

# *TABLES*



**Table D.1 Point Rainfall during Tropical Cyclones in 1991, 1992 and 1993**

(Unit:mm)

Yr.	Tropical Cyclones	Date	Point Rainfall			
			Piz	Sacobia	Zaragoza	Arayat
91	1 T.Diding	Jun. 14	-	-	97	2
	T.Diding	Jun. 15	-	-	127	17
	2 T.Etang	Jul. 11	-	-	0	35
	3 T.S.Helming	Jul. 22	133	-	29	8
	4 T.Luding	Aug. 13	79	-	15	15
	5 T.Trining	Oct. 28	75	67	-	5
6 T.S.Yayang	Nov. 17	-	129	-	-	
92	1 T.Asiang	Jun. 28	77	15	0	-
	2 T.S.Konsing	Jul. 11	83	84	0	-
	3 T.Ditang	Jul. 20	39	67	-	48
	4 T.S.Paring	Oct. 26	65	41	17	-
93	1 T.D.Elang	Jun. 19	0	0	0	7
	2 T.Goring	Jun. 26	193	252	180	108
	3 T.S.Huling	Jul. 7	0	0	0	2
	T.S.Huling	Jul. 8	0	2	9	2
	4 T.S.Ibiang	Jul. 15	0	39	64	37
	T.S.Ibiang	Jul. 16	0	10	14	4
	5 T.D.Walding	Sep. 8	35	8	2	14
	6 T.D.Anding	Sep. 20	-	-	1	13
	7 T.S.Kadiang	Oct. 4	57	182	93	65
	T.S.Kadiang	Oct. 5	102	247	131	97
8 T.D.Epang	Oct. 7	76	44	10	7	
9 T.S.Husing	Nov. 1	97	76	94	81	
10 T.Monang	Dec. 6	15	16	2	7	

Table D.2 Point and Basin Mean Daily Rainfall during Major Floods

Yr.	Date	Point Rainfall					Basin Rainfall					Remarks	
		(Unit:mm)					(Unit:mm)						
		Piz	Sacobia	Zaragoza	Arayat	Abacan	Sacobia-	Bamban	Abacan	Abacan			
74	Aug. 15	(285)	(197)	122	171	220	189						
	16	(282)	(328)	203	169	276	280						
	17	(235)	(86)	54	141	148	103						
	2	(289)	(20)	13	173	144	66						
75	Aug. 9	(152)	(233)	(78)	92	172	191						
	20	(174)	(109)	68	105	130	108						
76	May 22	(178)	(125)	78	107	138	120						
	23	(398)	(143)	89	238	249	172						
	29	(331)	(154)	96	198	223	167						
77	Nov. 14	(184)	(192)	119	111	171	167						
78	Oct. 26	(220)	(346)	(104)	132	251	282						
79	May 12	(28)	(307)	190	18	148	220						
	15	(240)	(9)	6	144	116	49						
	21	0	(250)	155	0	110	175						
80	Nov. 5	(142)	(250)	155	(210)	200	238						
81	Jul. 4	(119)	(122)	76	72	109	107						
	8	(75)	(143)	89	(108)	110	133						
82	Jul. 15	(302)	(210)	130	181	233	201						
83	Jul. 24	(124)	(1)	1	75	58	23						
	14	(77)	(106)	66	47	85	88						
	16	(63)	(62)	39	39	57	55						
84	Oct. 28	(28)	(242)	150	18	119	175						
	29	(152)	(65)	41	92	100	73						
85	Jul. 5	(253)	(368)	(110)	140	267	300						
86	May 18	(306)	(489)	(138)	183	353	397						
87	Aug. 18	(193)	(235)	146	116	194	200						
88	Oct. 24	(111)	(201)	125	(164)	159	190						
90	Jun. 14	(149)	(261)	162	(220)	210	249						
	7	(169)	(294)	182	(251)	237	281						

Yr.	Date	Point Rainfall					Basin Rainfall					Remarks
		(Unit:mm)					(Unit:mm)					
		Piz	Sacobia	Zaragoza	Arayat	Abacan	Sacobia-	Bamban	Abacan	Abacan		
91	Jun. 14	(1)	(156)	97	2	69	110					T.Diding
	15	(26)	(205)	127	17	102	148					T.Diding
	22	133	(46)	29	8	68	35					T.S.Helming
	13	79	(23)	15	15	41	21					T.Loding
	20	91	(30)	19	7	46	23					
	25	86	(35)	22	54	56	40					
	7	85	0	0	0	30	0					
	16	25	93	(19)	0	48	65					
	19	70	78	(19)	0	58	55					
	28	75	67	(22)	5	56	48					T.Tnning
	17	(88)	129	(80)	(55)	98	107					T.S.Yayang
92	May 19	0	0	113	0	3	0					
	28	77	15	0	(15)	36	15					T.Asiang
	11	83	84	0	(39)	72	71					T.S.Konsing
	13	30	85	0	(39)	54	71					
	26	79	48	0	(26)	53	42					
	18	96	54	(34)	(28)	63	46					
	20	140	57	(36)	(30)	80	49					
	28	76	210	(130)	(84)	135	172					
	29	69	170	(106)	(70)	112	140					
	30	48	76	(48)	(36)	57	64					
93	Jun. 26	193	252	180	108	200	209					T.Goring
	2	1	105	0	7	46	76					
	22	(14)	8	82	10	13	9					T.D.Luning
	27	84	47	15	33	56	43					
	30	80	72	10	10	61	53					
	18	(191)	(145)	90	115	153	136					T.S.Rubing
	28	30	130	1	26	70	99					
	30	94	24	1	0	43	17					
	4	57	182	93	65	112	147					T.S.Kadiang
	5	102	247	131	97	162	202					T.S.Kadiang
	7	76	44	10	7	47	33					T.D.Epang
	1	97	76	94	81	85	78					T.S.Iusing

Rainfall in parenthesis indicates estimated rainfall.

Rainfall in parenthesis indicates estimated rainfall.

**Table D.3 List of Rainfall Station in and Around Sacobia-Bamban and Abacan River Basins**

Agency	Station	Location Latitude	Longitude	Type of * Equipment	Remarks
<b>OCD</b>					
	Dolores			T	
	Sapang Bato			T	
	Pasig Potrero			T	
	Porac			T	
	Gumain			T	
<b>PAGASA</b>					
- Hydromet	Balucoc	14deg 58min	120deg 52min	M	
	Becuran	15deg 00min	120deg 34min	M and A	
	Cansinala	14deg 58min	120deg 46min	M and A	
	Lubao	14deg 56min	120deg 33min	M	
	San Agustin	15deg 09min	120deg 46min	A	
	Sta. Cruz	15deg 05min	120deg 33min	A	
- Pampanga	Arayat	15deg 10.10min	120deg 46.93min	A and T	
FFWS	Candaba	15deg 06.98min	120deg 51.02min	A and T	
	San Isidro	15deg 18.82min	120deg 54.15min	A and T	
	San Rafael	14deg 58.80min	120deg 55.60min	A and T	
	Sulipan	14deg 56.37min	120deg 45.52min	A and T	
	Zaragoza	15deg 26.60min	120deg 45.05min	A and T	
- Climate	BAI Magalang	15deg 13min	120deg 42min	M	
	Hacienda Luicita	15deg 26min	120deg 36min	M	
	Masantol	14deg 52min	120deg 42min	M	
	San Julian Subd.	15deg 02min	120deg 42min	M	
<b>PHIVOLCS</b>					
	Cuadrado	15deg 02.59min	120deg 21.22min	T	A/201
	O'Donnell-Upper Bucao	15deg 13.78min	120deg 20.61min	T	G/207
	Piz	15deg 13.26min	120deg 25.03min	T	C/203
	Sacobia	15deg 09.10min	120deg 27.08min	T	F/206
	Summit Rim	15deg 09.13min	120deg 21.55min	T	E/205 **

Note: \*A: Automatic Recorder, T: Telemeter, M: Manual  
 \*\*:in 1991 and 1992, this code was used for Gumain Station

**Table D.4 List of Water Level Gauging Stations in and Around Sacobia-Bamban and Abacan River Basins**

Agency	River	Station	Catchment Area (km <sup>2</sup> )	Location Latitude	Longitude	Type of * Equipment
DPWH	Bamban	San Nicolas	148	15deg 15.63min	120deg 33.43min	M (2)
		San Francisco				M (3)
	Abacan	San Juan				M (3)
		Pasig-Potrero	Cabeltican	242	15deg 59.40min	120deg 38.83min
	O'Donnell	HDA-Dolores	28	15deg 06.65min	120deg 31.97min	M (2)
		Palublub	240	15deg 23.78min	120deg 30.08min	M (2)
	Bangut	Patling	112	15deg 21.37min	120deg 26.45min	M (2)
		Sta. Lucia	90	15deg 22.17min	120deg 29.18min	M (2) and A
	Tarlac	Tibag	872	15deg 29.92min	120deg 34.00min	A
	Porac	Del Carmen	111	14deg 59.57min	120deg 32.08min	M (3)
Valdez		118	14deg 58.92min	120deg 32.10min	M (3)	
Nasudeco		119.1	14deg 59.57min	120deg 32.08min	M (3)	
PAGASA	Tarlac	Tibag	872	15deg 29.92min	120deg 34.00min	A

Note: \* A: Automatic recorder, M: Manual  
 Figures in parenthesis after M indicates times of staff reading a day.

**Table D.5 Monthly and Annual Rainfall In and Around Study Area**

Monthly and Annual Rainfall at San Julian Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1970	-	0.5	4.9	120.9	32.5	259.4	236.5	314.5	507.6	139.6	91.3	30.9	1738.6
1971	4.5	1.0	12.4	24.4	163.7	306.8	386.2	55.4	135.5	351.0	128.5	99.6	1669.0
1972	29.4	40.4	20.9	22.6	135.9	133.7	1982.9	993.9	274.0	13.9	16.8	13.2	3677.6
1973	1.3	0.0	2.0	3.8	46.3	106.9	270.8	312.9	148.6	406.3	145.3	10.7	1454.9
1974	1.8	1.0	71.9	23.4	51.5	410.0	239.9	1041.3	95.9	297.8	319.6	74.7	2628.8
1975	10.2	6.1	6.1	32.7	130.6	144.8	111.0	341.9	137.5	295.5	65.7	156.3	1438.4
1976	0.0	0.0	3.5	30.0	808.2	691.0	307.2	318.4	372.6	33.3	11.4	77.9	2653.5
1977	42.5	0.0	1.3	0.0	50.0	146.5	254.4	361.9	334.9	0.0	217.4	0.0	1408.9
1978	0.0	0.0	0.0	3.8	144.3	79.2	154.3	789.3	178.4	743.2	15.0	11.2	2118.7
1979	0.0	0.0	0.0	18.3	132.6	99.4	183.8	658.8	290.5	60.2	28.5	9.9	1482.0
1980	10.7	0.0	55.3	0.0	95.4	107.8	633.5	171.8	492.0	192.4	59.7	66.4	1885.0
1981	0.0	0.0	0.0	23.4	25.6	372.0	281.8	311.6	145.6	133.8	21.8	76.4	1392.0
1982	0.0	37.0	-	24.2	54.4	198.6	408.4	232.2	350.9	0.0	0.0	25.2	1330.9
1983	3.8	2.8	5.0	0.0	7.4	34.0	234.2	339.0	263.2	63.0	32.6	0.0	985.0
1984	0.0	0.0	71.9	58.0	179.4	304.4	212.8	606.2	99.2	592.6	0.0	0.0	2124.5
1985	0.0	0.0	0.0	183.8	57.8	1007.4	326.4	175.2	214.7	258.6	21.8	18.8	2264.5
1986	91.4	4.6	0.0	6.2	67.3	98.9	497.1	610.8	393.6	424.9	116.7	0.0	2311.5
1987	0.0	0.0	0.0	16.4	84.2	149.4	149.0	148.9	95.7	55.0	152.6	24.0	875.2
1988	0.0	0.0	0.0	57.6	177.2	272.2	49.8	86.1	112.4	254.6	40.0	9.8	1059.7
1989	16.2	19.8	97.4	86.0	176.4	145.6	140.2	183.3	302.0	93.0	70.4	50.4	1380.7
1990	8.6	15.8	27.6	12.0	157.6	379.6	247.2	272.0	439.0	64.2	232.6	27.4	1883.6
1991	18.0	8.4	14.8	12.8	55.6	100.6	387.8	372.4	278.6	135.2	73.6	3.2	1461.0
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	11.4	6.2	18.8	36.2	128.8	252.2	349.8	395.4	257.4	209.5	84.6	35.7	1786.0

Monthly and Annual Rainfall at Becuran Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1976	3.8	5.9	1.8	7.6	795.4	629.7	391.0	402.8	532.9	100.7	33.8	38.6	2944.0
1977	25.9	1.3	4.6	43.2	76.3	154.8	267.3	328.6	397.0	14.6	243.7	0.5	1557.8
1978	0.0	3.3	0.0	0.5	266.3	175.8	339.6	907.6	326.8	511.6	43.3	13.1	2587.9
1979	1.8	0.0	0.0	26.7	222.9	230.8	267.4	831.0	222.4	90.5	63.9	27.4	1984.8
1980	9.4	0.5	68.1	1.3	75.3	115.8	556.4	299.3	534.8	172.2	80.8	36.6	1950.5
1981	1.3	0.0	0.0	0.5	32.6	461.3	314.3	413.2	186.0	137.5	116.1	29.2	1692.0
1982	0.0	13.5	18.6	186.5	107.8	108.1	121.3	168.7	385.0	71.6	9.0	26.4	1216.5
1983	14.5	63.1	42.9	11.2	0.0	31.9	275.0	487.5	118.4	94.8	20.1	0.0	1159.4
1984	0.0	0.0	125.0	46.0	91.5	418.6	365.0	393.4	143.1	209.0	126.5	0.0	1918.1
1985	0.0	0.0	0.0	31.5	50.0	434.4	125.7	56.7	90.5	117.0	90.8	0.0	996.6
1986	35.8	46.5	0.0	0.0	158.8	460.8	314.3	299.8	195.9	178.0	155.2	73.1	1918.2
1987	9.2	0.0	0.0	50.9	36.6	186.4	189.5	126.9	90.4	44.2	66.2	13.4	813.7
1988	6.2	37.8	1.0	4.8	278.1	505.3	354.5	99.1	140.9	463.1	65.3	0.0	1956.1
1989	1.8	1.8	103.5	73.8	136.2	129.6	340.3	470.8	362.7	143.4	82.3	1.3	1847.5
1990	0.5	1.3	1.1	0.3	157.5	-	352.4	594.7	437.5	155.8	95.5	2.3	-
1991	6.2	4.4	5.8	30.2	88.3	180.0	321.1	586.2	358.1	104.4	104.4	3.9	1793.0
1992	4.6	43.8	18.1	0.5	52.0	115.0	-	859.7	642.8	164.0	77.3	3.0	-
1993	0.2	0.0	12.5	53.8	29.7	221.2	327.9	316.8	230.6	264.5	150.5	79.9	1687.6
Average	6.7	12.4	22.4	31.6	147.5	268.2	307.2	424.6	299.8	168.7	90.3	19.4	1798.8

**Table D. 6 Annual Maximum Rainfall for Short Duration  
at San Agustin Station**

Year	5 min.		10 min.		15 min.		30 min.		60 min.		120 min.	
	Date	R (mm)	Date	R (mm)	Date	R (mm)	Date	R (mm)	Date	R (mm)	Date	R (mm)
66	5/21	11.8	6/06	20.4	6/06	28.6	6/06	55.1	6/06	76.5	6/06	82.6
68	6/16	13.6	8/31	17.2	6/16	24.2	6/16	42.4	6/16	42.8	10/15	44.6
69	5/21	17.9	5/21	32.5	5/21	39.2	5/21	56.0	7/20	81.0	7/20	81.5
70	4/02	9.0	4/02	18.0	4/02	22.6	8/11	45.5	8/11	67.0	8/11	78.5
71	10/11	18.8	10/11	18.8	10/11	19.4	9/24	24.7	9/24	35.4	9/24	39.0
72	7/09	16.8	9/04	19.2	7/19	47.5	7/19	48.5	9/10	49.2	9/10	65.5
73	7/05	12.6	7/05	21.0	7/05	25.9	8/26	38.9	8/26	40.5	10/15	53.0
74	11/02	12.0	7/02	19.6	7/02	26.7	11/02	54.0	11/28	99.2	11/02	125.0
75	10/26	12.1	10/26	20.9	10/13	28.1	10/13	36.0	7/31	53.0	7/31	80.5
77	8/02	11.1	8/02	19.2	8/02	25.3	8/02	29.8	9/06	47.6	9/06	51.6

**Table D.7 Probable Rainfall at San Agustin Station  
Obtained from Probable Calculation**

(Unit:mm)

Return Period (Yr.)	Duration				
	5-min	10-min	15-min	30-min	1-hr
100	22.7	30.7	51.1	79.0	123.3
50	21.3	29.2	47.6	73.3	112.4
20	19.4	27.2	42.8	65.5	97.9
10	17.8	25.5	38.9	59.3	86.6
5	16.1	23.6	34.7	52.6	74.7
2	13.2	20.4	27.8	41.8	56.2

Remarks : Number of data is 10 years.

**Table D.8 Correlation and Regression Coefficients for Daily Rainfall**

**Correlation Coefficient for Daily Rainfall**

(1) Zaragoza and Arayat Station	
X	Y
Zaragoza	Zaragoza
Arayat	Arayat
	Piz
	Sacobia
	Arayat

Note : Data in parenthesis indicates number of data.

**(2) Other Stations**

X	Y	Piz	Sacobia	Zaragoza	Arayat
Piz	1.000 (146)	0.611 (77)	0.574 (42)	0.829 (18)	0.641 (41)
Sacobia	0.611 (77)	1.000 (109)	0.851 (28)	0.782 (32)	0.594 (16)
Zaragoza	0.574 (42)	0.851 (28)	1.000 (91)	0.617 (7)	0.355 (9.3)
Arayat	0.641 (41)	0.829 (18)	0.782 (32)	1.000 (64)	0.649 (7.1)

Note : Data in parenthesis indicates number of data.

**Regression Coefficient for Daily Rainfall**

(1) Zaragoza and Arayat Station	
X	Y
Piz	Piz
Sacobia	Sacobia
Arayat	Arayat

$Y = AX + B$

**(2) Other Stations**

X	Y	Piz	Sacobia	Zaragoza	Arayat
Piz	1.817 -30.4	0.992 -14.6	0.617 0.7	0.594 1.6	0.649 7.1
Sacobia	0.55 16.7	1.008 14.7	1.620 -1.1	0.617 0.7	0.355 9.3
Zaragoza	1.008 14.7	1.684 -2.6	2.815 -26	1.541 -11	0.649 7.1
Arayat	1.684 -2.6	2.815 -26	1.541 -11	0.649 7.1	0.649 7.1

$Y = AX + B$



Table D.9 Lahar Monitoring System under PHIVOLCS

1991/92 Lahar Monitoring System

(A) Rain Gauge

Code	Name
A/201	Mt. Cuadrado
B/202	Marella-Sto. Tomas
C/203	Piz
D/204	Mt. Cullinan
E/205	Gumain
F/206	Sacobia

Note: Alphabet code is used for maps and three-digit code is for computer system.

(B) Flow Sensor

Code	Name
010/011/012	Lower Sacobia
020/021/022	Marella-Sto. Tomas
030/031/032	Abacan Gap
040/041/042	Upper Sacobia
050/051/052	Gumain
060/061/062	Pasig-Potrero
070/071/072	Balin-Baquero

Note: Three digit code is used for computer system.  
 In three digit code, the first digit indicates  
 0: normal flow and 1: event flow when the vibration level of sensor exceeds the predetermined threshold level. The third digit indicates:

- 0: full band (10Hz-300Hz)
- 1: low band (10Hz-100Hz)
- 2: high band (101Hz-300Hz)

1993 Lahar Monitoring System

(A) Rain Gauge

Code	Name	Coordinate	Elevation (m)
A/201	Cuadrado	15 deg. 2.59 min. N 120 deg. 21.2 min. E	600
B/202	Bugz	15 deg. 5.05 min. N 120 deg. 16.9 min. E	600
C/203	Piz	15 deg. 13.3 min. N 120 deg. 25 min. E	773
D/204	Kammangi	15 deg. 10.2 min. N 120 deg. 17.9 min. E	600
E/205	Summit Rim	15 deg. 9.13 min. N 120 deg. 21.6 min. E	1,240
F/206	Sacobia	15 deg. 9.1 min. N 120 deg. 27.1 min. E	600
G/207	O'Donnell- Upper Bucao	15 deg. 13.8 min. N 120 deg. 20.6 min. E	588

(B) Flow Sensor

Code	Name	Coordinate	Elevation (m)
010/011/012	Lower Sacobia	15 deg. 10.5 min. N 120 deg. 28 min. E	400
020/021/022	Marella	15 deg. 3.24 min. N 120 deg. 17.6 min. E	300
030/031/032	Lopoton Creek	15 deg. 14.2 min. N 120 deg. 15.3 min. E	218
040/041/042	Upper Bucao	15 deg. 14.4 min. N 120 deg. 18.8 min. E	400
050/051/052	O'Donnell	15 deg. 14.5 min. N 120 deg. 21.9 min. E	418
060/061/062	Pasig-Potrero	15 deg. 8.11 min. N 120 deg. 27.7 min. E	400
070/071/072	Maraunot	15 deg. 11.1 min. N 120 deg. 13.8 min. E	270

**Table D. 10 Constants for Storage Function Model**

**Sacobia-Bamban River**

(1) Constants for Subbasin

Sub-Basin	A (km <sup>2</sup> )	K	p	TL (hr)
SA-B-1	24.11	11.82	0.6	0.310
SA-B-2	12.54	11.07	0.6	0.258
SA-B-3	2.58	9.43	0.6	0.165
SA-B-4	2.88	9.56	0.6	0.171
SA-B-5	4.28	9.95	0.6	0.191
SA-B-6	2.79	9.53	0.6	0.170
SA-B-7	5.02	10.11	0.6	0.200
SA-B-8	8.37	10.64	0.6	0.231
CA-B-1	10.95	10.93	0.6	0.249
CA-B-2	9.85	10.81	0.6	0.241
MA-B-1	12.12	11.04	0.6	0.256
MA-B-2	28.27	12.01	0.6	0.324
MA-B-3	24.21	11.83	0.6	0.311
BL-B-1	20.80	11.65	0.6	0.298
SA-B-9	22.90	11.76	0.6	0.306
SA-B-10	20.78	11.65	0.6	0.298
BA-B-1	8.18	10.61	0.6	0.229
BA-B-2	2.50	9.43	0.6	0.164
BA-B-3	1.50	8.96	0.6	0.143

For Case 2-1, & 2-2, constants below are used.

SA-B-91	11.68	11.00	0.6	0.253
SA-B-92	11.22	10.95	0.6	0.250

(2) Constants for River Channel (Case 1-1 & 1-2)

River Channel	Kc	Pc	K	P	T1	
					1-1	1-2
SA-C01	0.380	0.6	1.230	0.8	0.052	-
SA-C02	0.369	0.6	0.446	0.8	0.017	0.021
SA-C03	0.511	0.6	0.859	0.8	0.031	0.037
SA-C04	0.539	0.6	1.277	0.8	0.044	0.051
SA-C05	0.637	0.6	4.014	0.8	0.109	0.123
BL-C01	0.672	0.6	4.587	0.6	0.080	0.080
SA-C06	0.923	0.6	15.510	0.6	0.114	0.122
CA-C01	0.498	0.6	1.203	0.8	0.062	0.062
MA-C01	0.588	0.6	2.813	0.8	0.101	0.101
BA-C01	0.674	0.6	17.789	0.6	0.086	0.086
BA-C02	1.009	0.6	25.506	0.6	0.129	0.129
BA-C03	1.009	0.6	15.304	0.6	0.062	0.061

(3) Constants for River Channel (Case 2-1 & 2-2)

River Channel	Kc	Pc	K	P	T1	
					2-1	2-2
SA-C051	0.546	0.6	4.786	0.6	0.039	0.044
BA-C02	1.006	0.6	25.443	0.6	0.111	0.115
SA-C06	0.923	0.6	15.510	0.6	0.156	0.156

Constants which are not included in this Table are same as those for case 1-1 and 1-2, respectively.

(4) Constants for River Channel (Case 3-1 & 3-2)

River Channel	Kc	Pc	K	P	T1	
					3-1	3-2
SA-C05	0.570	0.6	2.995	0.6	0.024	0.028
BA-C01	0.674	0.6	17.789	0.6	0.074	0.078
BA-C02	1.009	0.6	25.506	0.6	0.113	0.118
SA-C06	0.923	0.6	15.510	0.6	0.144	0.144

Constants which are not included in this Table are same as those for case 1-1 and 1-2, respectively.

**Abacan River**

(1) Constants for Subbasin

Sub-Basin	A (km <sup>2</sup> )	K	p	TL (hr)
BT-B-1	1.80	9.12	0.6	0.150
BT-B-2	1.97	9.20	0.6	0.154
BT-B-3	3.31	9.69	0.6	0.178
BT-B-4	12.12	11.04	0.6	0.256
BY-B-1	2.25	9.33	0.6	0.160
BY-B-2	6.11	10.31	0.6	0.211
BY-B-3	5.74	10.24	0.6	0.208
AB-B-1	16.33	11.37	0.6	0.278
AB-B-2	13.24	11.13	0.6	0.262
AB-B-3	14.33	11.22	0.6	0.268

(2) Constants for River Channel

River Channel	Kc	Pc	K	P	T1
					T1
BY-C01	0.452	0.6	0.935	0.8	0.0564
BT-C01	0.354	0.6	0.336	0.8	0.0278
BT-C02	0.538	0.6	1.415	0.8	0.0822
AB-C01	0.533	0.6	7.686	0.8	0.0624
AB-C02	0.623	0.6	4.749	0.8	0.0348
AB-C03	0.719	0.6	5.928	0.8	0.0408

**Table D.11 Groundwater Statistical Data**

PROVINCE	TOWN/ CITY	NOS. OF WELLS CONSIDERED	AVERAGE WELL DEPTH (m)	AVERAGE STATIC WATER LEVEL (mbgs)	AVERAGE SPECIFIC CAPACITY (lps/m)
Pampanga	Angeles	28	82.63	11.00	0.79
	Mabalacat	21	36.19	5.50	0.65
	Magalang	17	46.90	3.53	0.91
	Mexico	36	61.10	2.33	1.00
	Arayat	28	40.38	3.05	0.88
	Candaba	26	52.90	3.15	0.49
Tarlac	Bamban	22	12.90	3.70	0.75
	Concepcion	29	12.30	1.80	1.05

**Table D.12 Post-eruption Groundwater and Well Characteristics in the Project Area based on Field Interviews**

PROVINCE	TOWN/ CITY	NO. OF WELLS CONSIDERED	RANGED OF STATIC WATER LEVEL DEPTH (mbgs)	DRILLING DEPTH (m)	WELL CLASSIFI- CATION
Pampanga	Angeles	3	1.8 to 3.0	6 to 12	shallow well
	Mabalacat	13	3.0 to 6.0	6 to 12	shallow well
	Mexico	3	6.0 to 10.4	>61	deep well
Tarlac	Bamban	3	3.0 to 4.6	>18	shallow well
	Concepcion	3	6.0 to 12.0	>12	shallow well

**Table D.13 Post-eruption Groundwater and Well Characteristics based on  
Bureau of Mines and Geo-Sciences' Study**

PROVINCE	TOWN/CITY	NO. OF WELLS CONSIDERED	RANGED OF DRILLING DEPTH (m)	WELL CLASSIFICATION *
Pampanga	Angeles	9	6.09 to 36.57	shallow to deep
	Mabalacat	22	6.06 to 180.0	shallow to very deep
	Mexico	7	5.48 to 32.0	shallow to deep
	Arayat	11	6.09 to 36.57	shallow to deep
	Magalang	12	3.04 to 27.44	shallow to moderately deep
Tarlac		No data		

\* Well classification is based on drilling depth as follows :

Shallow	0 - 6.25 m
Moderately deep	6.26 - 25.0 m
Deep	25.1 - 93.75 m
Very deep	> 93.75 m

Table D.14 Geo-Resistivity Results in Selected Sites in the Project Area

PROVINCE	TOWN/CITY	BARANGAY	RESISTIVITY LAYER	DEPTH (mbgs)	GROUNDWATER CONDITION	
Pampanga	Angeles	Sapang Bato	1st	0 - 1	No available water	
			2nd	1 - 10	Good aquifer	
			3rd	10 - 40	Good aquifer	
			4th	40 - 100	Good aquifer	
			5th	100 - 200	Good aquifer	
		Tacando	1st	0 - 2	No available water	
			2nd	2 - 12	No available water	
			3rd	12 - 200	Good aquifer	
		San Angelo	1st	0 - 1	No available water	
			2nd	1 - 9	Good aquifer	
			3rd	9 - 45	Good aquifer	
			4th	45 - 200	Good aquifer	
		Calibutbut	1st	0 - 1.4	No available water	
			2nd	1.4 - 10.64	Dry formation	
			3rd	10.64 - 98.64	Good aquifer	
			4th	98.64 - 200	clay	
		Mabalacat	Sta. Maria	1st	0 - 1	No available water
				2nd	1 - 3	Dry formation
				3rd	3 - 42	Good aquifer
				4th	42 - 200	Good aquifer
	Dau Expressway		1st	0 - 1.7	No available water	
			2nd	1.7 - 11.9	Dry formation	
	Mexico		Pandacacay	3rd	11.9 - 200	Good aquifer
				1st	0 - 1	No available water
				2nd	1 - 2.5	Dry formation
			San Jose	3rd	2.5 - 37.5	Good aquifer
		4th		37.5 - 200	Poor aquifer	
		1st		0 - 1.4	No available water	
	2nd	1.4 - 21		Good aquifer		
	San Juan	3rd	21 - 120	Poor aquifer		
		4th	120 - 200	Good aquifer		
		1st	0 - 1.1	No available water		
		2nd	1.1 - 7.7	Good aquifer		
	Dayot	3rd	7.7 - 17.5	Good aquifer		
		4th	17.5 - 200	Poor aquifer		
		1st	0 - 1	No available water		
		2nd	1 - 4	Good aquifer		
	Dolores	3rd	4 - 104	Poor aquifer		
		4th	104 - 200	clay		
		1st	0 - 1	No available water		
2nd		1 - 61	Poor aquifer			
Magalang	San Roque	3rd	61 - 200	Good aquifer		
		1st	0 - 1	No available water		
		2nd	1 - 5	Good aquifer		
		3rd	5 - 25	Good aquifer		
	La Paz	4th	25 - 200	Poor aquifer		
		1st	0 - 1	No available water		
		2nd	1 - 10	Good aquifer		
		3rd	10 - 150	Poor aquifer		
Tarlac	Concepcion	Sto. Nino	1st	0 - 5	No available water	
			2nd	5 - 18	Good aquifer	
			3rd	18 - 70	Poor aquifer	
			4th	70 - 200	Good aquifer	
	Tinang	1st	0 - 3	No available water		
		2nd	3 - 200	Good aquifer		
	Bamban		1st	0 - 3	No available water	
			2nd	3 - 46	Good aquifer	
			3rd	46 - 200	Poor aquifer	

**Table D.15 Potential Maximum Number of Wells in the Project Area**

PROVINCE	TOWN/CITY	POTENTIAL MAXIMUM NO. OF WELLS *	
		SW	DW
Pampanga	Angeles	2220	20
	Mabalacat	1550	100
	Magalang	1530	10
	Mexico	1390	-
	Arayat	1530	10
	Candaba	2630	-

\* Estimated as inflow/average capacity per well

Table D.16 Summary of Water Quality Standards

CRITERIA	PHILIPPINES (NPCC)		WORLD HEALTH ORGANIZATION	
	surface water Class D*	ground water GA** GB***	surface water	ground water
Dissolved Oxygen (DO), ppm	3	-	-	-
pH	6.0 - 8.5	6.0 - 8.5	-	6.5 - 8.5
Total Dissolved Solids (TDS)	1000	1000	1000	1000
Temperature	increases by 3	-	-	-
Calcium, mg/l	-	75	-	-
Magnesium, mg/l	-	50	-	-
Chlorides, mg/l	-	200	250	250
Hardness, mg/l	-	-	500	500
Coliform	-	50	-	0 - 10
<b>HEAVY METALS</b>				
Chromium (Cr), mg/l	0.10	0.05	-	0.05
Iron (Fe), mg/l	5.0	1.0	-	0.5
Copper (Cu), mg/l	0.20	1.0	-	1.0
Zinc (Zn), mg/l	2.0	5.0	-	5.0
Arsenic (As), mg/l	0.10	0.05	-	0.05
Cadmium (Cd), mg/l	0.01	0.01	-	0.005
Mercury (Hg), mg/l	-	0.002	-	0.001
Lead (Pb), mg/l	5.0	0.05	-	0.05

\* Class D = used for irrigation, agriculture

\*\* GA = Domestic water supply

\*\*\* GB = for irrigation, agriculture

Note: Sources used are : Philippines = NPCC; World Health Organization = WHO, 1984.

Table D.17 Physico-Chemical Aspects, Soil Organic Matter Content and Gross Primary Productivity of Sapang Bato

STATION Nos.	Temperature (°C)	Color	pH	Turbidity	DO (ppm)	Ortho-P (ppm)	Alkalinity (ppm)	Nitrate (ppm)	Ca (ppm)	Mg (ppm)	Total Hardness (mg CaCO <sub>3</sub> )	Specific Conductance (µ mhos/cm)	Chlorides (ppm)	Soil O.M. (%)	Gross Primary Productivity (gC/M <sup>2</sup> /day)
1	28	clear	6.3	clear	4.60	1.50	66.00	1.152	9.42	9.03	60	12032.10	16	3.91	0.75
2	28	clear	6.3	clear	5.55	1.70	62.10	1.645	9.61	12.07	174	11922.45	21	0.16	1.35
3	28	clear	6.3	clear	5.65	2.17	67.00	1.810	12.88	6.54	59	12088.61	28	0.73	2.10

Table D.18 Chemical Attributes of the Abacan River

STATION	pH	Conductivity (µmhos/cm)	Nitrate (ppm)	Ortho-P (ppm)	Alkalinity (ppm CaCO <sub>3</sub> )	Ca (ppm)	Mg (ppm)	Total Hardness (mg CaCO <sub>3</sub> )	Total Hardness (mg CaCO <sub>3</sub> )	Chloride (ppm)	Total Solids (mg/mg <sub>3</sub> )
1	7.5	19635.00	1.240	2.66	67	12.51	14.40	90	31	27	182
2	7.35	19635.00	1.240	3.25	64	15.23	6.83	66	38	13	160
3	7.45	19380.00	1.590	3.65	66	14.20	14.02	64	35	20	178
Average	7.43	19550.00	1.357	3.187	66	13.98	11.75	73	35	20	173



Table D.19 Water Quality of Three Central Luzon Rivers before the Mt. Pinatubo Eruption

STATION	pH	DO (ppm)	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Hardness (mg/l)	Cl (mg/l)	DATE
Sto. Nino, San Fernando, Pampanga	7.3	0	-	-	-	160.00	452.00	NWRC, 1983
San Jose, San Fernando, Pampanga	7.5	0.05	-	-	-	250.00	226.00	NWRC, 1983
Rio chico River, Zaragoza, Nueva Ecija	6.6	-	285.330	756.67	10.25	114.50	33.42	DPWH, 1986-87
	7.2	-	196.980	92.50	7.29	122.50	68.19	DPWH, 1989-90

Table D.20 Water Quality of Three Central Luzon Rivers after the Mt. Pinatubo Eruption

STATION	pH	DO (ppm)	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Hardness (mg/l)	Cl (mg/l)	DATE
Rio Chico River, Zaragoza, Nueva Ecija	6.65	-	186.25	110.00	21.87	200	95.00	DPWH 1991 - 92
	6.00	-	154.125	125.00	13.365	180	46.25	DPWH, 1993
Sacobia River, Concepcion, Tarlac	-	-	180.00	130.00	58.22	205	50.60	DPWH, Jan. - June 1994
Sacobia River, San Francisco, Capus, Tarlac	-	-	423.00	270.00	31.59	400	70.00	DPWH, 1991 - 92
Sacobia River, Concepcion, Tarlac	-	-	942.50	542.50	72.90	842.5	100.00	DPWH, 1993
	-	-	938.17	573.33	85.95	923.33	80.525	DPWH, Jan. - June 1994
Abacan River, San Juan, Mexico, Pampanga	-	-	319.25	185.00	15.795	240	80.00	DPWH, 1993
	-	-	209.67	165.00	3.645	160	38.97	DPWH, Jan. - June 1994

Table D.21 Surface Water Quality Data from Various River Sources after the Eruption of Mt. Pinatubo

STATION	pH	DO (ppm)	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Hardness (mg/l)	Cl (mg/l)	DATE
Sapang Libutad, Angeles City, Pampanga	7.0	6	1000	127.45	28.915	437.33	0.055	Sept. 1994
Dolores, Mabalacat, Pampanga	7.5	7	2266.67	204.40	132.81	1057.33	0.117	Sept. 1994
Sapang Bato, Angeles City, Pampanga	7.8	6	766.67	125.85	2.68	325.33	0.025	Sept. 1994
San Pablo, Mexico, Pampanga	6.5	6	800	60.65	19.88	233.33	0.045	Sept. 1994
Bamban, Tarlac	7.8	8	900	82.56	13.07	260.00	0.067	Sept. 1994
Chico River, Culiangan, Concepcion, Tarlac	6.8	4	833.33	76.42	6.11	216.00	0.055	Sept. 1994
San Francisco Bridge, Concepcion, Tarlac	7.5	6	1350	80.96	23.44	298.67	0.047	Sept. 1994
Sapang Bitas, Brgy. Dolores, Magalang, Pampanga	6.5	6	1516.67	233.80	116.96	1065.33	0.109	Sept. 1994

Table D.22 Water Quality Data from Groundwater in Pampanga and Tarlac (1/4)

LOCATION	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	Classification	Source
Dolores, Mabalacat, Pampanga	6.15	520	38	8.2	51.45	shallow well	IGST, 1991
Cacutud, Mabalacat, Pampanga	6.5	300	26.5	8.9	25.97	shallow well	IGST, 1991
Mamatitang, Mabalacat, Pampanga	6.3	722	40	11.1	90.41	shallow well	IGST, 1991
Sta. Maria, Mabalacat, Pampanga	6.5	269	10	3.5	3	shallow well	IGST, 1991
Sio. Rosario, Mabalacat, Pampanga	6.9	623	49.5	26.0	41.46	shallow well	IGST, 1991
Duquit, Mabalacat, Pampanga	6.6	395	31	9.3	31.09	shallow well	IGST, 1991
MEAN*	6.49	471.5	32.5	11.17	40.56	-	-
Tabun, Mabalacat, Pampanga	6.42	281.5	28	6.4	25.97	moderately deep	IGST, 1991
Tabun, Mabalacat, Pampanga	6.3	270	16.5	4.6	14.99	moderately deep	IGST, 1991
Bundagul, Mabalacat, Pampanga	6.85	348	23	6.3	26.97	moderately deep	IGST, 1991
Sio. Rosario, Mabalacat, Pampanga	7	246	14.5	5.5	9.49	moderately deep	IGST, 1991
Sia. Ines, Mabalacat, Pampanga	6.75	233	14.5	4.4	5	moderately deep	IGST, 1991
Mabiga, Mabalacat, Pampanga	7.15	348	24.5	12.2	22.48	moderately deep	IGST, 1991
San Francisco, Mabalacat, Pampanga	6.85	451	25	6.8	31.97	moderately deep	IGST, 1991
Mabiga, Mabalacat, Pampanga	7.2	222	14.5	4.4	5	moderately deep	IGST, 1991
Camachile, Mabalacat, Pampanga	7.3	202	13	3.9	4.98	moderately deep	IGST, 1991
Mabiga, Mabalacat, Pampanga	7.6	3.4	21.5	8.2	1.49	moderately deep	IGST, 1991
MEAN	6.94	260.49	19.5	6.27	14.83	-	-
Cacutud, MWD** Mabalacat, Pampanga	6.85	270	21	6.9	10.99	very deep	IGST, 1991
Mun. Hall, MWD Mabalacat, Pampanga	8	284	19	6.8	3.5	very deep	IGST, 1991
Public Market, MWD Mabalacat, Pampanga	7.6	275	13.5	4.7	2	very deep	IGST, 1991
Dona Maria, MWD Mabalacat, Pampanga	7.3	267	14.5	5.1	5.99	very deep	IGST, 1991
Dona Anastacia, MWD Mabalacat, Pampanga	7	286	19.5	7.1	5.99	very deep	IGST, 1991
Filipiniana, Mabalacat, Pampanga	7.4	264	11	4.6	4.5	very deep	IGST, 1991
MEAN	7.36	274.33	16.42	5.87	5.5	-	-
OVERALL MEAN***	6.93	335.44	22.81	7.77	20.3	-	-

Table D.22 Water Quality Data from Groundwater in Pampanga and Tarlac (2/4)

LOCATION	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	Classification	Source
Pulung Maragul, Angeles City, Pampanga	7.1	908	28.8	26	91	shallow well	IGST, 1991
Pulung Maragul, Angeles City, Pampanga	6.85	998	35.6	23.3	209.2	shallow well	IGST, 1991
Pandan, Angeles City, Pampanga	6.9	288	14.4	7.7	7.42	shallow well	IGST, 1991
MEAN*	6.95	731.53	26.27	19	102.54	-	-
Sapang Libutad, Angeles City, Pampanga	7.15	358	19.7	18	28.19	moderately deep	IGST, 1991
Pulung Cacuud, Angeles City, Pampanga	7.2	217	10.3	7.2	ND	moderately deep	IGST, 1991
Mining, Angeles City, Pampanga	7.05	274	15.6	11.8	16.82	moderately deep	IGST, 1991
MEAN	7.13	283	15.2	12.33	15	-	-
Angeles City Water District	7.15	259	11	4.8	ND	very deep	IGST, 1991
Sto. Domingo, Angeles City, Pampanga	7.5	337	14.2	9.8	ND	very deep	IGST, 1991
Angeles City E/S	7.25	256	10.8	5	2.47	very deep	IGST, 1991
Angeles City, Pampanga	7.4	275	13.2	7.4	8.9	very deep	IGST, 1991
MEAN	7.33	281.25	12.3	6.75	2.84	-	-
OVERALL MEAN***	7.14	431.86	17.92	12.69	36.4	-	-

Table D.22 Water Quality Data from Groundwater in Pampanga and Tarlac (3/4)

LOCATION	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	Classification	Source
Tibang, Concepcion, Tarlac	7.25	362	36	15.8	37.59	shallow well	IGST, 1991
Talimundoc, Concepcion, Tarlac	7.65	272	13	11.3	13.85	shallow well	IGST, 1991
Bancal, Concepcion, Tarlac	7.4	360	14.4	13	10.88	shallow well	IGST, 1991
Macabaclic, Concepcion, Tarlac	7	637	27.6	26.8	67.76	shallow well	IGST, 1991
Macabaclic, Concepcion, Tarlac	7.4	542	19.4	22.6	25.72	shallow well	IGST, 1991
Alfonso, Concepcion, Tarlac	7.4	549	17.8	21.8	53.41	shallow well	IGST, 1991
MEAN*	7.35	453.67	21.37	18.55	34.87		
Murcia, Concepcion, Tarlac	7.2	298	21	10.9	ND	moderately deep	IGST, 1991
Tinang, Concepcion, Tarlac	6.8	299	23	7.7	11.87	moderately deep	IGST, 1991
Talimundoc, Concepcion, Tarlac	7.2	283	29.5	12	9.89	moderately deep	IGST, 1991
Pao, Concepcion, Tarlac	7.1	247	15	13.8	4.95	moderately deep	IGST, 1991
Sto. Cristo, Concepcion, Tarlac	7.8	367	16.8	20.5	31.65	moderately deep	IGST, 1991
San Jose, Concepcion, Tarlac	7.15	334	16	13.8	20.28	moderately deep	IGST, 1991
Sta. Cruz, Concepcion, Tarlac	7.35	518	16	16.8	46.49	moderately deep	IGST, 1991
Cafe, Concepcion, Tarlac	7.5	371	22.7	18.9	4.95	moderately deep	IGST, 1991
Taede, Concepcion, Tarlac	7.3	368	18	19.3	6.92	moderately deep	IGST, 1991
Sa. Rita, Concepcion, Tarlac	6.9	724	36	33.5	96.94	moderately deep	IGST, 1991
San Nicolas, Concepcion, Tarlac	7.2	507	19	17.1	55.89	moderately deep	IGST, 1991
Santiago, Yanga, Concepcion, Tarlac	7.35	404	16.4	8.4	41.05	moderately deep	IGST, 1991
Santiago, Concepcion, Tarlac	7.2	566	23.4	23.5	36.1	moderately deep	IGST, 1991
Alfonso, Concepcion, Tarlac	7.85	572	27.6	18	96.94	moderately deep	IGST, 1991
MEAN	7.28	418.43	21.31	16.73	33.14		
OVERALL MEAN***	7.31	436.05	21.34	17.64	34.00		

