Table C.2.29 Tropical Cyclone Summary (1/3)

Year	Classification & Name Period of Occurrence	Max Winds Obs. (kph) place	M S L P Recorded & place	Max 24-Hr. RR (mm) Recorded & place	Brief History, Public Storm Signals (PSS) Raised and Damages
1977	Typhoon OPENG Sep. 14-20	205-Tuguegarao	977.0-Tuguegarao	359.1-Baguio	Crossed Cagayan, Kalinga, Apayao, Abra and Ilocos Sur in the evening of the 15th to 16th of Sep. Death toll and heavy damage to property were reported. Rest of Luzon and Visayas experienced rains gusty winds. Damages amounted to P21M, dead 54, missing 11.
1978	Tropical Storm MIDING Aug. 20-26	120-Baguio	985.5-Tuguegarao	534.2-Baguio	Crossed Northern Luzon as a storm and intensified the SW monsoon. Low lying area of Central Luzon including Metro Manila were flooded. Damages amounted to P88M, dead 47, missing 16, injured 4.
1979	Typhoon MAMENG Aug. 9-15	140-Recon 106-Virac	954.0-Recon 991.5-Basco	285.4-Baguio 398.4-Iba	Tracked an erratic movement. Center passed about 450 kms northeast of Basco, making its' exit in the Southern Is. of Japan, Ryukyus; induced the south-west monsoon which brought rains and gusty winds over Luzon and Visayas; flooding occurred in low lying areas of Metro Manila (Aug.15) & Central Luzon. PSS #3-Batanes, Cagayan, Ilocos Norte and northern portion of Kalinga-Apayao. PSS #2- Rest of Northern Luzon. PSS #1-Rest of Luzon including Metro Manila and Mindoro. Damages amounted to P45.2M, dead 24, injured 5, and missing 3.
1980	Typhoon DITANG May 10-21	145-Tuguegarao 185-Recon	942.0-Recon 993.5-Tuguegarao 995.0-Casigu	730.3-Baguio 191.2-Tuguegarao	DITANG crossed northeastern Cagayan on May 15, then recurved towards the east northeast. It brought rains and gusty winds along the eastern section of Luzon. PSS #3 was raised over Catanduanes, Camarines Norte and Sur, Aurora, Quirino, Cagayan, Mt. Province, Nueva Vizcaya, Ifugao, Batanes and Abra. PSS #2 ever northern and eastern Samar, rest of Bicol, Quezon, Masbate, Nueva Ecija and rest of Northern Luzon. PSS #1 over the rest of Visayas, rest of Luzon including Metro Manila. Damages reported was P2.2M, but no casualty was reported.

Table C.2.29 Tropical Cyclone Summary (2/3)

Year	Classification of Name Period of Occurrence	Max Winds Obs. (kph) place	M S L P Recorded & place	Max 24-Hr. RR (mm) Recorded & place	Brief History, Public Storm Signals (PSS) Raised and Damages
1981	Typhoon RUBING Sep. 15-21	205-Calayan 215-Recon	924.0-Recon 961.5-Calayan	764.0-Itbayat 375.5-Aparri	Crossed Northern tip of Cagayan. Stormy weather experienced over extreme Northern Luzon. PSS #3 hoisted over Cagayan, Ilocos Norte and Sur, Kalinga-Apayao, Abra and Mt. Province. PSS #2 hoisted over the rest of Northern Luzon, Pangasinan, Northern Samar, Bicol Region, Aurora, Quirino and Quezon. PSS #1 hoisted over the rest of Luzon including Metro Manila, Mindoro and the rest of Visayas. Damages to properties - P79.7M, casualty - dead 5.
1982	Typhoon ILIANG July 26-29	205-Recon 215-Calayan	915.0-Recon 976.3-Basco	567.8-Calayan 728.0-Itbayat	Entered the PAR as a typhoon. Moved westnorthwestward and crossed 120 kms north of Basco between 7-8 PM. It then made its exit towards Southern Taiwan. PSS #3 hoisted over Batanes Group, PSS #2 hoisted over Cagaya, Ilocos Norte and Kalinga-Apayao. PSS #1 hoisted over Metro Manila, Rest of Luzon including Mindoro and Marinduque.
1983	Tropical Storm ETANG Aug. 13-15	75-Recon	992.0-Recon	217.8-Baguio 189.8-Iba	Embedded along the active monsoon trough. It became a tropical depresstion 400 km west of Vigan, I.S. in the afternoon of Aug. 12. ETANG together with DIDING induced the southwest from Aug. 10-14 thereby western section of Luzon including Metro Manila experienced heavy monsoon rains with gustiness of 45-65 kph. PSS #2 hoisted over Batanes and Northern Cagayan. PSS #1 hoisted over Western Luzon including Metro Manila. No damage was reported.
1984	Tropical Storm MARING Aug. 27-30	120-Recon 110-Baler	983.0-Recon 985.3-Aparri	381.8-Baguio 150.5-Laoag	MARING developed into a depression 790 km eastsoutheast of Basco, Batanes. Packing maximum winds of about 95 kph, it crossed the northeastern tip of Cagayan. MARING left the PAR through the Babuyan Islands in the morning of Aug. 30. The monsoon rains triggered by Tropical Storm. MARING caused landslides and rivers to overflow flooding low lying areas. PSS #2 hoisted over Cagayan, Isabela, Kalinga-Apayao, Abra, Ilocos Norte and Sur and Batanes. PSS #1 hoisted over Metro Manila, Rest of Luzon including Mindoro. Damages to public and private property P411.2M. Casualties - dead 121, injured 26, missing 17.

Table C.2.29 Tropical Cyclone Summary (3/3)

Year	Classification & Name Period of Occurrence	Max winds Obs. (kph) place	M S L P Recorded & place	Max 24-Hr. RR (mm) Recorded & place	Brief History, Public Storm Signals (PSS) Raised and Damages
1985	Typhoon KURING Jun. 20-24	165-Recon 120-Tuguegarao	961.0-Recon 979.0-Tuguegarao	304.6-Baguio 271.4-Iba	KURING developed east of Luzon in the morning of June 20th. It moved westnorthwestward and crossed Babuyan Channel. PSS #3 hoisted over Cagayan, Isabela, Abra, Batanes Group and Kalinga-Apayao, PSS #2 hoisted over Rest of Northern Luzon. PSS #1 hoisted over Eastern Visayas and Rest of Luzon including Metro Manila. Damages to preperty P227.6M. Casualties: dead 5, missing 6.
1986	Typhoon GADING Jul. 6-10	220-Vigan 185-Recon	894.0-Recon 967.0-Aparri	709.6-Baguio 376.8-Dagupan	Embedded along the active monsoon trough, GADING as a typhoon, moved westnorthwest crossing Northern Luzon that brought in considerable amount of rainfall along Northern and Western Luzon. PSS #3 hoisted over Batanes, Cagayan, Kalinga-Apayao, Ilocos Norte and Sur, Abra and Mt. Province. PSS #2 hoisted over the Rest of Northern Luzon. PSS #1 hoisted over Central and Southern Luzon including Metro Manila and Mindoro. Damages to Public and Private Property P620,910,851.00. Casualties:dead 89, missing 20 and injured 16.

Table C.3.1 Observed Daily Runoff of Gauging Sites (1/2)

(Unit : m^3/sec)

Month	Day	Wangal	Balili	Pico	Bahong	Bineng
Sept.	1					
	2					
	3					
	4					
	5					
	6					
	7					2.240
	8			1.858		1.920
	9			1.099	0.812	1.472
	10			0.625	0.650	0.180
	11			0.672	0.550	0.120
	12			0.435	0.875	0.110
	13			0.295	0.550	0.110
	14			0.227	0.350	0.080
	15			0.181	0.300	0.100
	16			0.159	0.300	0.090
	17			0.136	0.230	0.060
	18			0.113	0.210	0.050
	19			0.113	0.190	0.140
	20			0.091	0.210	0.080
	21			0.159	0.170	0.060
	22			0.159	0.150	0.047
	23			0.136	0.150	0.045
	24			0.136	0.210	0.045
	25			0.136	0.230	0.039
	26	0.452		0.159	0.550	0.037
	27	0.452		0.272	0.170	0.039
	28	0.416		0.249	0.190	0.037
	29	0.452		0.227	0.170	0.037
	30	0.452		0.159	0.130	0.034
Oct.	1	0.416		0.159	0.130	0.034
	2	0.344		0.159	0.130	0.026
	3	0.344		0.136	0.190	0.026
	4	0.308		0.113	0.150	0.026
	5	0.308		0.136	0.150	0.029
	6	0.308		0.113	0.150	0.026
	7	0.272		0.091	0.150	0.026
	8	0.272		0.091	0.130	0.026
	9	0.235		0.068	0.110	0.026
	10	0.235		0.023	0.110	0.026
	11	0.235		0.023	0.110	0.024
	12	0.199		0.136	0.090	0.026
	13	0.199		0.113	0.090	0.026
	14	0.199		0.159	0.090	0.026
	15	0.199		0.136	0.090	0.026
	16	0.235		0.113	0.090	0.026
	17	0.127		0.091	0.070	0.026
	18	0.091		0.091	0.070	0.026
	19	0.091		0.091	0.050	0.024
	20	0.091		0.136	0.130	0.026
	21	0.127		0.204	0.110	0.024
	22	0.091		0.181	0.090	0.024
	23	0.878		1.668	0.550	0.160
	24	9.500		8.551	3.200	1.549
	25	0.933		4.566	0.650	1.472
	26	0.544		1.099	0.600	0.150
	27	0.452		0.957	0.600	0.090
	28	0.380		0.625	0.600	0.050
	29	0.308		0.249	0.300	0.039
	30	0.308		0.227	0.230	0.042
	31	0.308		0.227	0.230	0.045

