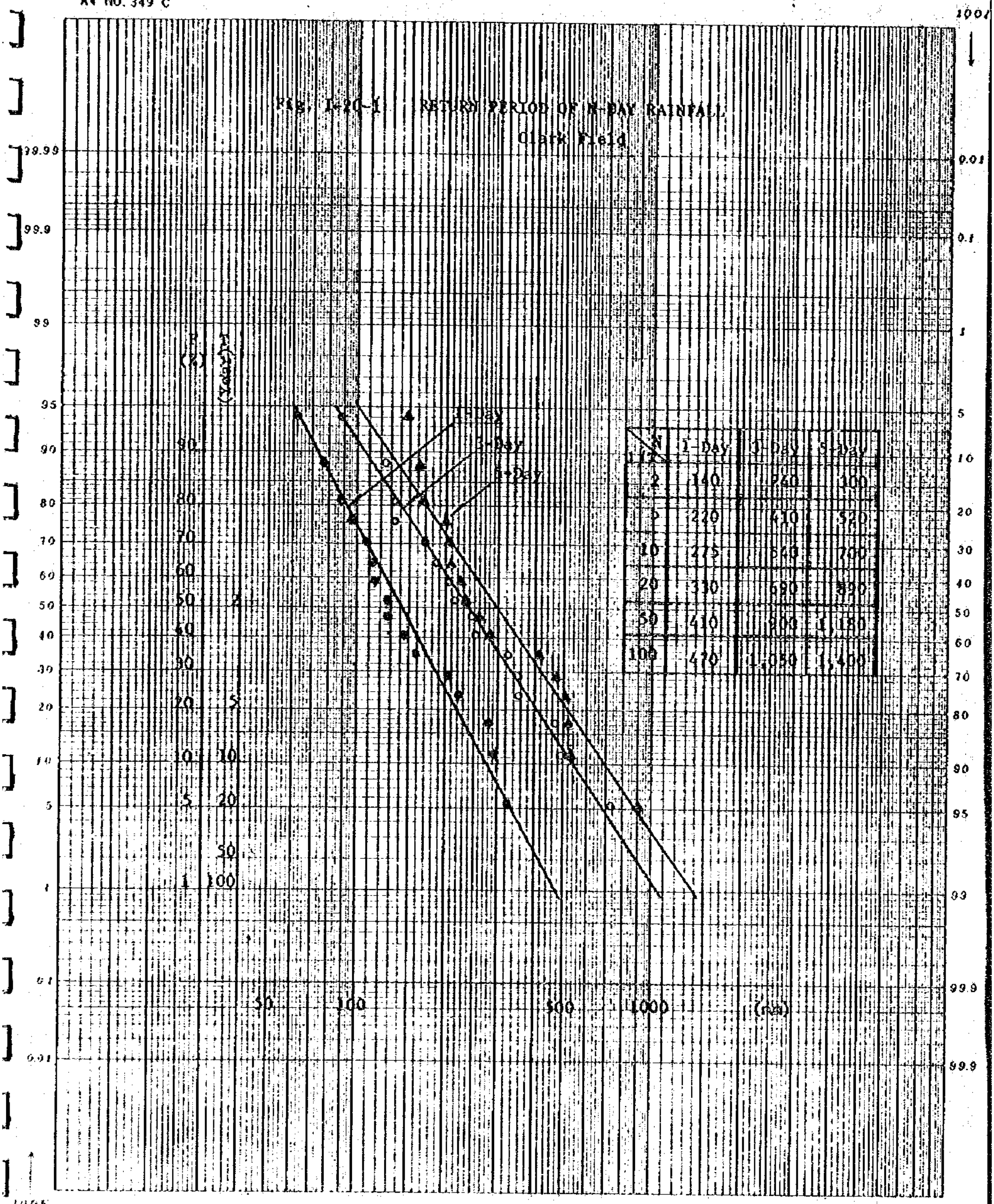
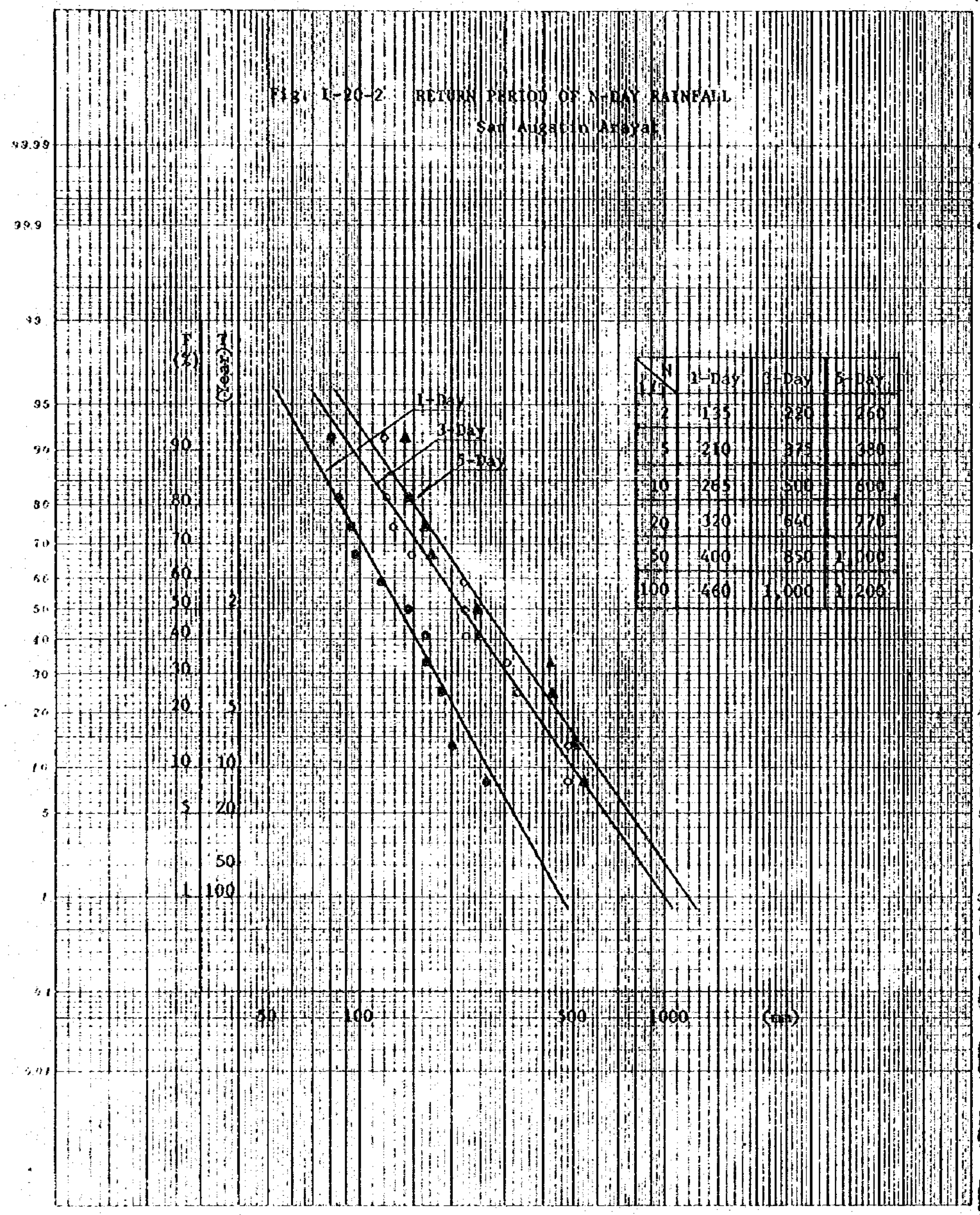


Fig. I-20-1 RETURN PERIOD OF N-DAY RAINFALL
Clark Field

T(Y) \ N	1-DAY	3-DAY	5-DAY
2	140	260	300
5	220	410	520
10	275	540	700
20	330	690	890
50	410	800	1,180
100	470	1,050	1,400

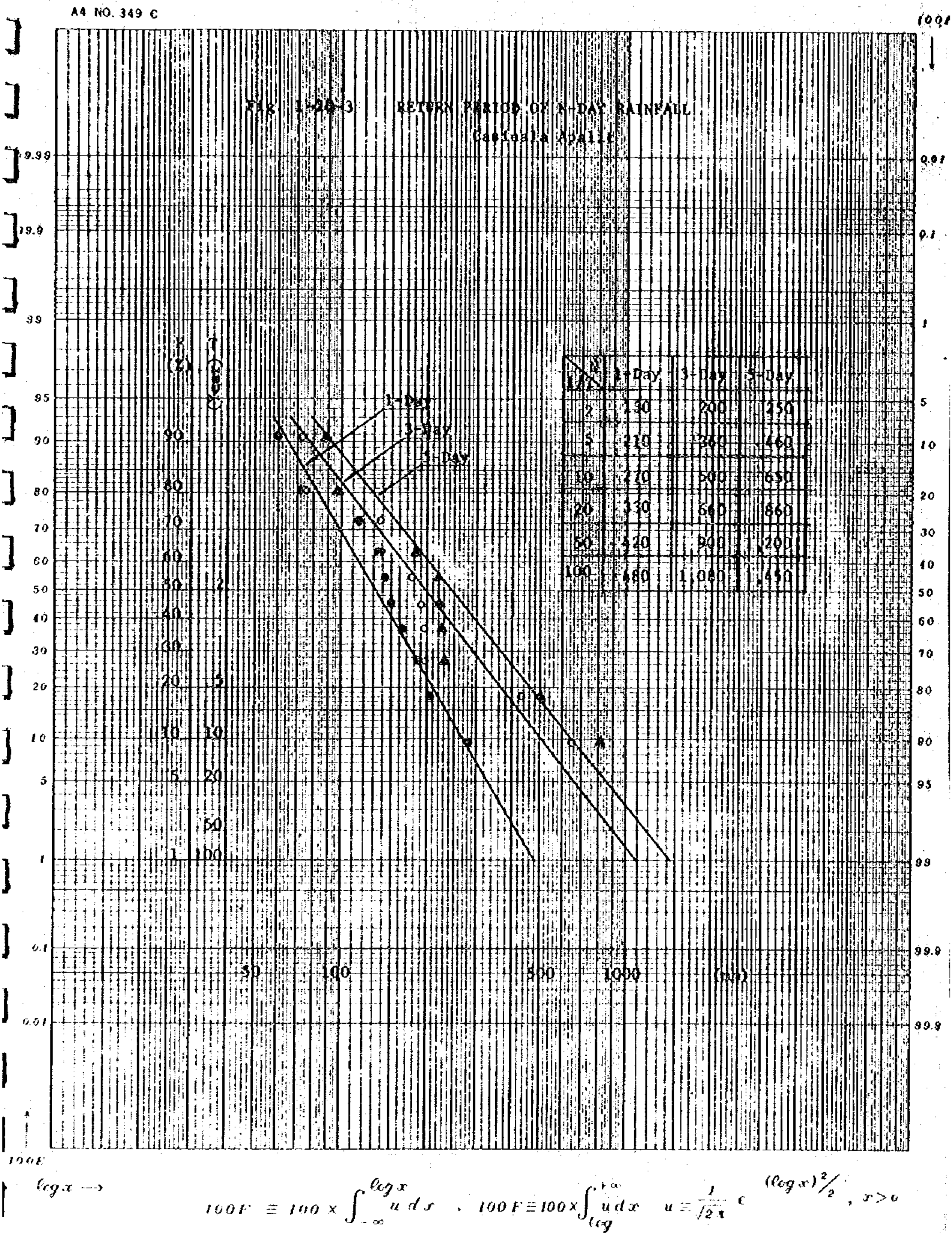
$$100F = 100 \times \int_{-\infty}^{\log x} u\,dx \quad , \quad 100F = 100 \times \int_{\log}^{+\infty} u\,dx \quad u = \frac{1}{\sqrt{2\pi}} e^{-(\log x)^2/2}, \; x > 0$$

A4 NO. 349 C



T \ N	1-Day	3-Day	5-Day
2	135	220	260
5	210	375	380
10	265	500	600
20	320	640	770
50	400	850	1,000
100	460	1,000	1,200

$100F = 100 \times \int_{0}^{\log x} u\,dx$, $100F = 100 \times \int_{\log x}^{\infty} u\,dx$ $\quad u = \frac{1}{\sqrt{2\pi}} e^{-(\log x)^2/2}$, $x > 0$



T \ N	1-Day	3-Day	5-Day
2	130	200	250
5	210	360	460
10	270	500	650
20	330	660	860
50	420	900	1,200
100	480	1,080	1,450

A4 NO. 349 C

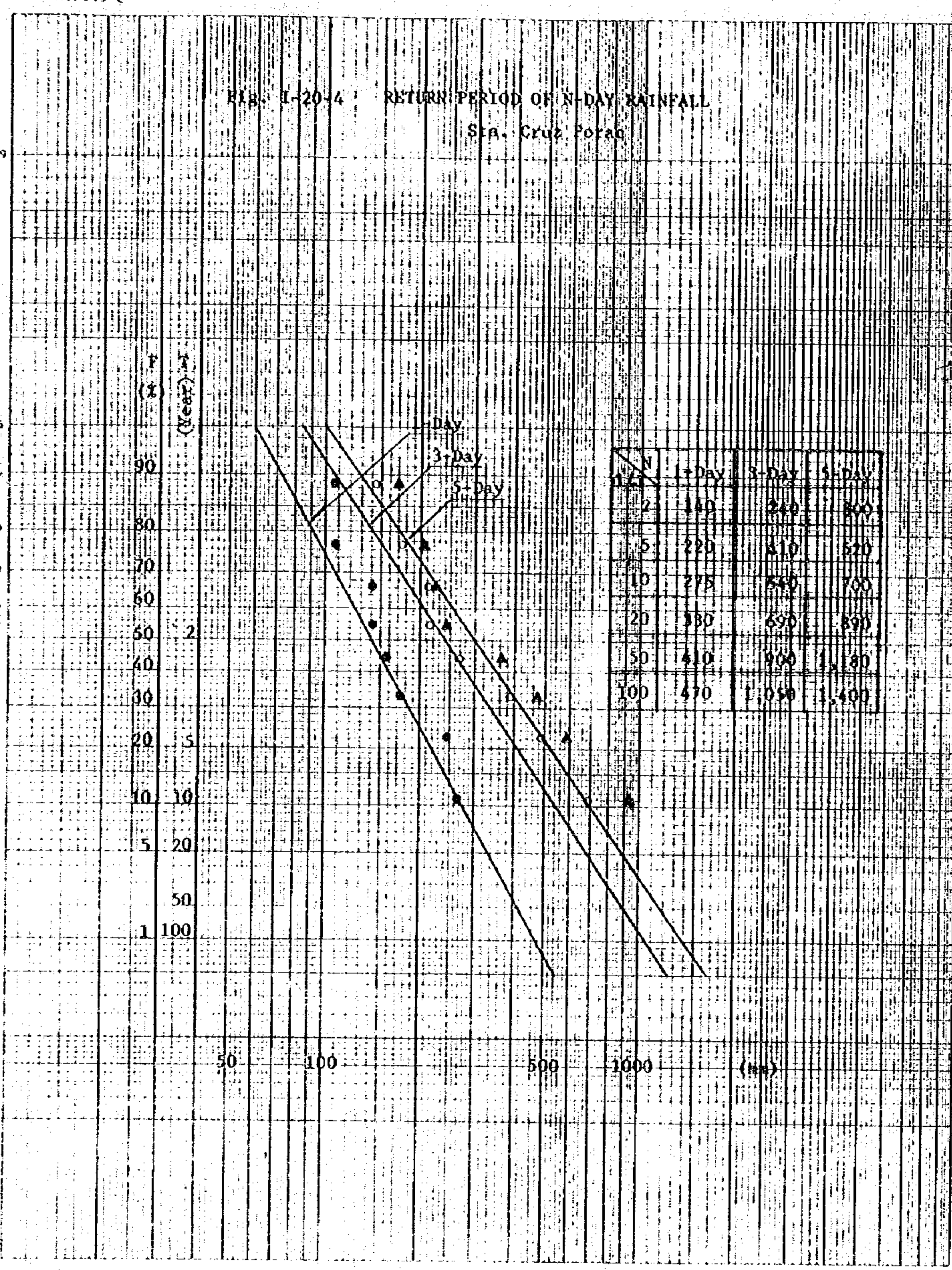


Fig. I-20-4 RETURN PERIOD OF N-DAY RAINFALL

Sta. Cruz Porac

T \ N	1-Day	3-Day	5-Day
2	140	240	300
5	220	410	520
10	275	540	700
20	330	690	890
50	410	900	1,180
100	470	1,050	1,400

TABLE I-17-1 ANNUAL MAXIMUM DAILY RAINFALL

NO. ①. CASINALA APALIT

(mm)

	1 - DAY		2 - DAY		3 - DAY		4 - DAY		5 - DAY		6 - DAY		7 - DAY	
	DATE	R_1	DATE	R_2	DATE	R_3	DATE	R_4	DATE	R_5	DATE	R_6	DATE	R_7
1977														
76	6/29	186.5	6/29-30	188.1	6/27-29	185.5	6/26-29	207.5	6/25-29	225.5	6/24-29	354.5	6/23-29	399.5
75	10/20	166.2	10/19-20	184.7	10/19-21	191.3	10/20-23	203.1	10/19-23	221.6	10/18-23	245.6	10/17-23	247.6
74	8/16	205.6	8/15-16	328.1	8/15-17	437.5	8/14-17	500.5	8/14-18	503.5	8/14-19	527.5	8/14-20	548.5
73	10/15	150.0	10/15-16	178.1	10/14-16	178.1	10/13-16	181.7	10/12-16	181.7	10/11-16	261.7	10/11-17	261.7
72	7/18	282.0	7/12-18	488.5	7/17-14	149.3	7/17-20	812.3	7/16-20	814.3	7/15-20	816.3	7/29-8/4	905.8
71	6/15	71.5	6/14-15	71.5	6/13-15	73.0	6/12-15	98.0	6/12-16	98.0	6/12-17	98.0	6/12-18	99.5
70	8/13	60.1	8/13-14	62.0	8/12-14	74.5	7/11-14	87.0	7/11-15	87.5	7/11-16	98.0	7/11-17	98.5
69	7/27	113.1	8/26-27	134.5	8/27-29	137.2	8/27-30	213.6	8/26-30	232.4	8/25-30	243.1	8/24-30	245.0
68	8/29	143.0	8/27-28	161.5	8/28-30	197.0	8/27-30	215.5	8/26-30	219.5	8/25-30	219.5	8/24-30	225.0
67	11/4	136.5	11/3-4	136.5	11/3-5	137.0	11/3-6	137.0	11/3-7	147.0	11/3-8	151.6	11/3-4	151.6

NO. ③ SAN AUGSTIN ARAYAT

(mm)

	1 - DAY		2 - DAY		3 - DAY		4 - DAY		5 - DAY		6 - DAY		7 - DAY	
	DATE	R_1	DATE	R_2	DATE	R_3	DATE	R_4	DATE	R_5	DATE	R_6	DATE	R_7
1977														
76	5/23	167.9	5/22-23	265.4	5/22-24	303.4	5/22-25	351.6	5/22-26	427.2	5/22-27	502.0	5/21-27	564.4
75	8/9	97.1	8/9-10	126.5	8/8-10	148.3	8/7-10	163.5	8/6-10	172.3	8/6-11	174.6	8/8-14	180.7
74	8/15	166.6	8/15-16	330.2	8/15-17	481.5	8/14-17	530.8	8/14-18	546.3	8/14-19	568.8	8/14-20	583.1
73	10/16	185.2	10/15-16	219.2	10/14-16	219.7	10/13-16	235.6	10/12-16	237.1	10/11-16	259.1	10/10-16	259.1
72	7/7	201.8	7/6-7	301.7	7/6-8	333.5	7/6-9	386.9	7/6-10	430.2	7/6-11	449.4	7/6-13	462.4
71	7/21	85.4	6/15-16	116.8	7/20-22	128.6	10/9-12	164.6	10/9-13	164.6	6/12-17	183.8	10/4-10	202.7
70	8/11	80.7	6/13-14	99.6	6/12-14	120.6	6/12-14	140.8	6/11-14	140.8	6/11-16	153.8	6/10-16	160.4
69	7/20	93.9	7/19-20	121.1	7/18-20	121.6	7/17-20	137.7	7/16-20	146.8	7/15-20	168.6	7/15-21	182.1
68	8/28	116.7	8/28-29	162.8	8/28-30	223.7	8/27-30	241.8	8/26-30	246.5	8/25-30	252.6	8/24-30	279.3
67	7/28	144.0	7/28-29	191.9	5/30-6/2	221.8	5/30-6/3	243.5	5/30-6/4	246.7	6/1-6	310.1	5/30-6/6	340.6
66	5/19	260.6	5/19-20	427.6	5/18-20	483.3	5/18-21	506.2	5/18-22	510.7	5/18-28	525.3	5/18-24	525.3

