6. DAILY DISCHARGE

6.1 Available Data

As discussed in the previous part, the available data on daily discharge in the Chama River Basin are limited, as follows:

Chama-Ejido (simulated)	1953-75
(observed)	1976, 1978-86
Chama-Mucurubá (observed)	1975-1976, 1978-1987
Mocotíes-La Victoria (simulated)	1953-1975

6.2 Daily Discharge

From the data period presented above, daily discharges were prepared for 1967-75. Since the entire Chama River Basin can be broadly divided into three zones for the amount of annual rainfall as presented in Fig. IV-19, the following conversion rates were applied to estimate the daily discharge from the Chama-Ejido and the Mocotíes-La Victoria data.

Zone	Sub-basin	Annual Rainfall (mm)	Conversion Rate
Zone 1	1, 2, 3, 4, 5, 6, 7, 10, 11	1,200	1.0 against Ejido
Zone 2	8, 9, 12, 13, 14, 15	650	0.54 against Ejido
Zone 3	16 to 21	1,170	1.0 against La Victoria

The monthly average daily discharges obtained from the calculation above are presented according to sub-basin in Table IV-11.

Table IV-1(1/2) LIST OF METEOROLOGICAL AND PLUVIOMETRIC STATIONS

No	Serial	Name	Type	State	Zone	Org	Alt	Lat	Long	Inst	Elim	Map
	Station Inside Chama River Basin											
1.	3024	Valle Grande	PR	ME	16	MA	2515	084300	710500	0361		5942
2.	3027	Paramo La Culata	PR	ME	16	MA	2920	084448	710415	0361		6142
3.	3029	Mucuruba	C3	ME	16	MA	2320	084222	705933	1048	0184	6042
4.	3035	El Vigia	C	ME	05	MA	130	083627	713747	0942		5841
5.	3038	Tabay	PR	ME	16	MA	1720	083807	710409	1048		5941
6.	3040	La Cuchilla	PR	ME	16	MA	2280	083800	712110	0663		5941
7.	3042	Mesa de Ejido	PR	ME	16	MA	1520	083300	711706	1148		5941
8.	3047	Merida Aeropuerto	C1	ME	16	SM	1470	083556	710925	0120		5941
9.	3052	Mesa Bolivar	PR	ME	05	MA	1000	082842	713505	0349		5841
10.	3054	Estanquez	PC	ME	16	MA	452	082732	713156	0942	1269	5841
11.	3070	Paramo El Molino	PR	ME	16	MA	2750	081831	713424	1061	0184	5840
12.	3072	Mucubaji	PR	ME	16	MA	3560	084810	704922	0169		6042
13.	3080	El Morro	PR	ME	16	MA	1830	082705	711104	0262		5941
14.	3108	El Meson	PR	ME	16	MA	1264	082445	713540	1267		5841
15.	3111	Paramo de Mucuchies	PR	ME	16	MA	3685	085105	705019	0142		6042
16.	3112	Paramo Pico Aguila	PR	ME	16	MA	4126	085100	704937	0353		6042
17.	3121	Mucuchies	PC	ME	16	MA	2950	084504	705503	0549	0184	6042
18.	3122	Mucuchies	C1	ME	16	AC	3100	084600	705400	0141		6042
19.	3132	Las Tapias	PR	ME	16	MA	1920	081341	705041	0868		5840
20.	3141	Tovar	C2	ME	16	MA	452	082030	714440	1068		5841
21.	3168	Hacienda El Carmen	C3	ME	16	MA	2250	084110	710545	0670	0184	5942
22.	3169	Jaji	PR	ME	16	MA	1827	083444	712005	0870		5941
23.	3170	San Juan de Lagnillas	C	ME	16	MA	1050	083040	712114	0970		5941
24	8049	La Punta	PR	ME	16	MA	1300	083349	711120	1075		5941
25.	8053	La Palmita	PR	ME	05	MA	600	083303	713602	0153		5841
26.	8056	San Pedro-Chiguara	PR	ME	16	MA	1078	083025	713430	1269		5841
27.	8057	Tostos	PR	ME	16	MA	2400	082536	712022	1169		5941
28.		Los Nevados				UL						
29.	3177	La Montana	PR	ME		SM						
30.	3176	La Aguada (Telef. No. 2)	PR	ME		SM						
31.	3175	Loma Redonda (Telef No. 3)	PR	ME		SM						
32.	3174	Pico Espejo (Telef. No. 4)	PR PR	ME		SM						

Note: Type : PR:Pluviometric Station; C1:Meteorological Station; C2:Meteorologocal Station; C3:Meteorologocal Station
State : ME:Merida; ZU:Zulia; TA:Tachira
Org : (Organization) MA:MARNR; SM:Fuerzas Aereas de Venezuela; AC:Ministerio de Agricultura y Cria; ULA:Universidad de Los Andes
Alt : Altitude (meter from the mean sea level)
Lat : Latitude (North)
Long : Long (East)
Inst : Installed month/year (1168; Nov.1968)
Elim : Eliminated month/year (1168; Nov. 1968)

Table IV-1(2/2) LIST OF METEOROLOGICAL AND PLUVIOMETRIC STATIONS

No	Serial	Name	Type	State	Zone	Org	Alt	Lat	Long	Inst	Elim	Map
	Station Neighboring Chama River Basin											
1.	2009	Santa Rosa Sur	PR	ZU	05	MA	2	090220	713443	1277		5843
2.	2095	Concha	PR	ZU	05	MA	5	090107	714503	1152	0284	5843
3.	2097	Torondoy Alcaldia	PC	ME	05	MA	1107	090223	710046	0250	0879	5943
4.	3001	Capuri	PR	ME	16	MA	1620	080800	713613	0766		5840
5.	3005	Paramo El Quemado	PR	ME	16	MA	2212	081445	714401	0766		5840
6.	3023	El Molino	PR	ME	16	MA	1877	081215	7133	0566		5840
7.	3025	Caracoli	PR	ZU	05	MA	40	084538	714412	0253		5842
8.	3030	Guaraque - La Quinta	PR	ME	16	MA	1710	080855	714238	0766		5840
9.	3073	Sabana Grande	PR	TA	06	MA	2000	081200	715643	1048		5840
10.	3074	Pueblo Hondo	PR	TA	06	MA	2100	081600	715500	0142		5840
11.	3083	La Grita	C3	TA	06	MA	1270	080850	715939	0341	0184	5840
12.	3089	La Culata	PR	ME	16	MA	2600	085712	703838	0169		6042
13.	3098	La Mesa de Aracay	PR	ME	16	MA	1980	085603	703646	0169	0184	6042
14.	3099	Las Piedras	C3	ME	16	MA	1657	085335	703821	0169	0184	6042
15.	3114	Santo Domingo	PR	ME	16	MA	2155	085227	704027	0657		6042
16.	3115	La Mitisus	PR	ME	16	MA	1666	085315	703630	0555		6042
17.	3133	Mucuchachi	PR	ME	16	MA	1020	080904	712011	0470		5940
18.	3134	Canagua	PR	ME	16	MA	1560	080808	712625	0968		5940
19.	3135	La Azulita	PR	ME	05	MA	1000	084330	712631	1168		5942
20.	3138	Chacanta	PR	ME	16	MA	1846	081032	712600	1169		5940
21.	3142	Zea - La Florida	PR	ME	05	MA	900	082322	714642	1068		5841
22.	3161	Los Plantios	PR	ME	16	MA	3878	084911	704705	0169		6042
23.	3166	Timotes	PR	ME	7	MA	2089	085914	704420	1169		6042
24.	3195	Las Mesas	PR	ME	16	MA	1366	085230	703535	0770		6042
25.	3196	Morro de Motus	PR	ME	16	MA	2450	085520	704035	0777	0184	6042
26.	3197	El Perol	PR	ME	16	MA	2460	085606	704045	0770		6042
27.	3198	Pueblo Llano	PR	ME	16	MA	2230	085525	703930	0770	0184	6042
28.	3198	Mucujepe	PR	ME	05	MA		083853	713408	0380		5841
29.	8054	Puente Escalante	PR	TA	05	MA	160	0830	7146	0660		5841
30.	8072	Los Guayabones	PR	ME	05	MA	70	084521	713552	0273		5842
31.	8073	Capazones	PR	ME	05	MA	115	084915	712641	0373		5942
32.	8075	Mesa Julia	PR	ME	05	MA	950	085547	711356	0373		5942

Note: Type : PR:Pluviometric Station; C1:Meteorological Station;
C2:Meteorologocal Station; C3:Meteorologocal Station
State : ME:Merida; ZU:Zulia; TA:Tachira
Org : (Organization) MA:MARNR; SM:Fuerzas Aereas de Venezuela;
AC:Ministerio de Agricultura y Cria; ULA:Universidad de Los Andes
Alt : Altitude (meter from the mean sea level)
Lat : Latitude (North)
Long : Long (East)
Inst : Installed month/year (1168; Nov.1968)
Elim : Eliminated month/year (1168; Nov. 1968)

Table IV-2 MONTHLY METEOROLOGICAL RECORDS

Area/Station	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Upper Reaches	3112 Mucuchies (Alt. 3,100m)													
Temperature	C.Deg.	11.0	11.3	11.6	11.7	11.7	11.4	11.0	11.2	11.3	11.4	11.2	11.1	11.3
Middle Reaches I	3047 Merida Aeropuerto (Alt. 1,470m)													
Temperature	C.Deg.	18.0	18.4	19.1	19.2	19.5	19.3	19.1	19.4	19.4	19.0	18.8	18.3	19.0
Relative Humidity	%	78	77	77	81	82	81	79	78	78	82	83	81	79.8
Middle Reaches II	3170 San Juan de Lagunillas (Alt. 1,050m)													
Temperature	C.Deg.	22.1	22.4	22.7	22.7	22.3	22.5	22.4	22.8	23.1	22.5	22.4	21.9	22.5
Evaporation	mm	183	176	186	164	160	153	167	170	163	157	161	167	2,007
Middle Reaches III	3141 Tovar (Alt. 952m)													
Temperature	C.Deg.	20.9	21.1	21.7	22.1	22.7	22.6	22.4	22.5	22.3	22.0	21.6	20.9	21.9
Relative Humidity	%	77	74	73	75	75	73	69	71	71	74	75	74	73.4
Evaporation	mm	97	90	103	95	109	111	120	127	112	99	93	93	1,249
Lower Reaches	3035 El Vigia (Alt. 130m)													
Temperature	C.Deg.	26.6	27.1	27.8	27.8	28.5	28.9	28.1	28.9	28.5	27.9	27.6	26.9	27.9
Evaporation	mm	113	112	130	117	136	130	141	150	148	137	118	109	1,541

Note: Temperature and relative humidity are of daily mean, while evaporation is of monthly value

Table IV-3 MONTHLY RAINFALL AT MAJOR STATIONS

Serial	Station	Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Upper Reaches															
3111	Paramo de Mucuchies	'42-'86	9.0	11.6	25.0	80.1	111.9	143.3	141.8	117.5	86.8	81.9	40.8	19.5	869.2
3121	Mucuchies	'53-'83	6.5	9.0	19.8	74.2	74.0	80.2	61.6	70.6	75.3	70.2	37.4	11.0	589.8
3029	Mucuruba	'50-'83	24.0	27.3	45.1	125.4	122.6	65.6	63.1	63.5	74.4	104.3	71.2	32.8	819.3
Middle Reaches I															
3038	Tabay	'50-'86	36.5	41.0	64.8	189.2	233.1	118.1	98.9	125.8	176.6	239.9	165.8	78.0	1567.7
3047	Merida Aeropuerto	'21-'85	49.4	46.2	61.6	168.3	248.7	164.6	119.5	135.9	189.2	263.1	203.1	86.8	1736.4
8049	La Punta	'77-'86	28.9	33.9	50.1	149.9	186.1	133.9	80.2	111.5	171.8	185.9	123.4	52.8	1308.4
3042	Mesa de Ejido	'50-'87	26.0	19.8	30.3	97.3	120.0	73.8	55.4	64.7	95.3	116.6	116.3	50.5	866.0
Middle Reaches II															
3170	San Juan de Lagunillas	'71-'86	13.2	12.9	20.8	78.3	79.0	37.1	29.9	47.2	82.3	76.7	40.6	21.9	539.9
8056	San Pedro-Chiguara	'70-'86	53.3	56.9	59.0	110.7	91.2	42.8	32.3	71.3	70.8	159.1	117.5	69.9	934.8
Middle Reaches III															
3141	Tovar	'69-'86	36.2	29.0	53.5	121.7	137.4	84.4	89.7	109.2	119.2	162.4	136.2	58.4	1137.3
3132	Las Tapias	'69-'86	28.0	25.8	39.5	107.6	85.9	60.5	55.8	61.0	81.1	89.3	77.5	40.3	752.3
Lower Reaches I															
3035	El Vigia	'53-'86	127.6	115.7	136.3	231.1	178.9	112.9	86.2	103.9	101.5	199.3	236.8	190.1	1820.3

Table IV-4 OBSERVED AVERAGE AND PEAK DISCHARGES OF THE CHAMA RIVER AT EJIDO AND MUCURUBA

Year	Ejido (1,130 km2)					Mucuruba (365km2)				
	Average	Peak				Average	Peak			
	m3/s	m3/s /100km2	m3/s	m3/s/km2	Month Occurred	m3/s	m3/s /100km2	m3/s	m3/s/km2	Month Occurred
1965	22.60	2.00	92.1	0.08	May	-	-	-	-	-
1966	34.10	3.02	169.0	0.15	Dec.	-	-	-	-	-
1967	26.80	2.37	166.0	0.15	Oct.	-	-	-	-	-
1968	31.50	2.79	168.0	0.17	Oct.	-	-	-	-	-
1969	33.80	2.99	279.0	0.25	Apr.	-	-	-	-	-
1970	29.00	2.57	174.8	0.15	Oct.	-	-	-	-	-
1971	37.80	3.35	325.8	0.29	May	-	-	-	-	-
1972	32.80	2.90	419.7	0.37	Apr.	-	-	-	-	-
1975	-	-	-	-	-	3.03	0.83	34.3	0.09	Jun.
1976*	33.40	2.96	153.1	0.14	May	5.46	1.50	46.6	0.13	Jun.
1977	-	-	-	-	-	-	-	-	-	-
1978	27.70	2.45	229.6	0.20	Apr.	4.92	1.35	78.9	0.22	Jun.
1979	28.80	2.56	128.4	0.11	Oct.	5.56	1.52	53.3	0.15	Jul.
1980	22.90	2.03	162.8	0.14	May	5.32	1.46	71.5	0.20	Jun.
1981	31.20	2.76	216.2	0.19	Jun.	5.77	1.58	48.7	0.13	Aug.
1982	25.80	2.28	357.4	0.32	May	5.55	1.52	53.3	0.15	Jun.
1983	20.60	1.82	270.7	0.24	May	6.33	1.73	48.7	0.13	Jul.
1984	15.30	1.35	185.7	0.16	Oct.	3.97	1.09	46.6	0.13	Jun.
1985	19.50	1.73	179.6	0.16	Dec.	4.60	1.26	44.5	0.12	Aug.
1986	24.50	2.16	254.7	0.23	Oct.	5.55	1.52	45.6	0.12	Jul.
1987	-	-	-	-	-	3.65	1.00	49.8	0.14	Oct.
1988	-	-	360.0	0.32	Sep.	-	-	-	-	-
78-86	24.00 *2	2.13	360.0 *3	0.32	-	5.12 *2	1.40	78.9 *3	0.22	-

Note: * : Data of February are lacking
*2 : Average value for 1978-86
*3 : Extreme value for 1978-88
Source: 1965-73 : Rio Mocoties Estuido Hodrologico, 1986
1975-88 : Direccion de Hidrologia y Meteorologia, MARNR

Return Period	Probable value of Ejido Peak Discharge (m3/s)
100	511.6
50	462.0
30	425.5
20	396.3
10	345.5
5	292.3
2	211.3

Table IV-5(1/2) Observed Hourly Rainfall during Annual Maximum Basin's Maximum Basin's Average One-Day Rainfall from 1967 to 1988

Serial	Station	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77
3005	P.El Quemado	26.7	7.6	49.9	44.5	-	44.2	37.6	1.2	24.7	11.4	12.5
3024	Valle Grande	1.7	38.7	-	13.2	26.9	38.6	19.9	16.2	-	10.5	27.3
3027	P.la Culata	15.0	-	37.8	10.3	30.9	-	26.2	8.5	120.0	90.8	17.1
3029	Mucuruba	19.9	13.0	24.2	8.9	23.6	18.3	16.8	4.6	12.0	1.7	29.0
3035	El Vigia	0.0	90.1	54.1	9.7	53.5	48.0	40.8	21.8	74.6	49.1	74.0
3038	Tabay	16.8	-	-	-	0.0	0.0	14.0	0.0	51.4	0.7	31.0
3040	La Cuchilla	8.3	27.7	43.1	18.3	60.8	32.8	44.4	10.2	14.8	33.6	24.7
3042	Mesa de Ejido	58.8	22.1	31.6	10.4	48.3	20.1	12.8	45.8	3.5	31.0	-
3047	Merida A/P	-	-	-	-	69.1	45.1	11.7	36.9	14.2	8.5	37.3
3052	Mesa Bolivar	3.2	65.5	70.0	2.3	50.0	10.0	0.5	-	0.5	88.3	60.4
3054	Estanquez	-	-	-	-	4.8	13.2	15.8	0.1	0.0	48.8	-
3070	Paramo El Molino	13.2	21.1	42.0	8.8	30.4	41.1	-	-	2.6	20.9	12.9
3080	El Morro	10.0	9.6	12.0	0.0	12.5	11.9	0.0	25.8	4.1	2.2	8.0
3108	El Meson	-	30.4	24.8	-	39.7	65.4	40.0	48.2	8.8	40.4	47.2
3111	P.de Mucuchies	14.0	5.9	10.3	-	21.4	-	14.1	1.1	-	4.0	4.8
3112	P.Pico El Aguila	-	7.7	-	7.6	-	5.5	9.1	1.6	-	5.4	-
3121	Mucuchies	-	-	-	-	22.8	10.0	5.0	15.0	10.0	8.0	4.0
3132	Las Tapias	-	-	-	32.2	7.8	32.9	41.8	1.0	0.0	25.1	23.9
3141	Tovar	-	-	77.1	13.7	11.1	59.2	24.2	21.7	15.0	77.4	25.9
3168	Hda.El Carmen	-	-	-	-	29.1	40.5	30.6	-	24.9	-	33.9
3169	Jaji	-	-	-	-	16.5	26.8	10.1	36.8	2.6	15.1	33.4
3170	S.J.de Lagunillas	-	-	-	-	34.7	20.4	13.4	27.2	4.8	50.3	11.2
8049	La Punta	-	-	-	-	-	-	-	-	-	-	-
8053	La Palmita	0.1	63.8	81.0	16.9	59.2	27.8	40.2	20.8	-	57.7	90.2
8056	San P. Chiguara	-	-	-	2.2	-	14.4	29.9	73.1	2.6	91.1	36.7
8057	Tostos	-	-	-	9.7	38.5	0.0	21.4	-	-	18.6	16.1
3023	El Molino	21.2	-	-	-	15.8	0.9	39.4	-	0.0	0.0	8.5
3073	Sabana Grande	1.5	-	46.7	16.6	27.9	20.1	45.8	-	27.2	25.4	7.0
3074	Pueblo Hondo	3.6	-	63.5	20.5	43.4	40.8	29.9	16.1	31.5	30.8	18.9
3142	Zea la Florida	-	-	-	-	23.7	44.1	30.0	-	9.5	41.5	21.2
3065	Santa Cruz de Mora	-	-	-	-	-	0.0	-	-	-	-	-
	Los Nevadas	-	-	-	-	-	-	-	0.3	0.1	0.0	-

Table IV-5(2/2) Observed Hourly Rainfall during Annual Maximum Basin's Maximum Basin's Average One-Day Rainfall from 1967 to 1988

Serial	Station	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88
3005	P.El Quemado	3.2	20.0	2.8	53.9	21.7	22.9	17.0	24.7	29.8	46.6	-
3024	Valle Grande	11.4	21.6	9.8	36.9	0.0	18.3	-	5.9	27.9	35.5	38.4
3027	P.la Culata	18.7	18.9	12.8	-	0.0	7.8	6.6	0.0	-	-	37.9
3029	Mucuruba	12.9	10.4	7.2	27.6	0.0	10.0	-	-	-	-	-
3035	El Vigia	14.4	105.7	10.2	9.7	19.8	34.0	-	12.7	2.3	1.3	2.9
3038	Tabay	-	20.9	7.8	-	47.8	-	17.3	51.3	-	57.1	-
3040	La Cuchilla	17.1	1.8	21.0	22.6	27.3	23.6	0.4	24.4	-	-	13.3
3042	Mesa de Ejido	70.8	5.1	57.7	-	19.2	51.2	4.1	4.0	-	-	12.5
3047	Merida A/P	14.8	-	-	49.4	19.5	26.3	44.9	-	-	-	-
3052	Mesa Bolivar	0.0	9.1	23.9		0.0	15.3	3.0	-	-	-	1.3
3054	Estanquez	4.0	0.0	0.6	12.9	-	-	-	-	-	-	-
3070	Paramo El Molino	-	14.4	3.2	19.7	81.6	60.0	-	-	-	-	-
3080	El Morro	20.5	-	12.4	12.2	13.8	10.9	4.5	-	-	0.0	20.9
3108	El Meson	31.3	22.4	-	15.7	0.0	17.5	-	-	38.8	96.1	10.0
3111	P.de Mucuchies	17.5	0.6	4.6	-	8.8	6.1	0.6	7.5	4.6	-	44.5
3112	P.Pico El Aguila	-	2.6	7.9	-	13.2	6.1	0.8	4.3	6.5	20.2	45.3
3121	Mucuchies	20.0	1.0	5.0	28.0	0.0	0.0	-	-	-	-	-
3132	Las Tapias	19.3	16.0	3.3	10.5	44.8	7.0	26.8	11.1	17.2	-	20.0
3141	Tovar	13.2	12.0	1.9	14.5	32.1	28.0	19.0	10.1	-	27.9	4.0
3168	Hda.El Carmen	12.9	41.5	12.1	45.3	45.6	11.9	-	-	-	-	-
3169	Jaji	27.2	13.0	16.8	-	40.4	16.9	6.1	28.7	-	14.2	16.8
3170	S.J.de Lagunillas	28.8	2.2	40.7	9.8	28.4	14.9	2.3	2.5	0.0	49.6	0.0
8049	La Punta	15.1	17.0	35.3	18.0	26.7	63.8	18.4	11.8	-	13.6	19.7
8053	La Palmita	15.8	23.7	2.6	9.4	0.0	26.0	-	-	-	-	5.1
8056	San P. Chiguara	15.0	19.4	16.5	14.6	32.5	19.6	1.9	10.4	0.0	-	0.0
8057	Tostos	-	1.9	16.7	-	-	-	-	3.9	31.1	-	13.1
3023	El Molino	-	-	16.9	27.5	19.2	11.2	-	-	-	-	-
3073	Sabana Grande	18.5	39.4	9.6	19.1	21.6	7.2	-	-	-	-	-
3074	Pueblo Hondo	22.9	14.0	20.5	13.4	31.7	6.7	-	-	-	-	-
3142	Zea la Florida	2.1	62.5	1.4	11.0	29.6	30.1	10.8	-	-	-	6.4
3065	Santa Cruz de Mora	-	-	-	-	-	-	-	-	-	-	-
	Los Nevadas	-	0.0	0.2	13.2	-	-	-	-	-	-	-

Table IV-6 OBSERVED HOURLY RAINFALL DURING SEPTEMBER 1988 FLOOD

(Unit: mm)

Station	3111	3112	3024	8049	3042	3080	3169	8057	3108	3035
Sep.6 9										
10					0.1					
11		3.5								
12	2.3	0.4								
13	1.6	2.9								
14	2.6	0.7	0.3							
15	0.6	2.2	0.2							
16	3.1	3.1				0.2	2.0			
17	2.7	1.2				0.2				
18	0.9	1.9								
19	1.8	3.0	4.0	2.5	0.1		0.2			
20	3.4	3.2	7.2	3.0	0.4		0.5			
21	2.6	2.0	3.8	2.1	0.9	0.9	0.9		0.6	
22	2.3	3.7	3.8	2.8	1.3	4.9	1.9	0.1	3.2	
23	4.9	0.6	5.8	6.0	3.0	7.3	3.2	0.2	3.0	1.6
Sep.7 0	2.8		6.8	3.3	5.7	5.5	5.4	1.0	2.3	0.8
1	4.4	1.3	5.4		1.0	1.8	2.7	2.4	0.7	0.3
2	2.3	1.1	1.1			0.1		3.9	0.2	0.2
3	2.7	0.8						5.3		
4	1.1	0.4						0.2		
5	0.9	2.3								
6	0.4	1.1								
7	0.6	6.2								
8	0.5	2.5								
9										
10										
11										
12		0.3								
13		0.1							0.1	
14										
15		0.7	3.3							
16	1.5									
17									0.4	
18			4.0						0.1	4.0
19			13.7							
20			0.9					6.6		
21										
22			0.1							
23										
Sep.8 0			0.3							
1			0.4							
2			0.8							
3			0.1							
4										
5										
6										
7										
8										
9										
10										
11										
12		0.6							0.1	
13	0.6	3.8							3.7	
14	1.1	4.1			0.3				13.8	
15	4.6	0.1	2.4		0.2	0.3	0.3			
16	1.2		2.5			3.7	1.1			1.4
17						0.5	0.1	0.1		
18								2.2		
19								1.1		
20										
21			0.4							
22			1.3							
23			0.1				1.2			
Sep.9 0			3.1				1.7			
1			0.9				0.3			3.4
2						0.4			1.4	50.0
3					3.0				16.8	9.0
4			0.9	2.2			6.0		1.0	3.4
5			0.9	5.1			5.7	0.3		2.2
6							0.3			
7										
8										

Table IV-7 RAINFALL INTENSITY BY DURATION (100-YEAR RETURN PERIOD)

Serial No.	Station	No.of Data	100-Year Return Period Point Rainfall 1-hr mm	1-hr mm/hr	3-hr mm	3-hr mm/hr	12-hr mm	12-hr mm/hr	24-hr mm	24-hr mm/hr
3111	Paramo de Mucuchies	32	15.9	15.9	25.8	8.6	58.1	4.8	75.3	3.1
3112	Paramo Pico El Aguila	30	14.8	14.8	23.4	7.8	58.1	4.8	71.8	3.0
3072	Mucubaji	9	15.1	15.1	30.3	10.1	47.3	3.9	50.4	2.1
3029	Mucuruba	21	48.4	48.4	49.0	16.3	56.7	4.7	63.9	2.7
3027	Paramo de Culata	20	36.6	36.6	45.5	15.2	59.9	5.0	62.4	2.6
3024	Valle Grande	21	56.7	56.7	76.1	25.4	78.2	6.5	83.7	3.5
3050	Merida	8	51.4	51.4	89.7	29.9	100.5	8.4	103.1	4.3
3080	El Morro	21	26.6	26.6	41.1	13.7	52.2	4.4	56.8	2.4
3042	Mesa de Ejido	22	67.8	67.8	86.8	28.9	100.4	8.4	109.1	4.5
3161	Jaji	13	77.6	77.6	84.7	28.2	91.6	7.6	96.0	4.0
3170	San Juan de Lagunillas	13	69.6	69.6	74.7	24.9	75.8	6.3	97.8	4.1
8057	Tostos	14	64.8	64.8	70.5	23.5	71.9	6.0	73.7	3.1
3070	Paramo El Molino	20	51.0	51.0	77.4	25.8	92.7	7.7	111.9	4.7
3132	Las Tapias	15	35.2	35.2	49.7	16.6	64.1	5.3	67.0	2.8
3141	Tovar	16	97.1	97.1	114.3	38.1	128.6	10.7	131.2	5.5
3108	El Meson	16	95.8	95.8	129.6	43.2	131.0	10.9	163.7	6.8
8056	San Pedro Chiguara	14	99.6	99.6	144.7	48.2	152.7	12.7	157.0	6.5
8053	La Palmita	31	89.0	89.0	115.7	38.6	118.5	9.9	138.1	5.8
3035	El Vigia	21	96.7	96.7	126.6	42.2	155.3	12.9	168.6	7.0

Table IV-8 SUMMARY OF CONATANTS OF STORAGE FUNCTION MODEL FOR UPPER/MIDDLE REACHES

No.	Sub-Basin	A (km2)	L (km)	h (m)	1/i	K	p	Tl (hr)	f
1.	Upper Mucuruba	365.0	3.33	2,160	15.4	11.0	0.333	1.01	0.60
2.	Chama Mucuruba-Merida	134.2	9.5	2,240	4.2	16.3	0.245	0	0.60
3.	La Mucuy	102.4	18.0	2,400	7.5	13.7	0.281	0.29	0.60
4.	Mucujun	205.7	30.3	3,040	10.0	12.5	0.301	0.86	0.60
5.	Tabay-La Penta Left Bank	192.7	12.0	2,960	4.1	16.4	0.244	0	0.60
6.	Albarregas	130.0	28.0	3,200	8.8	13.0	0.292	0.76	0.60
7.	Chama Lower Ejido	98.0	12.0	2,720	4.4	16.0	0.248	0	0.61
8.	Upper Nuestra Senora	304.8	32.0 (52.0)	3,280	9.8	12.6	0.299	1.88	0.60
9.	Lower Nuestra Senora	338.0	28.0	3,200	8.8	13.0	0.292	0.76	0.61
10.	Las Gonzales	118.6	30.5	3,200	9.5	12.7	0.297	0.87	0.61
11.	La Sucia	63.2	15.5	2,000	7.8	13.5	0.284	0.17	0.61
12.	Upper Laguillas Left Bank	58.8	8.8	2,040	4.3	16.1	0.247	0	0.65
13.	Vizcanina	136.6	23.8	2,760	8.6	13.1	0.290	0.56	0.61
14.	Laguillas-Chiguara Right Bank	191.5	15.0	1,760	8.5	13.2	0.289	0.15	0.68
15.	Lower Laguillas Left Bank	45.4	10.5	2,200	4.8	15.6	0.253	0	0.67
16.	San Pablo	270.7	25.5	2,640	9.7	12.6	0.298	0.64	0.61
17.	Santo Domingo	74.7	16.3	2,120	7.7	13.6	0.283	0.21	0.62
18.	Upper Mocoties	241.0	25.0	2,640	9.5	12.7	0.297	0.62	0.60
19.	Lower Mocoties	173.5	8.8	2,800	3.1	17.8	0.228	0	0.60
20.	Mejias	119.9	19.3	3,040	6.3	14.4	0.270	0.35	0.60
21.	Upstream of El Vigia	152.3	13.0	1,800	7.2	13.8	0.278	0.05	0.60
Total		3,517.0							

River Channel	K	p	Tl	Tlz
A Upper Chama	0	0.5	0	0.56
B Middle Chama I	0	0.5	0	0.69
C Middle Chama II	36.4	0.6	0.189	0.83
D Mocoties	0	0.5	0	0.82

Table IV-9(1/4) Observed Hourly Rainfall during Annual Maximum Basin's Average One-Day Rainfall from 1985 to 1988

Dec.2, 1985 (Unit: mm)

Serial	Station	9	10	11	12	13	14	15	16	17	18	19	20
3005	P.El Quemado												
3024	Valle Grande			0.1	0.1		0.8	5.1	1.0	0.4	3.2	2.1	0.1
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia												
3038	Tabay									0.6	1.7	1.0	0.3
3040	La Cuchilla					0.8							
3042	Mesa de Ejido									0.1			0.4
3047	Merida A/P												
3052	Mesa Bolivar			0.3			0.4		0.3				
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji								0.4	0.6	0.1		
3080	El Morro												
3108	El Meson												
3111	P.de Mucuchies						1.0	2.2	1.6	0.7			
3112	P.Pico El Aguila												
3121	Mucuchies												
3132	Las Tapias									1.0			
3141	Tovar											0.3	
3168	Hda.El Carmen												
3169	Jaji					0.2		0.3					
3170	S.J.de Lagunillas												
8049	La Punta												5.1
8053	La Palmita												2.3
8056	San P. Chiguara												
8057	Tostos												
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida												