Table C.3.1 Observed Daily Runoff of Gauging Sites (2/2)

(Unit : m³/sec)

Month	Day	Wangal	Balili	Pico	Bahong	Bineng
Nov.	1	0.272		0.136	0.210	0.045
	2	0.272		0.136	0.170	0.037
	3	0.272		0.136	0.150	0.034
	4	0.235	0.950	0.113	0.150	0.026
	5	0.235	0.950	0.113	0.130	0.021
	6	0.235	0.950	0.113	0.130	0.021
	7	0.235	0.950	0.113	0.110	0.018
	8	0.199	0.860	0.091	0.110	0.018
	9	0.199	0.860	0.091	0.090	0.018
	10	0.199	0.770	0.091	0.090	0.016
	11	0.163	0.680	0.068	0.070	0.016
	12	0.163	0.590	0.068	0.070	0.016
	13	0.163	0.590	0.068	0.050	0.016
	14	0.163	0.590	0.068	0.050	0.016
	15	0.163	0.590	0.068	0.050	0.016
	16	0.163	0.500	0.068	0.050	0.013
	17	0.163	0.475	0.068	0.050	0.013
	18	0.199	0.500	0.091	0.050	0.016
	19	0.199	0.475	0.091	0.050	0.016
	20	0.199	0.475	0.091	0.050	0.016
	21	0.199	0.475	0.091	0.050	0.016
	22	0.199	0.450	0.091	0.050	0.016
	23	0.199	0.475	0.091	0.050	0.016
	24	0.199	0.450	0.091	0.050	0.016
	25	0.272	0.450	0.136	0.050	0.013
	26	0.272	0.450	0.136	0.050	0.013
	27	0.272	0.425	0.136	0.050	0.013
	28	0.235	0.400	0.113	0.050	0.013
	29	0.199	0.375	0.091	0.050	0.011
	30	0.199	0.375	0.091	0.050	0.011
Dec.	1	0.163			0.050	0.011
	2	0.163			0.050	0.011
	3	0.163			0.050	0.011
	4	0.235			0.050	0.008
	5	0.272			0.050	0.011
	6	0.272			0.045	0.011
	7	0.272			0.045	0.011
	8	0.235			0.045	0.011
	9	0.199			0.035	0.011
	10	0.199			0.035	0.008
	11	0.199			0.030	0.008
	12	0.091			0.030	0.008
	13	0.091			0.030	0.008
	14	0.091			0.030	0.008
	15	0.091			0.025	0.008
	16	0.163			0.025	0.005
	17	0.235			0.020	0.005
	18	0.235			0.020	0.005
	19	0.235			0.020	0.008
	20	0.199			0.020	0.008
	21	0.127			0.020	0.008
	22	0.127			0.020	0.008
	23	0.127			0.015	0.008
	24	0.091			0.015	0.018
	25	0.055			0.015	0.018
	26	0.055			0.015	0.011
	27	0.055			0.015	0.011
	28	0.163			0.010	0.011
	29	0.163			0.010	0.011
	30	0.163			0.010	0.011
	31	0.163			0.010	0.011

Table C.3.2 Estimated Runoff of the Balili River (31.4 sq.km)

(Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1977	0.78	0.58	1.19	0.93	3.27	4.36	12.00	20.74	31.55	7.79	4.44	1.48
1978	0.87	0.64	0.64	0.57	4.32	9.63	13.09	27.77	13.35	6.86	2.66	1.92
1979	0.94	0.63	0.62	1.04	8.30	6.60	13.96	21.98	6.91	5.74	1.31	0.96
1980	0.70	0.54	0.54	0.47	22.09	6.03	27.52	8.13	15.31	6.04	24.77	2.11
1981	1.12	0.71	0.69	1.29	4.62	17.37	12.57	26.52	17.98	8.14	6.52	2.04
1982	0.99	0.68	0.68	2.26	5.66	7.71	30.89	24.10	15.20	6.91	3.22	1.31
1983	1.01	0.70	0.68	0.59	1.91	5.87	5.67	21.89	8.44	4.47	2.76	1.03
1984	0.65	0.52	0.55	2.19	7.71	7.13	9.12	29.13	12.23	7.97	2.84	1.08
1985	0.77	0.59	0.67	1.56	6.59	26.54	10.42	32.43	15.25	5.48	3.69	1.63
1986	0.93	0.68	0.68	0.65	8.05	7.41	27.54	23.98	25.65	4.22	1.70	1.10
1987	0.80	0.65	0.64	0.59	2.99	8.22	5.50	13.92	12.28	11.03	2.83	1.10
Average	0.9	0.6	0.7	1.1	6.9	9.7	15.3	22.8	15.8	6.8	5.2	1.4

Annual Runoff Coefficient

Year	Max.Daily Runoff (cu.m/s)	Min.Daily Runoff (cu.m/s)	Ave.Daily Runoff (cu.m/s)	Annual Runoff (MCM)	Annual Runoff (mm)	Annual Rainfall (mm)	Runoff Coeff. (%)
1977	54.425	0.212	2.826	89.12	2838.2	3676.8	77.2
1978	56.364	0.191	2.611	82.33	2621.9	3406.3	77.0
1979	35.274	0.207	2.188	69.01	2197.6	2903.4	75.7
1980	86.150	0.167	3.613	114.24	3638.4	4524.0	80.4
1981	43.179	0.227	3.157	99.56	3170.7	3987.7	79.5
1982	34.509	0.239	3.159	99.62	3172.5	4033.6	78.7
1983	34.958	0.197	1.744	55.01	1751.8	2372.6	73.8
1984	47.534	0.174	2.566	81.13	2583.7	3428.7	75.4
1985	42.779	0.195	3.349	105.60	3363.0	4362.4	77.1
1986	71.531	0.207	3.253	102.59	3267.3	4057.7	80.5
1987	40.651	0.192	1.920	60.54	1928.0	2574.9	74.9