TABLE I-17-2 ANNUAL MAXIMUM DAILY RAINFALL

NO. ⑩ STA CRUZ PORAC

	1-DAY		2-DAY		3-DAY		4-DAY		5-DAY		6-DAY		7-DAY	
	DATE	R1	DATE	R2	DATE	R3	DATE	R4	DATE	R5	DATE	R6	DATE	R7
1977														
76	5/23	246.9	5/22-23	370.0	5/22-24	488.6	5/22-25	522.6	9/22-26	591.1	5/22-27	693.1	5/21-27	725.6
75	10/20	140.5	10/20-21	176.6	10/19-21	211.9	10/19-22	220.1	10/18-22	224.6	10/17-22	226.1	10/16-22	226.6
74	6/10	173.0	8/15-16	282.1	8/15-17	389.7	8/14-17	445.6	8/14-18	477.8	8/14-19	485.3	8/14-20	502.8
73	8/3	107.5	8/2-3	157.1	7/13-15	214.0	8/2-5	237.5	7/12-16	245.6	8/3-8	256.5	8/2-8	306.1
72	7/18	289.4	9/17-18	457.9	9/18-20	697.2	9/17-20	885.7	9/17-21	927.2	7/17-22	933.2	7/17-23	1007.7
71	6/25	141.7	7/25-26	174.6	7/25-27	174.6	10/9-12	190.7	10/9-13	204.2	7/20-25	275.0	7/20-26	307.9
70	9/1	157.7	9/1-2	175.5	8/31-9/2	268.7	8/31-9/3	350.5	8/30-9/3	366.4	8/29-9/3	371.0	8/28-9/3	376.1
69	9/6	108.4	9/6-7	116.0	9/6-8	144.5	9/6-9	163.0	9/6-10	169.5	9/5-10	172.6	9/5-11	172.4
68														
67														

NO. ⑪ SAN FERNAND (mm)

	1-DAY		2-DAY		3-DAY		4-DAY		5-DAY		6-DAY		7-DAY	
	DATE	R1	DATE	R2	DATE	R3	DATE	R4	DATE	R5	DATE	R6	DATE	R7
1977														
76	6/30	342.8	6/29-30	457.7	6/28-30	457.7	6/27-30	457.7	6/26-30	457.7	6/25-30	457.7	6/24-30	476.7
75	10/20	128.5	10/19-20	168.9	10/19-21	181.4	10/19-22	206.6	10/18-22	208.9	10/17-22	213.2	10/16-22	213.2
74	8/6	442.2	8/15-16	602.7	8/15-17	750.5	8/14-17	845.2	8/13-17	857.1	8/13-18	861.4	8/13-19	879.4
73	10/15	130.1	10/15-16	195.0	10/14-16	232.3	10/13-16	232.3	10/12-16	232.3	10/11-16	260.2	10/10-16	260.2
72	7/28	247.3	7/27-28	400.8	7/27-29	473.1	7/27-30	579.5	7/27-31	654.2	7/27-8/1	833.0	7/27-8/2	1000.1
71	6/16	80.5	6/15-16	146.8	6/15-17	146.8	6/15-18	150.9	6/15-19	151.4	6/15-20	161.8	6/15-21	161.8
70	9/1	266.2	9/1-2	296.4	9/1-3	342.6	9/1-4	388.8	8/31-9/4	401.5	8/31-9/5	404.3	8/30-9/5	405.3
69														
68														
67														

TABLE I-17-3 ANNUAL MAXIMUM DAILY RAINFALL

NO. ④ BACOLOR

	1 - DAY		2 - DAY		3 - DAY		4 - DAY		5 - DAY		6 - DAY		7 - DAY	
	DATE	R1	DATE	R2	DATE	R3	DATE	R4	DATE	R5	DATE	R6	DATE	R7
1977														
76	6/30	352.0	6/29-30	568.4	6/28-30	611.6	6/27-30	618.2	6/26-30	633.7	6/25-30	760.4	6/24-30	781.4
75	10/20	145.5	10/19-20	193.2	10/19-21	202.9	10/19-22	207.2	10/19-21	209.0	10/18-21	210.3	10/17-21	212.3
74	8/16	505.5	8/15-16	654.6	8/15-17	842.5	8/14-17	929.1	8/14-18	946.4	8/14-19	968.5	8/14-20	984.2
73	8/23	86.3	8/22-23	107.2	8/21-23	119.6	8/20-23	126.2	8/19-23	146.9	7/18-23	146.9	7/18-24	149.2
72	7/18	259.1	7/17-18	489.1	7/17-19	690.7	7/17-20	855.0	7/17-21	872.5	7/17-22	899.2	7/17-23	944.2
71	6/14	83.8	6/14-15	149.1	6/13-15	149.1	6/12-15	168.9	6/11-15	168.9	6/10-15	171.4	6/9-15	171.4
70	9/1	312.4	8/31-9/1	571.9	8/30-9/1	617.6	8/30-9/2	623.1	8/30-9/3	696.7	8/30-9/4	744.7	8/30-9/5	747.7
69	7/30	93.2	7/29-30	146.2	7/28-30	172.9	7/27-30	233.9	7/26-30	266.9	7/25-30	273.0	7/24-30	276.8
68														
67														
66														

NO. ⑨ MASANTOL

	1 - DAY		2 - DAY		3 - DAY		4 - DAY		5 - DAY		6 - DAY		7 - DAY	
	DATE	R1	DATE	R2	DATE	R3	DATE	R4	DATE	R5	DATE	R6	DATE	R7
1977														
76	5/23	167.0	5/22-23	261.8	5/22-24	346.2	5/22-25	371.6	5/22-26	481.2	5/22-27	548.7	5/21-27	567.2
75	8/9	154.7	8/8-9	174.5	8/7-9	188.7	8/6-9	253.7	8/6-10	264.1	8/5-10	269.7	8/4-10	269.7
74	8/16	184.4	8/6-17	358.3	8/15-17	485.8	8/14-17	548.3	8/13-17	561.8	8/12-17	578.6	8/11-17	599.2
73	10/15	130.6	10/15-16	172.8	10/14-16	172.8	8/13-16	172.8	8/12-16	172.8	8/11-16	234.0	8/10-16	234.0
72	8/3	239.0	8/2-3	417.1	8/1-3	625.1	7/31-3	771.5	7/30-3	838.8	7/29-3	894.7	7/29-4	985.9
71	6/15	94.0	8/15-16	140.5	8/14-16	140.5	8/13-16	140.5	8/12-16	183.9	8/11-16	183.9	8/10-16	183.9
70	9/1	374.7	8/31-1	474.0	8/30-1	538.0	8/30-2	565.9	8/30-3	661.4	8/30-4	724.4	8/29-4	749.5
69	7/27	154.7	7/26-27	175.0	7/26-28	187.2	7/25-28	199.1	7/25-29	199.1	7/25-30	291.0	7/25-31	291.0
68														
67														

TABLE I-17-4 ANNUAL MAXIMUM DAILY RAINFALL

NO (22) CLARK FIELD (INCH)

	1 - DAY		2 - DAY		3 - DAY		4 - DAY		5 - DAY		6 - DAY		7 - DAY	
	DATE	R_1	DATE	R_2	DATE	R_3	DATE	R_4	DATE	R_5	DATE	R_6	DATE	R_7
1977														
76														
75														
74														
73														
72	7/19	11.48	7/18-19	21.46	7/18-20	28.89	7/18-21	32.42	7/17-21	35.93	7/16-21	36.26	7/27-8/2	37.28
71	10/12	4.46	10/11-12	6.27	7/8-12	7.35	7/9-12	7.50	10/9-13	7.87	10/7-12	8.00	10/6-12	10.22
70	9/1	8.74	8/31-9/1	12.14	8/31-9/2	14.03	8/31-9/3	17.12	8/31-9/4	20.13	8/31-9/5	20.67	8/30-9/5	20.79
69	8/6	4.24	8/5-6	4.67	8/4-6	5.32	8/3-6	8.83	8/3-7	8.90	8/3-8	11.96	8/2-8	12.57
68	8/28	12.77	8/28-29	17.34	8/28-30	19.35	8/27-30	19.66	8/25-30	21.19	8/26-31	22.45	8/28-9/1	22.70
67	7/29	5.68	7/29-30	8.90	7/29-31	9.94	6/1-4	8.51	6/4-8	10.19	6/3-8	12.83	6/2-8	14.10
66	5/19	11.02	5/19-20	16.52	5/18-20	18.5	5/18-21	19.19	5/18-22	21.00	5/18-23	21.62	5/18-24	21.98
65	7/14	4.54	7/13-14	6.74	7/12-14	8.18	7/12-15	18.18	7/12-16	8.26	7/12-17	9.19	7/12-18	9.19
64	12/15	3.79	12/14-15	4.48	8/21-23	4.89	8/21-24	4.93	8/21-25	6.62	8/20-25	6.88	8/19-25	7.36
63	6/28	6.29	6/27-28	8.90	6/27-29	8.50	6/27-30	9.17	6/27-7/1	9.17	6/27-7/2	10.21	6/27-7/3	12.86
62	7/20	5.03	7/19-20	9.88	7/19-21	12.83	3/19-22	13.91	7/19-23	10.041	7/19-24	19.26	7/18-24	19.96
61														
60	6/27	8.06	8/13-14	11.11	10/13-15	14.04	10/13-16	18.05	10/12-16	18.83	8/11-16	19.26	8/10-16	21.71
59	8/12	2.42	8/12-13	3.45	8/29-31	3.45	8/12-15	5.14	8/12-16	5.78	8/12-17	5.81	8/12-18	6.18
58	7/13	5.02	7/13-14	48.36	3/13-15	9.60	7/13-16	11.10	7/13-17	11.21	7/13-18	11.66	7/13-19	12.79
57	6/11	3.03	7/15-16	4.31	8/15-17	5.27	8/15-18	6.23	7/12-16	6.51	7/11-16	6.54	7/10-16	6.54
56	9/21	3.46	9/21-22	4.75	9/8-10	6.71	9/7-10	8.06	9/7-11	8.12	9/7-12	8.17	9/7-13	8.56

1 INCH = 2.54 cm

4-8 Tide Record

The tide level is recorded at the southern part of Manila located at lat. 14°34'30"N and long .120°57'40"E. Hourly observation by the self-register tide level has been conducted since 1976. In the Bureau of Geodetic and Survey, the results of monthly extreme (highest and lowest) tide record are summarized in TABLE I-18. The highest tide level records of each year are given in the following table.

TABLE I-18 Highest Tide Record

Year	Date		Tide Height	Year	Date		Tide Height
	Month	Day	(Feet)		Month	Day	(Feet)
1950	Aug.	13	10.9	1965	July	14	10.9
51	Aug.	16	11.1	66	Aug.	15	11.0
52	June	11	10.9	67	July	9	11.0
53	June	28	11.0	68	July	25	11.3
54	July	1	10.5	69	June	30	11.0
55	June	22	10.5	1970	Aug.	17	11.4
56	June	10	10.5	71	Oct.	11	11.4
57	June	29	10.2	72	July	12	12.0
58	July	17	10.1	73	July	1	11.3
59	Aug.	5	10.1	74	July	20	12.0
1960	Aug.	7	11.0	75	July	9	10.4
61	July	29	10.6				
62	Aug.	1	10.9				
63	July	21	10.6				
64	Aug.	7	11.7				

The table above shows that the highest tide level during 26 years from 1950 to 1975 is 12.0 feet (3.66 m) recorded on July 12 in 1972. According to the research of BPW, the flood trace survey (in August of 1960) near the estuary of the Pasig-Potrero River concluded that the highest water level is 13.632 m (3.16 m MSL). Authough the height of 13.672 (3.29 m MSL) is employed to the river improvement plan, as far as the tide level is concerned, the tide level in June of 1972 is higher by one foot than that in the flood period in August of 1960. As causes for ponding in the down-stream during a flood, the influence of backwater due to the tide level, the rainfall amount and the condition of drainage are considered. During a flood, however, the rainfall amount seems to be the main cause for the flood together with bad drainage condition in the down-stream.

The highest tide levels in 1960, 1966, 1970 and 1974 when floods occured are so high, compared with those in other years with a difference in height confined within ± one foot.

Hydrological factors in 1966 and 1972 are compared as follows.

Flood	① Monthly Rainfall	② Catchment Basin (km^2)	(1) x (2)	Inundation Area	Inundated Water Depth
1966 Aug.	1,038.1mm	125Km^2	129.75 x $10^6 m^3$	(20)Km^2	0.22m ≑ 25cm
1972 July	2,274.5mm	125Km^2	284.31 x $10^6 m^3$	20 Km^2	0.47m ≑ 50cm

The ponding area can be assued to be approximately 20 km^2, which is the same area in 1966. Judging from the values in the table, values of ponding depth are 25 cm in 1966 and 50 cm in 1972 approximately, assuming that water spread in the ponding area equally, which coincide with the information obtained at the site.

On the other hand, since net-work water channels are developed due to the influence of back water, back water calculation used for ordinary water channels is not applicable in this case. Therefore, following the determination based on the exsisting maximum flood trace survey, Ho = 3.50 m is adopted as a starting water level to the Pasig-Potrero River adjusting the starting water level of Ho = 3.20 m which is determined by BPN from the flood trace survey in August of 1966 with Ho = 30 cm.

This starting water level should be reviewed when the river improvement plan for the down-stream of Gua-Gua River is established.

III-5 Runoff Investigation

As mentioned before, the design high-water discharge in the Pasig-Potrero River has been determined at Qp = 900 m^3/S in 1964 by BPW. On the other hand, according to the relation* between discharge frequency and drainage area for Central Luzon (FIGURE) studied by BPW, discharge frequency "T" (year) at the base point of the Marcatian Bridge (A = 44 km^2) is estimated at so much as 1,000 years approximately. A study on this value is carried out as follows with various data.

5-1 Review of BPW Formula

According to the runoff data of the Philippine stream from "Note on Intense Rainfall and Runoff in Central Luzon" by Villanveva and Delena, Philippine Engineering Record in December of 1939, the

TABLE 1-19 MONTHLY EXTREMES TIDE RECORD — HIGHEST TIDE —

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOU	DEC	REMARKS
1946	/	/	/	/	/	/	/	/	6, 11 9.9	14 9.6	/	/	
47	/	/	6 9.7	25 9.7	24, 25 10.1	20 11.1	18, 19 10.9	14 10.6	12 10.1	6 10.6	15 10.8	28 10.5	
48	25 10.3	23, 24 9.7	22 9.2	28 9.5	13 9.9	11, 12 10.3	8, 9 10.5	3, 31 10.4	1 11.1	22, 23 9.6	20 9.9	19 9.9	
49	15 10.1	12 9.9	13 9.4	16, 18 9.3	15 9.9	2, 29 10.1	/	/	/	/	/	/	
1950	/	/	/	/	/	/	27 10.9	3, 4 10.9	20 10.2	2 10.2	13 10.3	10 10.3	
51	8 10.2	5, 6 9.9	29, 30 9.4	26 9.8	24 10.1	20, 20 10.4	19 10.7	6, 7 11.1*	1 10.1	7, 8 9.6	30 10.1	1 10.3	
52	26, 27 9.9	23, 24 9.6	19, 22 9.2	14, 29 9.5	13 10.2	11 10.9*	9 10.8	5 10.9*	3 10.4	23 9.9	19, 21 10.0	18, 19 10.2	
53	15, 16 10.1	12, 13 9.9	13 9.6	18 9.8	15 10.3	28, 29 11.0*	11 10.3	12 10.5	1 10.3	25, 26 10.0	22 10.1	20, 21 10.0	
54	5, 6 10.0	3 9.8	3 9.5	8 9.6	5 10.2	2, 4 10.3	1 10.5*	14, 24 10.4	11, 19 10.1	12, 18 10.2	1, 2 10.3	10 10.5*	
55	8, 9 10.0	4, 5, 6 9.8	4, 30 9.3	26 9.7	23 10.4	22 10.5*	19 10.5*	16, 17 10.2	1, 2 9.8	6, 7 10.1	3 10.3	29 10.4	
56	27 9.8	24 9.6	20 9.2	16 9.8	13 10.1	10 10.5*	7, 9 10.5*	6 10.4	3 10.5*	25 9.9	20 10.1	18 10.1	
57	16, 17 9.8	14 9.4	3, 4 9.0	19 9.2	30, 31 9.8	24 10.2*	1 10.1	25 10.1	21 9.8	14 9.5	12 9.9	9, 22 9.3	
58	6, 7 9.2	4 9.2	1, 5 8.7	8 9.1	6 9.5	3 9.9	17 10.1*	15 9.6	10, 13 9.7	15, 17 9.4	13 9.8	11 9.6	
59	9 9.4	6, 23 9.0	30 8.8	26 9.5	24, 25 9.6	2, 22 10.0	20 10.0	5, 18 10.1*	25 9.7	9 9.7	4 9.8	31 10.0	
1960	29 9.6	11, 25 9.1	20, 25 8.8	16, 17 9.3	28 10.0	11, 12 10.5	9, 10 10.3	7 11.0*	10.0	25 9.5	22 9.9	18 10.1	
61	16, 17 9.4	15 9.4	15 8.8	19 9.1	4, 17 9.6	30 10.6*	29 10.6*	25 10.6*	22 9.8	3 9.3	14, 24 9.5	10, 11 9.8	
62	7 9.9	4, 6 9.3	5, 6 9.1	25, 26 9.3	22 9.6	20, 21 10.0	20 10.8	1 10.9*	13 10.0	18, 19 9.5	15 10.0	12, 29 9.8	
63	10, 11 9.6	8 9.3	23 9.2	28 9.4	26 10.0	22, 23 10.3	21 10.6*	5, 18 9.9	5 10.2	9 9.4	4, 6 9.4	3 9.9	
64	1 9.8	25 9.2	21 3.9	18 9.5	15 10.1	12 10.3	10, 11 10.5	7 11.7*	4 10.3	24 10.1	22, 24 10.2	20, 21 10.3	
65	18 10.0	15 9.8	14, 15 9.4	21 9.3	31 10.0	30 10.6	14, 28 10.9*	27 10.2	21 10.2	18 9.4	11, 12 10.2	11 10.2	
66	3, 9 10.2	5 10.0	6, 7 9.7	25, 26 9.6	25, 26 10.1	21 10.4	19 10.7	15 11.0*	13 10.9	19 9.8	29 10.3	13 10.5	
67	26 10.1	24 10.0	21 9.4	28 10.1	26 10.6	23 10.7	9 11.0*	19 11.0*	3 10.8	9, 10 10.1	4 10.7	3, 4 10.2	
68	2 10.1	14 9.7	22 9.6	18 9.9	15 10.3	2, 3 10.8	25, 26 11.3*	8, 9 10.9	5 11.1	25 10.3	23 10.4	21 10.6	
69	18 10.4	15 10.2	1, 2 9.6	9 9.9	6 10.6	30 11.0*	/	1 10.9	10 10.7	2 10.4	13 10.8	10 10.8	
1970	9 10.6	6 10.5	5 10.0	25, 26 10.2	24, 25 10.8	20 11.1	20 11.1	7 11.4*	11 11.2*	18 10.7	15 11.0	15 10.8	
71	27 10.7	24 10.5	31 10.1	28 10.6	26, 27 10.7	24, 25 10.8	20 11.3	7 11.1	5 10.6	11 11.4*	6 10.8	3 11.0	
72	1 11.0	15 10.3	21 10.0	18 10.7	15 11.1	13, 25 11.1	12 12.0*	7, 8 11.3	4, 5 10.5	27 10.4	23 10.7	21 10.7	
73	19 10.6	15, 16 9.9	13 9.9	7 10.1	6 10.7	30 11.2	1 11.3	25, 27 11.0	20, 22 10.5	15 11.6*	13 11.1	12 11.3*	
74	9 11.0	5, 6 10.6	6 10.4	26, 27 10.5	24 11.1	21 11.4	20 12.0*	17 11.8	12, 13 10.5	16 11.0	7 11.3	30 10.4	
75	27 10.12	26 9.39	25 9.45	28 9.91	27 10.0	13 10.49	9, 10 10.36	7 10.55*	5 10.55*	10, 11 9.95	4 10.06	4 10.77	