Table D.22 Water Quality Data from Groundwater in Pampanga and Tarlac (4/4)

LOCATION	pH	TDS (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl (mg/l)	Classification	Source
Anupul, Bamban, Tarlac	7.2	399	35.5	13.5	48.47	shallow well	IGST, 1991
San Pedro, Bamban, Tarlac	7	340	16	11.8	19.29	shallow well	IGST, 1991
Anupul, Bamban, Tarlac	6.18	522	36.8	15	58.86	shallow well	IGST, 1991
MEAN*	6.79	420.53	29.43	13.43	42.21	-	-
Pag-asa, Bamban, Tarlac	7	252	9.4	6.9	ND	moderately deep	IGST, 1991
San Pedro, Bamban, Tarlac	7.15	291	13.6	8.1	14.34	moderately deep	IGST, 1991
Rolling Hills, Bamban, Tarlac	7.05	330	13.2	9.4	3.96	moderately deep	IGST, 1991
MEAN	7.07	291	12.07	8.15	6.1	-	-
OVERALL MEAN***	6.93	355.67	20.75	10.78	24.15	-	-

\* MEAN = average of each parameter according to classification

\*\*MWD = Mabalacat Water District

\*\*\*OVERALL MEAN = average of each parameter for each area (e.g. Mabalacat, Pampanga)

Table D.23 Typical Groundwater Data

STATION	TDS (mg/l)	coliform (MPN/100m)	Ca (mg/l)	Mg (mg/l)	Hardness (mg/l)	Cl (mg/l)	DATE
Sapang Libutad, Angeles City, Pampanga	866.67	25	118.10	46.94	488	0.068	Sept. 1994
Sapang Baro, Angeles City, Pampanga	700	-	87.64	ND*	148	0.023	Sept. 1994
Clark Air Base, Angeles City, Pampanga	450	0	125.85	ND	112	0.017	Sept. 1994
Cacutud, Mabalacat, Pampanga	750	0	62.52	17.15	226.67	0.038	Sept. 1994
Bamban, Tarlac	583.33	0	48.90	12.77	174.67	0.039	Sept. 1994
Culiatangan, Concepcion, Tarlac	1100	13	69.74	37.05	326.67	0.139	Sept. 1994

\* ND = non-detectable

**Table D.24 Microbiological Analysis Undertaken on Groundwater Supplies in Selected Places in Pampanga and Tarlac**

LOCATION	CFU/mL	MPN/100ml	
		E.coli per 100ml	MPN
Sapang Libutad	2.3	25	13
Bamban	1.0	0	0
Culatingan	1.3	13	2
Cacutud	9.9	0	0
Clark Air Base faucet	7.0	0	0

CFU - colony forming units

MPN - most probable number



Table D.25 Daily Rainfall Observed by JICA Stations

Station : Sacobia  
 Year : 1994  
 Agency : JICA

(Unit : mm)

	Jul	Aug	Sep	Oct	Nov	Dec
1			0.0	0.0	0.0	0.0
2		29.5	1.5	0.0	0.0	0.0
3		6.0	1.5	0.0	0.0	0.0
4		0.0	6.0	0.0	0.0	0.0
5		0.0	0.0	0.0	0.0	0.0
6		0.0	0.0	0.0	0.0	0.0
7		0.0	27.0	0.0	0.0	0.0
8		0.0	18.0	0.0	0.0	0.0
9		1.0	0.0	0.0	0.0	0.0
10		93.0	37.0	0.0	0.0	0.0
11		0.0	0.0	0.0	0.0	0.0
12		0.0	0.5	0.0	0.0	0.0
13		0.0	47.0	0.5		
14		0.0	2.0	21.0		
15		0.0	0.0	0.0	0.0	0.0
16		1.5	3.0	0.0		
17		16.0	4.0	0.0		
18		0.0	0.0	0.0	0.0	0.0
19		0.0	30.0	0.0		
20		0.0	23.0	0.0		
21		0.0	6.0	72.0		
22		0.0	0.0	29.0		
23		6.0	0.0	0.0	0.0	0.0
24		8.0	24.0	0.0		
25		28.0	53.0	0.0		
26		7.0	4.5	0.0		
27		0.0	0.0	0.0	0.0	0.0
28		0.5	2.0	0.0		
29		57.0	9.0	0.0		
30		4.0	0.0	0.0		
31		9.0	0.0	0.0		
Total	266.5	301.2	122.5	Annual Total =		
Daily Max	93	53	72			
Rainy Day	14	19	4			

Station : Bamban  
 Year : 1994  
 Agency : JICA

(Unit : mm)

	Jul	Aug	Sep	Oct	Nov	Dec
1		5.0	91.0			
2		26.0	3.5			
3		115.5	0.5			
4		10.5	0.0			
5		11.0	4.5			
6		10.0	1.0			
7		13.0	0.5			
8		16.5	35.5			
9		0.5				
10		0.0				
11		0.0				
12		0.0				
13		0.0				
14		0.0				
15		0.0				
16		0.0				
17		0.0				
18		0.0				
19		0.0				
20		2.0				
21		0.0				
22		0.0				
23		47.5	0.0			
24		23.0	75.0			
25		3.5	52.5			
26		4.0	17.5			
27		0.1	0.5			
28		3.5	0.0			
29		2.0	7.5			
30		11.4	118.0			
31		57.1	28.0			
Total	152.1	509.0	136.5	Annual Total =		
Daily Max	57.1	118.0	91.0			
Rainy Day	9	17	25			

Station : Angeles  
 Year : 1994  
 Agency : JICA

(Unit : mm)

	Jul	Aug	Sep	Oct	Nov	Dec
1		7.0	0.0	0.5		
2		46.5	3.0	0.0		
3		56.0	3.0	0.0		
4		1.0	2.0	0.0		
5		6.0	10.0	5.5		
6		18.5	0.0	0.0		
7		23.0	34.0	0.0		
8		0.0	10.5	0.0		
9		0.0	7.5	0.0		
10		0.0	33.0	0.0		
11		0.0	0.0	0.0		
12		0.0	8.0	0.0		
13		0.0	31.0	37.5		
14		0.0	44.0	49.5		
15		0.0	1.0	0.0		
16		0.0	2.0	0.0		
17		15.0	2.0	2.0		
18		0.0	18.5	0.0		
19		0.0	6.0	0.0		
20		0.0	33.5	0.0		
21		0.0	55.5	87.5		
22		0.0	1.0	27.5		
23		33.5	27.5	1.0	0.0	
24		54.5	8.0	11.5	0.0	
25		31.5	43.5	51.0	0.0	
26		3.0	0.5	12.0	0.0	
27		3.5	0.0	0.5	0.0	
28		6.0	1.5	0.0	0.0	
29		14.0	125.0	5.0	0.0	
30		41.5	4.5	0.0	2.0	
31		42.0	41.0	0.0		
Total	229.5	424.5	386.5	212.0	Annual Total =	
Daily Max	54.5	125.0	55.5	87.5		
Rainy Day	9	16	25	8		

Table D.26 Groundwater Level Observed by JICA Station (1/4)

Station : Gucco E/S  
Year : 1994

	(Unit : m)				Agency :	JICA
	Jul	Aug	Sep	Oct		
1	2.62	1.90	1.25	1.53		
2	2.56	1.82	1.26	1.55		
3	2.48	1.77	1.27			
4	2.38	1.73	1.29			
5	2.29	1.72	1.30			
6	2.21	1.70	1.32			
7	2.17	1.70	1.34			
8	2.10	1.70	1.37			
9	2.07	1.68	1.39			
10	2.04	1.67	1.41			
11	2.02	1.66	1.43			
12	2.00	1.64	1.46			
13	1.99	1.63	1.49			
14	1.99	1.62	1.51			
15	1.99	1.59	1.52			
16	2.00	1.55	1.53			
17	2.00	1.52	1.53			
18	2.00	1.50	1.53			
19	2.01	1.48	1.54			
20	3.58	2.02	1.47	1.55		
21	3.42	2.04	1.45	1.56		
22	3.28	2.05	1.43	1.58		
23	3.18	2.07	1.40	1.55		
24	3.13	2.08	1.38	1.52		
25	3.06	2.10	1.36	1.50		
26	3.00	2.11	1.33	1.49		
27	2.90	2.10	1.30	1.49		
28	2.83	2.09	1.27	1.49		
29	2.80	2.09	1.26	1.50		
30	2.75	2.08	1.25	1.51		
31	2.70	1.98	1.22	1.52		
Average	3.05	2.12	1.55	1.45		1.54

Station : Dau E/S  
Year : 1994

	(Unit : m)				Agency :	JICA
	Jul	Aug	Sep	Oct		
1	3.89	3.20	3.09	3.15		
2	3.80	3.20	3.09	3.15		
3	3.78	3.19	3.09	3.15		
4	3.70	3.19	3.02	3.15		
5	3.69	3.11	3.03	3.15		
6	3.61	3.09	3.15	3.15		
7	3.55	3.09	3.15	3.15		
8	3.50	3.09	3.15			
9	3.45	3.09	3.15			
10	3.35	3.09	3.15			
11	3.30	3.09	3.15			
12	3.25	3.09	3.15			
13	3.20	3.09	3.15			
14	3.20	3.09	3.15			
15	3.19	3.09	3.15			
16	3.18	3.09	3.13			
17	3.12	3.09	3.12			
18	3.11	3.09	3.15			
19	3.10	3.09	3.15			
20	3.10	3.09	3.15			
21	3.11	3.09	3.15			
22	3.12	3.09	3.15			
23	3.17	3.09	3.15			
24	3.15	3.09	3.13			
25	4.19	3.19	3.09	3.14		
26	4.30	3.19	3.09	3.15		
27	4.30	3.19	3.09	3.15		
28	4.09	3.19	3.09	3.15		
29	4.00	3.20	3.09	3.15		
30	3.98	3.20	3.09	3.15		
31	3.90	3.20	3.15	3.15		
Average	4.11	3.32	3.10	3.13		3.15

Station : Mahabacat E/S  
Year : 1994

	(Unit : m)				Agency :	JICA
	Jul	Aug	Sep	Oct		
1	1.60	0.85	1.50	2.00		
2	1.53	0.82	1.58	2.02		
3	1.40	0.80	1.60	2.06		
4	1.00	1.00	1.65			
5	1.04	1.09	1.70			
6	1.01	1.13	1.70			
7	1.09	1.20	1.75			
8	1.00	1.15	1.80			
9	1.10	1.19	1.82			
10	1.18	1.11	1.89			
11	1.22	1.05	1.90			
12	1.30	1.10	1.93			
13	1.35	1.15	1.99			
14	1.40	1.10	2.00			
15	1.49	1.11	1.95			
16	1.51	1.20	1.90			
17	1.59	1.25	1.94			
18	1.60	1.30	1.99			
19	1.65	1.40	2.00			
20	1.70	1.35	2.05			
21	1.75	1.30	2.09			
22	2.80	1.80	2.25	2.00		
23	2.78	1.92	2.25	1.80		
24	2.69	1.80	1.30	1.80		
25	2.50	1.70	1.38	1.79		
26	2.35	1.69	1.40	1.85		
27	2.28	1.69	1.40	1.85		
28	2.20	1.70	1.37	1.89		
29	2.10	1.70	1.40	1.90		
30	2.18	1.40	1.48	1.95		
31	1.98	1.10	1.99			
Average	2.39	1.45	1.20	1.86		2.03

Table D.26 Groundwater Level Observed by JICA Station (2/4)

Station: Sio. Rosano, Nag E/S  
Year: 1994

	(Unit: m)				Agency:	JICA
	Jul	Aug	Sep	Oct		
1	1.62	1.13	1.42	1.81		
2	1.50	1.25	1.46	1.84		
3	1.40	1.30	1.50	1.87		
4	1.25	1.33	1.55	1.90		
5	1.30	1.36	1.60			
6	1.30	1.38	1.64			
7	1.30	1.41	1.78			
8	1.30	1.33	1.72			
9	1.33	1.35	1.76			
10	1.37	1.40	1.80			
11	1.40	1.30	1.83			
12	1.45	1.32	1.86			
13	1.50	1.35	1.90			
14	1.51	1.33	1.93			
15	1.56	1.28	1.96			
16	1.60	1.32	1.99			
17	1.64	1.31	2.01			
18	1.67	1.32	2.04			
19	1.67	1.29	2.07			
20	1.71	1.30	2.09			
21	1.75	1.21	2.11			
22	2.52	1.78	1.19	1.92		
23	2.48	1.82	1.29	1.76		
24	2.38	1.54	1.32	1.77		
25	2.22	1.40	1.35	1.79		
26	2.12	1.31	1.32	1.77		
27	2.02	1.34	1.26	1.66		
28	2.00	1.38	1.31	1.68		
29	1.96	1.40	1.36	1.72		
30	1.91	1.13	1.40	1.76		
31	1.82	1.20		1.79		
Average	2.14	1.47	1.31	1.79	1.86	

Station: Sn. Francisco E/S  
Year: 1994

	(Unit: m)				Agency:	JICA
	Jul	Aug	Sep	Oct		
1	0.28	0.40	0.78	1.25		
2	0.33	0.40	0.81	1.28		
3	0.32	0.48	0.85	1.32		
4	0.18	0.55	0.90	1.28		
5	0.30	0.62	0.95			
6	0.40	0.68	1.05			
7	0.45	0.72	1.15			
8	0.48	0.78	1.22			
9	0.52	0.79	1.28			
10	0.58	0.80	1.35			
11	0.63	0.81	1.44			
12	0.70	0.79	1.56			
13	0.75	0.79	1.66			
14	0.85	0.80	1.70			
15	0.92	0.70	1.75			
16	1.00	0.58	1.76			
17	1.02	0.40	1.75			
18	1.05	0.39	1.70			
19	1.08	0.43	1.68			
20	1.10	0.46	1.65			
21	0.40	1.12	0.40	1.63		
22	0.48	1.17	0.33	1.65		
23	0.50	1.20	0.35	1.61		
24	0.40	1.22	0.40	1.53		
25	0.30	0.98	0.50	1.52		
26	0.38	0.80	0.58	1.48		
27	0.45	0.73	0.64	1.37		
28	0.48	0.72	0.68	1.30		
29	0.50	0.73	0.70	1.25		
30	0.55	0.80	0.73	1.22		
31	0.55	0.68		1.22		
Average	0.45	0.74	0.59	1.38	1.28	

Station: San Juan, Mexico E/S  
Year: 1994

	(Unit: m)				Agency:	JICA
	Jul	Aug	Sep	Oct		
1			5.12	4.90	5.08	
2			5.12	4.90	5.08	
3		1.36	5.12	4.90	5.02	
4		1.27	5.12	5.08	5.02	
5		1.28	5.12	5.20		
6		1.31	5.12	5.20		
7		1.35	5.12	5.08		
8		1.36	5.12	5.08		
9		1.40	5.12	5.08		
10		1.44	5.12	5.08		
11		1.49	5.12	5.08		
12		1.53	5.12	5.08		
13		5.12	5.08	5.08		
14		5.12	5.08	5.08		
15		5.12	5.10	5.08		
16		5.12	5.08	5.08		
17		5.12	5.08	5.08		
18		5.12	5.09	5.08		
19		5.12	5.09	5.08		
20		5.12	5.10	5.08		
21		5.12	5.10	5.08		
22		5.12	5.10	5.08		
23		5.12	5.10	5.08		
24		5.12	5.10	5.08		
25		5.12	5.10	5.08		
26		5.12	5.10	5.08		
27		5.12	5.10	5.08		
28		5.12	4.85	5.08		
29		5.12	4.85	5.08		
30		5.12	4.85	5.08		
31		5.12		5.08		
Average		3.83	5.08	5.07	5.05	

Table D.26 Groundwater Level Observed by JICA Station (3/4)

Station : Bamban E/S  
 Year : 1994  
 Agency : JICA

	(Unit: m)					
	Jul	Aug	Sep	Oct	Nov	Dec
1	1.30	1.20	1.20	1.79	2.03	
2	1.33	1.27	1.81	2.08		
3	1.29	1.40	1.85	2.09		
4	0.98	1.50	1.90	2.10		
5	1.20	1.60	1.91			
6	1.29	1.65	1.94			
7	1.35	1.70	1.98			
8	1.33	1.69	2.00			
9	1.45	1.68	2.00			
10	1.54	1.70	2.01			
11	1.61	1.70	2.05			
12	1.69	1.71	2.08			
13	1.73	1.75	2.09			
14	1.80	1.78	2.10			
15	1.82	1.79	2.03			
16	1.89	1.88	2.00			
17	1.90	1.47	2.00			
18	1.95	1.47	2.00			
19	1.98	1.40	2.02			
20	2.00	1.45	2.05			
21	2.03	1.50	2.08			
22	1.51	2.05	1.52	1.93		
23	1.49	2.10	1.58	1.96		
24	1.45	2.05	1.62	1.95		
25	1.25	1.90	1.70	1.98		
26	1.23	1.80	1.72	2.00		
27	1.33	1.80	1.70	1.95		
28	1.43	1.81	1.65	1.95		
29	1.50	1.85	1.70	1.98		
30	1.68	1.72	1.73	2.00		
31	1.60	1.45	2.01			
Average	1.45	1.68	1.60	1.98	2.08	

Station : Culubasan E/S  
 Year : 1994  
 Agency : JICA

	(Unit: m)					
	Jul	Aug	Sep	Oct	Nov	Dec
1	0.60	0.70	0.70	1.40	1.60	
2	0.70	0.81	0.81	1.48	1.79	
3	0.58	0.92	0.92	1.50	1.72	
4	0.53	1.02	1.02	1.50	1.76	
5	0.70	1.10	1.10	1.56	1.78	
6	0.75	1.05	1.05	1.61		
7	0.78	1.11	1.11	1.64		
8	0.78	0.97	0.97	1.67		
9	0.95	0.99	0.99	1.67		
10	1.05	0.81	0.81	1.69		
11	1.20	0.65	0.65	1.71		
12	1.31	0.75	0.75	1.78		
13	1.35	0.77	0.77	1.80		
14	1.41	0.60	0.60	1.90		
15	1.48	0.63	0.63	1.90		
16	1.50	0.75	0.75	1.90		
17	1.52	0.81	0.81	1.91		
18	1.51	0.90	0.90	1.92		
19	1.58	0.98	0.98	1.95		
20	1.62	0.96	0.96	1.97		
21	1.70	0.92	0.92	2.00		
22	1.69	0.70	0.70	1.78		
23	1.78	0.81	0.81	1.45		
24	1.31	1.50	0.93	1.42		
25	0.80	1.25	1.08	1.47		
26	0.79	1.00	1.00	1.50		
27	0.88	1.05	1.12	1.50		
28	0.90	1.12	1.21	1.50		
29	0.95	1.15	1.21	1.60		
30	0.90	0.78	1.35	1.59		
31	0.70	0.77	1.60			
Average	0.90	1.15	0.92	1.67	1.73	

Station : San Jose E/S  
 Year : 1994  
 Agency : JICA

	(Unit: m)					
	Jul	Aug	Sep	Oct	Nov	Dec
1	1.05	1.20	1.42	1.79		
2	1.09	1.11	1.47	1.79		
3	1.02	1.20	1.50			
4	0.82	1.35	1.52			
5	0.95	1.30	1.57			
6	1.01	1.32	1.60			
7	1.05	1.38	1.61			
8	1.00	1.39	1.65			
9	1.10	1.38	1.69			
10	1.20	1.38	1.70			
11	1.22	1.35	1.73			
12	1.30	1.37	1.78			
13	1.33	1.40	1.80			
14	1.40	1.30	1.81			
15	1.43	1.20	1.85			
16	1.50	1.15	1.85			
17	1.53	1.18	1.87			
18	1.59	1.20	1.90			
19	1.60	1.22	1.90			
20	1.62	1.28	1.91			
21	1.50	1.65	1.25	1.93		
22	1.50	1.69	1.21	1.91		
23	1.50	1.70	1.20	1.70		
24	1.50	1.70	1.25	1.68		
25	1.40	1.60	1.30	1.67		
26	1.35	1.51	1.30	1.69		
27	1.31	1.45	1.31	1.67		
28	1.30	1.45	1.33	1.70		
29	1.26	1.49	1.39	1.70		
30	1.25	1.40	1.40	1.75		
31	1.20	1.29	1.79			
Average	1.37	1.35	1.29	1.72	1.79	

Table D.26 Groundwater Level Observed by JICA Station (4/4)

Station: Magalang E/S  
Year: 1994

	(Unit: m)											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1	0.19	0.76	1.00	1.01								
2	0.25	0.86	1.05	1.05								
3	0.19	0.90	1.10									
4	0.80	0.95	1.10									
5	0.85	0.98	1.11									
6	0.90	0.99	1.18									
7	0.89	1.00	1.18									
8	0.88	0.90	1.20									
9	0.90	0.90	1.20									
10	0.95	0.95	1.21									
11	0.99	0.97	1.25									
12	1.00	0.99	1.26									
13	1.01	1.00	1.29									
14	1.09	0.88	1.30									
15	1.10	0.78	1.30									
16	1.10	0.85	1.30									
17	1.11	0.89	1.30									
18	1.12	0.90	1.30									
19	1.12	0.90	1.31									
20	1.12	0.90	1.32									
21	0.20	1.19	0.90	1.32								
22	0.39	1.20	0.80	1.00								
23	0.30	1.20	0.85	0.89								
24	0.15	0.90	0.90	0.92								
25	0.15	0.82	0.90	1.00								
26	0.20	0.80	0.90	0.90								
27	0.25	0.90	0.90	0.90								
28	0.21	0.92	0.90	0.95								
29	0.22	0.98	0.98	1.00								
30	0.21	0.79	1.00	1.02								
31	0.15	0.81	1.02	1.02								
Average	0.25	0.91	0.91	1.13	1.03							

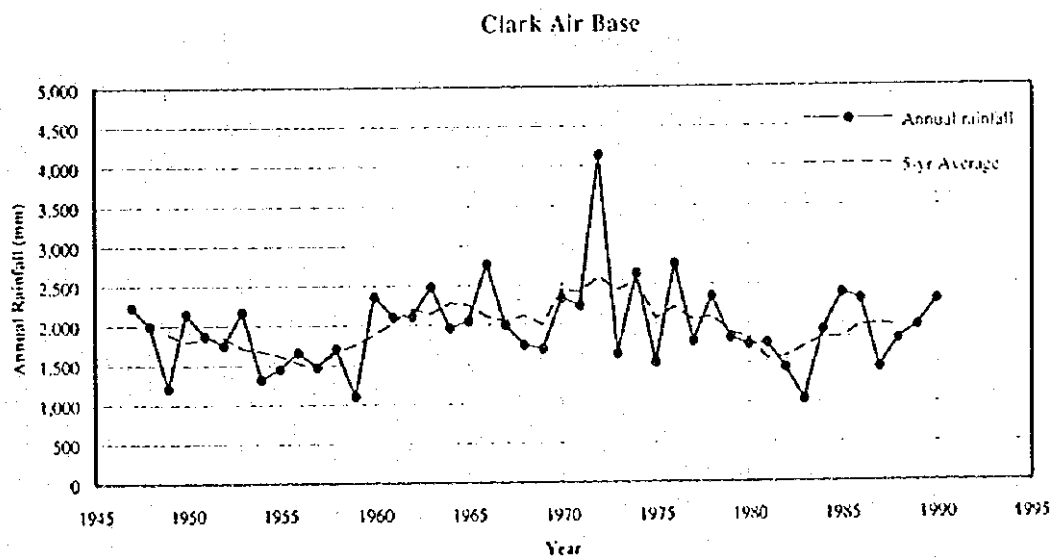
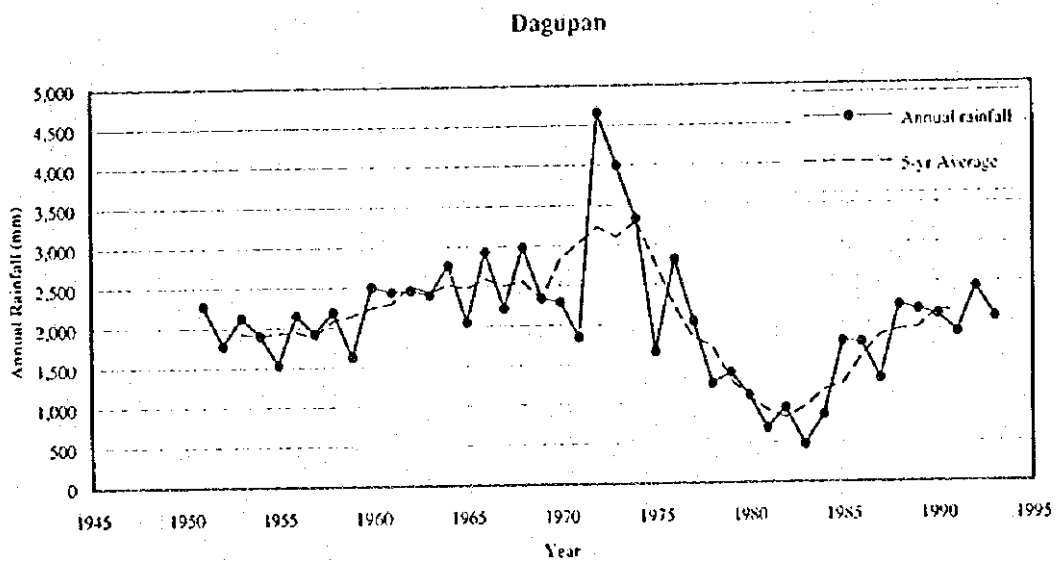
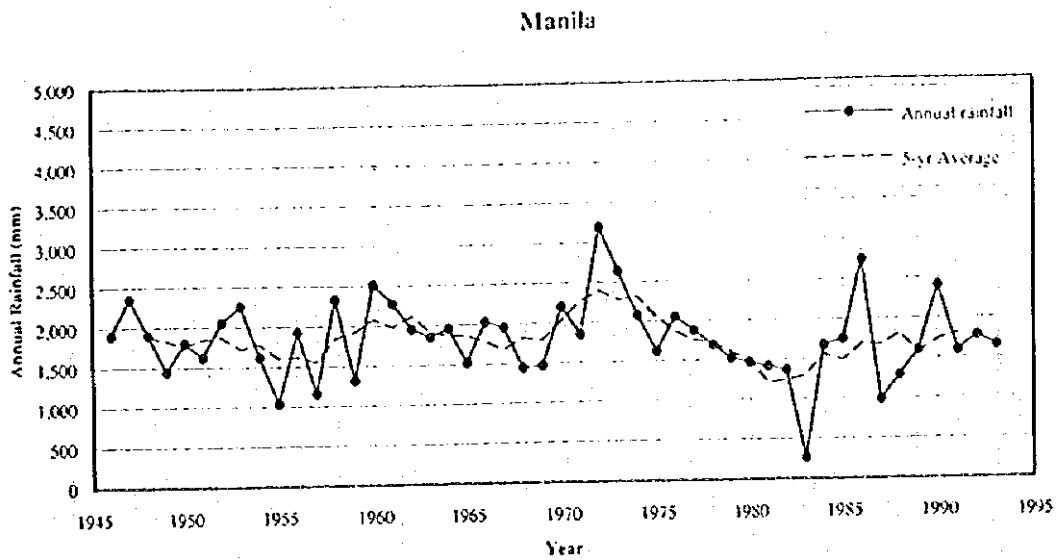
Station: Telipayang E/S  
Year: 1994

	(Unit: m)											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1	0.04	0.15	0.41	0.50								
2	0.12	0.22	0.43	0.53								
3	0.03	0.29	0.47	0.56								
4	0.11	0.35	0.51									
5	0.23	0.40	0.54									
6	0.31	0.40	0.56									
7	0.29	0.41	0.49									
8	0.24	0.30	0.49									
9	0.30	0.27	0.55									
10	0.33	0.23	0.61									
11	0.35	0.23	0.65									
12	0.37	0.25	0.67									
13	0.40	0.26	0.68									
14	0.42	0.14	0.70									
15	0.44	0.11	0.73									
16	0.52	0.17	0.74									
17	0.60	0.20	0.74									
18	0.37	0.34	0.74									
19	0.30	0.31	0.74									
20	0.31	0.25	0.76									
21	0.22	0.33	0.18	0.79								
22	0.26	0.36	0.18	0.46								
23	0.27	0.40	0.23	0.19								
24	0.14	0.17	0.30	0.24								
25	0.06	0.13	0.34	0.31								
26	0.12	0.13	0.21	0.33								
27	0.20	0.19	0.21	0.25								
28	0.15	0.28	0.25	0.31								
29	0.20	0.29	0.31	0.41								
30	0.16	0.11	0.38	0.49								
31	0.07	0.15	0.51	0.51								
Average	0.17	0.28	0.26	0.53	0.53							

Station: San Barolome E/S  
Year: 1994

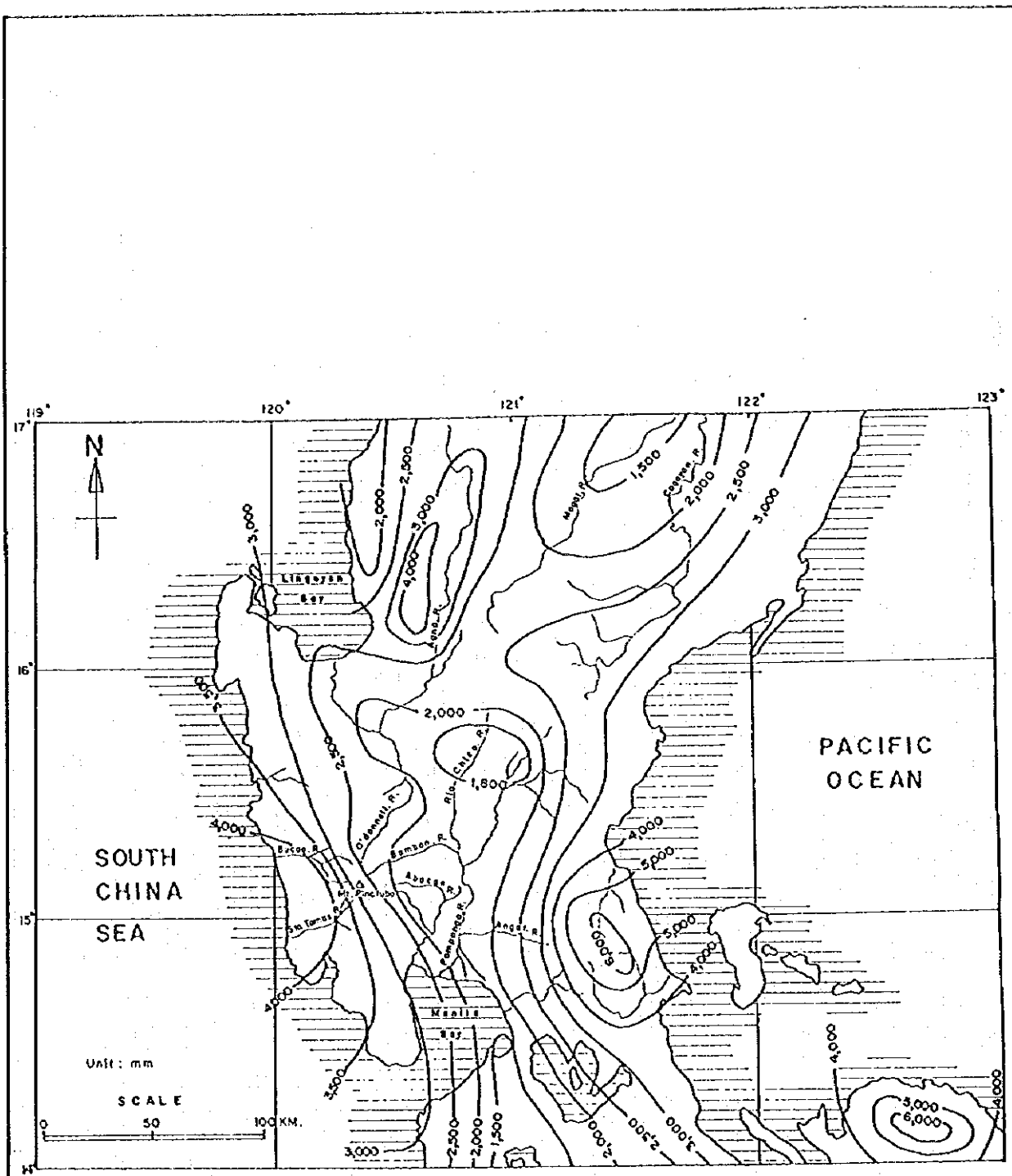
	(Unit: m)											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1	2.35	1.28	1.50	2.09								
2	2.22	1.29	1.52	2.10								
3	2.01	1.30	1.60	2.11								
4	1.83	1.40	1.61	2.13								
5	1.85	1.43	1.70									
6	1.75	1.49	1.72									
7	1.68	1.50	1.80									
8	1.70	1.42	1.82									
9	1.70	1.42	1.88									
10	1.70	1.48	1.90									
11	1.70	1.45	1.95									
12	1.79	1.47	2.00									
13	1.80	1.50	2.00									
14	1.84	1.50	2.03									
15	1.89	1.30	2.09									
16	1.92	1.05	2.09									
17	1.95	0.80	2.10									
18	2.00	0.99	2.10									
19	2.01	0.99	2.12									
20	2.02	0.98	2.19									
21	2.11	0.89	2.20									
22	3.20	2.15	0.70	2.12								
23	3.12	2.17	0.90	2.10								
24	3.09	1.98	1.01	2.09								
25	3.00	1.80	1.10	2.05								
26	2.98	1.72	1.19	2.02								
27	2.82	1.75	1.20	2.00								
28	2.75	1.80	1.30	2.00								
29	2.70	1.75	2.00	2.00								
30	2.61	1.63	1.40	2.01								
31	2.50	1.49	2.02	2.02								
Average	2.88	1.87	1.36	1.95	2.11							

***FIGURES***



**Figure D.1 Variation of Annual Rainfall**

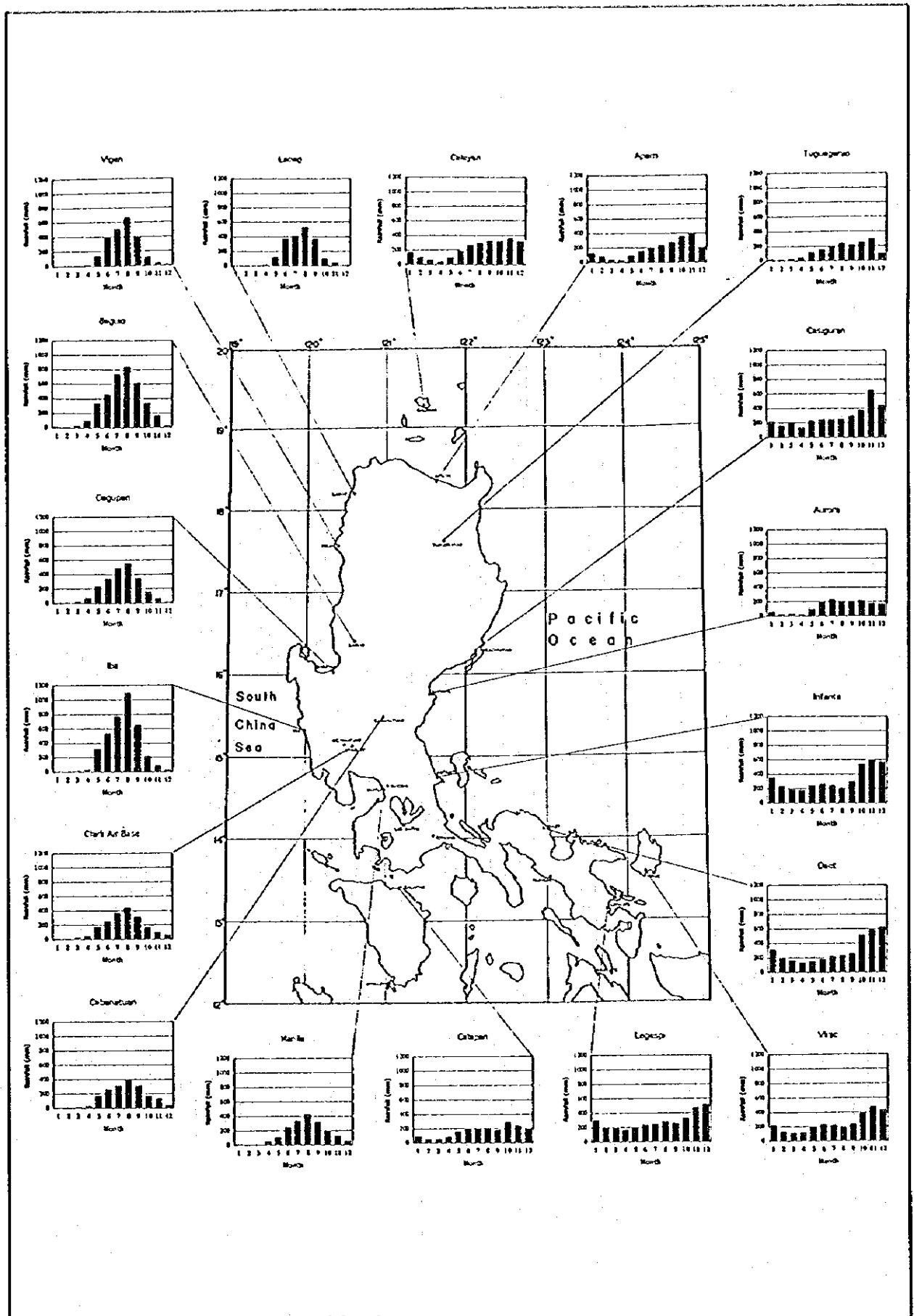
THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
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**Figure D.2 Isohyetal Map of Annual Rainfall**

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**Figure D.3 Monthly Average Rainfall**

THE GOVERNMENT OF THE PHILIPPINES  
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 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

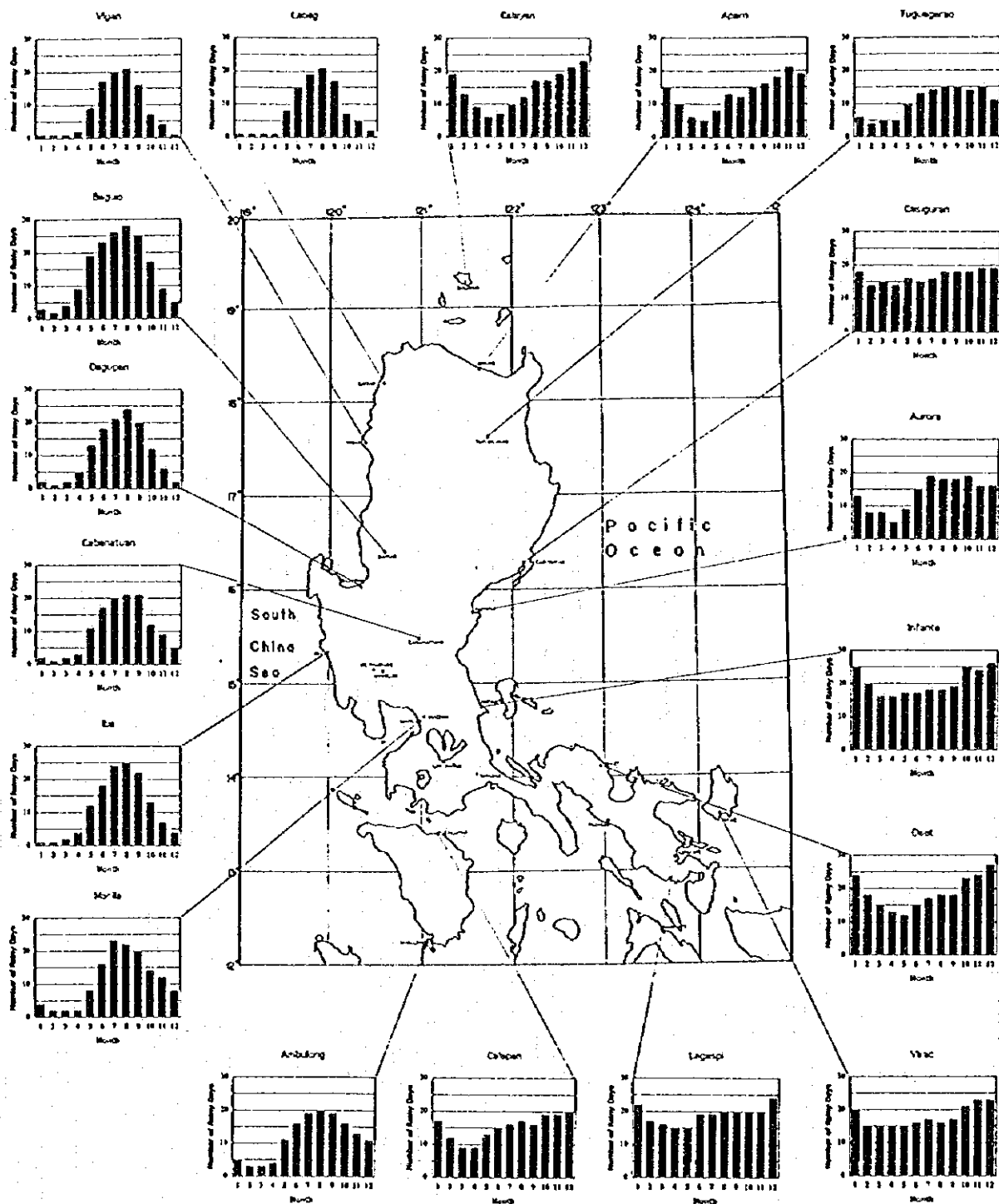
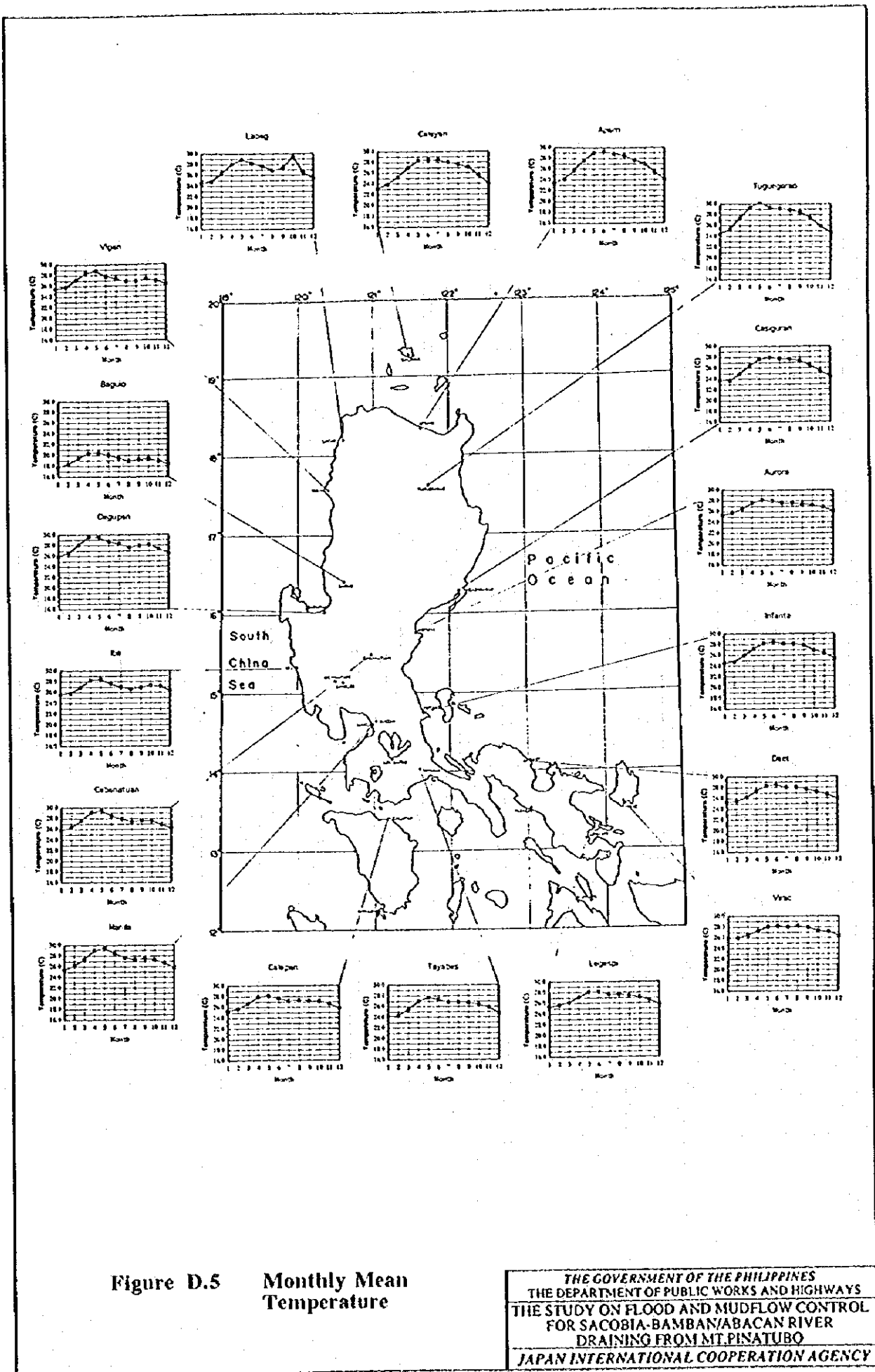