Serial	Station	21	22	23	24	1	2	3	4	5	6	7	8
3005	P.El Quemado												
3024	Valle Grande												
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia							3.6	0.6			0.6	5.2
3038	Tabay	0.1											
3040	La Cuchilla												
3042	Mesa de Ejido	17.4	20.7	0.8	3.5	0.1	7.3	7.7	3.3	0.1			
3047	Merida A/P												
3052	Mesa Bolivar								1.2	0.4	0.1		
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji												
3080	El Morro												
3108	El Meson												
3111	P.de Mucuchies												
3112	P.Pico El Aguila	9.1	2.9	0.9	0.6	2.6	3.0	0.4					
3121	Mucuchies												
3132	Las Tapias												
3141	Tovar		0.4										
3168	Hda.El Carmen												
3169	Jaji					0.3	0.5						
3170	S.J.de Lagunillas							0.3	0.1				
8049	La Punta	0.1	0.6		0.1	4.6	1.2	2.9	4.6	7.2	1.6		
8053	La Palmita	0.4							8.8	0.6	0.2		
8056	San P. Chiguara						0.7	0.1	12.4	0.1		0.1	
8057	Tostos												
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida												

Table IV-9(2/4) Observed Hourly Rainfall during Annual Maximum Basin's Average One-Day Rainfall from 1985 to 1988

Oct.18, 1986 (Unit: mm)

Serial	Station	9	10	11	12	13	14	15	16	17	18	19	20
3005	P.El Quemado												2.1
3024	Valle Grande						0.5	0.1		2.9	0.3		
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia												
3038	Tabay												
3040	La Cuchilla												
3042	Mesa de Ejido												
3047	Merida A/P												
3052	Mesa Bolivar											0.9	0.2
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji												
3080	El Morro												
3108	El Meson												
3111	P.de Mucuchies									0.3	0.4	0.1	0.1
3112	P.Pico El Aguila								0.4	0.1	0.1		
3121	Mucuchies												
3132	Las Tapias										9.5	2.4	0.3
3141	Tovar												
3168	Hda.El Carmen												
3169	Jaji												
3170	S.J.de Lagunillas												
8049	La Punta												
8053	La Palmita												
8056	San P. Chiguara												
8057	Tostos												
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida												

Serial	Station	21	22	23	24	1	2	3	4	5	6	7	8
3005	P.El Quemado	23.7	2.5	0.5	0.9	0.1							
3024	Valle Grande	0.1	0.1	8.3	1.6	6.1	5.4	2.5					
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia				0.2	0.4	0.5	0.6	0.2		0.1	0.3	
3038	Tabay												
3040	La Cuchilla												
3042	Mesa de Ejido												
3047	Merida A/P												
3052	Mesa Bolivar								10.2	4.0	1.5	0.3	
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji												
3080	El Morro					0.8							
3108	El Meson	6.4	24.4	5.8	0.3	1.6	0.2		0.1				
3111	P.de Mucuchies				0.3	1.0	1.6	0.8					
3112	P.Pico El Aguila					2.3							
3121	Mucuchies												
3132	Las Tapias	3.9	0.3			0.1		0.4	0.1				
3141	Tovar	1.5	4.9	1.7	1.5	0.5	0.1						
3168	Hda.El Carmen												
3169	Jaji												
3170	S.J.de Lagunillas												
8049	La Punta												
8053	La Palmita		0.6	1.0	1.3	0.8		0.2	0.2				
8056	San P. Chiguara												
8057	Tostos					16.9	14.2						
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida												

Table IV-9(3/4) Observed Hourly Rainfall during Annual Maximum Basin's Average One-Day Rainfall from 1985 to 1988

Oct.14, 1987 (Unit: mm)

Serial	Station	9	10	11	12	13	14	15	16	17	18	19	20
3005	P.El Quemado										1.0		19.1
3024	Valle Grande	0.1	0.1					4.6	7.7				
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia												5.2
3038	Tabay												
3040	La Cuchilla												
3042	Mesa de Ejido												
3047	Merida A/P												
3052	Mesa Bolivar		0.5		0.1	8.4	6.8	5.5	1.2	0.1		0.9	1.7
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji												
3080	El Morro												
3108	El Meson					0.1	1.5	0.1		23.1	38.4	20.7	4.1
3111	P.de Mucuchies												
3112	P.Pico El Aguila												
3121	Mucuchies												
3132	Las Tapias												
3141	Tovar												
3168	Hda.El Carmen												
3169	Jaji							0.5	0.9		0.1		
3170	S.J.de Lagunillas				4.3	21.6		3.3	0.3				0.5
8049	La Punta											0.9	10.1
8053	La Palmita												
8056	San P. Chiguara												
8057	Tostos												
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida												

Serial	Station	21	22	23	24	1	2	3	4	5	6	7	8
3005	P.El Quemado	2.0	3.7	0.6			0.6	1.1	7.0	5.4	2.5	2.8	0.8
3024	Valle Grande												
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia	1.5	3.9	0.2				0.7	0.2	0.4			
3038	Tabay	4.4	30.8	12.5	4.6	3.7			0.7	0.2	0.1	0.1	
3040	La Cuchilla												
3042	Mesa de Ejido												
3047	Merida A/P												
3052	Mesa Bolivar	0.2	0.4										
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji				1.0	11.1	1.9	0.2					
3080	El Morro	2.1	5.4	6.7	3.5	0.2		0.1	0.1				
3108	El Meson	3.4	0.7	0.1	0.2	1.6	0.6	0.1		0.3	1.0	0.1	
3111	P.de Mucuchies												
3112	P.Pico El Aguila	5.3	5.1	1.3	1.6	1.9	2.4	1.6					1.0
3121	Mucuchies												
3132	Las Tapias												
3141	Tovar												
3168	Hda.El Carmen												
3169	Jaji	0.6	5.1	5.2	0.6	0.2		0.3	0.2	0.4		0.1	
3170	S.J.de Lagunillas							0.4	15.3	3.2	0.7		
8049	La Punta	2.3	0.3										
8053	La Palmita												
8056	San P. Chiguara												
8057	Tostos												
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida												

Table IV-9(4/4) Observed Hourly Rainfall during Annual Maximum Basin's Average One-Day Rainfall from 1985 to 1988

Sep.7, 1988

(Unit: mm)

Serial	Station	9	10	11	12	13	14	15	16	17	18	19	20
3005	P.El Quemado							1.4			1.1		
3024	Valle Grande						0.3	0.2				4.0	7.2
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia												
3038	Tabay								0.2			0.1	1.6
3040	La Cuchilla						0.2	0.1	0.5				0.1
3042	Mesa de Ejido		0.1									0.1	0.4
3047	Merida A/P												
3052	Mesa Bolivar												
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji			0.1		0.1		0.2	0.1	0.1			
3080	El Morro								0.2	0.2			
3108	El Meson												
3111	P.de Mucuchies				2.3	1.6	2.6	0.6	3.1	2.7	0.9	1.8	3.4
3112	P.Pico El Aguila			3.5	0.4	2.9	0.7	2.2	3.1	1.2	1.9	3.0	3.2
3121	Mucuchies												
3132	Las Tapias							0.1	1.4	4.3	1.0	0.8	
3141	Tovar									0.3			
3168	Hda.El Carmen												
3169	Jaji								2.0			0.2	0.5
3170	S.J.de Lagunillas												
8049	La Punta											2.5	3.0
8053	La Palmita												
8056	San P. Chiguara												
8057	Tostos												
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida		3.4										

Serial	Station	21	22	23	24	1	2	3	4	5	6	7	8
3005	P.El Quemado		0.3	3.7	2.3	1.0	0.6	0.2					
3024	Valle Grande	3.8	3.8	5.8	6.8	5.4	1.1						
3027	P.la Culata												
3029	Mucuruba												
3035	El Vigia			1.6	0.8	0.3	0.2						
3038	Tabay	2.3	2.9	4.5	8.0								
3040	La Cuchilla	1.0	1.9	2.3	2.9	3.7	0.6						
3042	Mesa de Ejido	0.9	1.3	3.0	5.7	1.0							
3047	Merida A/P												
3052	Mesa Bolivar		0.8	0.5									
3054	Estanquez												
3070	Paramo El Molino												
3072	Mucubaji				3.0	3.8	7.6	10.1	4.9	0.5	0.2		
3080	El Morro	0.9	4.9	7.3	5.5	1.8	0.1						
3108	El Meson	0.6	3.2	3.0	2.3	0.7	0.2						
3111	P.de Mucuchies	2.6	2.3	4.9	2.8	4.4	2.3	2.7	1.1	0.9	0.4	0.6	0.5
3112	P.Pico El Aguila	2.0	3.7	0.6		1.3	1.1	0.8	0.4	2.3	1.1	6.2	2.5
3121	Mucuchies												
3132	Las Tapias			8.5	2.6	1.0	0.2	0.1					
3141	Tovar		0.2	0.9	1.4	0.4	0.5	0.3					
3168	Hda.El Carmen												
3169	Jaji	0.9	1.9	3.2	5.4	2.7							
3170	S.J.de Lagunillas												
8049	La Punta	2.1	2.8	6.0	3.3								
8053	La Palmita		0.1	1.1	1.9	1.1	0.6	6.3					
8056	San P. Chiguara		0.3	1.4	2.4	1.8	0.5						
8057	Tostos		0.1	0.2	1.0	2.4	3.9	5.3	0.2				
3023	El Molino												
3073	Sabana Grande												
3074	Pueblo Hondo												
3142	Zea la Florida		0.1	1.0	1.0	0.4	0.2	0.2			0.1		

Table IV-10 DESIGN RAINFALL OF THE 1986 TYPE OF RAINFALL

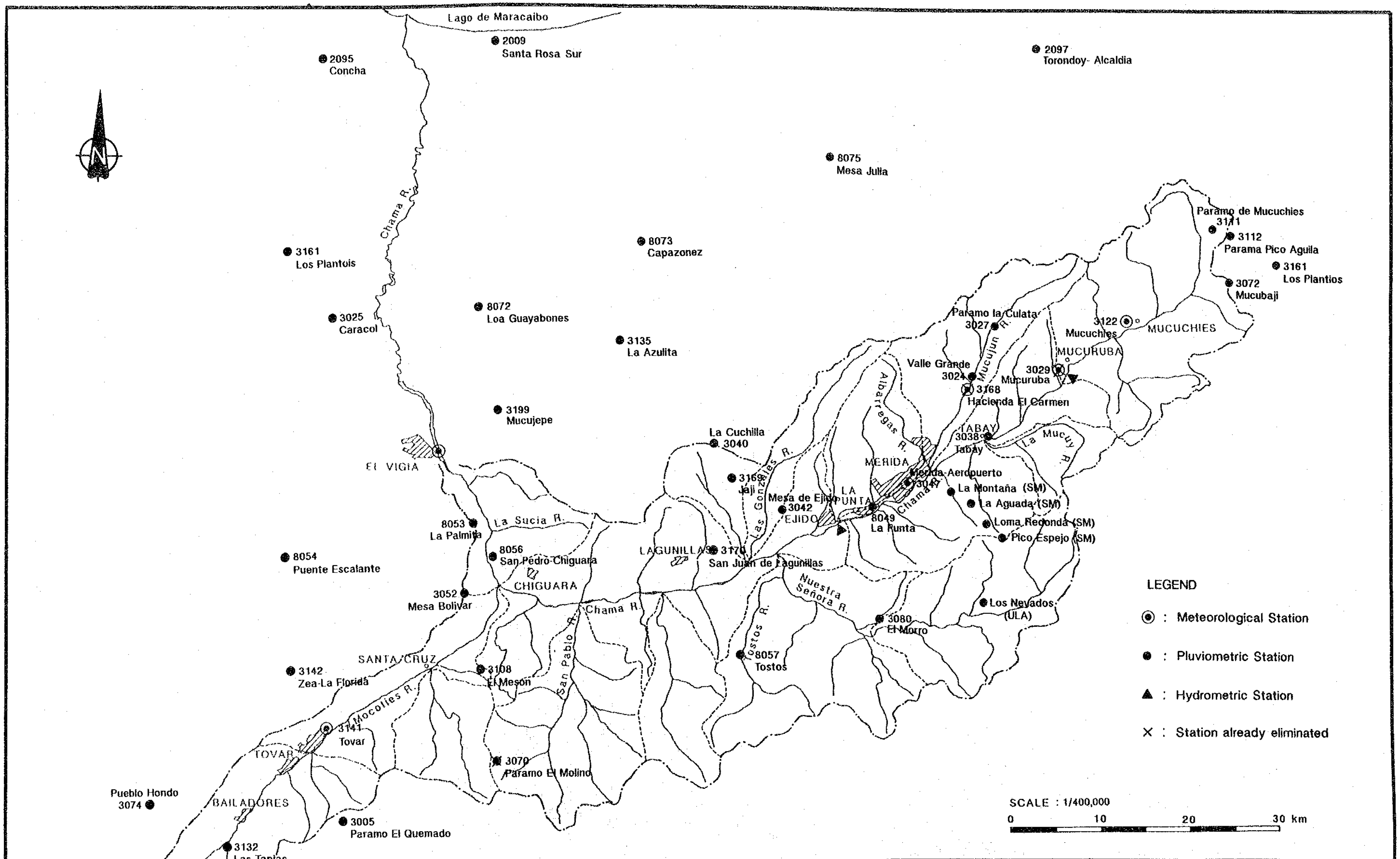
	Time											
Sub-Basin	9	10	11	12	13	14	15	16	17	18	19	20
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.88	0.47	0.47	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.64	0.13	0.00	3.71	0.38	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.32	0.06	0.00	1.86	0.19	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.60	0.12	0.00	3.48	0.36	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.91	0.18	0.00	5.28	0.55	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.62	0.12	0.00	3.60	0.37	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.68	0.14	0.00	3.97	0.41	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.52	0.38	0.38	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.64	0.13	0.00	3.71	0.38	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.57	5.45	0.68
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.18	5.86	0.73
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Time											
Sub-Basin	21	22	23	24	1	2	3	4	5	6	7	8
1	0.00	0.00	0.00	0.00	10.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.13	0.13	10.62	2.05	7.81	6.91	3.20	0.00	0.00	0.00	0.00	0.00
3	0.06	0.06	5.31	1.02	3.90	3.46	1.60	0.00	0.00	0.00	0.00	0.00
4	0.12	0.12	9.96	1.92	7.32	6.48	3.00	0.00	0.00	0.00	0.00	0.00
5	0.18	0.18	15.11	2.91	11.10	9.83	4.55	0.00	0.00	0.00	0.00	0.00
6	0.12	0.12	10.29	1.98	7.56	6.70	3.10	0.00	0.00	0.00	0.00	0.00
7	0.14	0.14	11.37	2.19	8.36	7.40	3.42	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	8.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.13	0.13	10.62	2.05	7.81	6.91	3.20	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	1.03	2.06	2.57	3.08	1.03	0.00	0.51	1.54	0.00
11	0.00	0.00	0.00	0.93	1.86	2.32	2.78	0.93	0.00	0.46	0.39	0.00
12	0.00	0.00	0.00	0.00	29.57	24.85	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	35.15	29.54	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	1.36	2.72	3.41	4.09	1.36	0.00	0.68	2.04	0.00
15	0.00	0.00	0.00	0.00	34.64	29.11	0.00	0.00	0.00	0.00	0.00	0.00
16	12.35	47.09	11.19	0.58	3.09	0.39	0.00	0.19	0.00	0.00	0.00	0.00
17	10.30	39.28	9.34	0.48	2.58	0.32	0.00	0.16	0.00	0.00	0.00	0.00
18	8.85	0.68	0.00	0.00	0.23	0.00	0.91	0.23	0.00	0.00	0.00	0.00
19	9.52	0.73	0.00	0.00	0.24	0.00	0.98	0.24	0.00	0.00	0.00	0.00
20	12.03	45.87	10.90	0.56	3.01	0.38	0.00	0.19	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	1.00	2.00	2.50	2.99	1.00	0.00	0.50	1.50	0.00

Table IV-11 MONTHLY AVERAGE DAILY DISCHARGE BY SUB-BASIN

(Unit: m3/s)

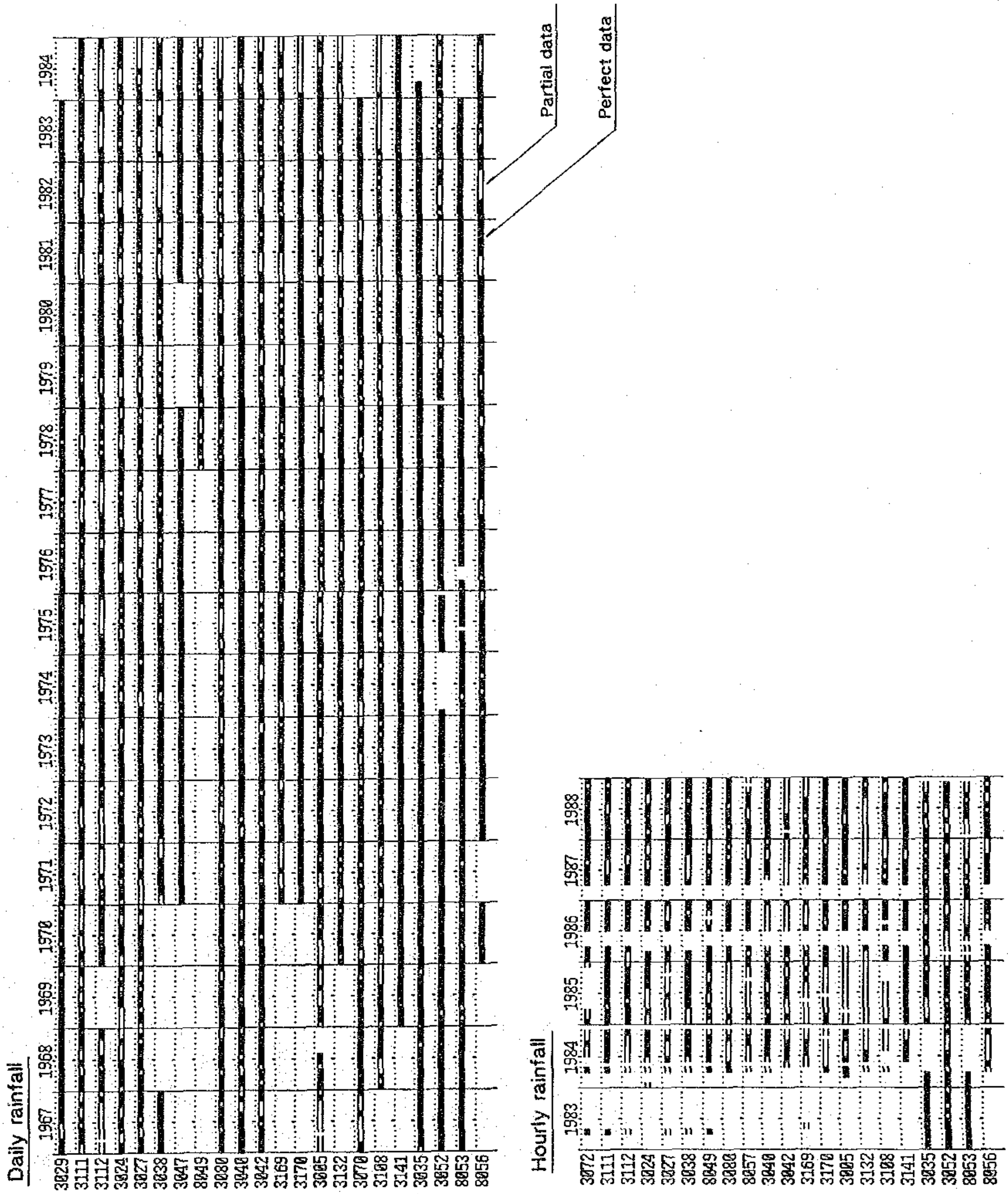
Sub-basin	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
BASIN- 1	2.1	1.2	1.4	7.8	13.0	8.5	4.6	5.9	10.4	15.4	15.8	7.3	7.8
BASIN- 2	0.8	0.4	0.5	2.9	4.8	3.1	1.7	2.2	3.8	5.7	5.8	2.7	2.9
BASIN- 3	0.6	0.3	0.4	2.2	3.7	2.4	1.3	1.7	2.9	4.3	4.4	2.1	2.2
BASIN- 4	1.2	0.7	0.8	4.4	7.3	4.8	2.6	3.3	5.8	8.7	8.9	4.1	4.4
BASIN- 5	1.1	0.6	0.7	4.1	6.9	4.5	2.4	3.1	5.5	8.1	8.3	3.9	4.1
BASIN- 6	0.7	0.4	0.5	2.8	4.6	3.0	1.6	2.1	3.7	5.5	5.6	2.6	2.8
BASIN- 7	0.6	0.3	0.4	2.1	3.5	2.3	1.2	1.6	2.8	4.1	4.2	2.0	2.1
BASIN- 8	1.0	0.6	0.6	3.6	6.0	3.9	2.1	2.7	4.8	7.1	7.3	3.4	3.6
BASIN- 9	1.1	0.6	0.7	4.0	6.6	4.3	2.4	3.0	5.3	7.9	8.0	3.7	4.0
BASIN-10	0.7	0.4	0.5	2.5	4.2	2.8	1.5	1.9	3.4	5.0	5.1	2.4	2.5
BASIN-11	0.4	0.2	0.2	1.4	2.3	1.5	0.8	1.0	1.8	2.7	2.7	1.3	1.4
BASIN-12	0.2	0.1	0.1	0.7	1.2	0.8	0.4	0.5	0.9	1.4	1.4	0.6	0.7
BASIN-13	0.4	0.2	0.3	1.6	2.7	1.8	1.0	1.2	2.1	3.2	3.2	1.5	1.6
BASIN-14	0.6	0.3	0.4	2.3	3.8	2.5	1.3	1.7	3.0	4.4	4.6	2.1	2.3
BASIN-15	0.1	0.1	0.1	0.5	0.9	0.6	0.3	0.4	0.7	1.1	1.1	0.5	0.5
BASIN-16	2.6	1.5	1.5	6.0	9.7	6.6	3.8	4.6	7.7	11.2	11.9	6.2	6.1
BASIN-17	0.7	0.4	0.4	1.6	2.7	1.8	1.0	1.3	2.1	3.1	3.3	1.7	1.7
BASIN-18	2.3	1.4	1.4	5.3	8.6	5.9	3.4	4.1	6.8	10.0	10.6	5.5	5.4
BASIN-19	1.7	1.0	1.0	3.8	6.2	4.2	2.4	2.9	4.9	7.2	7.6	3.9	3.9
BASIN-20	1.2	0.7	0.7	2.6	4.3	2.9	1.7	2.0	3.4	5.0	5.3	2.7	2.7
BASIN-21	1.5	0.9	0.9	3.4	5.5	3.7	2.1	2.6	4.3	6.3	6.7	3.5	3.4
Total	21.6	12.3	13.5	65.6	108.5	71.9	39.6	49.8	86.1	127.4	131.8	63.7	66.1



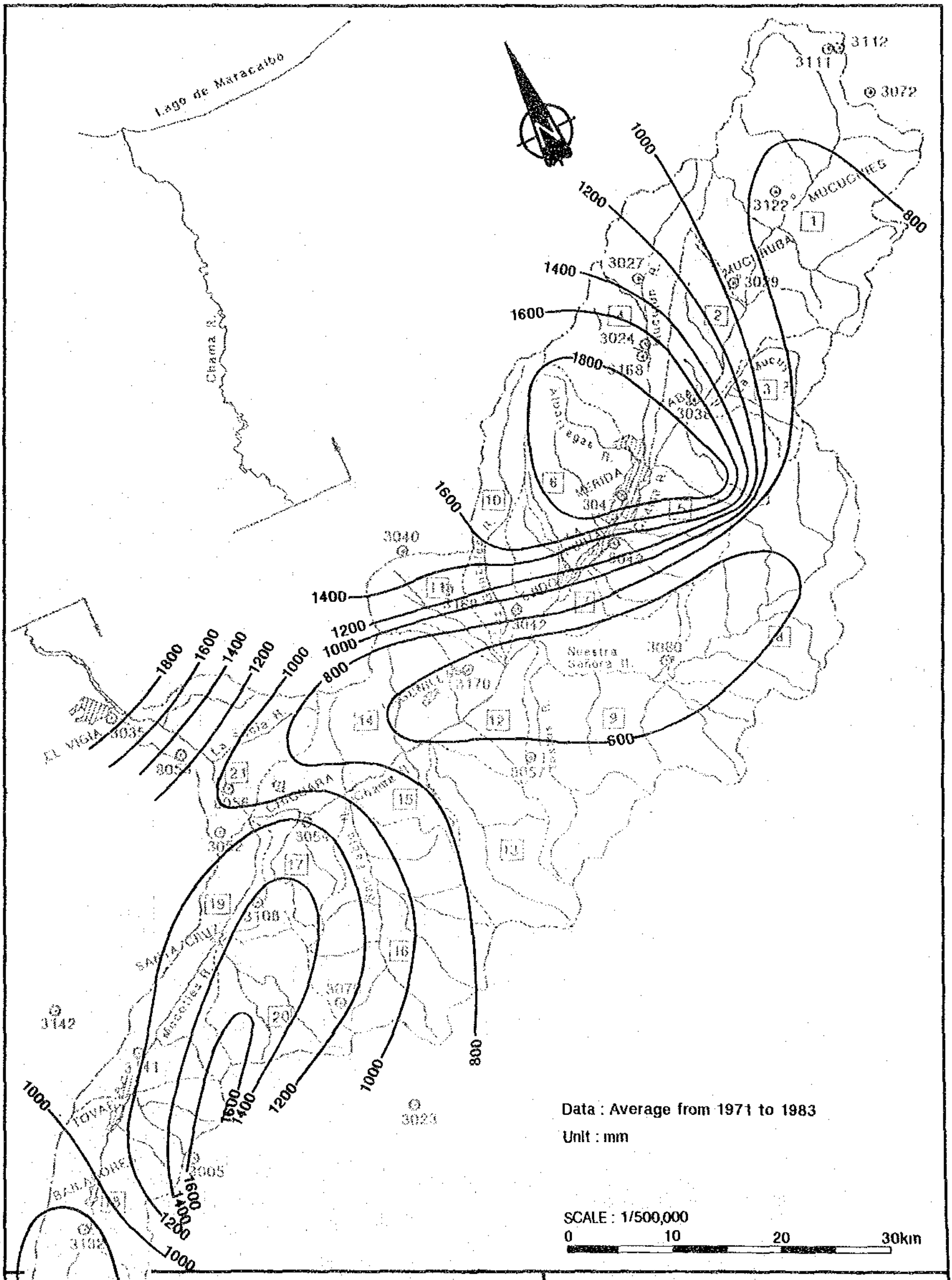
STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

LOCATION MAP OF METROLOGICAL AND HYDROLOGICAL STATIONS

Fig. IV-1



AVAILABLE DATA AND PERIOD FOR DAILY AND HOURLY RAINFALL	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-2	JAPAN INTERNATIONAL COOPERATION AGENCY