LEFT SIDE; DATE, RIGHT SIDE; HIGHEST TIDE OBSEVVED / : NO RECORD

*; YEARLY EXTREAM UNIT; FEET

TABLE I-20 MONTHLY EXTREMES TIDE RECORD — LOWEST TIDE—

	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC	REMARKS
1946	/	/	/	/	/	/	/	/	21 5.1	17 5.2	/	/	
47	/	/	4/5 4.7	26 4.8	24/25 4.5	21 4.7	18 4.8	15 4.9	12 5.2	23 5.5	30 4.8	30/31 4.0	
48	26/27 4.2	23/24 4.4	21/22 4.7	18/19 4.9	25 4.7	9 4.5	8 4.4	4/5 4.4	29 5.1	25 5.0	19/22 4.8	18/19 4.1	
49	16 4.1	13 4.5	2/3 4.6	17 4.6	15 4.5	12 4.4	/	/	/	/	/		
1950	/	/	/	/	/	/	1 4.5	25 5.1	22 5.4	17 5.0	12/13 4.4	1/2 3.9	
51	7 3.8 *	5/6 4.1	5 4.3	25 4.4	23 4.1	21 4.0	18 4.3	15 5.3	12 4.9	8/9 5.1	30 4.3	29/30 3.9	
52	26 3.8 *	23 4.3	22 4.7	16 4.8	12 4.5	10 4.8	7/8 4.6	4 4.9	28/29 5.2	26 5.1	20/21 4.8	30 4.4	
53	15/16 4.0 *	13 4.6	12 4.9	16/17 5.2	15/31 5.0	12/13 5.0	25 4.7	22/23 5.3	4/5 5.6	25/26 5.0	22 4.5	21 4.6	
54	3/18 4.6	2 4.8	2/3 5.1	2/3 5.1	3 4.5	3 4.5	1 4.9	12/13 5.5	10 5.7	15 5.3	14 4.7	11 4.4 *	
55	8 4.1 *	5/6 4.9	28/29 5.0	25/26 4.7	24 4.8	20/21 4.6	18/20 5.0	16 5.2	11/12 5.6	20 5.7	5/30 5.0	30 4.4	
56	26/27 4.5 *	24 5.0	23 5.1	14 5.3	12/14 4.9	10/11 4.7	8 4.8	4 5.2	29 5.0	23 5.5	20 4.9	19 4.5 *	
57	16 4.4 *	13 4.6	13 5.2	17 5.0	3 4.8	28 5.0	26/27 5.0	7 5.5	3 5.6	26/27 5.0	24 4.4 *	22 4.5	
58	6/7 4.3 *	3/4 4.6	5 5.0	7 5.0	5/6 4.7	3 4.8	1/2 4.9	1 5.3	20/22 5.9	16/17 5.3	15 4.8	12 4.4	
59	9 4.4 *	6 4.6	3/30 5.1	26 4.9	24/25 4.6	22 4.9	20 4.9	17 5.7	12/13 5.8	8/9 5.6	3 5.0	30/31 4.5	
1960	27/28 4.5 *	25 5.0	22/24 5.4	15/16 5.3	13/14 5.0	10/11 5.0	9 4.9	6 5.9	4 5.5	28 5.5	22 4.8	20/21 4.7	
61	19 4.1 *	14/15 4.5	14/15 5.0	11 5.2	3/31 5.1	1 4.8	27 5.2	25/26 5.8	20 5.6	18 5.3	25/26 5.0	7 4.7	
62	8/9 4.6	6 4.2 *	3 4.6	1 5.2	24 5.1	4/20 5.1	2 5.2	14 5.3	11 5.5	9/10 5.4	7 5.2	29 4.7	
63	26/27 4.2	7/8 4.7	7/8 5.1	27/28 4.9	26 4.7	23 4.8	21 5.1	18 5.0	30 5.5	9/11 5.5	4/5 4.7	31 4.1 *	
64	1 4.1 *	4.6	12/26 4.8	16/17 4.9	15 4.8	1/2 4.1	10 4.7	3/5 5.5	3/4 5.4	25 5.4	5.3	21 4.5	
65	17/18 4.3 *	16 4.5	16 4.8	5.0	5 4.7	30 4.6	1 4.8	25/26 4.9	22 5.3	17 5.1	26/27 5.1	10/11 4.5	
66	9 4.1 *	5/6 4.4	4/5 4.8	28/29 5.1	8 4.9	21 4.8	19 4.8	16 3.3	10/11 3.8	20 3.2	10 5.1	29/30 4.7	
67	26/27 4.4	7 4.6	23/24 5.0	27 4.8	23 5.0	20/21 5.4	6 5.3	29/30 5.8	29 5.6	5 4.9	31 4.9	31 4.2 *	
68	23/24 4.2	25/26 4.6	12 5.0	17 4.6	13/14 4.5	12 4.5	10 4.8	7 5.1	3 5.7	23/24 5.2	22 4.6	21 4.0 *	
69	18/19 4.2 *	15 4.6	14/15 4.9	10 5.0	4/5 4.8	2 4.7	/	26 5.2	22 5.5	16/17 5.6	13/14 5.2	11/12 4.7	
1970	8 4.3 *	3/4 4.6	5/6 5.1	22/23 5.4	22/23 5.2	21 5.2	19 5.2	14/15 5.7	14/15 5.9	18/19 6.2	30 5.3	30/31 5.0	
71	10/11 5.1	8 5.3	6/7 5.7	27/28 5.4	25/26 5.2	11 5.2	9 5.3	17 5.8	3 5.8	27 6.0	5/6 5.5	4 5.2	
72	17 5.1	13 5.6	12 5.9	17 5.6	14 5.3	10 5.1	9 5.9	7 6.2	4/5 6.0	26/27 5.4	23/24 4.3 *	21 4.7	
73	18/19 5.0 *	15 5.1	2/3 5.7	6/7 5.4	5 5.0	2 5.1	2 5.4	26/27 6.3	21/22 6.4	19/20 6.4	16 5.7	12 5.2	
74	9 5.1 *	5 5.2	5 5.8	25 5.7	24 5.7	21 5.7	18/19 5.7	9 6.1	13 6.2	7 6.4	16/17 5.9	30/31 5.5	
75	25/26 5.12	23 5.18	9 5.47	28 5.68	26 5.48	23 5.49	6 5.85	8 5.55	2 4.10 *	19/20 6.04	3/2 5.50	2/3 5.43	

LEFT SIDE ; DATE, RIGHT SIDE : HIGHEST TIDE OBSERVED / ; NO RECORD * YEARLY EXTREAM UNIT : FEET

TABLE I-21 OBSERVATION RECORD OF MAIN FLOODS

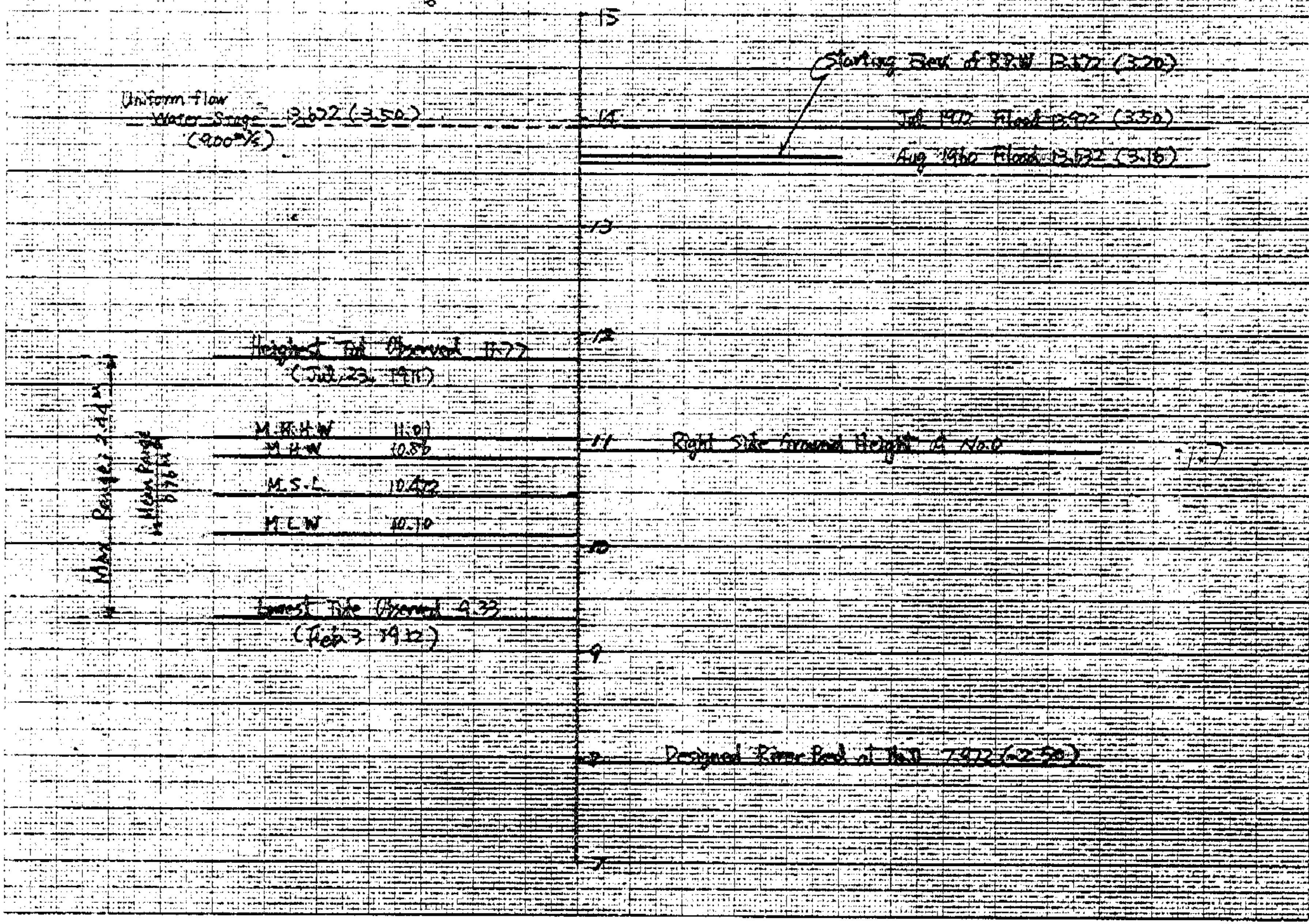
Flood	Flood Mark*			Tide Record (feet)	Water Stage Record			Rainfall at Porac		
	Bacolor (m)	Calumpit (m)	Apalit (m)		Cabetican Bacolor (m)	Calumpit (m)	Apalit (m)	Daily Max. (mm)	Flood Total (mm)	Monthly Total (mm)
1960. Aug	3.20**	4.94	5.91	11.0		Aug15. 5.20	Aug15, 5.11	Aug14, 175.5 (Clark)	Jul26~Aug18, 922.0	Jun. 169.2 Aug 1038.1 (Clark)
1966 May	3.15	3.97	4.20	10.1	May20. 2.14		May24, 4.22	May19, 280.0 (Clark)	May14~May28 753.4	May 813.8 (Clark)
1970 Sep.				11.2	Sep.2 1.86		Sep.5, 4.31	Sep.1 157.7	Aug23~Sep3, 417.6	Aug. 273.4 Sep. 257.7
1972 Jul	3.50***	5.33	6.33	12.0	Jul21, Aug1, 2.11		Aug 1, 5.86	Jul18, 269.4	Jul2~Aug7 2784.0	Jul. 2278.5 Aug. 916.6
1974 Aug.				12.0	Aug 17 2.22		Aug 19, 5.40	Aug 10, 154.6	Aug6~Aug30 671.7	Aug. 665.6
1976 May.					May 24 1.84		May27, 5.52	May 23, 246.9	May17~May29 818.5	May 869.2

* Quoted from 「Flood Plain of the Pampanga River Basins」 by. B.P.W (c.f Reference Material)

** 3.20 is the initial water stage of B.P.W Design in 1964.

*** Right bank side ground height is about 3.0m and inundation depth is about 0.5m by reconnaisance survey.

Fig. I-21 INITIAL WATER STAGE



following equations are proposed as shown in FIGURE I-23.

Eq. (1) $Q = 235 \cdot A/\sqrt{A+32}$ .... Extreme

Eq. (2) $Q = 185 \cdot A/\sqrt{A+13}$ .... Rare

Eq. (3) $Q = 85 \cdot A/\sqrt{A+11}$ .... Occasional

Eq. (4) $Q = 50 \cdot A/\sqrt{A+9}$ .... Frequent

The design high-water discharge of 900 m^3/S is established from Eq. (2), assuming a drainage area of 44 km^2 at the Mancatian Bridge.

The relation with specific discharge converted from Eq. (4) is presented in Fig.

Calculated Runoff Discharge ——— CASE A ———

	Mancatian	No.1	No.2	No.3	No.4	No.5
A (km^2)	44	23.3	16.8	14.3	9.2	4.3
Q (m^3/s)	900	600	480	430	300	160

5-2 Based on Discharge Record

Discharge records serving as a base of "Regional Discharge Frequency-Discharge Area Relationship" (FIGURE I-22) are applicable only to a river basin with a drainage area of 100 km^2 or above. The specific discharge ($q = Q/A$) will increase reasonably in case of a smaller basin. Therefore, the relation between specific discharge and drainage area (A) based on the discharge records at obtained as shown in FIGURE . The discharge-frequency and discharge distribution thus obtained at the Mancatian Bridge as given in Fig.

Calculated Runoff Discharge ——— CASE B ———

	Mancatian	No.1	No.2	No.3	No.4	No.5
A (km^2)	44	23.3	16.8	14.3	9.2	4.3
Q (m^3/s)	900	620	500	420	320	190

* "Regional Discharge Frequency-Drainage Area Relationship for central Luzon Basin" BPW Manila June 1964

5-3 Based on Rainfall Record

i) From Daily Rainfall Record

By the rainfall intensity equation (Dr. N. Monorobe's equation) in an arbitrary duration period in case that only daily rainfall is given, the discharge is obtained as follows.

$$t = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5.1)$$

where; t: Mean rainfall intensity in a period of "t"(mm/hr)

t: Time of flood concentration (hr)

R_{24}: Rainfall in 24 hours (mm)

As to the Time of flood concentration, Ruchiha's Equation often used in Bayern district in Germany is utilized as follows.

$$t = L/W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 5.2$$

$$W_1 = 72(H/L)^{0.6}[km/hr] \quad \ldots\ldots\ldots\ldots \quad 5.3$$

$$W_2 = 20(h/l)^{0.6}[m/sec] \quad \ldots\ldots\ldots\ldots \quad 5.4$$

where; W_1, W_2: Time of flood concentration

L, l : Horizontal length from the estuary to the up-stream end

The results of the calculation are given in FIGURE I-31 .

Calculated Runoff Discharge ——— CASE C ———

	Mancatian	No.1	No.2	No.3	No.4	No.5
A (km^2)	44	23.3	16.8	14.3	9.2	4.3
Q (m^3/s)	850	640	620	580	510	260

Judging from the above results, it is possible to estimate rainfall in a short period in Mancatian, No.1 Dam, No.2 Dam and No.3 Dam. However, rainfall in a short period in No.4 Dam and No.5 Dam which have a great discharge considering their small areas can be hardly estimated.

ii) From Hourly Rainfall intensity curves can be drawn from hourly rainfall records at Porac as shown in FIGURE I-33. Comparative study with rainfall intensity (refer to Extreme Value of Rainfall of Various Duration for Manila) is summarized in the following table.

		10 min	30 min	1 hr	3 hr	12 hr
1/T = 1/5	(1) Manila	168.7	111.9	74.1	35.9	14.9
	(2) Porac	125.0	90.0	68.0	39.0	15.0
	= (1)/(2)	1.34	1.24	1.1	0.92	9.99
1/T = 1/10	(1) Manila	194.6	129.3	84.3	41.8	17.8
	(2) Porac	148.0	105.0	80.0	48.0	19.0
	= (1)/(2)	1.31	1.23	1.1	0.88	0.94
1/T = 1/20	(1) Manila	219.3	146.0	94.0	47.4	20.6
	(2) Porac	171.0	121.0	94.0	58.0	23.0
	= (1)/(2)	1.28	1.21	1.0	0.81	0.90
1/T = 1/50	(1) Manila	251.4	167.7	106.7	54.6	24.1
	(2) Porac	196.0	141.0	110.0	69.0	28.0
	= (1)/(2)	1.28	1.18	0.96	0.79	0.87
1/T = 1/100	(1) Manila	275.4	183.9	116.2	60.0	26.8
	(2) Porac	218.4	158.6	124.0	78.0	35.0
	= (1)/(2)	1.26	1.16	0.94	0.79	0.75

As shown in the Talbe, rainfall intensity at Manila especially in a short period of less than one hour can be said to surpass that at Porac by 20% or 30%. This phenomenon is attributed to measurement method, rainfall pattern and topographic feature. It is naturally contemplated, however, that rainfall intensity at Porac located near the hilly area should surpass that at Manila.

The relation between elevation and rainfall is studied as shown in FIGURE I-34. Assuming an average elevation of 800 m in the Project Area, rainfall intensity in season all rainfall will increase by 50%, therefore, the rainfall intensity in the hilly area is estimated, though approximate, by multipling rainfall intensity at Porac by 1.5. The results thus obtained are given in FIGURE .