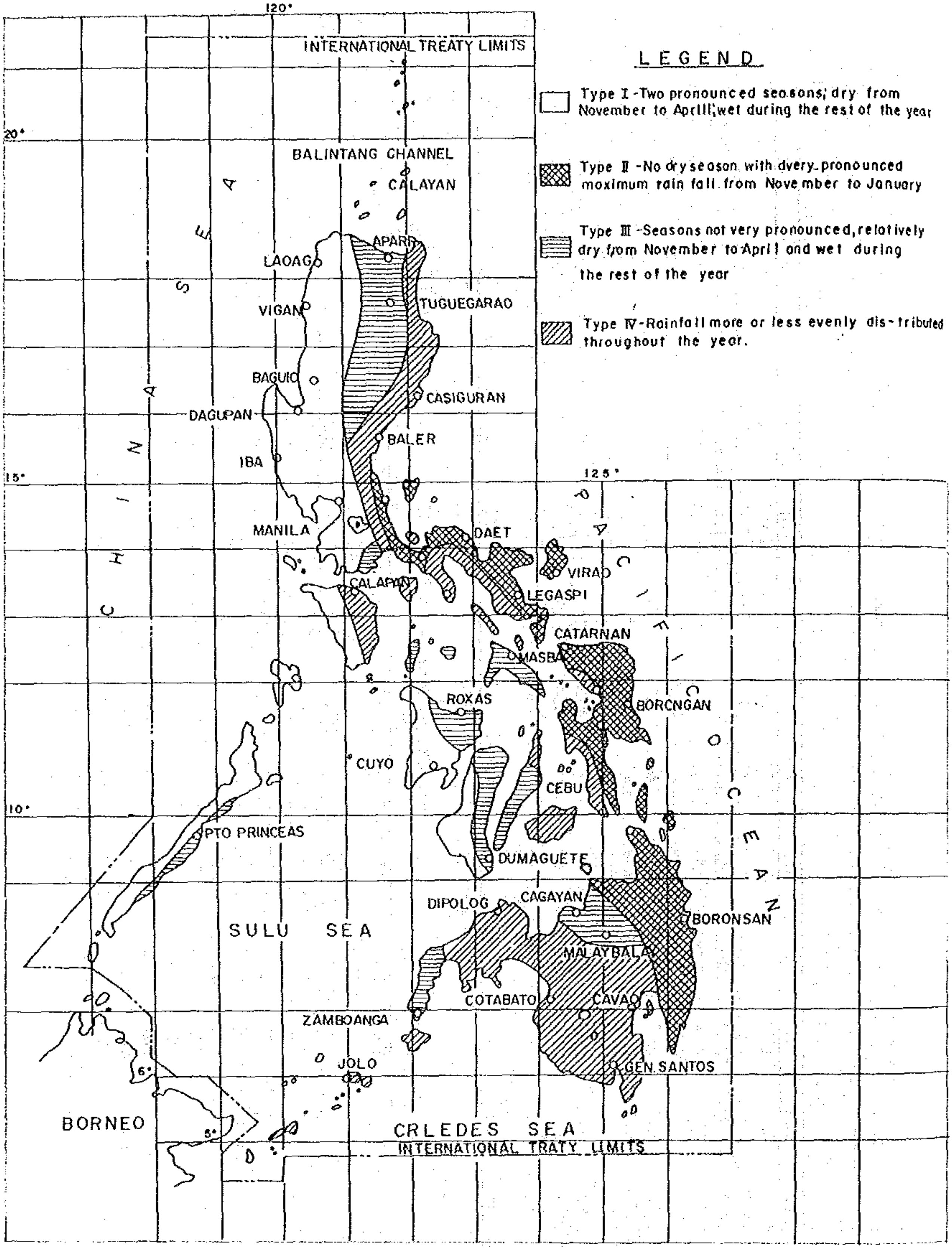

Fig.C.1.1 Climate Map of the Philippines

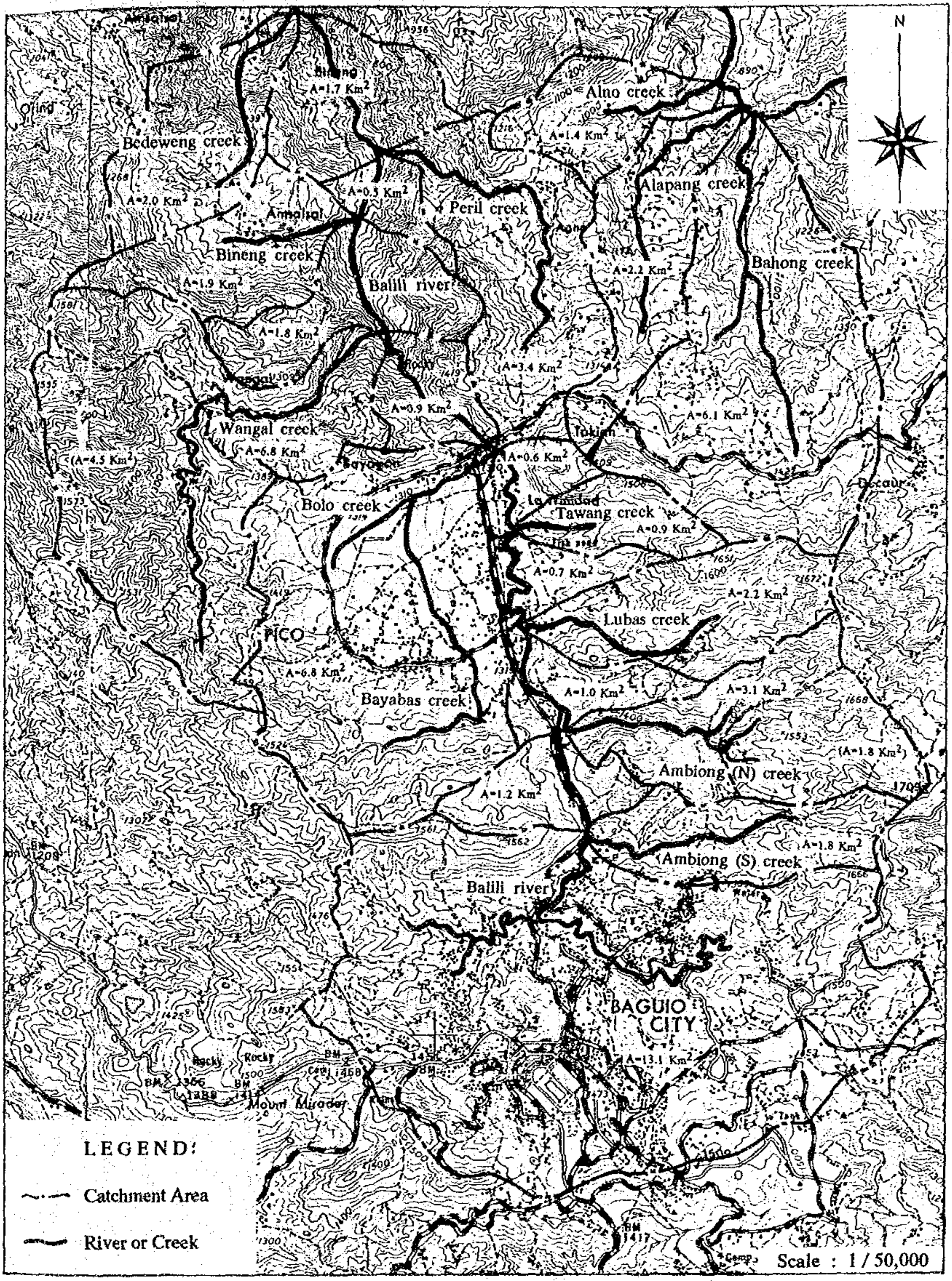

Fig.C.1.2 River System of Balili River Basin

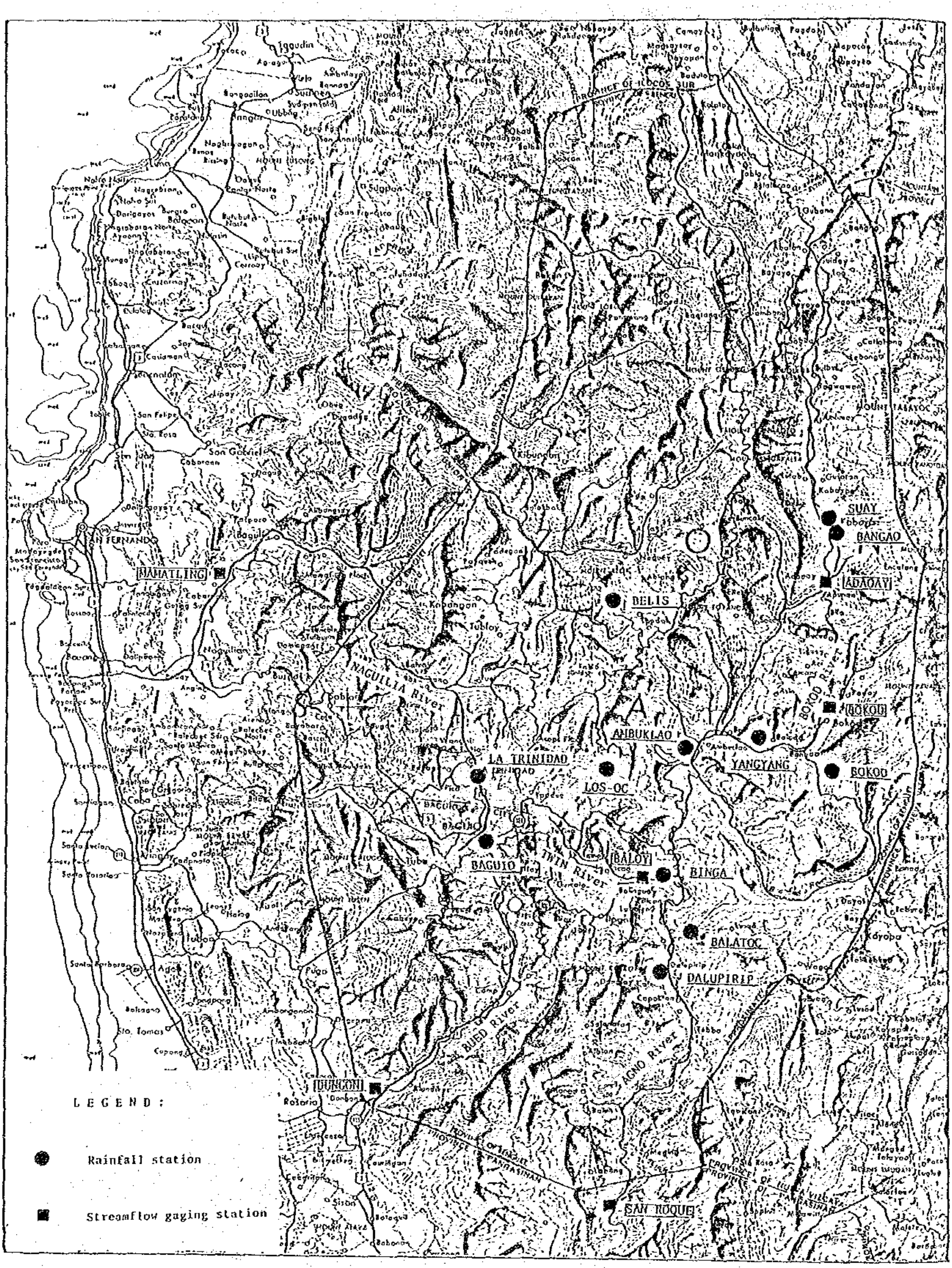

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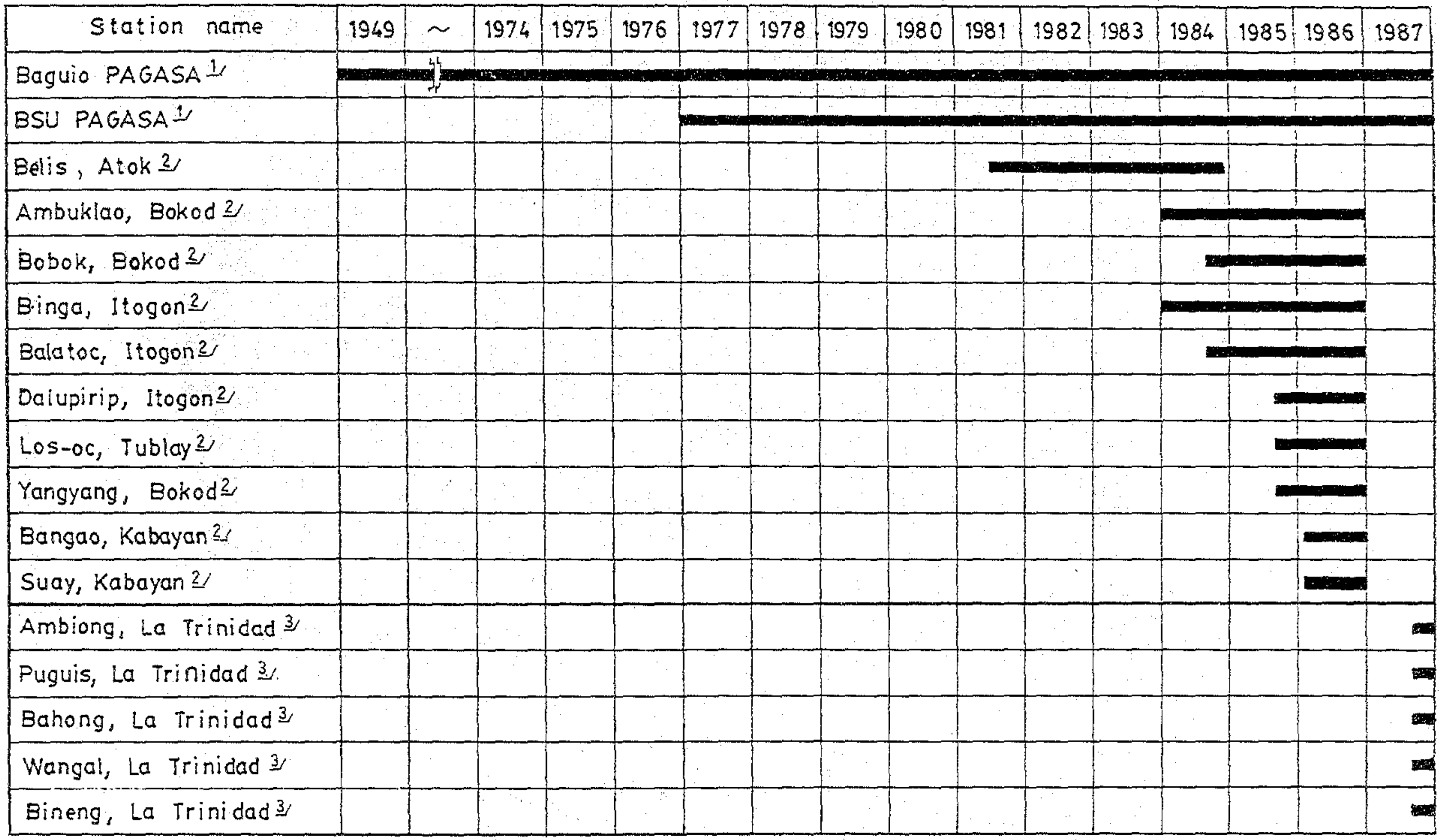
Fig.C.2.1 Location of Existing Rainfall and Streamflow Stations