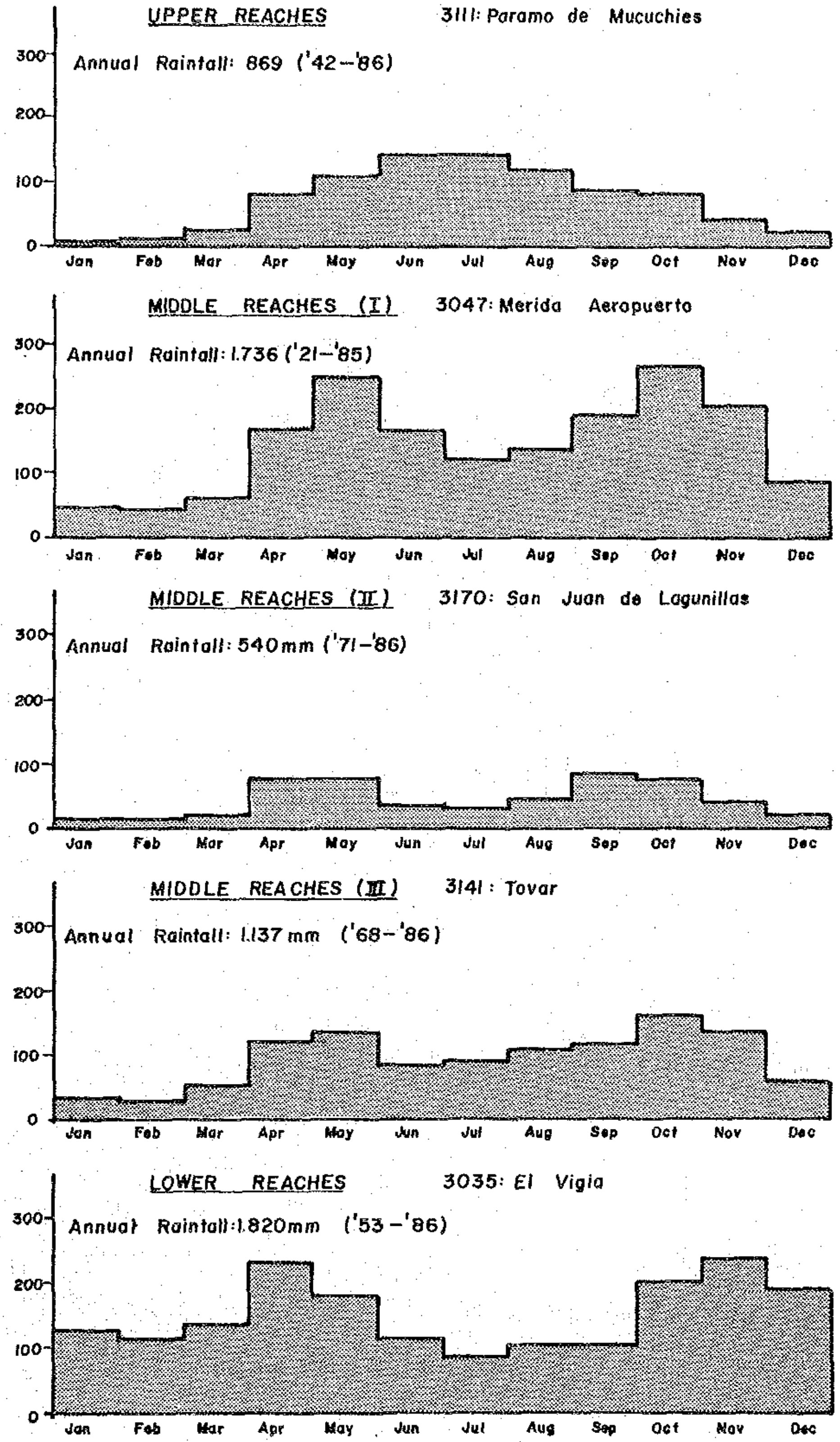


ISOHYETAL MAP OF ANNUAL RAINFALL

Fig. IV-3

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

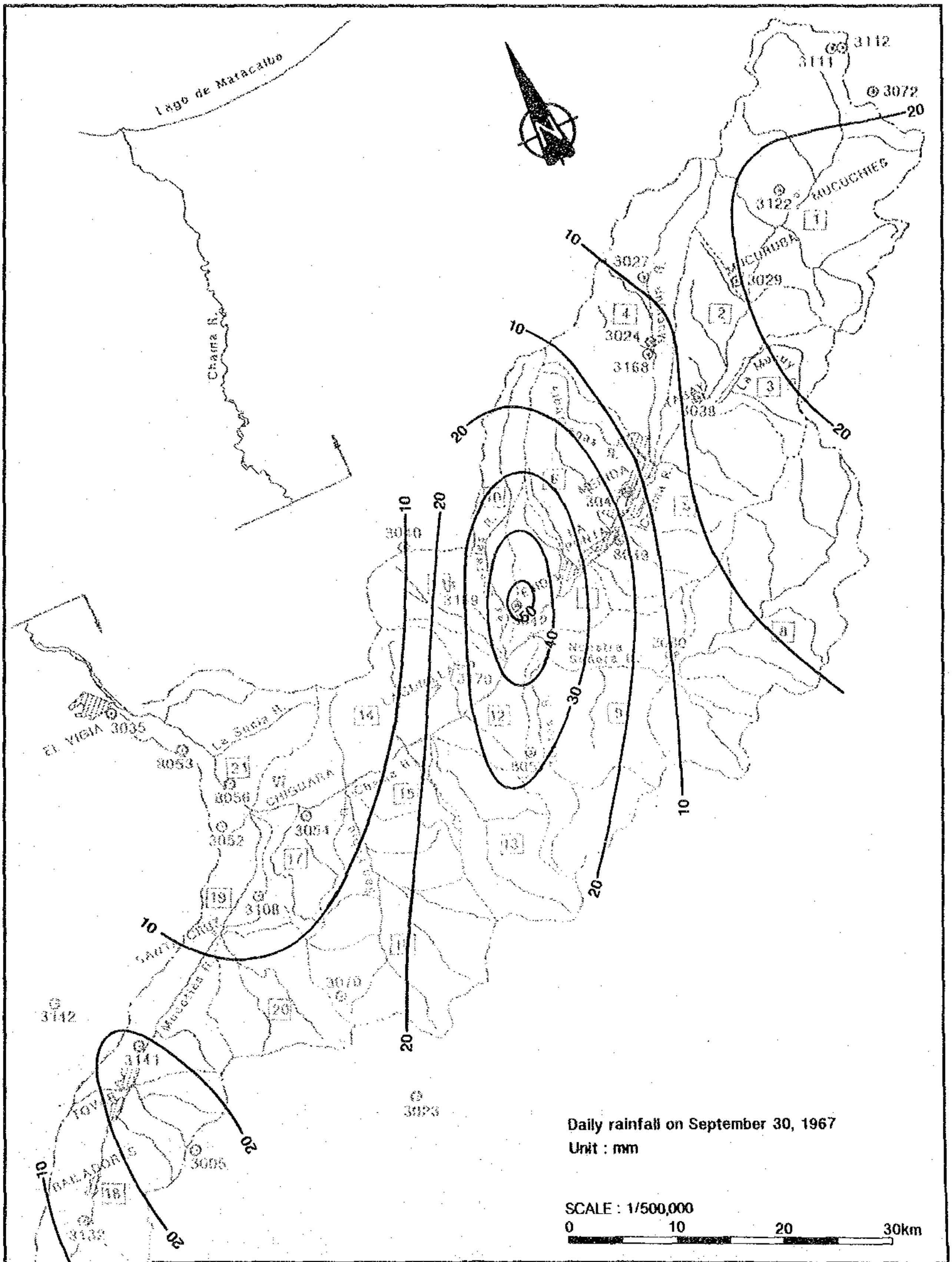


ANNUAL RAINFALL PATTERNS

Fig. IV-4

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

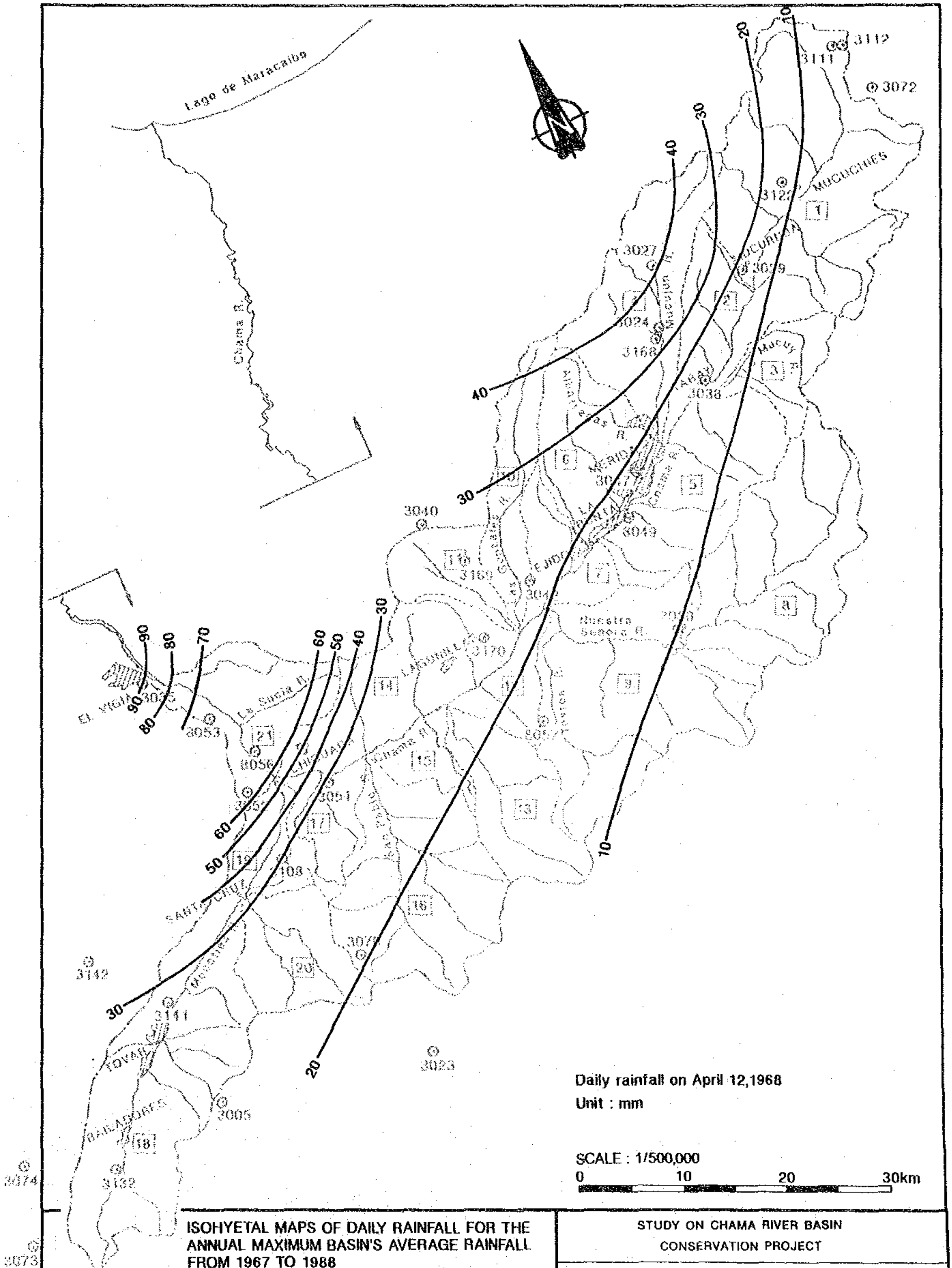


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (1/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

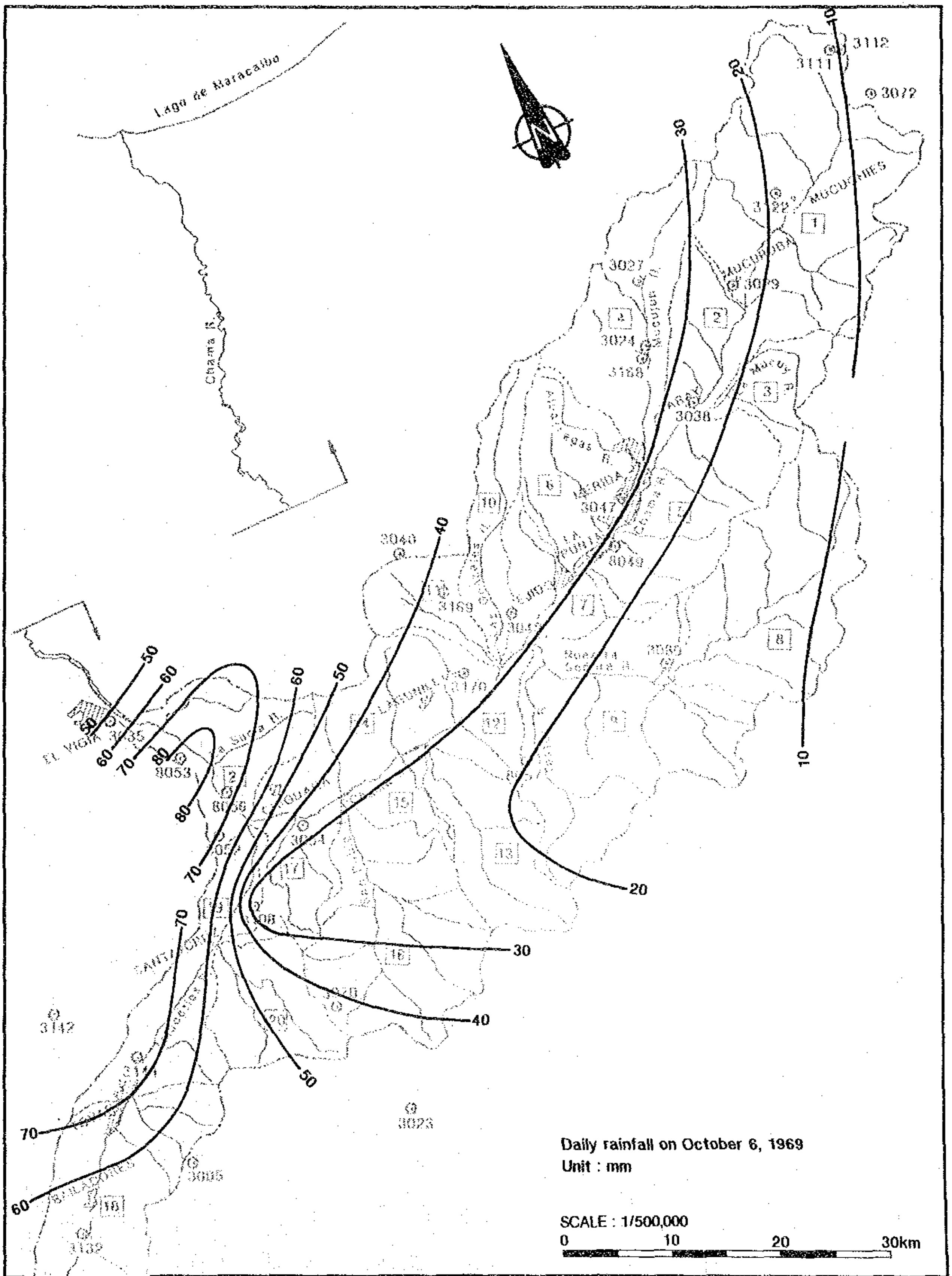


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (2/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

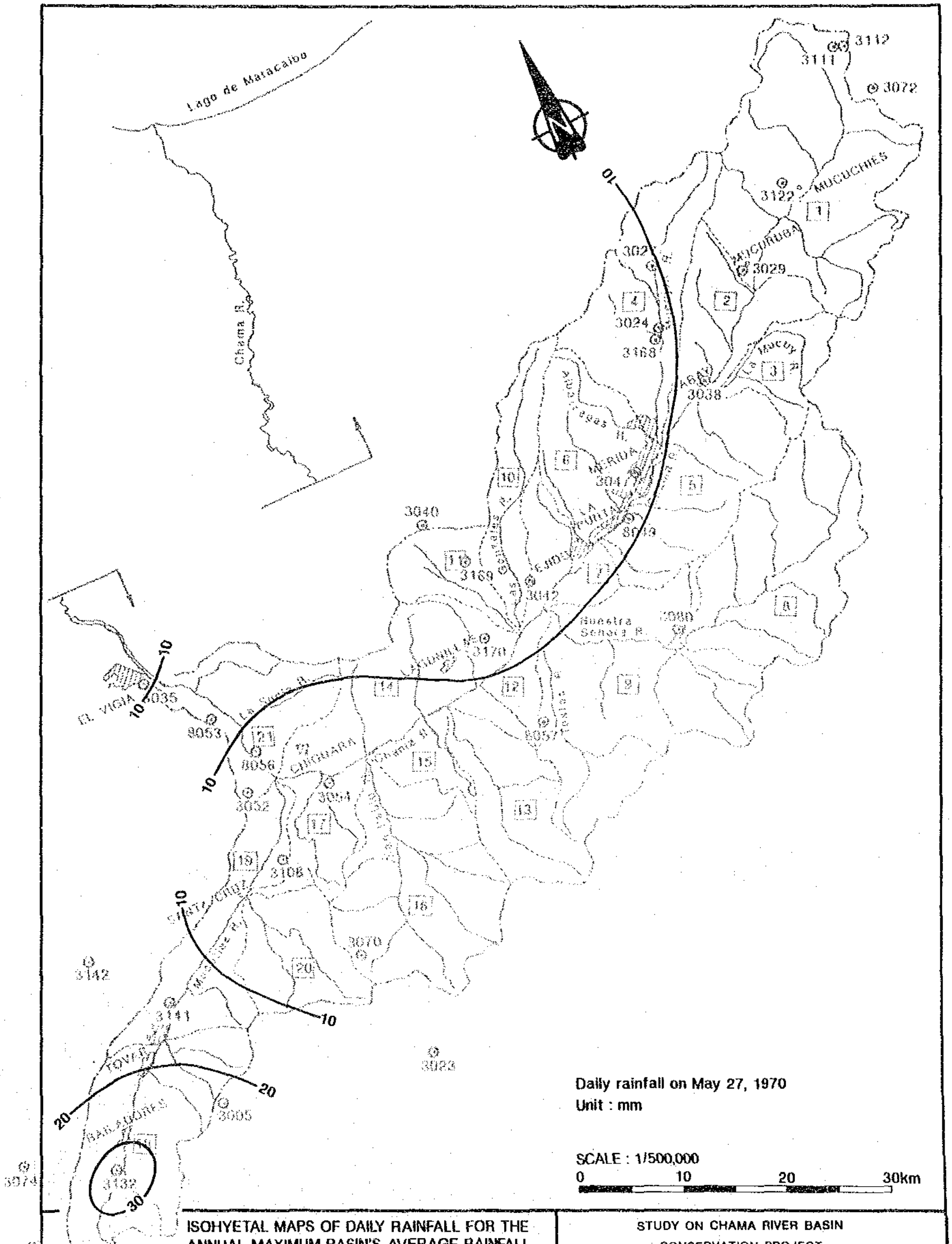


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (3/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

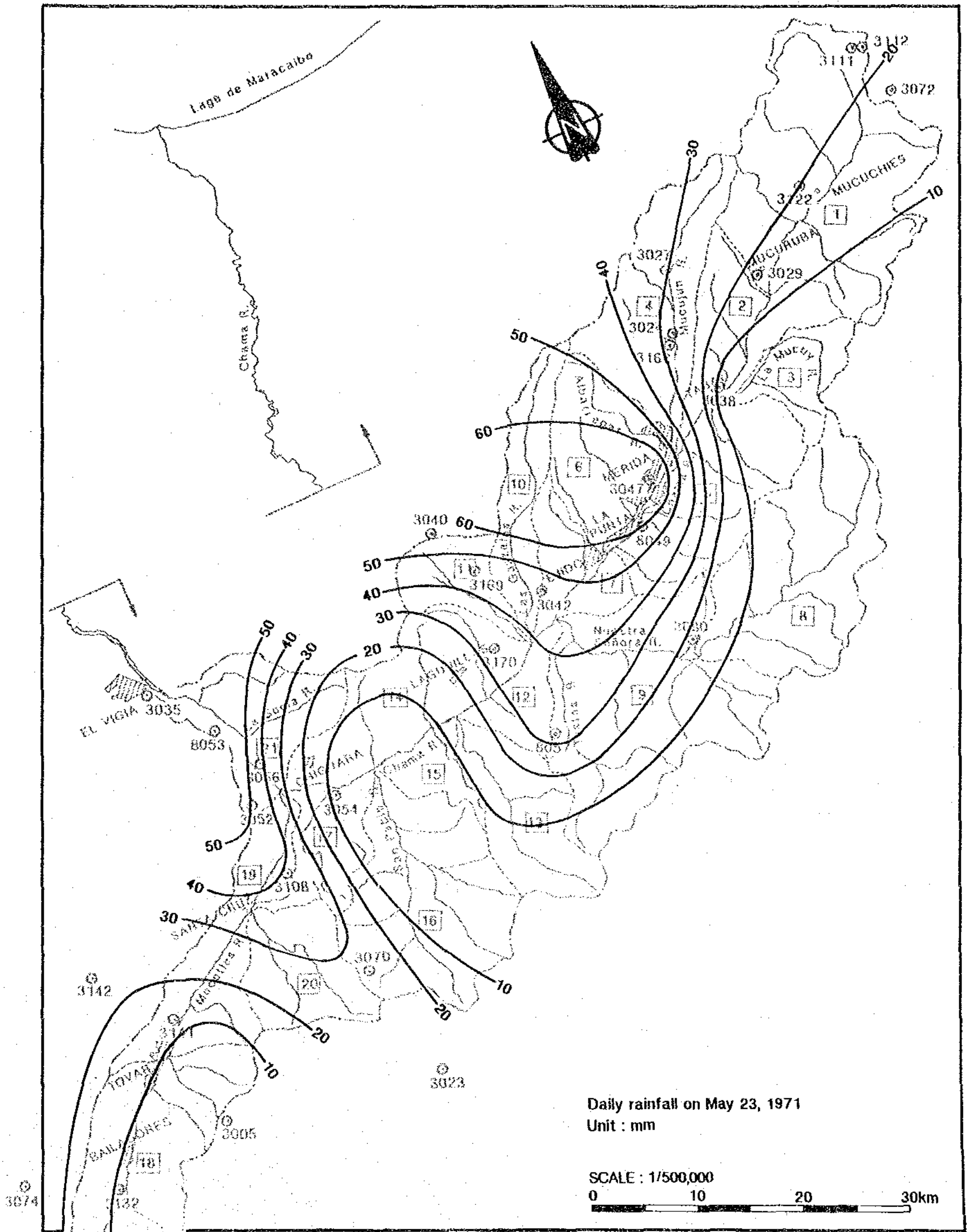


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (4/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

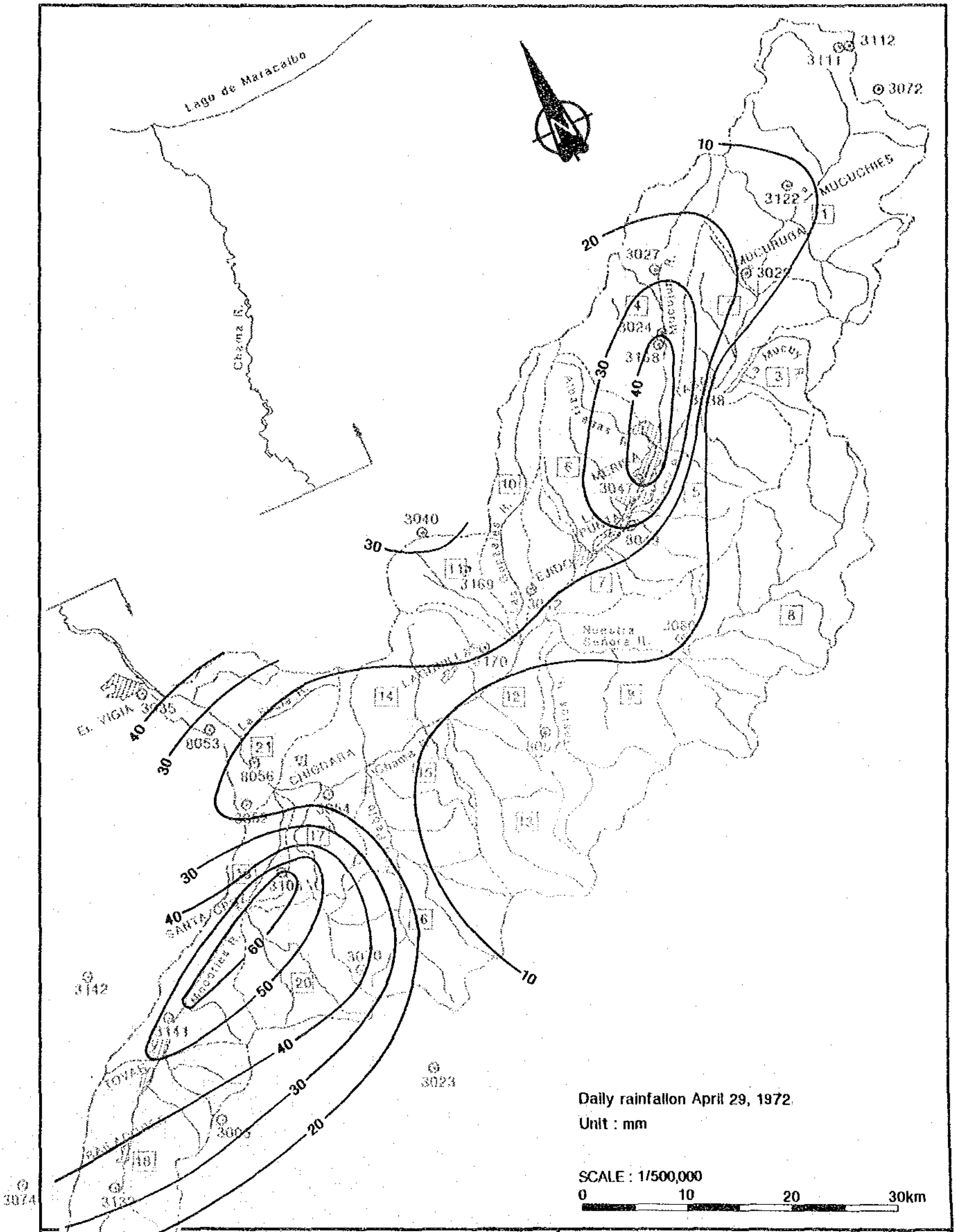


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (5/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

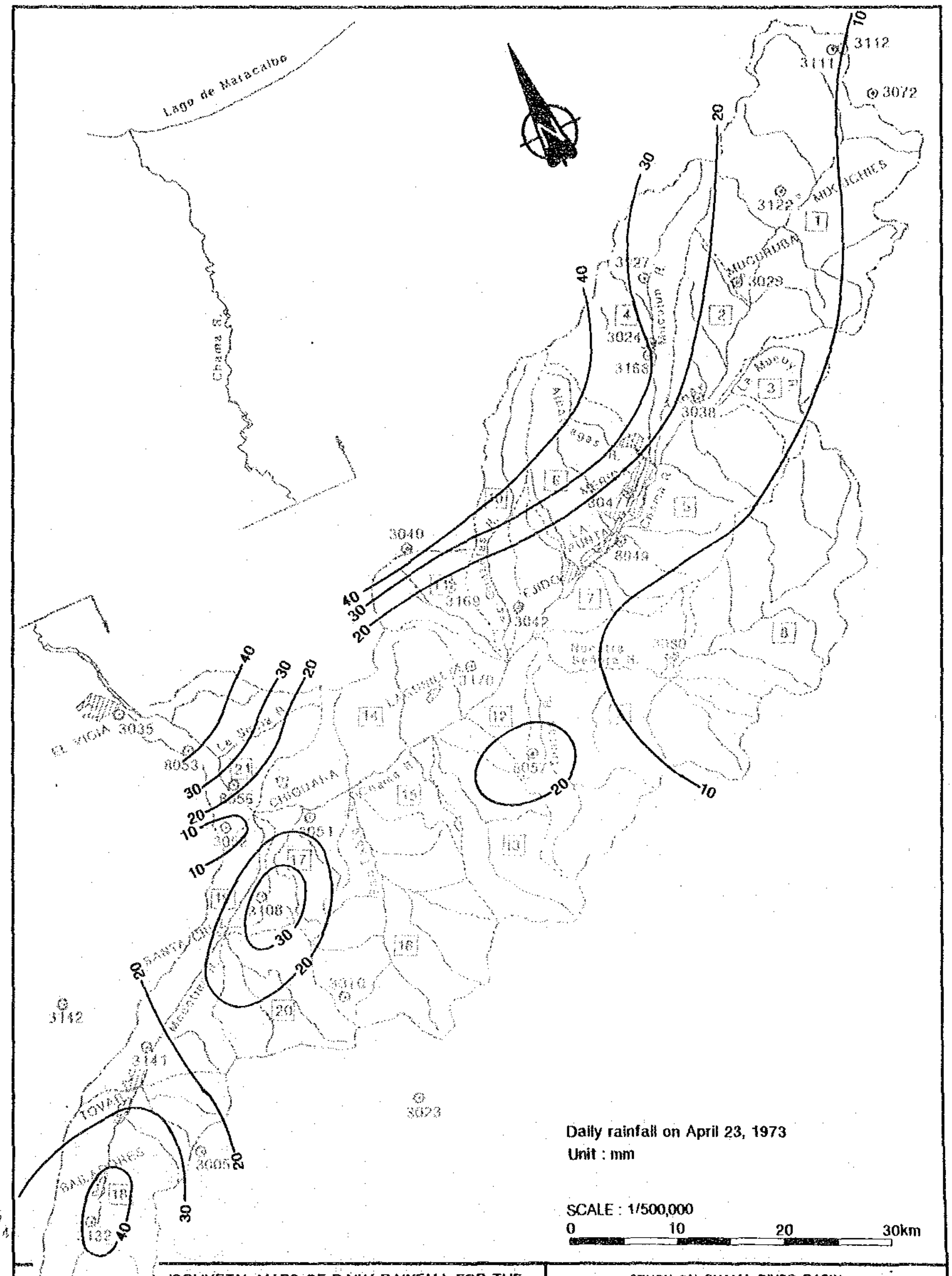


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5(6/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

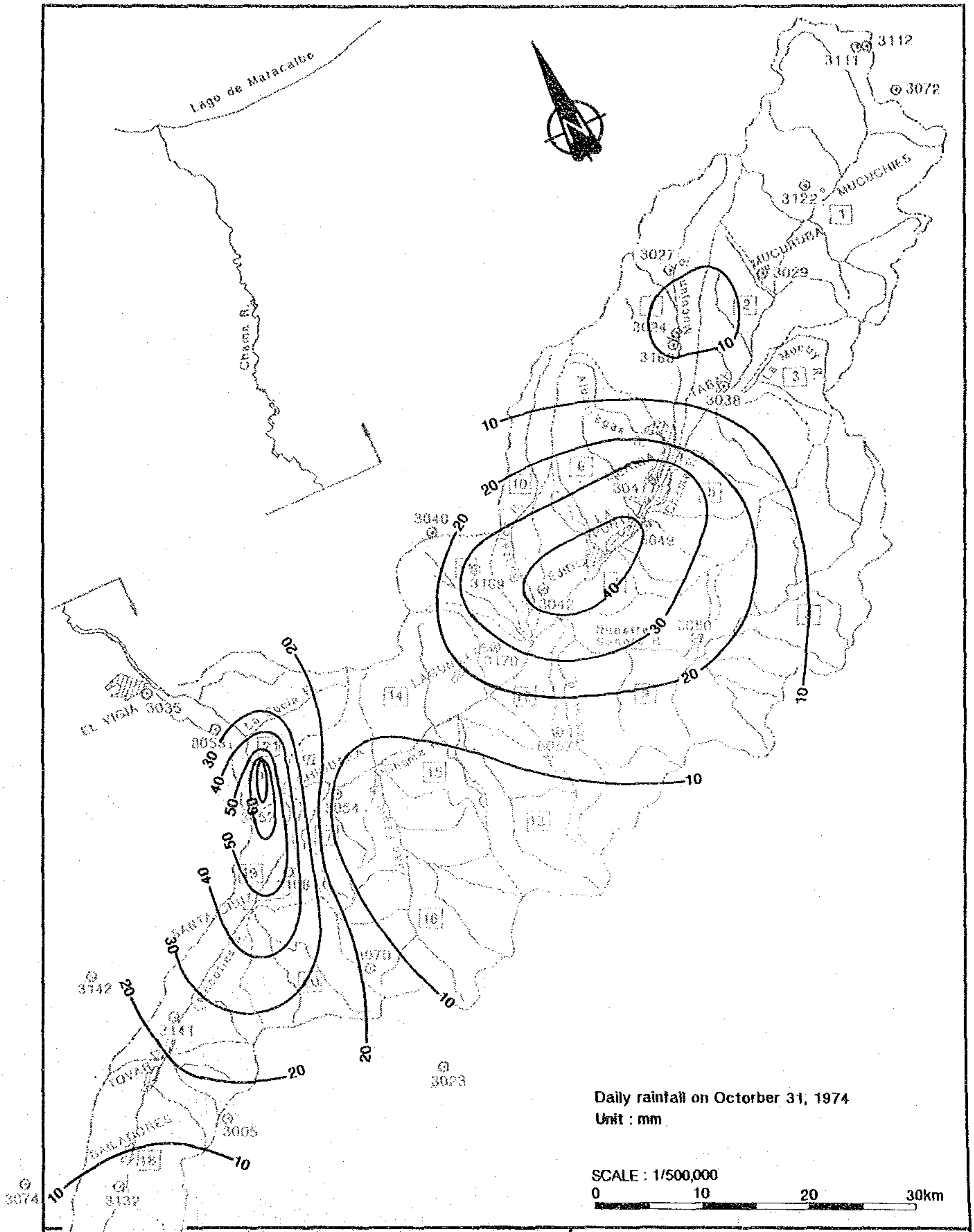


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (7/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

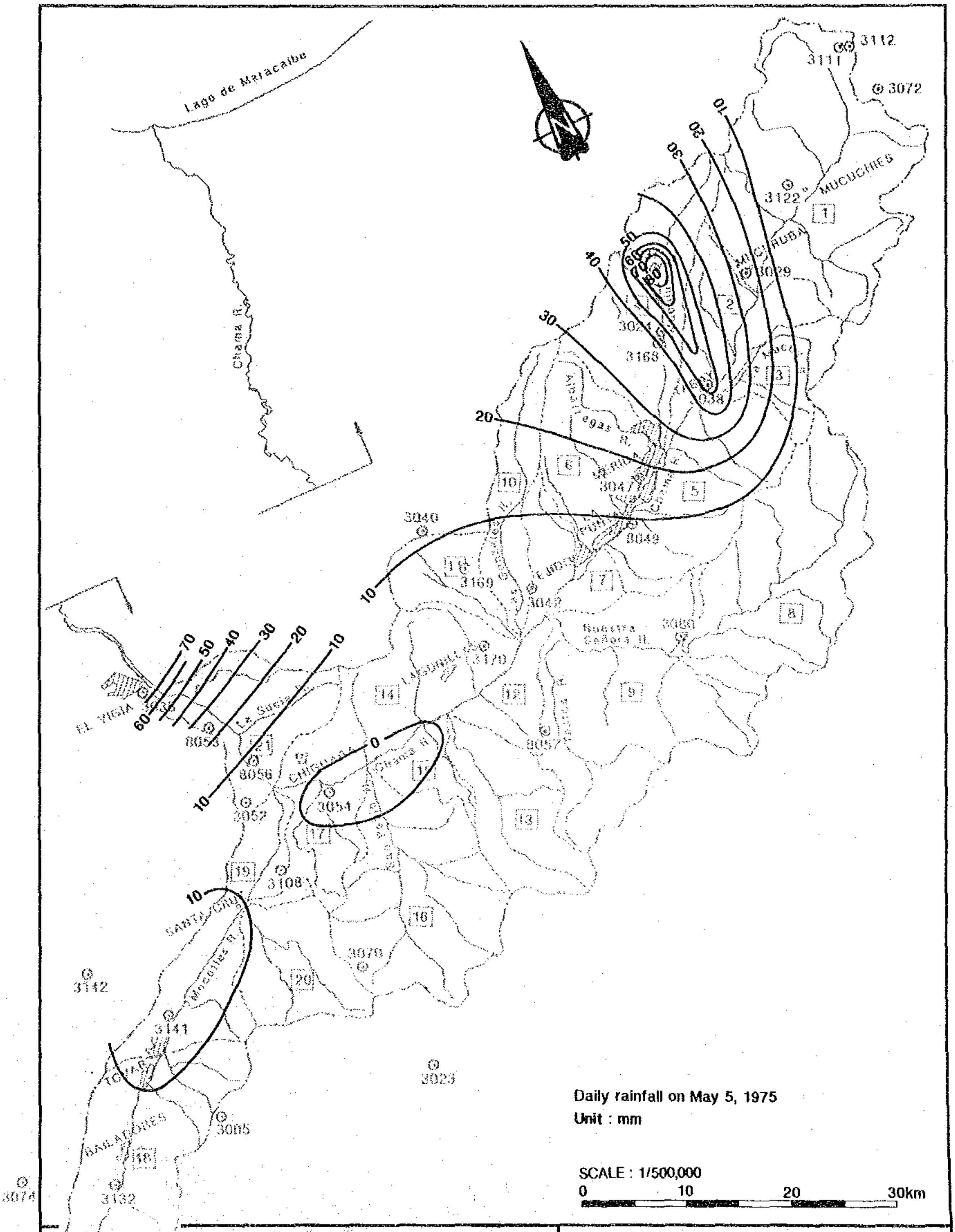


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (8/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