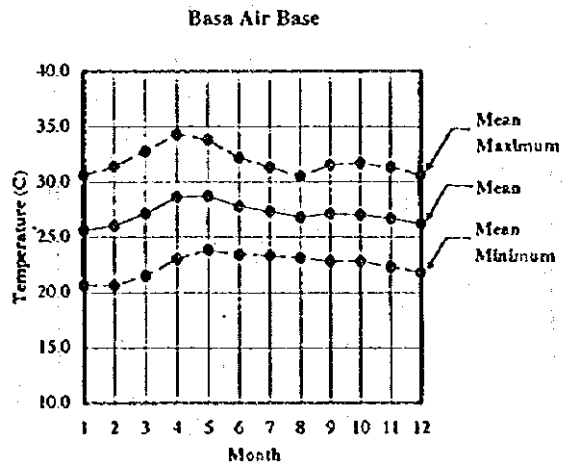
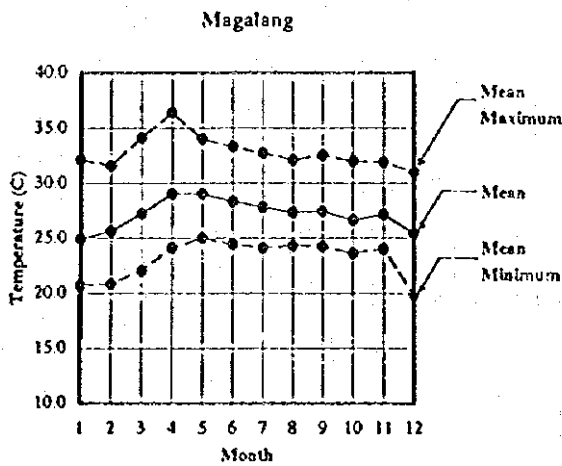
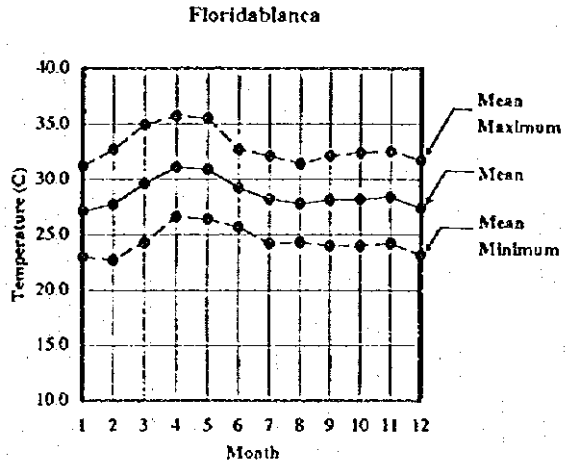
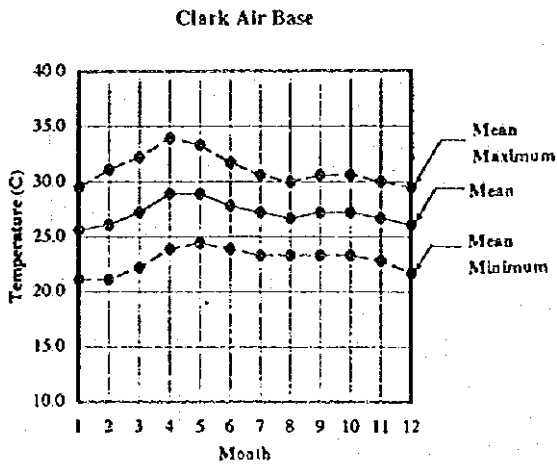
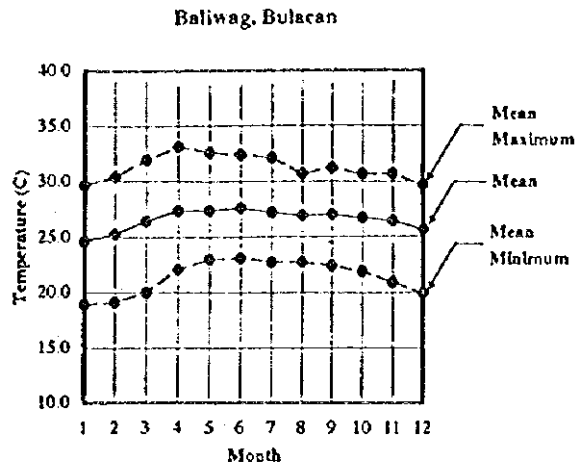
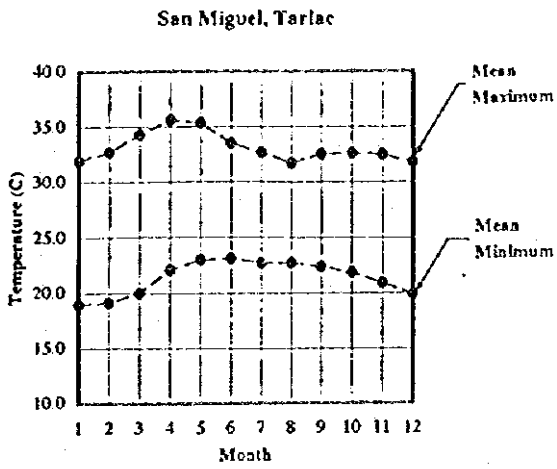
Figure D.4 Monthly Number of Rainy Days

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/BACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



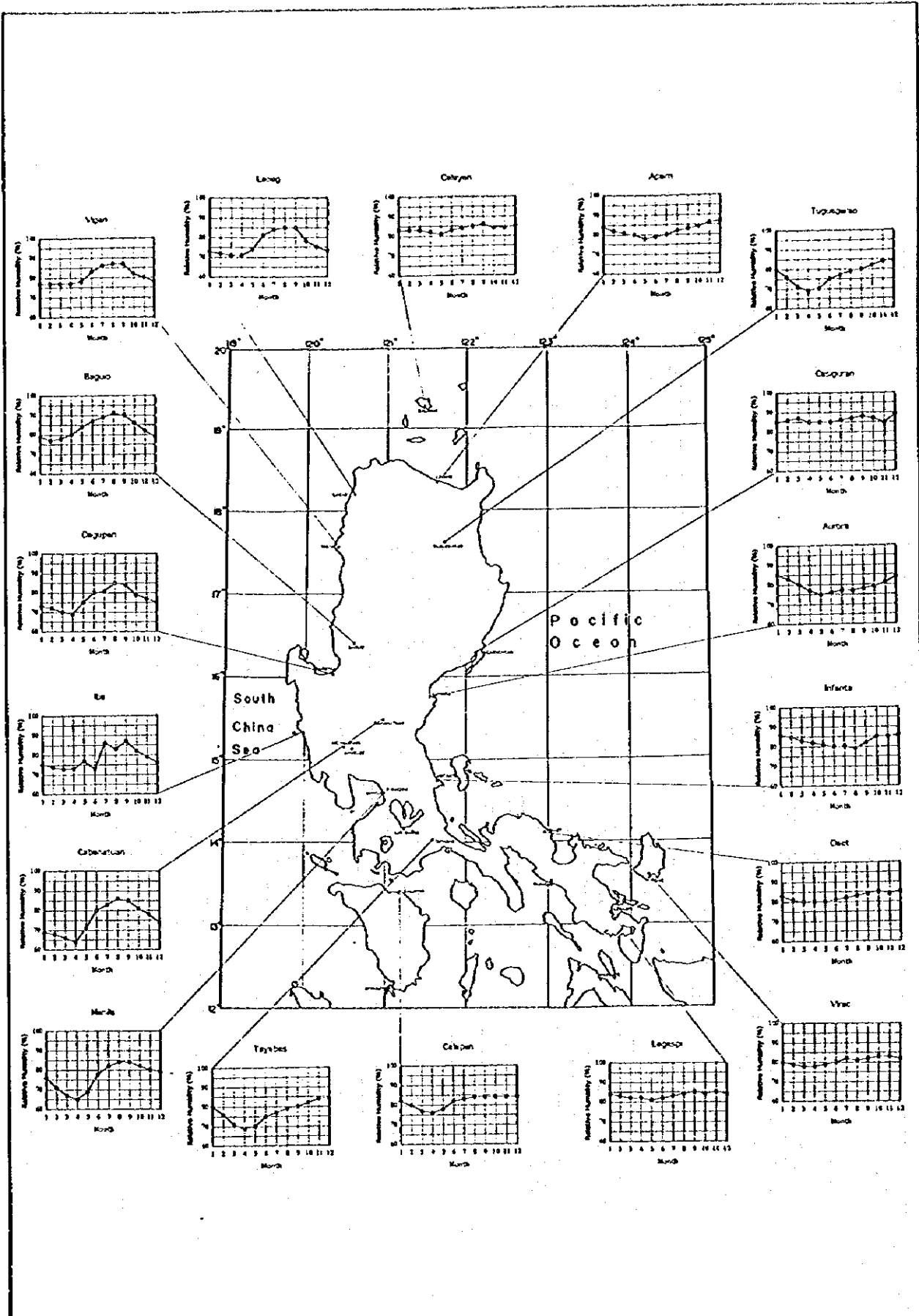
**Figure D.5 Monthly Mean Temperature**

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



**Figure D.6** Variation of Monthly Mean Temperature in and Around the Study Area

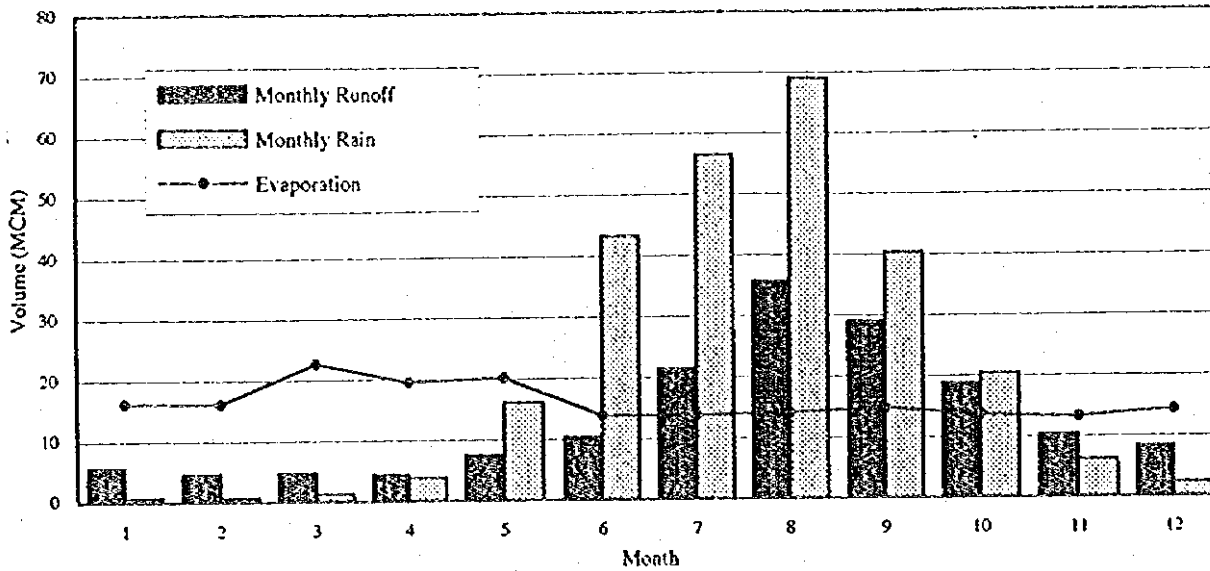
THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
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**Figure D.7 Monthly Mean Relative Humidity**

THE GOVERNMENT OF THE PHILIPPINES  
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### Monthly Variation of Rainfall, Runoff and Evaporation



### Ratio of Runoff Volume to Rainfall Volume at Porac River

DESCRIPTION	UNIT	MONTH												TOTAL
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Monthly Average Rainfall	mm	6	6	11	35	145	390	509	622	364	184	56	21	2,348
Monthly Average Rainfall Volume	MCM	0.666	0.688	1.265	3.843	16.128	43.257	56.466	68.998	40.360	20.446	6.205	2.331	260.672
Monthly Average Evaporation *	mm	146	146	204	176	182	125	124	128	134	123	120	129	1,736
Monthly Average Evaporation Rate	MCM	16.206	16.162	22.666	19.514	20.181	13.820	13.797	14.208	14.874	13.642	13.276	14.352	192.696
Monthly Average Discharge	m <sup>3</sup> /sec	2.1	1.9	1.8	1.7	2.8	4.0	8.0	13.3	11.2	7.0	4.0	3.1	5.1
Monthly Average Runoff	MCM	5.649	4.565	4.757	4.316	7.433	10.358	21.406	35.676	29.057	18.730	10.358	8.324	160.630
Rainfall:Runoff Ratio	%	848.2	663.3	375.9	111.7	46.1	23.9	37.9	51.7	72.0	91.6	166.9	357.1	61.6

Remarks: Marked (\*) means the annual average.

Discharge data at Del Carmen (111 km<sup>2</sup>) and rainfall data at Basa Air Base were recorded for 15 years (1958-1972).

Evaporation data was recorded at Floridablanca for 1965 to 1967.

**Figure D.8 Ratio of Runoff Volume to Rainfall Volume**

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

	Name	Period of Occurrence
1	T.S. Auring	Mar. 11-13
2	T.S. Bebeug	Apr. 24-26
3	T. Karing	May 11-16
4	T. Diding	Jun. 12-15
5	T. Elang	Jul. 09-11
6	T. Gening	Jul. 16-19
7	T.S. Helming	Jul. 20-23
8	T. Ising	Jul. 23-27
9	T. Luding	Aug. 13-14
10	T. D. Marneng	Aug. 28-29
11	T. Neneug	Sep. 11-12
12	T. Oniang	Sep. 15-29
13	T. Pepang	Sep. 16-18
14	T. Rosing	Sep. 22-26
15	T. Sendang	Oct. 05-09
16	T. Trining	Oct. 21-31
17	T.S. Urang	Nov. 02-07
18	T. Waring	Nov. 08-14
19	T.S. Yayang	Nov. 14-19

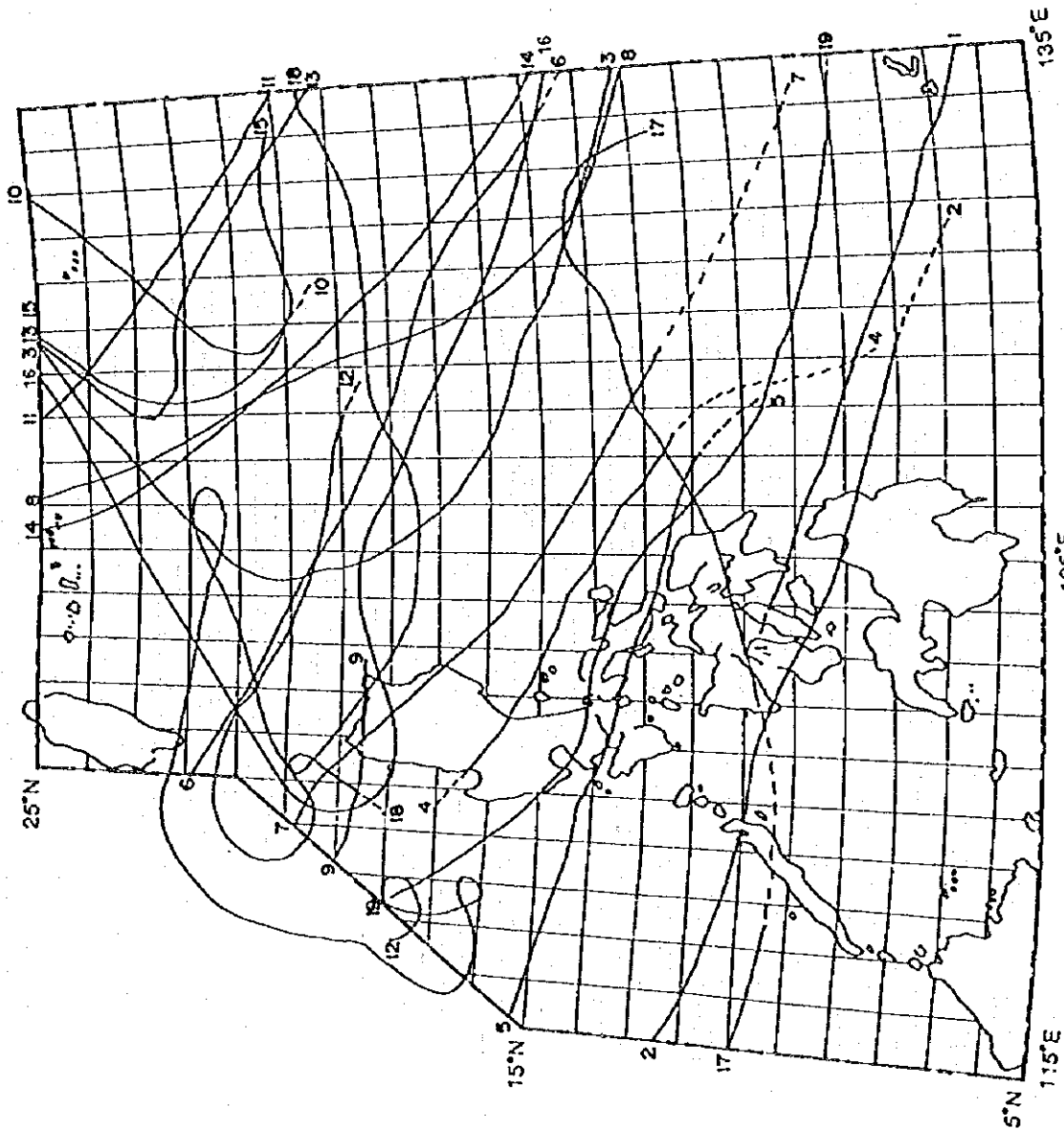
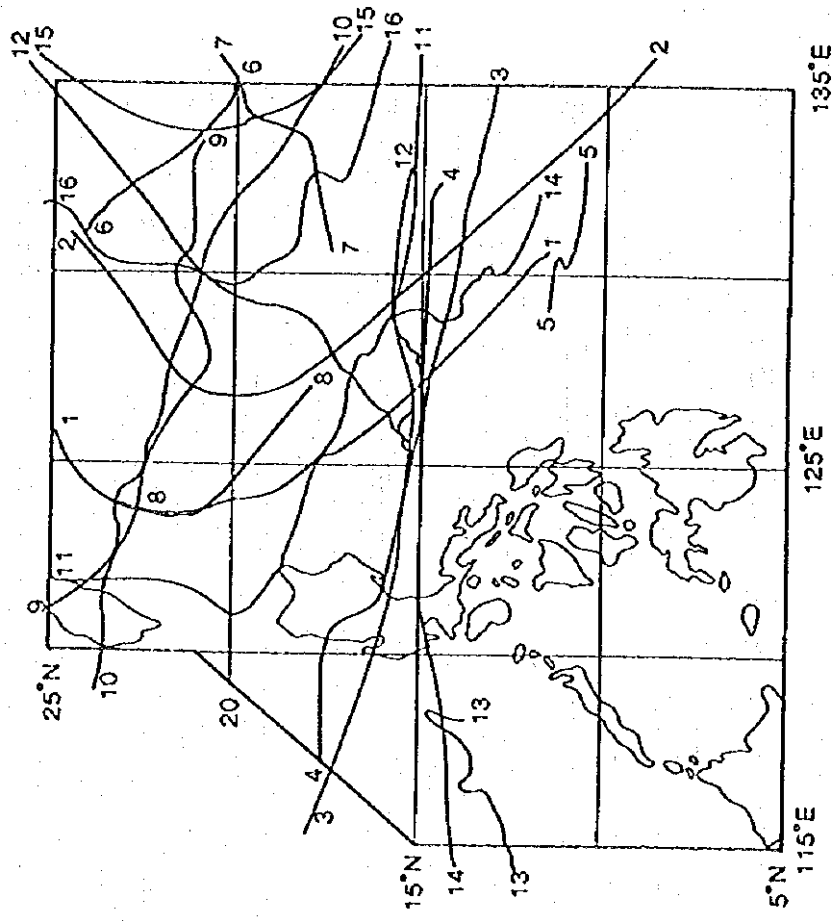


Figure D.9 Tracks of Tropical Cyclones in 1991

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



Name	Period of Occurrence
1 T. Asiang	Jun. 24-28
2 T.S. Biring	Jun. 30-Jul. 03
3 T.S. Konsing	Jul. 09-12
4 T.D. Dilang	Jul. 17-21
5 T.D. Edjeng	Jul. 26-27
6 T. Janis	Aug. 04-06
7 T.D. Ghorng	Aug. 16-18
8 T.D. Huaning	Aug. 26-27
9 T.S. Isang	Aug. 26-31
10 T. Lusing	Aug. 31-Sep. 05
11 T.S. Maring	Sep. 18-23
12 T. Ningning	Oct. 07-16
13 T. Osang	Oct. 16-18
14 T. Paring	Oct. 18-27
15 T. Reiming	Nov. 05-06
16 T. Seniang	Nov. 25-29

Figure D.10 Tracks of Tropical Cyclones in 1992

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



Name	Period of Occurrence
1 T.D.Aving	Feb.28-Mar.02
2 T.D.Bining	Apr.12-13
3 T.D.Koring	Apr.23-27
4 T.D.Daling	May01-04
5 T.D.Elang	Jun.17-20
6 T.Goring	Jun.22-27
7 T.S.Iuling	Jul.07-09
8 T.S.Ibiang	Jul.13-17
9 T.D.Luming	Jul.20-23
10 T.D.Miling	Jul.26
11 T.S.Marsing	Jul.27-28
12 T.Openg	Aug.05-08
13 T.S.Pining	Aug.11-12
14 T.S.Rubing	Aug.16-19
15 T.S.Saling	Aug.22-26
16 T.Tasing	Aug.29-Sep.02
17 T.S.Unsing	Sep.05-07
18 T.Walding	Sep.08-12
19 T.Yeyeng	Sep.12-16
20 T.D.Anding	Sep.18-20
21 T.D.Binang	Sep.21-22,23-27
22 T.Kadiang	Sep.30-Oct.07
23 T.Diang	Oct.03-06
24 T.D.Epang	Oct.06-13
25 T.S.Gundang	Oct.07-10
26 T.I.Iunsing	Oct.28-Nov.02
27 T.S.Indang	Nov.11-12
28 T.S.Luring	Nov.18-22
29 T.Monang	Dec.03-07
30 T.Naming	Dec.06-13
31 T.D.Ohing	Dec.14-17
32 T.S.Puring	Dec.24-29

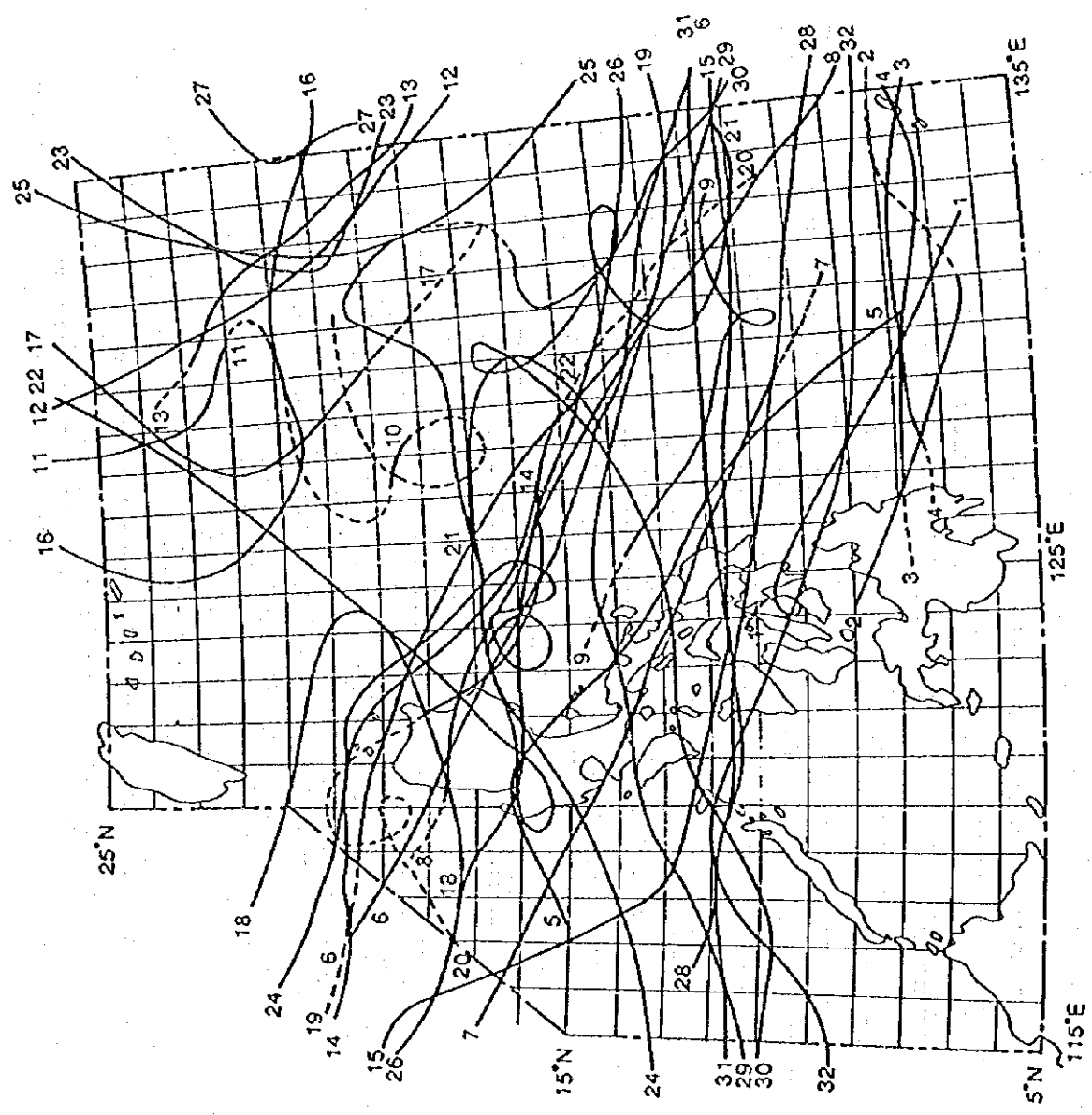
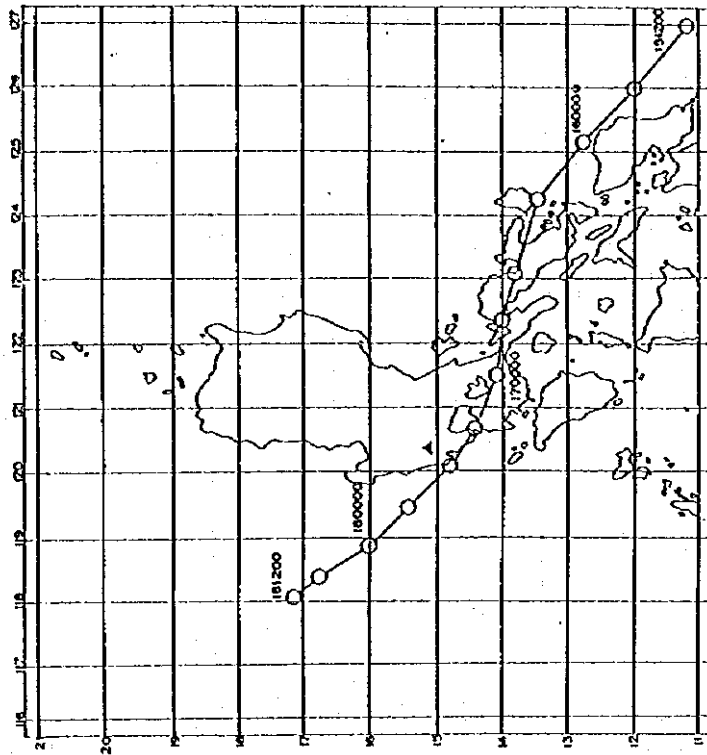
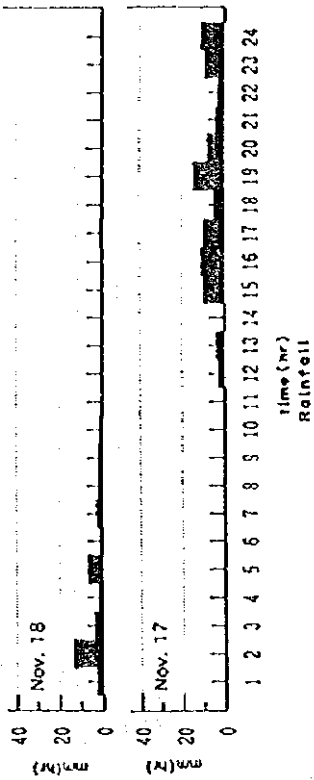
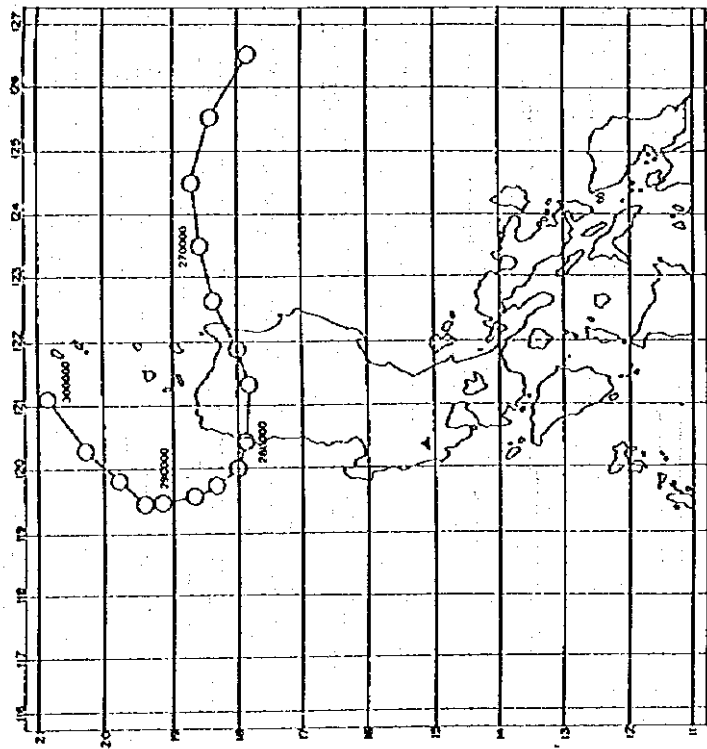
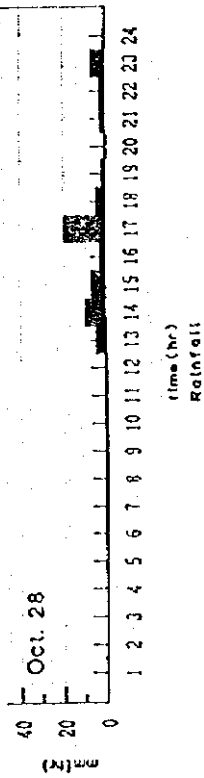


Figure D.11 Tracks of Tropical Cyclones in 1993

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATURO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



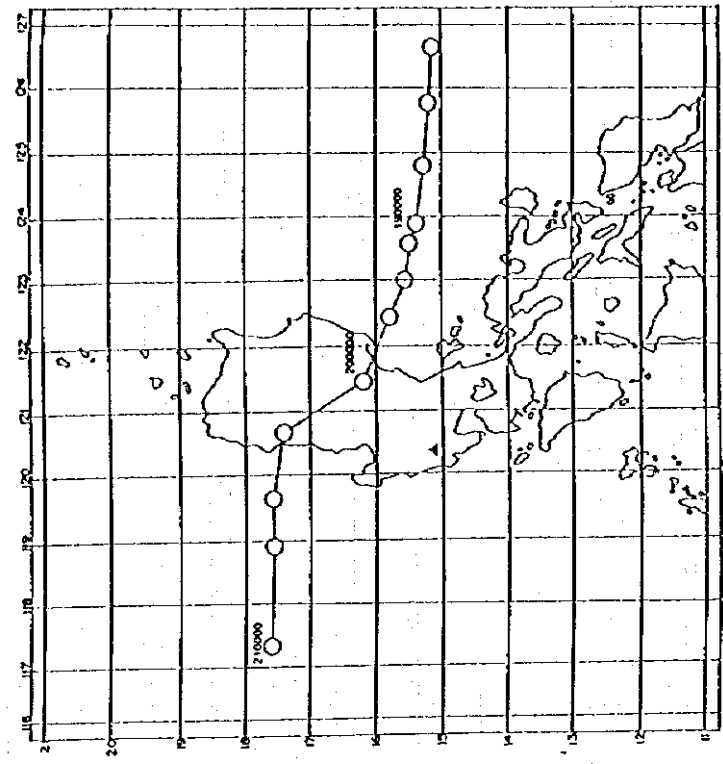
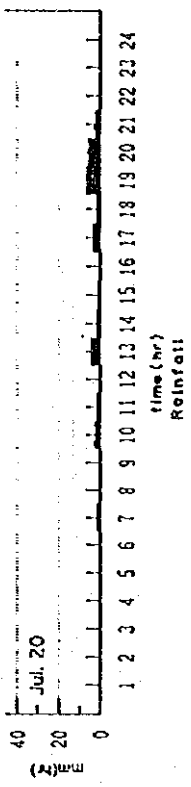
T.S. Yayang  
Nov. 14-19, 1991  
▲ Mt. Pinatubo



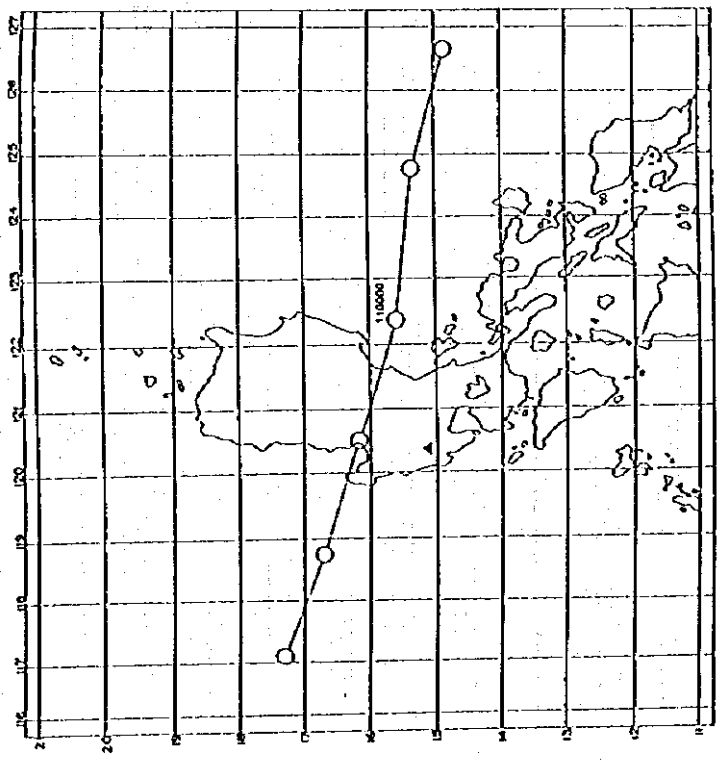
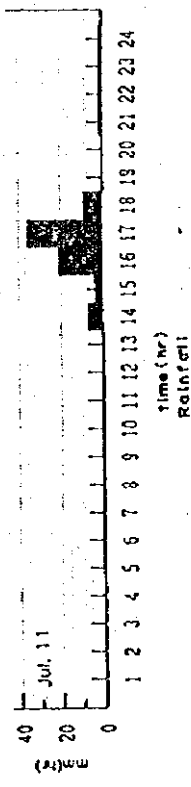
Typhoon Trining  
October 24 - 31, 1991

Figure D.12 Rainfall Intensity and Track during Tropical Cyclones (1/5)

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY



T.D. Ditang  
July 17 - 21, 1992



T.S. Kansing  
July 09 - 12, 1992

Figure D.12 Rainfall Intensity and Track during Tropical Cyclones (2/5)

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY

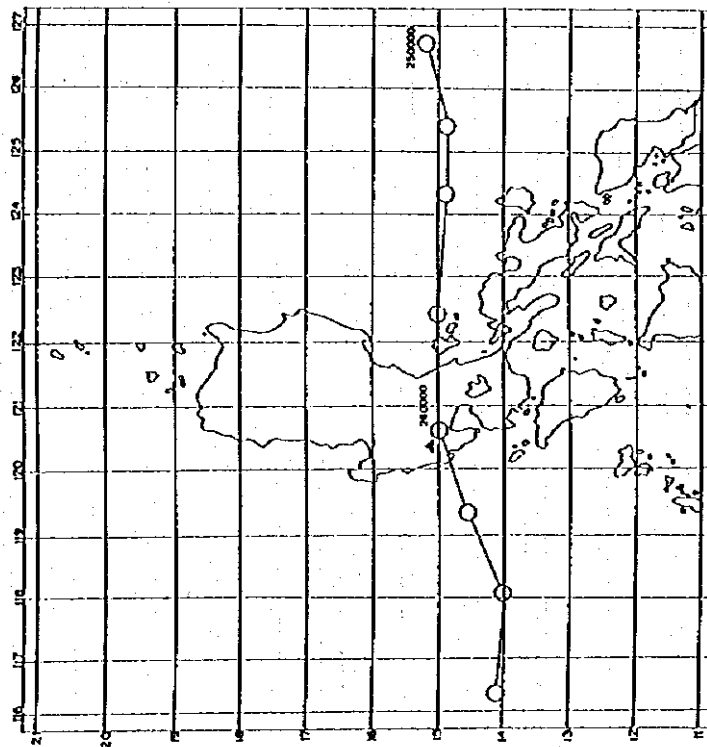
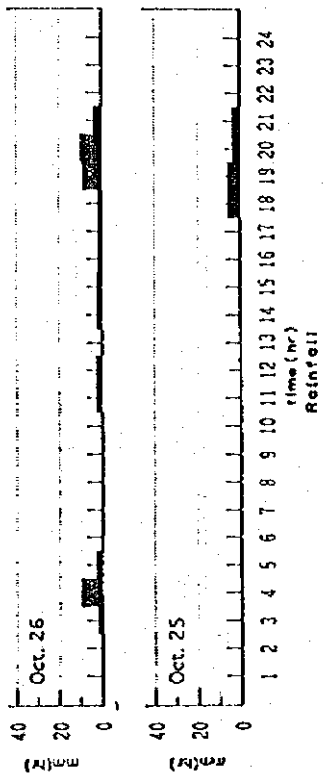
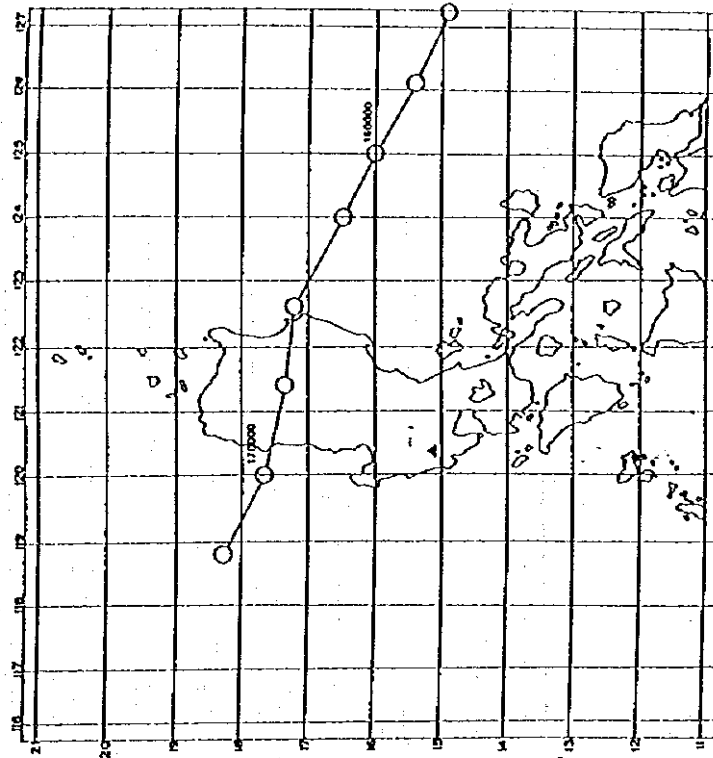
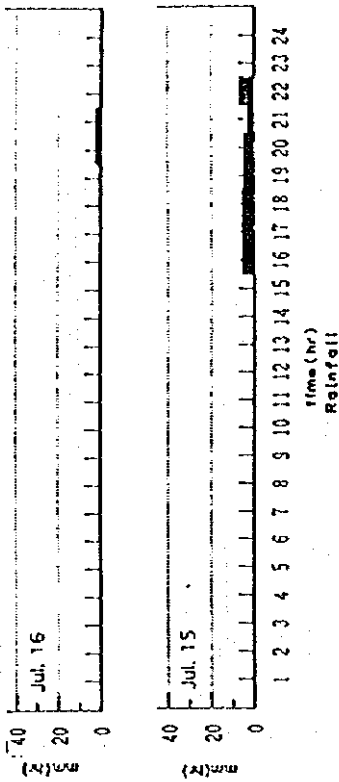
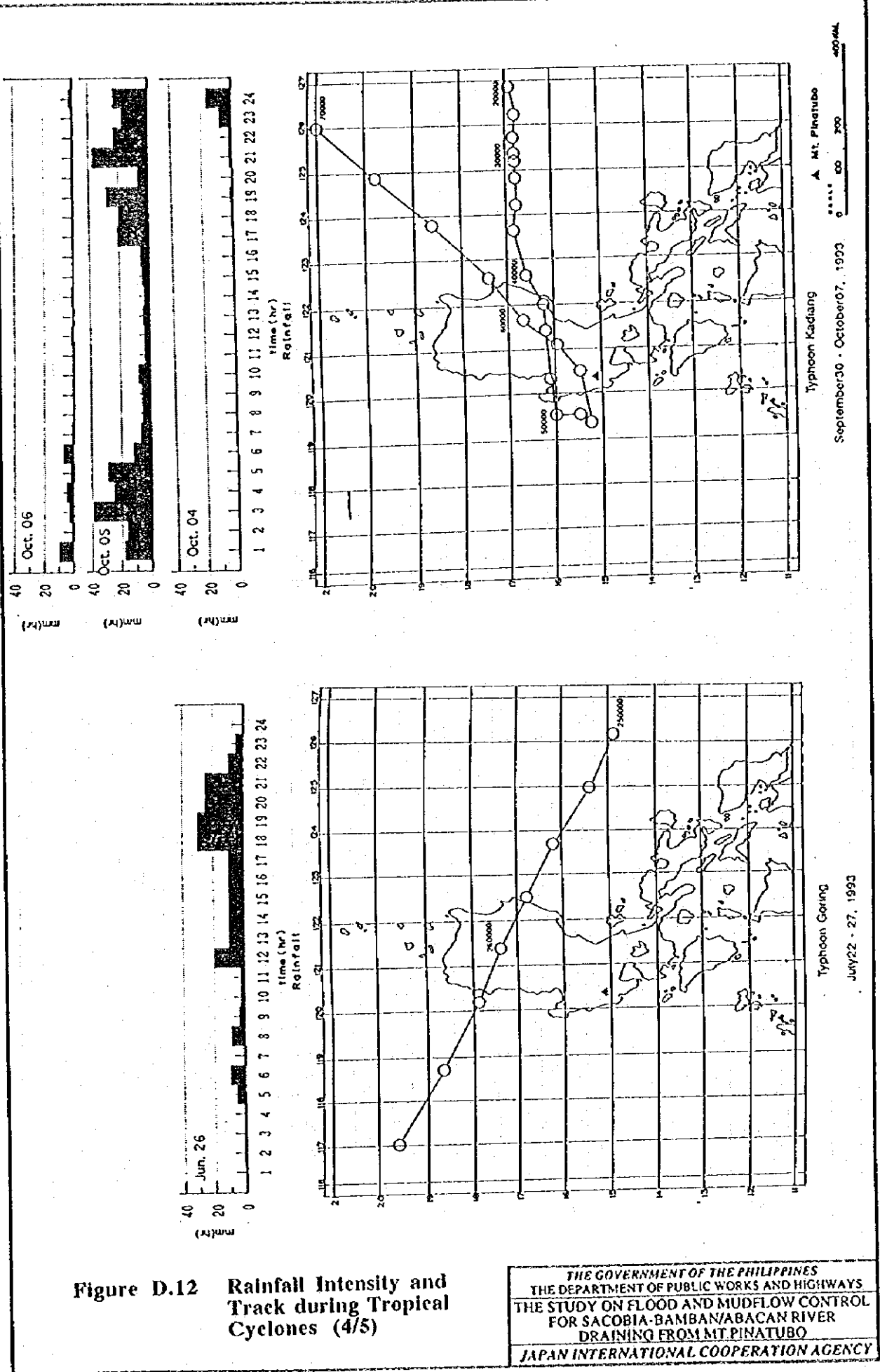
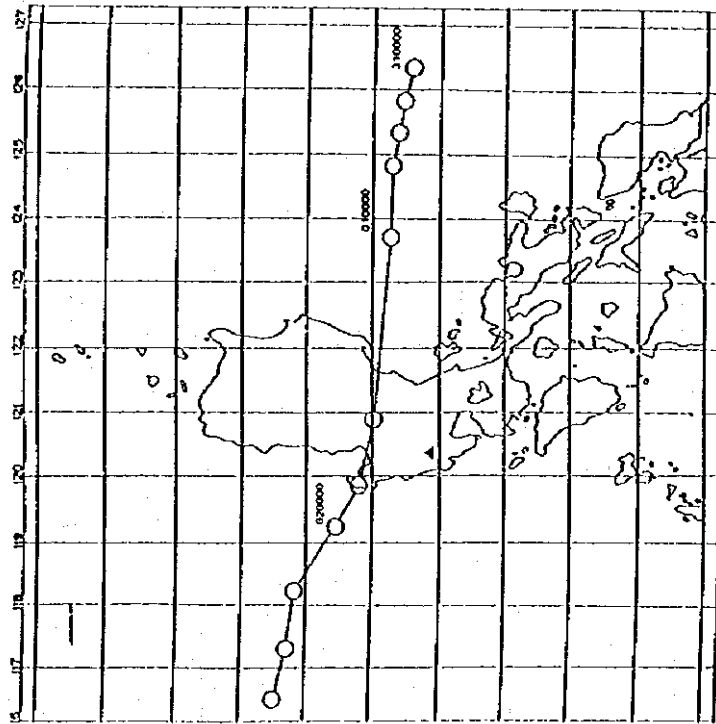
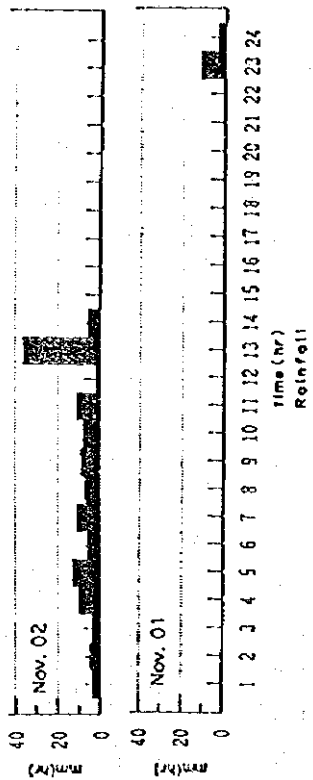