Fig.C.2.2 Collected Meteorological Data



1/ : Meteorological data 2/ : Rainfall data only 3/ : Rainfall data only, observed by JICA team

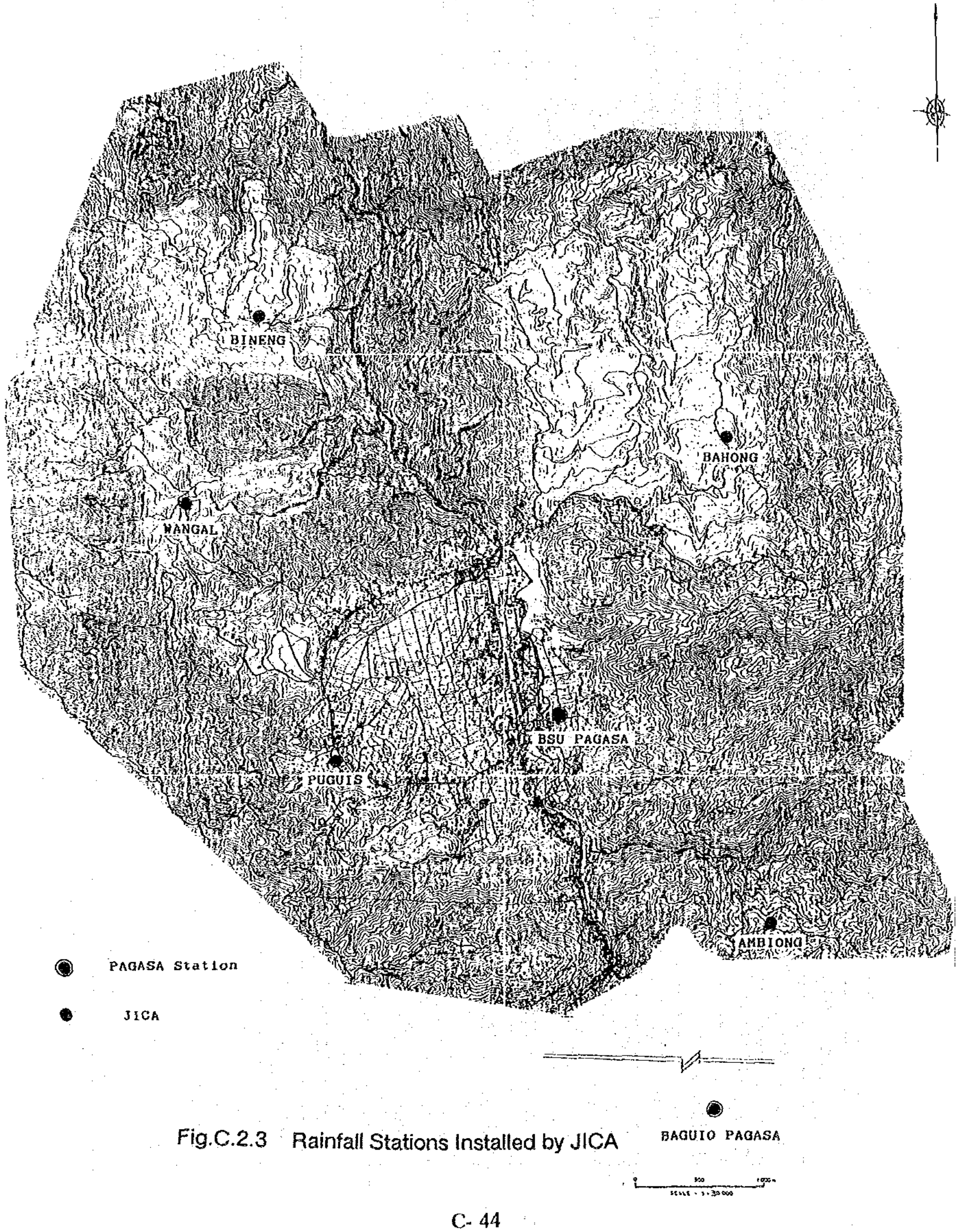


Fig.C.2.3 Rainfall Stations Installed by JICA

Correlation
Coefficient : 0.97

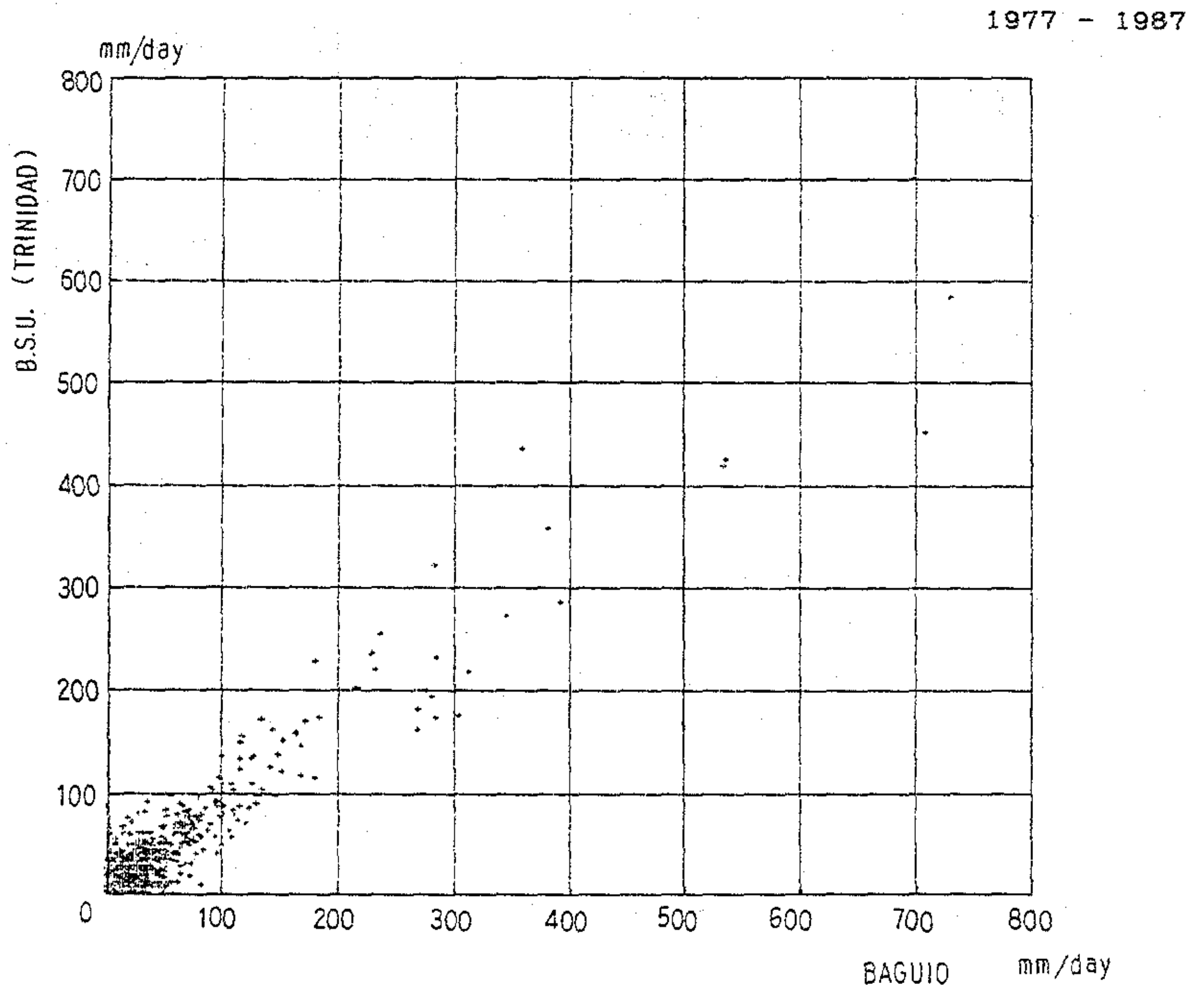


Fig.C.2.4 Correlation Relation of Daily Rainfall between Baguio Station and BSU Station