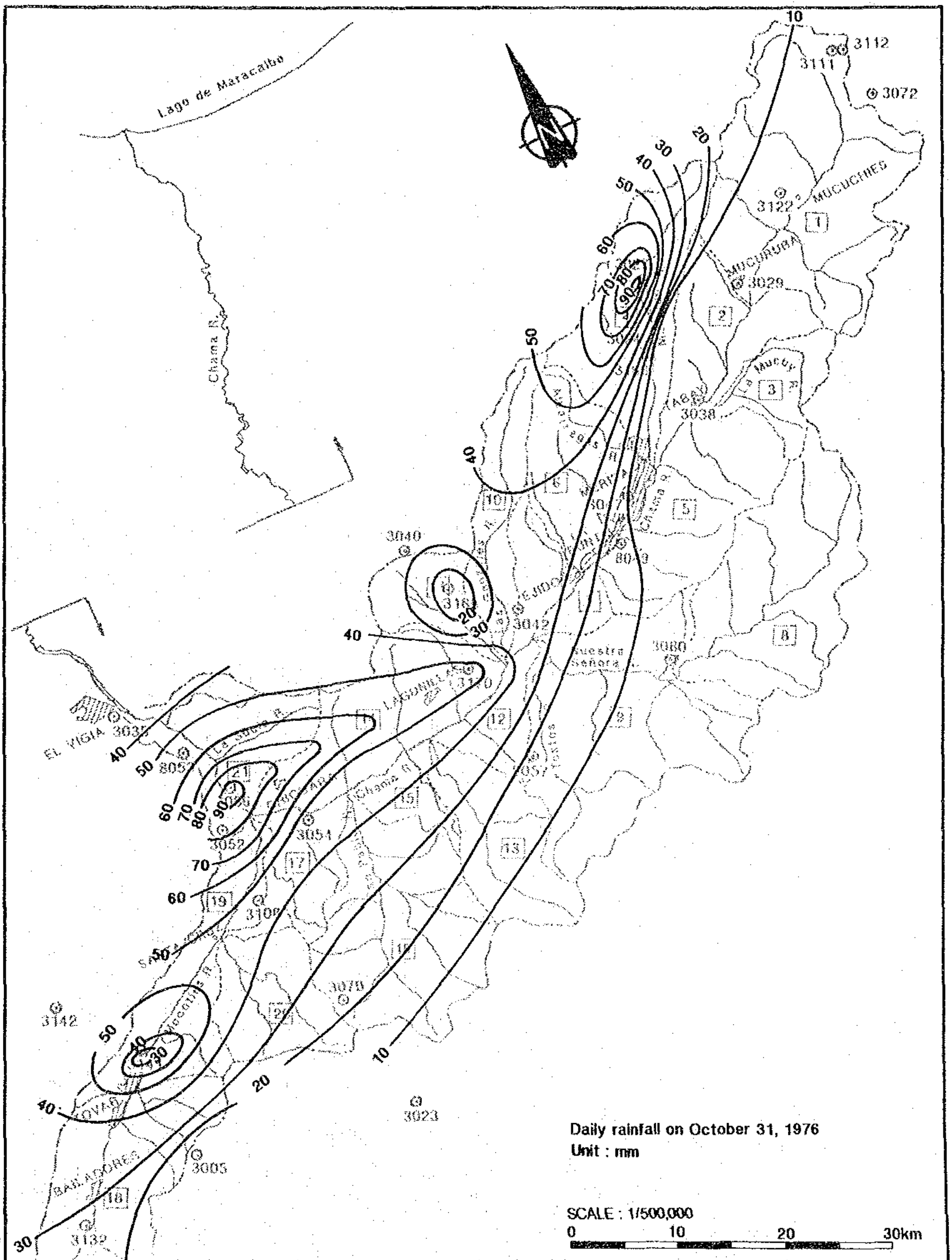


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (9/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

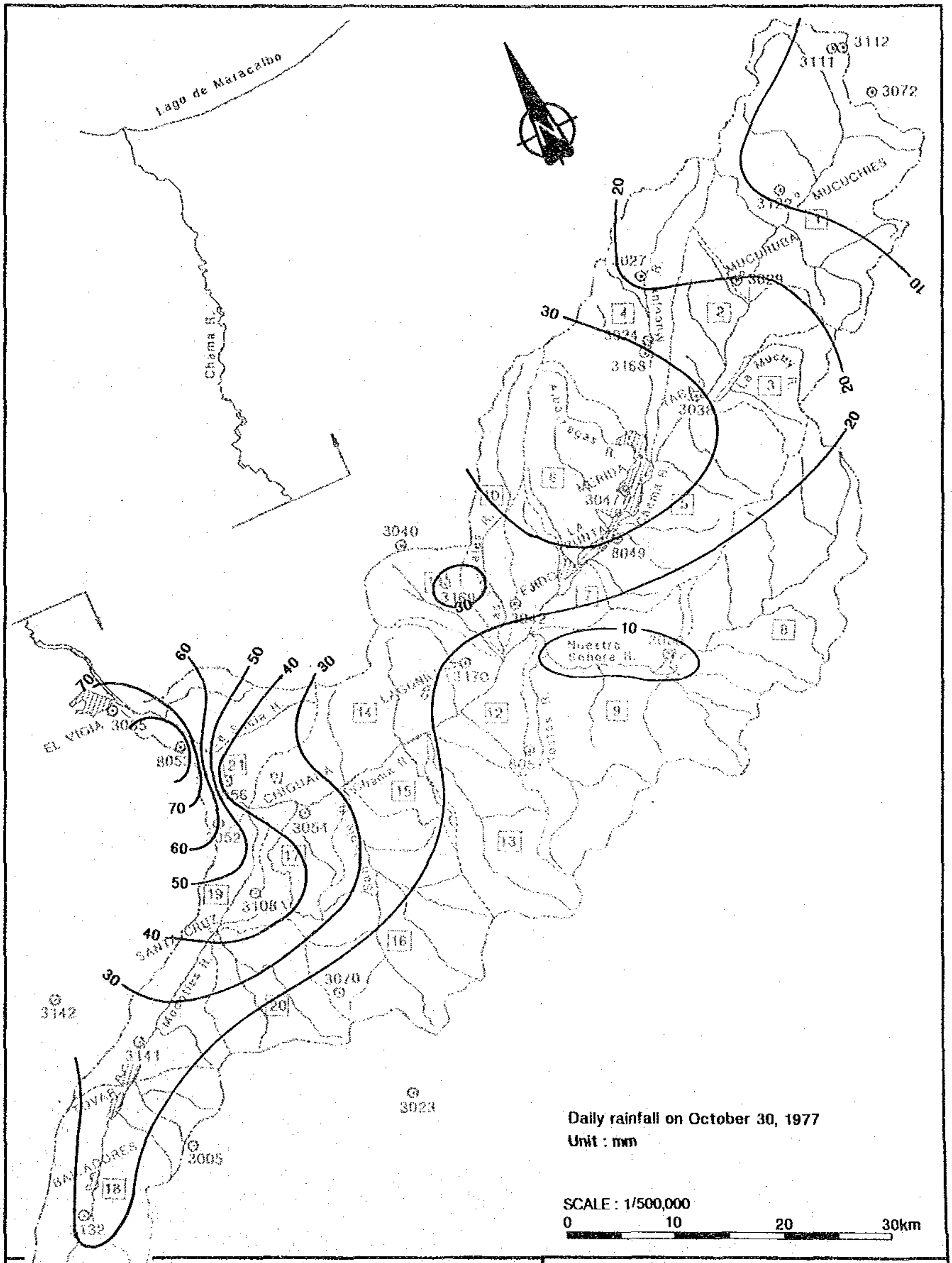


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (10/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

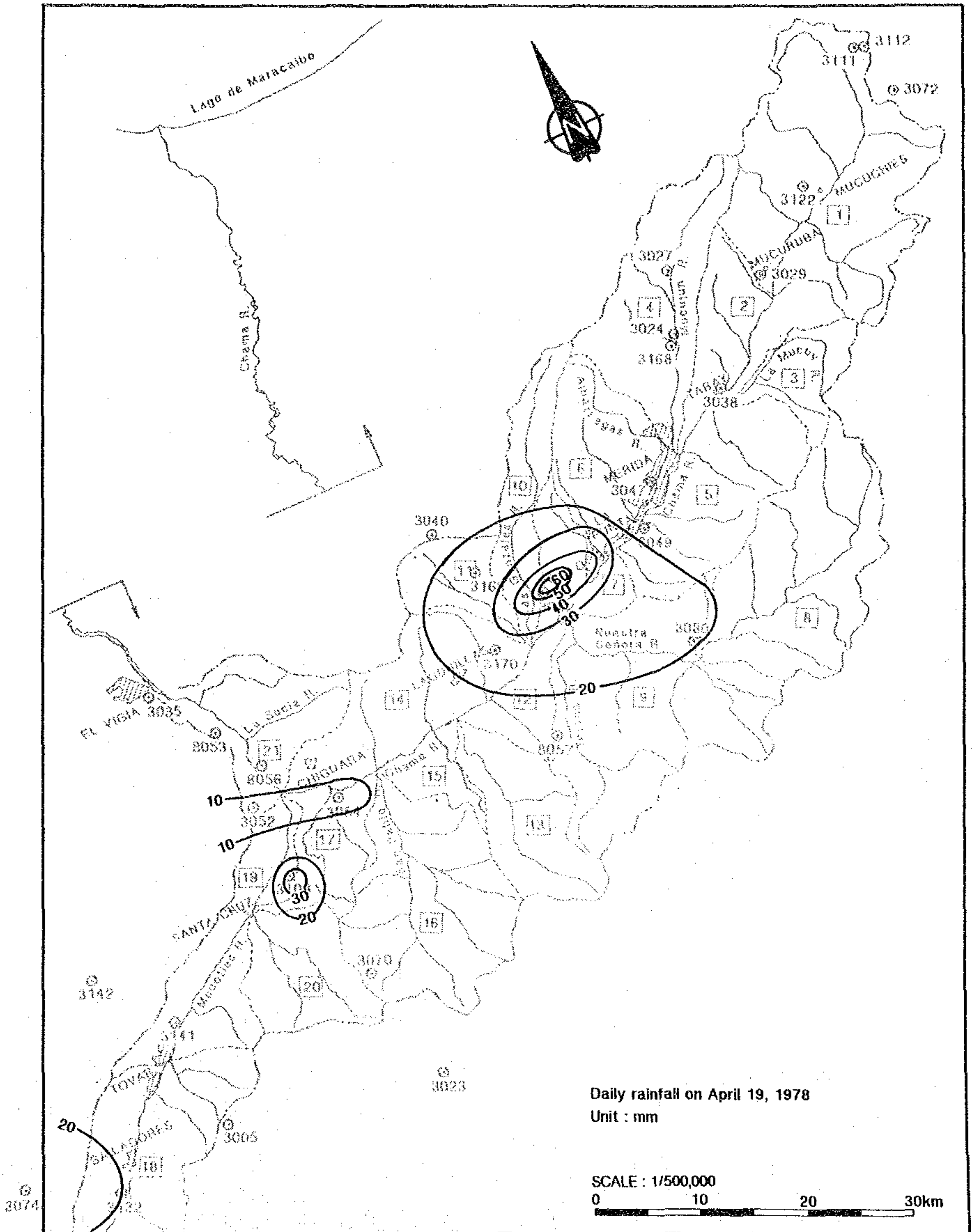


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (11/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

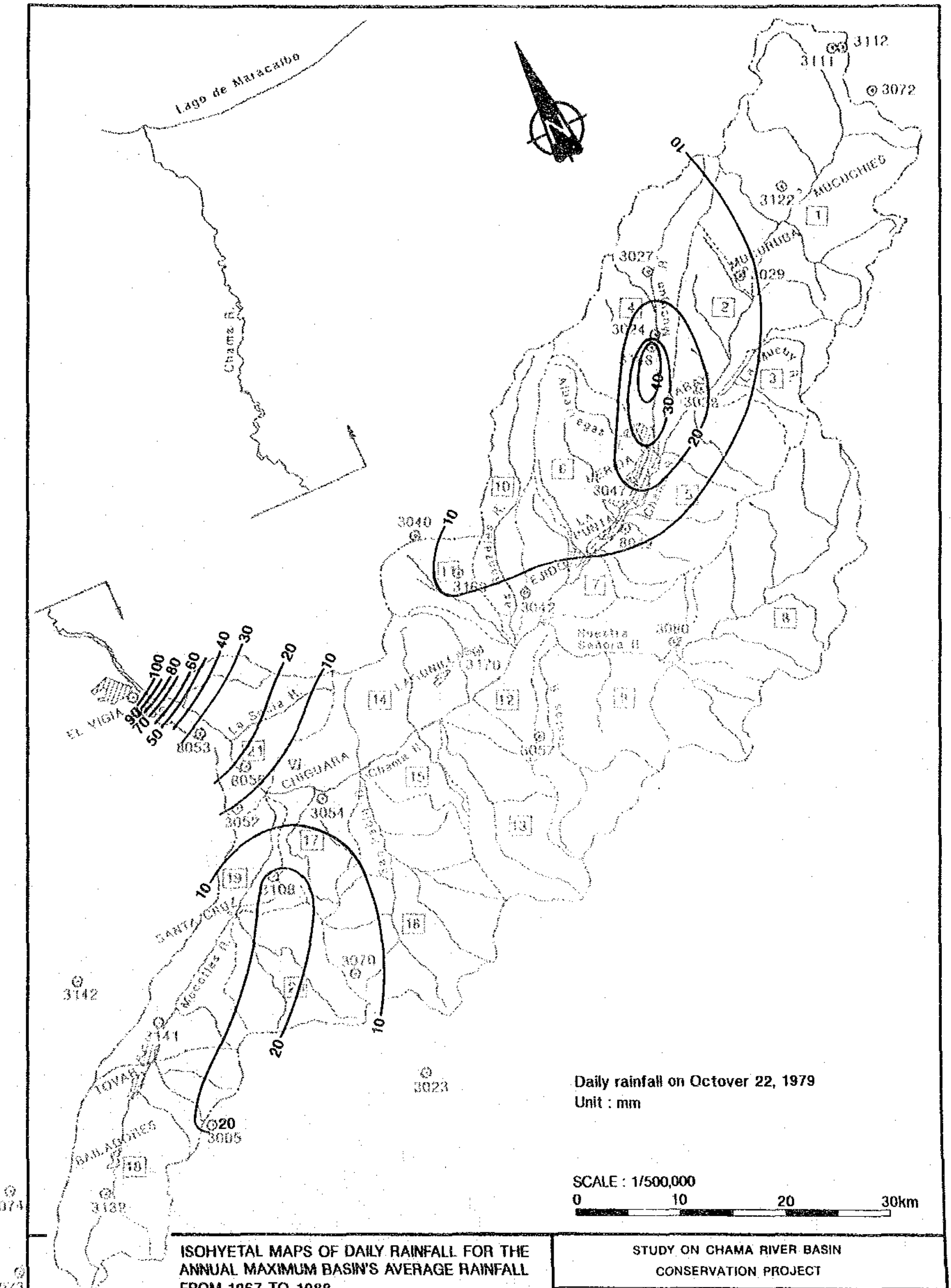


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (12/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

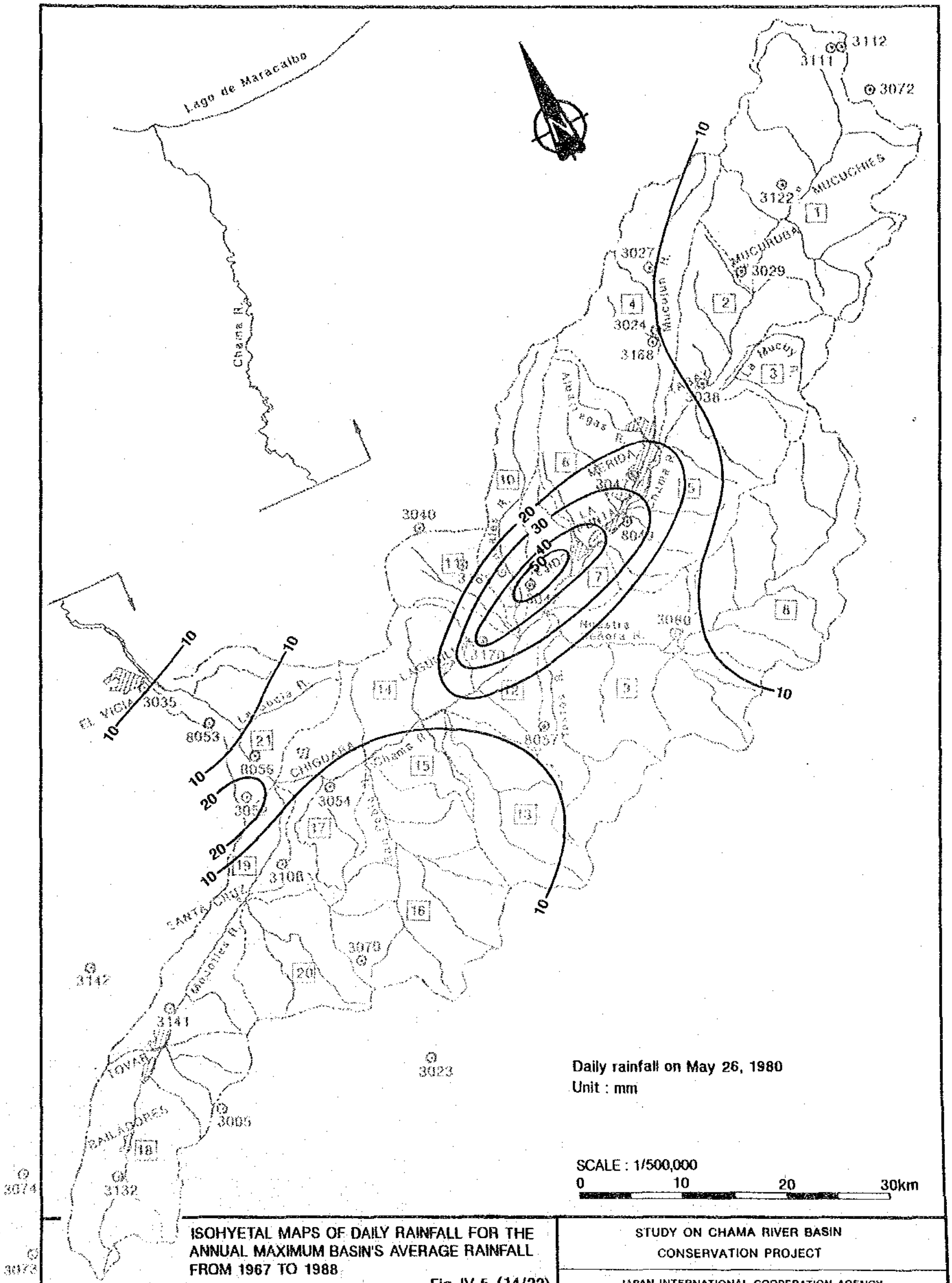


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (13/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

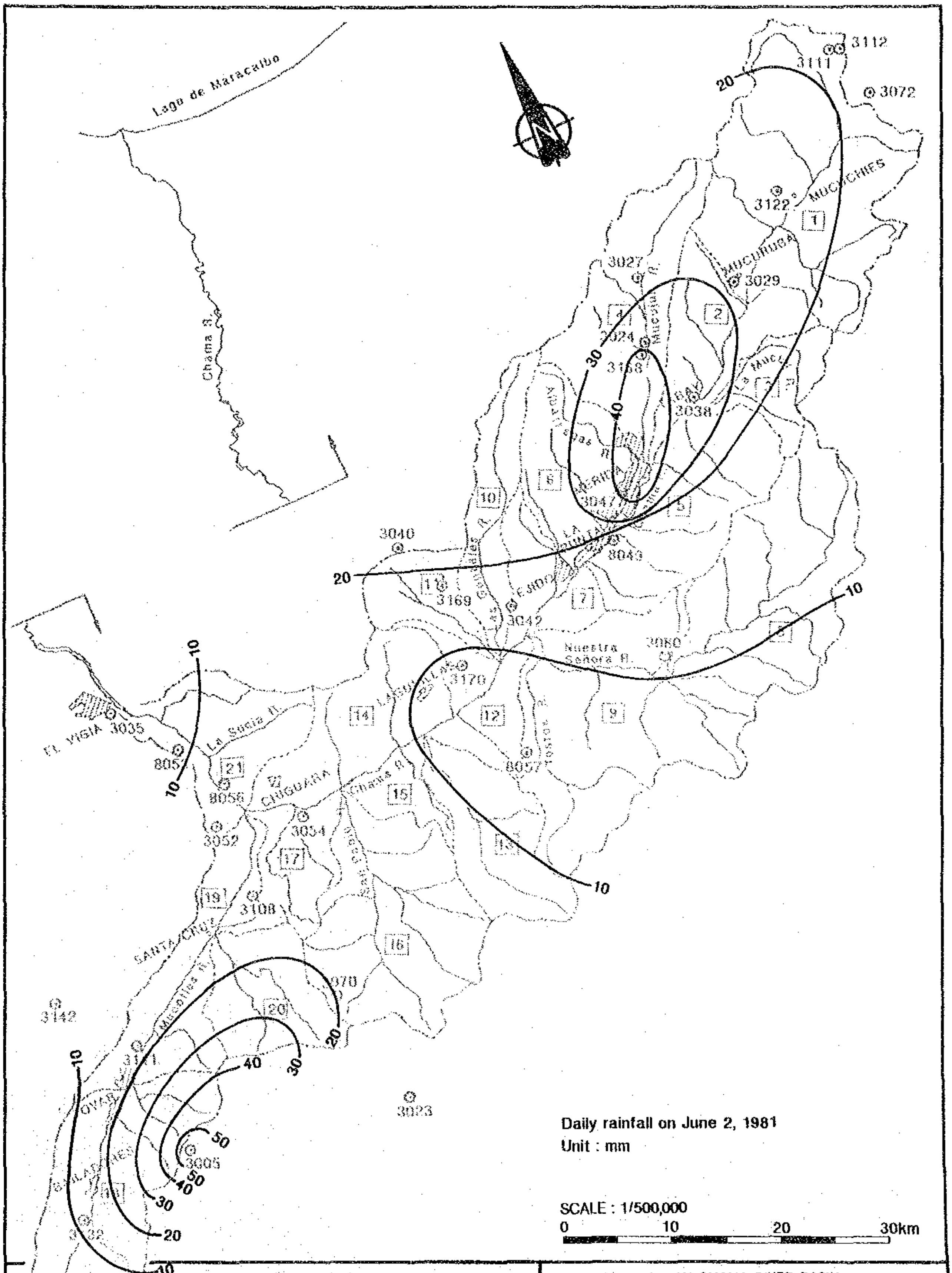


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (14/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

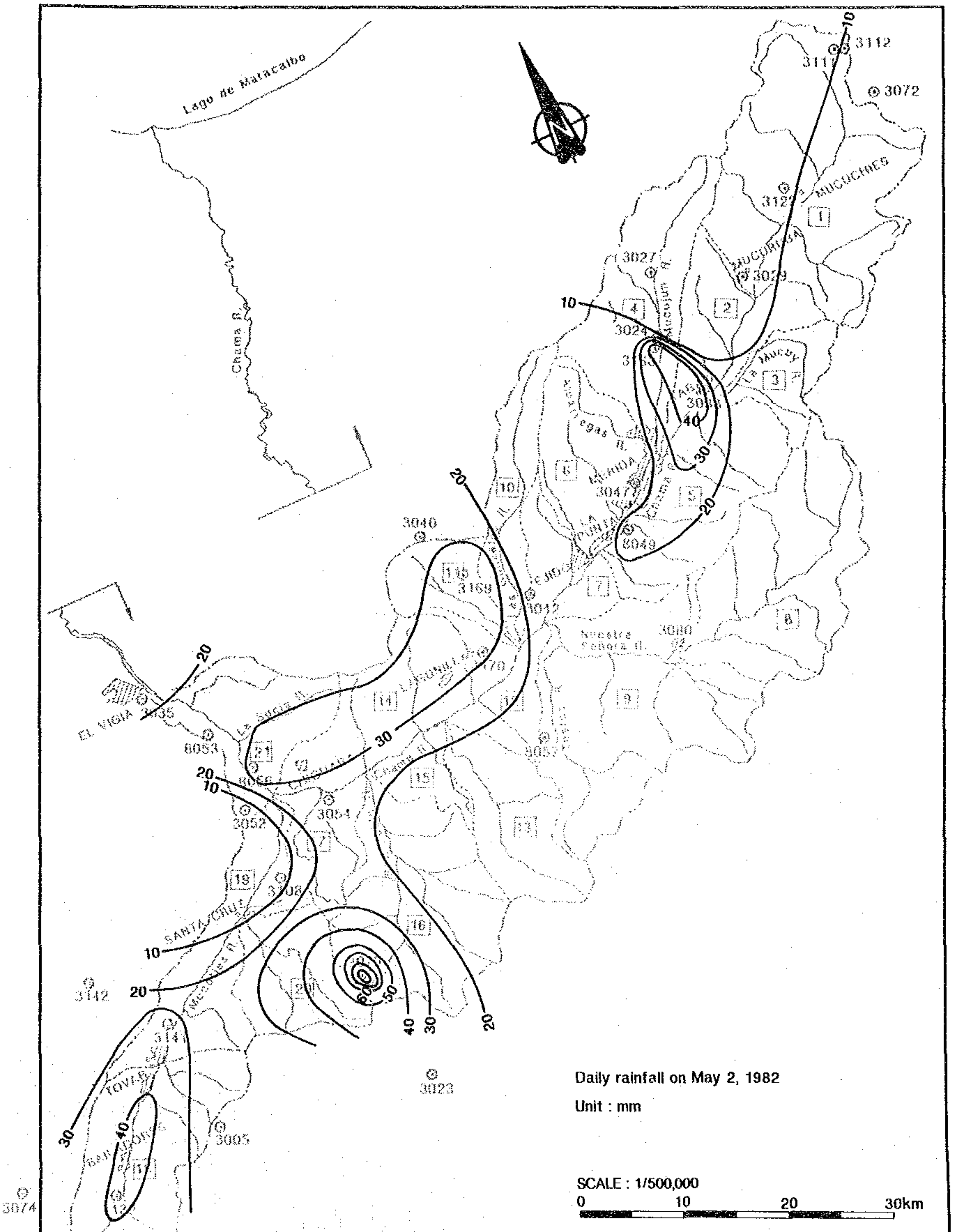


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (15/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

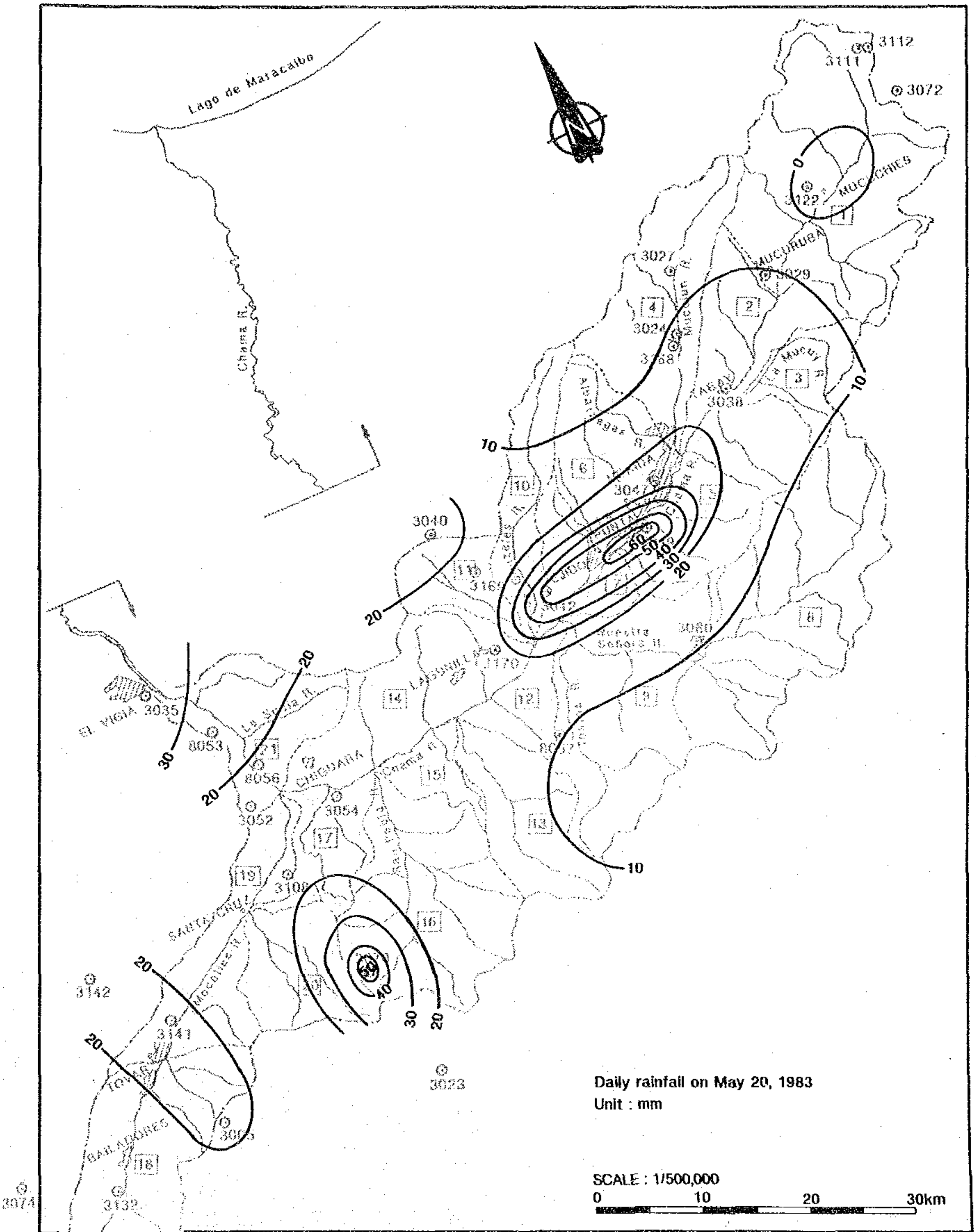


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (16/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