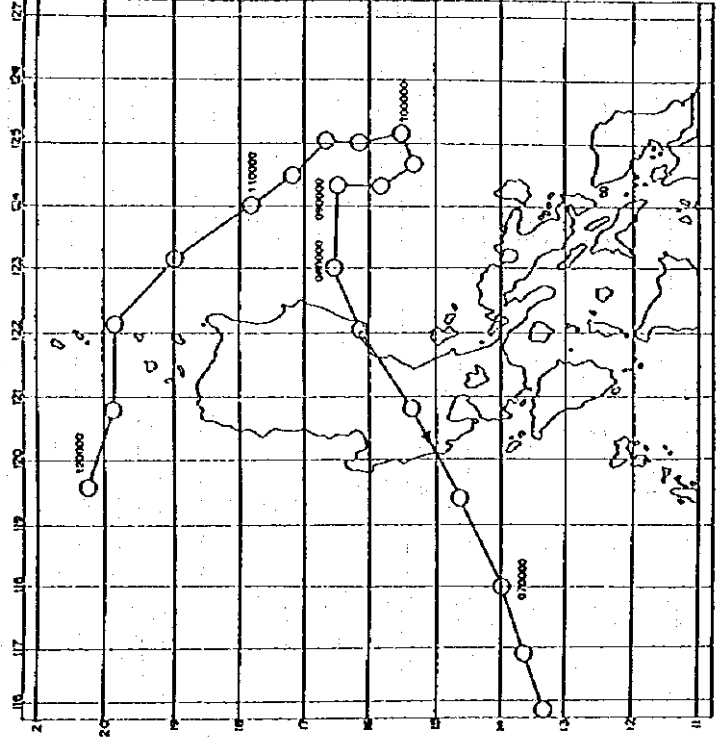
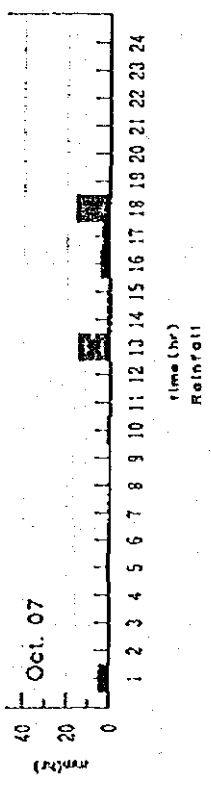
Figure D.12 Rainfall Intensity and Track during Tropical Cyclones (3/5)

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY





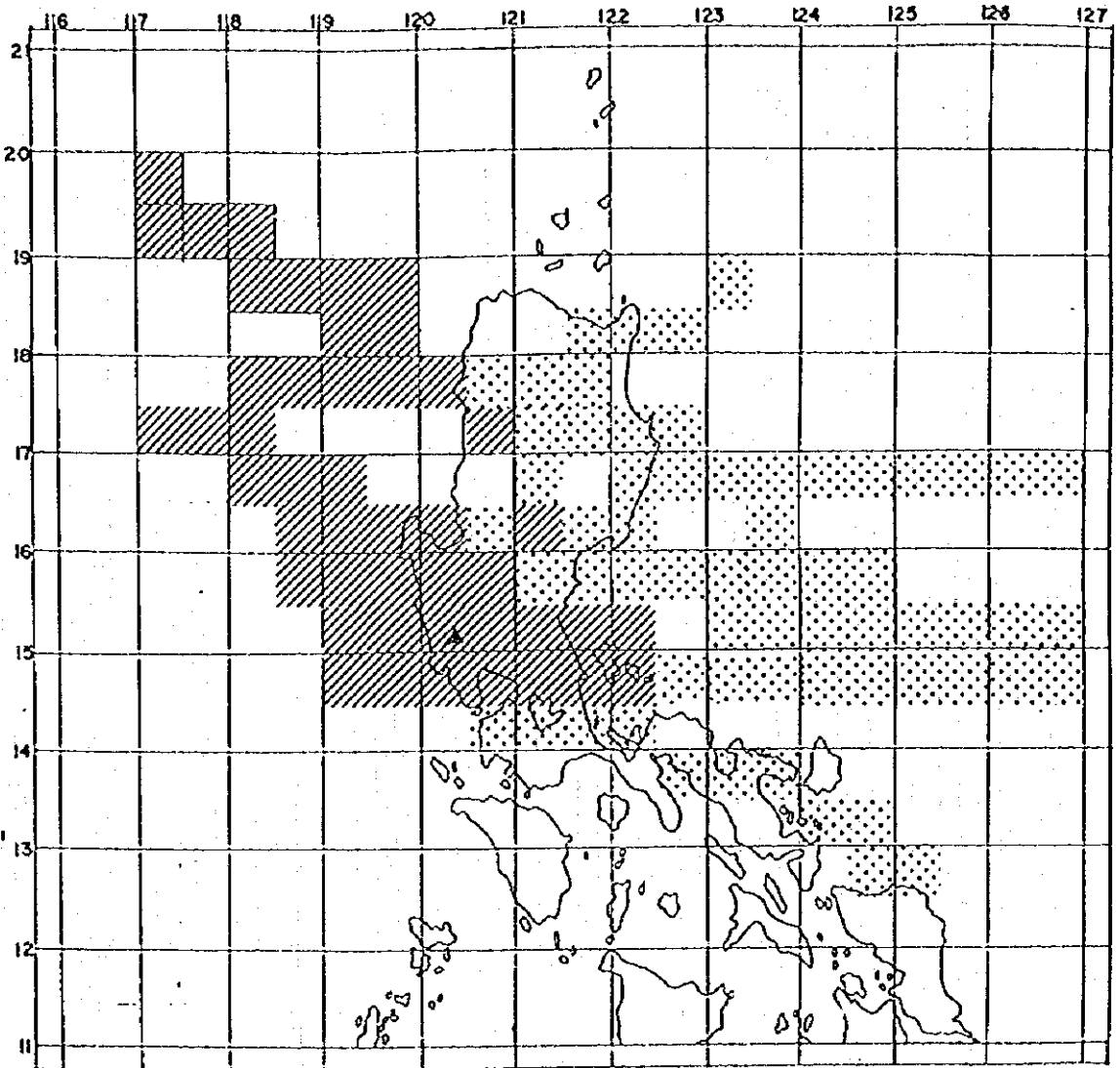
Typhoon Huring  
 October 29 - November 02, 1993  
 A Mt. Pinatubo  
 0 100 200 400 KM



Typhoon Eping  
 October 06 - 13, 1993

Figure D.12 Rainfall Intensity and Track during Tropical Cyclones (5/5)

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
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 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



Location of Tropical Cyclones w/ Rainfall at Sacobia Station



Location of Tropical Cyclones w/o Rainfall at Sacobia Station

▲ Mt. Pinatubo

SCALE  
0 100 200 400 KM.

**Figure D.13 Typhoon Track and Rainfall at Sacobia Station**

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY

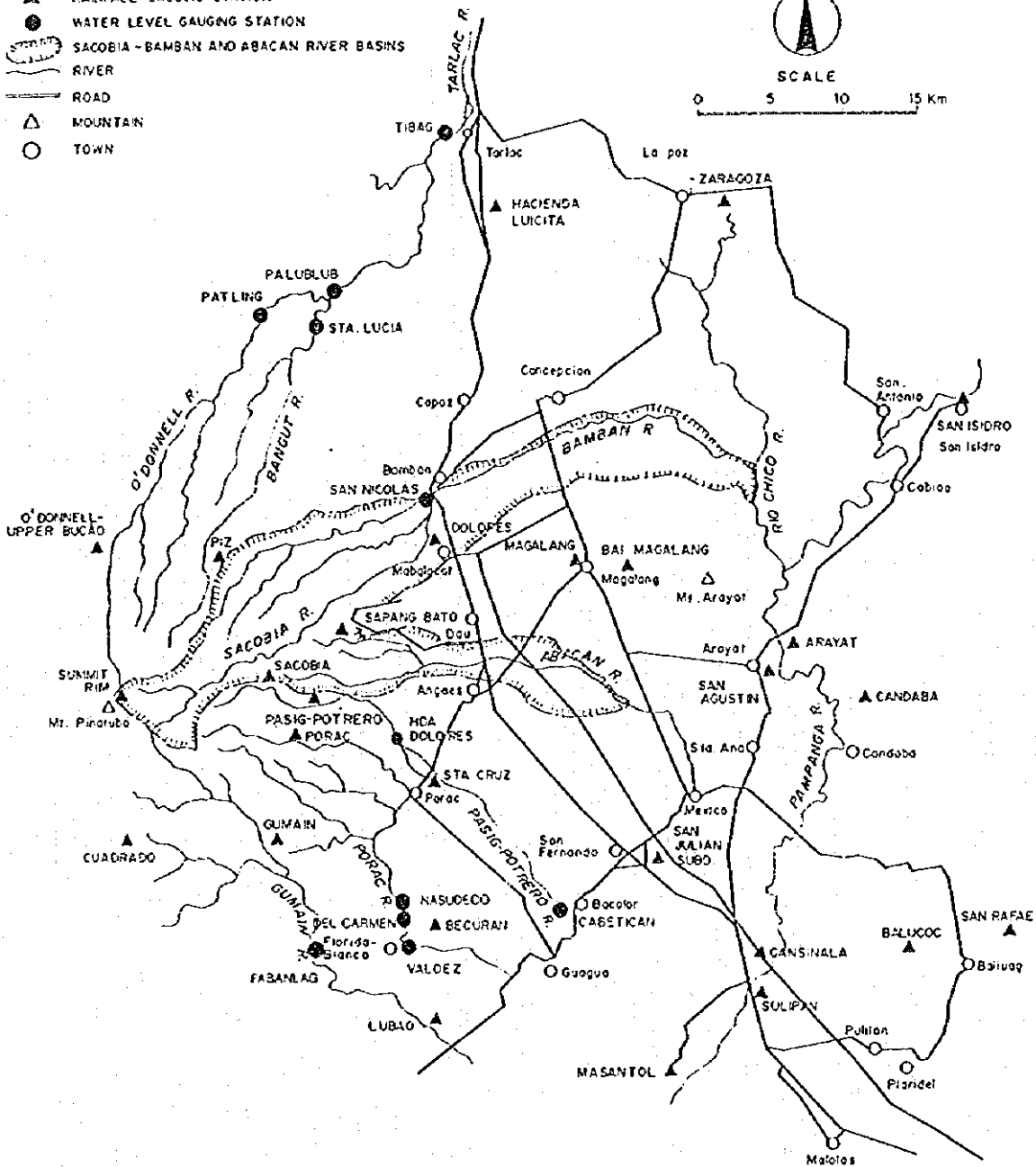
**LEGEND:**

- ▲ RAINFALL GAUGING STATION
- WATER LEVEL GAUGING STATION
- SACOBIA-BAMBAN AND ABACAN RIVER BASINS
- RIVER
- ROAD
- △ MOUNTAIN
- TOWN



SCALE

0 5 10 15 Km

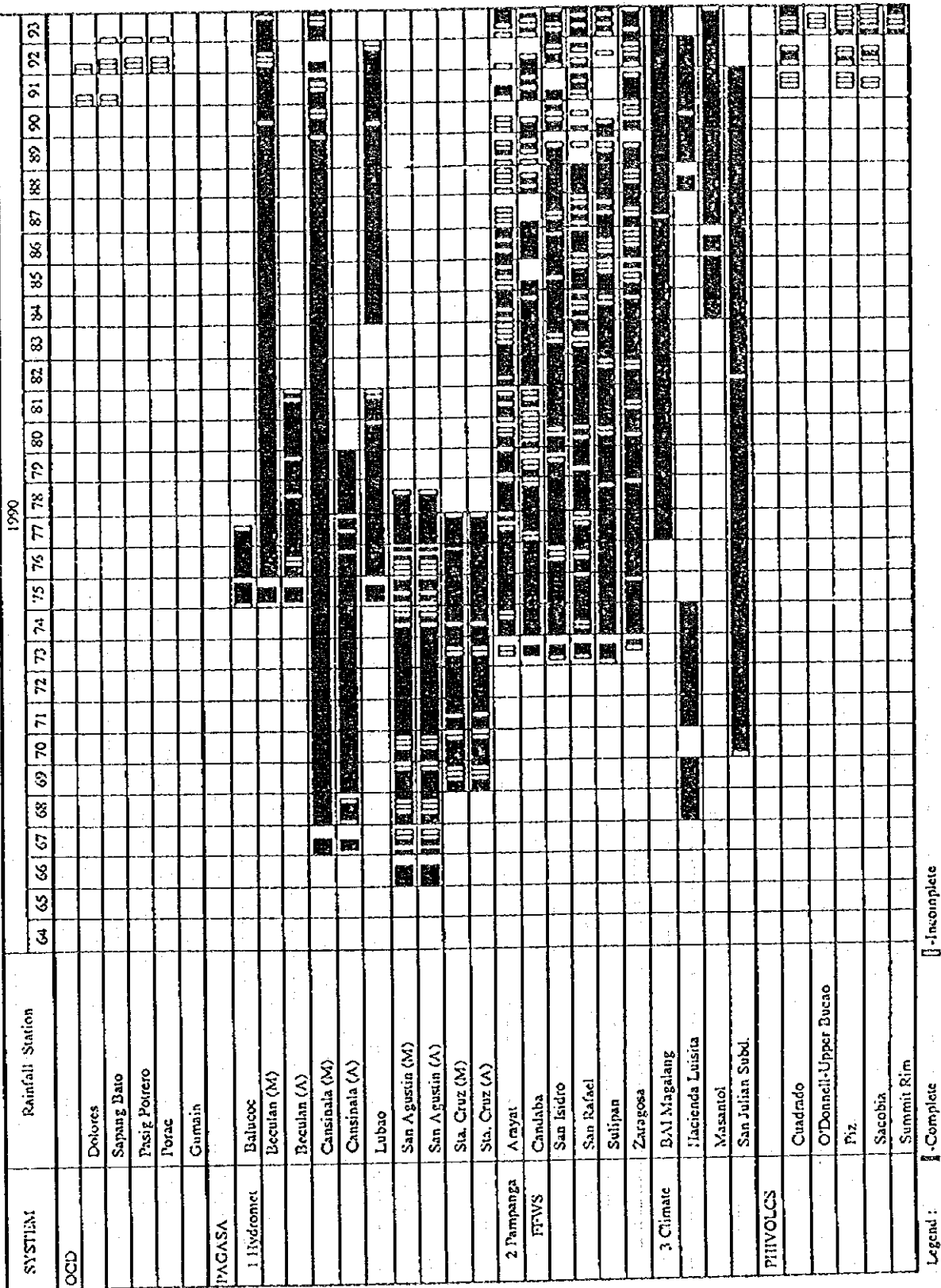


**Figure D.14 Location of Hydrological Station**

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



RAINFALL DATA

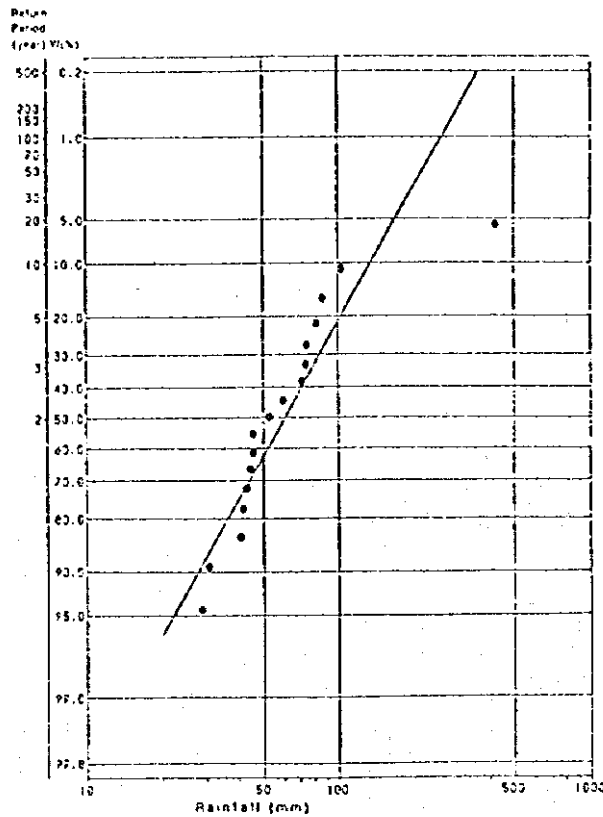


Legend: -Complete -Incomplete

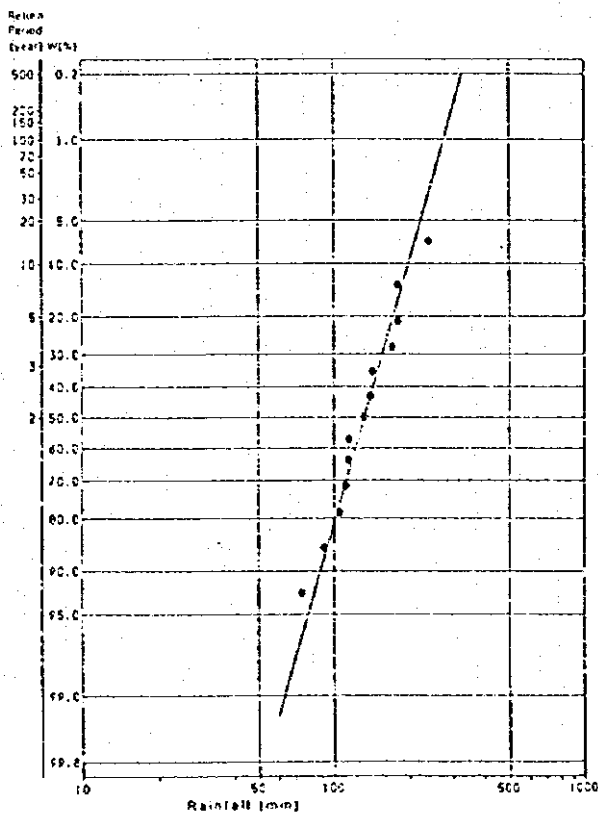
Figure D.15 Available Rainfall Data

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

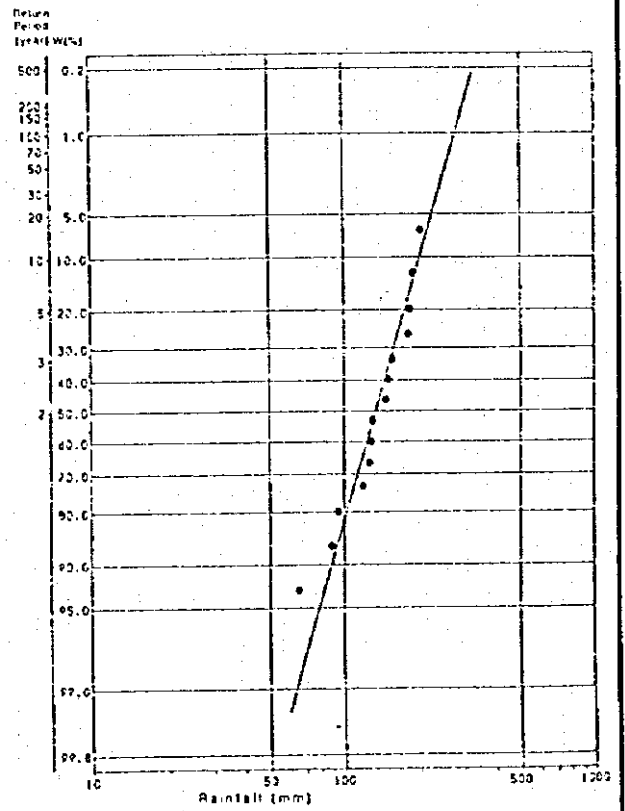




BAI MAGALAN STATION



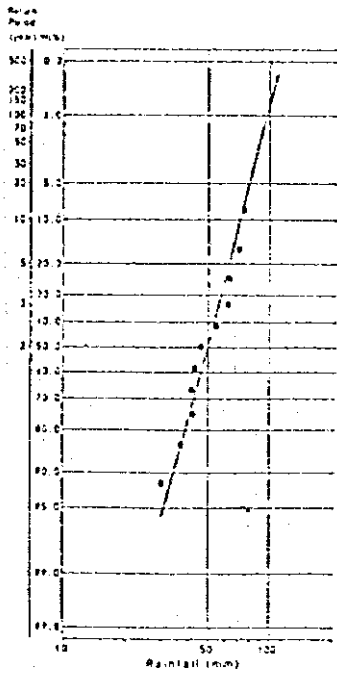
ARAYAT STATION



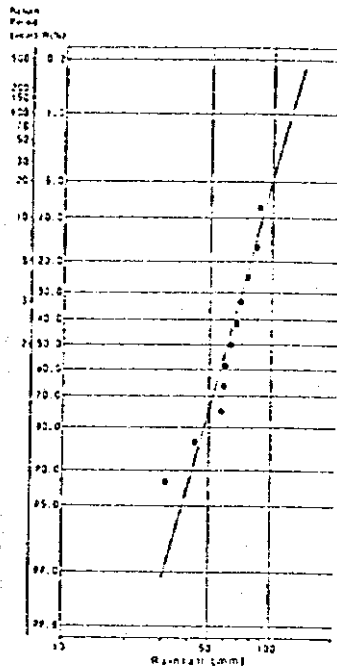
ZARAGOZA STATION

Figure D.17 Probable Daily Point Rainfall

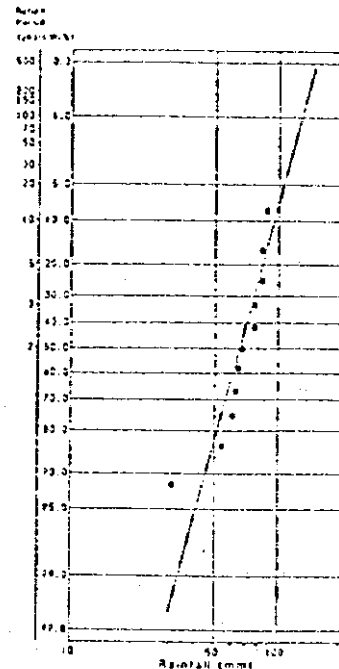
THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



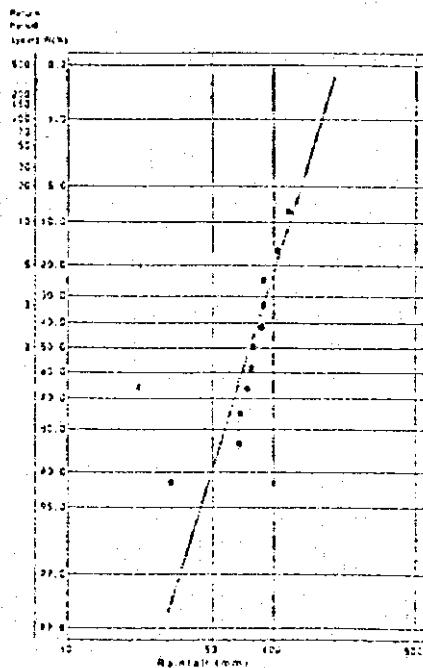
1-HR RAINFALL



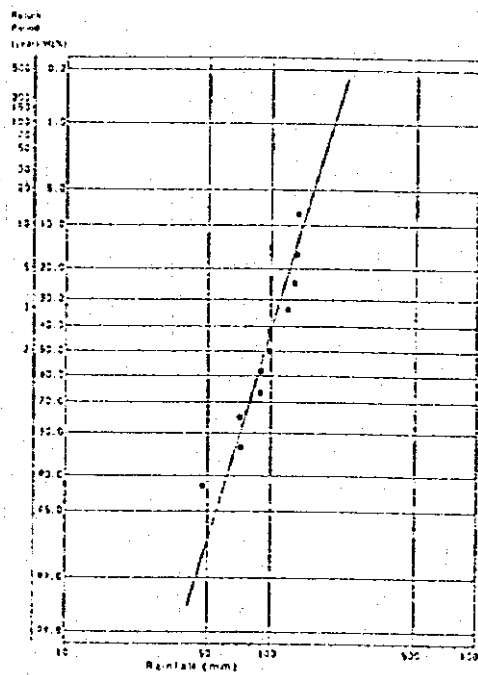
2-HR RAINFALL



3-HR RAINFALL



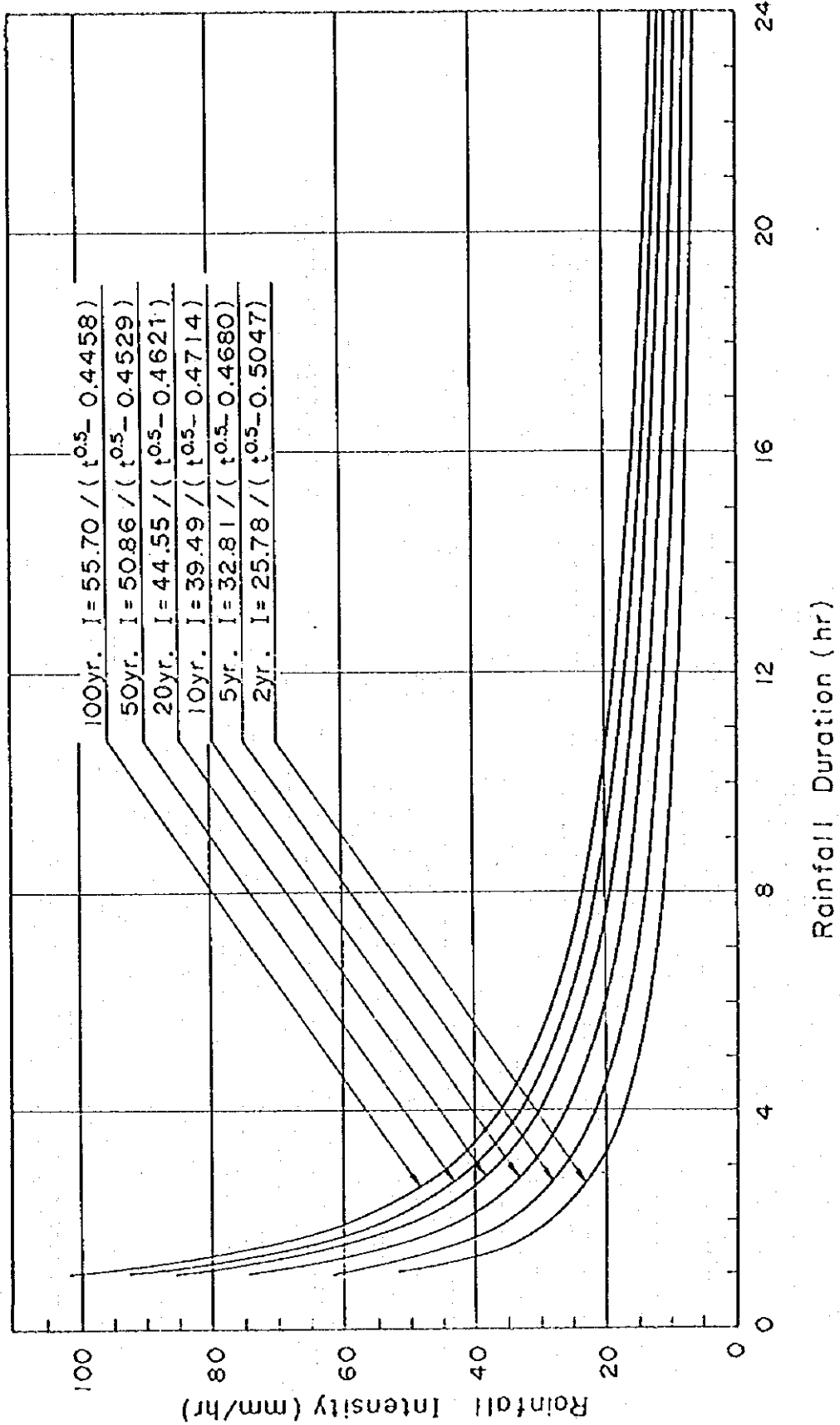
6-HR RAINFALL



12-HR RAINFALL

Figure D.18 Probable Point Rainfall at Zaragoza Station

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



**Figure D.19** Rainfall Intensity Duration Curve at Zaragoza Station (Long Duration)

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

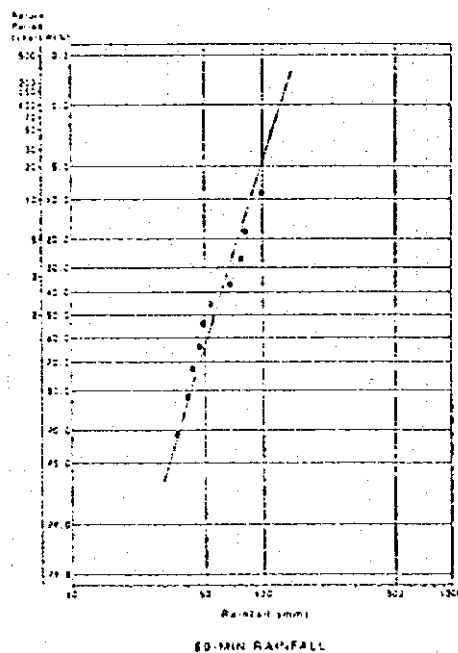
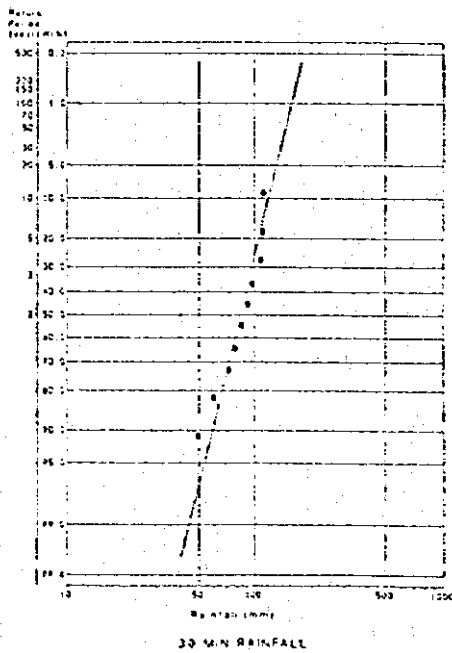
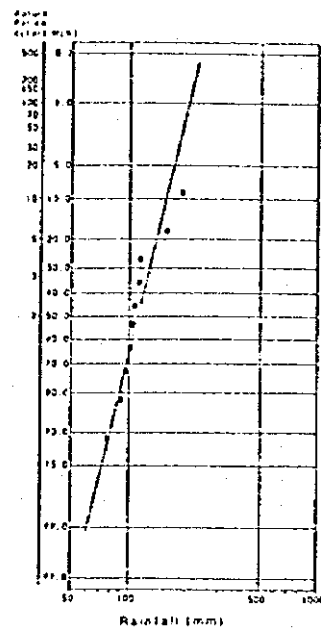
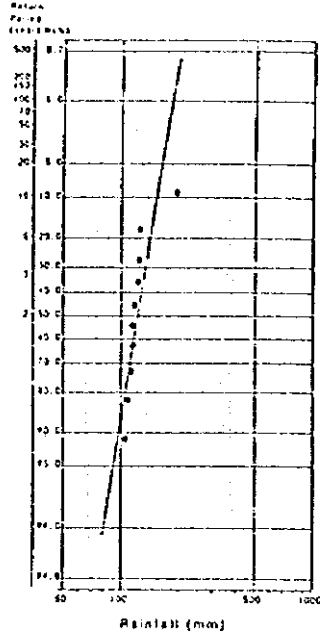
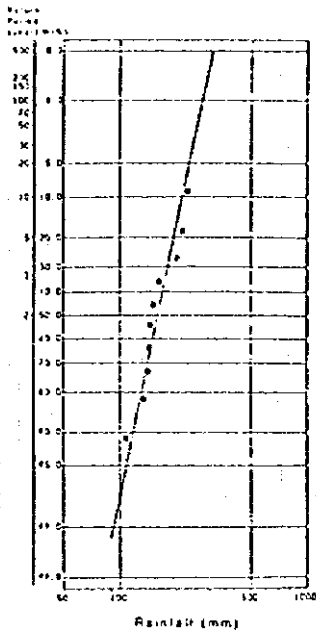
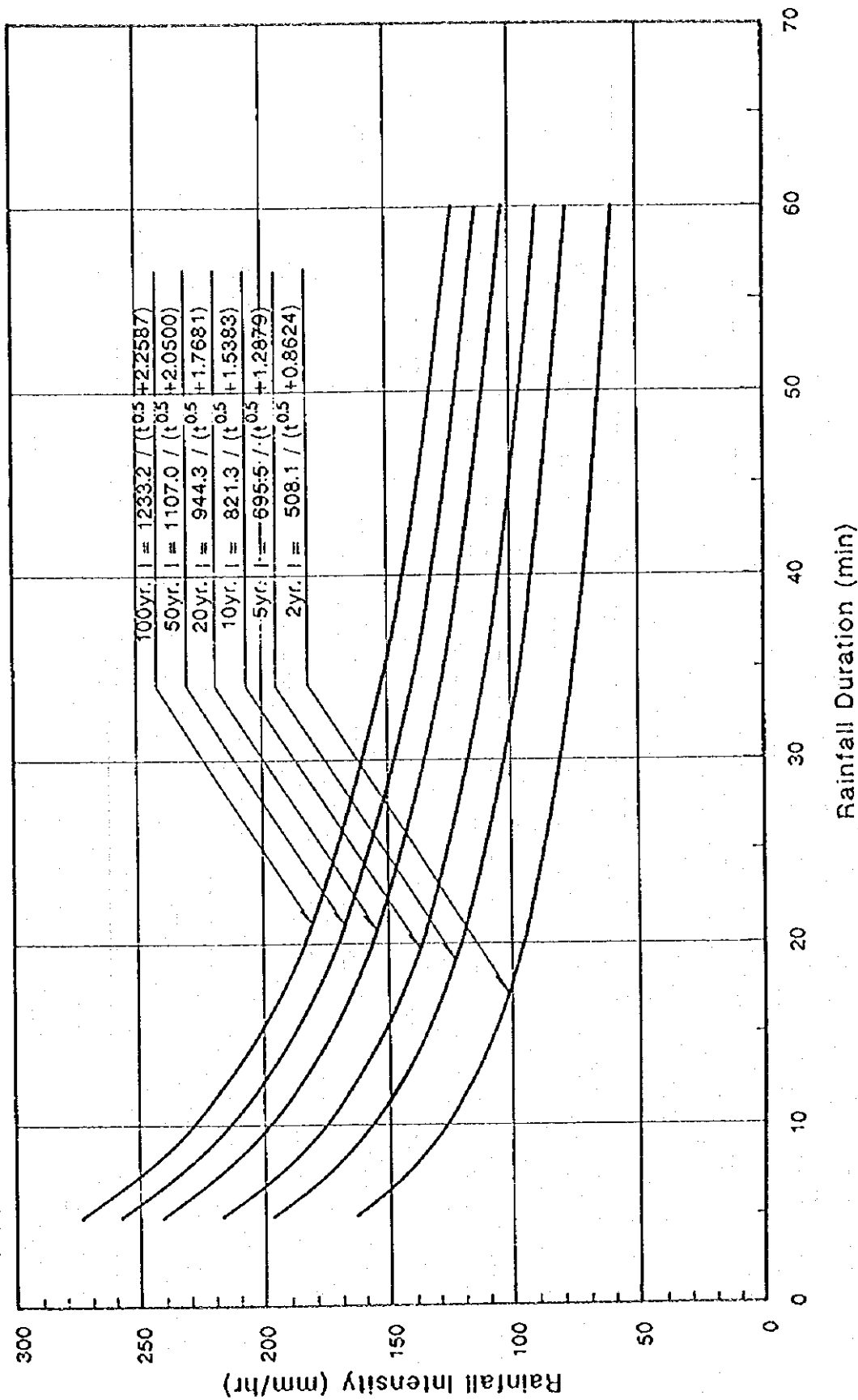


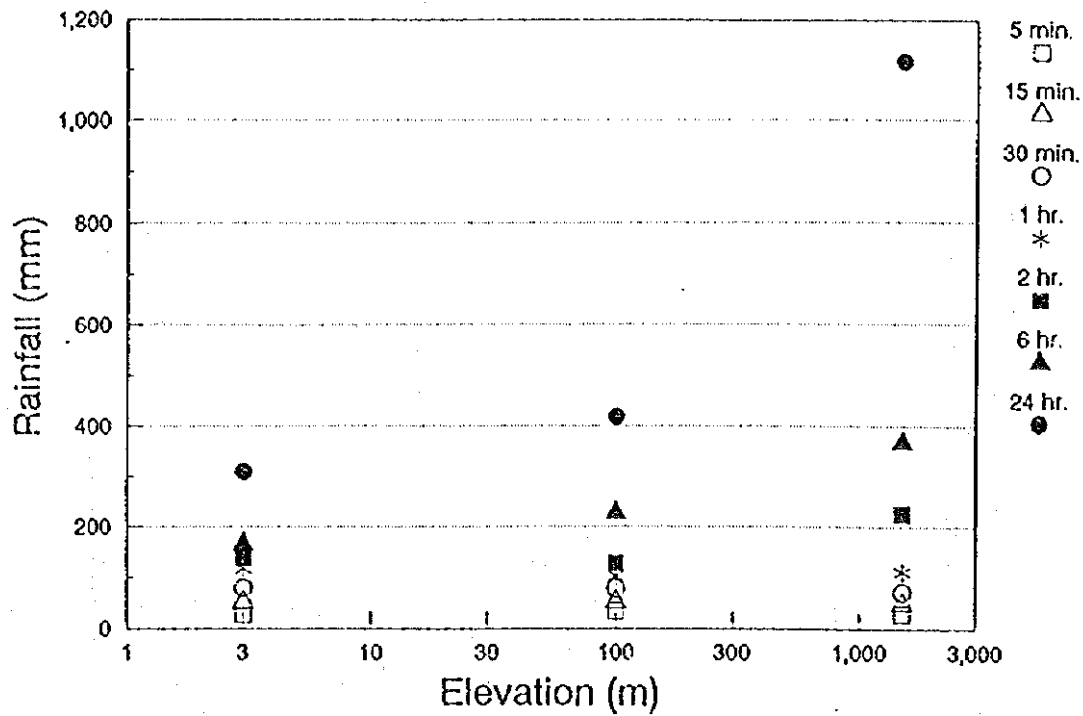
Figure D.20 Probable Point Rainfall at San Agustin Station

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

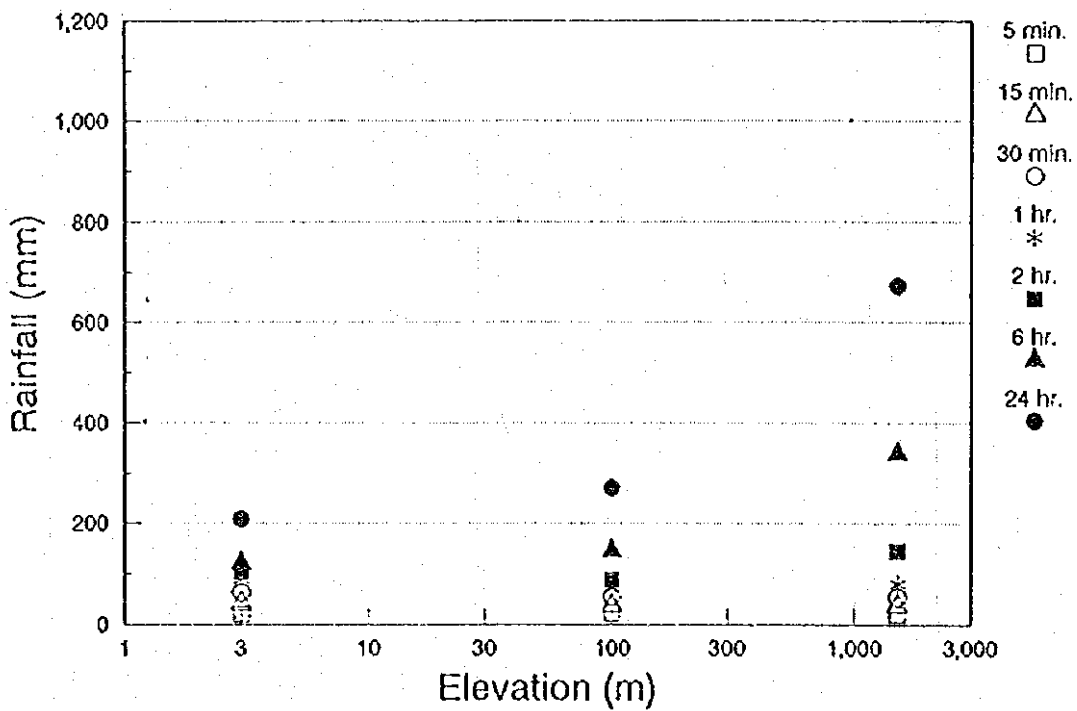


**Figure D.21** Rainfall Intensity Duration Curve at San Agustin Station (Short Duration)

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATURO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