Fig. C.2.5 Accumulation of Observed Rainfall

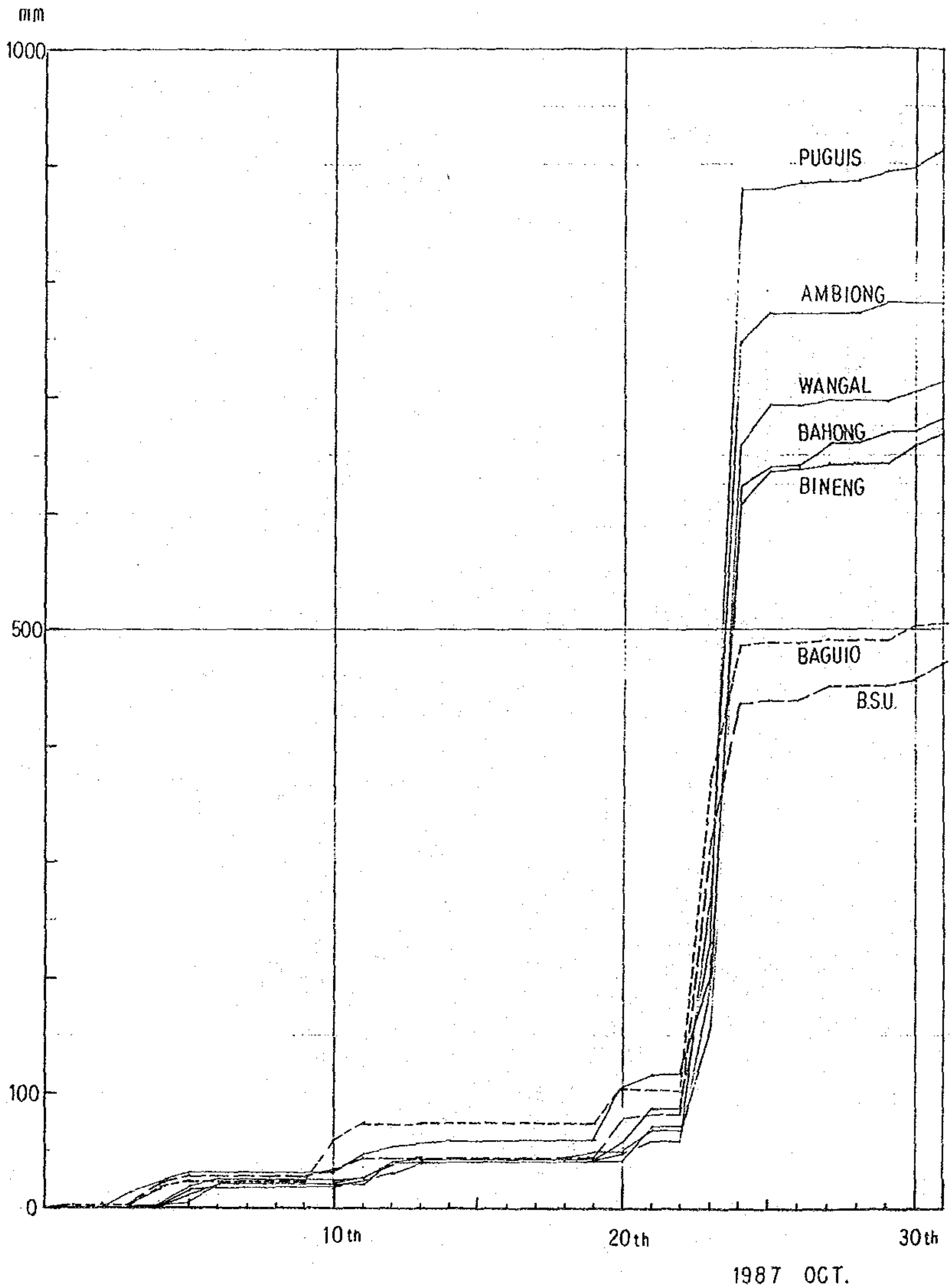
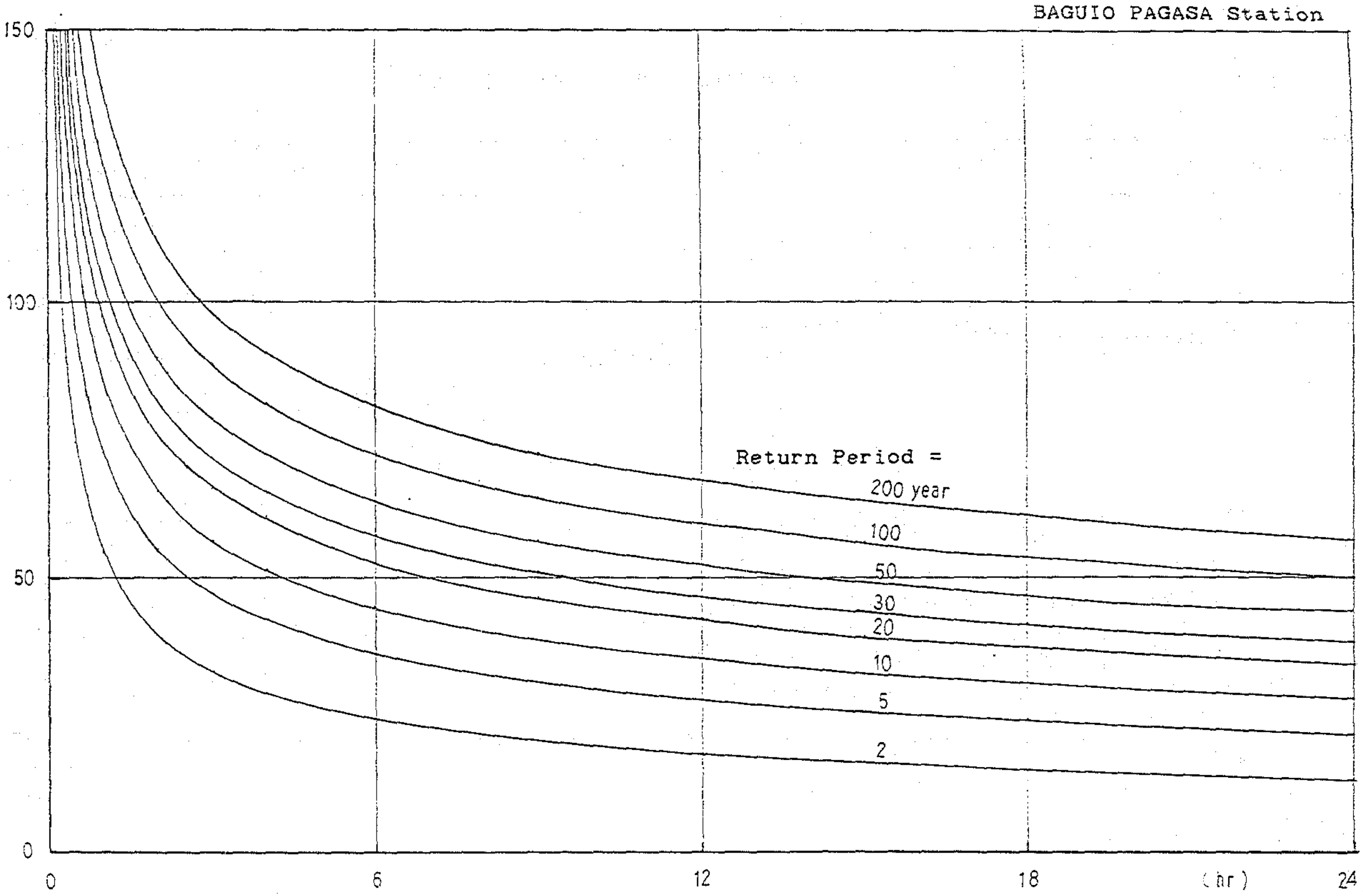