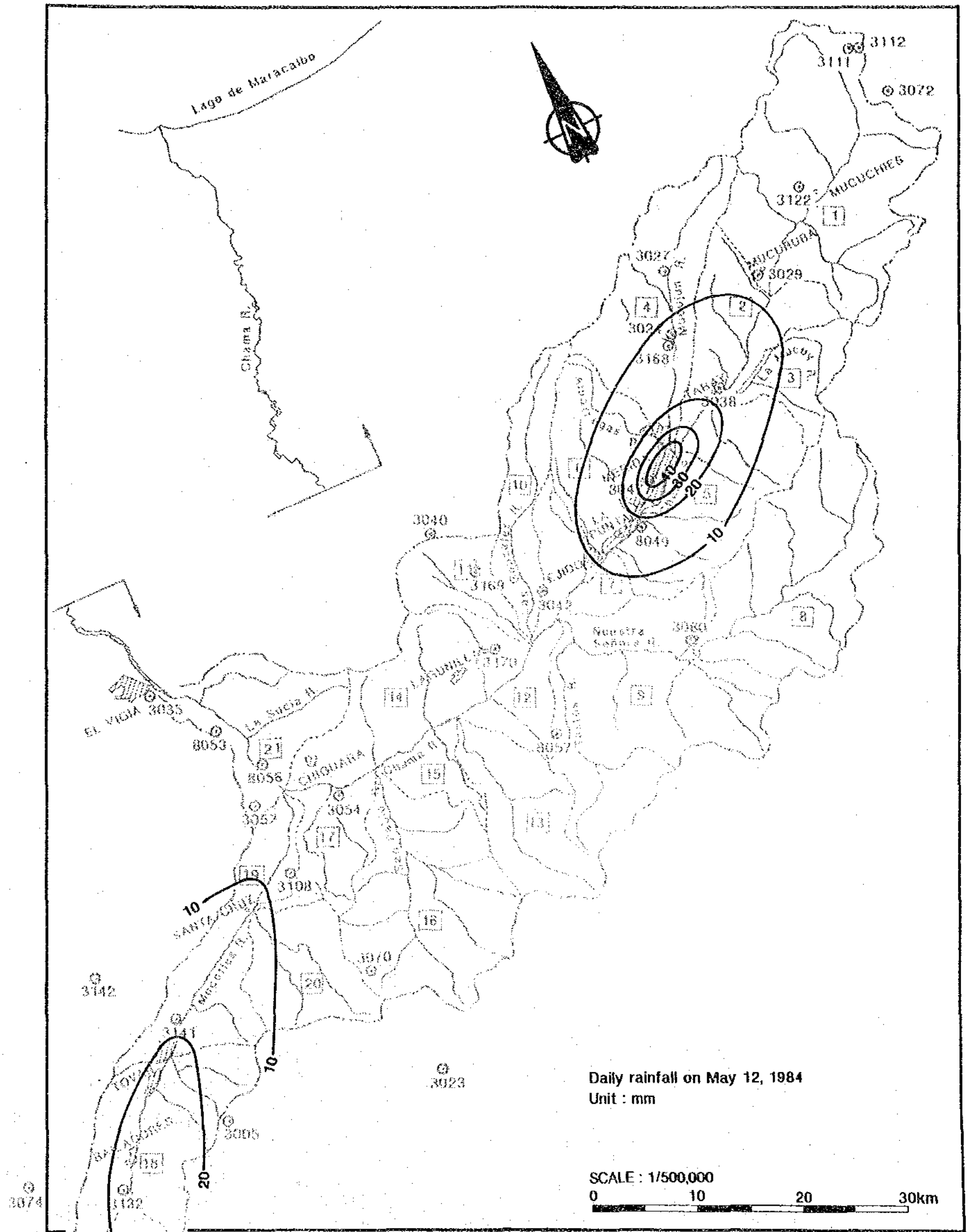


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (17/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

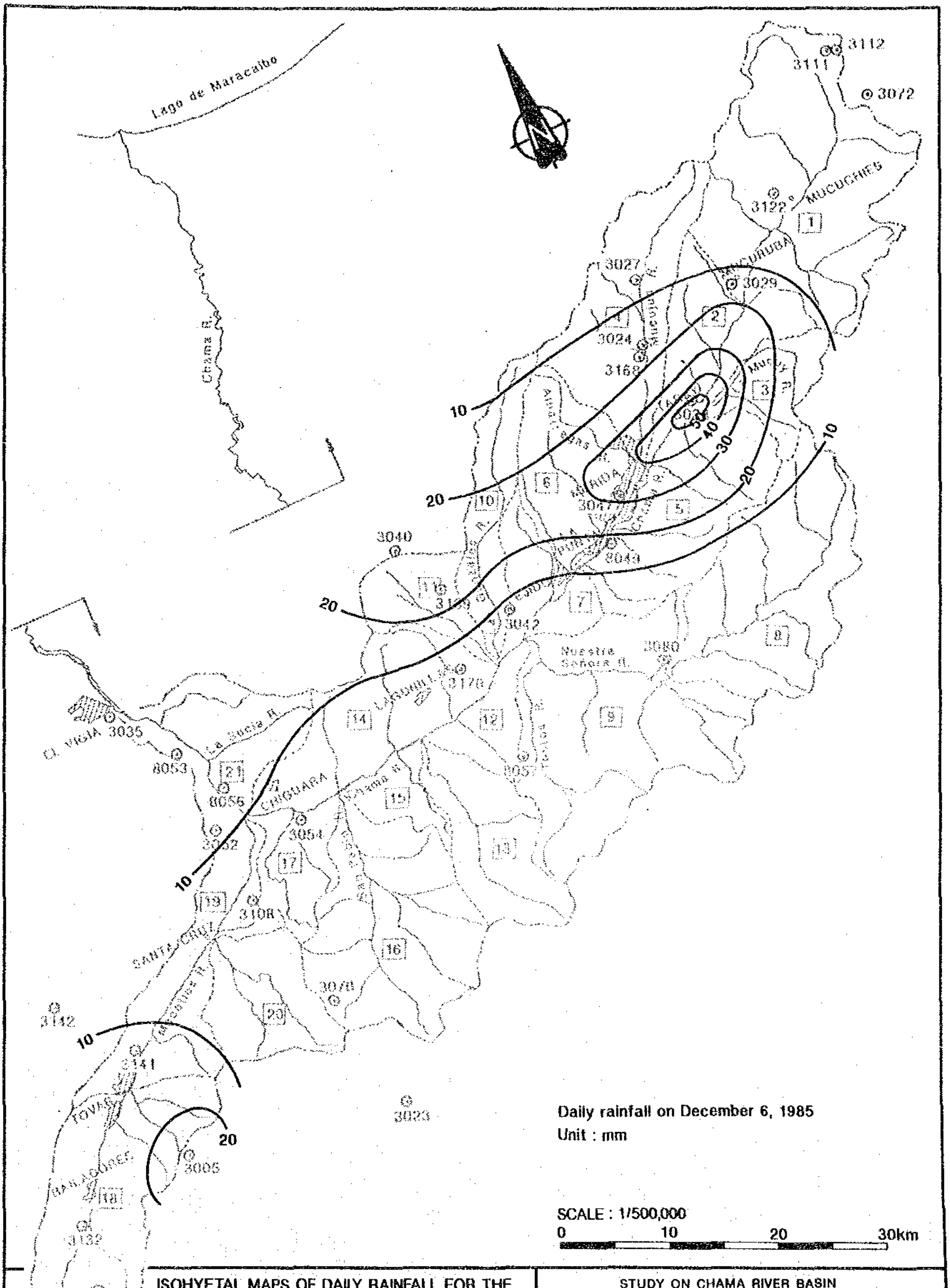


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (18/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

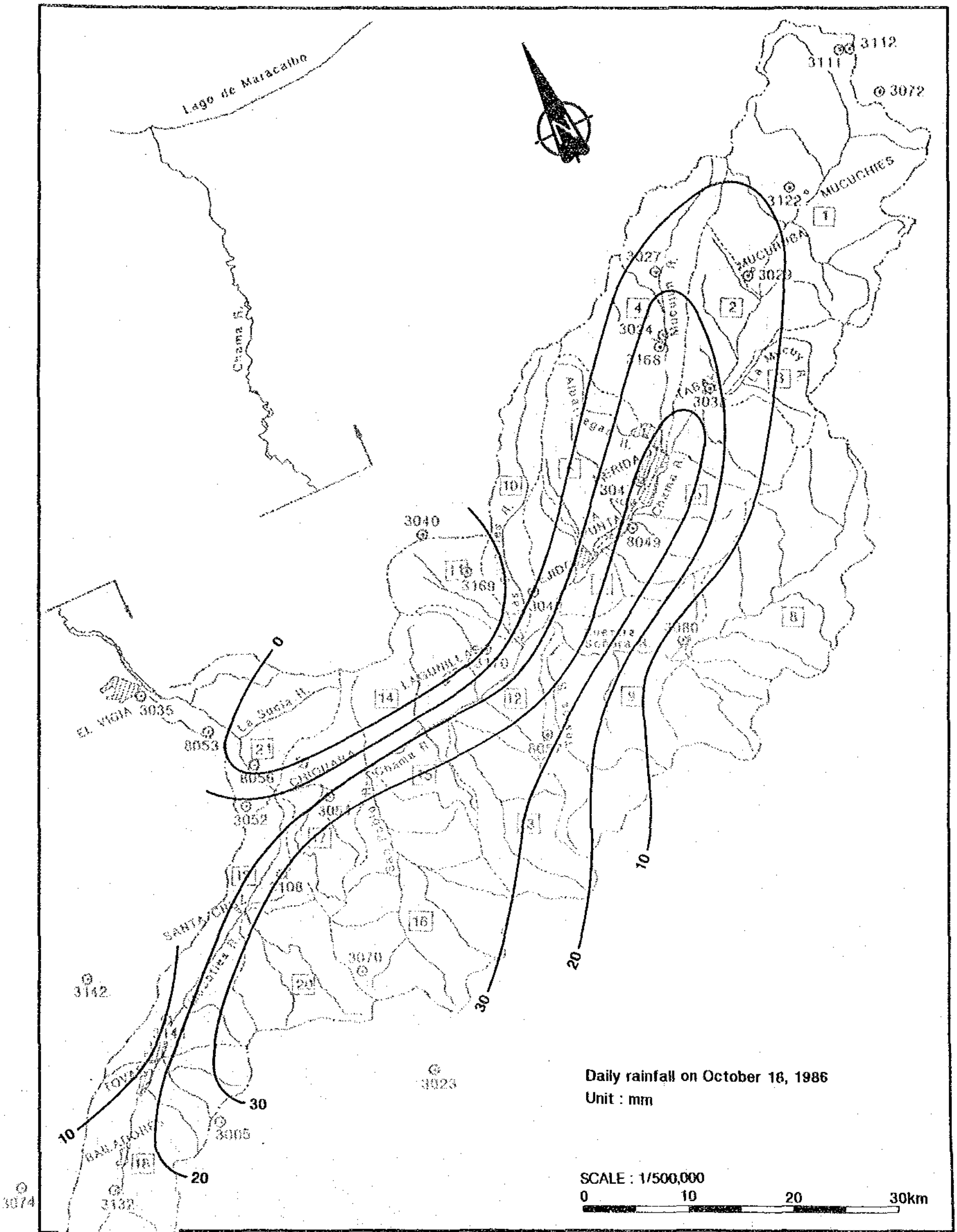


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (19/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

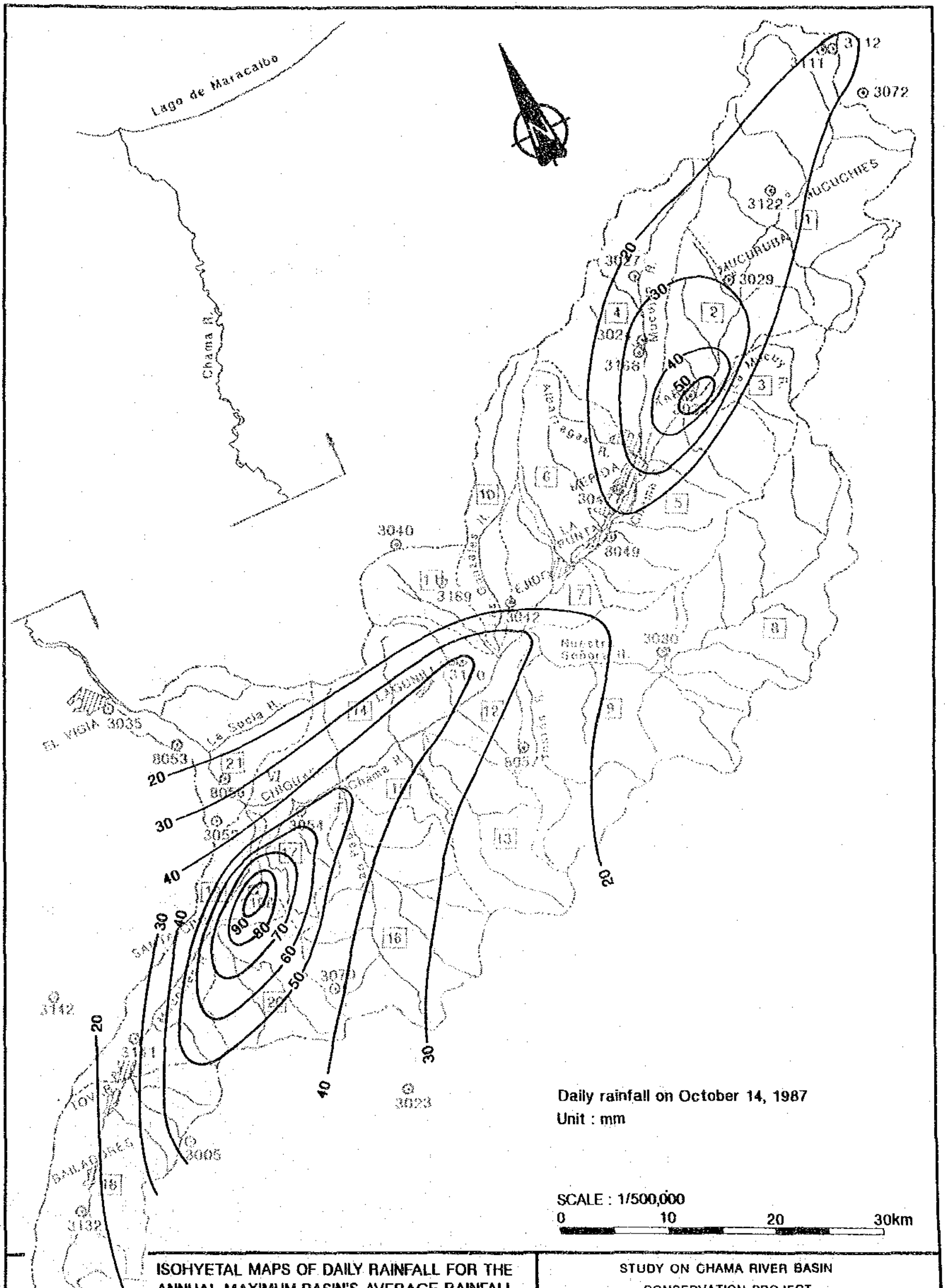


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (20/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

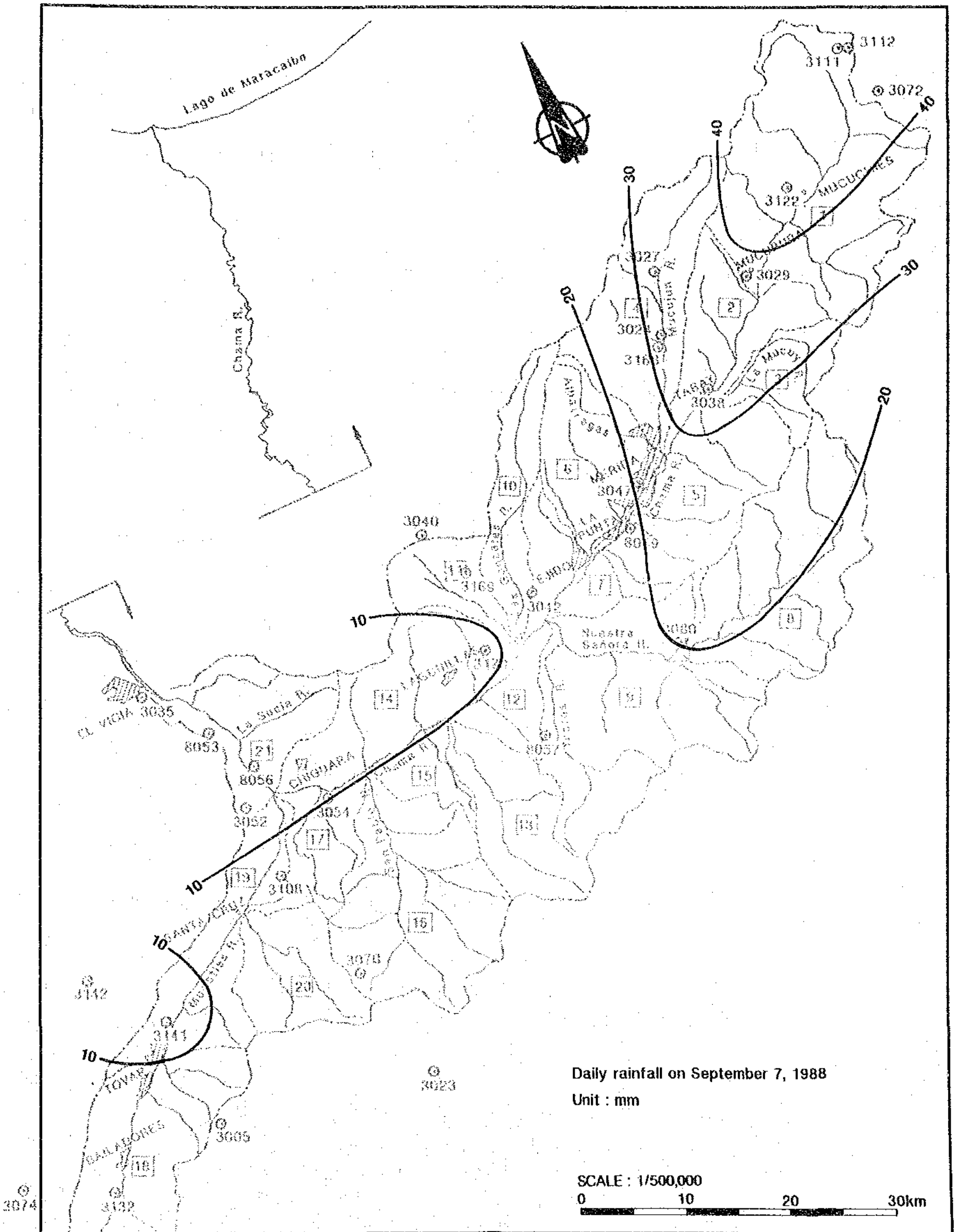


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (21/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

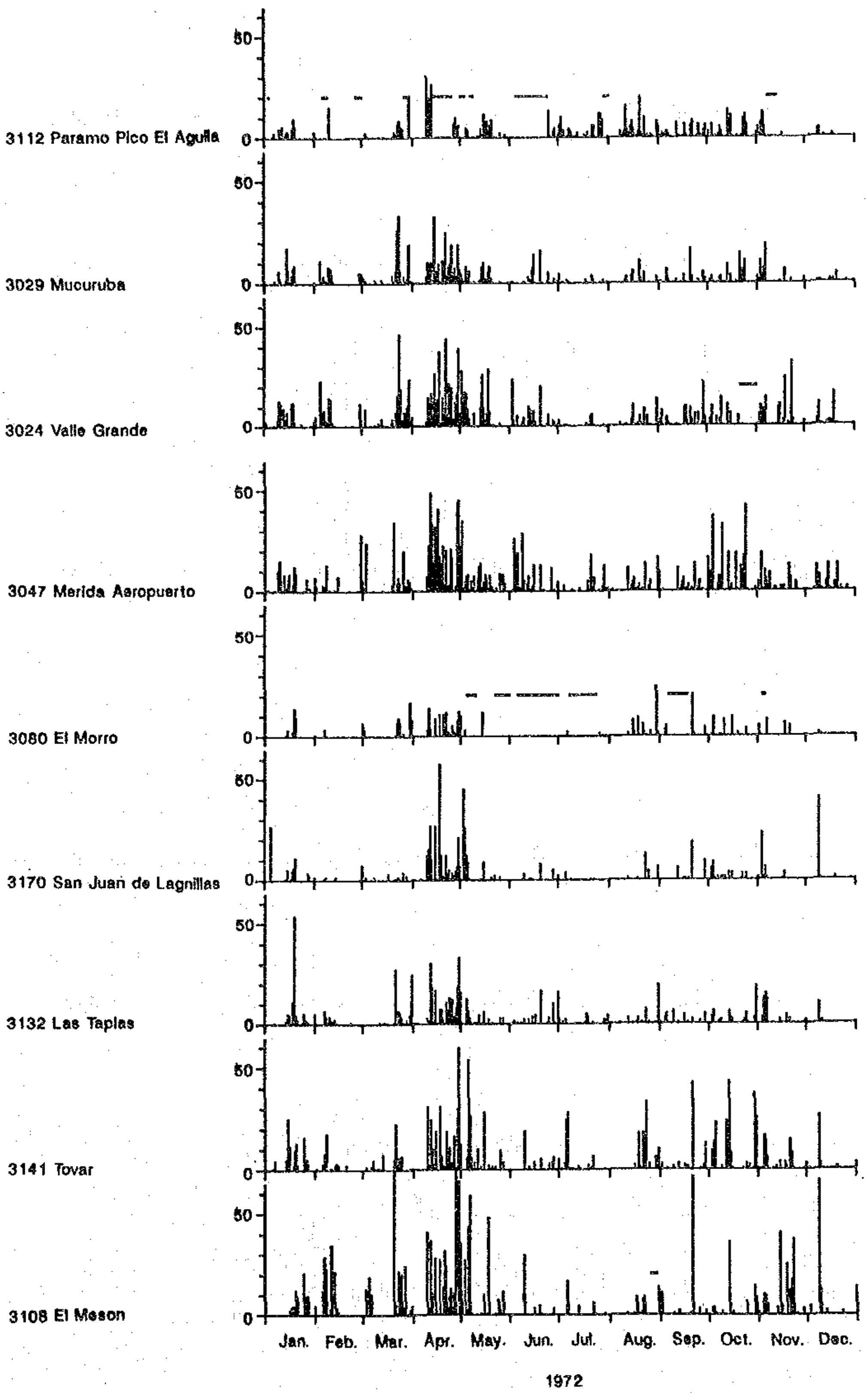


ISOHYETAL MAPS OF DAILY RAINFALL FOR THE ANNUAL MAXIMUM BASIN'S AVERAGE RAINFALL FROM 1967 TO 1988

Fig. IV-5 (22/22)