Calculated Runoff Discharge ——— CASE D ———

	Mancatian	No.1	No.2	No.3	No.4	No.5
A (km^2)	44	23.3	16.8	14.3	9.2	4.3
Q (m^3/s)	900	630	540	480	380	190

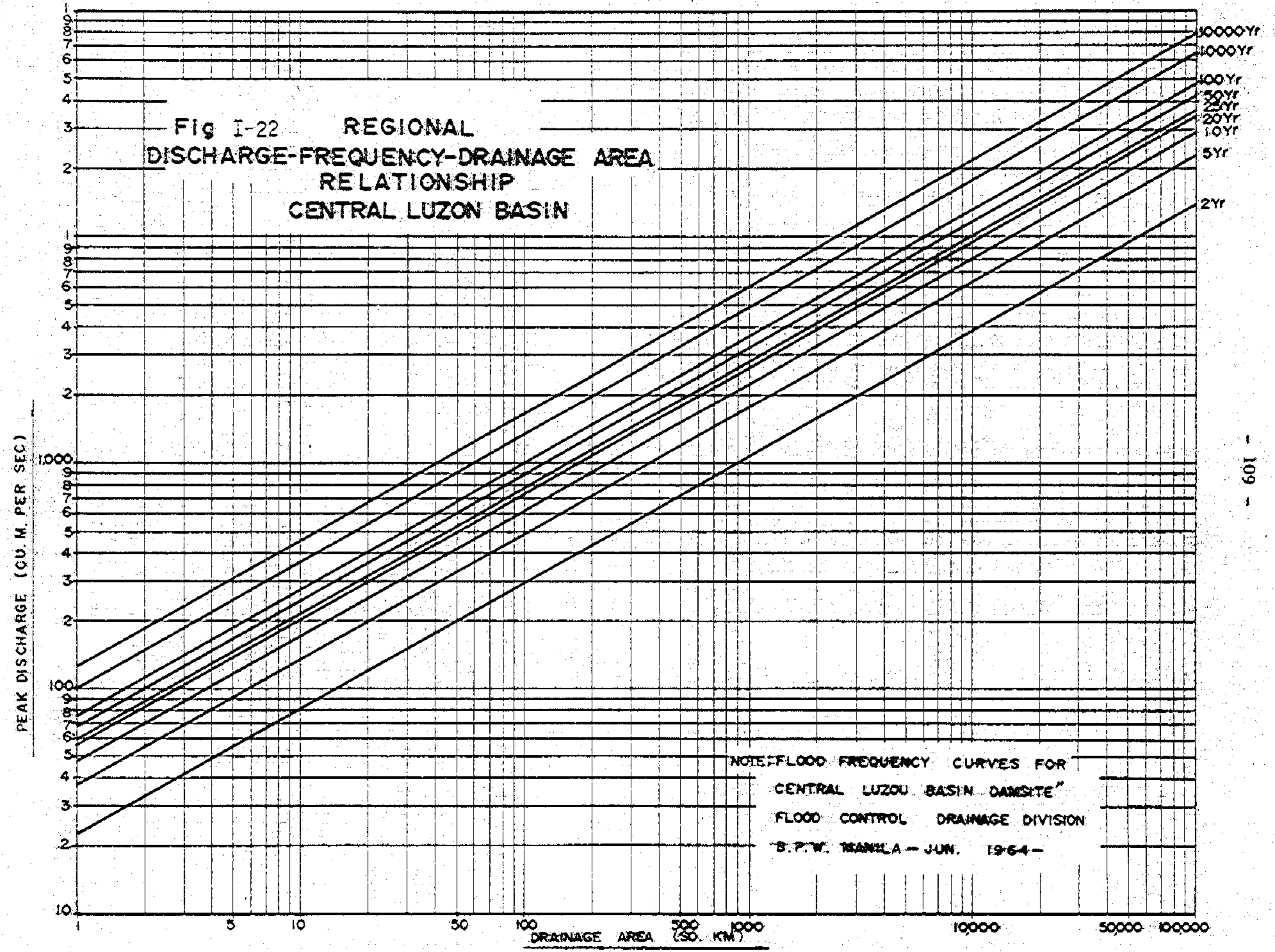


Fig I-22 REGIONAL
DISCHARGE-FREQUENCY-DRAINAGE AREA
RELATIONSHIP
CENTRAL LUZON BASIN
10000Yr
1000Yr
100Yr
50Yr
25Yr
20Yr
10Yr
5Yr
2Yr
PEAK DISCHARGE (CU. M. PER SEC)
DRAINAGE AREA (SQ. KM)
NOTE: FLOOD FREQUENCY CURVES FOR
CENTRAL LUZOU BASIN DAMSITE"
FLOOD CONTROL DRAINAGE DIVISION
B.P.W. MANILA — JUN. 1964 —

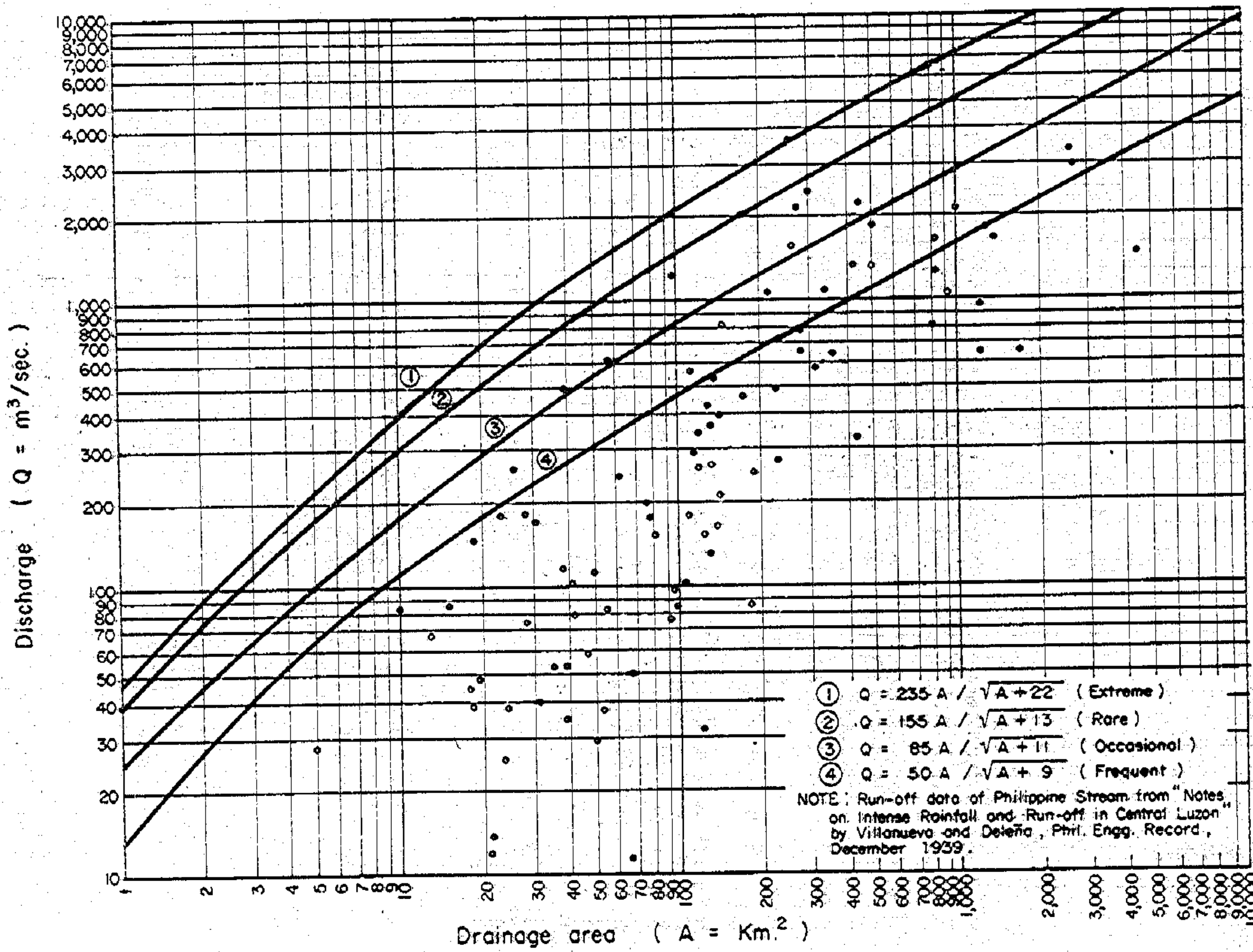


Figure I - 23 RELATION BETWEEN DRAINAGE AREA AND DISCHARGE IN THE PHILIPPINES

Table I-22-1 MAXIMUM DISCHARGE RECORD IN MAIN REIVERS (1)

	RIVER BASIN	NAME OF RIVER	STATION	DRAINAGE AREA A (km²)	MAX. DISCHARGE Q_{max} (m³/s)	DATE OF OCCURRENCE	OBSERVATION PERIOD	$q = \frac{Q_{max}}{A}$	TYPE OF CLIMATE	REMARKS
1	LAOAG	BONGA	BANGAY	534	4392	10/6, 1947	1946~1965	8.22	I	
2	〃	LAOAG	POBLACION	1355	11345	8/30, 1962	1958~1965	8.37	〃	
3	ABRA	TINEG	PANG-OT	664	1860	9/4, 1964	1957~1965	2.80	〃	
4	〃	ABRA	BANAOANG	4813	10740	8/31, 1962	1958~1965	2.23	〃	
5	〃	〃	BUMAGCAT	2575	4493	9/9, 1964	1958~1965	1.74	〃	
6	〃	SINALANG	LINGSAD	120	951	7/21, 1962	1958~1965	7.93	〃	
7	AGNO	AGNO	ADAOAY	246	577	4/7, 1964	1959~1965	2.34	〃	
8	〃	〃	SAN ROQUE	1225	3638	10/6, 1947	1945~1965	2.97	〃	
9	〃	AMBAYAO	STA MARIA	281	951	8/7, 1964	1958~1965	3.38	〃	
10	〃	AGNO	CARMEN	2209	4330	7/6, 1946	1945~1965	1.96	〃	
11	〃	〃	POBLACION	2284	910	7/23, 1962	1945~1965	0.40	〃	
12	〃	O'DONNELL	PATLING	112	210	8/15, 1960	1958~1965	1.88	〃	
13	〃	〃	PALOBLUB	240	243	9/30, 1964	1964~1965	1.01	〃	
14	〃	BUISA	VILLA AGLIPAY	405	2259	7/24, 1962	1960~1965	5.58	〃	
15	〃	TARLAC	TIBAG	872	1890	6/26, 1961	1917~1965	2.17	〃	
16	〃	CAMILING	NAMBALAN	142	644	11/15, 1964	1964~1965	4.54	〃	
17	〃	〃	POBLACION	280	1280	11/16, 1964	1954~1965	4.57	〃	
18	〃	PILA	PACALAT	126	607	9/20, 1964	1957~1965	4.82	〃	
19	〃	AGNO	DORONGAN	5134	2558	9/13, 1963	1958~1965	0.50	〃	
20	BALINGAGOING	BALINGAGOING	NIBALIW	145	1302	7/20, 1962	1959~1965	8.98	〃	
21	NAYON	NAYON	QUISQUIS	128	1896	7/14, 1957	1955~1965	14.81	〃	
22	BUCAO	BOCAO	SAN JUAN	615	2525	8/16, 1960	1955~1965	4.10	〃	
23	STO TOMAS	STO TOMAS	DACAWAUAN	177	855	7/25, 1962	1947~1965	4.83	〃	
24	GUAGUA	GUMAIN	PABANGLAG	128	375	9/30, 1964	1946~1965	2.93	〃	
25	〃	GUMAIN FLOODWAY	STA CRUZ	370	860	7/24, 1962	1958~1965	2.32	〃	
26	〃	PORAC	DEL CARMEN	111	508	9/11, 1946	1910~1965	4.58	〃	
27	〃	〃	VALDEZ	118	333	4/20, 1960	1958~1965	2.82	〃	
28	PAMPANGA	CARRANGLAN	BOIDARTE	259	1210	11/18, 1959	1958~1965	4.67	〃	
29	〃	PANTABANGAN	POBLACION	253	1163	7/13, 1965	1958~1965	4.60	〃	

Table I-22-2 MAXIMUM DISCHARGE RECORD IN MAIN RIVERS (2)

	RIVER BASIN	NAME OF RIVER	STATION	DRAINAGE AREA A (km²)	MAX DISCHARGE Q_{max} (m³/s)	DATE OF OCCURRENCE	OBSERVATION PERIOD	$q = Q_{max}/A$	TYPE OF CLIMATE	REMARKS
30	PAMPANGA	PAMPANGA	MALUAN	838	1412	8/14, 1963	1959~1965	1.68	I	
31	〃	SANTOR	SAN VICENTE	544	435	8/15, 1964	1957~1965	0.80	〃	
32	〃	CORONEL	BANG KEROWAN	709	1224	11/15, 1964	1959~1965	1.73	〃	
33	〃	PAMPANGA	MALATE	2015	1866	11/13, 1957	1955~1965	0.93	〃	
34	〃	CABU	CABU	143	271	9/12, 1963	1957~1965	1.90	〃	
35	〃	PAMPANGA	VALDE FUENTE	2441	2524	7/11, 1965	1964~1965	1.03	〃	
36	〃	〃	SAN ANTON	2851	1674	7/22, 1962	1958~1965	0.59	〃	
37	〃	CHICO	ILOG NA MUNTI	149	564	6/30, 1964	1960~1965	3.78	〃	
38	〃	SUMACBAO	PIAS	287	1414	10/23, 1960	1960~1965	4.93	〃	
39	〃	PENARANDA	SAN JOSE	512	1265	10/11, 1946	1911~1965	2.47	〃	
40	〃	〃	POBLACION	523	1304	11/12, 1957	1945~1965	2.47	〃	
41	〃	〃	SAN VICENTE	3467	1107	11/10, 1959	1958~1965	0.32	〃	
42	〃	BALIWAG	CATACANALAN	284	461	11/13, 1957	1956~1965	1.63	〃	
43	〃	BENITUAN	PASONG-INSIK	208	886	8/15, 1961	1957~1965	4.26	〃	
44	〃	TALAVERA	LUMBOY	261	894	8/9, 1964	1956~1965	3.43	〃	
45	〃	〃	KABORULONAN	431	1179	11/6, 1959	1959~1965	2.73	〃	
46	〃	RIO CHICO	STO ROSARIO	1,177	530	8/16, 1960	1960~1965	0.45	〃	
47	〃	PALUA	SAN NICOLAS	198	192	6/27, 1960	1958~1965	1.30	〃	
48	〃	RIO CHICO	BANGA	1246	444	8/9, 1964	1964~1965	0.36	〃	
49	〃	PAMPANGA	SAN AGUSTIN	6487	2372	8/10, 1960	1946~1965	0.37	〃	
50	〃	MADLUM	SIBUL SPRING	102	462	9/23, 1955	1955~1965	4.53	〃	
51	〃	BALAONG	STA INES	204	850	9/2, 1961	1955~1965	4.17	〃	
52	〃	SAN MIGUEL	SAN VICENTE	256	1051	10/13, 1960	1955~1965	4.10	〃	
53	〃	PAMPANGA	PASIG	7468	1329	8/17, 1960	1958~1965	0.18	〃	
54	〃	MAASIM	DILIMAN	150	1399	10/13, 1960	1919~1965	9.33	〃	
55	〃	〃	BAHAY PARE	174	618	7/31, 1962	1956~1965	3.55	〃	
56	〃	ANGAT	NORZAGARAY	629	3128	7/21, 1962	1956~1965	4.97	〃	
57	〃	〃	LUNGOS	959	1702	7/21, 1962	1909~1965	1.77	〃	
58	LAGUNA	BALANAC	BOKAL	116	396	10/ 1960	1958~1965	3.41	〃	
59	LAGUNA LAKE	STA CRUZ	CALUMPANG	103	298	10/28, 1953	1920~1965	2.89	〃	

Table I-22-3 MAXIMUM DISCHARGE RECORD IN MAIN RIVERS (3)

	RIVER BASIN	NAME OF RIVER	STATION	DRAINAGE AREA A (km²)	MAX DISCHARGE Q_{max} (m³/s)	DATE OF OCCURRENCE	OBSERVATION PERIOD	$q = Q_{max}/A$	TYPE OF CLIMATE	REMARKS
60	LAGUNA LAKE	MARIKINA	SAN RAFAEL	282	937	11/2, 1959	1956~1965	3.32	1	
61	"	"	STO. NINO	499	2348	8/14, 1960	1958~1965	4.70	"	
62	MARAGONDON	MARAGONDON	MABALACAO	260	3495	6/30, 1964	1945~1965	13.40	"	
63	PALICO	PALICO	BILARAN	158	1880	9/5, 1962	1956~1965	11.90	"	
64	TAAL LAKE	PANSIPIT	POBRACION	644	63	9/6, 1962	1958~1965	0.10	"	
65	MALAGO	MALAGO	HDA. CABUNGAHAN	129	1801	11/19, 1964	1960~1965	13.96	"	
66	BAGO	BAGO	MA-AO	683	3425	7/3, 1952	1949~1965	5.01	"	
67	BINAL BAGAN	BINALBAGAN	CADRE	350	296	8/8, 1962	1955~1965	0.85	"	
68	ILOG	ILOG	DAHILE	1390	2480	12/21, 1958	1955~1965	1.78	"	
69	"	"	DANDAN	1453	2510	9/21, 1956	1956~1965	1.75	"	
70	"	HILABANGAN	TAGBAG	392	249	1/10, 1965	1965	0.63	"	
71	"	"	PANGSOD	431	1391	11/25, 1955	1950~1965	3.06	"	
72	"	ILOG	SAN JOAN	1947	1780	11/20, 1964	1950~1965	1.10	"	
73	"	"	CAMUGAO	1959	1775	6/30, 1964	1954~1965	0.91	"	
74	ILOCOS NORTE	GASGAS	MANALPAC	73	1025		21 Years	14.04	"	
75	" Sur	BOCONG	SALVADOR	40	475		15	10.78	"	
76	" "	STA. MARIA	SABANGAN PINGAN	67	261		8	3.89	"	
77	LA UNION	MARAGAYAP	BITALAG	36	496		11	13.78	"	
78	PANGASINAN	TAGAMUSING	SAN FILIPE	53	214		7	4.03	"	
79	Mt. PROVINCE	BOKOD	BOKOD	48	135		6	2.81	3	
80	PANGASINAN	BAYAKAS	MAPLES	64	168		7	2.62	1	
81	ZAMBALES	BAGSIT	DAMPAI	68	185		5	2.72	"	
82	BATAAN	BOLATE	BOLATE	16	90		21	5.62	"	
83	"	COLO	COLO	76	148		10	1.95	"	
84	"	MIRAY	LAMING BUNI	3	70		30	23.33	"	
85	"	PILAR	NAGWALING	14	270		15	19.30	"	
86	PAMPANGA	CACHAMAN	PARANLAG	22	249		11	11.28	"	
87	NUEVA ECIJA	DIGMALA	LABI	52	191		6	2.92	"	
88	"	SANTOR	COYAPA	89	277		8	3.11	"	
89	"	TABUATING	SOLEDAD	81	351		5	4.33	"	

Table I-22-4 MAXIMUM DISCHARGE RECORD IN MAIN RIVERS (4)

	RIVER BASIN	NAME OF RIVER	STATION	DRAINAGE AREA A (km²)	MAX DISCHARGE Q_{max} (m³/s)	DATE OF OCCURRENCE	OBSERVATION PERIOD	$q = Q_{max}/A$	TYPE OF CLIMATE	REMARKS
90	BULACAN	GARLANG	GARLANG	5	21	4.20	10	4.20	1	
91	LAGUNA	MACA	CCBALAN	35	41	1.17	11	1.17	〃	
92	〃	STA MARIA	MAKASIPAK	25	31	1.24	11	1.24		
93	〃	MAYOR	PAGUMBAYAN	45	140	3.11	11	3.11	〃	
94	〃	MABACAN	MABACAN	46	381	8.28	15	8.28	〃	
95	〃	PAEUTOK	〃	8.5	91	1.07	11	1.07	〃	
96	〃	ARANGILAN	GALAMIAS	87	330	3.80	11	3.80	〃	
97	CAVITE	ILANG-ILANG	IMUS	60	489	8.15	11	8.15	〃	
98	〃	PANAYSAYAN	PALUFLOBAN	29	228	7.87	9	7.87	〃	
99	BATANGAS	MOLINO	GUINHAWA	51	225	4.31	13	4.31	〃	
100	QUEZON	DISACIT	SAN LUIS	25	12.5	0.50	8	0.50	〃	
1	〃	DUMACCAA	AISAM	54	425	7.87	9	7.87	2	
2	〃	IRIA	AYAAS	15	155	10.32	10	10.32	〃	
3	〃	DUMACA - A	LAKAWAN	74	574	7.75	20	7.75	〃	
4	〃	HIBANGA	NAWALA	5	38	7.60	9	7.60	〃	
5	〃	MORONG	MORONG	12	97	8.08	9	8.08	〃	
6	〃	BULAKIN	BULAKIN	10.5	57	5.43	7	5.43	〃	
7	CAMARINES NORTE	DAET	ALAWIHAO	80	466.8		11	5.84	2	
8	〃	MATOGDON	MATOGDON	28	239.0		15	8.58	〃	
9	〃	TALISAY	CAHABAAN	22	218		9	9.93	4	
110	ALBAY	UGSONG	BEHAUAN	11	159		11	14.35	4	
1	CAMARINES SUR	ANAYAN	SAN ROQUE	17	319		11	18.75	2	
2	〃	ASLONG	SAN ISIDRO	12	222		11	18.50	〃	
3	〃	HINAGIANAN	MANGUIRING	23	101		11	4.39	〃	
4	〃	LAGONOY	CAGAYCAY	45	358		10	7.95	〃	
5	〃	TIGMAN	CABANBANAN	34	292		11	8.58	〃	
6	SORSOGON	CUMADCAD	CUMADCAD	13	234		8	18.0	4	
7	〃	CAWAYAN	SASUD	15	78		12	5.20	〃	
8	〃	NAMUAT	STA CRUZ	10	216		12	21.60	〃	
9	〃	SAN FRANCISCO	HOHORAWON	36	302		12	8.38	〃	

Table I-23 SPILLWAY DESIGN FLOOD PEAKS AND MAXIMUM OBSERVED FLOOD PEAKS

No.	DAM SITE	DRAINAGE AREA A(km2)	DESIGN DISCHARGE $Q_d(m^3/s)$	$q_D = Q_D/A$	OBSERVED MAX. DISCHARGE* Qmax (m^3/s)	q = Qmax/A	r = Qd/Qmax
1	Pantabangan	845	12,045	14.3	5,170	6.1	2.33
2	Mt. Puncan	242	5,480	22.6	2,300	9.5	2.38
3	Papaya	124	2,535	20.4	1,478	11.9	1.72
4	Mt. Balintingon	228	4,065	17.8	2,024	8.9	1.83
5	Ligaya	477	7,450	15.6	3,500	7.3	2.80
6	Kalangan	89	2,215	24.8	1,200	13.5	1.85
7	Bulu	45.2	365	21.3	781	17.2	1.04
8	San Roque	1,221	13,940	11.4	1,350	1.1	2.20
9	Tayum	1,155	13,760	11.8	6,140	5.3	2.24
10	Lubas	89	1,850	20.7	1,200	13.5	1.54
11	San Nicolas	275	4,750	17.3	2,470	8.9	1.92
12	Sapinit	240	4,530	18.8	2,200	9.5	1.88
13	Balog-Balog	282	5,390	19.1	2,510	8.9	2.15
14	O'donnell	139	2,890	20.8	1,500	10.8	1.83
15	Bangat	44.5	1,095	24.6	778	17.5	1.41
16	Camiling	221	5,270	23.9	2,160	2.4	2.44
17	Pila	117	2,580	22.1	1,430	12.2	1.81

MAX. PEAK RATIO: r max = 2.44

* Obtained from "Envelope Curve of Peaks V.S Drainage Area for Central Luzon.