Fig.C.2.6 Probable Rainfall Intensity Curve



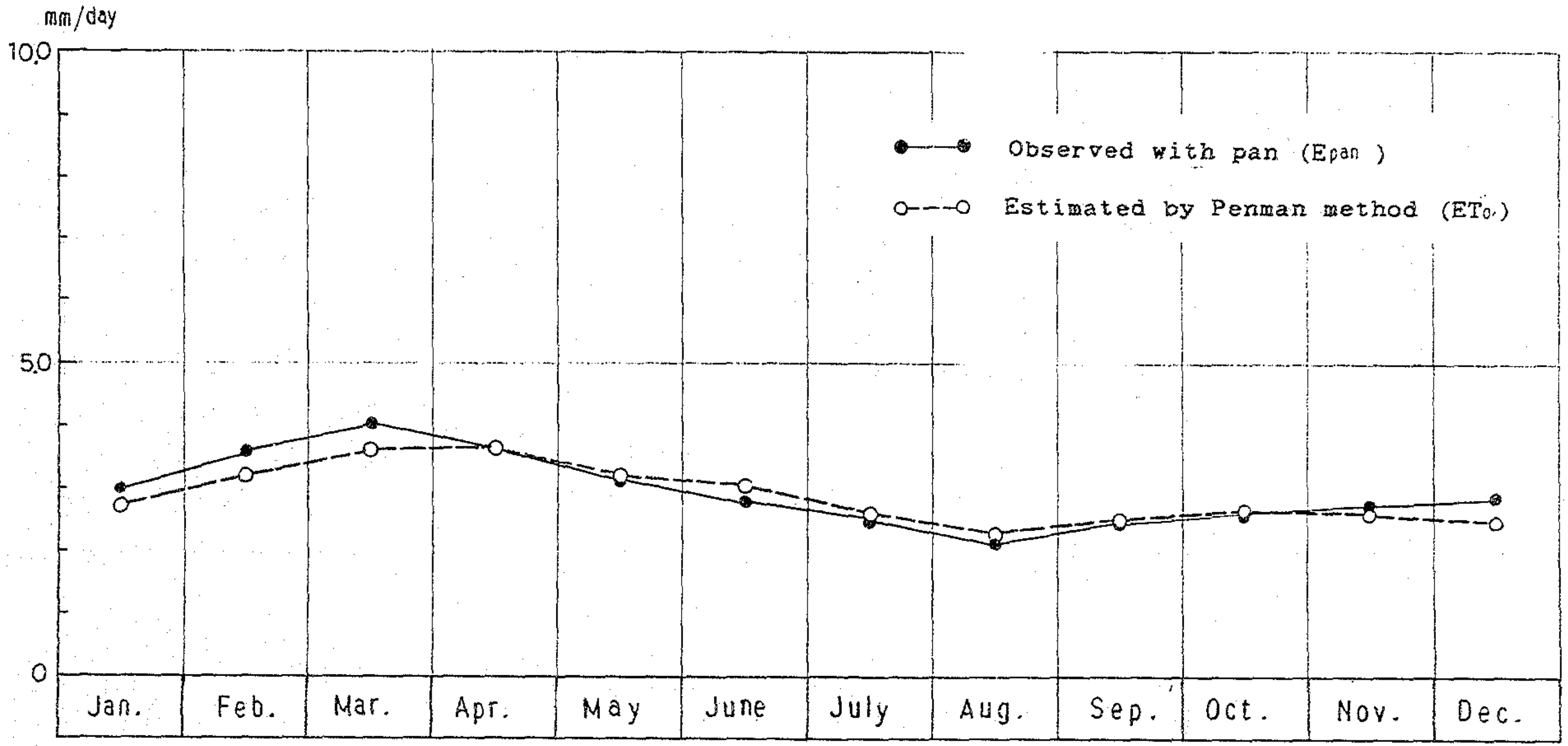


Fig.C.2.7 Comparison of Evaporation

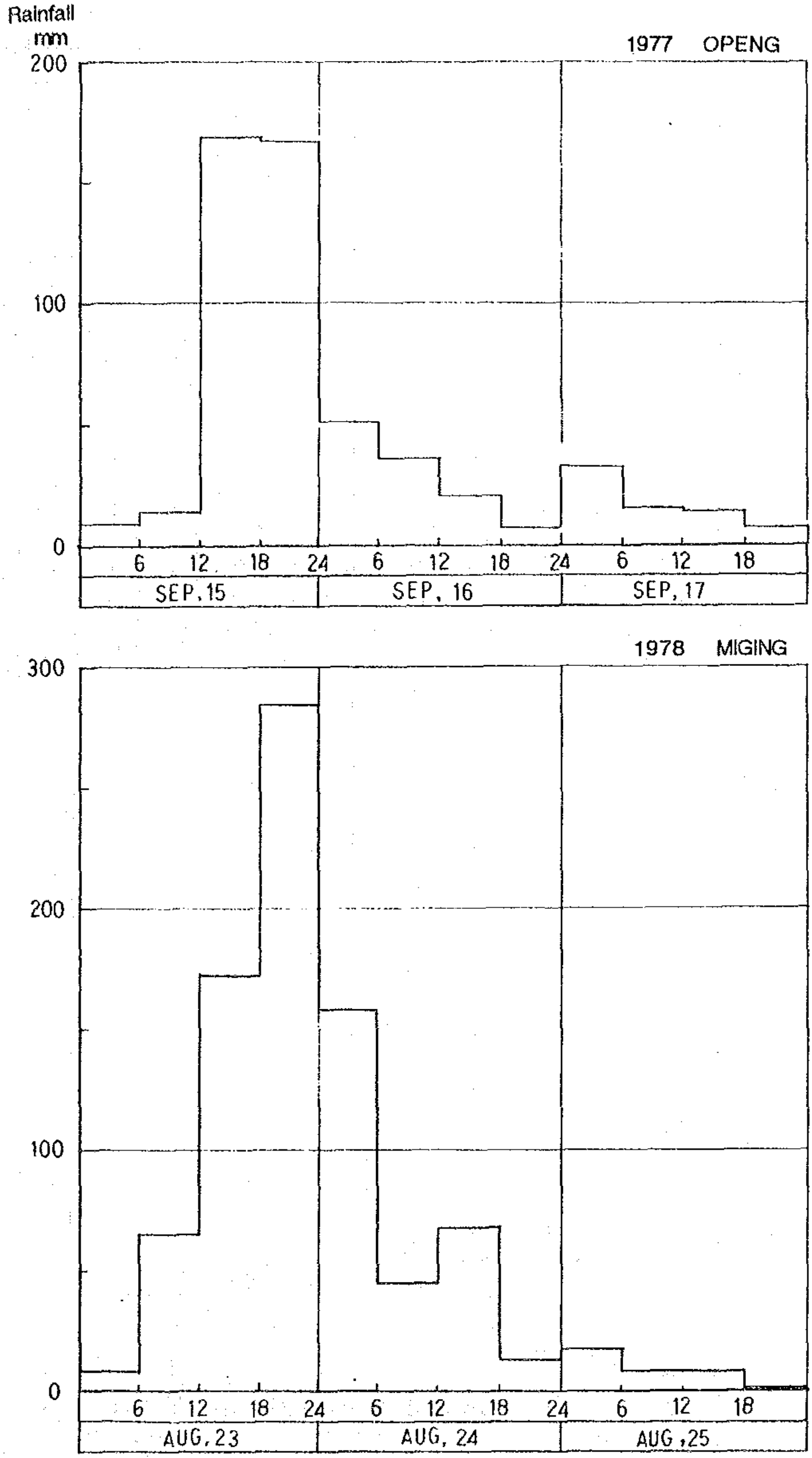


Fig.C.2.8 Hyetograph in Most Severe Typhoon (1/5)