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

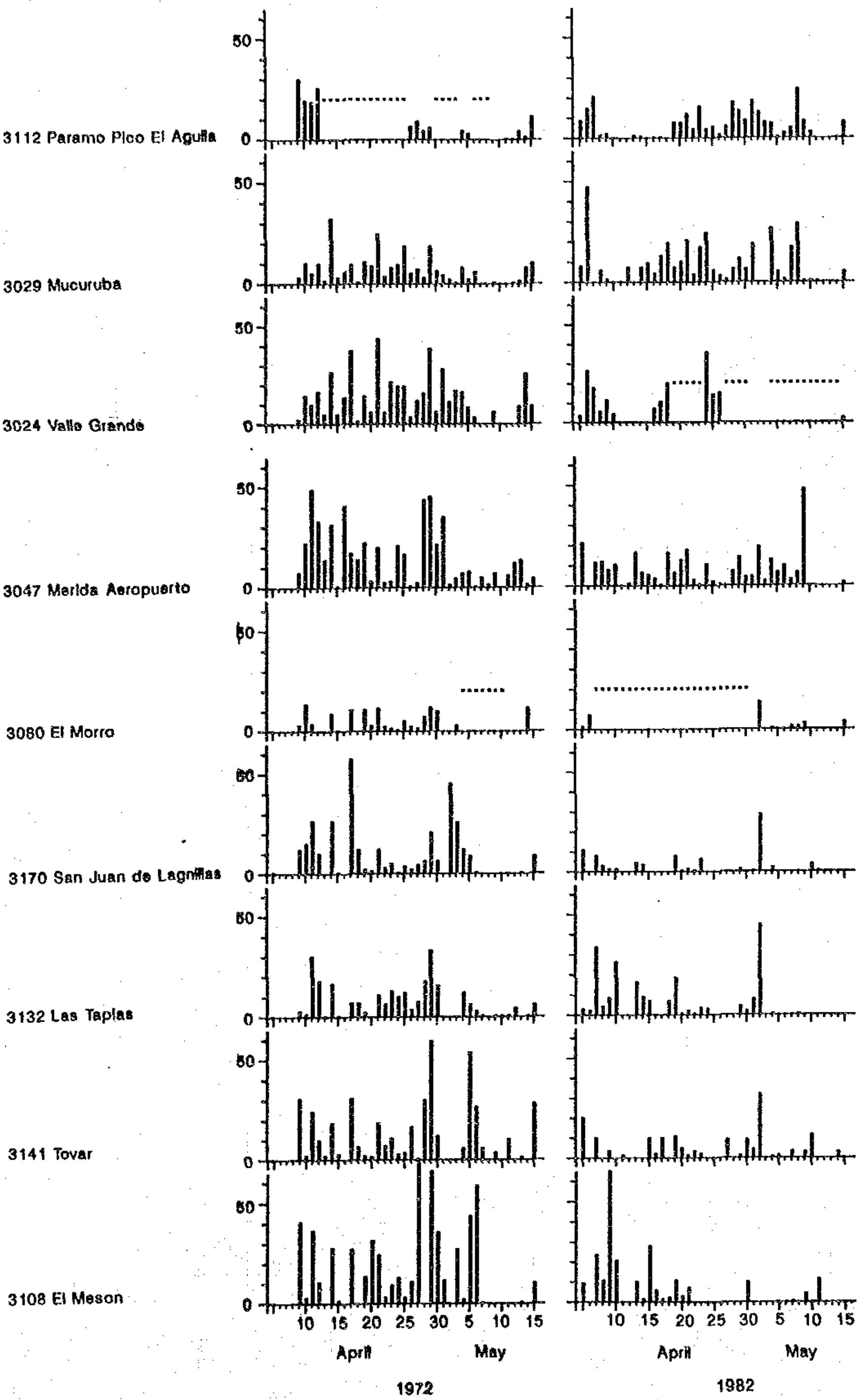


ANNUAL DAILY RAINFALL DISTRIBUTIONS AT MAJOR STATIONS IN 1972

Fig. IV-6

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

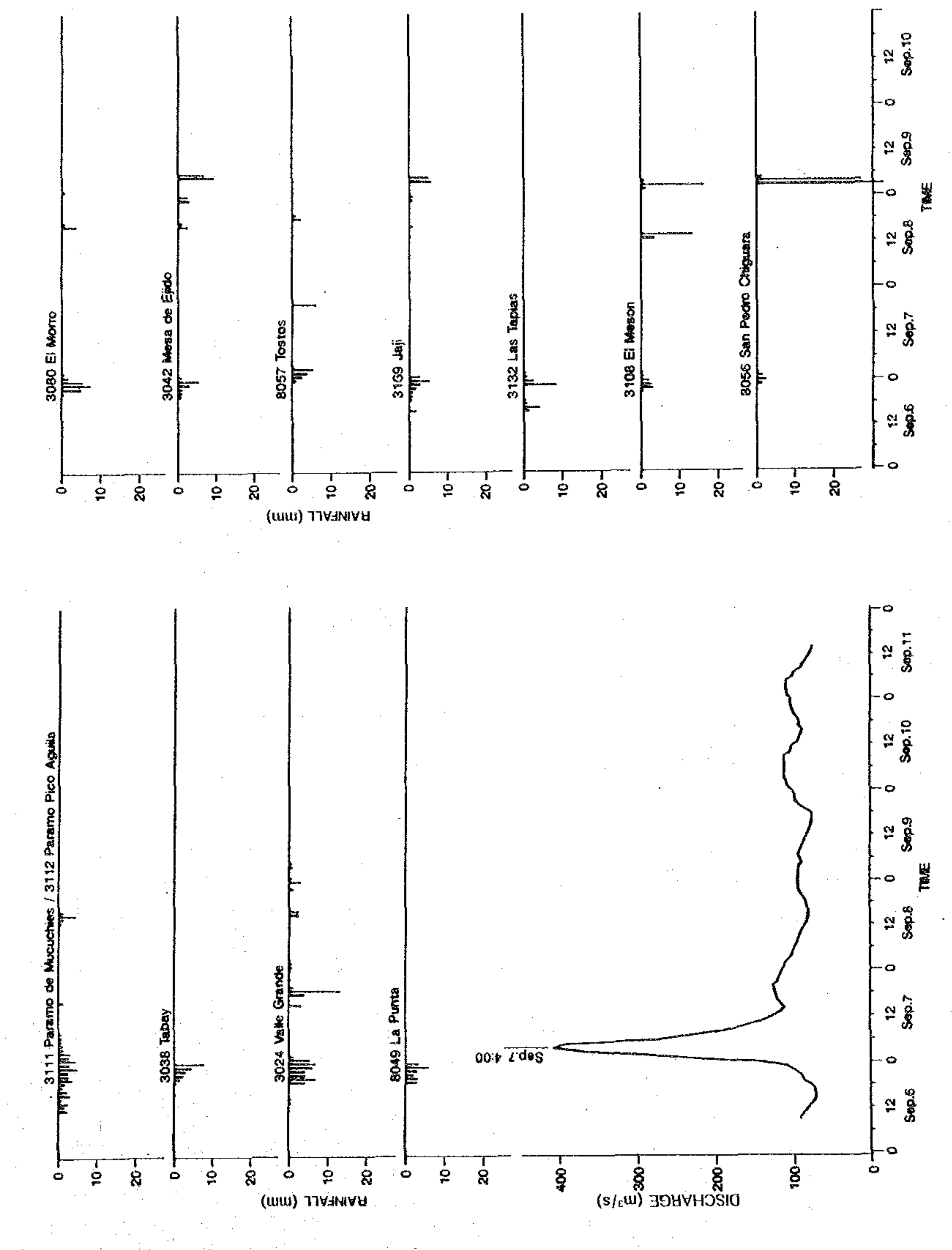


DAILY RAINFALL DISTRIBUTION DURING 1972/82 FLOODS

Fig. IV-7

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

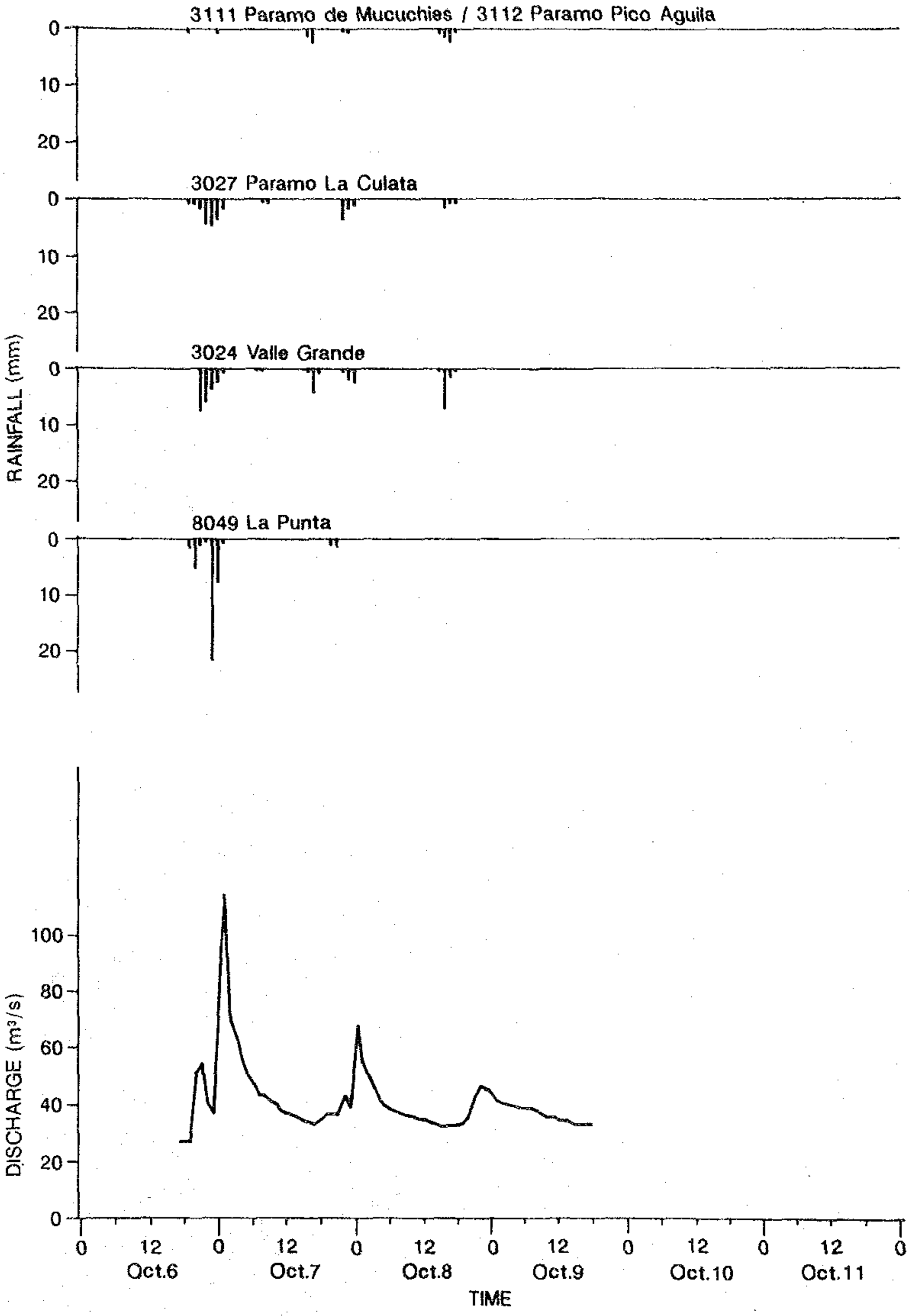


HOURLY RAINFALL DISTRIBUTION AND HYDROGRAPH OF CHAMA-EJIDO DURING SEPTEMBER 1988 FLOODS

Fig. IV-8

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

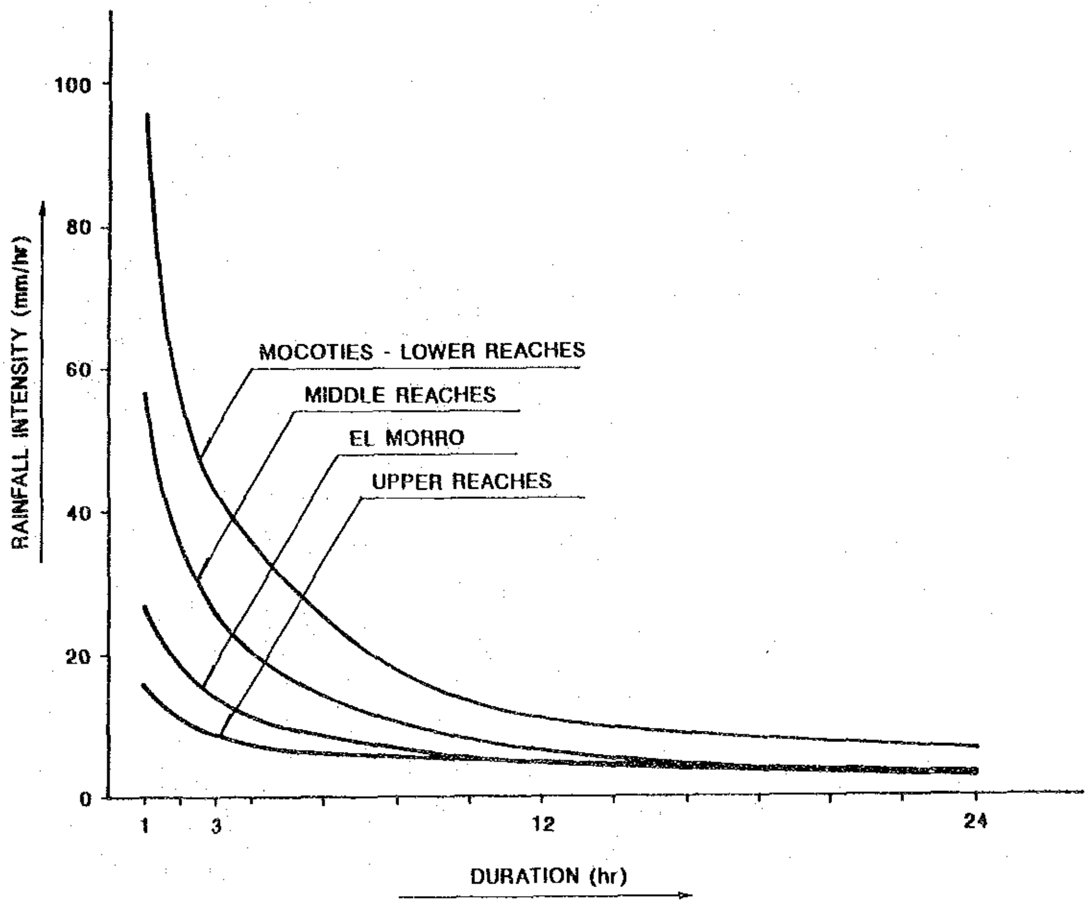


HOURLY RAINFALL DISTRIBUTION AND HYDROGRAPH OF CHAMA-EJIDO DURING OCTOBER 1988 FLOODS

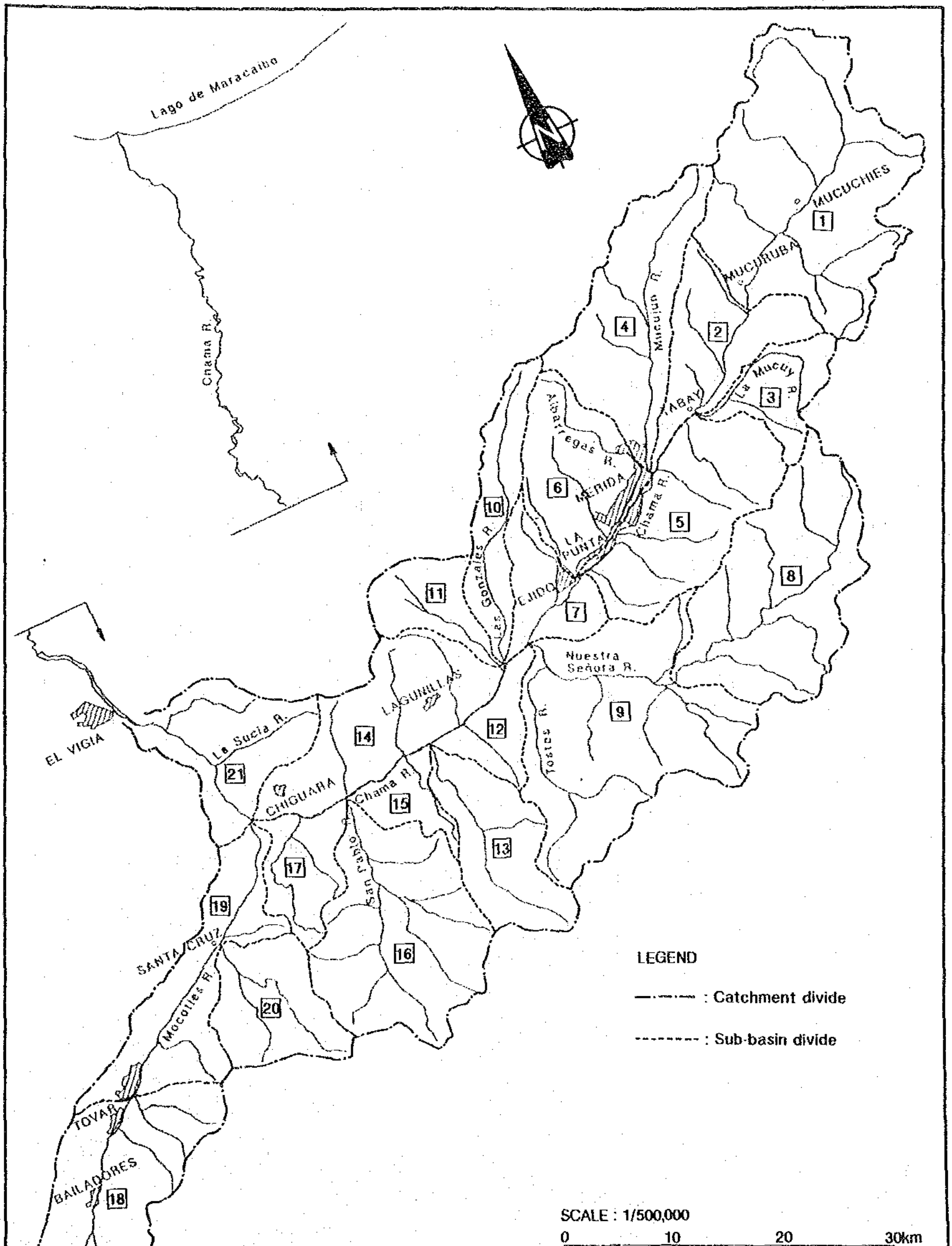
Fig. IV-9

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



RAINFALL INTENSITY-DURATION CURVE (100-YEAR RETURN PERIOD)	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-10	JAPAN INTERNATIONAL COOPERATION AGENCY

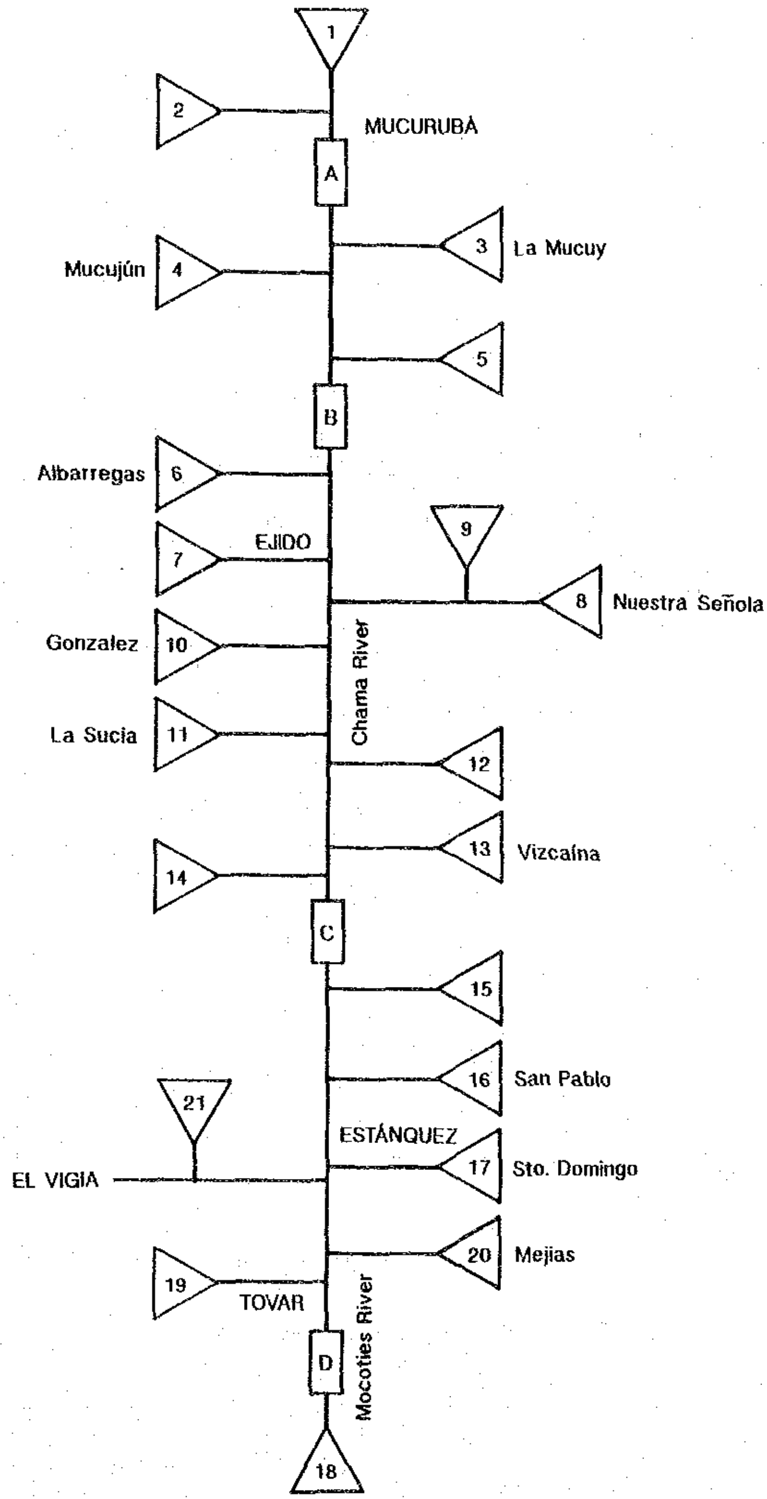


DIVISION OF SUB-BASIN

Fig. IV-11

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

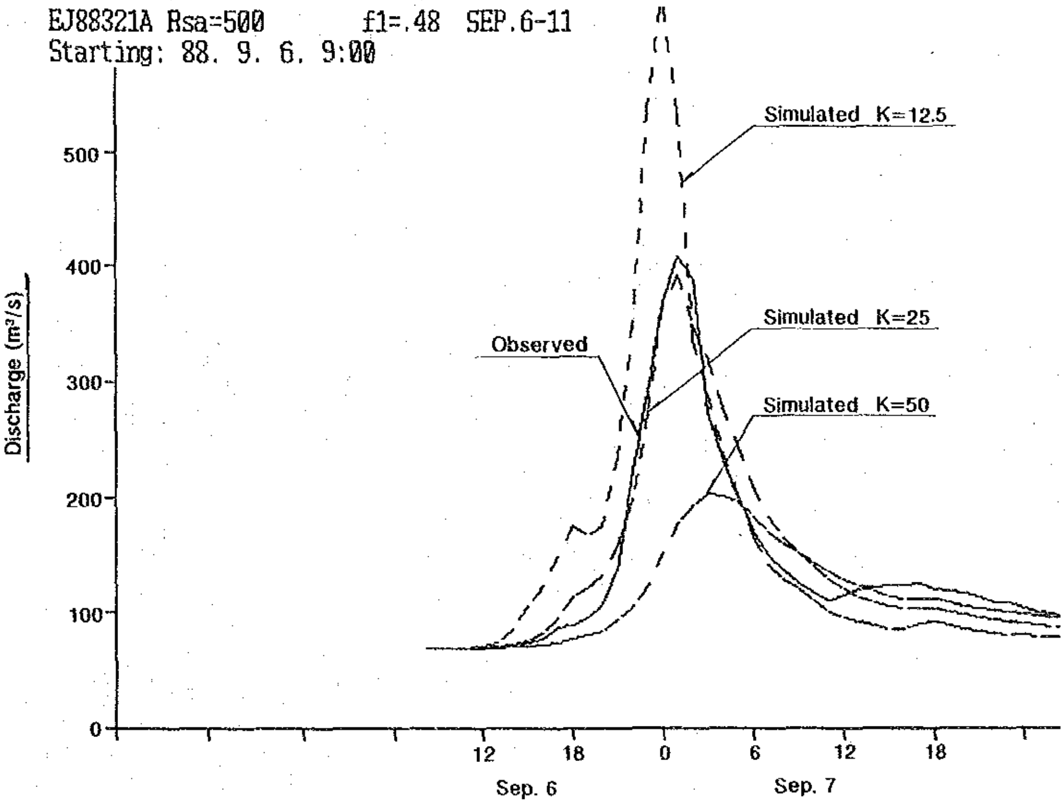


MODEL DIAGRAM FOR STORAGE FUNCTION MODEL SIMULATION

Fig. IV-12

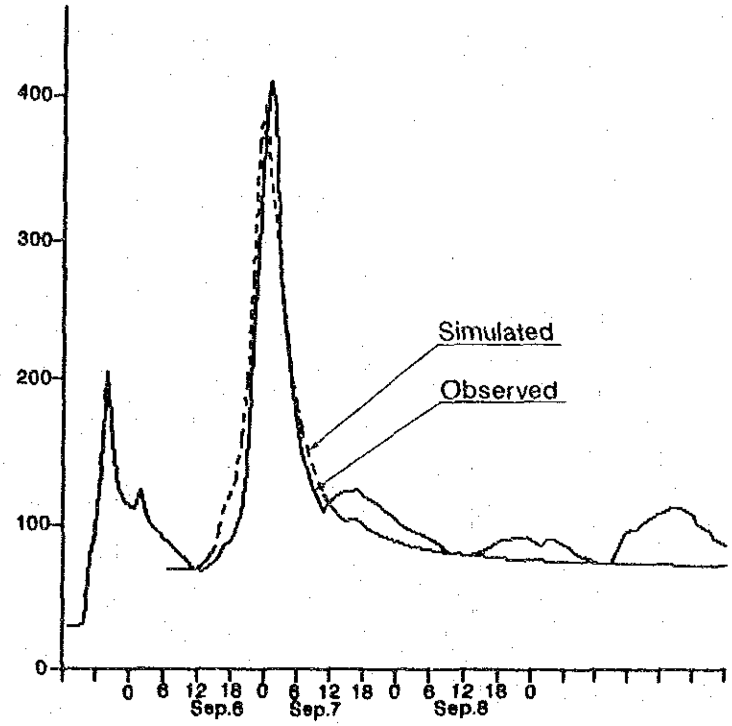
STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

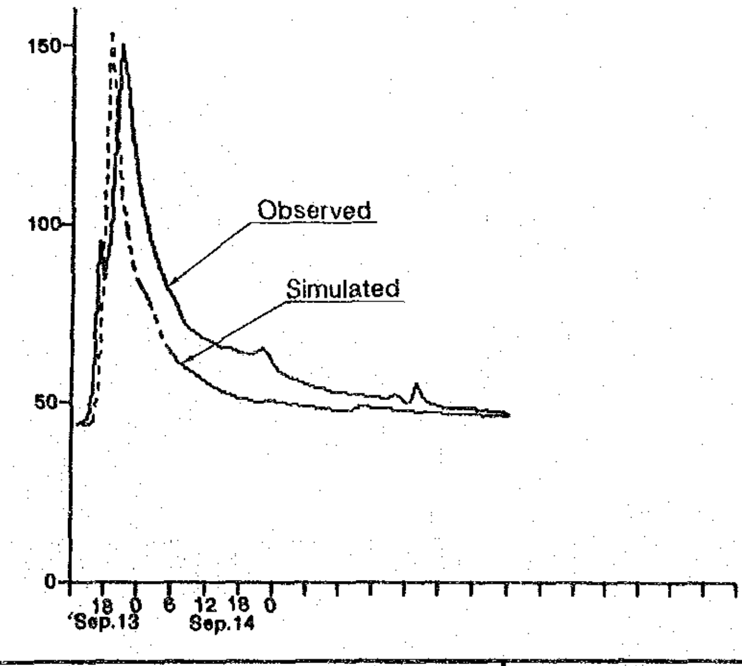


CHANGE OF SIMULATED HYDROGRAPH BY K OF S=KQP	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-13	JAPAN INTERNATIONAL COOPERATION AGENCY

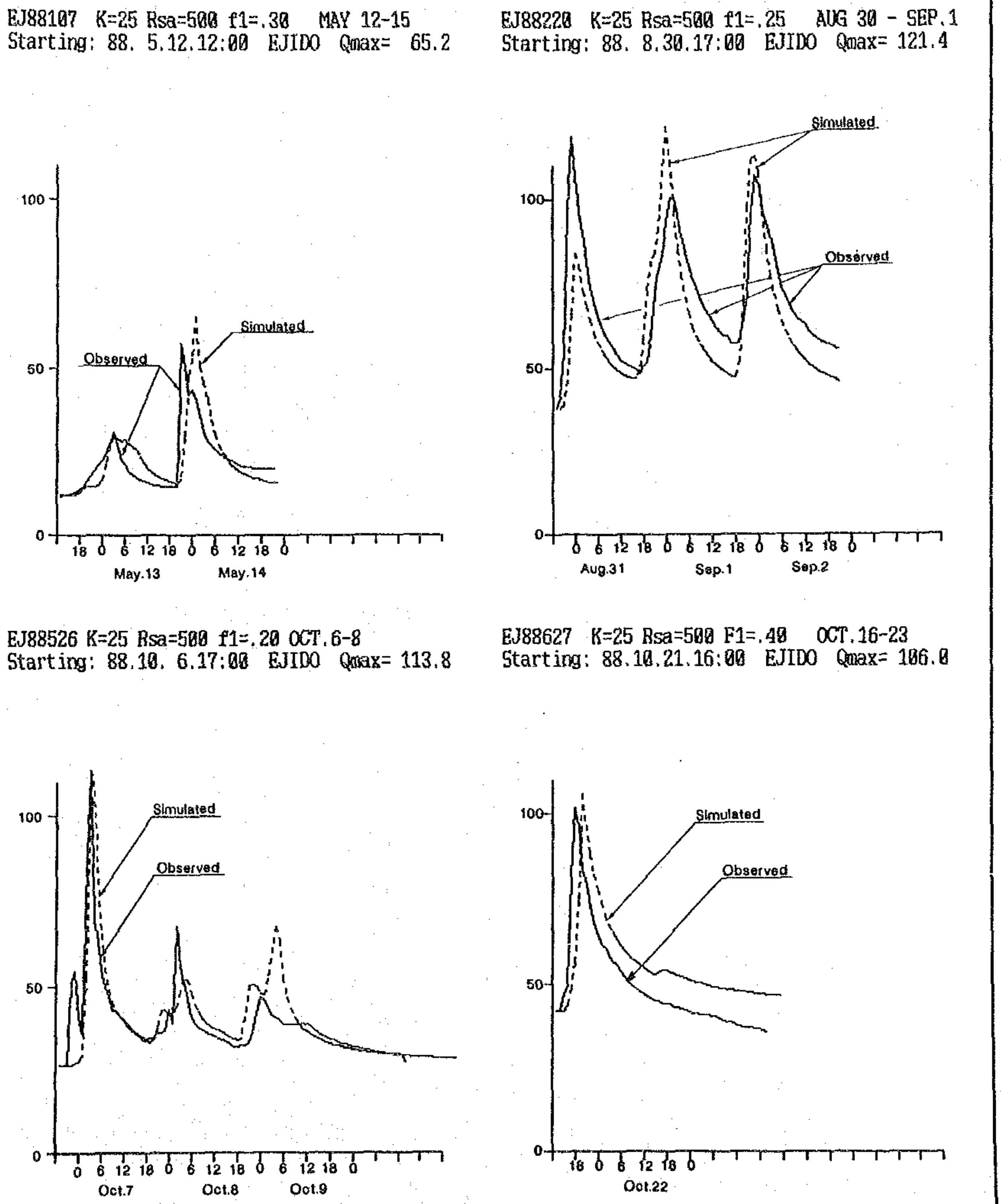
EJ88321 Rsa=500 K=25 f1=.48 SEP.6-11
Starting: 88. 9. 6. 9:00 EJIDO Qmax= 392.8



EJ88422 K=25 Rsa=500 f1=.20 SEP.13 - SEP.15
Starting: 88. 9.13.13:00 EJIDO Qmax= 153.5

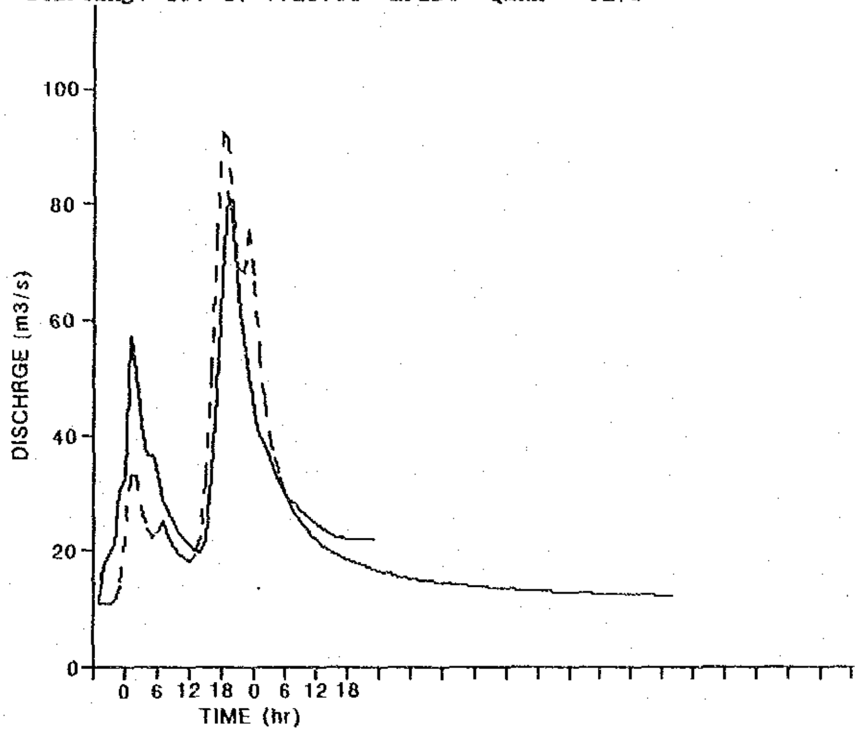


VERIFICATION OF STORAGE FUNCTION MODEL	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-14 (1/3)	JAPAN INTERNATIONAL COOPERATION AGENCY

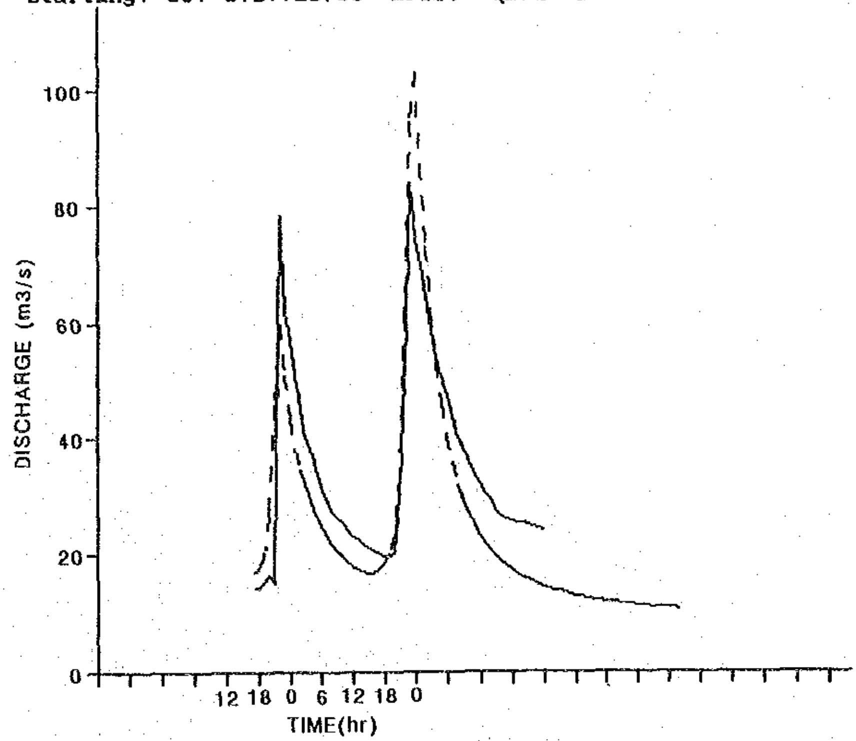


VERIFICATION OF STORAGE FUNCTION MODEL	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-14 (2/3)	JAPAN INTERNATIONAL COOPERATION AGENCY

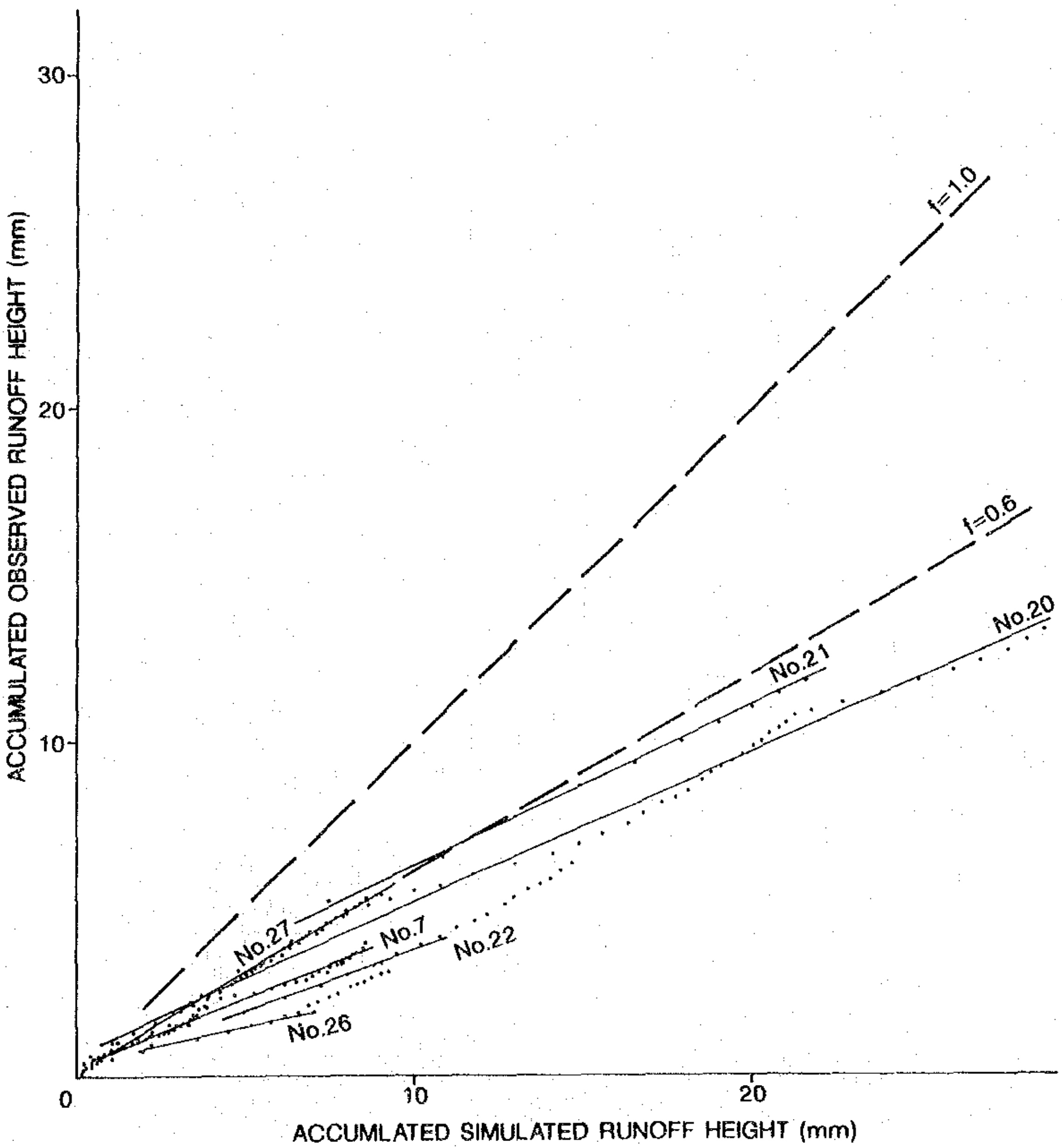
EJ89728 K=25 Rsa=500 F1=.25 MAY.7-8
Starting: 89. 5. 7.20:00 EJIDO Qmax= 92.3



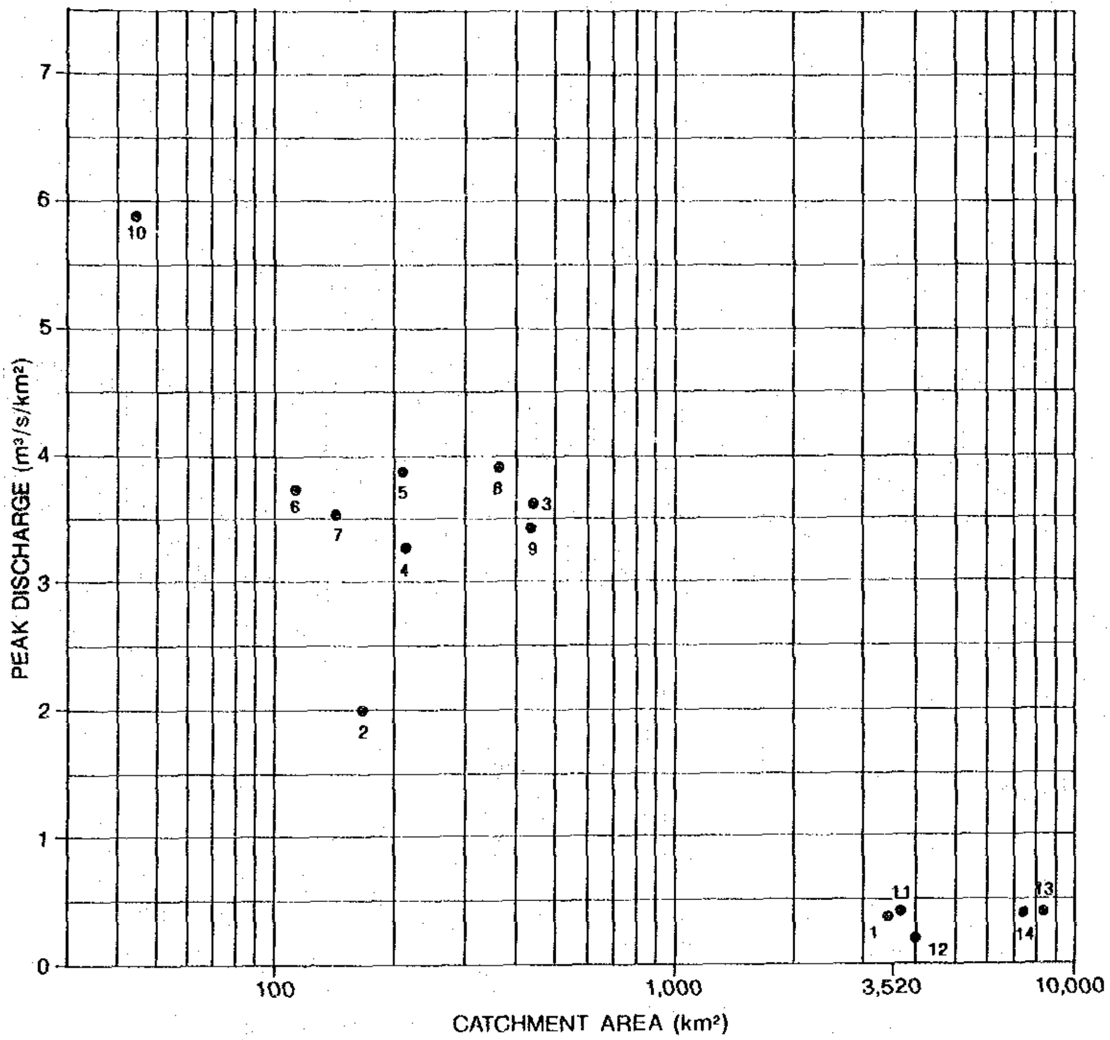
EJ89829 K=25 Rsa=500 F1=.20 MAY.27-29
Starting: 89. 5.27.13:00 EJIDO Qmax= 148.3