Fig. I 24 DRAINEGE AREA(A) V.S SPECIFIC DISCHARGE (Q)

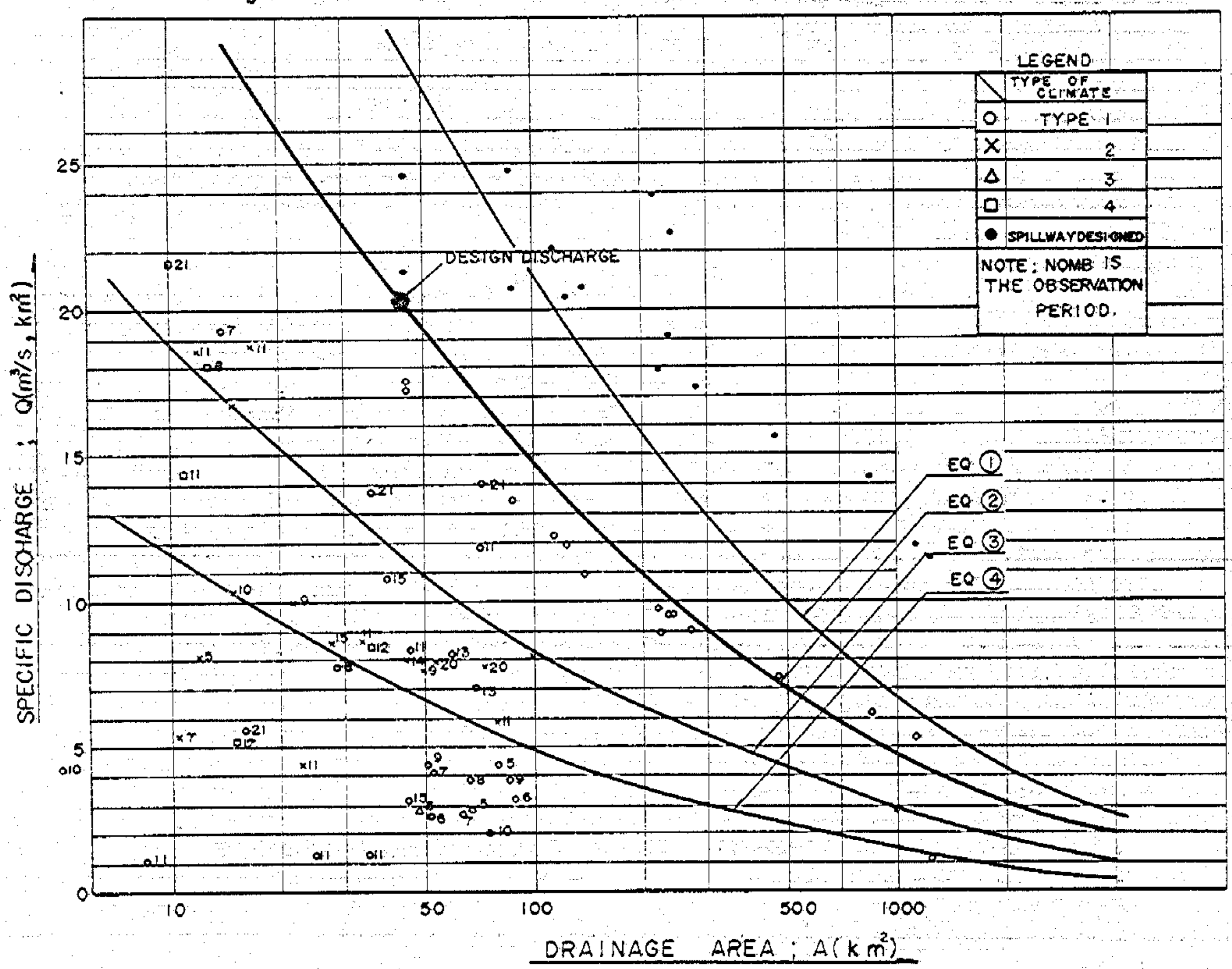
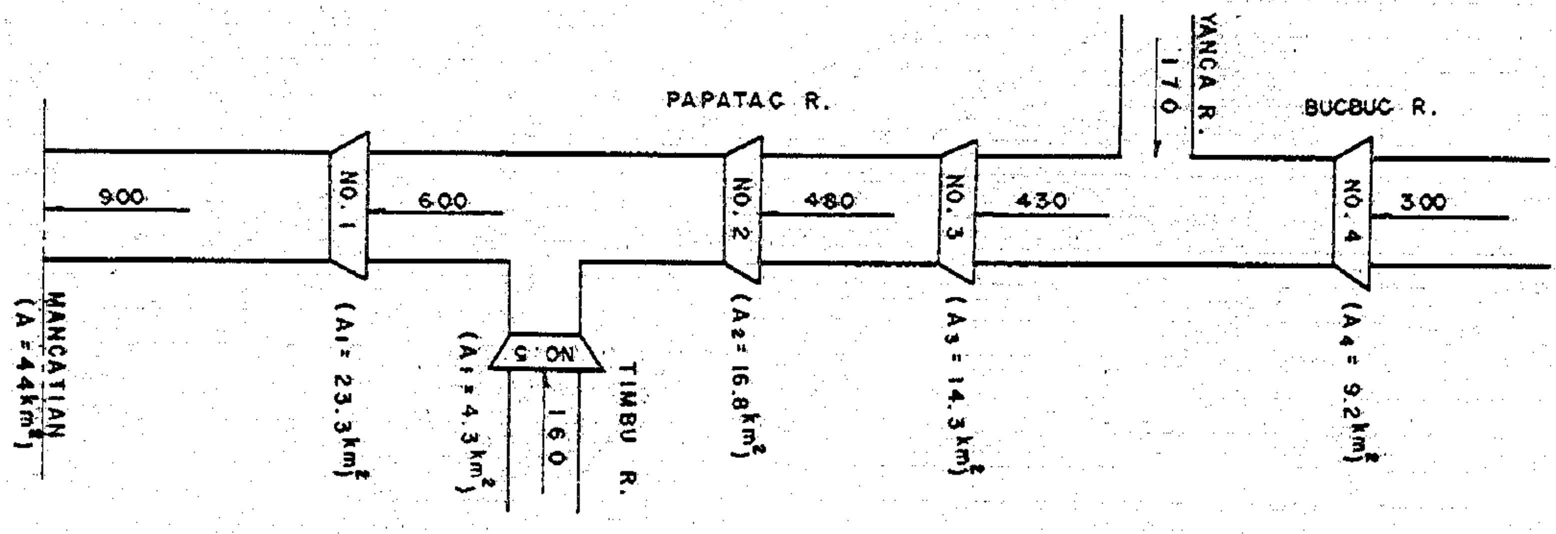


Fig-II-25 CALCULATED RUNOFF DISCHARGE. — CASE A —



$Q = 155A / \sqrt{A+13}$

	A (km²)	155 A	$\sqrt{A+13}$	Q (m³/s)	Q' (m³/s)	q (m³/s·km²)	REMARKS
NO. 1 DAM	23.5	3642	6.04	602.9	600	25.5	
2	16.8	3604	5.46	476.9	480	28.5	
3	14.3	2216	5.22	424.6	430	30.0	
4	9.2	1426	4.71	302.2	300	32.6	
5	4.3	666	4.19	160.2	160	37.2	
YANCA	4.6	713	4.19	169.9	170	36.9	
MANCATIAN	44.0	6820	7.55	903.0	900	20.4	

Fig. I-26 SPECIFIC DISCHARGE(Q)V.S DRAINAGE AREA (A)

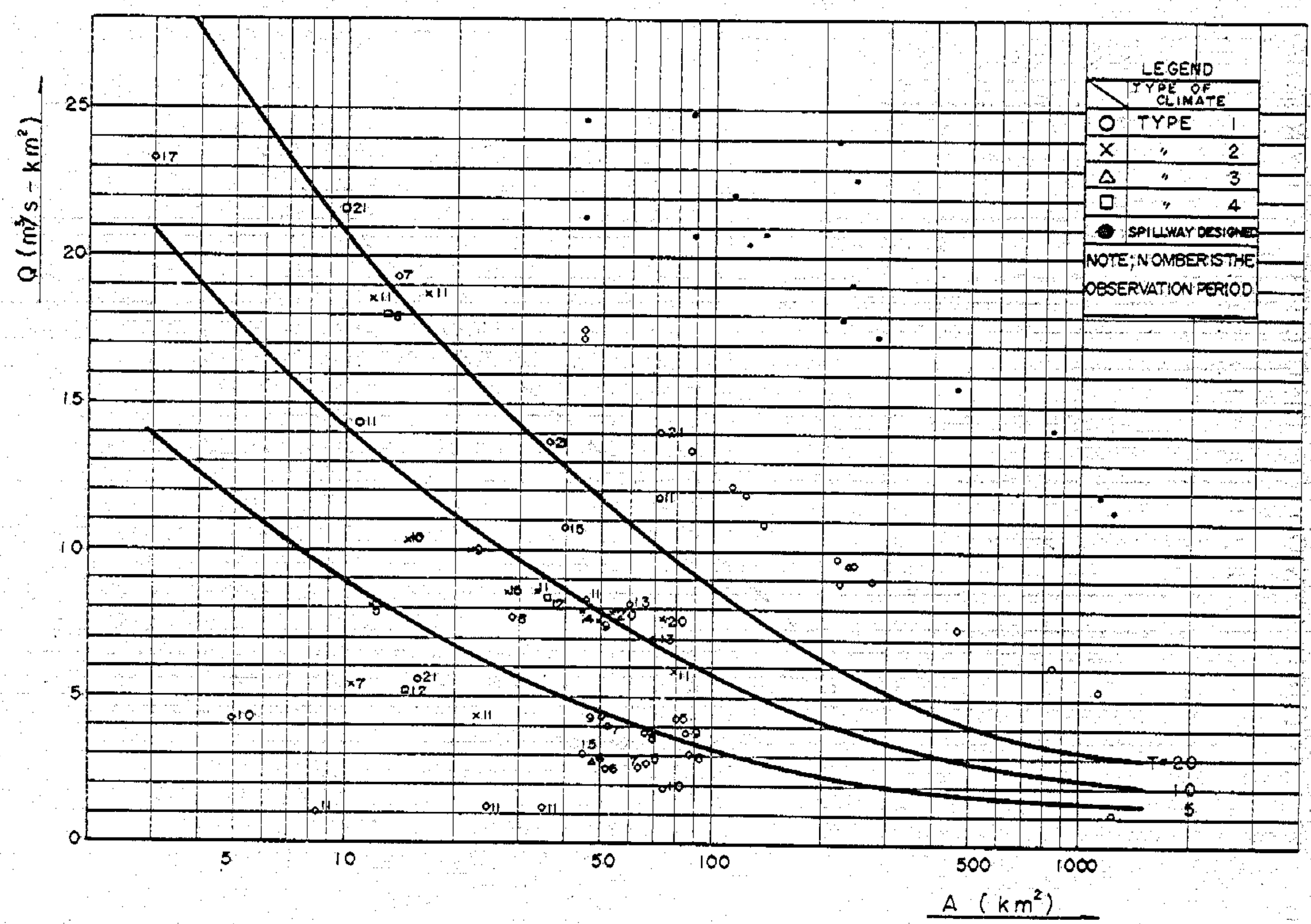


Fig. I-27 RETURN PERIOD OF DISCHARGE AT MANCATIAN BRIDGE

— FROM SPECIFIC DISCHARGE —

1/T	Q_T
1/2	145
1/5	285
1/10	410
1/20	550
1/50	790
1/80	900
1/100	970
1/200	1200
1/500	1600

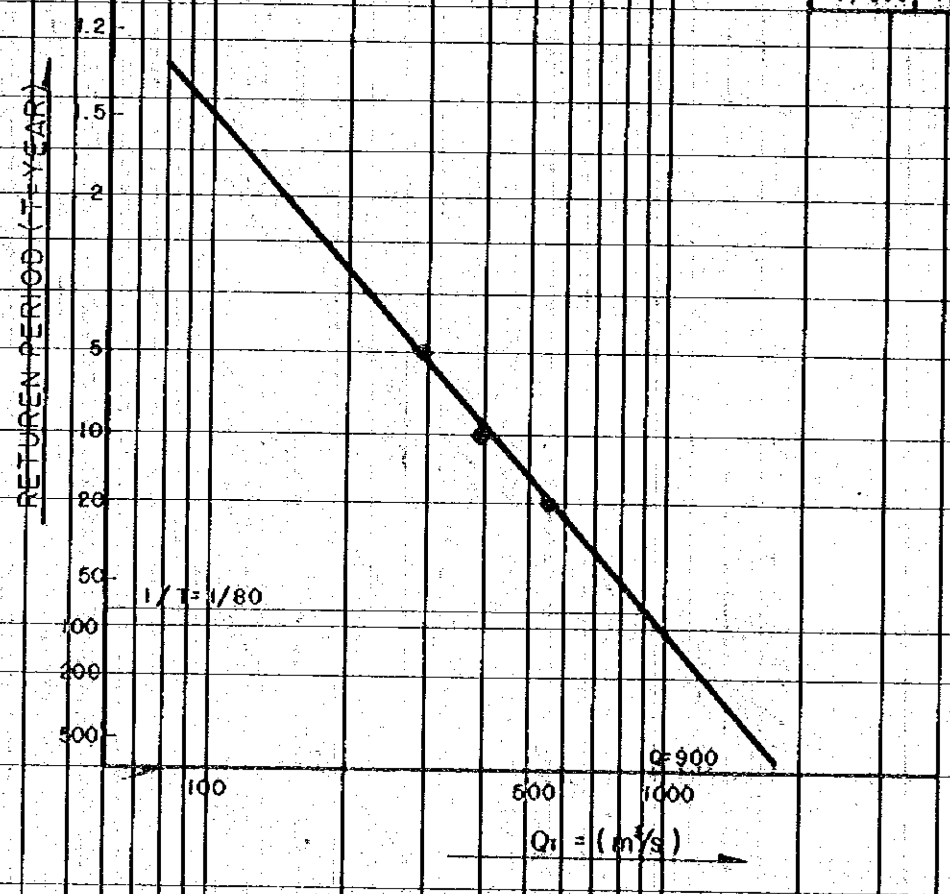
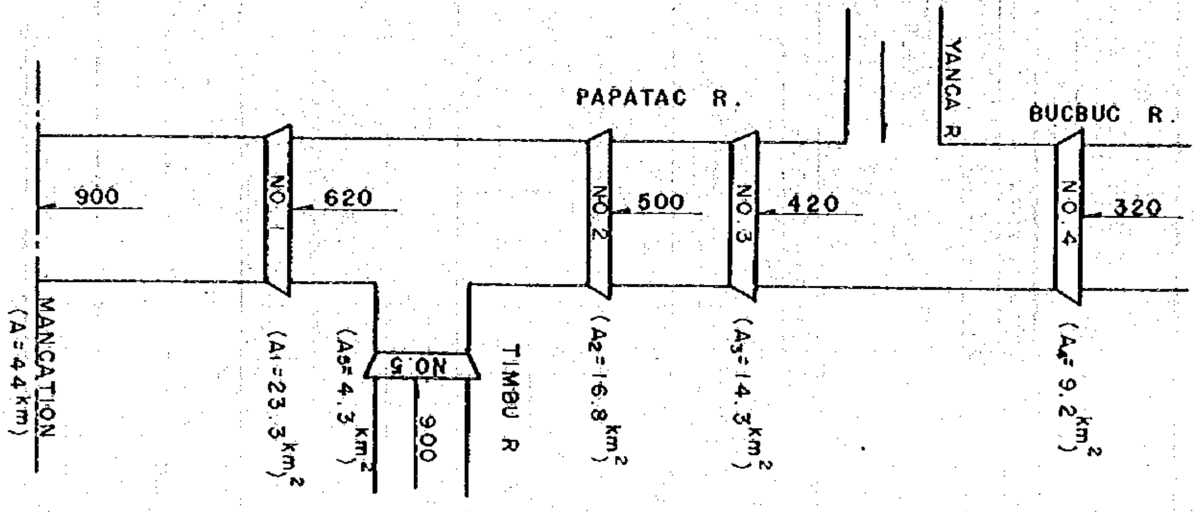
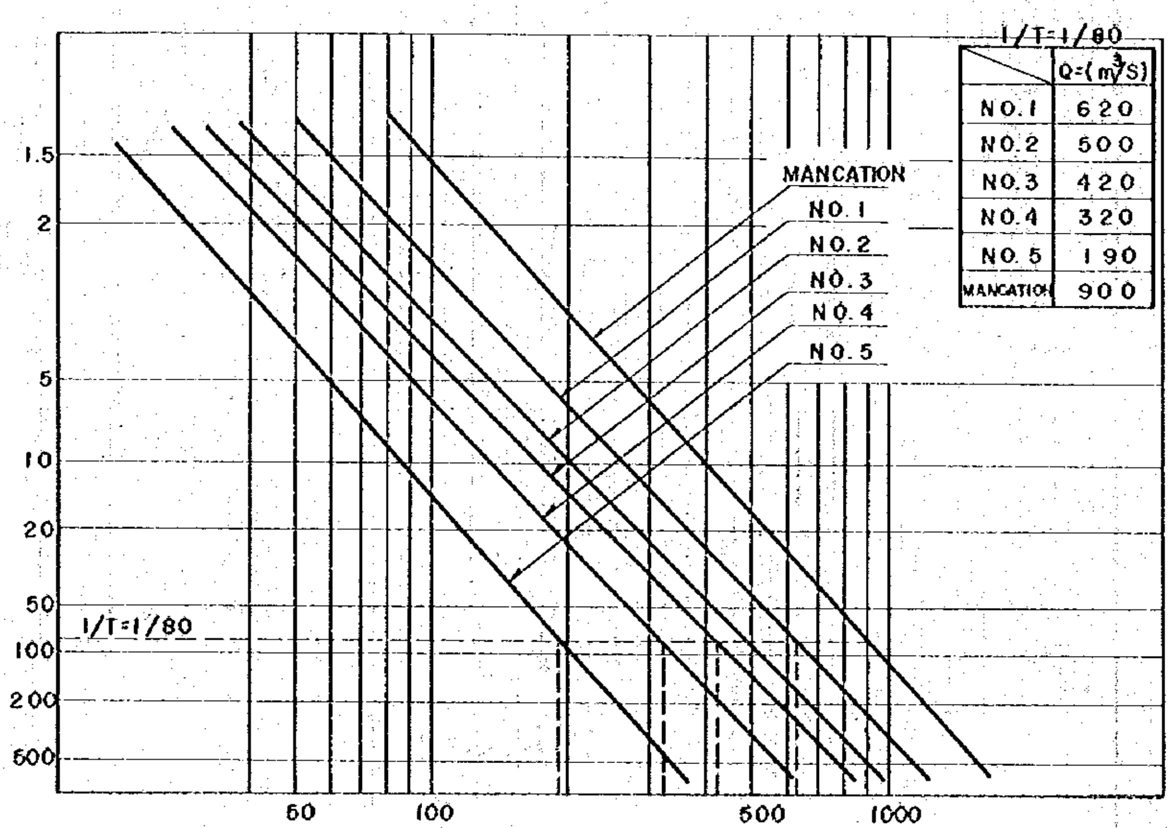