100-yr. Return Period

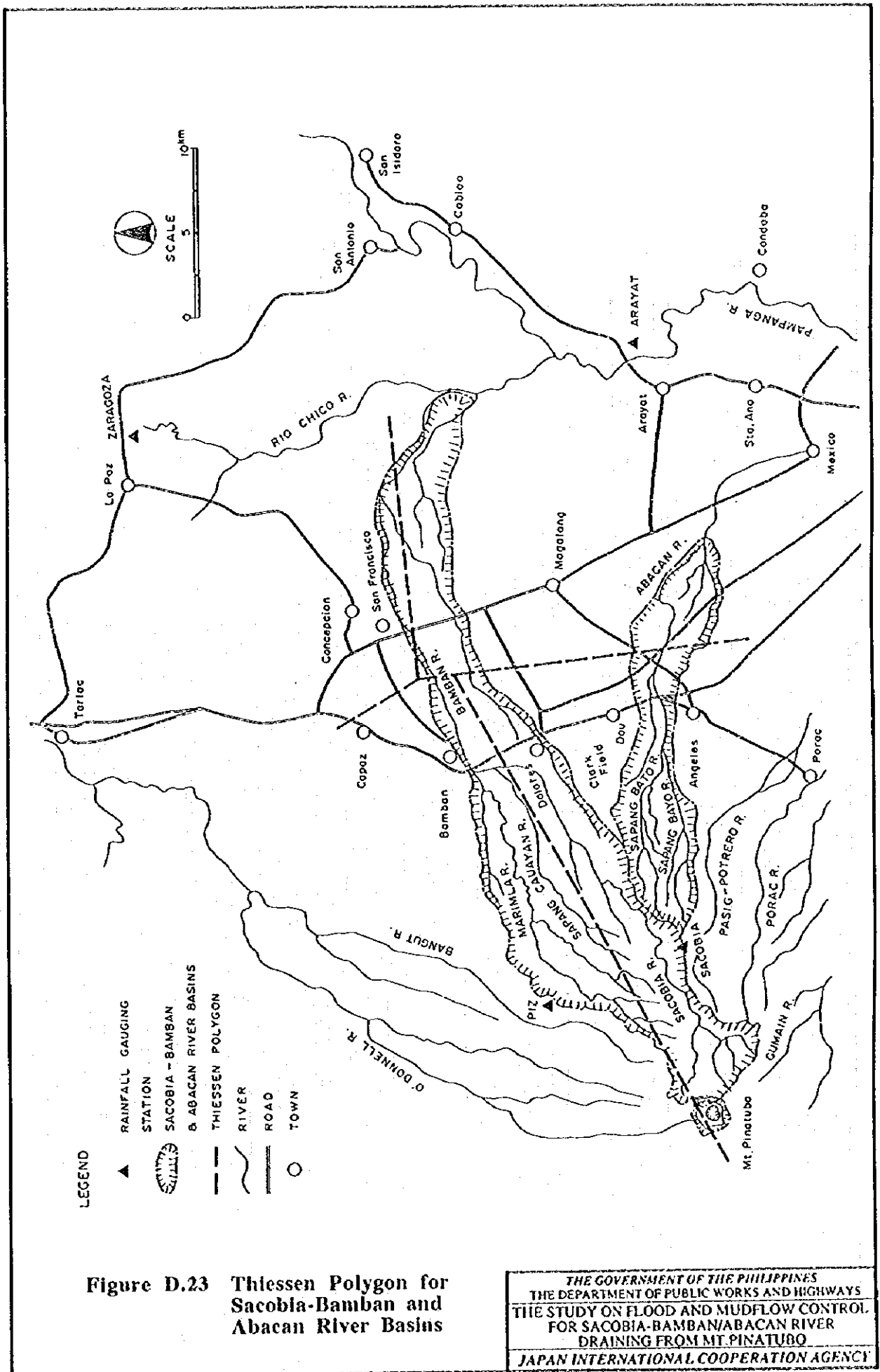


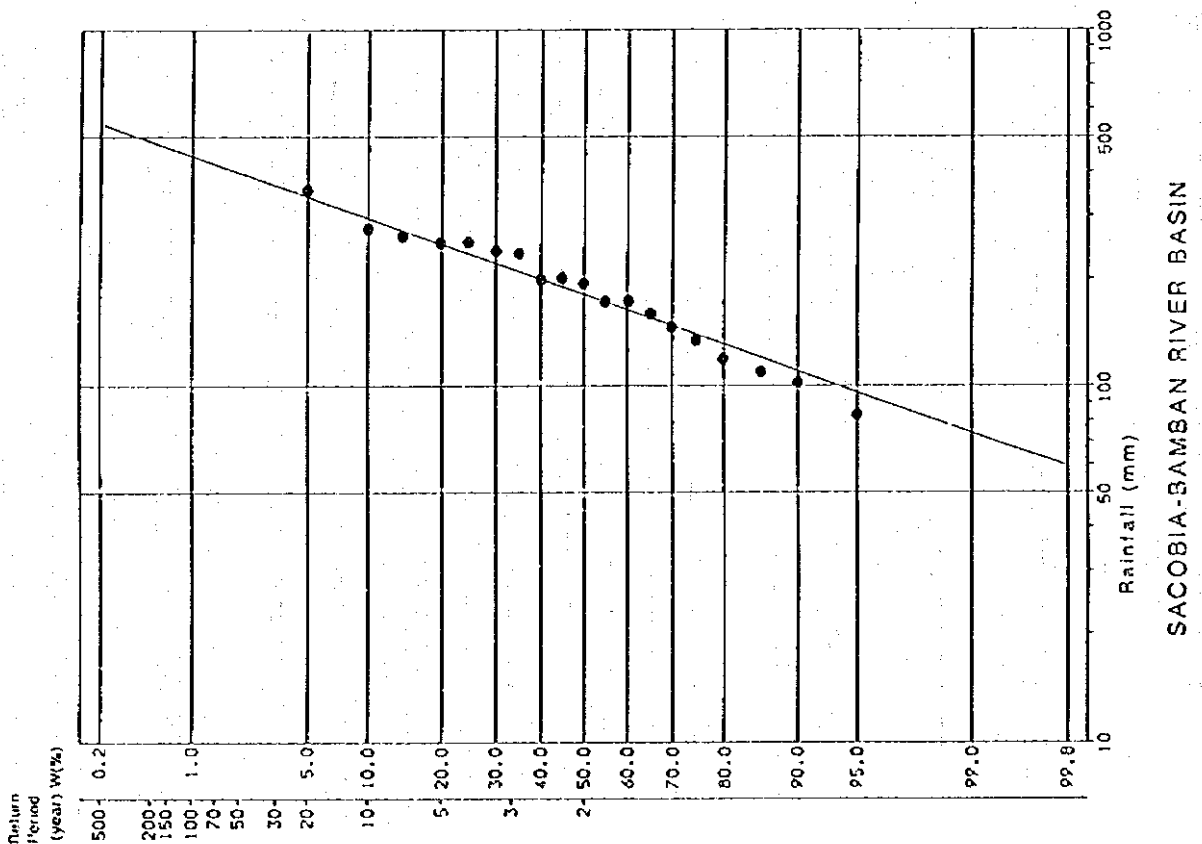
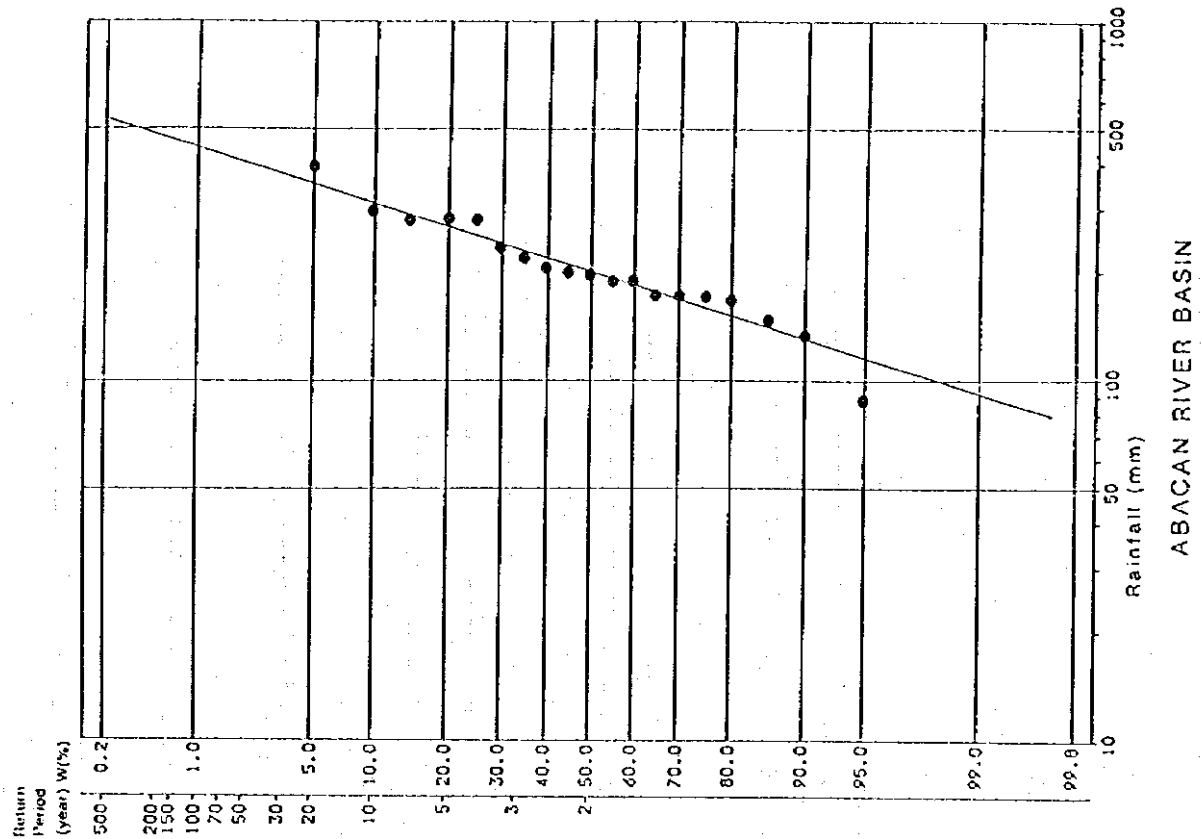
10-yr. Return Period

Figure D.22 Relation between Rainfall and Elevation

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



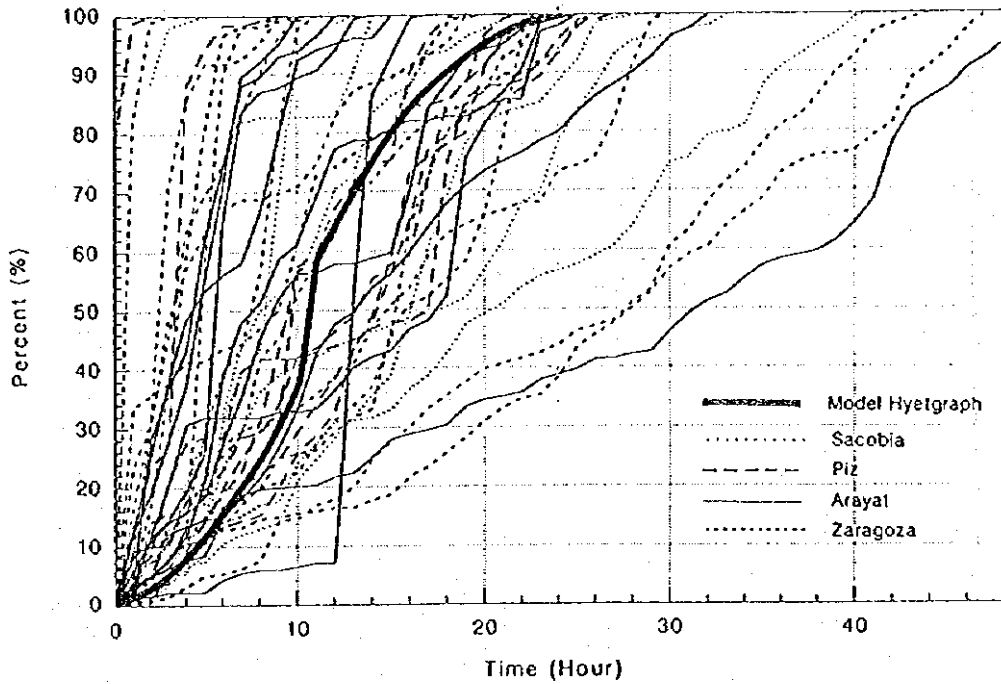




**Figure D.24 Probable Basin Mean Daily Rainfall**

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

### Rainfall Duration and Accumulated Rainfall Rate



### Hourly Rainfall Distribution

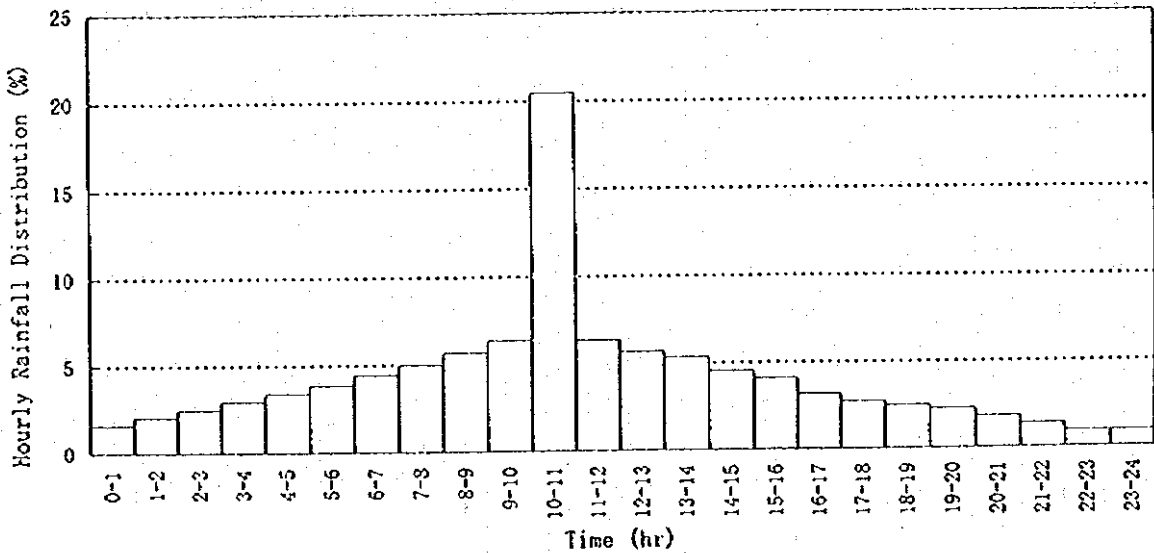
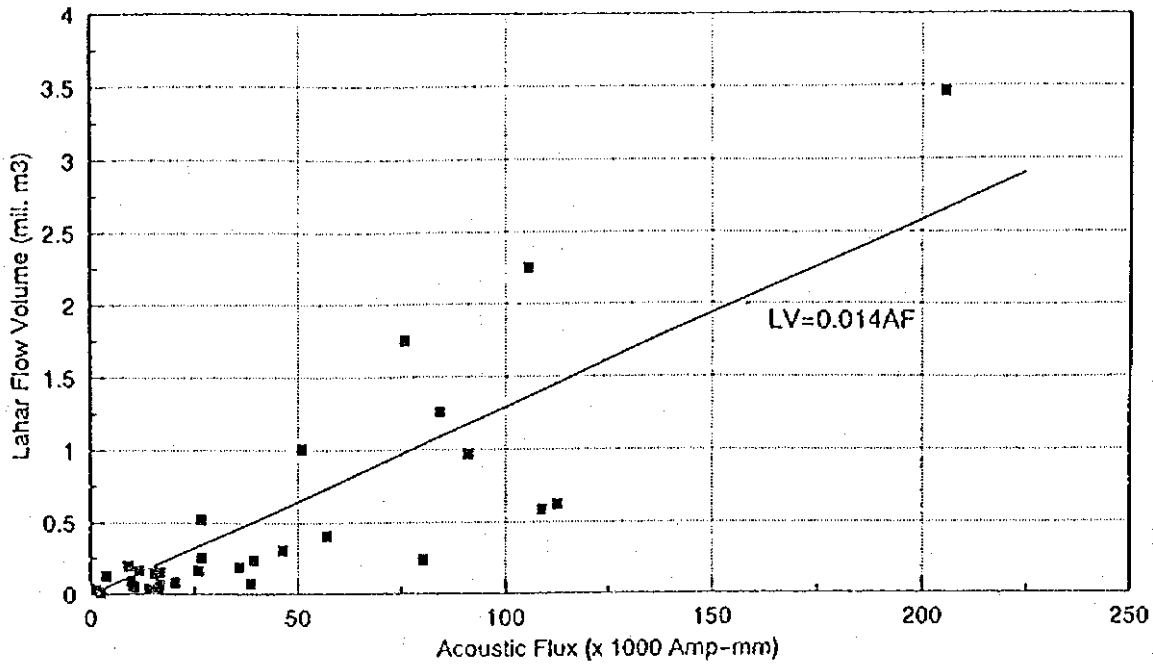


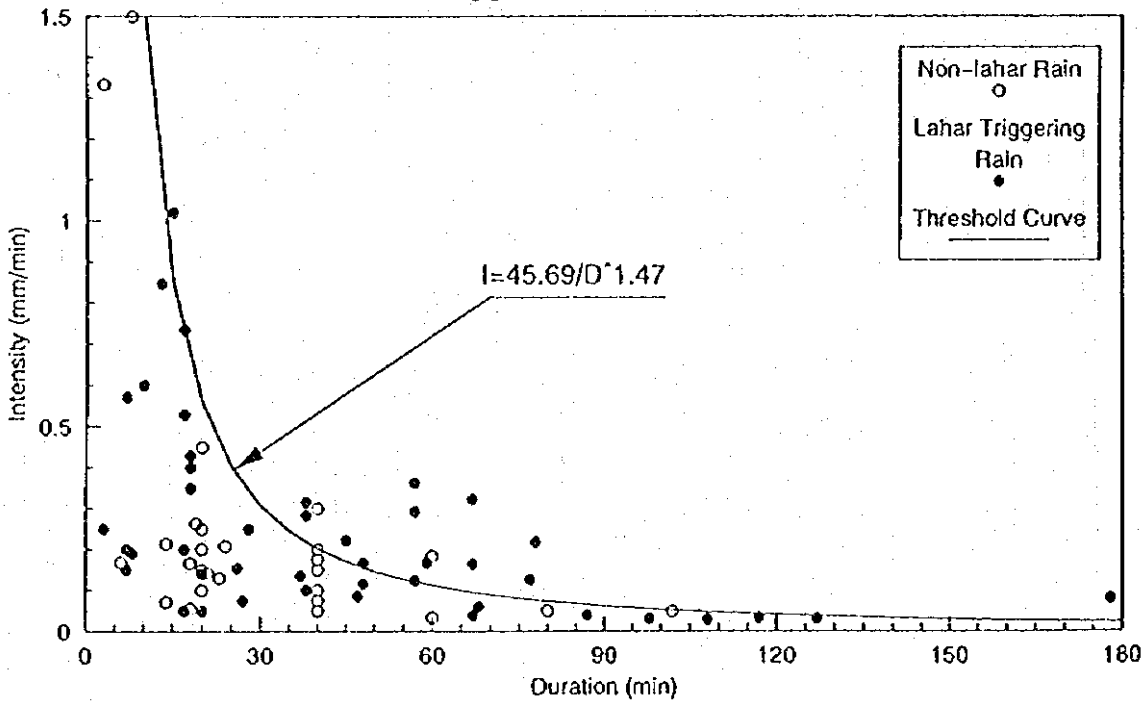
Figure D.25 Model Hyetgraph

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

### Lahar Volume and Acoustic Flux at Mactan Gate

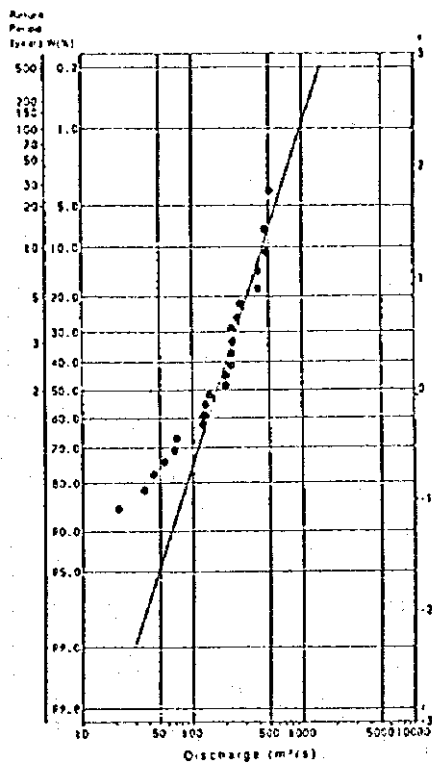


### Lahar Trigger Threshold Curve

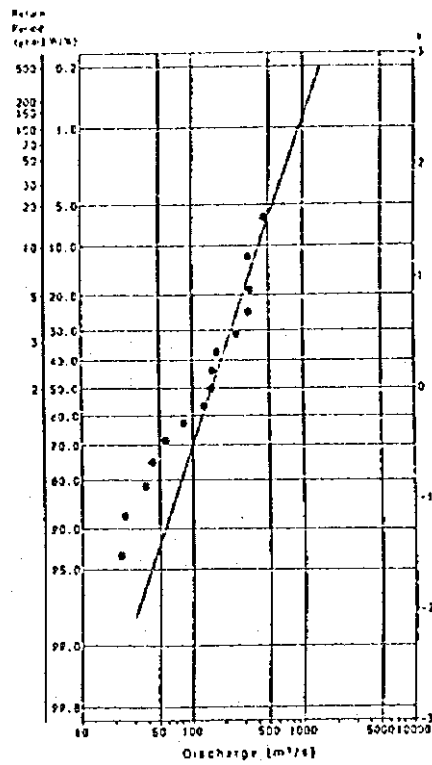


**Figure D.26 Lahar Volume and  
Threshold Curve by  
PHIVOLCS**

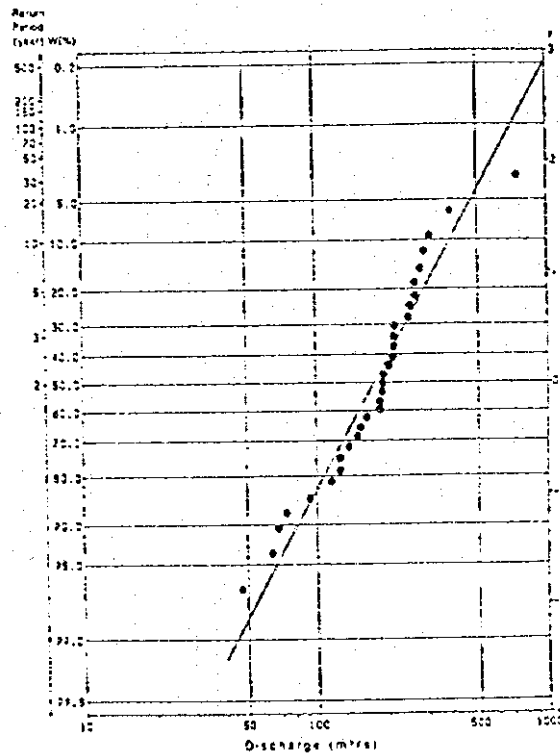
THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATURO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



DEL CARMEN (PORAC RIVER)



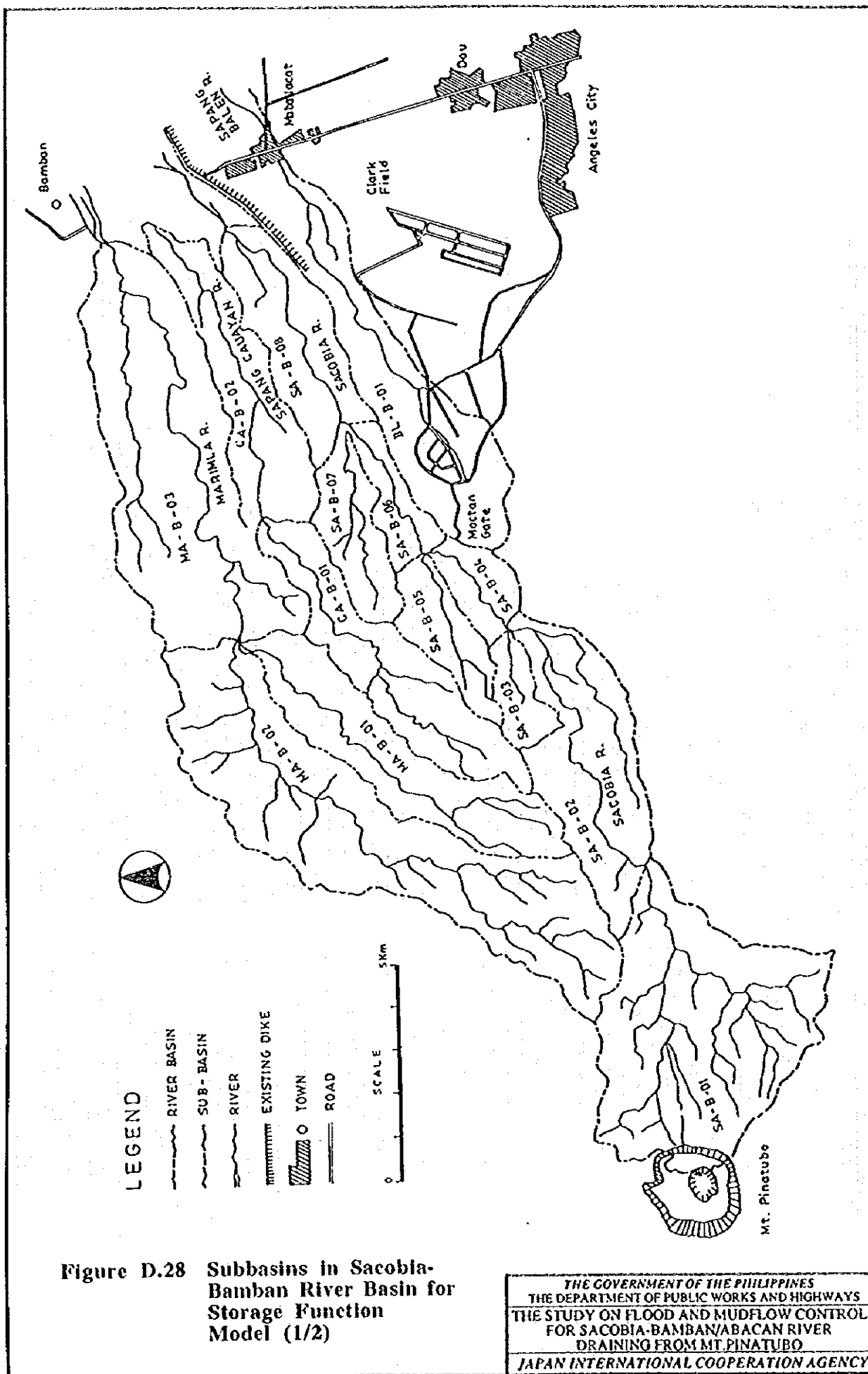
VALDEZ (PORAC RIVER)

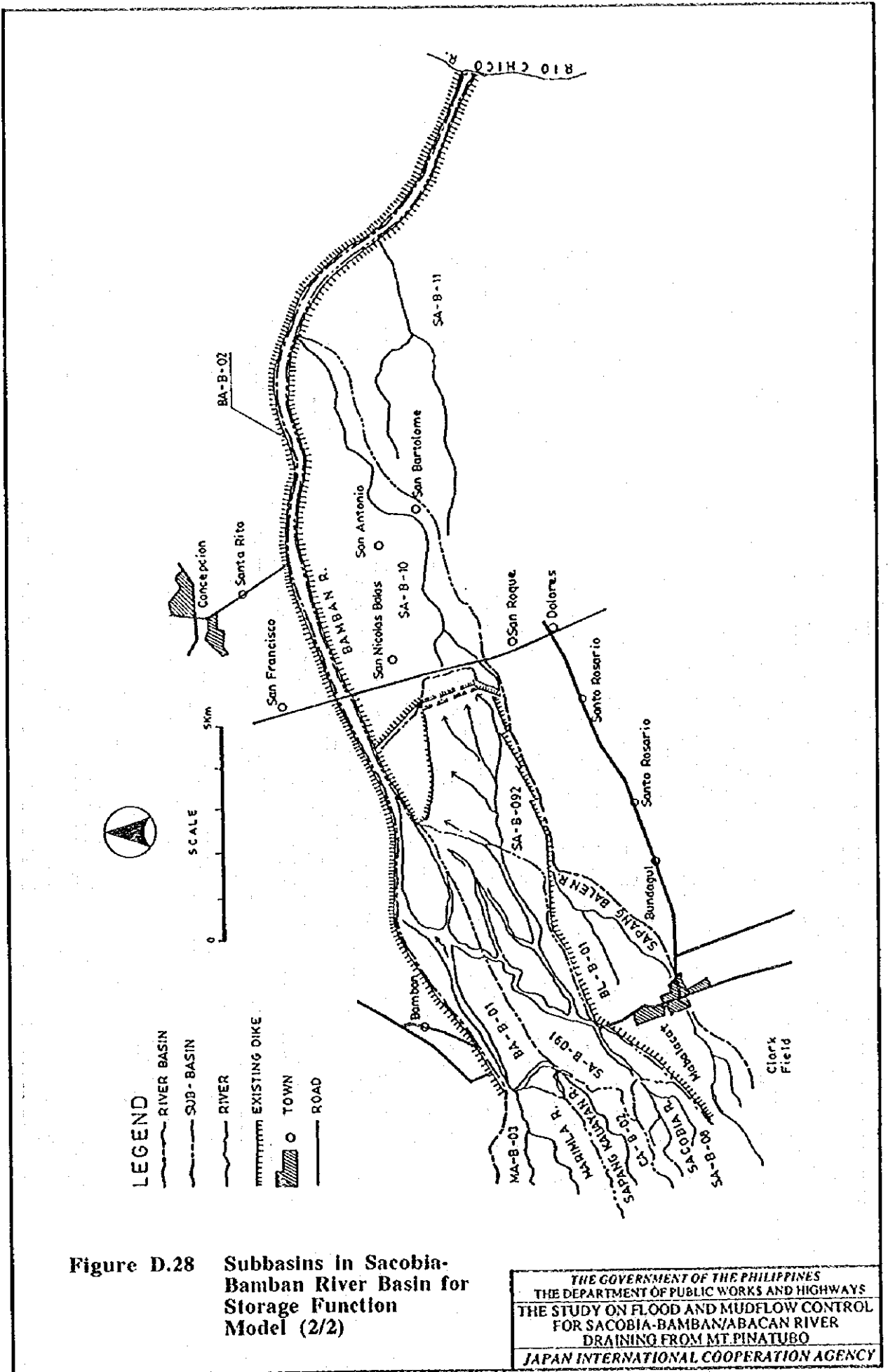


PABANLAG (GUMAIN RIVER)

Figure D.27 Probable Discharge in Porac and Gumain Rivers

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY





**Figure D.28** Subbasins in Sacobia-Bamban River Basin for Storage Function Model (2/2)

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY

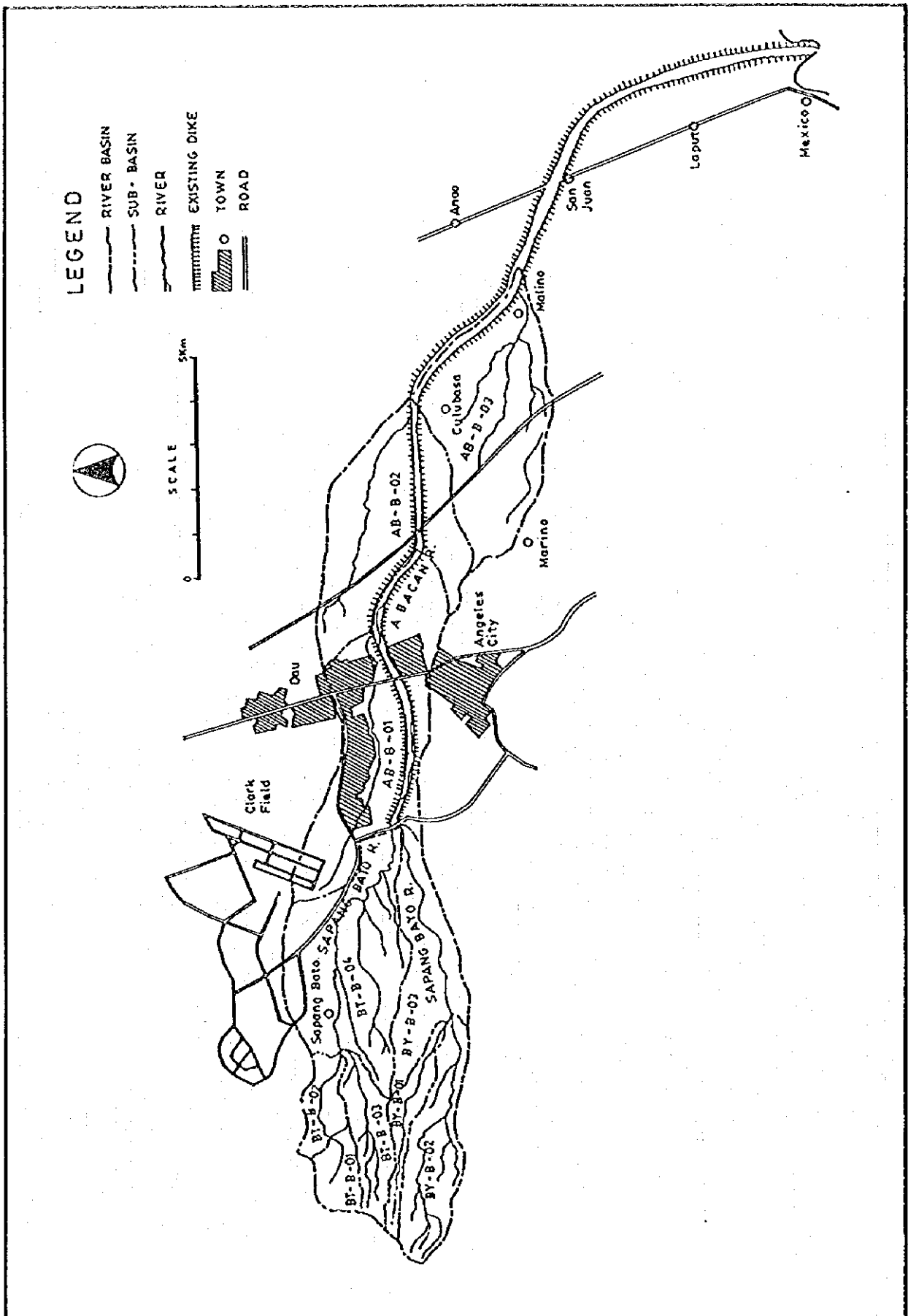
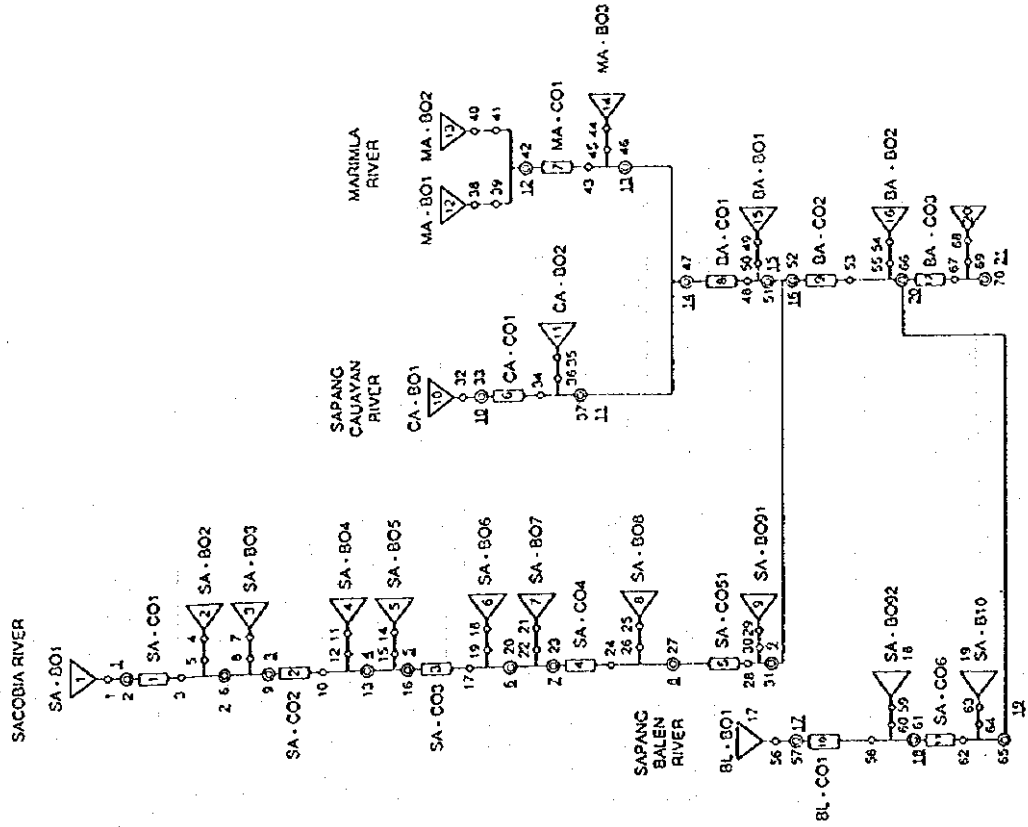


Figure D.29 Subbasins in Abacan River Basin for Storage Function Model

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
 THE STUDY ON FLOOD AND MUDFLOW CONTROL  
 FOR SACOBIA-BAMBAN/ABACAN RIVER  
 DRAINING FROM MT. PINATUBO  
 JAPAN INTERNATIONAL COOPERATION AGENCY



SACOBIA-BAMBAN RIVER  
CASE 2-1



SACOBIA-BAMBAN RIVER  
CASE 1-1

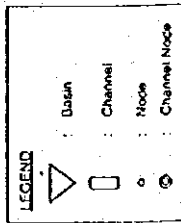
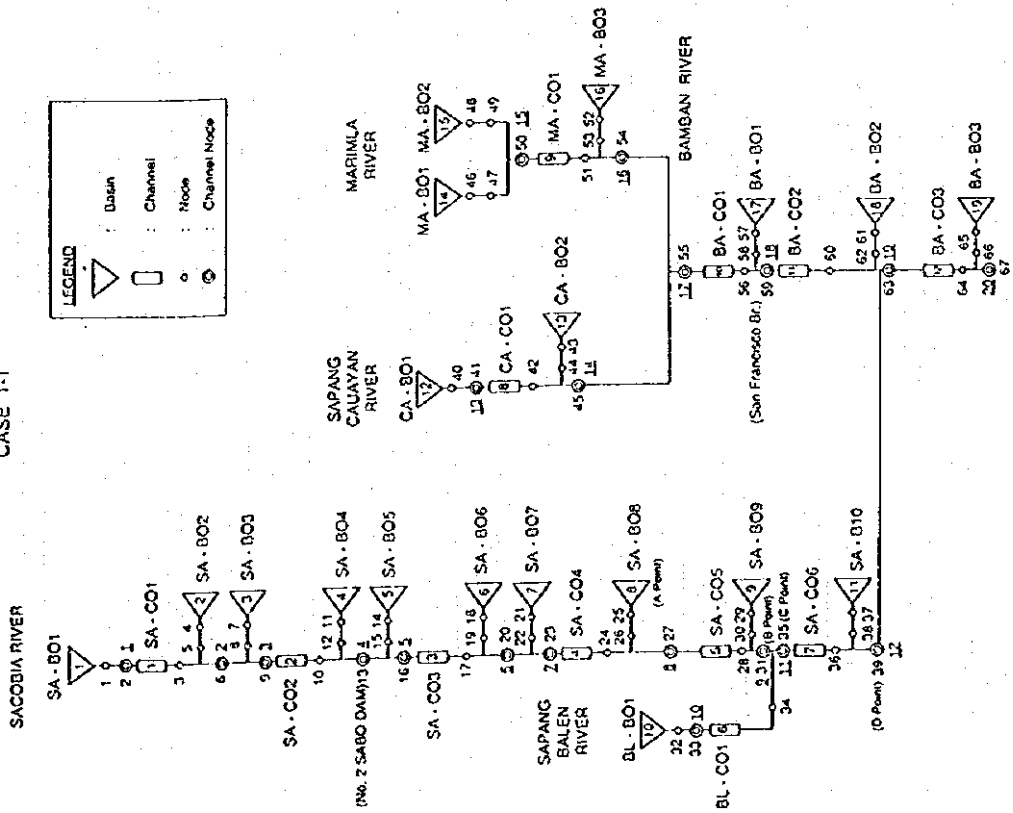
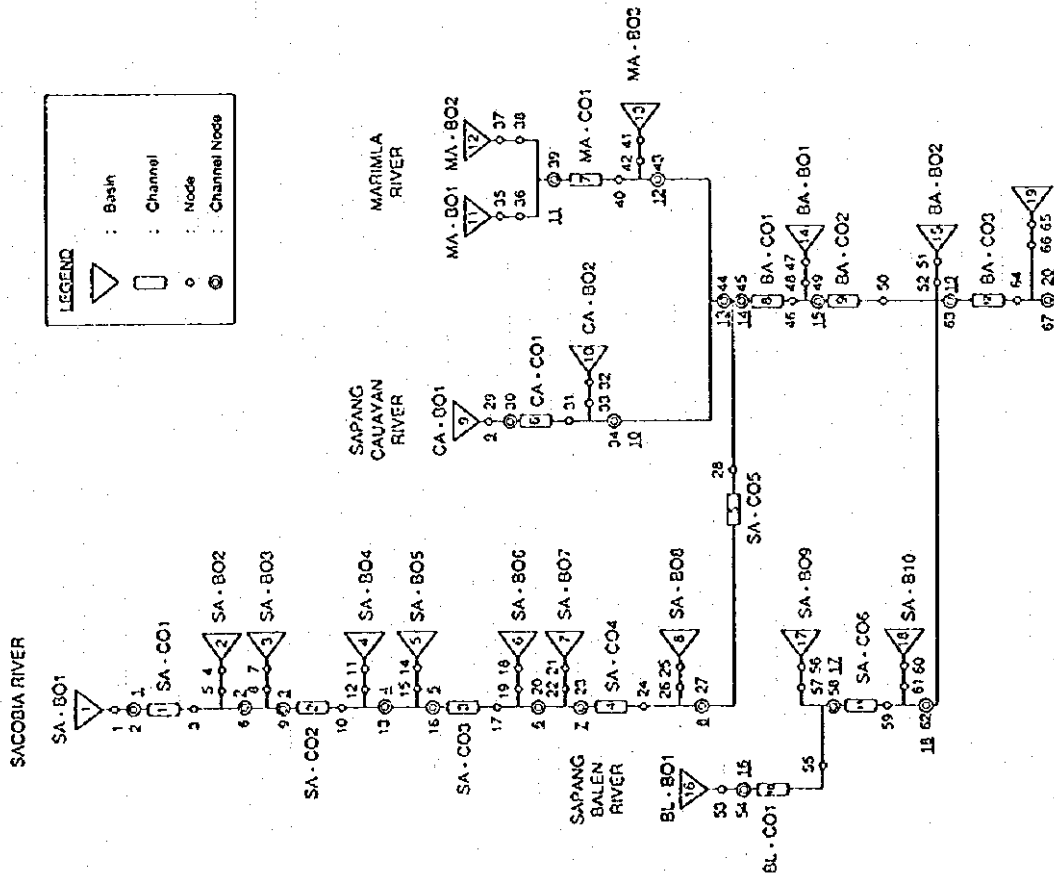


Figure D.30 Model Diagram for Storage Function Model (1/2)

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY

SACOBIA-BAMBAN RIVER  
CASE - 3-1



ABACAN RIVER

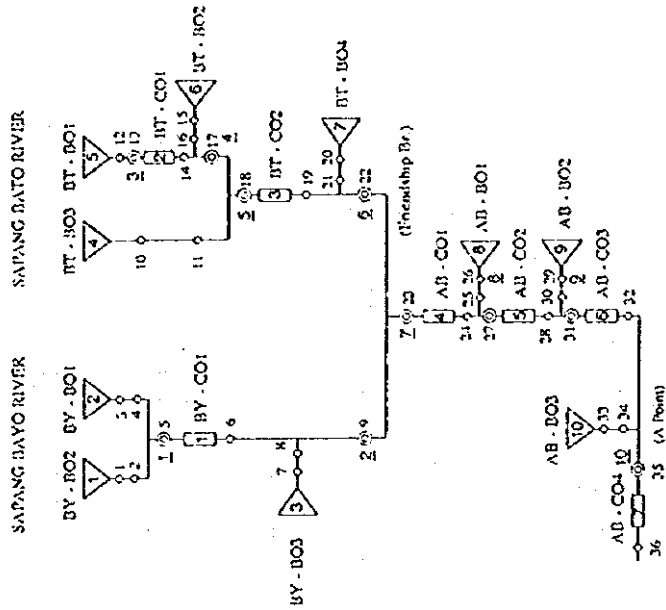
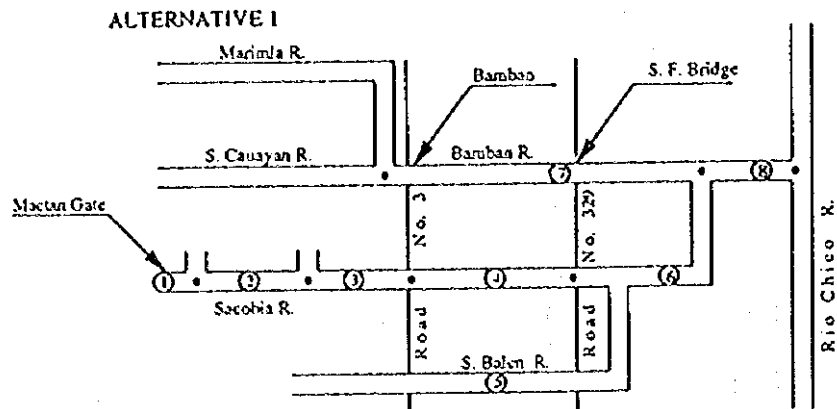