VERIFICATION OF STORAGE FUNCTION MODEL	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-14 (3/3)	JAPAN INTERNATIONAL COOPERATION AGENCY

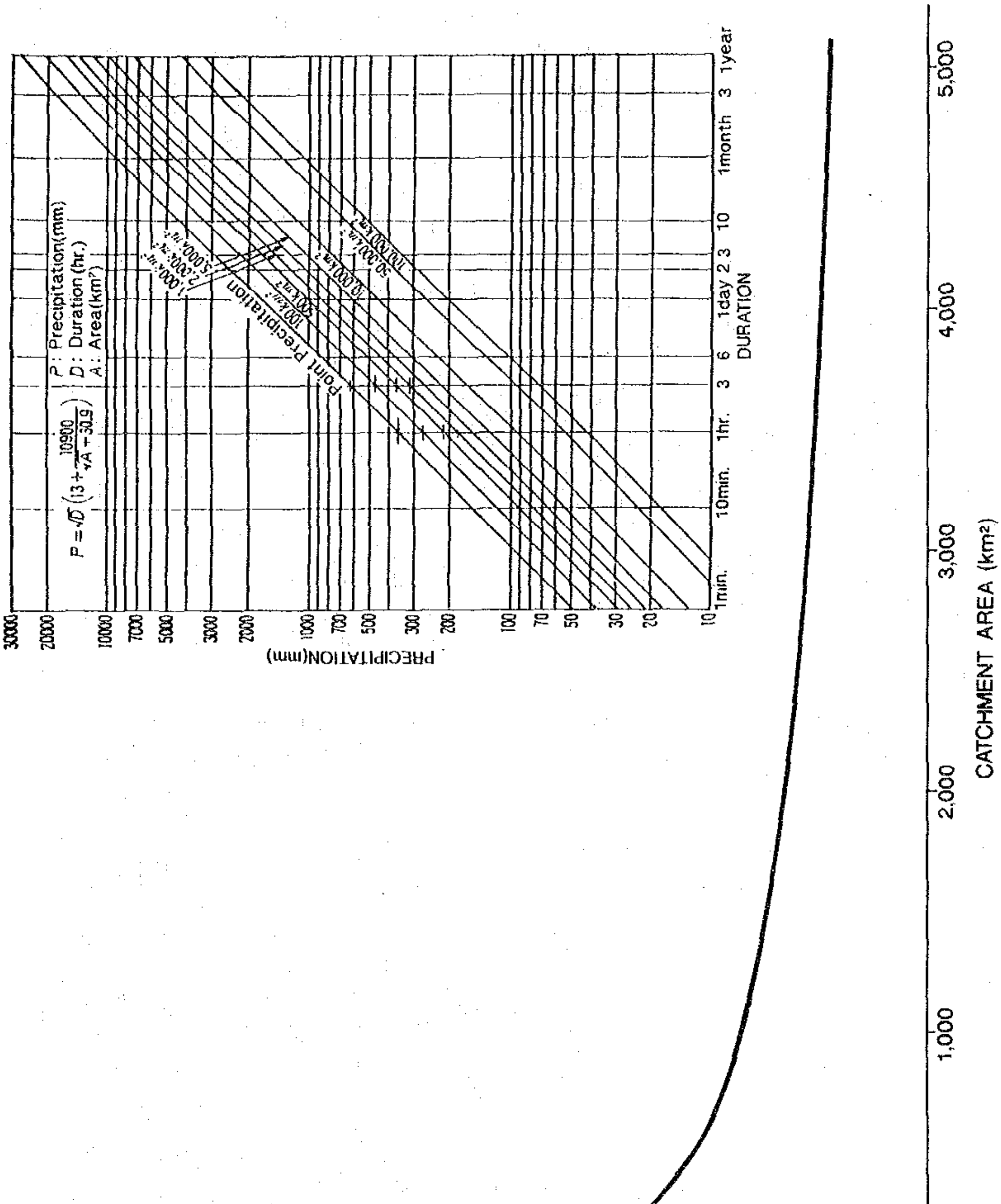


ACCUMULATED RUNOFF HEIGHT PLOTTING FOR F1 DETERMINATION	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-15	JAPAN INTERNATIONAL COOPERATION AGENCY

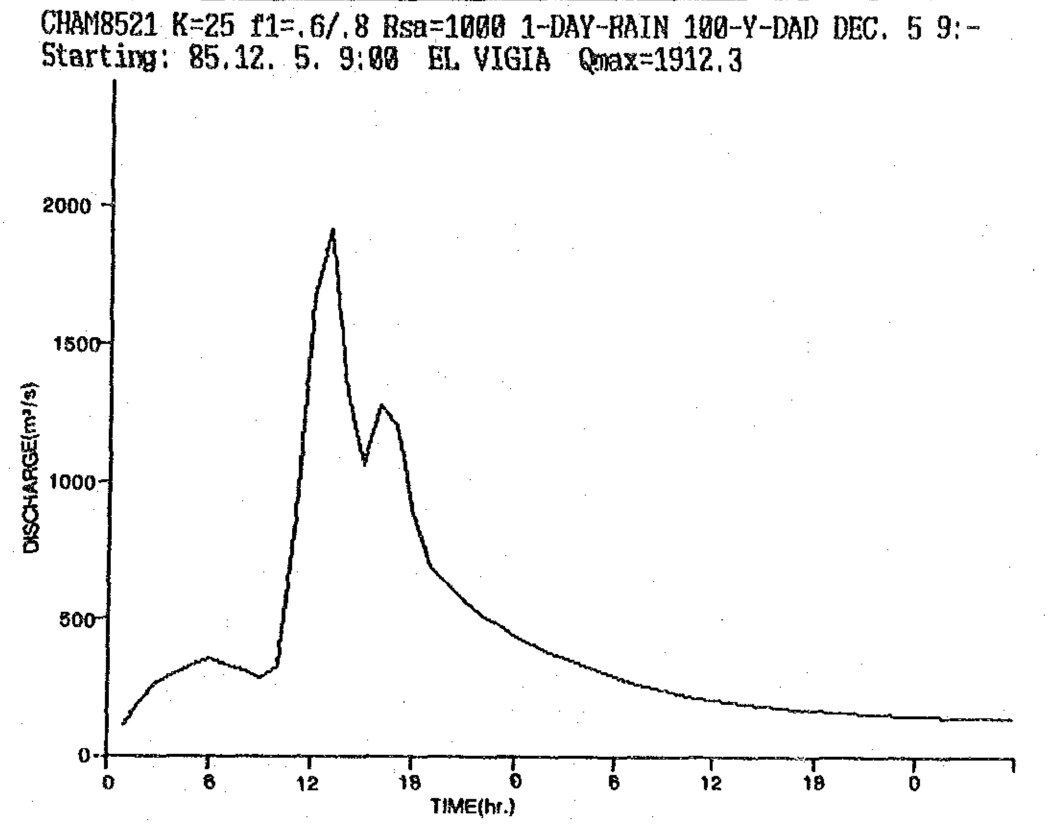


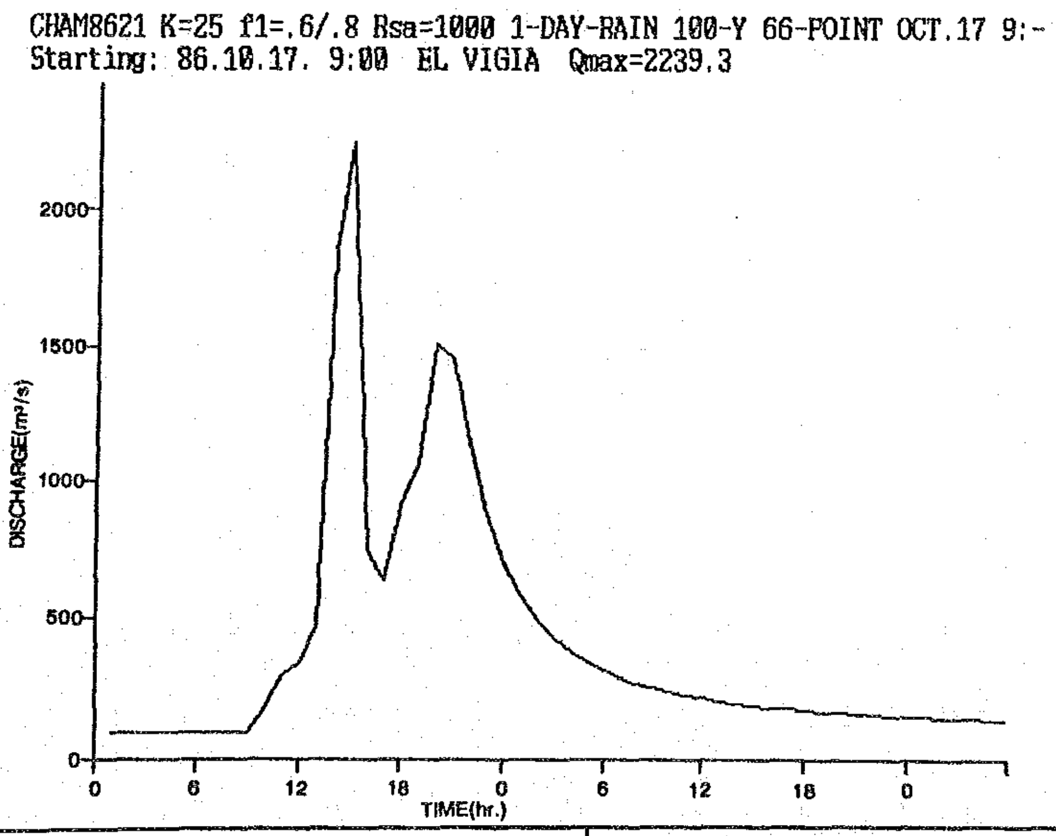
LEGEND
1 : Chama - El Vigia
2 : Mocotíes - La Victoria
3 : Torondoy
4 : Chiruri
5 : Cans
6 : Vichu
7 : Poco
8 : Tucani
9 : Capaz
10 : Arapuey
11 : Chama
12 : Escalante
13 : Catatumbo
14 : Zulia

SPECIFIC PEAK DISCHARGE PLOT	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-16	JAPAN INTERNATIONAL COOPERATION AGENCY



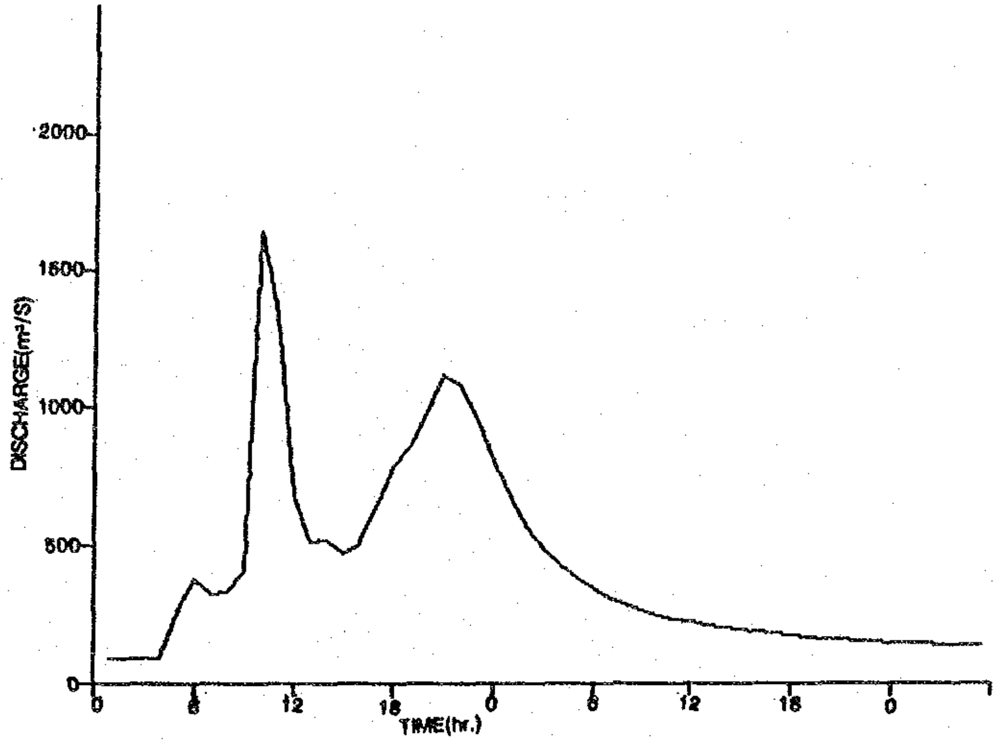
AREAL RAINFALL INTENSITY REDUCTION FACTOR	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT	
Fig. IV-17	JAPAN INTERNATIONAL COOPERATION AGENCY	



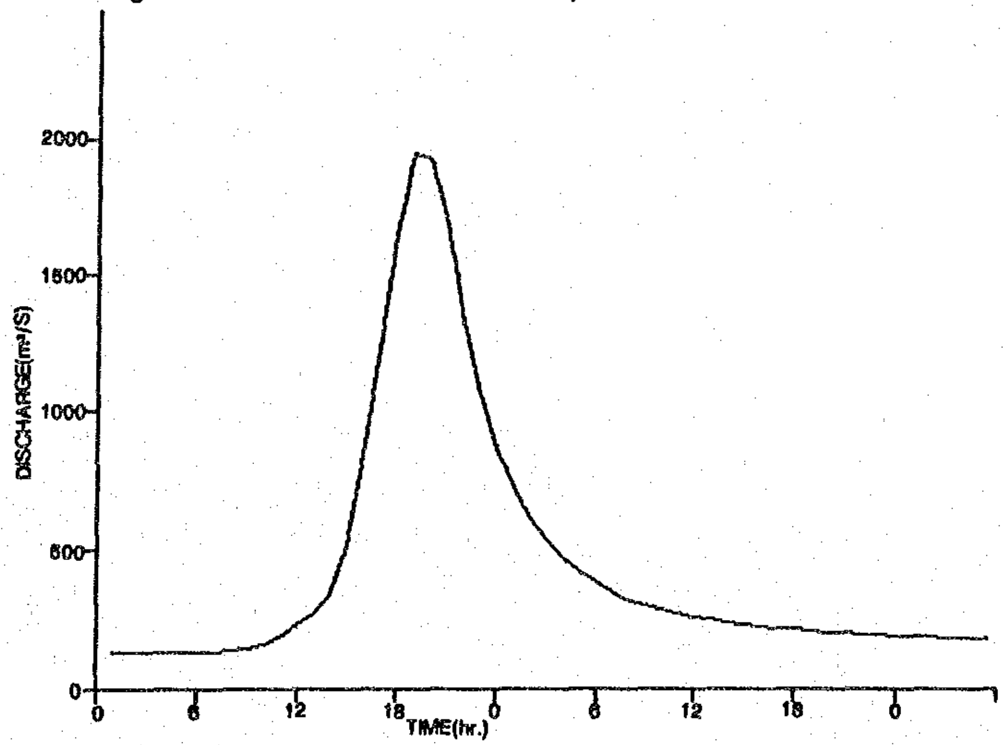


SIMULATED FLOOD HYDROGRAPH FOR 1985-88	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-18(1/2)	JAPAN INTERNATIONAL COOPERATION AGENCY

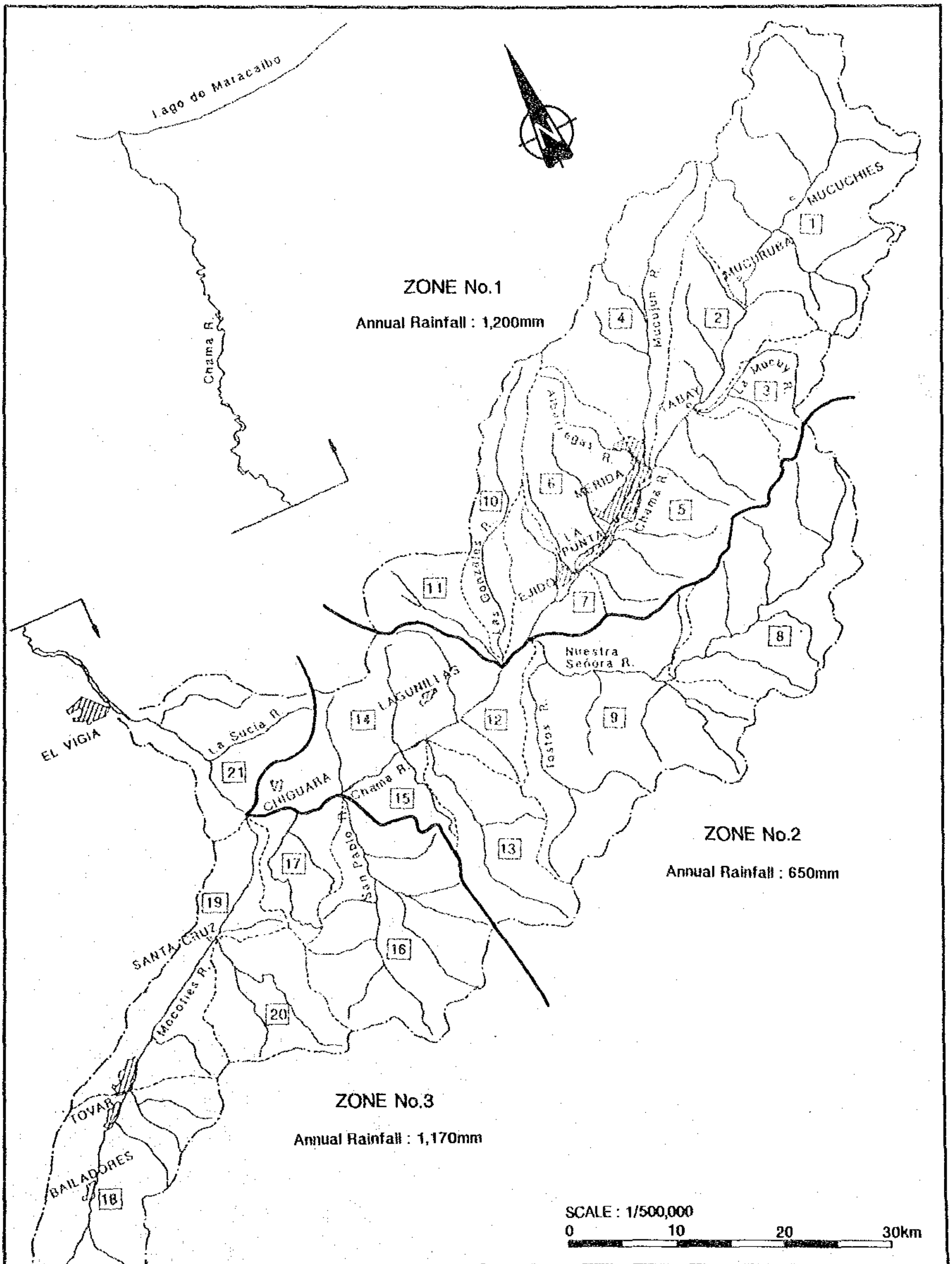
CHAM8721 K=25 f1=.6/.8 Rsa=1000 1-DAY-RAIN 100-Y OCT.13 9:-
Starting: 87.10.13. 9:00 EL VIGIA Qmax=1642.4



CHAM8821 K=25 f1=.6/.8 Rsa=1000 1-DAY-RAIN 100-Y-DAD SEP. 6 9:-
Starting: 88. 9. 6. 9:00 EL VIGIA Qmax=1946.6



SIMULATED FLOOD HYDROGRAPH FOR 1985-88	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-18 (2/2)	JAPAN INTERNATIONAL COOPERATION AGENCY



ANNUAL RAINFALL AMOUNT ZONES	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. IV-19	JAPAN INTERNATIONAL COOPERATION AGENCY

V. SEDIMENT AND FLOOD DISASTER

SUPPORTING REPORT

V. SEDIMENT AND FLOOD DISASTERS

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1. INTRODUCTION

For the purpose of estimating conditions and damages of sediment and flood disasters in the Chama River Basin, past disasters were investigated. Data related to the disasters were obtained from the agencies concerned such as MARNR, MTC, Defensa Civil, Corpoandes, MINDUR, FONAIAP and MAC, and the interviews with the residents at the sites.

Disasters in the Chama River Basin occur differently between the upper/middle reaches and the lower reaches which are divided by El Vigía City. Sediment from torrents or slope failures cause the disasters in the upper/middle reaches and floods from the Chama River cause the disasters in the lower reaches. Since the damaged assets are also different between the two reaches, sediment and flood disasters are herein separately studied.

2. PRESENT CONDITION OF SEDIMENT AND FLOOD DISASTERS

2.1 Disaster in Lower Reaches

Historical Floods

Floods have occurred every year in the lower reaches, but those in 1972, 1982 and 1988 were in particular very serious. The inundated areas indicated in Figs. V-1, V-2 and V-3 were estimated at 7,400, 8,500 and 15,800 ha, respectively, based on the disaster reports and the interviews with the residents concerned. During the 1982 and 1988 floods, the 12 km earth dike on the left bank which was constructed in 1975 downstream of El Vigía City was breached.

The flood prone areas are (1) the areas downstream of El Vigía City to Los Naranjos, (2) the areas just downstream of Puerto Chama, and (3) the areas downstream of La Fortuna to the river mouth at the Maracaibo Lake. Inundation depth varied between 0.3 and 1.5 meters, but it was mostly within 1 meter. Inundation duration also varied from several hours to a few days in the southern area of El Vigía City, while it was around one week in the northern area near the Maracaibo Lake because of the flat terrain.

The lower reaches were mostly covered by the plantain plantations and pastures as indicated in Fig. V-4. The major damaged assets due to inundation were plantains, pastures, livestocks, houses and farm machinery. Damage to plantain was extremely serious because of its weakness to inundation, while the other assets suffered no serious flood damage because the inundation was not so high to inflict serious damage on livestocks and houses.

Damage on Plantain Plantation

The existing plantain plantation between the Escalante and the Mucujepe rivers in the lower reaches is about 26,100 ha and the yield of plantain in and around the Chama River Basin is about 12,000 kg/ha/year on an average, fluctuating between 8,000 and 16,000 kg/ha/year. The producer's price depends on the yield at the year, ranging from 50 to 100 bolivares against the production of 30 kg.

The damage on plantain plantations in the 1972, 1982 and 1988 floods were estimated using the following equations, where production rate, unit price and restoration cost of plantain plantations are assumed values. Concerning damage rate, the plantain is said to die off completely when flooded at the inundation depth of more than 20 cm for three successive days or longer.

$$Damage = Ia \times (Pr \times Up + Rc) \times Dr$$

where,

- Ia : inundation area in the plantain land
- Pr : production rate of plantain (12,000 kg/ha/year)
- Up : unit price of plantain (2.5 Bs./kg)
- Rc : restoration cost (4,200 Bs./ha)
- Dr : damage rate

The area of plantain plantation inundated by the floods in 1972, 1982 and 1988 were 4,900, 5,900 and 8,900 ha, respectively. Damage by the respective floods was accordingly calculated from the above equation at 84, 101 and 152 million bolivares, assuming a damage rate of 50%.

Other Damages

With regard to the other assets like the pasture land, livestock, house, farmland and public utilities, flood from the Chama River does not give any serious damage. The pasture land is durable against muddy water and vegetation usually recover within two weeks after inundation. Livestock in the pasture land is mostly cattle, and the inundation is not high enough to inflict damage. Moreover, there is enough space in adjacent lands where livestock can take refuge while the pasture is inundated.

Houses in the inundation area are mostly located in places where the inundation water does not rise to a serious level. Furthermore, the inhabitants usually keep valuable furniture at higher locations owing to past experiences. Accordingly, the damage to houses and residents seem to be slight. Although upland crops are cultivated in the inundation area, the area is quite small.

Total Damage

Indirect damage includes the interruption of local roads, outbreak of epidemics, stoppage of human activity and so on, but these are intangible. Twenty percent of the damage on plantain plantations was applied to other direct and indirect damages, therefore, total direct and indirect damages caused by the three floods amounted to 101, 121 and 183 million bolivares, respectively.

2.2 Disaster in Upper/Middle Reaches

Disaster Records

Disaster in the upper/middle reaches has been increasing year by year. The latest serious damage in the Chama River Basin has been precisely recorded in 1987 and 1988; hence, the data has been adopted for the study on past disasters in the upper/ middle reaches.

The location of disasters in 1987 and 1988 and the remarkable ones in the past are indicated in Fig. V-5, while the damage conditions are presented in Table V-1. With regard to the road disaster, only the damage to arterial roads was considered because of its significant social impact.

As shown in Table V-1, debris flow, slope failure, bank erosion and floods are the causes of disaster in the upper/middle reaches. Interruption of roads is most common, inundation of houses and farms is the next, and interruption of domestic water supply and electricity, as well as communication facilities, also occurred.

Damage on Road

Road disasters are most common in the upper/middle reaches, as mentioned above, and they occur at various places along the Chama River. In 1979, road traffic was interrupted for over a week, but recently the most common duration is between one and three hours owing to the improvement of road restoration activities.

Road disasters cause interruption or delay of transportation and the damage is estimated on the basis of the GRDP, traffic volume, travelling cost, etc. Road disasters are classified under two situations; namely, Situation 1 with a detour route and Situation 2 without a detour route, as described in the following paragraphs.

In Situation 1, it is possible to make detours during interruption of the arterial road. With detours, however, the travelling distance and time are increased and the damage is estimated for the increase in operation cost and the delay in product distribution activities. In Situation 2, there is no detour route during road interruption. Therefore, all the distribution activities are stopped, and the damage cost is estimated for that period. The following equations were used for calculating the damage cost under each situation.

(1) Situation 1

$$\text{Damage} = Tv \times (Oc \times Id + Pv \times Pp \times Lt)$$

where,

- Tv : traffic volume
- Oc : operation cost of vehicles
- Id : incremental distance by detouring
- Pv : people in vehicles
- Pp : per capita productivity
- Lt : loss of time for economic activities

(2) Situation 2

$$\text{Damage Cost} = GRDP \cdot At \cdot Dt \cdot Anp$$

where,

- GRDP: Gross Regional Domestic Product per capita per hour
- At : affected time due to the road interruption
- Dt : decreased traffic volume due to the road interruption
- Anp : average number of passengers

The damage in 1988 on the arterial roads was estimated by the above equations at 1.8 million bolivares, as shown in Table V-2. In the above equations, the following situations were assumed.

- All cars and trucks passing through the arterial roads were presumed to be running at the speed of 60 km/hr.

- All cars and trucks passing through detours were presumed to be running at the speed of 30 km/hr and 10 km/hr, respectively.

- Actual traffic interruption time was longer than the time of inundation or the time consumed for removing sand and rocks from the roads, by 50% before and after the inundation.

- Unit running and time costs of cars and trucks estimated under a transport study by the Ministry of Transportation and Communication (MTC), is as shown in the following table.

Vehicle	Running Cost (Bs./km)	
	Arterial Road	Detour
Cars	0.68	0.70
Trucks	1.61	2.10

- Daily per capita production was estimated at 122 Bs/day from the GRDP in 1988.

- The number of people taking vehicles affected was assumed at 2 persons/vehicles on an average.

Other Damages

Disaster on farms rarely occurred in the past. Only two farms with few crops suffered from floodwaters with gravel and sand from the Chama River, and their inundation areas were only 4 and 5 ha, respectively.

Flood or debris flow sometimes attached houses in the cities of Tabay, Mérida or Ejido, but no large scale disaster on houses had occurred in the past and only a few, usually ten, were inundated with shallow water. There is no significant loss of assets at present, except the case when a house was covered with sediment.

The frequency of disaster on local roads is more than the arterial roads and since they are not maintained in good condition, the period of interruption is longer. However, traffic volume on local roads is low and interruption does not cause any serious social problem.

Local utilities such as electric and domestic water supply are sometimes interrupted because these utilities were simply installed and thus easily get damaged by sediment. As a result, communities beyond the service area of these utilities become isolated and social conditions become worse.

The population of the cities of Mérida and Ejido is increasing year by year, and the residential areas are expanding towards the flood prone areas along the Albarregas and Montalbán rivers which flow through the cities. Although about 10,000 inhabitants of the area are presently protected from floods by the concrete dike, there is a strong possibility that the area will suffer from enormous damage due to *disasters. Fig. V-6 shows the urban development plan for Mérida and* Ejido cities.

Total Damage

As mentioned above, several disasters occur in the upper/middle reaches, but the damage to assets except the arterial road do not give any serious social problem in the Chama River Basin. Usually, the damage is intangible and cannot be use to estimate damage cost. Twenty percent is then applied for the damage on arterials roads, and the estimated total damage in the upper/middle reaches amounts to 2.16 million bolivares.

3. DISASTER PREVENTION WORKS

To cope with the chronic disasters caused by flooding and sedimentation, private entities and the Government of Venezuela had been undertaking various kinds of prevention works. The MARNR is the principal agency responsible for the implementation of the works in the Chama River Basin. Zone Office No. 16 of the MARNR has been undertaking all sediment control works in the upstream of El Vigía and Zone Office No. 5 has been concentrating on the flood control works in the downstream of the Chama River.

3.1 Sediment Control in the Upstream Area

Sediment control works in the upstream area which covers almost all of the Chama River Basin can be categorized into two; namely, soil conservation and stream channel control.

Soil Conservation

Soil conservation has been initiated as one of the important components of a rural development project by the MAC. This rural development project consists of, among others, electrification, road construction, housing, potable water supply and irrigation, aiming at the upliftment of living conditions in the rural area.

The MAC prepared a program for soil conservation in 1960 and implemented the works in an area of 450 ha in the upstream of the Chama River Basin around Mucuchíes from 1962 to 1966. The works, costing 159,500 bolívares, was mainly composed of water tanks, small ponds and diversion canals to convey stream water to farmlands. Secondary and tertiary channels with either contour trench or stone/concrete walls were also constructed with the cooperation of the rural communities.

Operation and maintenance of the structures were undertaken by the MAC for ten years from 1967 to 1977. Upon the foundation of the MARNR in 1978, it took up the operation and maintenance of the soil conservation works in the area.

Stream Channel Control

Stream channel control works in the Chama River Basin are mainly composed of check dams, retaining walls and groundsills. In the last five years from 1984 to 1988, the MARNR has invested 21,763,384 bolivares for the works which have been concentrically undertaken for the rivers that may affect urban or populated areas (refer to Table V-3). The works were then provided mainly to protect specific areas from sediment disaster, rather than a basin-wide sedimentation control. The standard design of structures is presented in Figs. V-7 and V-8.

In addition to the works undertaken by the MARNR, some sediment control works in the upstream of the Chama River Basin were done by the MTC and the ULA. The MTC constructed the channel works on the Limos River in 1982 to protect arterial road Route No. 7 from debris. The ULA implemented the sabo works consisting of a series of check dams on the La Virgén River as a pilot project.