Fig. I-28 CALCULATED RUNOFF DISCHARGE -CASE B-





1/T=1/80

	Q=(m³/S)
NO.1	620
NO.2	500
NO.3	420
NO.4	320
NO.5	190
MANCATION	900

Fig-II-29 FLOOD PROPAGATE VELOCITY (W) V·S RIVER BED GRADIENT (i)

	A(km)	L(km)	H/L	W(k/h)	T(hr)
NO. 1	23.5	13.2	1/80	5.5	2.4
2	16.8	11.0	1/20	6.0	1.5
3	14.3	8.1	1/60	6.5	1.3
4	9.2	5.9	1/45	7.3	0.8
5	4.2	4.2	1/50	6.6	0.7
MANCA	44.0	21.0	1/90	5.0	4.0

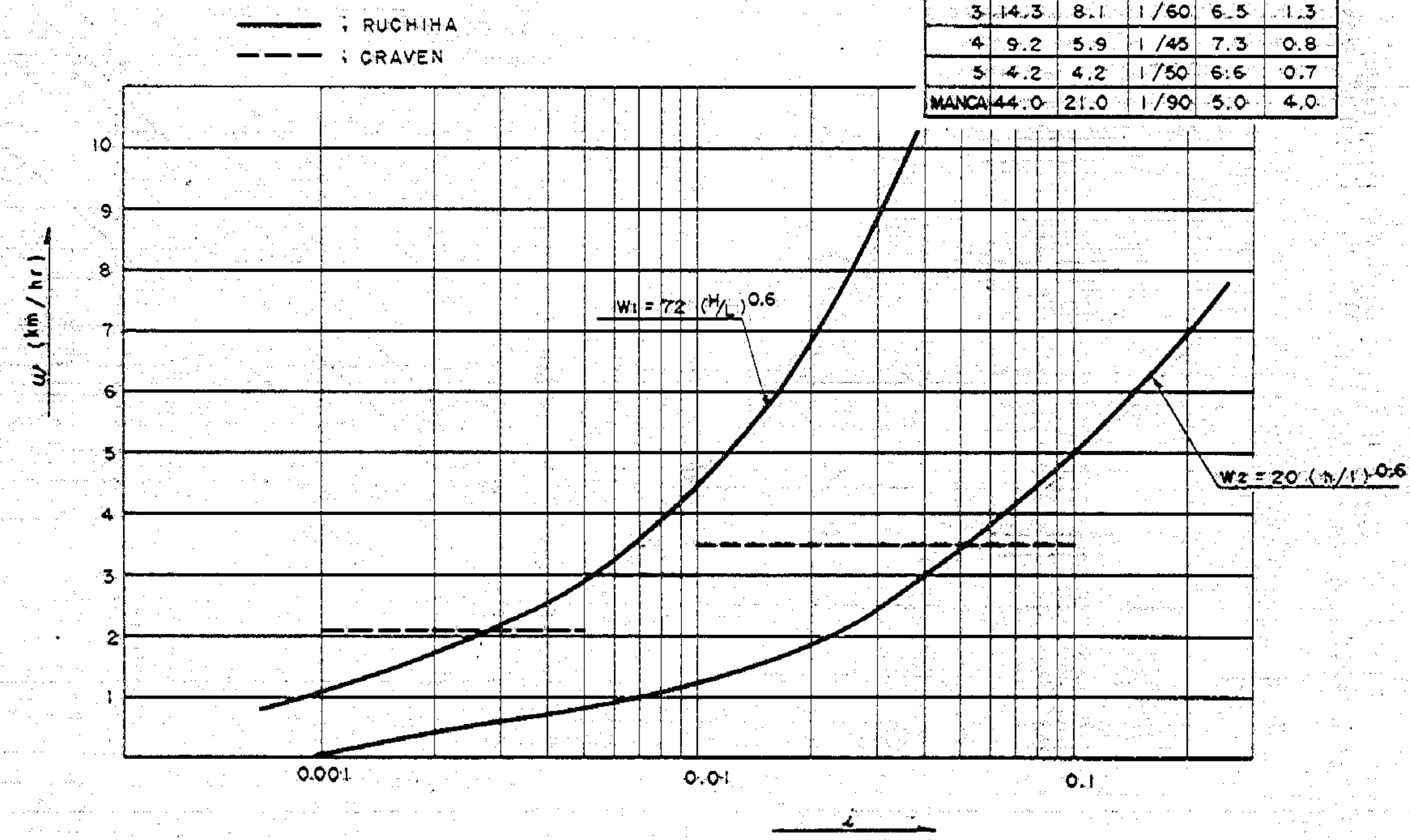


Fig I-30 DAILY RAINFALL (R) V.S RAINFALL INTENSITY (r_T)

$$r_T = \frac{R}{24}\left(\frac{24}{t}\right)^{2/3}$$

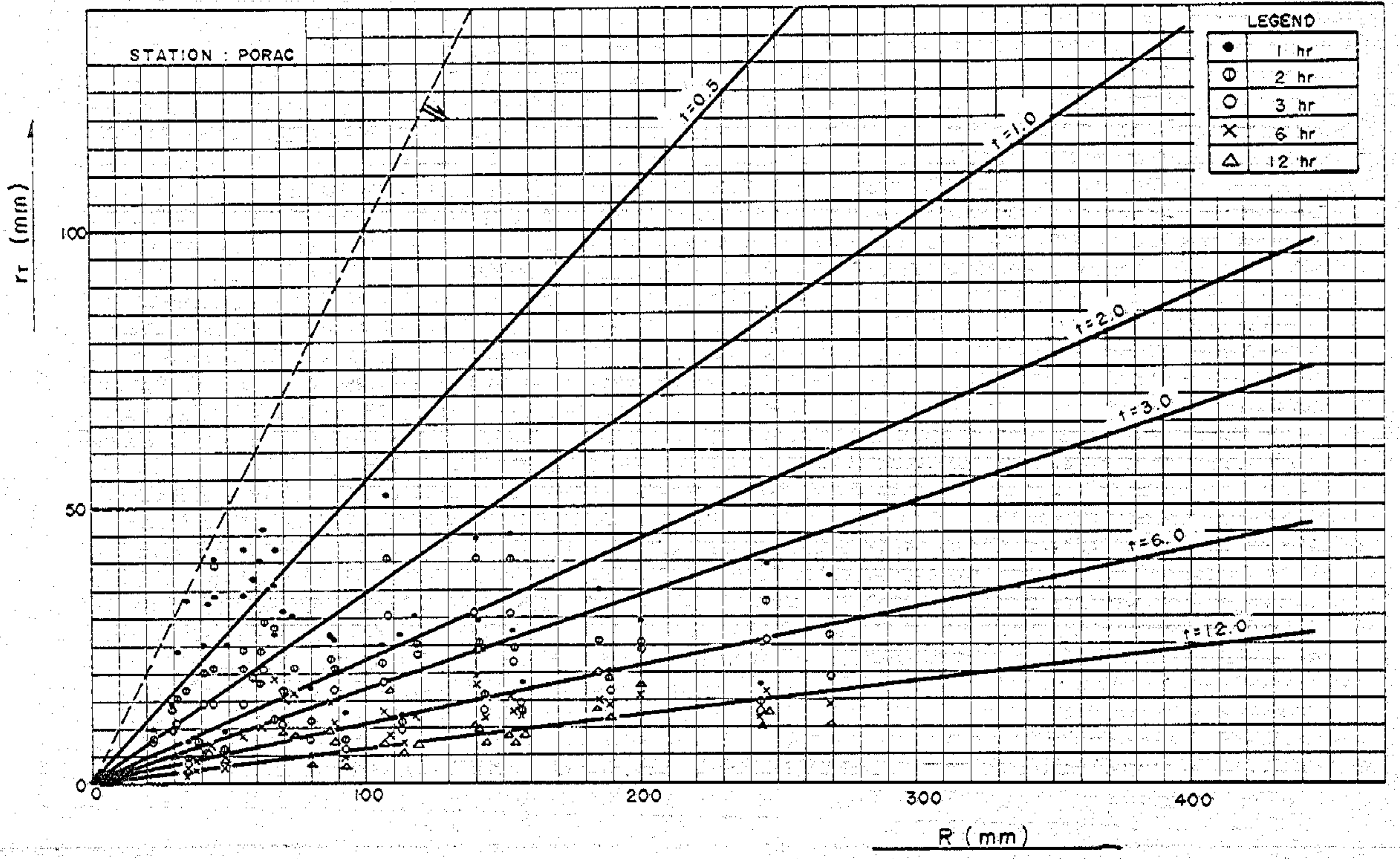


Fig. I-3 CALCULATED RUNOFF DISCHARGE. — CASE C —

	A (km²)	T (hr)	R / 24	$(24/T)^{2/3}$	r_T	r_T' (=1.5r_T)	$Q = \frac{1}{3.6} f r_T \cdot A$ (m^3/s)	
NO. 1	23.5	2.4	18.75	4.64	87	130.5	637	640
2	16.8	1.5	"	6.34	118	177.0	618	620
3	14.3	1.3	"	6.98	131	196.0	585	580
4	9.2	0.8	"	9.65	181	271.0	519	510
5	4.3	0.7	"	10.35	195	292.0	261	260
MANCATIAN	44.0	4.0	"	3.30	61.1	91.6	844	850

$r_T = \frac{R}{24}\left(\frac{24}{T}\right)$, $R_{\frac{1}{80}}$ = 450 mm (AT PORAC STATION)

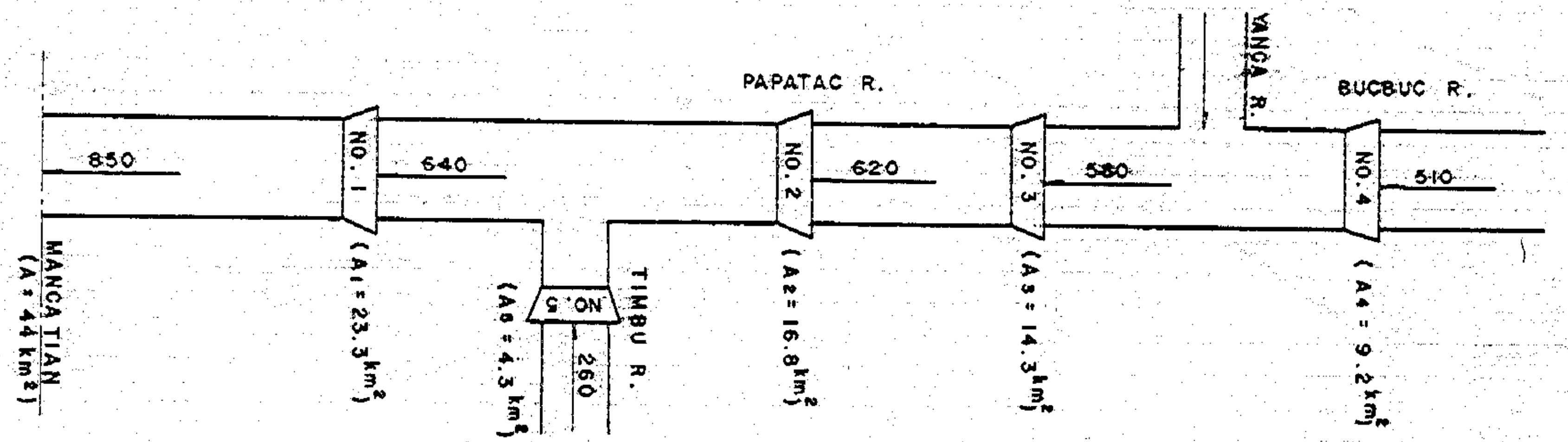


Table I-24 DAIY RAINFALL V-S HOURLY RAIRFALL INTENSITY

Poroc

Flood	Daily Rainfall R(mm.)	1 hr r1'	1 hr r1	2 hr r2'	2 hr r2	3 hr r3'	3 hr r3	6 hr r6'	6 hr r6	12 hr r12'	12 hr r12	Remarks
1969. July 20	56.8	24.0		41.9	20.0	43.9	14.3	51.6	8.6			
〃 27	36.2	7.7		8.9	4.5	9.5	3.2	18.3	3.1	20.1	1.68	
〃 28	38.9	12.8		14.8	7.4	14.8	4.9	23.3	4.0	24.3	2.02	
Sep. 6	108.4	52.8		80.3	40.2	90.1	30.3	102.9	17.1	105.9	8.8	
Nov. 23	31.8	29.2		30.8	15.4	31.3	10.4					
〃 25	39.7	32.2		38.2	19.1	38.2	12.7	38.2	6.37	39.7	3.1	
1970. Jun. 3	34.5	33.0		34.5	17.3							
〃 13	47.6	9.8		14.0	7.0	20.6	7.0	27.3	4.5	31.5	2.6	
Jul. 14	74.1	30.6		41.9	21.0	49.8	16.7	52.6	8.8	64.3	5.3	
〃 28	31.0	28.5		29.0	15.0	29.5	9.8	50.5	5.1	31.5	2.63	
Aug. 20	36.5	28.0		36.0	18.0					36.5	3.04	
〃 31	93.2	13.1		16.1	8.1	17.6	6.0	26.3	4.4	37.9	3.15	
Sep. 1	157.7	18.6		27.0	13.5	42.9	14.5	74.5	12.6	106.6	8.9	
1971 Jun. 15	71.1	12.1		14.1	7.1	21.2	7.1	36.4	6.4	54.0	4.5	
〃 16	89.7	26.2		42.4	21.2	51.5	17.2	68.6	11.4	88.7	7.4	
Jul. 20	88.1	26.9		47.3	23.6	53.4	14.5	59.9	9.8	80.1	6.7	
〃 21	44.2	9.9		18.3	9.2	21.3	7.1	33.8	5.6	41.7	3.5	
〃 25	141.7	29.3		51.5	25.8	72.7	24.2	107.0	58.0	130.1	10.9	
〃 30	45.5	40.5		44.0	22.0							
Sep. 10	30.0	14.7		28.0	14.0	28.5	9.5	30.0	5.0			
〃 24	63.4	46.8		58.0	29.1	63.4	21.1					
1972. Jun. 24	67.0	42.5		56.5	28.3	57.0	19.0					
〃 25	38.2	10.6		18.6	9.3	29.2	9.1	35.1	6.0	38.2	3.2	
Jul. 7	185.0	135.0		53.0	26.5	60.0	20.0	89.0	15.0	174.5	14.5	
〃 8	65.4	16.0		22.6	11.3	26.6	8.5	50.3	13.2			
〃 9	69.4	31.7		33.7	16.9	33.7	11.2	66.2	11.0	88.0	7.3	
〃 10	183.0	35.5		39.5	19.8	56.5	13.5	94.5	16.0	115.0	9.6	
〃 17	188.5	20.5		38.0	19.0	52.0	17.0	83.0	14.0	148.5	12.1	
〃 18	269.4	37.4		54.0	27.0	57.5	19.2	86.8	14.5	126.6	10.6	

r': Cumulative Hourly Rainfall, r: Hourly Rainfall Intesity, R: Daily Rainfall.

Table I-24-2 DAILY RAINFALL V·S HOURLY RAINFALL INTENSITY

PORAC

FLOOD	R(mm)	1 hr		2 hr		3 hr		6 hr		12 hr		REMARK
		r'	r	r'	r	r'	r	r'	r	r'	r	
1972 JUL. 19	244.0	18.0		30.0	15.0	40.0	13.3	79.0	13.0	130.0	10.8	
〃 23	74.5	10.5		11.5	5.7	12.5	4.2	36.5	6.1	46.5	3.9	
〃 27	114.0	12.0		22.0	11.0	29.0	9.7	44.5	7.4	65.5	5.5	
〃 28	74.5	11.0		15.5	16.0	17.0	6.3	28.5	4.8	47.0	3.9	
〃 29	118.5	30.3		51.0	25.5	67.2	23.1	73.1	12.1	80.2	6.7	
AUG. 16	143.0	24.0		32.0	16.0	39.0	13.0	73.0	12.1	92.0	7.7	
1973 JUN. 20	56.6	42.8		49.7	24.9							
JUL. 5	39.0	14.5										
〃 14	80.5	17.5		22.0	11.0	24.0	8.0	30.0	5.0	42.5	3.5	
〃 15	73.0	14.5		10.5	8.3	18.0	6.3	23.5	4.0	63.0	5.3	
AUG. 2	49.6	25.4		32.5	6.3	36.5	12.3	45.1	7.5			
〃 3	107.5	25.0		44.0	22.0	54.0	18.0	86.0	13.0	87.5	7.3	
SEP. 10	41.5	25.0		41.0	20.5	41.5	14.0					
OCT. 8	84.9	20.9		22.8	11.4	27.1	9.0	39.6	6.6	58.7	4.9	
1974 APR. 23	67.0	27.0		44.5	12.3	45.0	15.0					
〃 25	70.0	46.6		54.4	27.2	55.9	18.6	56.4	9.4	70.0	5.8	
JUN. 10	173.0	40.0		63.0	31.5	79.0	29.8	118.0	19.3	141.0	11.8	
JUL. 2	43.5	33.0		10.5	5.3							
〃 20	140.0	44.0		81.0	40.5	92.0	31.0	113.5	19.0	124	10.3	
AUG. 15	154.6	28.0		49.0	24.5	66.0	22.0	79.5	13.3	90.5	7.5	
SEP. 24	23.5	60.0		82.0	41.0	83.0	28.0					
OCT. 17	113.5	27.0		34.5	7.9	39.0	13.0	50.0	8.3	87.0	7.3	
NOV. 28	153.5	45.0		82.0	41.0	80.5	30.2	94.5	16.0	49.5	8.3	
1975 MAY. 24	43.4	33.8		42.4	21.2	42.4	14.1	43.4	7.3			
AUG. 26	60.6	40.9		48.5	24.3	55.1	18.7	64.1	10.0			
1976 MAY. 23	246.9	39.4		67.2	33.6	78.4	26.1	99.6	16.6	21.1	17.6	
JUN. 25	200.6	28.8		51.0	25.5	73.2	24.4	98.8	16.5	166.2	13.8	

Fig 1-52 DAILY RAINFALL (R) V.S RAINFALL INTENSITY (r_T)

STATION : PORAC

1/T	R	r_1	r_2	r_3	r_6	r_6	r_{12}	r_{24}
1/100	460	125	99	79	68	49	35	19.2
1/70	440	120	95	75	64	46	32	18.3
1/50	390	115	90	69	58	42	28	16.3
1/20	315	97	74	59	47	36	25	13.1
1/10	260	82	63	49	40	31	20	10.8
1/5	210	68	52	40	35	26	19	8.8
1/2	130	48	36	26	21	18	11	5.4