Figure D.30 Model Diagram for Storage Function Model (2/2)

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY



Probable Peak Discharge Distribution  
CASE 1-1 Unit :m<sup>3</sup>/s

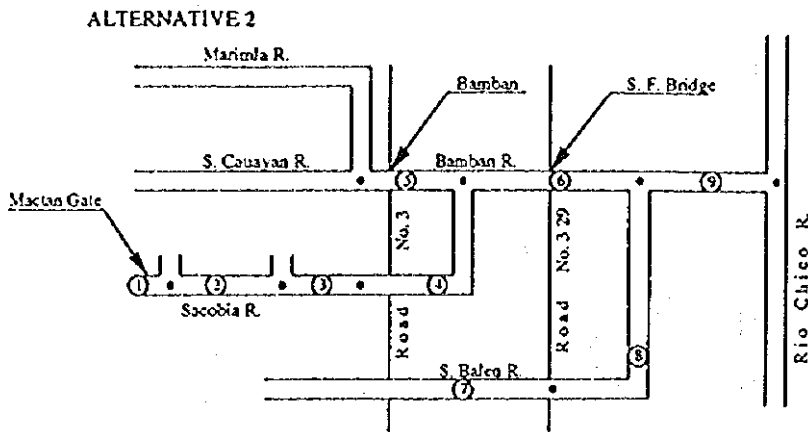
Reach	Return Period					
	100	50	20	10	5	2
No.1	400	350	290	250	190	140
No.2	460	400	340	290	220	160
No.3	570	500	420	350	270	200
No.4	710	610	510	430	320	240
No.5	200	170	145	125	90	70
No.6	1010	870	720	610	460	340
No.7	750	630	520	430	320	240
No.8	1760	1480	1200	1020	750	550

Probable Peak Discharge Distribution  
CASE 1-2 Unit :m<sup>3</sup>/s

Reach	Return Period					
	100	50	20	10	5	2
No.1	180	160	135	115	85	60
No.2	250	220	180	155	115	85
No.3	370	330	270	230	170	125
No.4	520	440	380	320	240	175
No.5	200	170	145	125	90	70
No.6	850	730	610	510	380	280
No.7	760	640	520	430	320	230
No.8	1570	1320	1060	900	660	490

Figure D.31 Probable Peak Discharge Distribution in Sacobia-Bamban River (1/3)

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY



Probable Peak Discharge Distribution  
CASE 2-1 Unit :m<sup>3</sup>/s

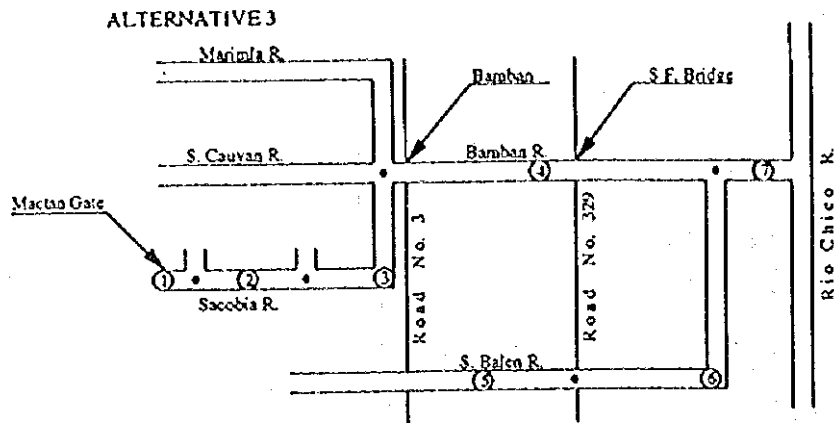
Reach	Return Period					
	100	50	20	10	5	2
No.1	400	350	290	250	190	140
No.2	460	400	340	290	220	160
No.3	570	500	420	350	270	200
No.4	660	580	480	410	310	230
No.5	800	690	580	490	360	270
No.6	1440	1250	1040	870	650	480
No.7	200	170	145	125	90	70
No.8	440	380	310	260	195	140
No.9	1820	1540	1260	1070	780	580

Probable Peak Discharge Distribution  
CASE 2-2 Unit :m<sup>3</sup>/s

Reach	Return Period					
	100	50	20	10	5	2
No.1	180	160	135	115	85	60
No.2	250	220	180	155	115	85
No.3	370	330	270	230	170	125
No.4	470	410	340	290	210	160
No.5	800	690	580	490	360	270
No.6	1240	1070	890	750	560	410
No.7	200	170	145	125	90	70
No.8	440	380	310	260	195	140
No.9	1610	1360	1110	940	690	510

Figure D.31 Probable Peak Discharge Distribution in Sacobia-Bamban River (2/3)

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY



Probable Peak Discharge Distribution  
CASE 3-1 Unit :m<sup>3</sup>/s

Reach	Return Period					
	100	50	20	10	5	2
No.1	400	350	290	250	190	140
No.2	460	400	340	290	220	160
No.3	570	500	420	350	270	200
No.4	1340	1150	970	800	590	440
No.5	200	170	145	125	90	70
No.6	540	470	390	330	240	180
No.7	1810	1530	1250	1050	770	570

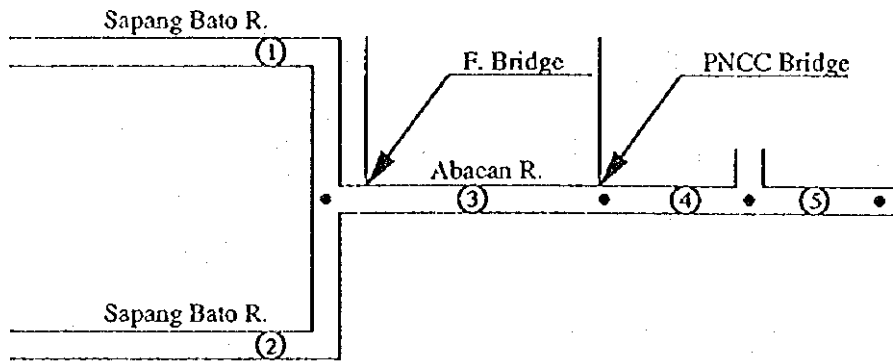
Probable Peak Discharge Distribution  
CASE 3-2 Unit :m<sup>3</sup>/s

Reach	Return Period					
	100	50	20	10	5	2
No.1	180	160	135	115	85	60
No.2	250	220	180	155	115	85
No.3	370	330	270	230	170	125
No.4	1160	1000	830	700	510	380
No.5	200	170	145	125	90	70
No.6	540	470	390	330	240	180
No.7	1610	1360	1110	930	680	500

Figure D.31 Probable Peak Discharge Distribution in Sacobia-Bamban River (3/3)

THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
THE STUDY ON FLOOD AND MUDFLOW CONTROL  
FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
JAPAN INTERNATIONAL COOPERATION AGENCY

# ABACAN RIVER



Probable Peak Discharge Distribution  
 ABACAN RIVER Unit :m<sup>3</sup>/s

Reach	Return Period					
	100	50	20	10	5	2
No.1	150	130	120	100	80	60
No.2	200	170	150	130	100	80
No.3	490	430	370	310	240	180
No.4	590	510	440	380	290	230
No.5	710	620	520	450	350	270

Figure D.32 Probable Peak Discharge Distribution in Abacan River

THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
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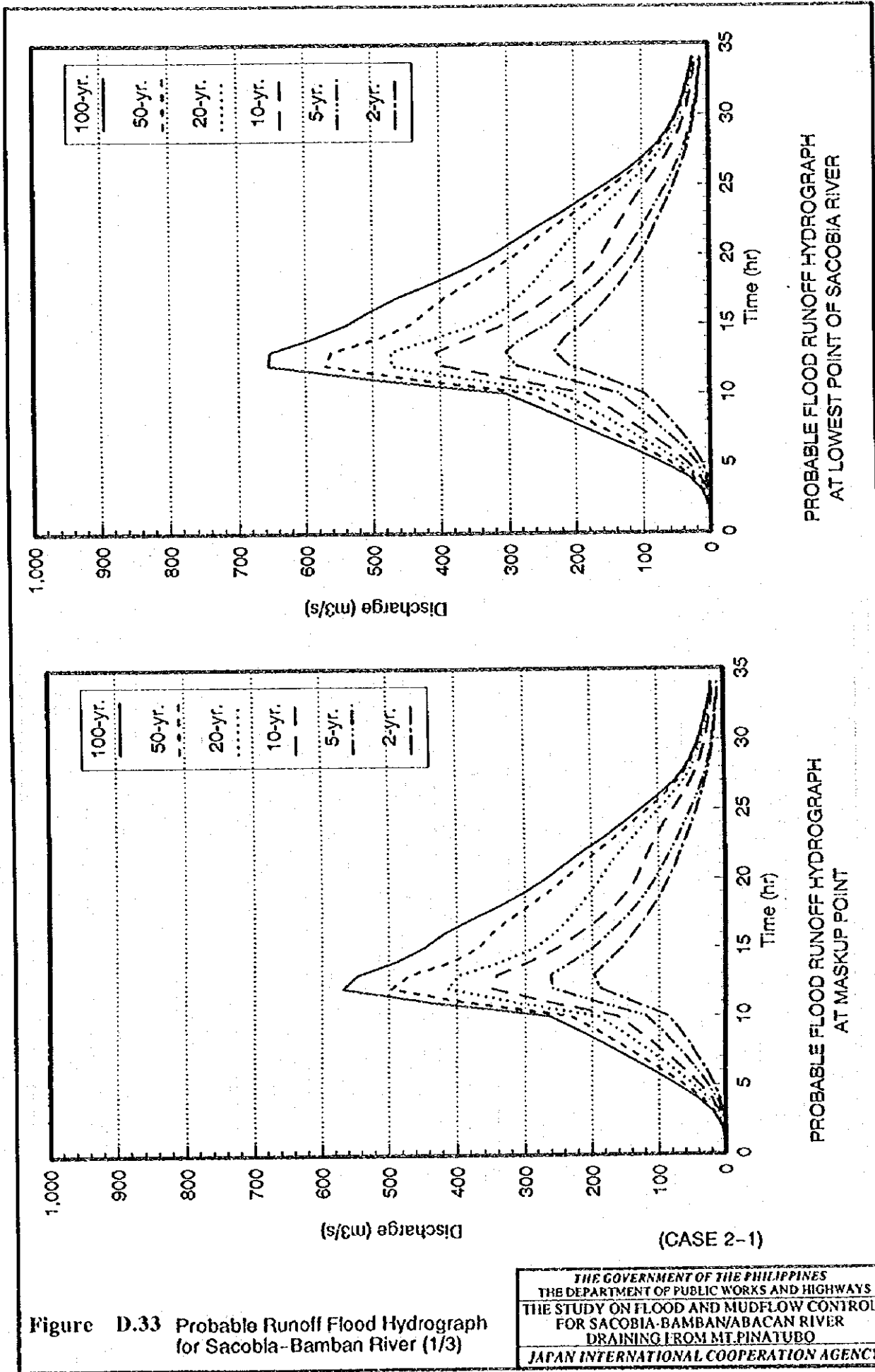
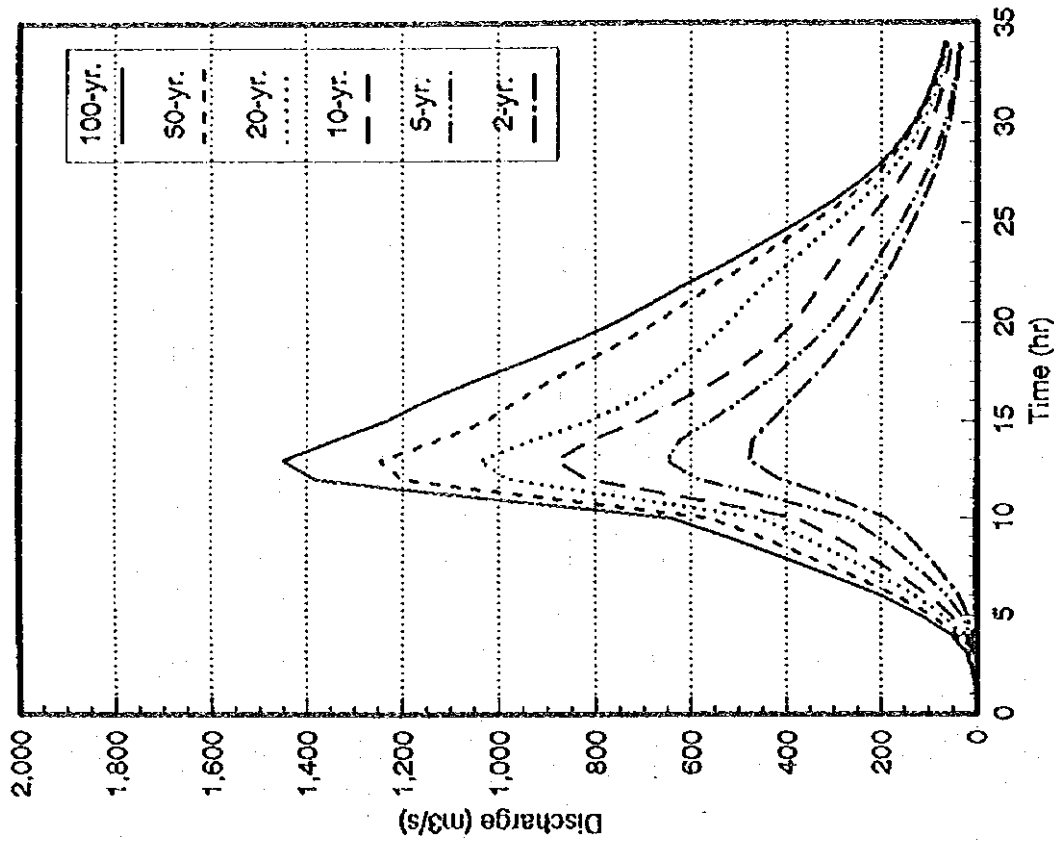
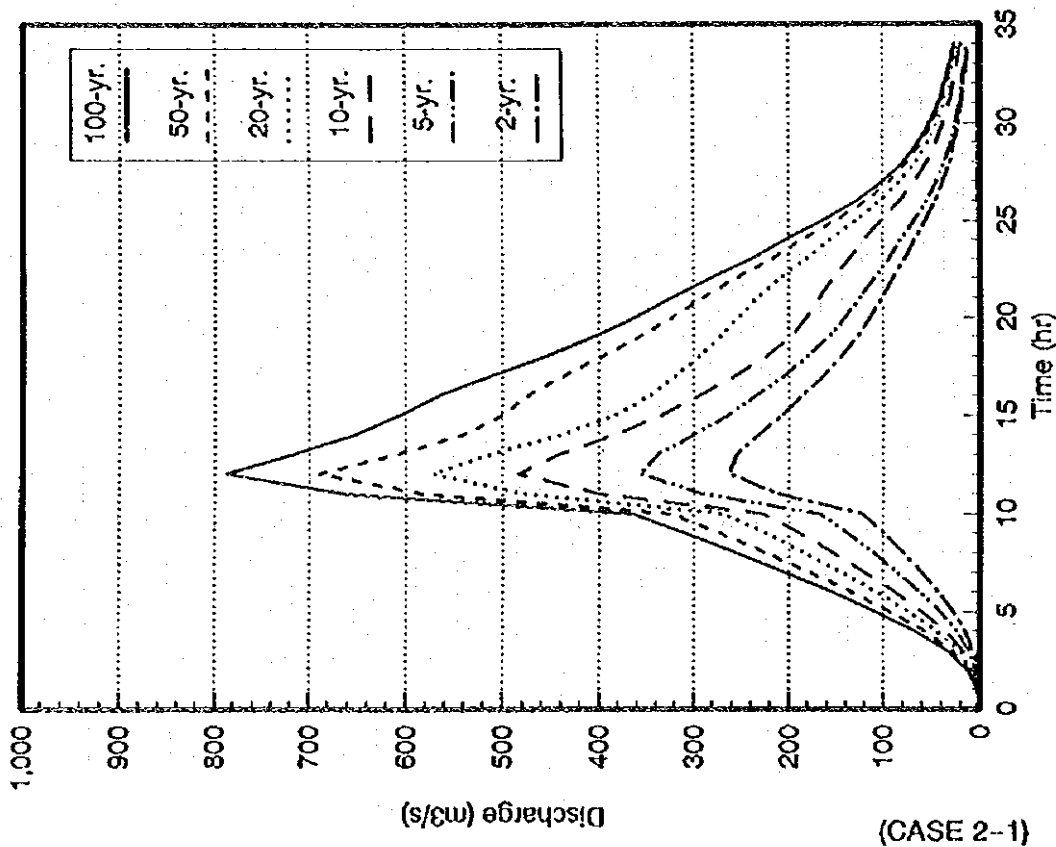


Figure D.33 Probable Runoff Flood Hydrograph for Sacobia-Bamban River (1/3)

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PROBABLE FLOOD RUNOFF HYDROGRAPH  
AT SAN FRANCISCO BRIDGE OF BAMBAN RIVER



PROBABLE FLOOD RUNOFF HYDROGRAPH  
AT ROUTE NO. 3 OF BAMBAN RIVER

(CASE 2-1)

Figure D.33 Probable Runoff Flood Hydrograph  
for Sacobia-Bamban River (2/3)

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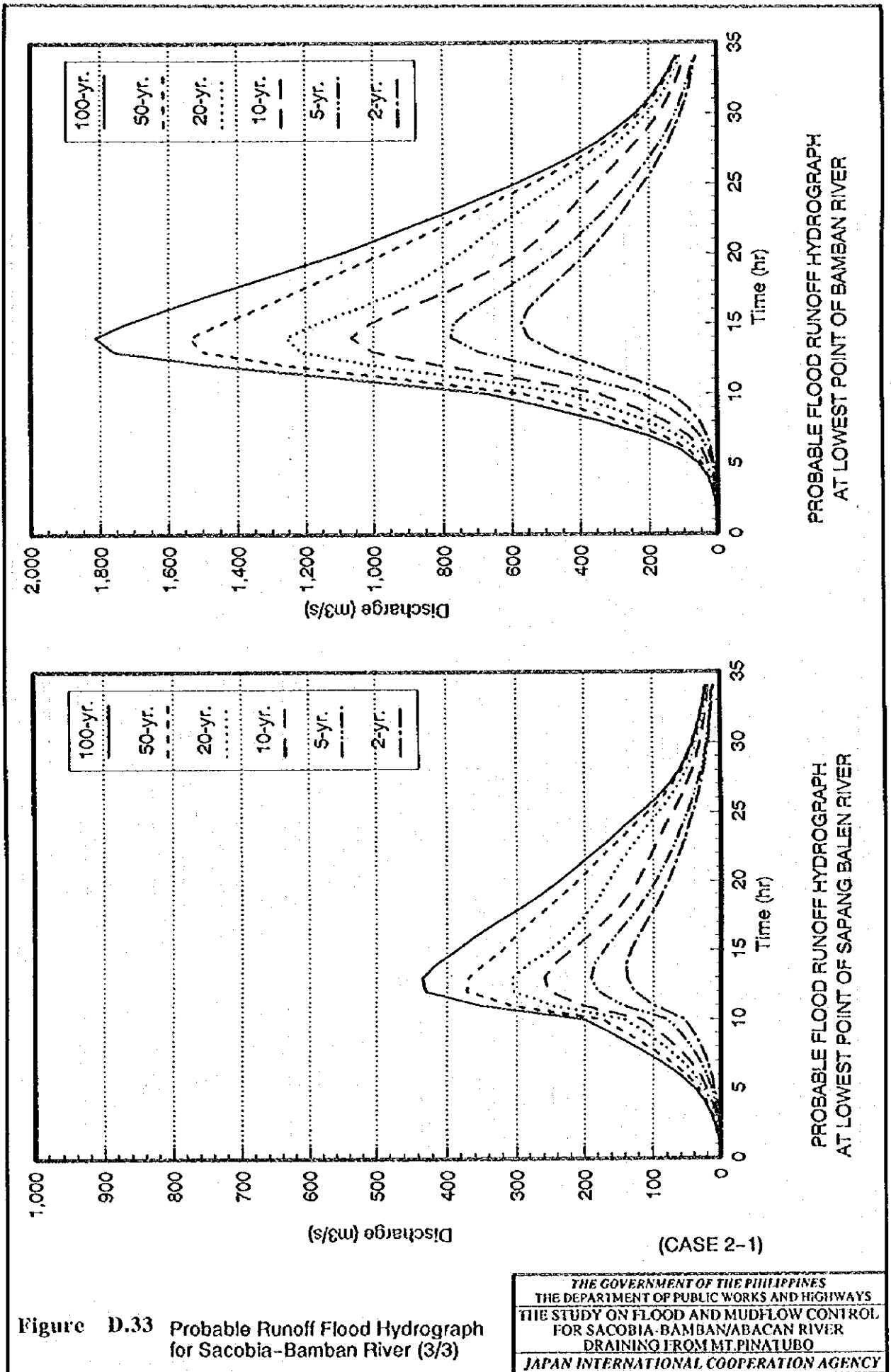
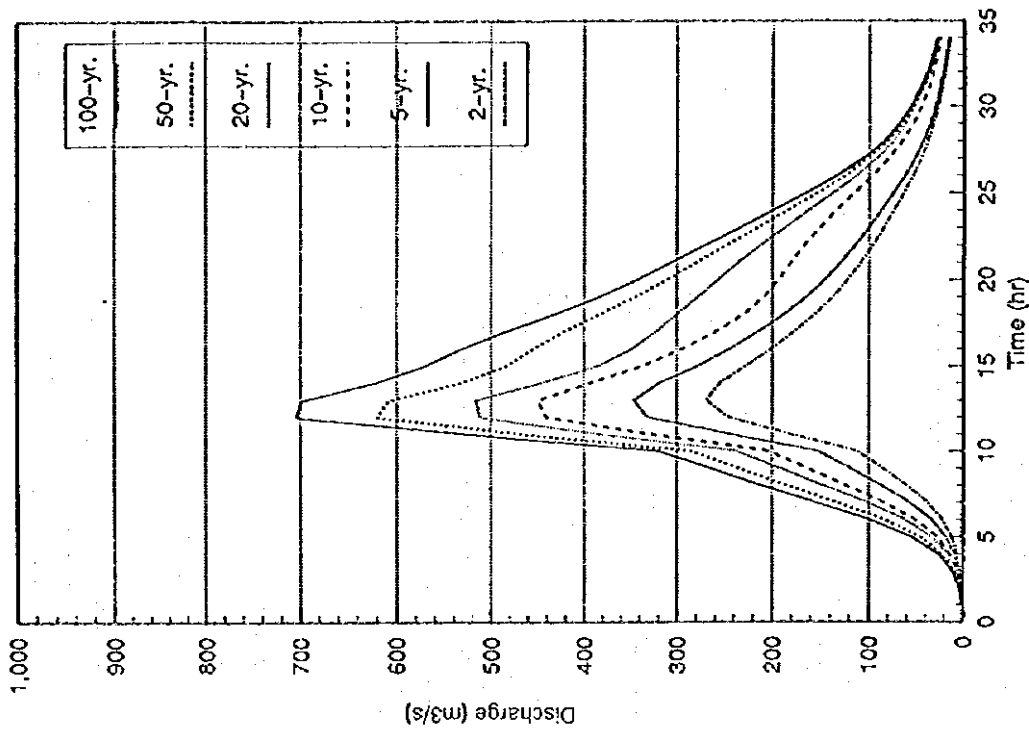
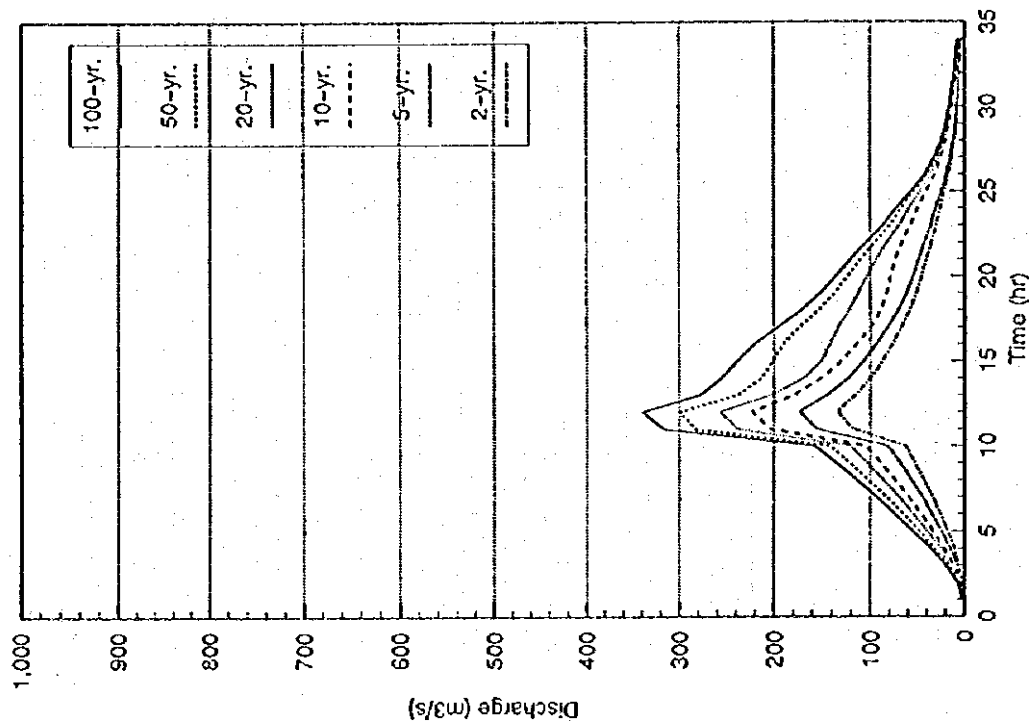


Figure D.33 Probable Runoff Flood Hydrograph for Sacobia-Bamban River (3/3)



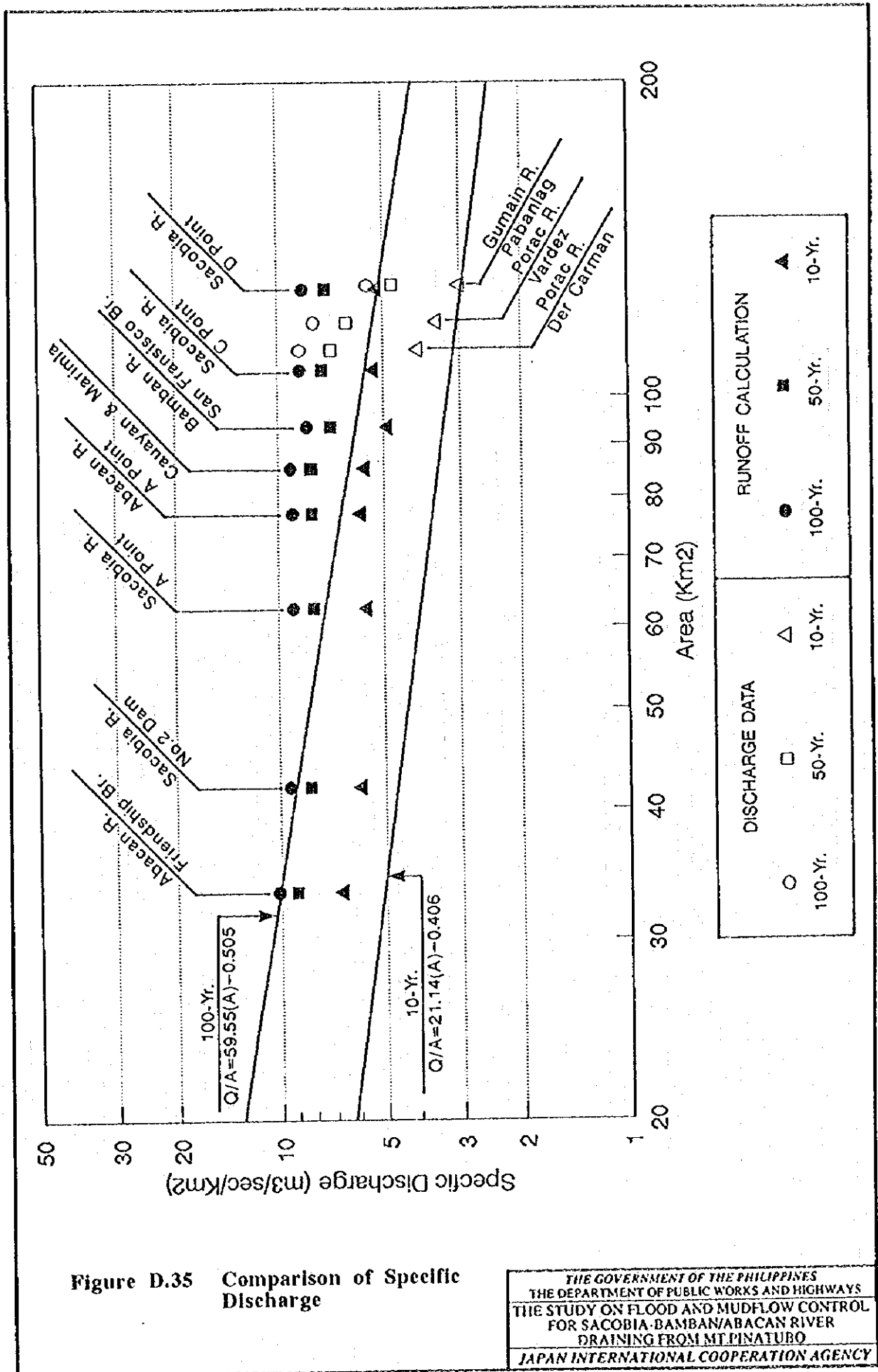
PROBABLE FLOOD RUNOFF HYDROGRAPH  
AT LOWEST POINT OF ABACAN RIVER

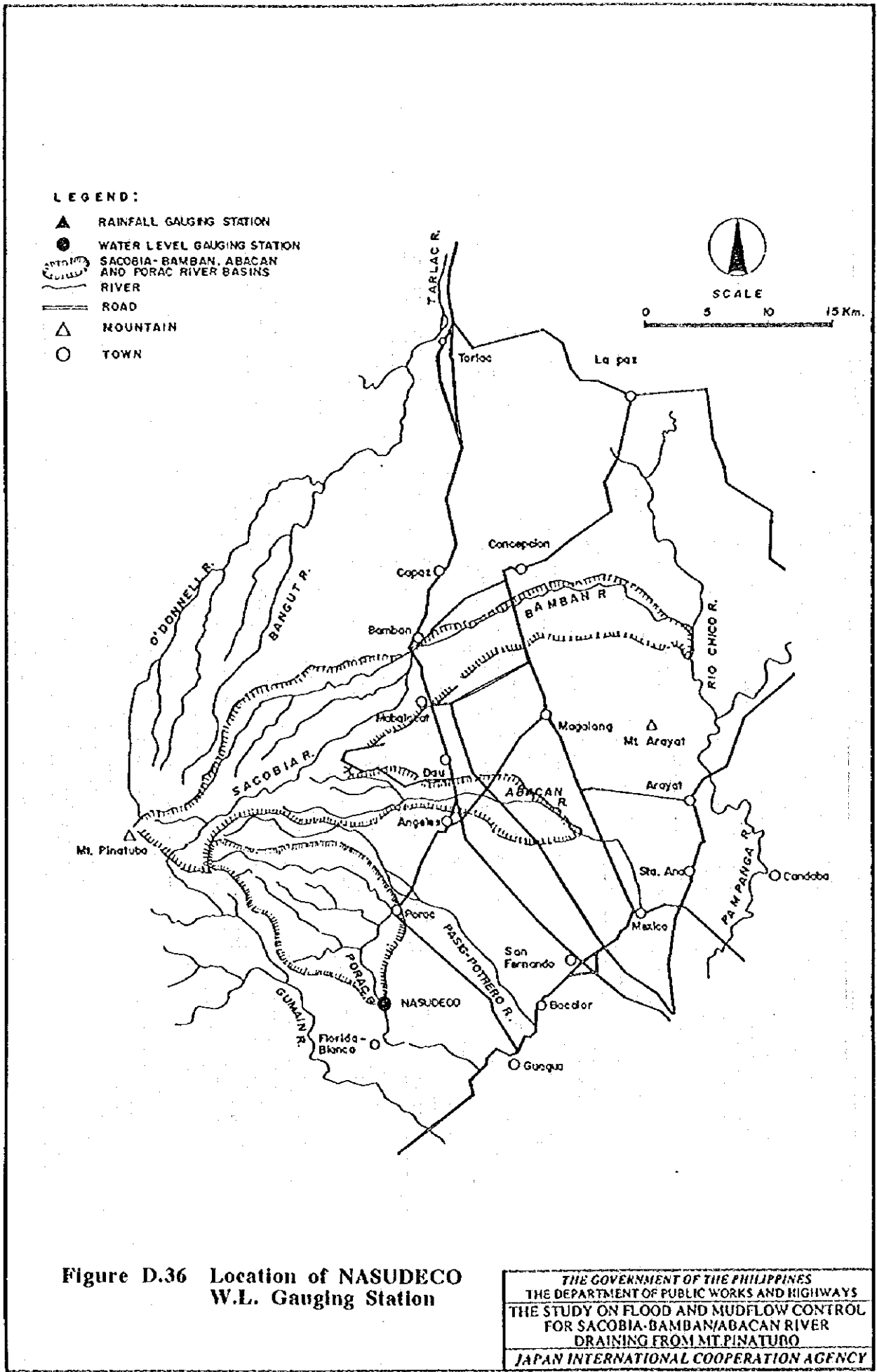


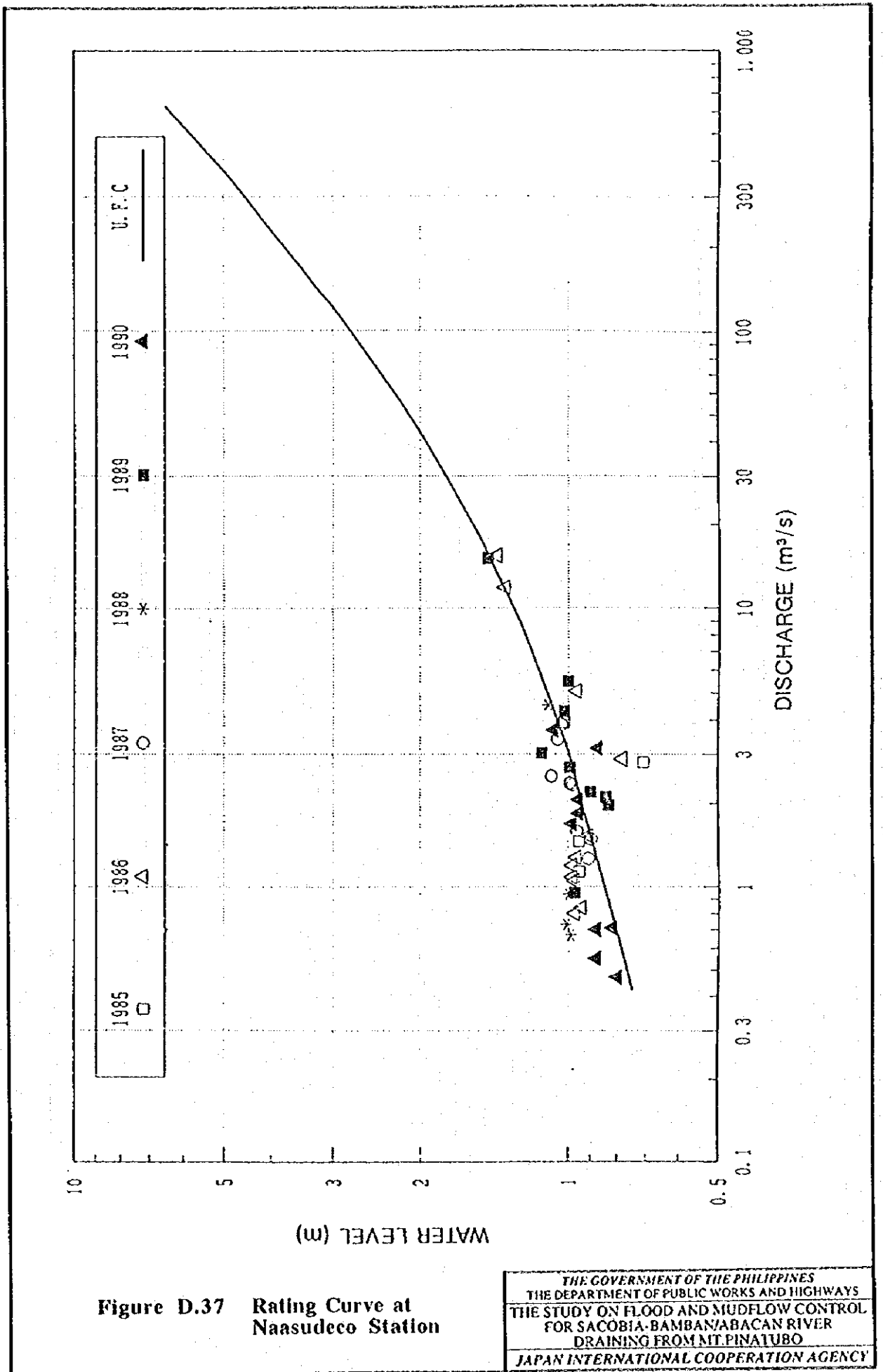
PROBABLE FLOOD RUNOFF HYDROGRAPH  
AT FRIENDSHIP BRIDGE

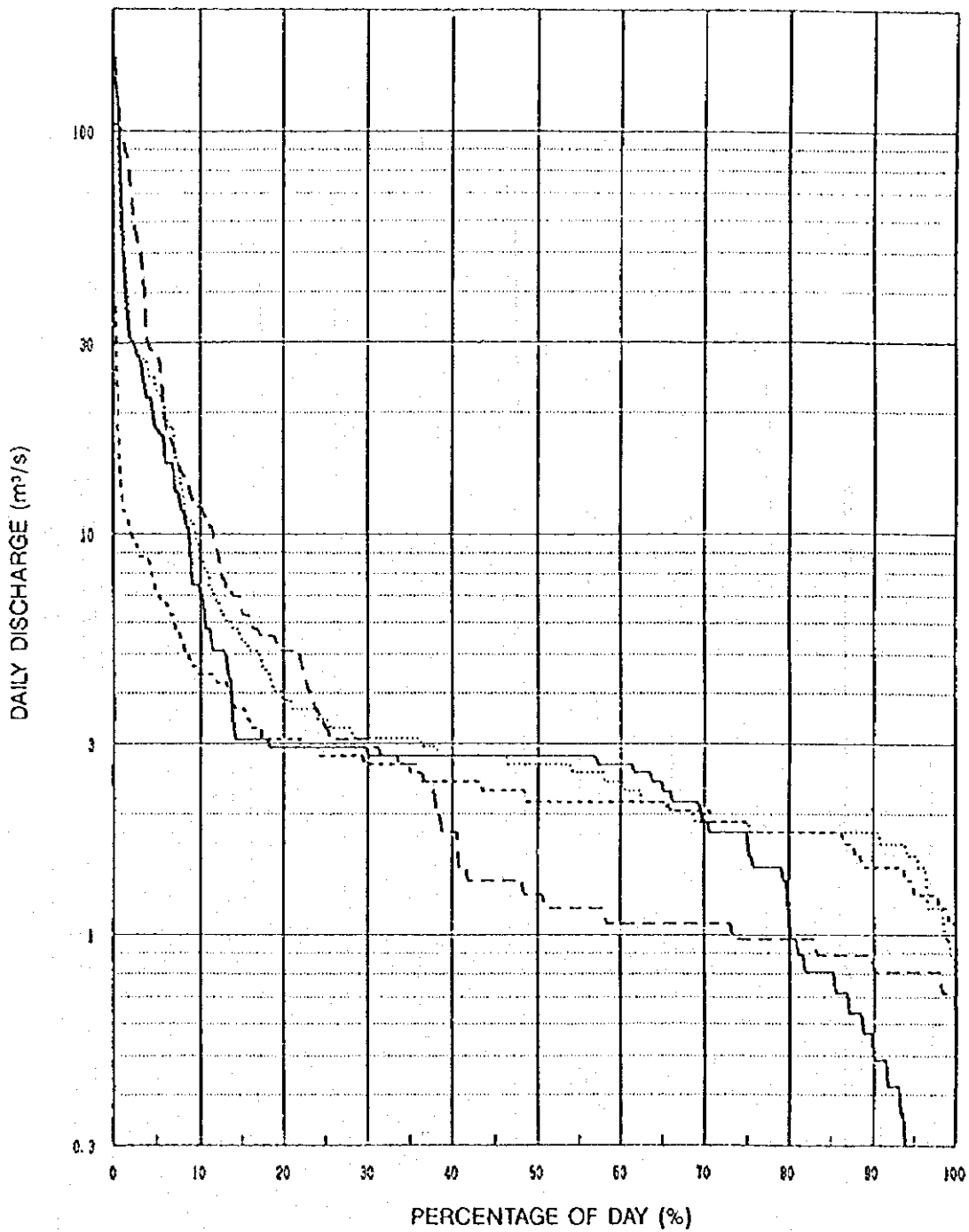
Figure D.34 Probable Runoff Flood Hydrograph for Abacan River

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FOR SACOBIA-BAMBAN/ABACAN RIVER  
DRAINING FROM MT. PINATUBO  
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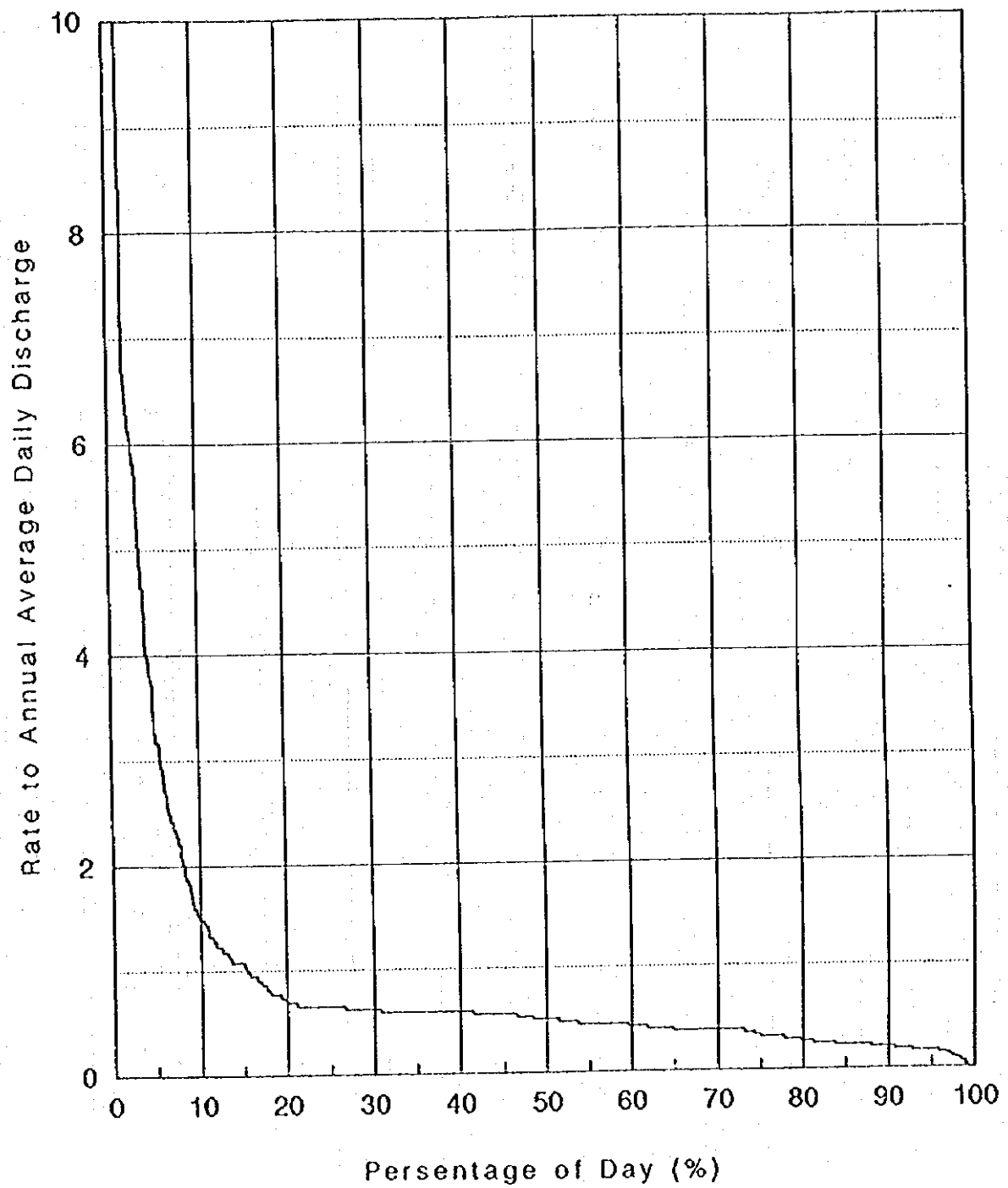