3.2 Flood Control in the Downstream Area

The main flood control works undertaken by Zone Office No. 5 was a 12-km earth dike along the left bank from the Chama Bridge to the downstream constructed at a cost of 23 million bolivares in 1975. The dike aims at preventing inundation to the plantain plantation in the west, the residential area and the roads. To avoid dike breaching, some impermeable groins of gabbion mattress were also constructed to dissipate the strong current at the river bend. The typical cross-section and structure of the groin are presented in Fig. V-9.

River dredging was also undertaken in 1985 to remove sediment deposits around the river mouth. Dredging was done for a stretch of about 2.0 km from the river mouth at a cost of 8.0 million bolivares.

4. IDENTIFICATION OF TARGET ASSET

The assets that are damaged in the Chama River Basin are classified into four groups according to damage value or the social effects. Among the four groups, (1) plantain plantation in the lower reaches and (2) national road in the upper/middle reaches have suffered from serious damage which are forecasted to increase in the future because of the projected increase in the area of plantain plantations and the volume of traffic on the arterial road.

On the other hand, (3) residential areas within the cities in the upper/middle reaches have suffered only from small scale damages in the past, but the disasters directly affect society and inundations in these areas have the probability to cause huge damage due to future urbanization.

Pasture land, livestock, farmland, local utilities, etc., belong to group (4), the micro assets which had suffered or may suffer from damage. Damage in these assets is not serious because of the small quantity and the low damage rate, however, they indirectly affect social conditions.

The assets classified above are explained in the following sections.

4.1 Plantain Plantation in the Lower Reaches

The plantain plantation in the lower reaches between the Escalante and the Mucujepe rivers is about 270 km^2 and it occupies some 14 percent of the lower reaches. This plantation had suffered from damage many times in the past, and the damage cost of the disaster in September 1988 was estimated at 108,824,000 bolivares.

The above estimate was made on the basis of land use in 1988. The plantain plantation in the inundation area of the September 1988 flood shared about 50 percent of the reaches and the other 50 percent was mostly utilized as pasture land. However, the lower reaches is underdeveloped according to "The Development Plan of Southern Area in Lake Maracaibo". The expansion of the plantain production is being promoted because it has a production rate better than the pasture land. If the flood from the Chama River is controlled in the future, the area of plantain plantation in the lower reaches will expand and a large amount of the damage cost will be converted into production benefit in proportion to the area of plantain plantation.

4.2 Arterial Road in Upper/Middle Reaches

There are three important arterial roads serving the state of Mérida, namely route No. 7, No. 2 and No. 3, as shown in Fig. V-10. Route No. 7 and No. 2 were damaged at various places many times in the past, while Route No. 3 has not suffered any damage. The total damage cost on arterial roads in the Chama River Basin was estimated at 6,100,000 bolivares in 1988.

For the purpose of studying the damage on arterial roads in the future, a reconnaissance study was carried out for the former two arterial roads and about 30 points were identified to have the probability of disasters. The probable disaster points are shown in Fig. V-10 and their situations are presented in Table V-4.

The damage cost of road disasters depends on various factors such as traffic volume, interruption period, existence of detouring route, GRDP and so on. Based on these factors, the damage for the probable disaster points in Fig. V-10 were estimated in 1988 at 538,010,000 bolivares as shown in Table V-5.

Table V-5 shows that the total damaged cost is mostly represented by Nos. 12, 13, 14 and 15. Under these disasters, the situation is that all bridges are destroyed and there is no detour. In such a situation, the interruption period becomes the longest and damage cost is high.

Among the factors applied for the calculation of damage cost, the interruption period has become shorter because of the improvement of restoration activities, excepting the cases of bridge or road destruction. However, traffic volume will increase twice within the next 20 years (from 8,200 cars in 1985 to 17,400 cars in 2005 near Mérida City), according to the study of the Ministry of Transportation and Communication (MTC). Therefore, the damage cost in the future will increase in accordance with the increase of traffic volume.

In the case of sediment disaster, restoration cost is required in addition to the damage cost. The restoration costs were estimated for the probable disaster points based on the sediment volume assumed through the reconnaissance study and the results are presented in Table V-6. The total restoration cost amounts to 4,125,000 bolivares.

It was found from the above estimates that increase in traffic volume will increase damage cost or restoration cost. If bridges or roads are destroyed or washed out by sediment and if there is no alternative route for detours, the effect to society will be serious.

4.3 Urban Area in Upper/Middle Reaches

The major urban areas in the upper/middle reaches are the cities of Mérida, Ejido, Santa Cruz and Tovar. Small scale urban disasters have happened in Mérida and Ejido cities, but the other cities received no damage in the past. In the past, most of the damage in these cities were caused by the inundation from the tributaries of the Albarregas, the Milla and the Portuguesa rivers flowing through the above cities, as seen in Fig. V-6.

The number of urban disasters in these areas have been increasing year by year. There are about 10,000 residents along the above three rivers at present and the number is increasing. The runoff coefficient in these areas is also growing higher with the housing development or urbanization. Therefore, inundation is occurring more easily in these areas and there is a probability of huge damage caused by flood in these areas. Such an urban disaster will present serious problems because it directly affects human life and society.

4.4 Minor Assets

The past disasters have inflicted damage to minor assets such as pasture land, livestock, farmland, agricultural products and farm machinery, and local public utilities. Damage cost on these assets are not so large because of the small damage rate, damage volume or number of people affected.

However, damage on local public utilities such as local roads, water supply systems and power supply systems sometimes make the residents in local areas isolated and cause an unfavorable social environment. Although the damage to the local inhabitants is not so serious, the control of disasters is desirable for the development of local conditions.

Floods with the inundation water depth of more than two meters may hit the pasture land in the future and damage to livestocks may be serious even if there are surrounding places for refuge. In this respect, it also desirable to consider some countermeasures to such floods.

Table V-1 PAST DISASTERS IN THE CHAMA RIVER BASIN

No.	Place	River	Date	Cause	Situation of Disaster
1.	Cacute	Chama	1988	Land Failure & Bank Erosion Debris Flow	1-day interception of Route 7
2.	Tabay	Qd.La Pueblo	1979	Debris	1 week interception of Route 7; Destruction of 1 gas station, 4 houses and graveyard;
3.	Ivega Farm	Chama	1988	Flood	2 day inundation of 15 ha farm; 2 day interception of domestic water and electricity; 0.5 m inundation of 15 houses.
4.	Capilla del Carmen	Chama	1987 & 88	Slope Faillure	3 hours interception of Route 7
5.	Andres Eloy Milla	Chama	1975	Flood	0.5 m inundation of 5 houses
6.	El Rincon	El Rincon	1987 & 88	Flood	1 m inundation of 5 houses
7.	San Jacinto	Qd La Fria	1987 & 88	Flood	0.5 m inundation of 3 houses
8.	La Pedre-gosa	Qd La Resbalosa		Flood	0.5 m inundation of 10 houses 1 day inundation of 3 ha farm 3 houses interception of electricity
9.	Urbanizacion Carabobo	La Gavidia	1987 & 88	Flood	1.3 m inundation of houses
10.	Ejido	Portuguesa	1988	Flood	0.3 m inundation of 1 houses and 1 gas station
11.	San Onofre	Chama	1987	Slope Failure	1 day interception of Route 7; 1 hour interception of electri-city; Destruction of 2 houses.
12.	Rio Negro	Chama	1988	Bank Erosion	Half day interception of Route 7
13.	La Gonzalez	Chama	1988	Slope Failure	Half day interception of Route 7
14.	Chichy	Chama	1988	Flood	One day inundation of 4 ha farm 0.5 m inundation of 2 houses
15.	La Honda	Chama	1987 & 88	Slope Failure	Mud inundation of 12 ha pasture 3 hours interception of Route 2
16.	La Provi-dencia	Chama	1988	Slope Failure	2 to 3 hours interception of Route 2
17.	Carabanchel	Chama	1988	Slope Failire	2 to 3 hours interception of Route 7
18.	Qd. Romero	Mocoties	1988	Slope Failire	2 to 3 hours interception of Route 7
19.	Tabacal	Qd.Cubalibre	1988	Debris Flow	2 to 3 hours interception of Route 7
20.	Tabacal		1988	Debris Flow	2 to 3 hours interception of Route 7
21.	Balero	Qd.Silencio	1988	Debris Flow	2 to 3 hours interception of Route 7
22.	Tovar	Penon II	1988	Debris Flow	2 to 3 hours interception of Route 7

Table V-2 ESTIMATED DAMAGE BY DISASTER IN 1988

No.	Place	Detour Way (Y/N)	Intercep-tion Period (hours)	Traffic Volume in 1988		Estimated Damage (1000 Bs.)
				Cars	Trucks	
1	Cacute	No	24	3,760		910
4	Capilla del Carmen	No	3	3,760		10
12	Rio Negro	Yes	12	7,970	1,430	380
13	Las Gonzalez	Yes	12	7,970	1,430	380
15	La Honda	No	3	9,770		30
16	La Palmita	No	3	9,770		30
17	Carabanchel	No	3	9,770		30
18	Qd. Romero	No	3	3,620		10
19	Qd. Tabacal	No	3	3,620		10
20	Qd. Tabacal	No	3	3,620		10
21	Balero	No	3	3,620		10
22	Tovar	No	3	3,620		10
	Total					1,820

Table V-3 SEDIMENT DISASTER PREVENTION WORKS (1984-1988)

No.	Work Item	Work Volume	Total Cost (Bs)	Location
1.	Sediment Control Works -Check Dam -Groundsill	470 ha	5,243,840	Mamon Romero, Granates, Barro, Chorro
2.	Retaining Works -Retaining Wall -Embankment	3.95 km	11,779,544	Albarregas, Milla, Resbalosa
3.	Channeling Works -Excavation -Embankment	---	4,590,000	Mocoties, La Sucia
4.	Reforestation and Maintenance	10 ha	150,000	San Juan De Lagunillas
5.	Tree Nursery	---	---	---
6.	Soil Conservation	---	---	---
Total			21,763,384	

Table V-4 PROBABLE DISASTERS ON ARTERIAL ROAD ROUTE 2 AND 7

No.	Location	Cause	Probable Disaster
1	El Pedregal	Bank erosion	Road destruction
2	La Muchchache	Debris flow	Destruction of few house and bridge
3	Cacute	Bank erosion	Road destruction
	Cacute	Slope failure	Interception of road with sediment
4	Tampacel	Bank erosion	Road destruction
5	Tabay	Debris flow	Interception of road with sediment
6	El Salado	Bank erosion	Road destruction
7	Mesa de La Virgen (1)	Slope failure	Interception of road with sediment
8	Mesa de La Virgen (2)	Slope failure	Interception of road with sediment
9	Merida	Bank erosion	Road destruction
10	Qd. Los Higuerones	Debris flow	Interception of road with sediment
11	Conf. of Chama & N.S	Slope failure	Interception of road with sediment
	Conf. of Chama & N.S	Bank erosion	Road destruction
12	Qd. Los Limos	Debris flow	Destruction of bridge
13	Qd. Maciqual	Debris flow	Interception of road with sediment Destruction of bridge
14	Arraquales	Debris flow	Destruction of bridge
15	Qd. La Jaya	Debris flow	Destruction of bridge
16	Qd. El Diablo	Bank erosion	Destruction of bridge
17	La Honda	Slope failure	Interception of road with sediment
18	La Palmita	Slope failure	Interception of road with sediment
19	La Providencia	Slope failure	Interception of road with sediment
20	Carabanchel	Debris flow	Interception of road with sediment
21	Qd. Romero	Slope failure	Interception of road with sediment
22	Qd. Cubalibre	Debris flow	Interception of road with sediment
23	---	Debris flow	Interception of road with sediment
24	Qd. Tabacal	Debris flow	Interception of road with sediment
25	Qd. Silencio	Debris flow	Interception of road with sediment
26	---	Debris flow	Interception of road with sediment
27	Qd. Caciquito	Debris flow	Interception of road with sediment
28	Qd. Penon II	Debris flow	Interception of road with sediment

Note: --- means location is not identified

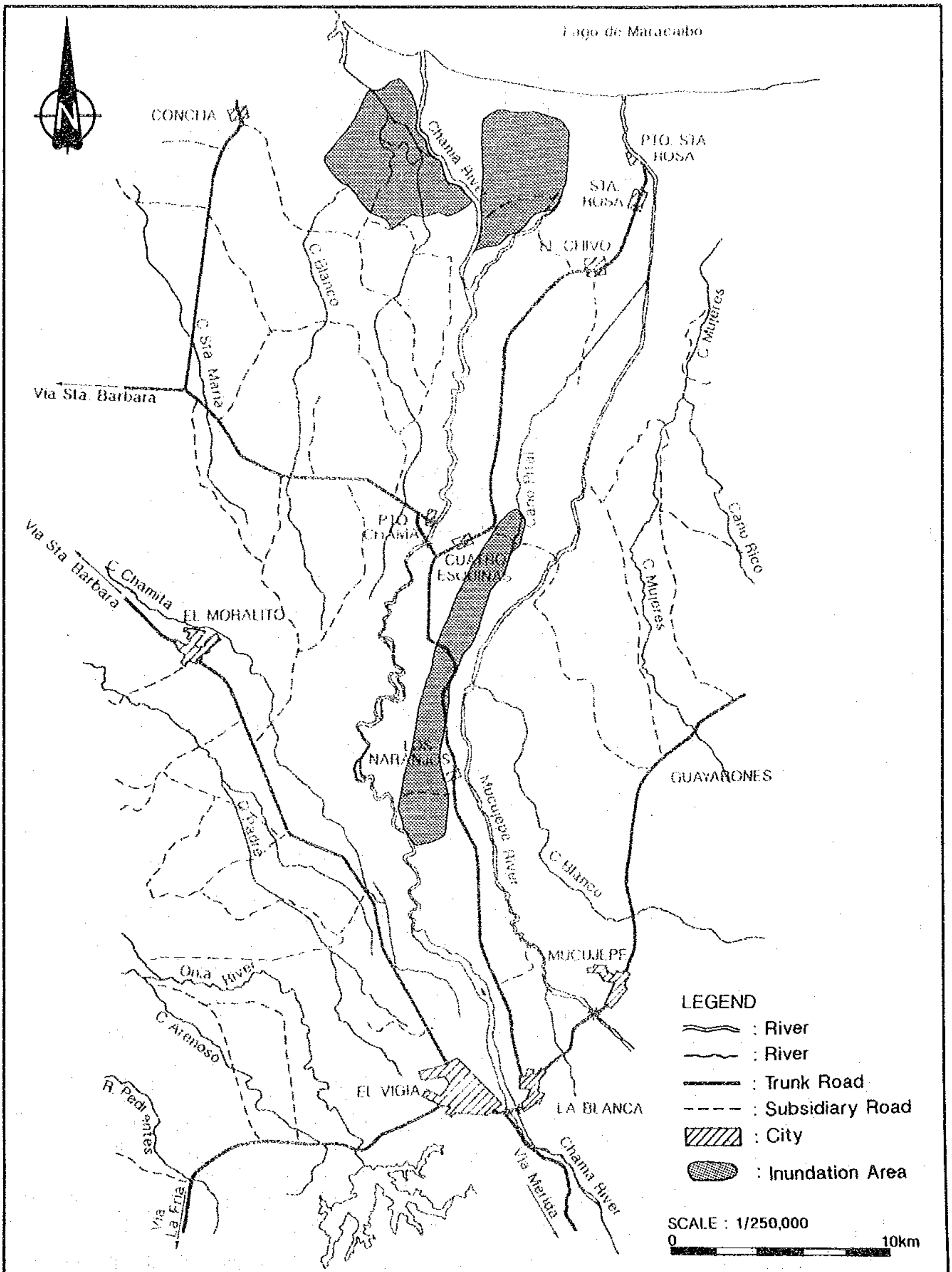
Table V-5 ESTIMATE OF TRAFFIIC DAMAGE BY PROBABLE ROAD DISASTERS

No.	Place	Detour Way (Y/N)	Interruption (hr.)	Traffic Volume (Vehicles) 1988	2000	2010	2020	Traffic Damage (1000 Bs.) 1988	2000	2010	2020
1	El Pedregal	No	24	3,760	5,930	7,950	9,970	910	1,440	1,930	2,420
2	La Muchchache	No	48	3,760	5,930	7,950	9,970	3,660	5,770	7,740	9,710
3	Cacute	No	24	3,760	5,930	7,950	9,970	910	1,440	1,930	2,420
4	Tampacel	No	24	3,760	5,930	7,950	9,970	910	1,440	1,930	2,420
5	Tabay	No	3	3,760	5,930	7,950	9,970	10	20	30	30
6	El Salado	No	24	3,760	5,930	7,950	9,970	910	1,440	1,930	2,420
7	Mesa de La Virgen (1)	No	3	3,760	5,930	7,950	9,970	10	20	30	30
8	Mesa de La Virgen (2)	No	3	3,760	5,930	7,950	9,970	10	20	30	30
9	Merida	No	0	3,760	5,930	7,950	9,970	0	0	0	0
10	Qd. Los Higuerones	Yes	12	9,410	14,840	19,890	24,940	380	600	800	1,010
11	Conf. of Chama & N.S	Yes	12	9,410	14,840	19,890	24,940	380	600	800	1,010
12	Qd. Los Limos	No	48	9,960	15,730	21,110	26,490	9,700	15,320	20,560	25,810
13	Qd. Maciqual	No	48	9,960	15,730	21,110	26,490	9,700	15,320	20,560	25,810
14	Arraques	No	48	9,960	15,730	21,110	26,490	9,700	15,320	20,560	25,810
15	Qd. La Jaya	No	48	9,960	15,730	21,110	26,490	9,700	15,320	20,560	25,810
16	Qd. El Diablo	Yes *	3	9,770	15,660	21,250	26,840	30	50	80	100
17	La Honda	Yes *	3	9,770	15,660	21,250	26,840	30	50	80	100
18	La Palmita	Yes *	3	9,770	15,660	21,250	26,840	30	50	80	100
19	La Providencia	Yes *	3	9,770	15,660	21,250	26,840	30	50	80	100
20	Carabanchel	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
21	Qd. Romero	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
22	Qd. Cubalibre	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
23	----	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
24	Qd. Tabacal	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
25	Qd. Silencio	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
26	----	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
27	Qd. Caciquito	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
28	Qd. Penon II	Yes *	3	3,620	5,820	7,720	9,620	10	20	20	30
						Total		47,100	74,450	99,890	125,410
						Damage Per Place		1,682	2,659	3,568	4,479

NOTE *: Due to a short interruption time, vehicles are assumed not to take a detour route.

Table V-6 ESTIMATE OF RESTORATION COST FOR PROBABLE ROAD DISASTER

No.	Place	Length of Collapse (m)	Width of Collaspe (m)	Depth of Collapse (m)	Volume of Collapse (m3)	Restoration Cost (1,000Bs)
1	El Pedregal	(1) 6	(1) 2	(1) 3	(1) 36	57
		(2) 4	(2) 2	(2) 3	(2) 24	38
2	La Muchchache	-	-	-	-	-
3	Cacute	80	10	4	3,200	1,407
		(1) 30	(1) 15	(1) 3	(1) 1,350	62
		(2) 40	(2) 15	(2) 3	(2) 1,800	83
4	Tampacel	30	2	10	600	767
5	Tabay	50	2	2	200	9
6	El Salado	28	6	7	1,176	665
7	Mesa de La Virgen (1)	150	5	1	375	17
8	Mesa de La Virgen (2)	50	100	1	4,000	184
9	Merida	10	5	3	150	7
10	Qd. Los Higuerones	1,500	8	4	48,000	2,208
11	Conf. of Chama & N.S	(1) 100	(1) 100	(1) 1.5	(1)15,000	690
		(2) 100	(2) 100	(2) 1.5	(2)15,000	690
		200	5	6	6,000	3,928
12	Qd. Los Limos	1,500	10	2	22,500	7,811
13	Qd. Maciqual	100	4	2	600	28
		60	4	2	360	5,110
14	Arraques	30	5	3	450	5,099
15	Qd. La Jaya	1,000	12	1	12,000	9,692
16	Qd. El Diablo	5	10	1	50	2
17	La Honda	100	20	8	16,000	736
18	La Palmita	90	20	5	9,000	414
19	La Providencia	10	40	1	400	18
20	Carabanchel	20	5	2	200	9
21	Qd. Romero	15	4	1	60	3
22	Qd. Cubalibre	30	10	1	300	14
23		100	8	1	800	37
24	Qd. Tabacal	200	15	2	6,000	276
25	Qd. Silencio	150	15	2	4,500	207
26		50	10	1	500	23
27	Qd. Caciquito	1,000	20	1	20,000	920
28	Qd. Penon II	100	9	1	900	41

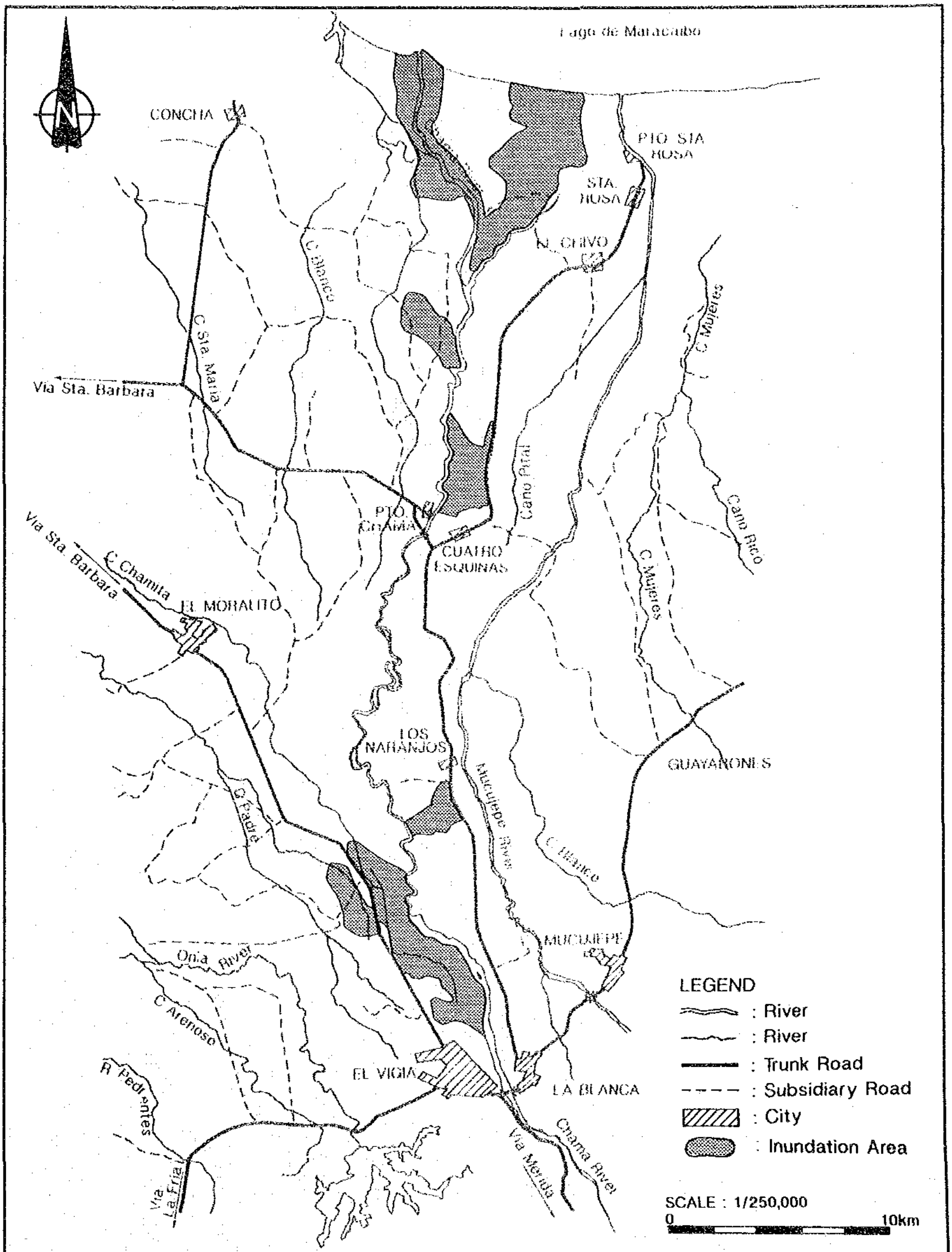


INUNDATION AREA BY 1972 FLOOD

Fig. V-1

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

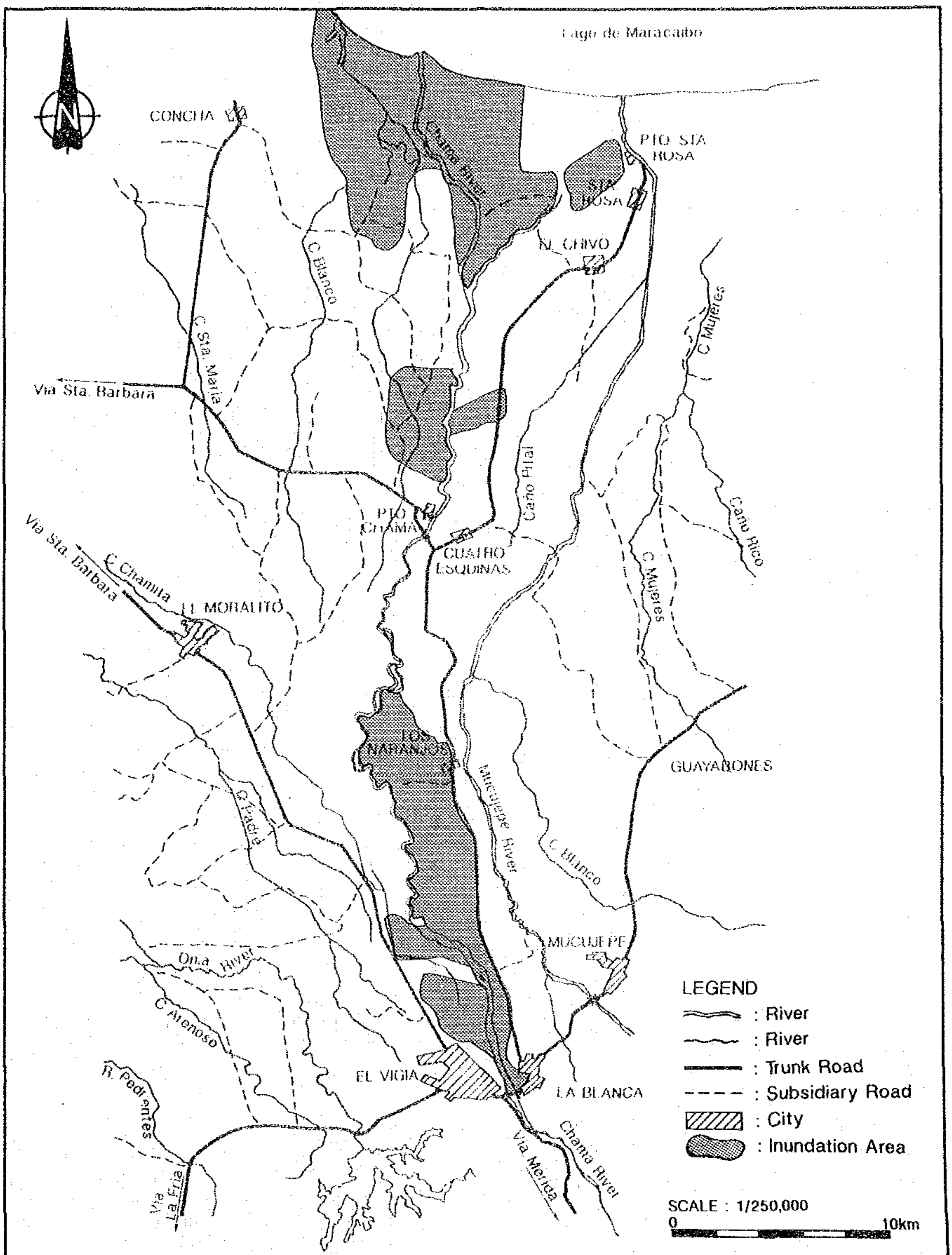


INUNDATION AREA BY 1982 FLOOD

Fig. V-2

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

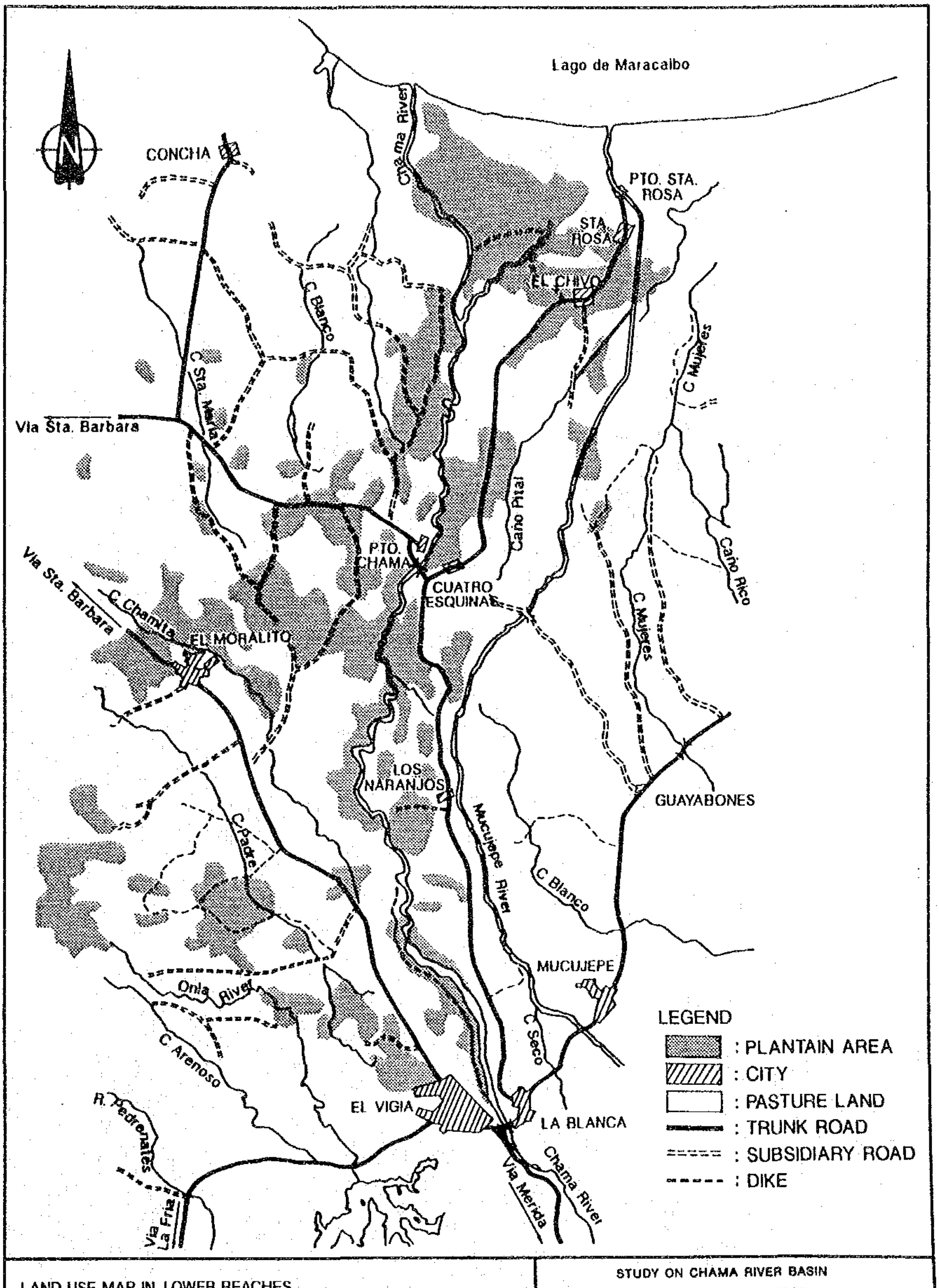


INUNDATION AREA BY 1988 FLOOD

Fig. V-3

STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



LAND USE MAP IN LOWER REACHES	STUDY ON CHAMA RIVER BASIN CONSERVATION PROJECT
Fig. V-4	JAPAN INTERNATIONAL COOPERATION AGENCY