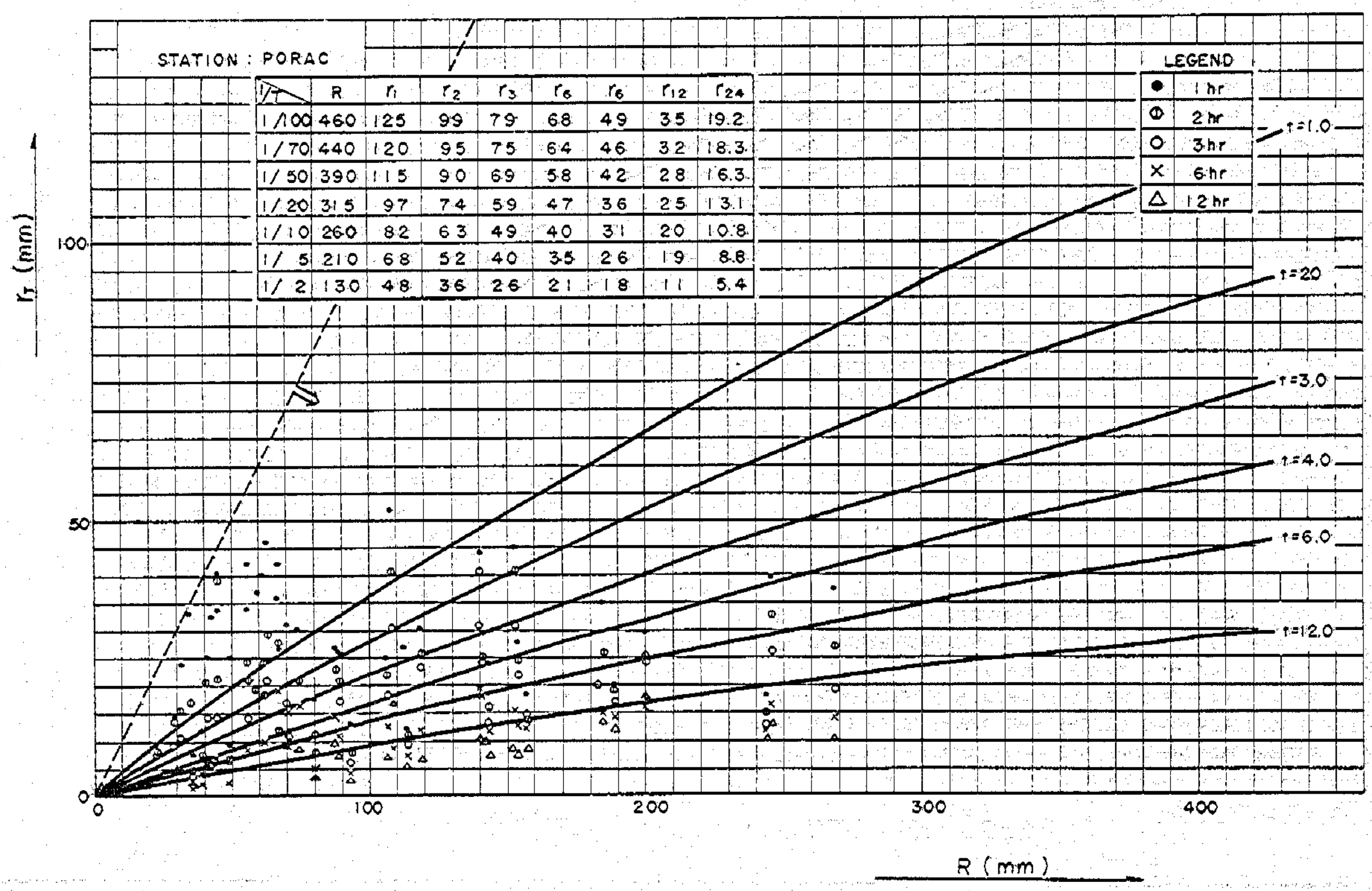
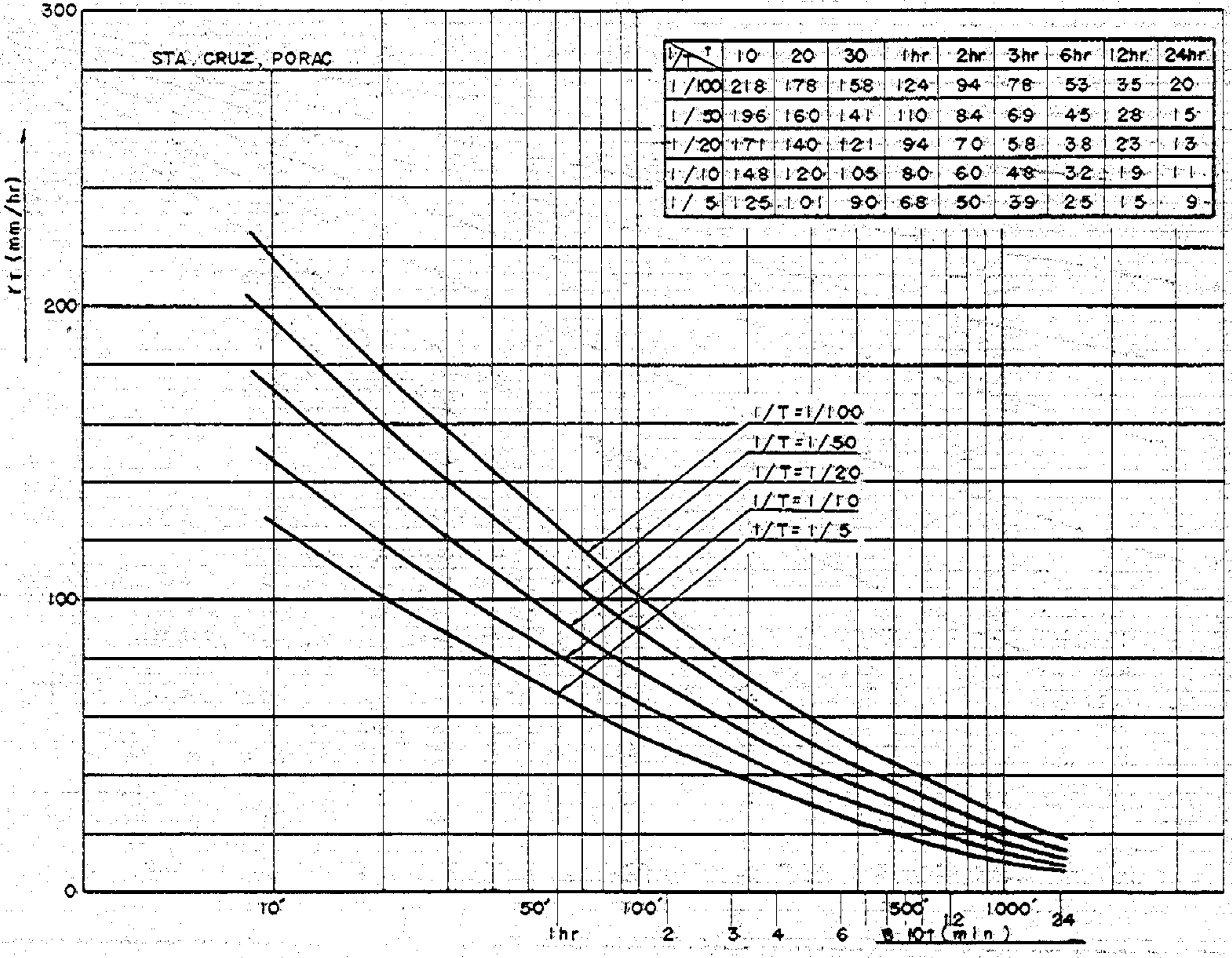


Fig.I-33 RAINFALL INTENSITY DURATION CURVE.(rt v.s t)



1/T \ t	10	20	30	1hr	2hr	3hr	6hr	12hr	24hr
1/100	218	178	158	124	94	78	53	35	20
1/50	196	160	141	110	84	69	45	28	15
1/20	171	140	121	94	70	58	38	23	13
1/10	148	120	105	80	60	48	32	19	11
1/5	125	101	90	68	50	39	25	15	9

EXTREME VALUES OF RAINFALL OF VARIOUS DURATIONS

FOR

MANILA (PORT AREA)

COMPUTED EXTREME VALUES (IN MM) OF PRECIPITATION

RETURN PERIOD (YEARS)	5 MINS	10 MINS	15 MINS	30 MINS	60 MINS	2 HRS	3 HRS	6 HRS	12 HRS	24 HRS
2	13.2	21.6	28.2	42.8	58.7	72.7	81.5	102.8	126.2	162.4
5	16.9	28.1	37.0	55.9	74.1	95.4	107.8	139.8	178.7	237.8
10	19.4	32.4	42.9	64.7	84.3	110.4	125.3	164.2	213.4	287.8
15	20.8	34.9	46.1	69.6	90.0	118.9	135.2	178.0	232.9	315.9
20	21.8	36.6	48.4	73.0	94.0	124.8	142.1	187.6	246.7	335.6
25	22.5	37.9	50.2	75.7	97.1	129.4	147.4	195.1	257.2	350.8
50	24.9	41.9	55.7	83.8	106.7	143.4	163.8	218.0	289.8	397.6
100	27.2	45.9	61.1	92.0	116.2	157.4	180.0	240.7	322.1	444.1

INTENSITY (IN MM/HR) OF THE COMPUTED MAXIMU PRECIPITATION

RETURN PERIOD (YEARS)	5 MINS	10 MINS	15 MINS	30 MINS	60 MINS	2 HRS	3 HRS	6 HRS	12 HRS	24 HRS
2	158.0	129.8	113.0	85.5	58.7	36.3	27.2	17.1	10.5	6.8
5	203.0	168.7	148.2	111.9	74.1	47.7	35.9	23.3	14.9	9.9
10	232.8	194.6	171.4	129.3	84.3	55.2	41.8	27.4	17.8	12.0
15	249.6	209.1	184.6	139.1	90.0	59.4	45.1	29.7	19.4	13.2
20	261.4	219.3	193.7	146.0	94.0	62.4	47.4	31.3	20.6	14.0
25	270.4	227.2	200.8	151.3	97.1	64.7	49.1	32.5	21.4	14.6
50	298.3	251.4	222.6	167.7	106.7	71.7	54.6	36.3	24.1	16.6
100	326.0	275.4	244.3	183.9	116.2	78.7	60.0	40.1	26.8	18.5

Fig.I-34 ELEVATION V·S MEAN SEASONAL (MAY TO OCT) RAINFALL.

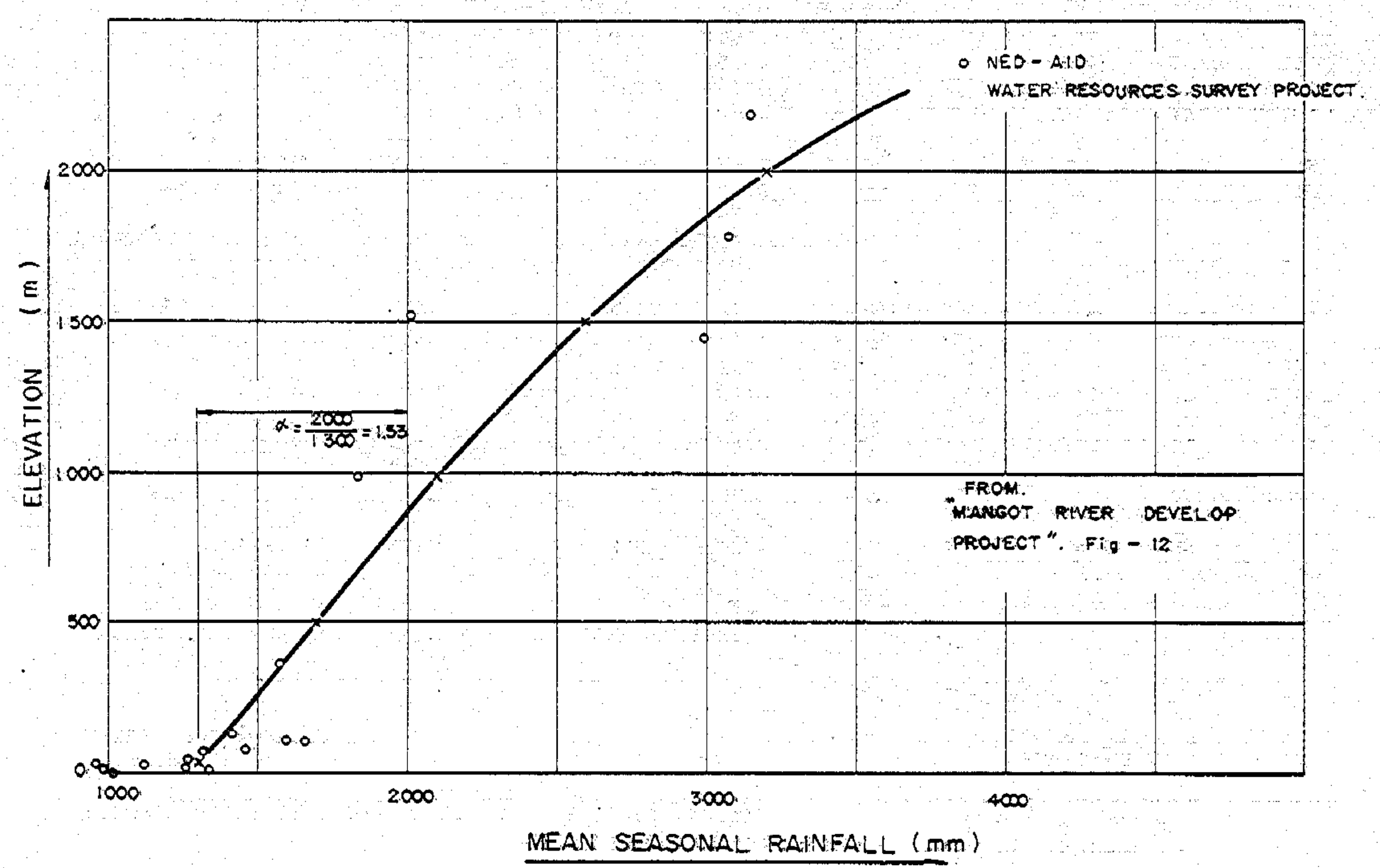


Table I-25 ELEVATION V.S MEAN SEASONAL(JUNE TO SEP.) RAINFALL

NO	Statcons	Mean Seasonal Rainfall (mm)	Elevation(m)	Year of Period	NO of Year Recorded
1	BONGABON, N. ECIJA	1320	70	1928 ~ 1934 1936 ~ 1939	11
2	MUNOZ, N. ECJA	1270	50	1945 ~ 1950	16
3	PENARANDA RIS POB. N.E	988	15	1945 ~ 1961	15
4	SAN JOSE REF. SU JOSE N.E	1635	106	1945 ~ 1958	13
5	CABANATUAN CITY. N. ECIJA	1155	30	1935 ~ 1960	15
6	BAGUIO CITY. MT. PROVINCE	3000	1450	1902 ~ 1934 1936 ~ 1939	32
7	SUGARMILL CABIAO. N. ECIJA	1115	10	1928 ~ 1934 1936 ~ 1938	10
8	AMBUKLAO PRAJ. MT. PROY	1340	995	1949 ~ 1960	12
9	SAN ISLARO. NUEVA ECIJA	1268	20	1903 ~ 1906 1908 ~ 1932	29
10	CAMILING. TARAC	1340	15	1921 ~ 1931	11
11	O'DONNEL RIS. SU. MIGUEL. TARAC	1415	130	1949 ~ 1962	11
12	ABOAY KABAYAN MT. PRAV	1585	370	1950 ~ 1962	12
13	PENARANDA. RIS SU JOSEF NE	963	30	1945 ~ 1960	15
14	SANTON RIS SU VICEUTE, LOUR NE	1460	80	1958 ~ 1962	3
15	PALPALAN. MT. PROVINCE	3090	1785	1922 ~ 1932	10
16	ATOK. MT. PROVINCE	3150	2290	1921 ~ 1932 1950 ~ 1961	24
17	BNGUET MINES. MT. PROVINCE	2015	1520	1947 ~ 1961	15
18	TARAVERA RIS HEADWORKS NE.	1600	105	1946 ~ 1960	15

* "NEO-AID WATER RESOURSES SURVEY PROJECT" CENTRAL LUZON BAISN HYDROLOGY, FLOOD CONTROL AND DRAINAGE DIVISION B. P. W. JULY. 1964.

** ELEVATION ARE OBTAINED FROM AMONG MAPS AND WEATHER PURAN SCIENTIFIC PAPER, NO.407 "ANNUAL CHIMATOLOGICAL SERIES".

Table I-26 RUN - OFF DISCHARGE.

Moncotlan

I/T	A(km²)	t(hr)	r(mm/h)	r'(mm/h)	$Q_P=\frac{1}{3.6}f.r.A$	
1/100	44.0	4.0	68	102	$Q=\frac{1}{3.6}\times0.75\times102\times44=935$	940
1/50	〃	〃	57	85.5	$Q=\frac{1}{3.6}\times0.75\times85.5\times44=783$	780
1/20	〃	〃	45	67.5	$Q=\frac{1}{3.6}\times0.75\times67.5\times44=618$	600
1/10	〃	〃	40	60.0	$Q=\frac{1}{3.6}\times0.75\times60\times44=511$	510
1/5	〃	〃	32	48.0	$Q=\frac{1}{3.6}\times0.75\times48\times44=409$	410

NO.1 DAM

	A(km²)	t(hr)	r(mm/h)	r'(mm/h)	Q_P	
1/100	23.5	2.4	86	129	$Q=\frac{1}{3.6}\times0.75\times129\times23.5=631$	630
1/50	〃	〃	76	114	$Q=\frac{1}{3.6}\times0.75\times114\times23.5=557$	560
1/20	〃	〃	62	93	$Q=\frac{1}{3.6}\times0.75\times93\times23.5=458$	450
1/10	〃	〃	52	78	$Q=\frac{1}{3.6}\times0.75\times78\times23.5=381$	380
1/5	〃	〃	44	66	$Q=\frac{1}{3.6}\times0.75\times66\times23.5=322$	320

NO.2

	A(km²)	t(hr)	r(mm/h)	r'(mm/h)	Q_P	
1/100	16.8	1.5	105	157.5	$Q=\frac{1}{3.6}\times0.75\times157.5\times16.8=551.3$	550
1/50	〃	〃	93	140	$Q=\frac{1}{3.6}\times0.75\times140\times16.8=490$	490
1/20	〃	〃	80	120	$Q=\frac{1}{3.6}\times0.75\times120\times16.8=420$	420
1/10	〃	〃	68	102	$Q=\frac{1}{3.6}\times0.75\times102\times16.8=352$	352
1/5	〃	〃	56	84	$Q=\frac{1}{3.6}\times0.75\times84\times16.8=280$	280

NO.3

	A(km²)	t(hr)	r(mm/h)	r'(mm/h)	Q_P	
1/100	14.3	1.3	112	168	$Q=\frac{1}{3.6}\times0.75\times168\times14.3=498$	500
1/50	〃	〃	98	147	$Q=\frac{1}{3.6}\times0.75\times147\times14.3=436$	440
1/20	〃	〃	84	126	$Q=\frac{1}{3.6}\times0.75\times126\times14.3=374$	370
1/10	〃	〃	71	106	$Q=\frac{1}{3.6}\times0.75\times106\times14.3=315$	310
1/5	〃	〃	60	90	$Q=\frac{1}{3.6}\times0.75\times90\times14.3=267$	260

NO.4

	A(km²)	t(hr)	r(mm/h)	r'(mm/h)	Q_P	
1/100	9.2	0.8	135	195	$Q=\frac{1}{3.6}\times0.75\times195\times9.2=374$	370
1/50	〃	〃	120	180	$Q=\frac{1}{3.6}\times0.75\times180\times9.2=345$	345
1/20	〃	〃	102	153	$Q=\frac{1}{3.6}\times0.75\times153\times9.2=293$	290
1/10	〃	〃	88	132	$Q=\frac{1}{3.6}\times0.75\times132\times9.2=253$	250
1/5	〃	〃	72	108	$Q=\frac{1}{3.6}\times0.75\times108\times9.2=207$	200

NO.5

	A(km²)	t(hr)	r(mm/h)	r'(mm/h)	Q_P	
1/100	4.3	0.7	140	210	$Q=\frac{1}{3.6}\times0.75\times210\times4.3=186$	190
1/50	〃	〃	126	189	$Q=\frac{1}{3.6}\times0.75\times189\times4.3=168$	170
1/20	〃	〃	106	159	$Q=\frac{1}{3.6}\times0.75\times159\times4.3=141$	140
1/10	〃	〃	92	138	$Q=\frac{1}{3.6}\times0.75\times138\times4.3=122$	120
1/5	〃	〃	77	116	$Q=\frac{1}{3.6}\times0.75\times116\times4.3=102$	100

Fig. I-35 RETURN PERIOD OF RUN-OFF DISCHARGE AT MANCATIAN B.