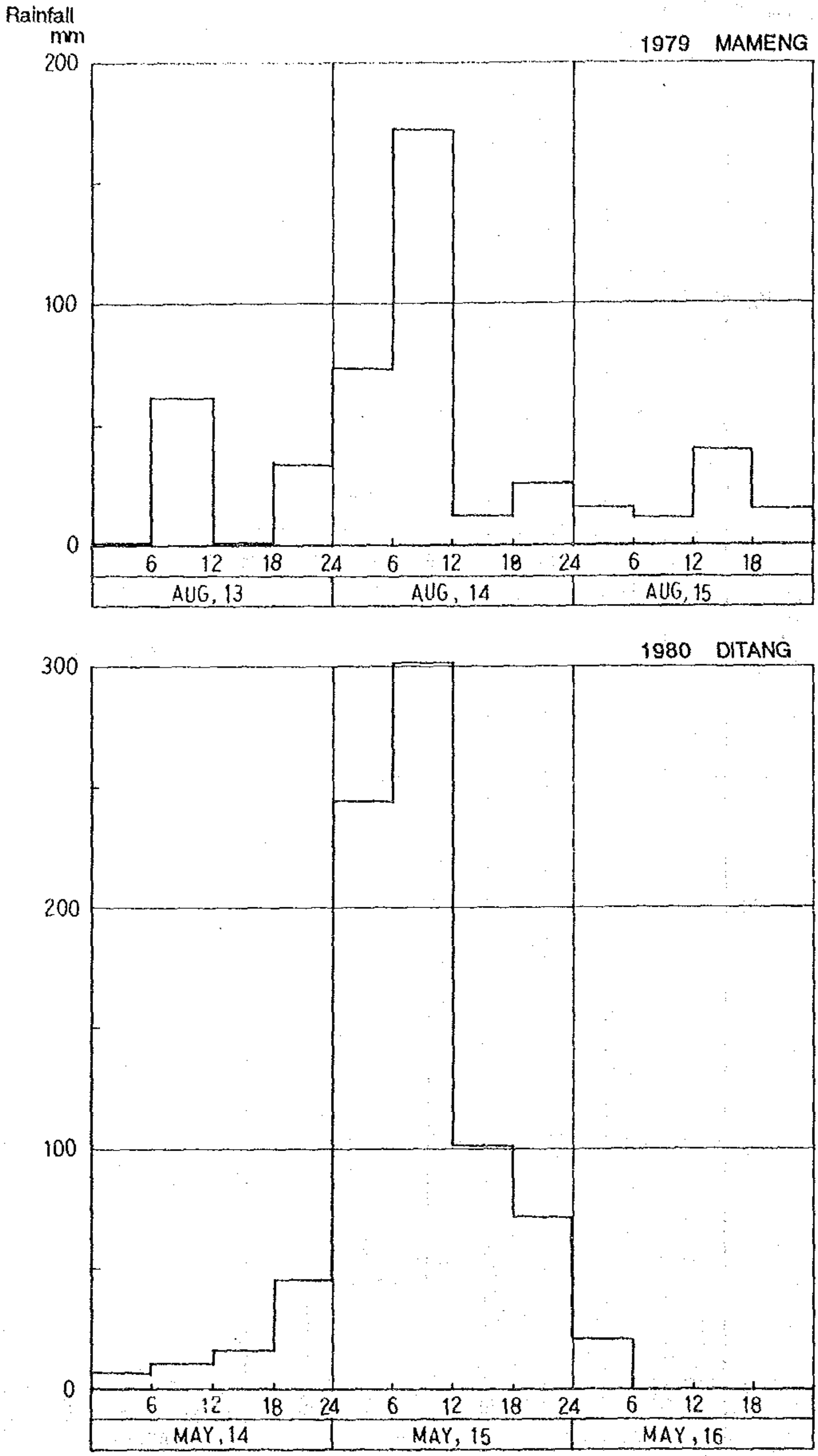


Fig.C.2.8 Hyetograph in Most Severe Typhoon (2/5)

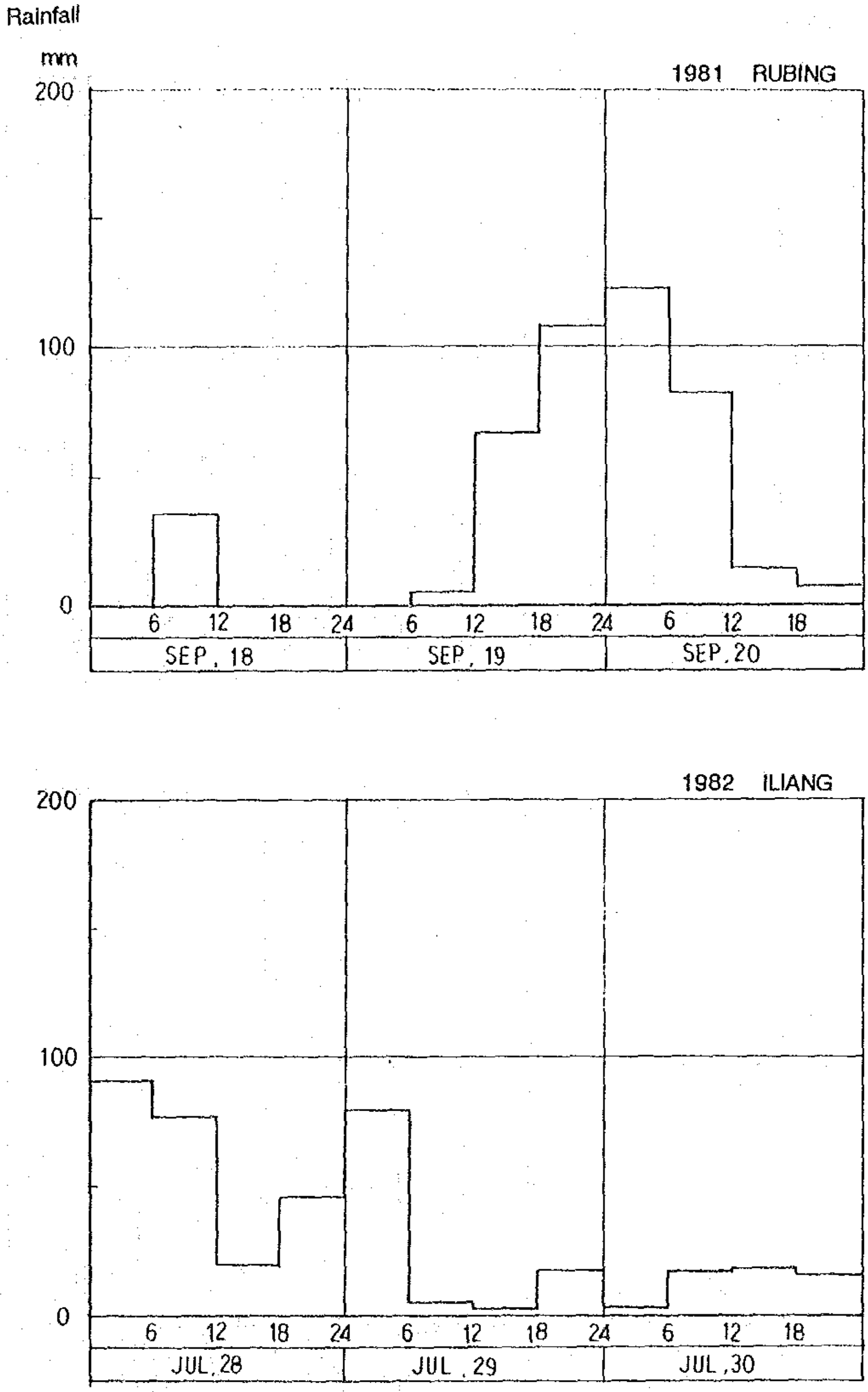
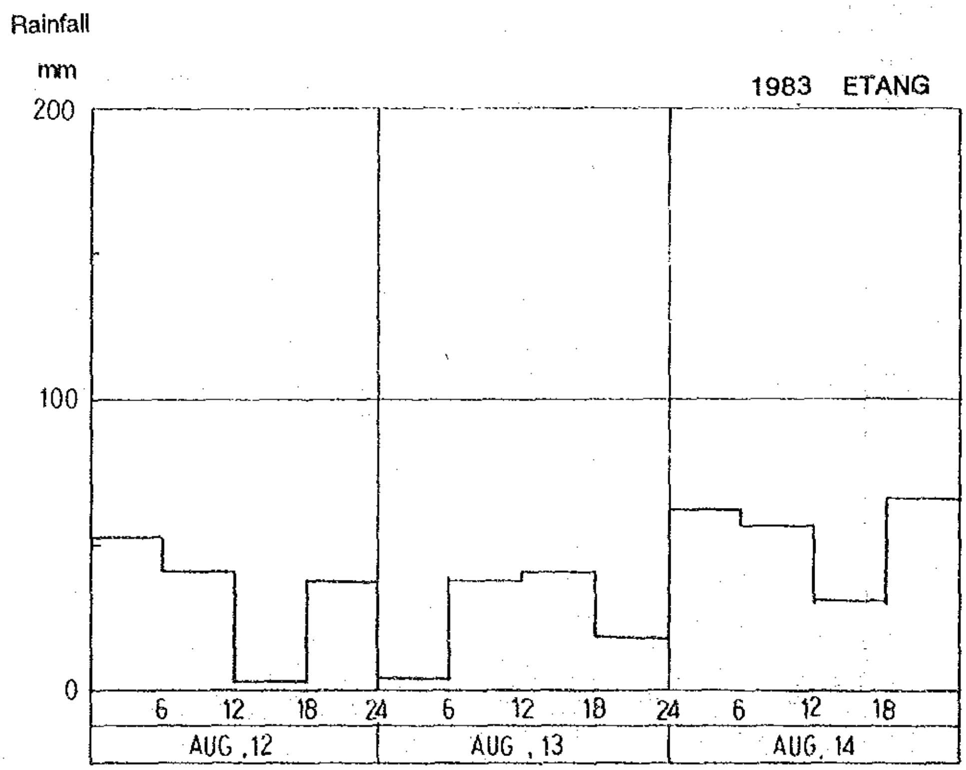


Fig.C.2.8 Hyetograph in Most Severe Typhoon (3/5)