1986      1987      1989      1990

**Figure D.38** Flow Duration Curve of Observed Daily Discharge at Nasudeco Station

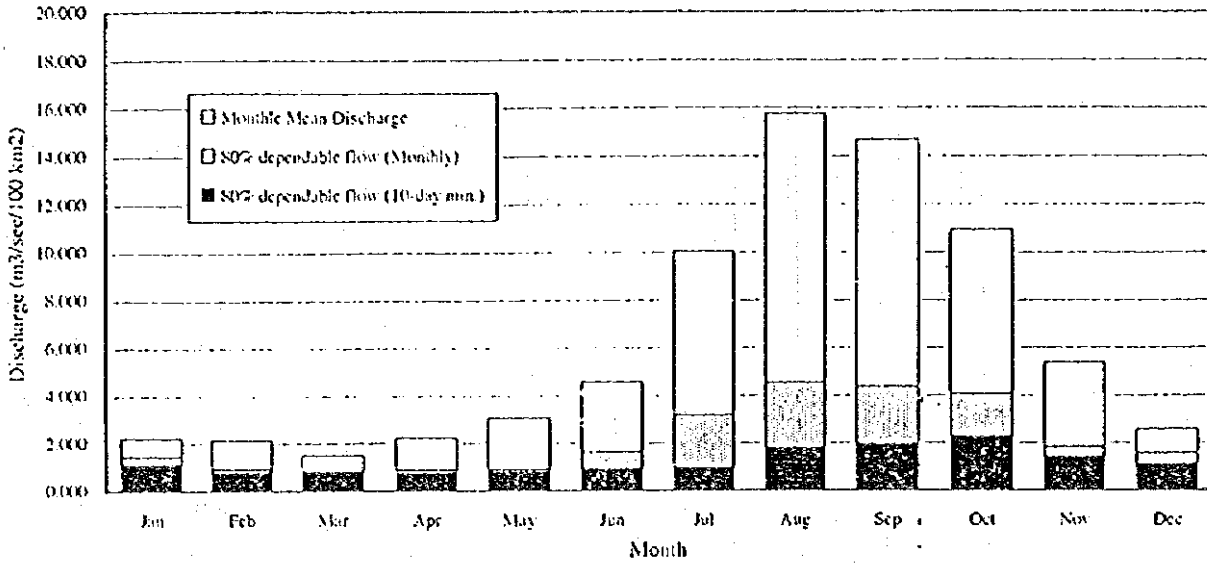
THE GOVERNMENT OF THE PHILIPPINES  
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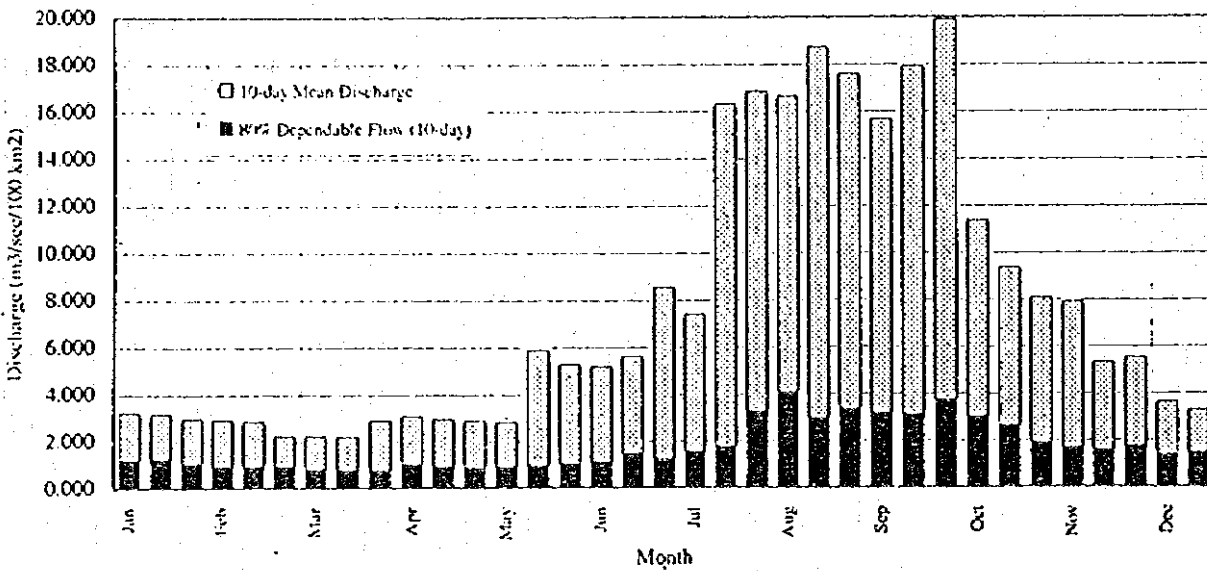
**Figure D.39 Normalized Daily Flow Duration Curve**

THE GOVERNMENT OF THE PHILIPPINES  
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### Monthly Flow Pattern



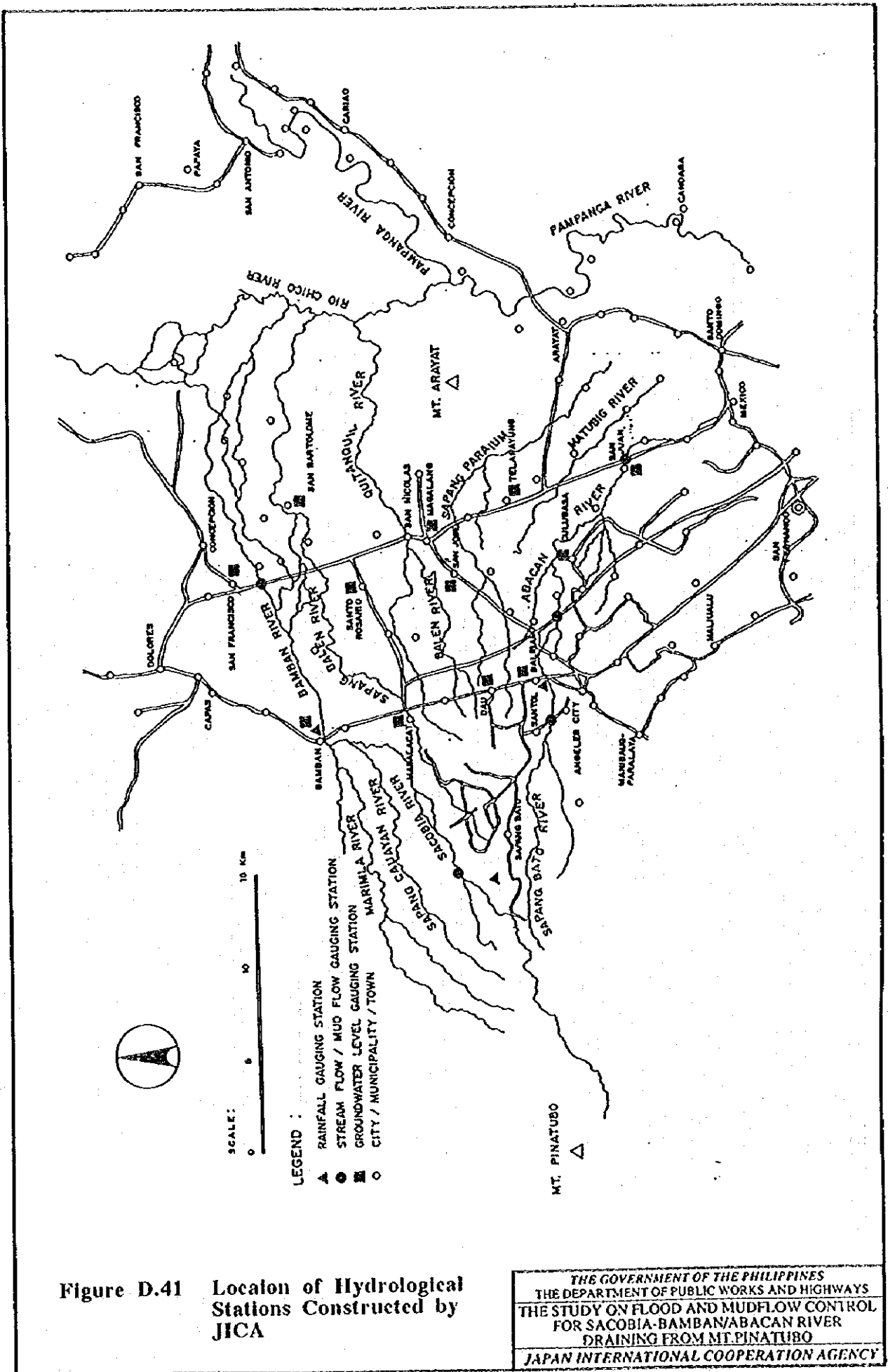
### 10-Day Decadal Flow Pattern



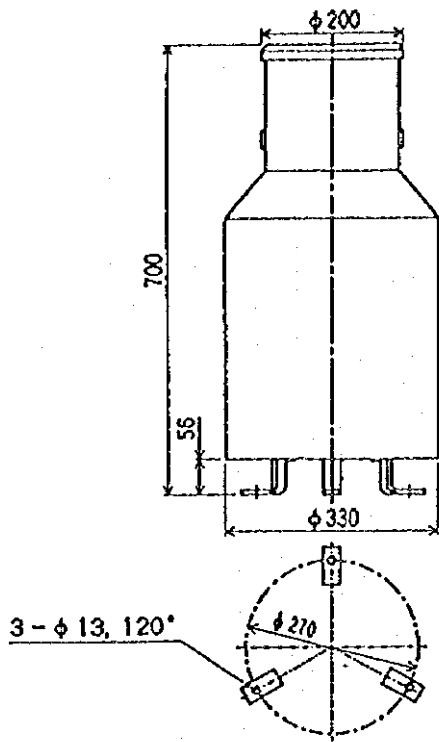
**Figure D.40 Monthly Average and Dependable Discharge**

THE GOVERNMENT OF THE PHILIPPINES  
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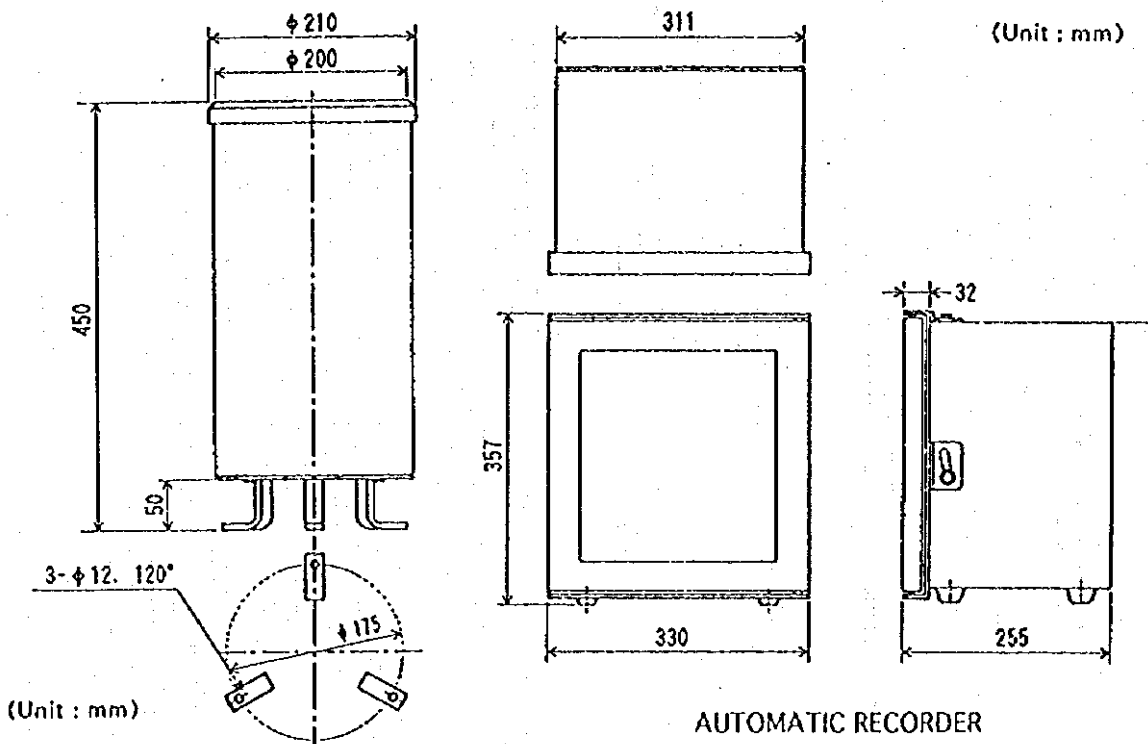


**Figure D.41** Localon of Hydrological Stations Constructed by JICA



ONE UNIT TYPE

(Unit : mm)



(Unit : mm)

RAINFALL GAUGE

AUTOMATIC RECORDER

SEPARATE TYPE

Figure D.42 Automatic Rainfall Gauge

THE GOVERNMENT OF THE PHILIPPINES  
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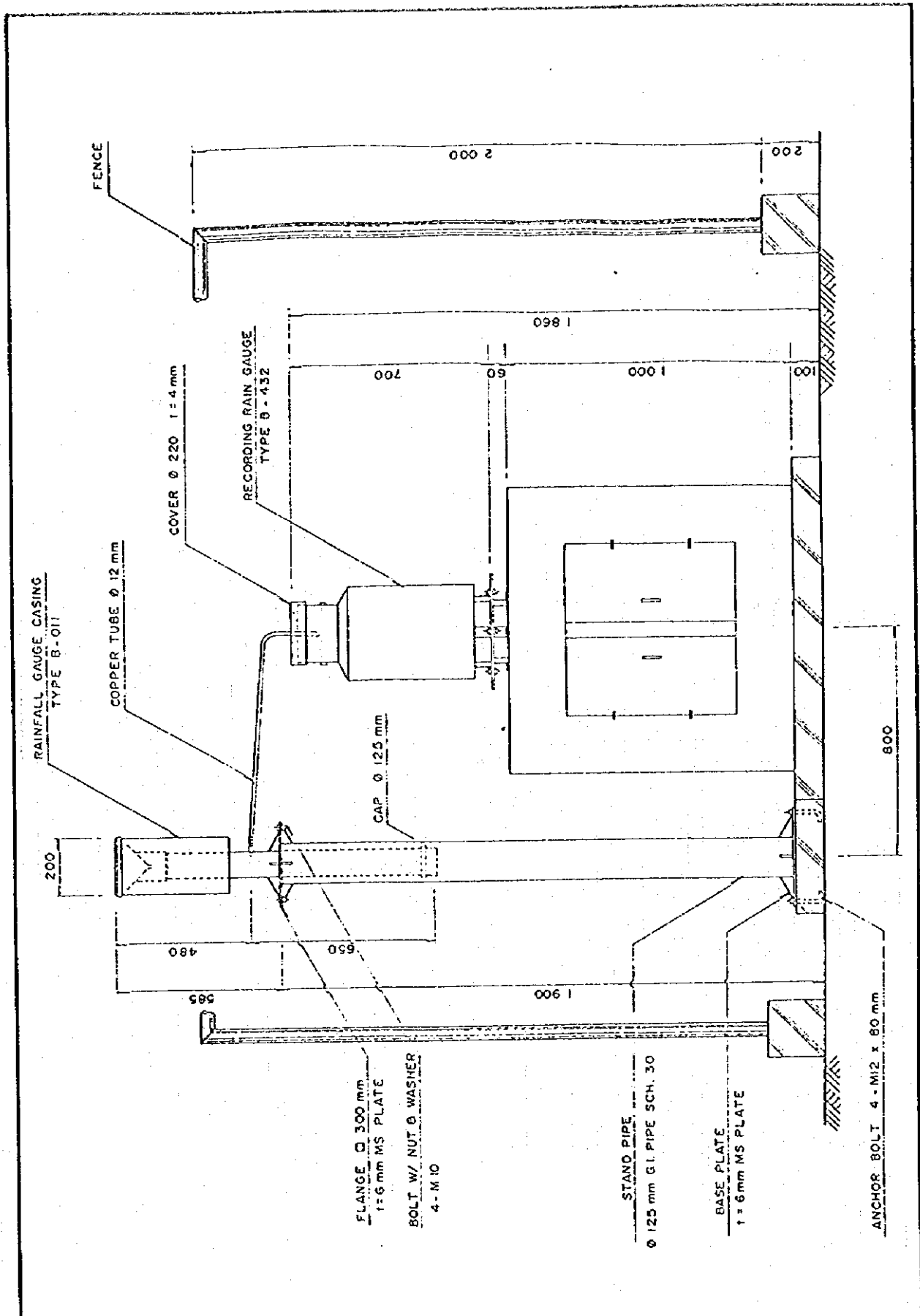
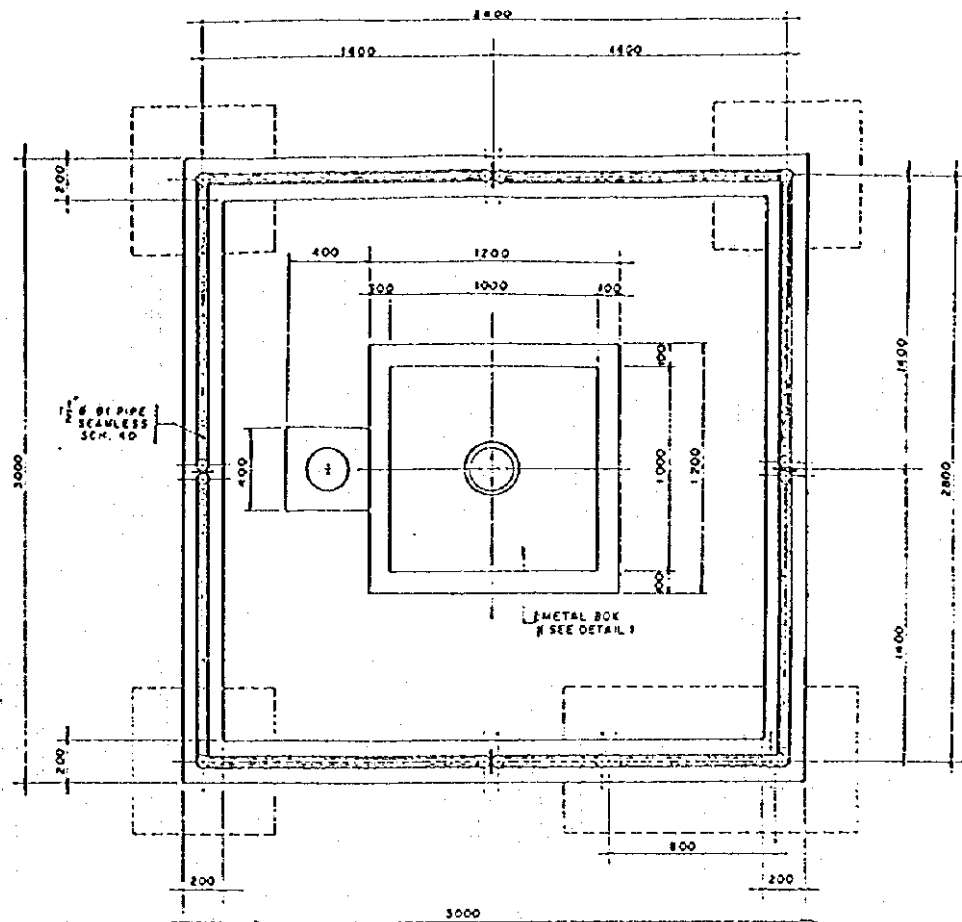
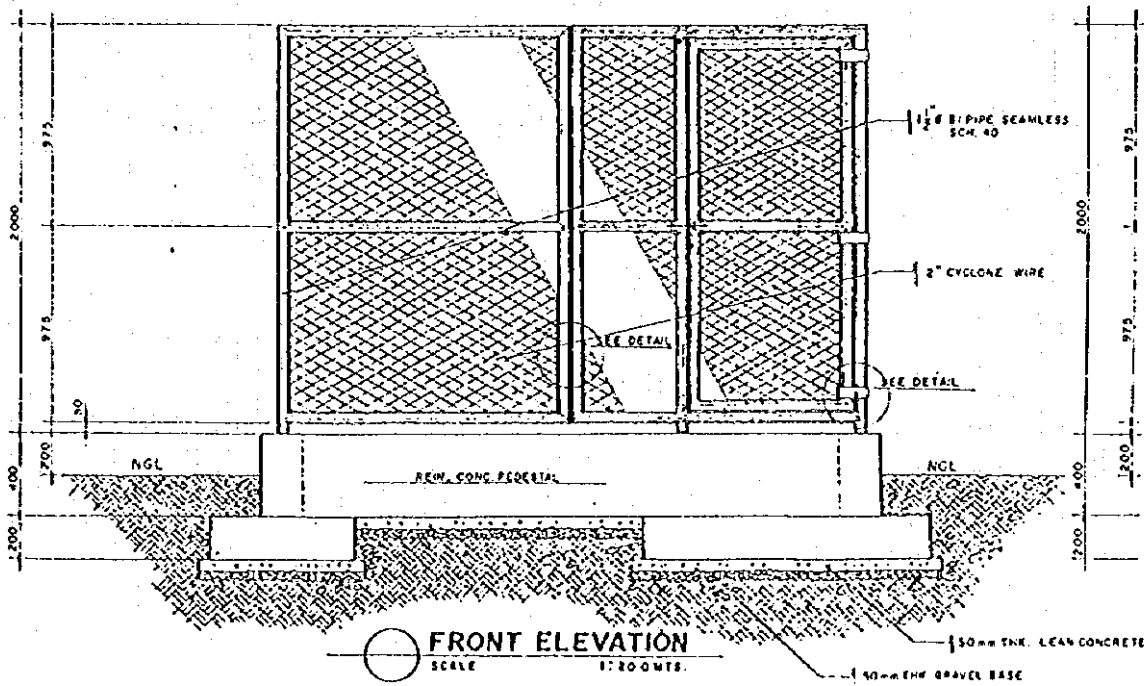


Figure D.43 Rainfall Collector at Sacobia Rainfall Gauging Station

THE GOVERNMENT OF THE PHILIPPINES  
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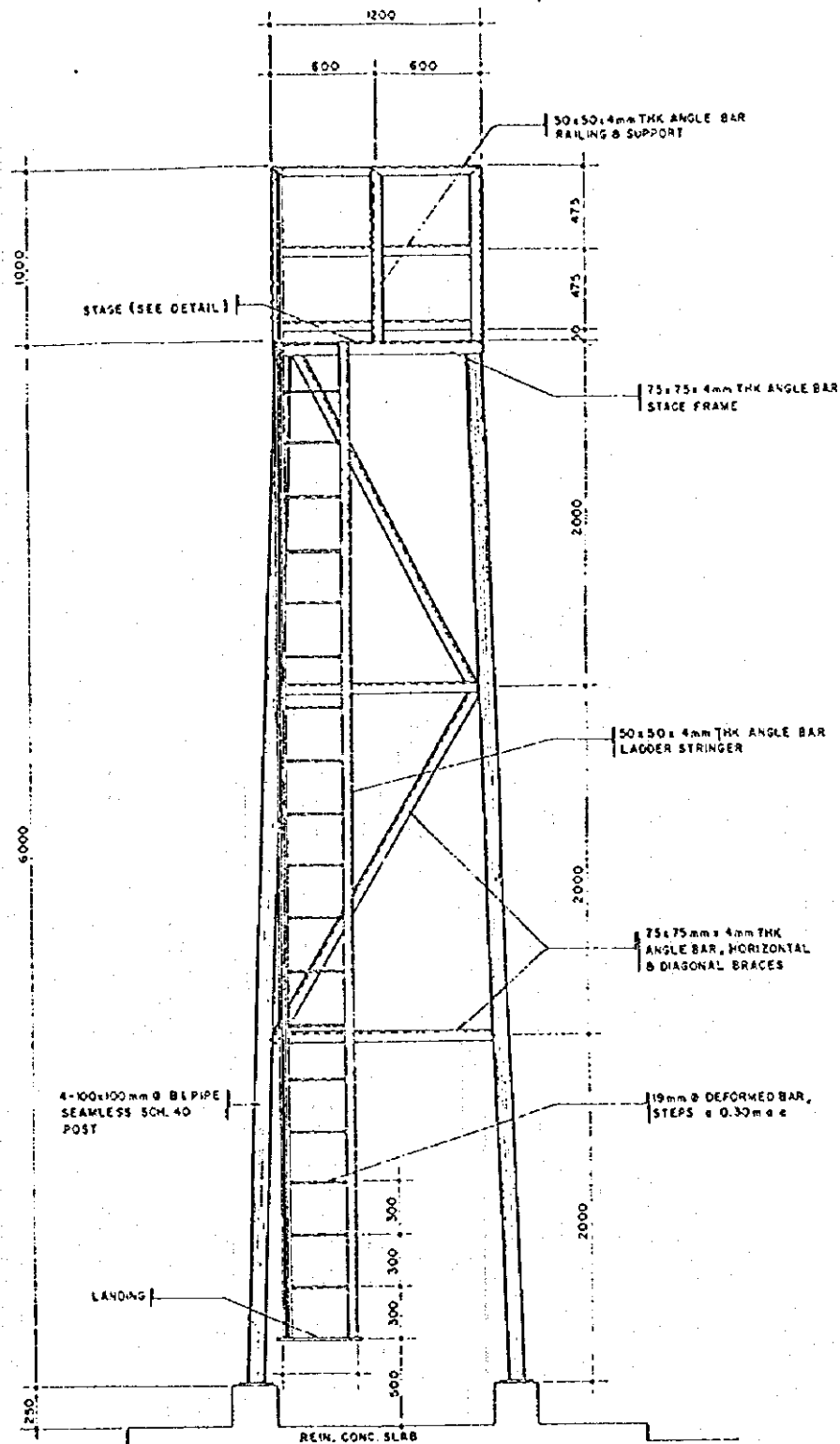
PLAN  
SCALE 1:200 MTS.



FRONT ELEVATION  
SCALE 1:200 MTS.

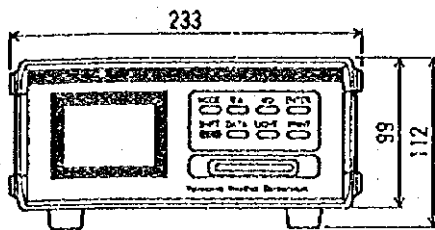
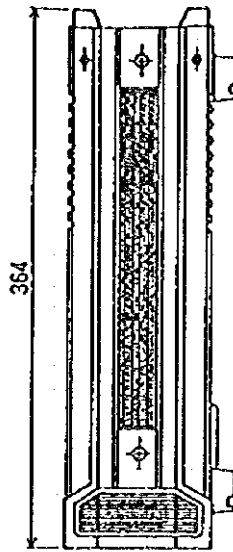
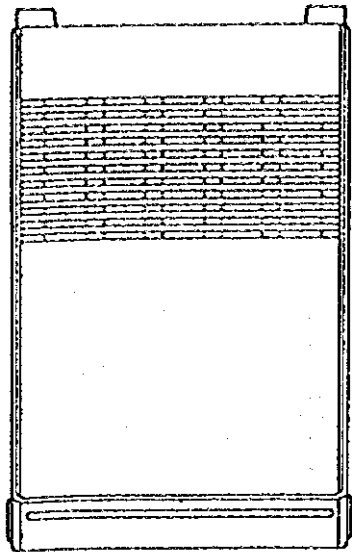
Figure D.44 Sacobla Rainfall Gauging Station

THE GOVERNMENT OF THE PHILIPPINES  
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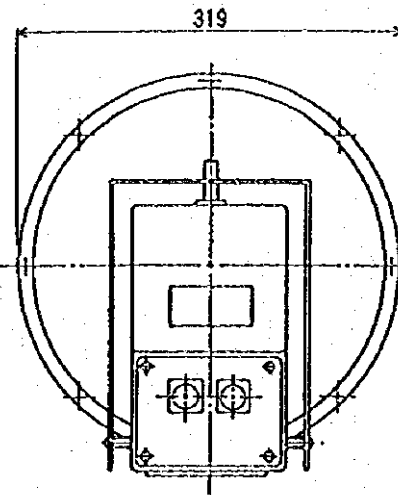
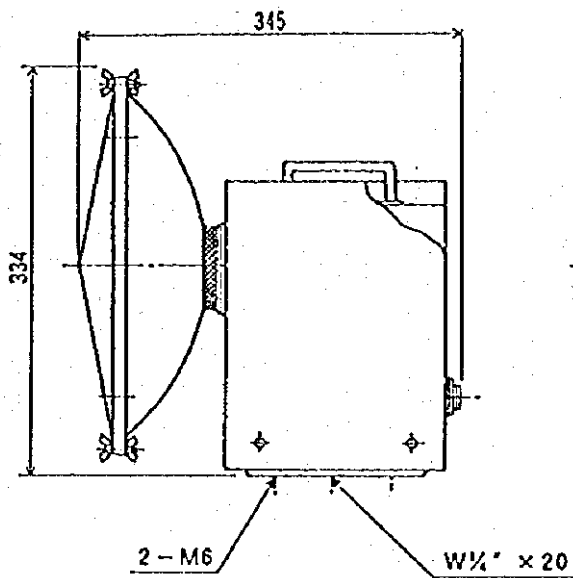
**Figure D.45 Tower At Bamban and Angeles Rainfall Gauging Station**

THE GOVERNMENT OF THE PHILIPPINES  
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(Unit : mm)

CURRENT METER WITH MEMORY  
CARD LOGGER

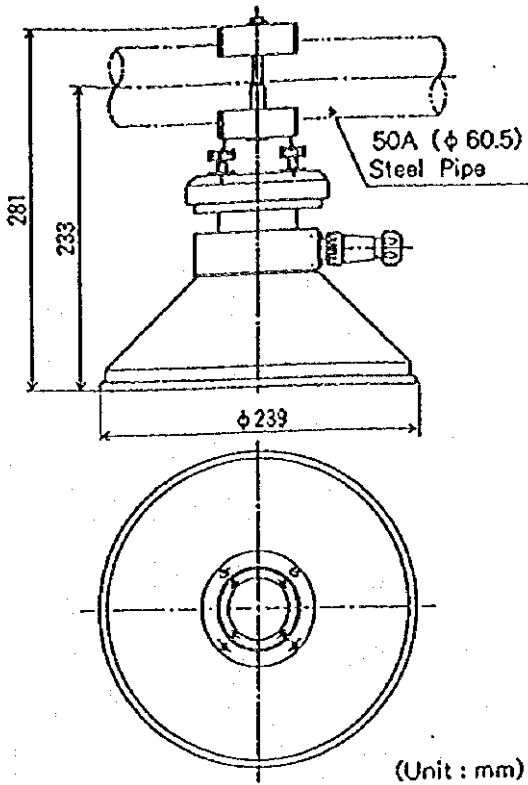


(Unit : mm)

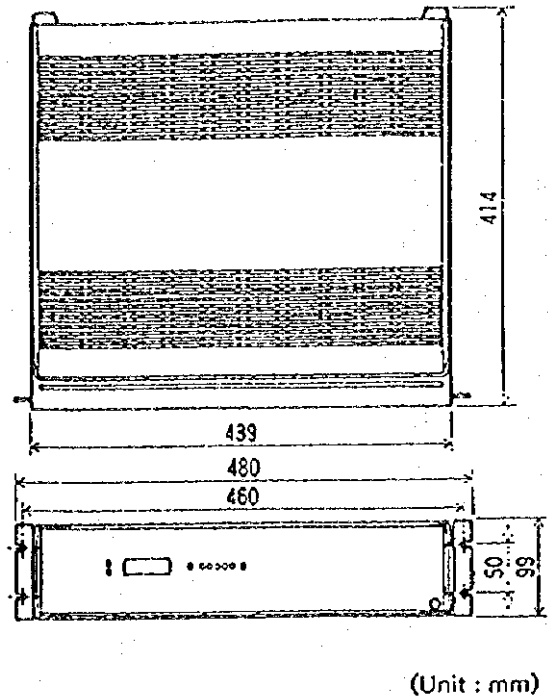
SENSOR

**Figure D.46 Radio Wave Current Meter**

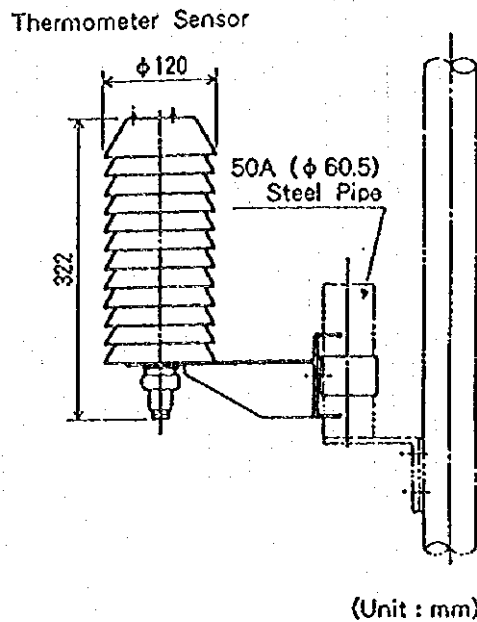
THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
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FOR SACOBIA-BAMBANABACAN RIVER  
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WATER LEVEL SENSOR



WATER LEVEL CONVERTER



TEMPERATURE SENSOR

**Figure D.47 Sensors and Converter for Water Level Gauge**

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Stand for Velocity Sensor

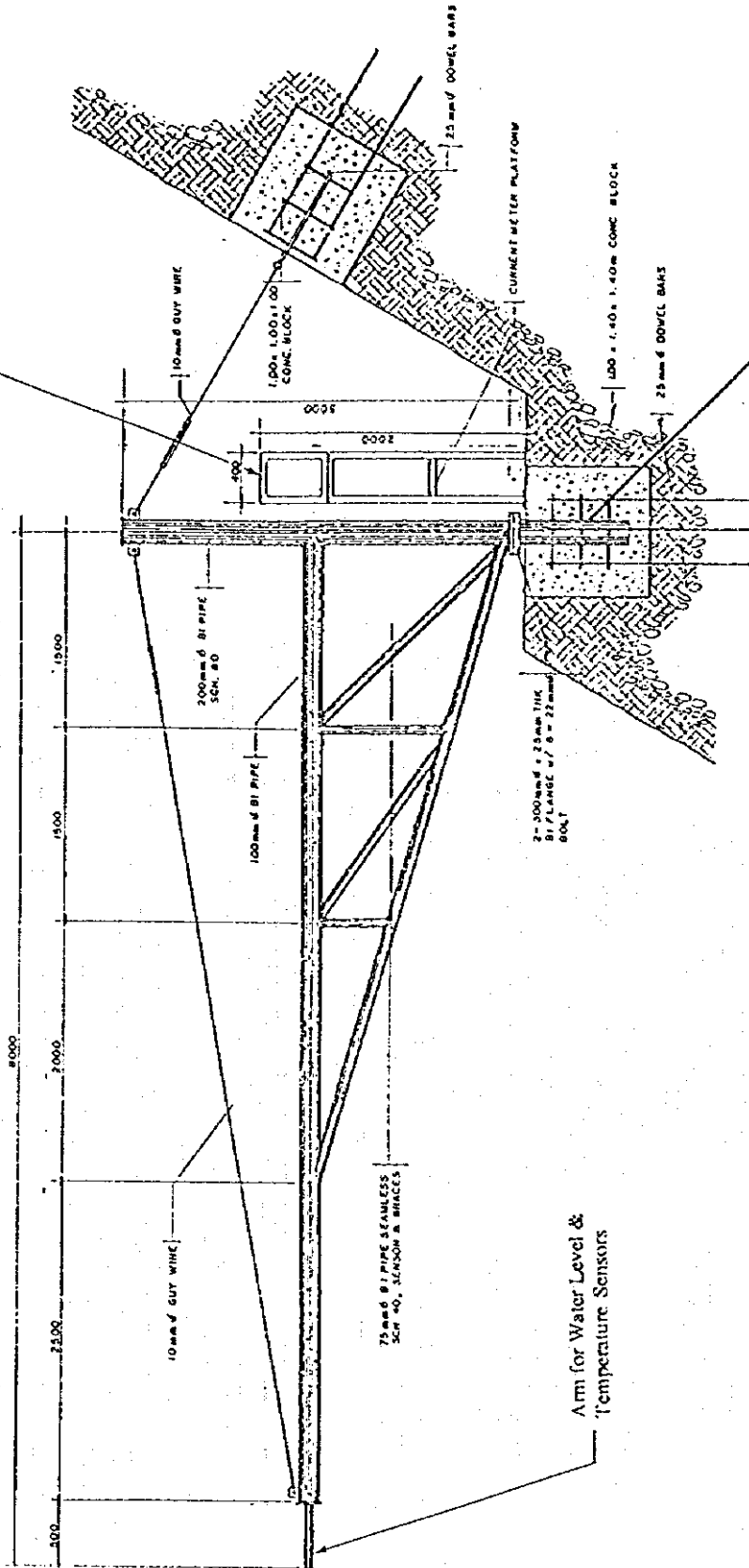
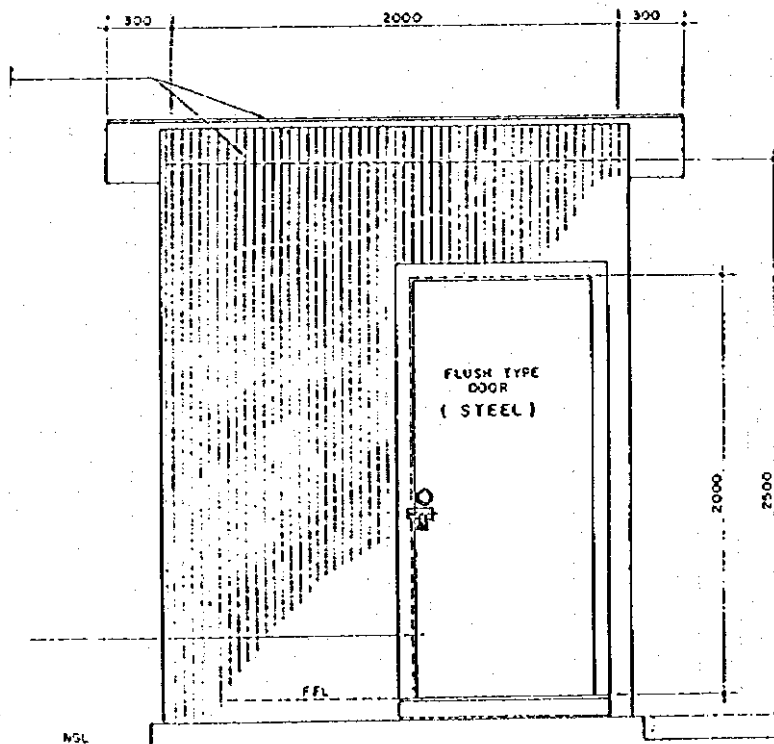
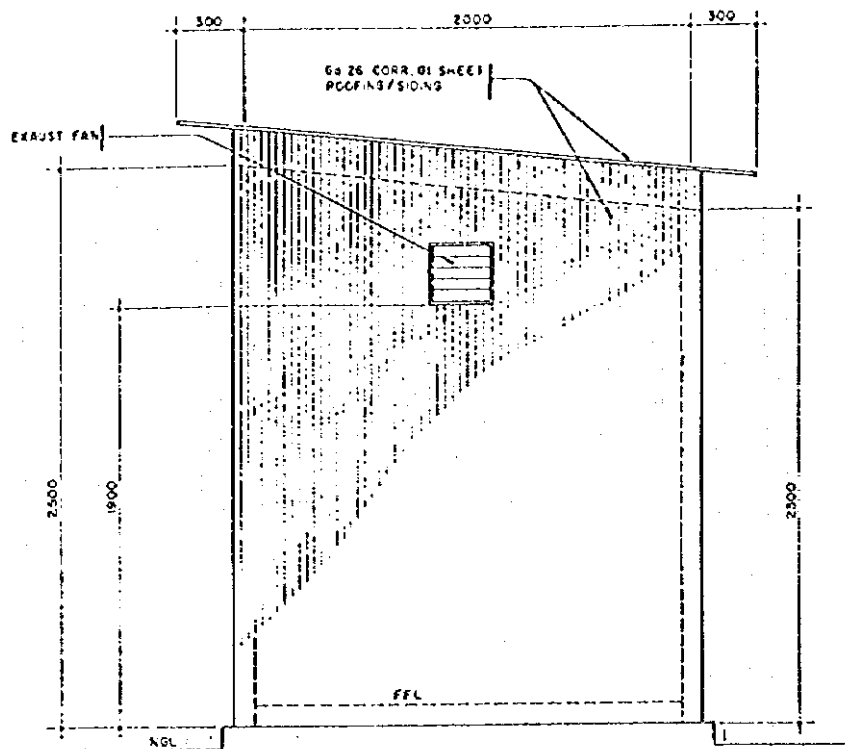


Figure D.48 Gauging Arm at Sacobia Stream Flow/Mud Flow Gauging Station

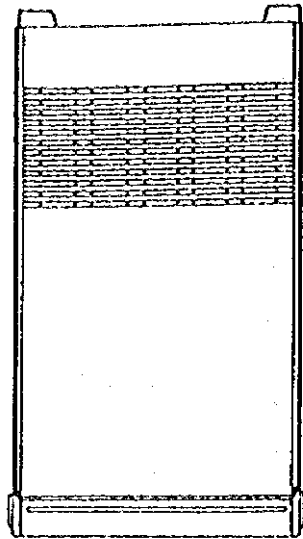
THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
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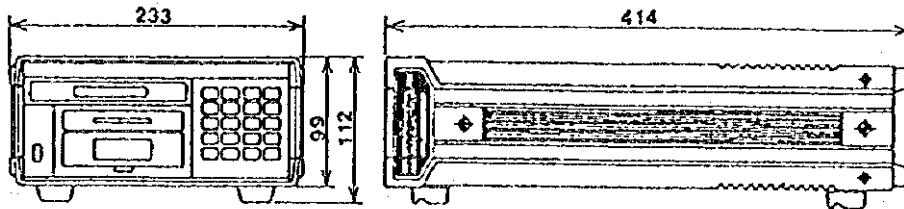


**Figure D.49 Electric House for Stream Flow/Mud Flow Gauging Station**

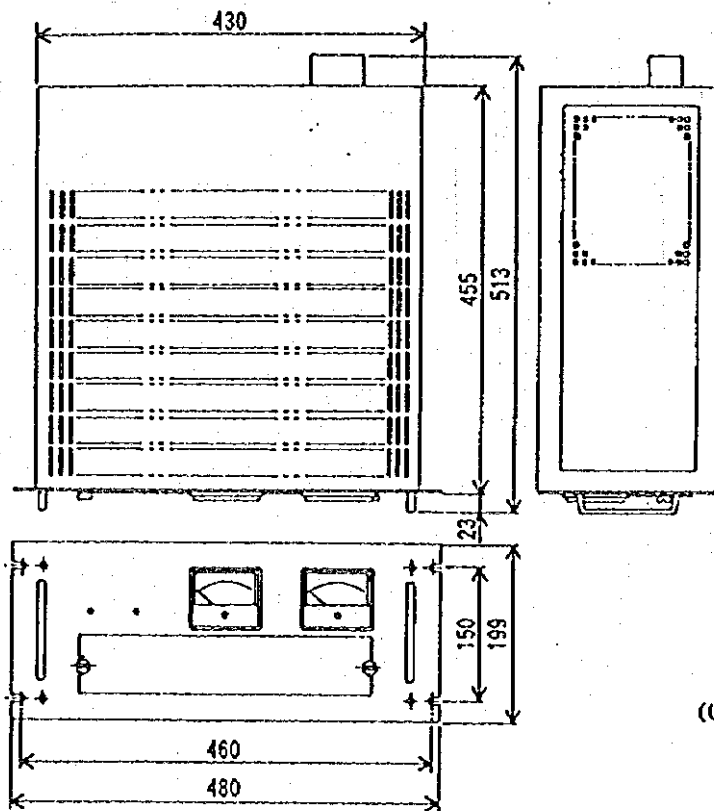
THE GOVERNMENT OF THE PHILIPPINES  
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(Unit : mm)