— FROM RAINFALL DURATION INTENSITY CURVE —

I/T	Qi/T
1/2	250
1/5	400
1/10	520
1/20	640
1/50	820
1/80	900
1/100	950
1/200	1100
1/500	1350

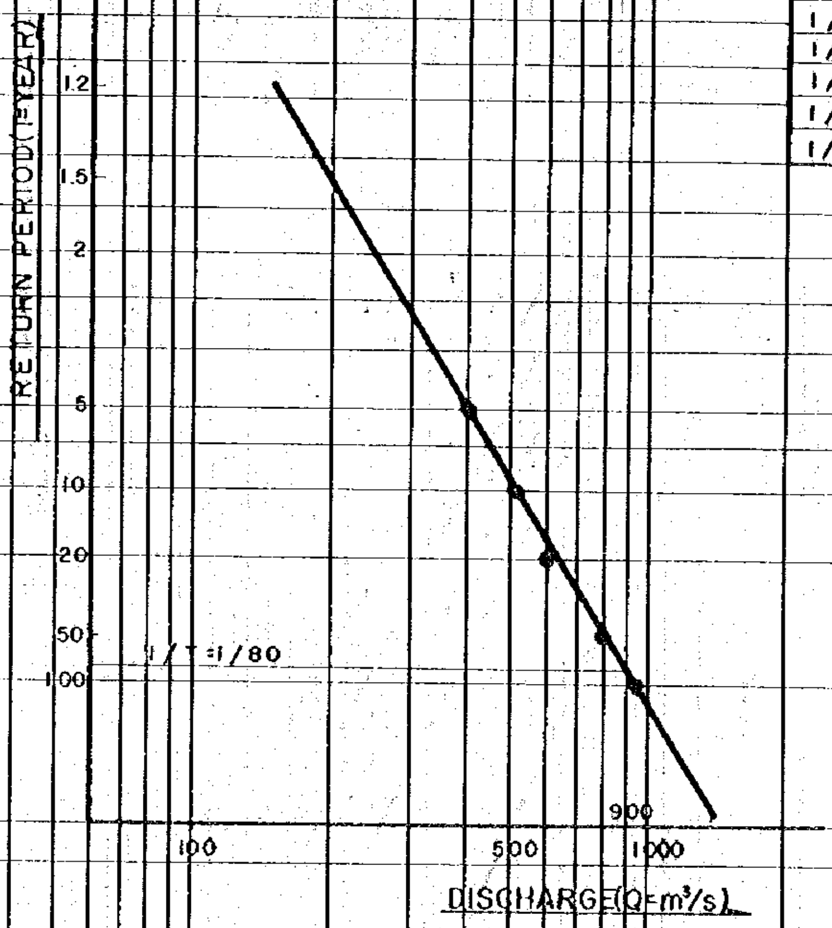
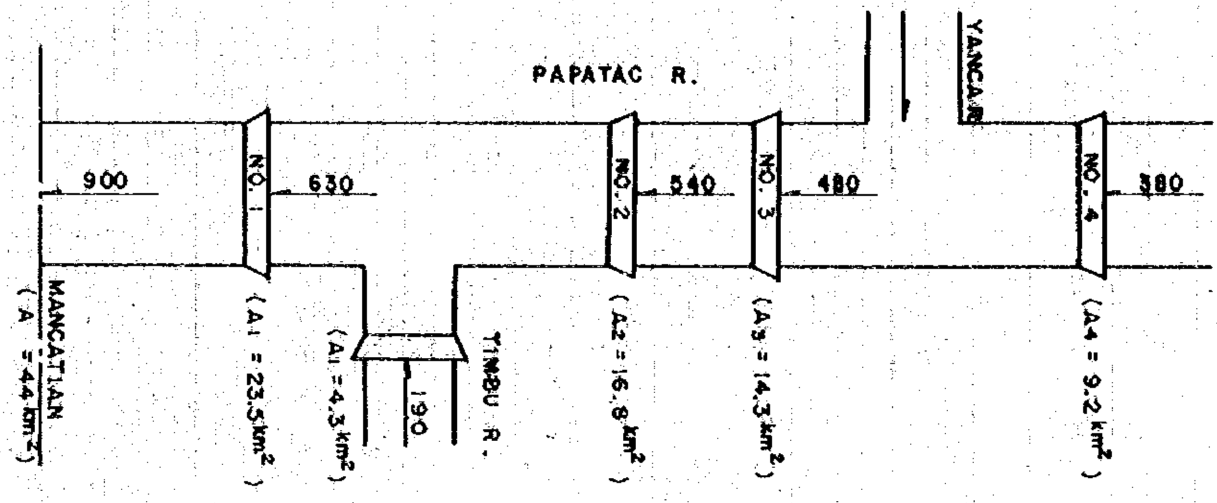


Fig. I-36 CALCULATED RUNOFF DISCHARGE — CASE D—



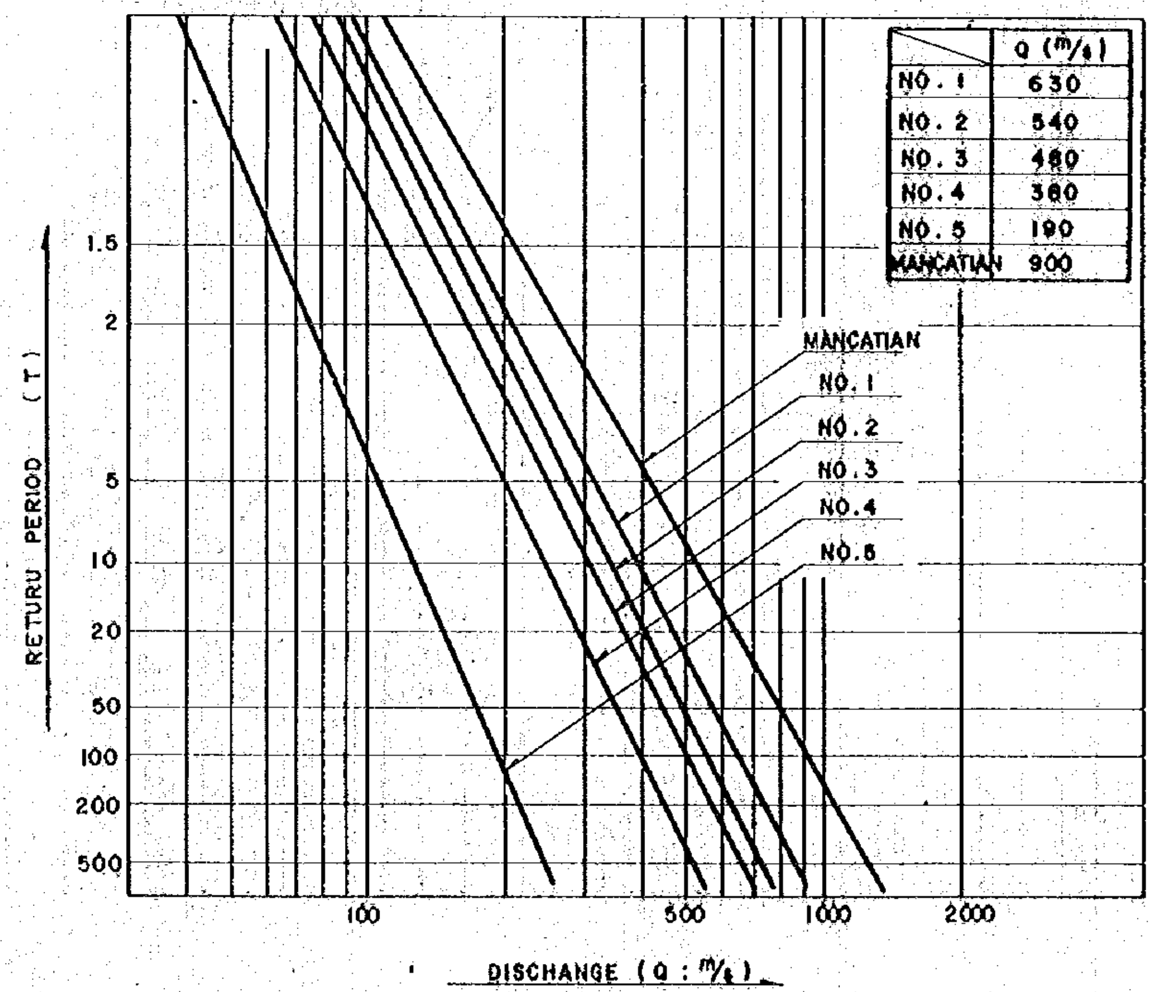
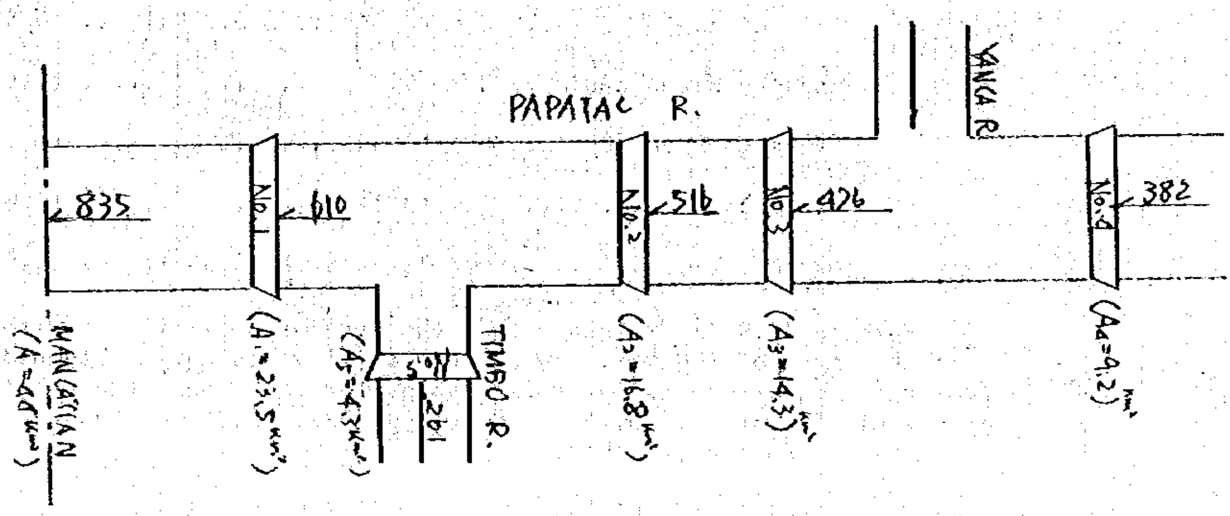
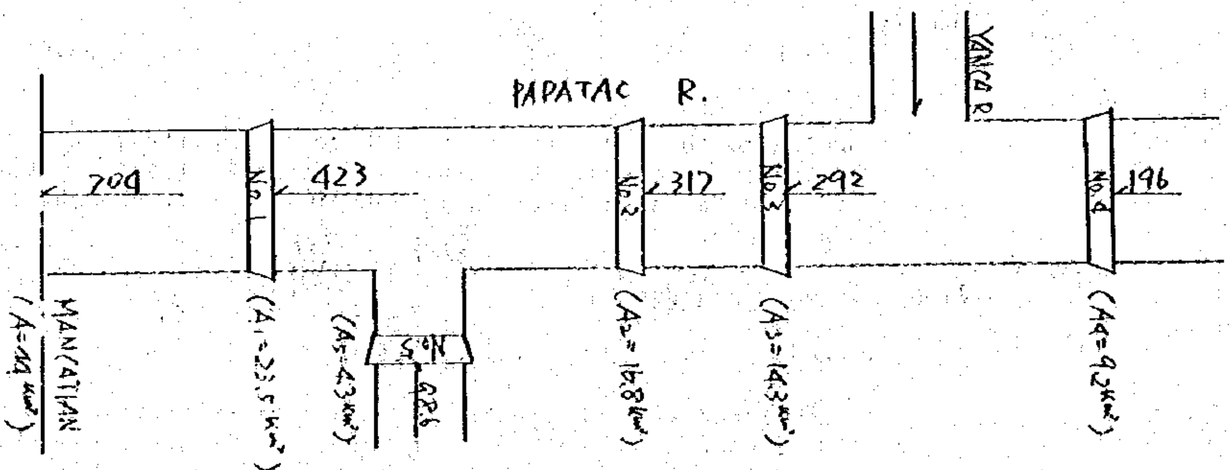


Fig. I - 37 CALCULATED RUNOFF DISCHARGE

— CASE E —



— CASE F —



5-4 Based on the Formula Proposed in Pampanga Basin

According to M.M. Obradovich* below-mentioned the calculation formulars for peak discharge based on discharge records in a period of 1908-1965 covering main rivers all over the Philippines are recommended.

All Philippine .... $Q = 27.5A\ (1.2A^{-0.05}-1)$ ... (5.5)

Cagayan River Basin .. $Q = 269A$ .... (5.6)

Pampanga River Basin.. $Q = 126A$ .... (5.7)

Mindanao .... $Q = 134A$ .... (5.8)

Luzon .... $Q = 22.5A\ (1.1A^{-0.05}-1)$ ... (5.9)

Formula (5.9) is resulted from the data of small rivers with a catchment area of 100 km^2. Though probability discharge obtained from these equations is not so reliable, for reference, the results of calculation of Eq. (5.7) —— Case E and Eq. (5.9) —— Case F are given in the following table.

Calculated Runoff Discharge ——CASE E and CASE F——

		Mancatian	No.1	No.2	No.3	No.4	No.5
A (km^2)		44	23.3	16.8	14.3	9.2	4.3
Q(m^3/s)	CASE E	835	610	516	476	382	261
	CASE F	704	423	317	292	196	98.6

According to the above table, Case F reads smaller values compared with other cases. The results of Equation (5.7) —— Case E utilized for the Pampanga River Basin are similar to those obtained from rainfall data.

III-6 Design Discharge

6-1 Comparison of Runnoff Investigation

Results of runoff investigation in III-5 are summarized in TABLE , CASE B, CASE C and CASE D among the cases in the table have been statistically asured. However, Case C is not reasonable to be adopted to a small river basin with a short time of flood concentration. And Case B is the specific discharge based on discharge data

* [Envelope Curves For Peak Discharges in the Philippines] by Dipl. Evg. M.M. OBRADOVICH, Technical series No.18, WMO/UNDP Project, January, 1973.

all over the Philippines. Therefore, Case D based on rainfall records at Porac shall be used as a design high-water discharge.

6-2 Determination of Design Discharge

Design high-water discharge (probability: T ≒ 80) at each station to which CASED is adopted is presented in the table below. Double section shall be adopted to Pasig Potrero River having a serious variation of flow regime to protect and maintain the levees and the channel. This design high-water discharge is estimated at 120 m^3/s (T = 1.1).

Design Discharge Distribution

	Mancatian	No.1 -DAM	No.2 -DAM	No.3 -DAM	No.4 -DAM	No.5 DAM
A (km^2)	44	23.5	16.8	14.3	9.2	4.3
Q (m^3/s)	900	630	540	480	380	190

Table I-27 COMPARISON OF CALCULATED RUNOFF DISCHARGE

	CASE A	CASE B	CASE C	CASE D	CASE E	CASE F	CASE G
NO.1 DAM	600	620	640	630	610	423	700
NO.2	480	500	620	540	516	317	
NO.3	430	420	580	480	476	292	
NO.4	300	320	(510)	380	382	196	
NO.5	160	190	(280)	190	261	986	
MANCATION	900	900	850	900	835	704	

CASE A ; FROM EQ 2, $Q = 155A/\sqrt{A+13}$

CASE B ; FROM SPECIFIC DISCHARGE DATA (1/T = 1/80)

CASE C ; FROM RAIN FALL DATE (BY USING DR MONONOBE EQ $r = \frac{R}{24}(\frac{24}{T})^{2/3}$)

CASE D ; 〃 (1/T = 1/80)

CASE E ; RUNOFF EQ. $Q = 126A^{\frac{1}{2}}$ (PANPANGA BASIN $A > 100^{km^2}$) BY. M.M. OBRADOVICH

CASE F ; 〃 $Q = 22.5A^{(1.1A^{-0.05}-1)}$ ($A < 100^{km^2}$) 〃

CASE G ; DR. ENDO MEMO.

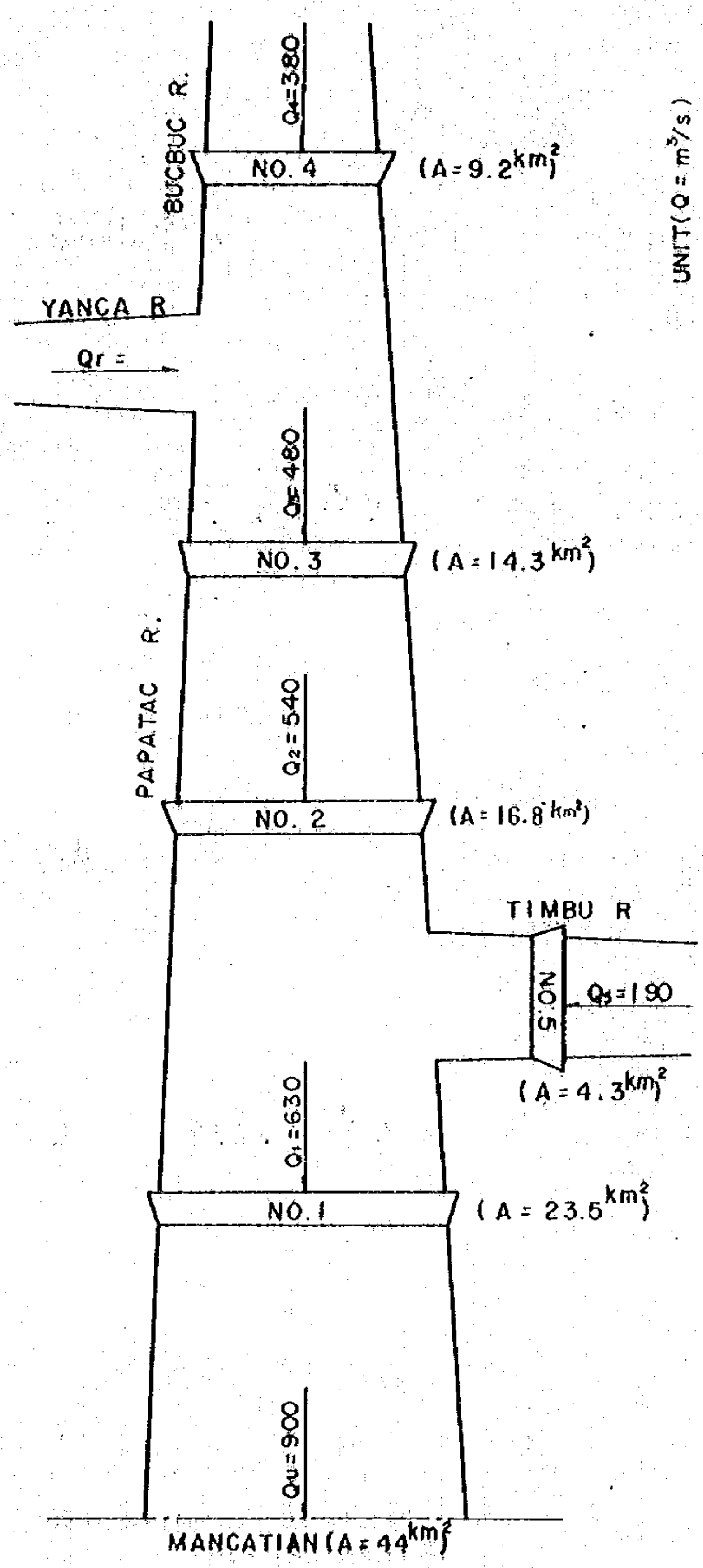


Fig I-38 DESIGN DISCHARGE DISTRIBUTION