MEMORY CARD LOGGER



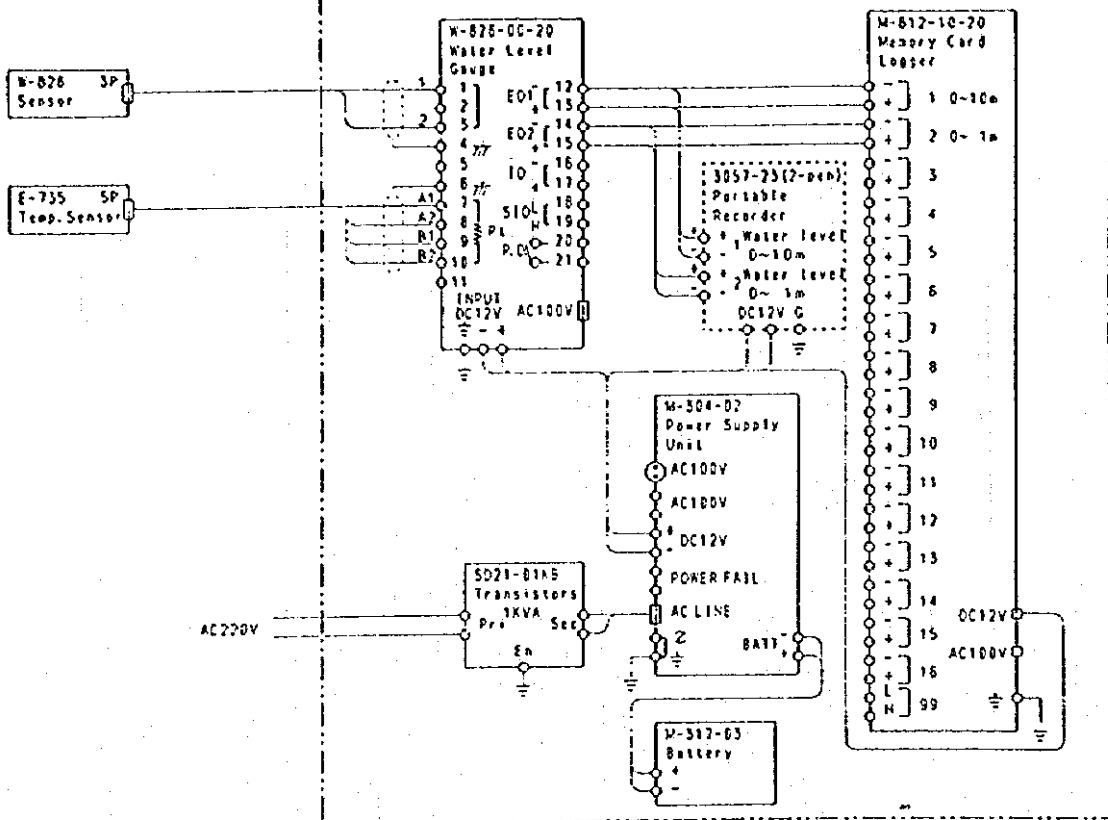
(Unit : mm)

POWER SUPPLY UNIT

Figure D.50 Memory Card Logger and Power Supply Unit

THE GOVERNMENT OF THE PHILIPPINES  
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Water level gauge  
(Dotted line: 2-pen recorder, 3 stations with and 3 stations without recorder)



Water Current Meter  
(Dotted line: 1-pen recorder, 3 stations with and 3 stations without recorder)

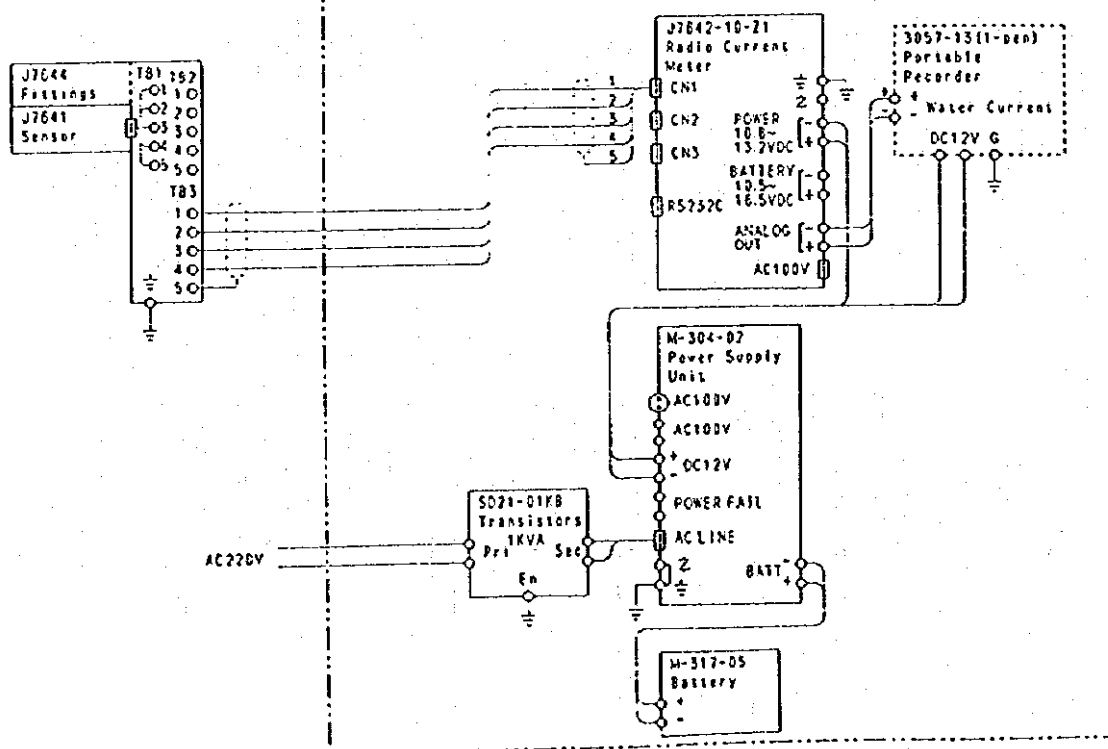
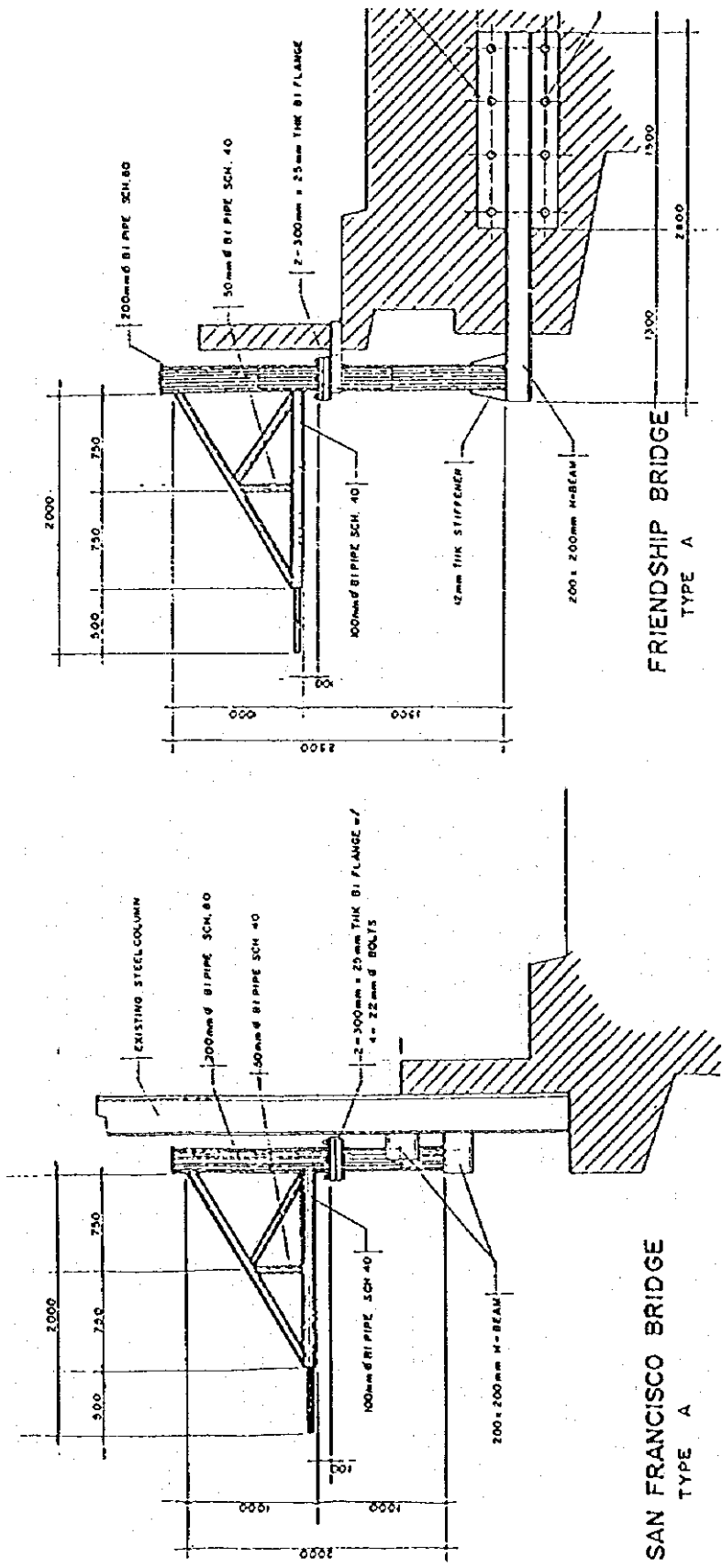


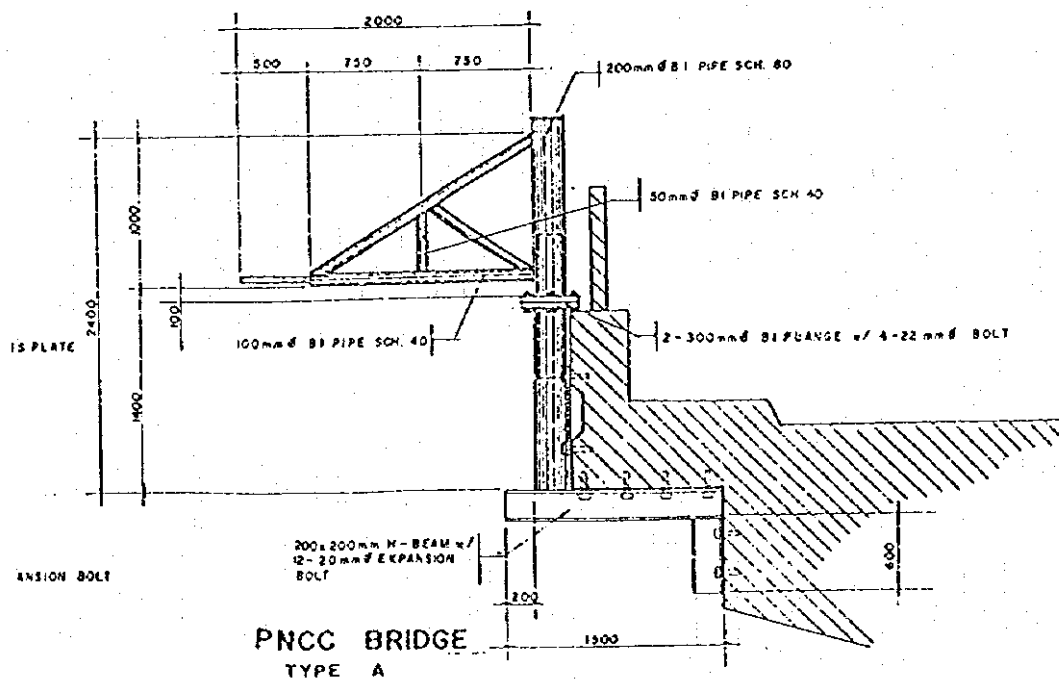
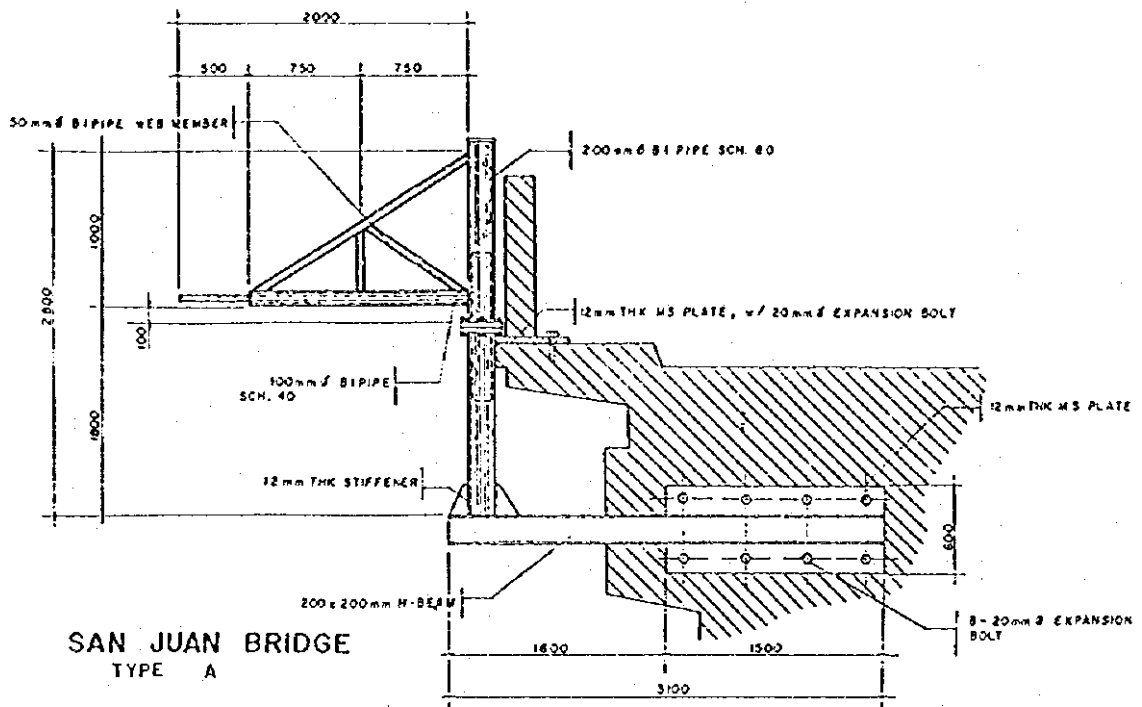
Figure D.51 Wiring Diagram for Stream Flow/Mud Flow Gauging Station

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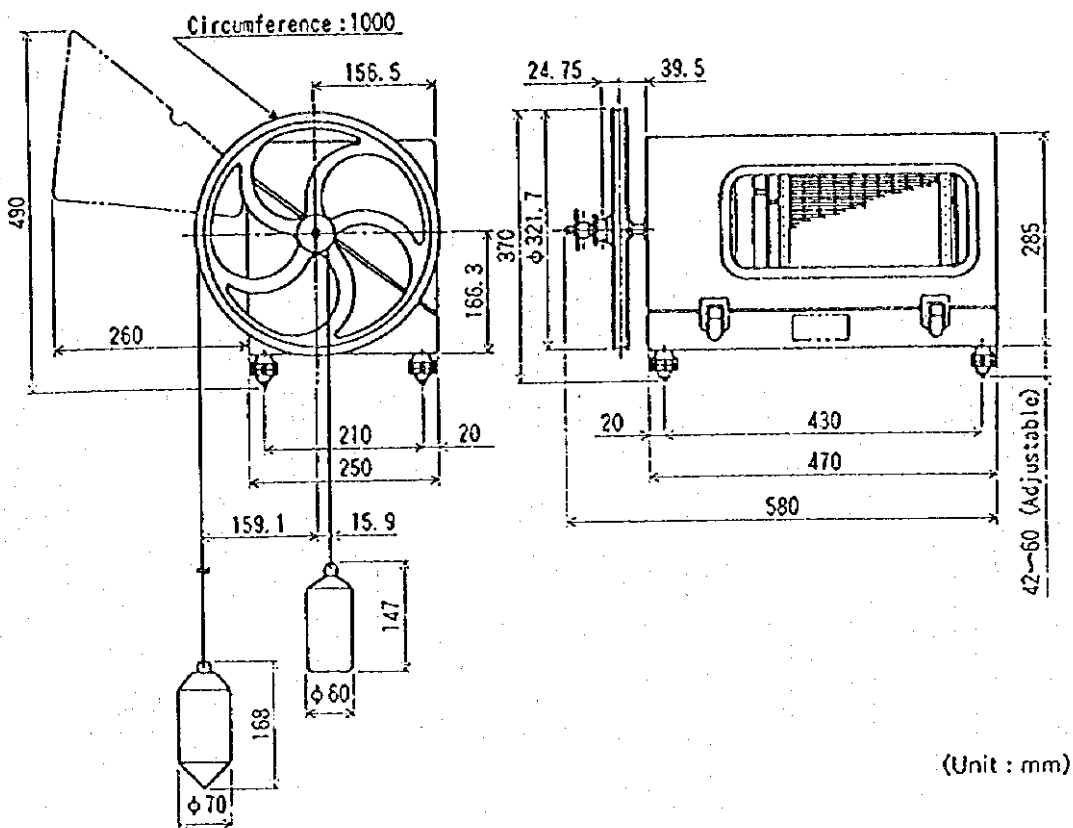
**Figure D.52 Gauging Arm at San Francisco and Friendship Stream Flow/Mud Flow Gauging Stations**

THE GOVERNMENT OF THE PHILIPPINES  
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THE STUDY ON FLOOD AND MUDFLOW CONTROL  
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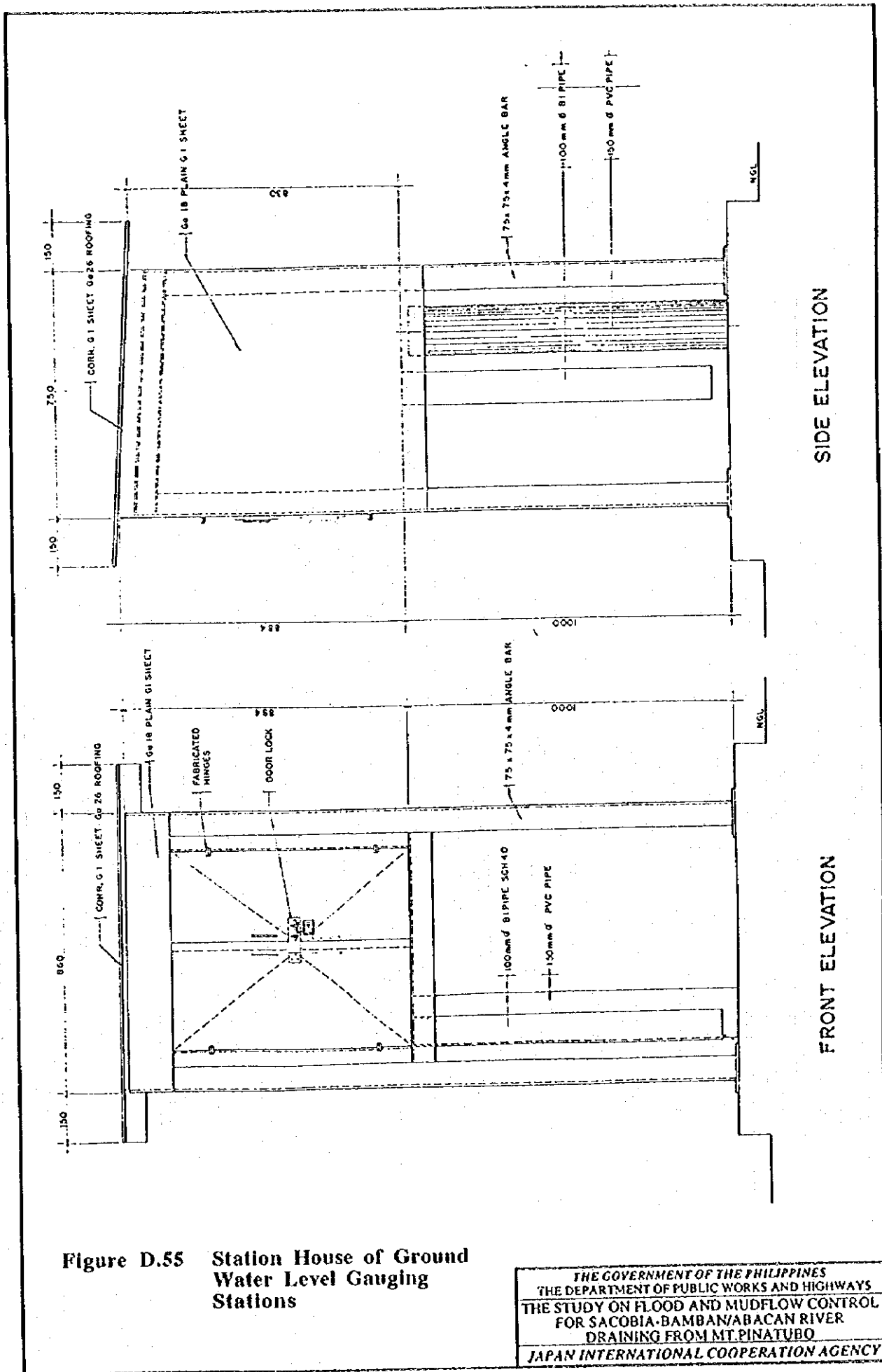
**Figure D.53 Gauging Arm at San Juan and Capaya Stream Flow/Mud Flow Gauging Stations**

THE GOVERNMENT OF THE PHILIPPINES  
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**Figure D.54 Ground Water Level Gauging Equipment**

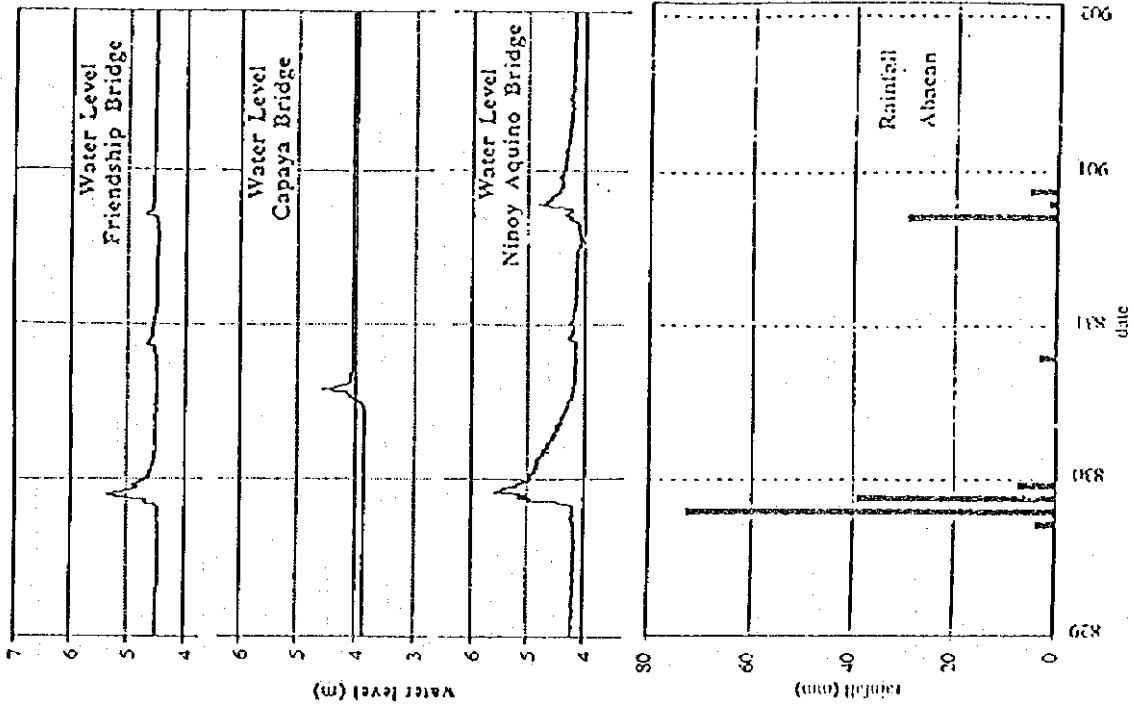
THE GOVERNMENT OF THE PHILIPPINES  
 THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
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**Figure D.55** Station House of Ground Water Level Gauging Stations

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Abacan River



Sacobia-Bamban River

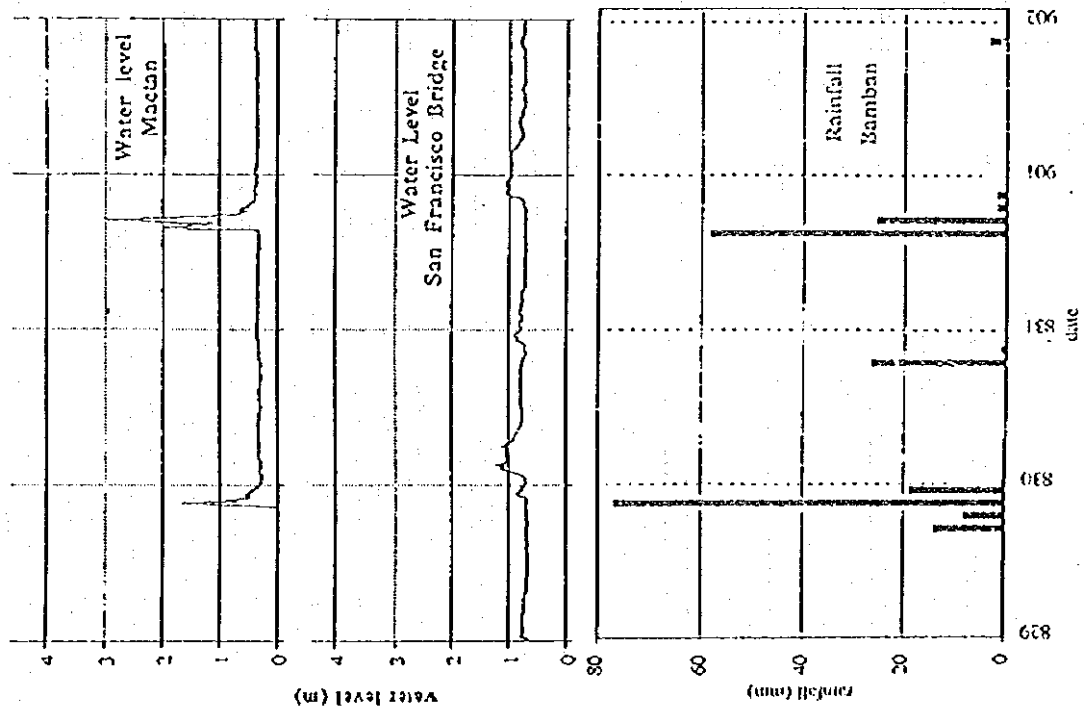
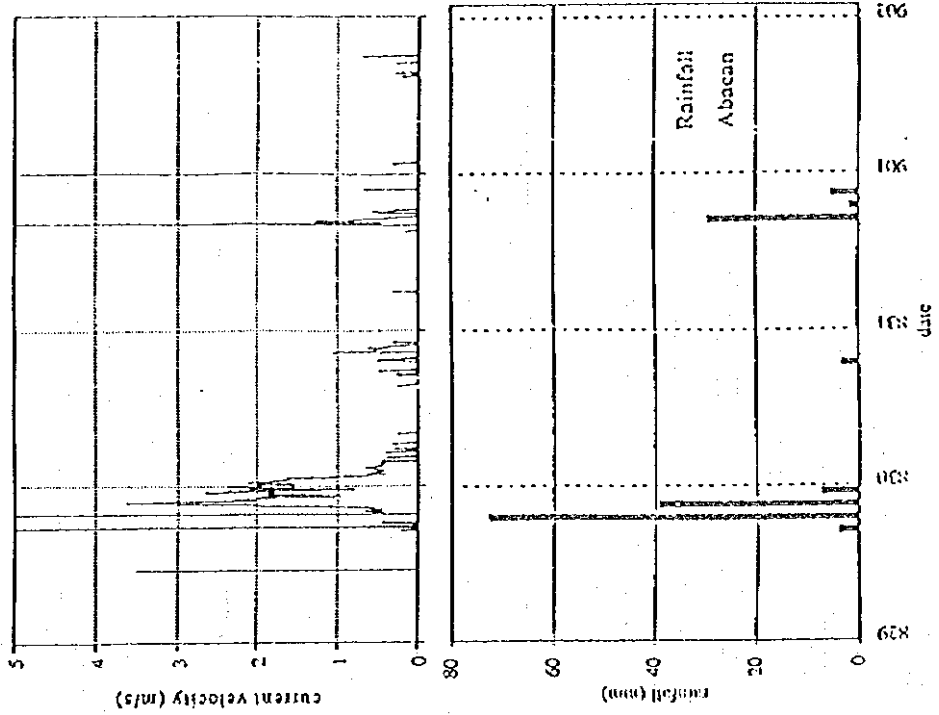


Figure D.56 Relation of Water Level to Rainfall Observed by JICA Stations

THE GOVERNMENT OF THE PHILIPPINES  
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Current Velocity  
Friendship Bridge



Current Velocity  
San Francisco Bridge

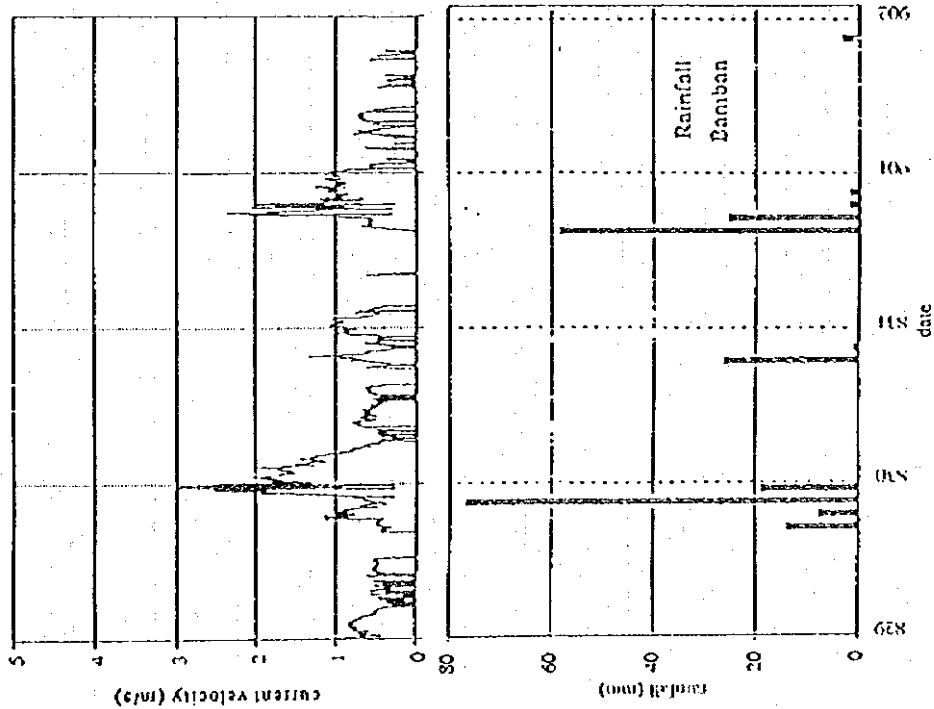
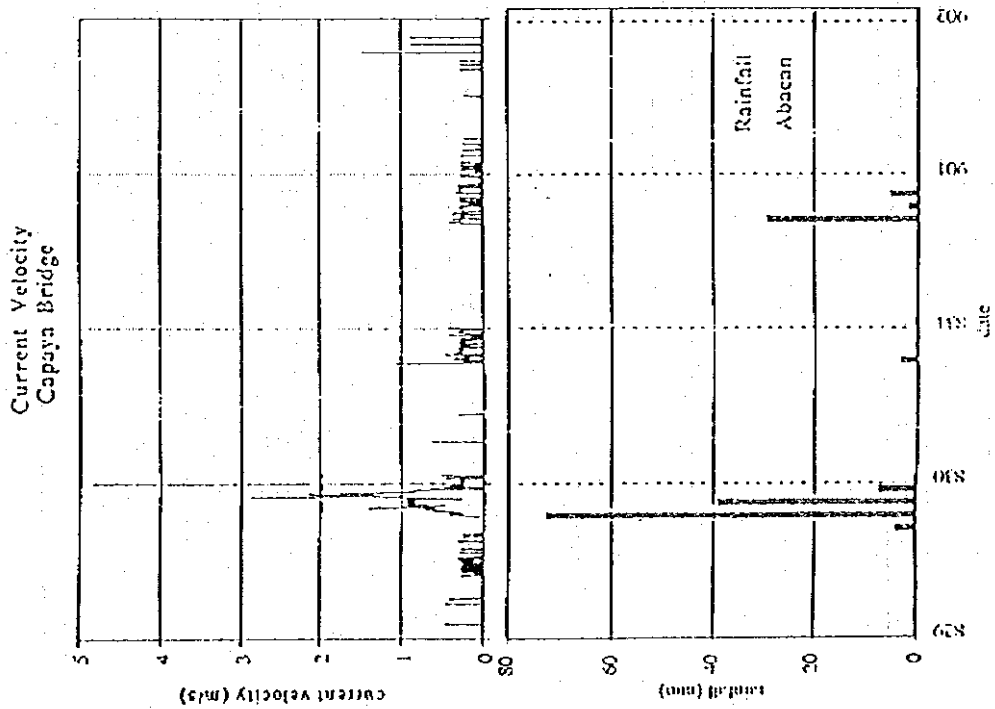
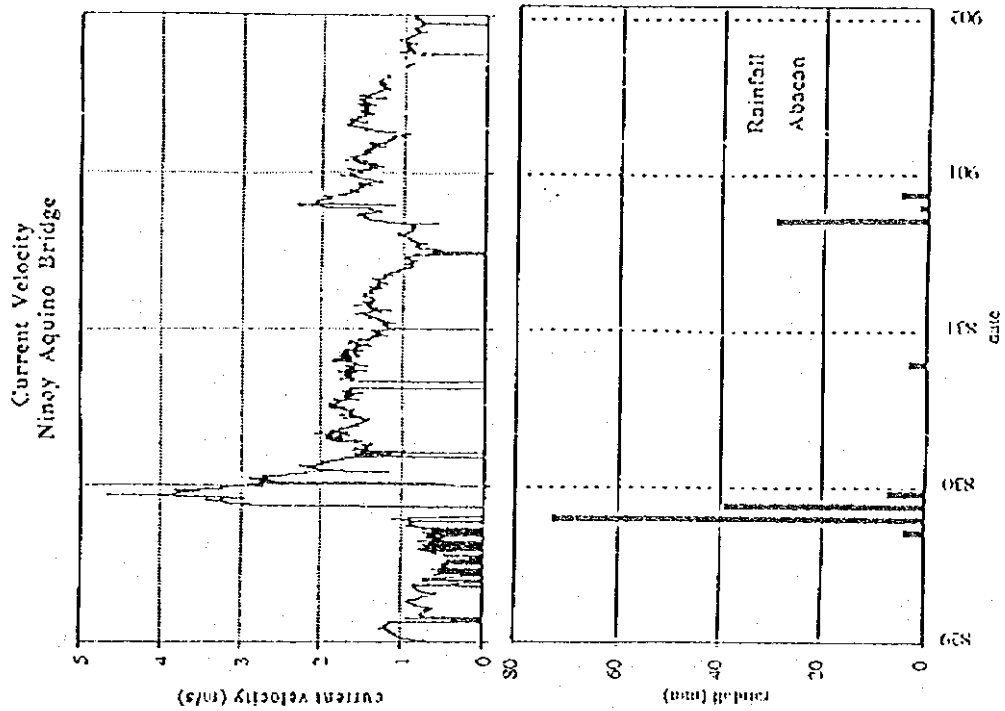


Figure D.57 Relation of Current Velocity to Rainfall Observed by JICA Stations (1/2)

THE GOVERNMENT OF THE PHILIPPINES  
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**Figure D.57 Relation of Current Velocity to Rainfall Observed by JICA Stations (2/2)**

THE GOVERNMENT OF THE PHILIPPINES  
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*APPENDIX E*

*LAND USE*

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**APPENDIX E**

**LAND USE**

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## *E.1 LAND USE*

The land use maps before and after the eruption in the study area are prepared based on (a) the Landsat images with a scale of 1:50,000, taken in January 1991 and January 1993; (b) the land use map of Magalang, Mexico, Santa Ana and Arayat in Pampanga Province with a scale of 1:15,000, taken from January to April 1991 and prepared under "The Mapping and Agricultural Potential Study for the Integrated Rural Development Program in Pampanga, November 1992, (JICA)"; and, (c) the topographic map with a scale of 1:10,000, taken in April 1994 under this present JICA study.

### *1.1 LAND USE BEFORE ERUPTION*

The land use map of the study area before the eruption is shown in Figure E.1. Based on this map, the study area is classified into eleven land use categories; namely, Rice Paddy, Sugarcane, Upland Crops, Fruit Trees, Grassland, Primary Forest, Secondary Forest, Fishpond, Swamp, Built-up Area, and Miscellaneous.

Angeles City is the center of economic activities in Pampanga Province because of the presence of Clark Air Base in Mabalacat. In 1975, the built-up area of Angeles City was 43% of its land area, and the Export Processing Zone is situated along the North Expressway. The built-up areas of Mabalacat are mainly situated around Clark Air Base. In Magalang, Bamban, Concepcion, Mexico, Santa Ana and Arayat, the compact built-up areas are located in the poblacion.

The forest areas are located in the Mt. Arayat National Park and the upper watershed of Abacan and Sacobia-Bamban rivers. Mt. Arayat National Park is about 3,715 ha in Arayat and Magalang. It serves as a recreational area. The watersheds of Marimla, Sapang Cauayan and Sacobia rivers have very little forest vegetation. The remaining forests are located on very steep slopes of gullies and ravines and along the rivers and creeks. Grassland is extensive in the upper part of these watersheds and that of Abacan River.

Agriculture is the dominant land use in the study area, as shown in Table E.1 and in Figure E.1. Rice and sugarcane are the extensively grown crops. Cassava, sweet potato, legumes, fruits and commercial crops are also planted. Muskmelon and watermelon are grown at the Candaba Swamp during the dry season. Rainfed and irrigated paddy rice, sugarcane, root crops, vegetables and fruit trees are grown on the lower river terraces and broad alluvial plains. Rainfed lowland rice is also grown on the foot of volcanic hills and moderately sloping pyroclastic hills. Other upland crops are grown on these land management units. Forest, shrubs and grassland are extensive on the pyroclastic hill, foot of volcanic hills and pyroclastic mountain. Most built-up areas are located on the broad alluvial plains, residual terrace and pyroclastic hills.

### *1.2 LAND USE AFTER ERUPTION*

Figure E.2 shows the land use map after the eruption. With the change in land use conditions due to ashfall and mudflow in the study area, land use of the landscape has markedly changed. The upper watershed of Abacan and Sacobia-Bamban rivers is covered with ashfall ranging from 5 to 30 cm. The lahar deposit areas from 1991 to 1994 in Sacobia-Bamban river system is about 11,693 ha and in Abacan river system, about 2,930 ha. Lahar-dammed lakes were formed at Sapang Cauayan and Marimla rivers in the Sacobia river system in 1991 and 1992.

The built-up area in Sacobia-Bamban river system, at both sides of Bamban Bridge were completely damaged by lahar in 1991 and 1992, and barangays Sta. Rita, Malupa, San Martin and Magao in Concepcion were also damaged by thick lahar deposits in 1991.

Stream bank erosion on the Abacan River in Angeles City completely destroyed residential establishments in 1991, and partially in 1992.

Agricultural lands in the study area were seriously damaged by lahar deposits and sediments from 1991 to 1993. In the Sacobia-Bamban river system, a total of 10,602 ha were damaged; about 1,623 ha in Bamban in 1991, about 6,596 ha in Concepcion from 1991 to 1993, about 1,370 ha in Mabalacat from 1991 to 1993, and about 1,013 ha in Magalang from 1992 to 1993. In the Abacan river system, a total of 2,593 ha were damaged; about 95 ha in Angeles city in 1991, about 288 ha in Arayat from 1991 to 1993, about 1,816 ha in Mexico in 1991 and 1993, and about 394 ha in Santa Ana in 1991. These lahar deposit and sediment affected areas mostly remain idle or changed to grassland, and some farmers are trying to grow watermelon or sugarcane at the sedimentary cropland.

# *TABLES*

Table E.1 Agricultural Land Use before and after the Eruption in the Study Area

Town / City	Year	Irrigated Rice		Rainfed Rice		Sugarcane		Cassava		Rootcrops		Com.		Legume		Fishpond		Commercial Crops		Fruit Trees		Other Crops		Total (ha)	
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)		
Coneception	1980	14,820	(77)			3,490	(18)			51	(0)												866	(5)	19,176
	1993	7,135	(62)	2,196	(19)	925	(8)	750	(7)						168	(1)	16	(0)	263	(2)					11,504
Bamban	1990	2,326	(42)			1,441	(26)			65	(1)	30	(1)	81	(1)							1,640	(29)		5,383
	1993	882	(24)			995	(27)			65	(2)	21	(1)	44	(1)							1,640	(45)		3,647
Angeles City	1988	265	(13)	14	(1)	1,024	(51)	27	(1)	578	(29)			38	(2)										1,996
	1992	190	(13)	5	(0)	801	(55)	13	(1)	344	(24)			77	(5)										1,445
Mabalacat	1985	993	(21)			1,400	(30)			2,259	(49)														4,652
	1992	1,391	(32)	226	(5)	2,297	(53)	28	(1)	334	(8)														4,310
Mexico	1991	4,742	(40)	2,791	(23)	2,234	(19)	1,074	(9)	10	(0)			911	(8)										11,892
Magalang	1993	2,889	(41)	1,892	(27)	1,885	(26)										448	(6)							7,114
Santa Ana	1993	2,300	(98)			6	(0)	15	(1)					10	(0)										2,348



***FIGURES***



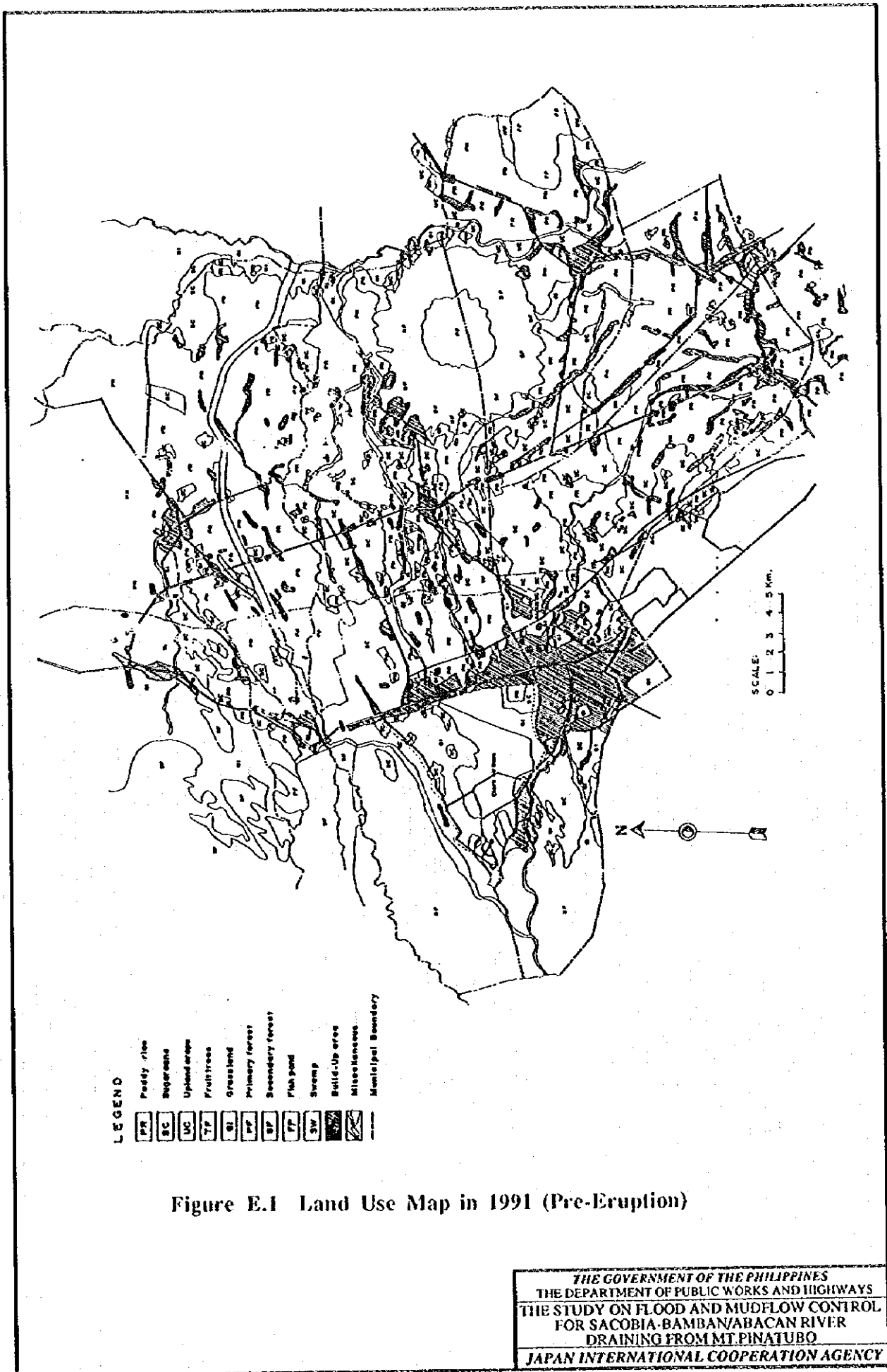


Figure E.1 Land Use Map in 1991 (Pre-Eruption)