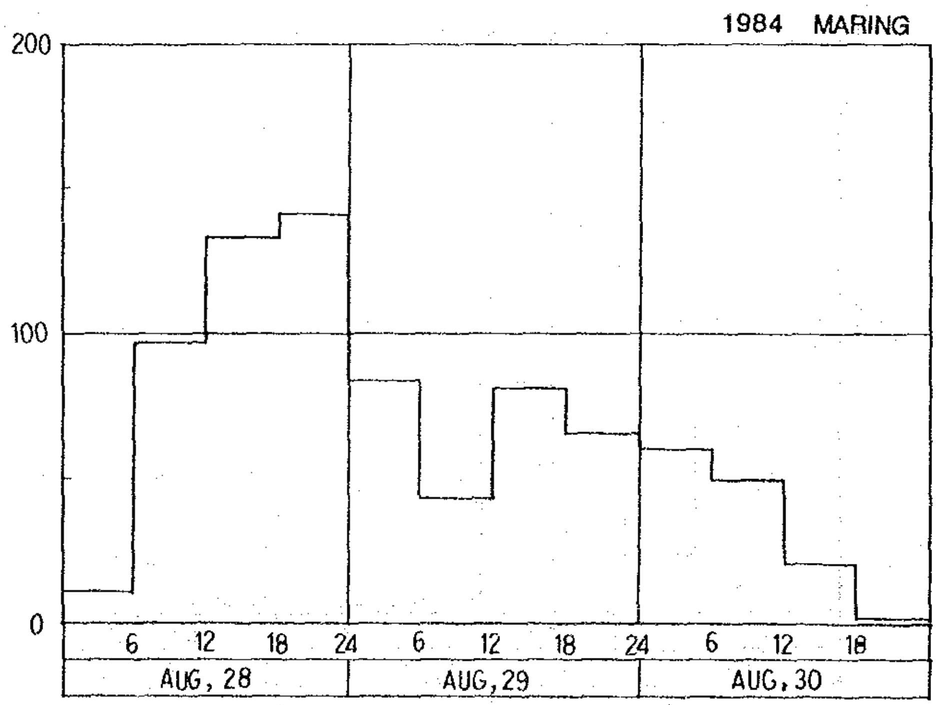
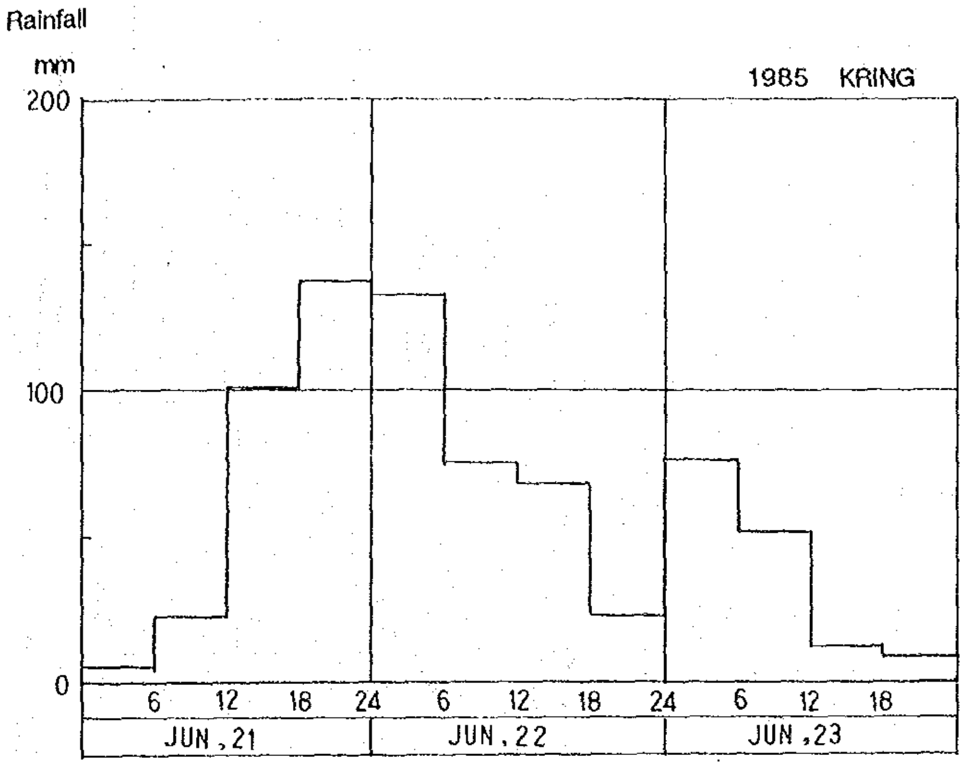


Fig.C.2.8 Hyetograph in Most Severe Typhoon (4/5)



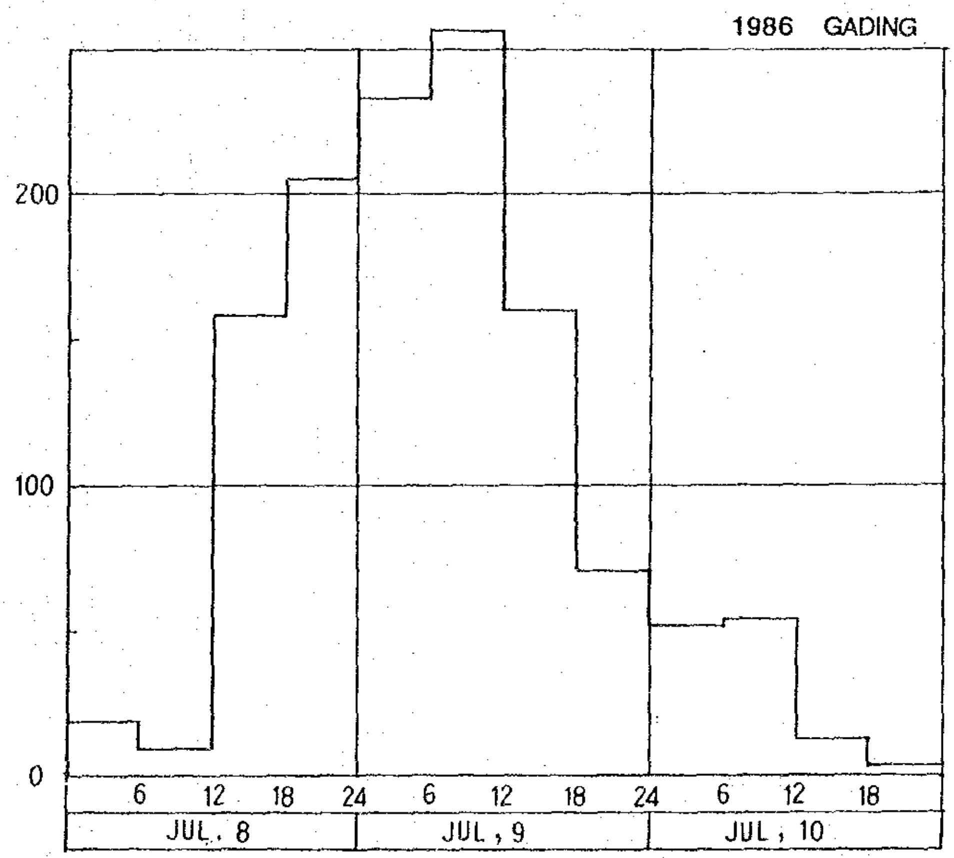


Fig.C.2.8 Hyetograph in Most Severe Typhoon (5/5)

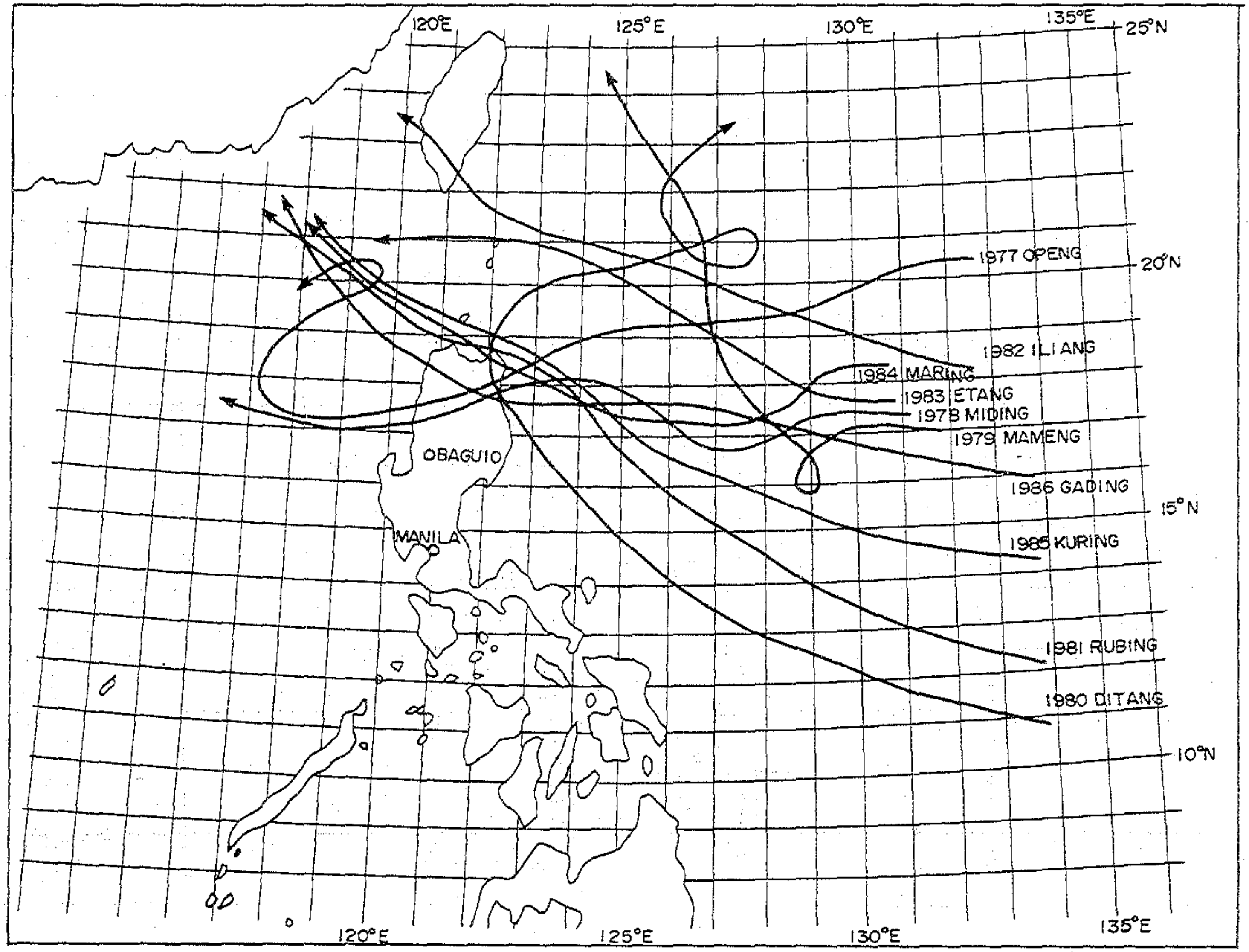
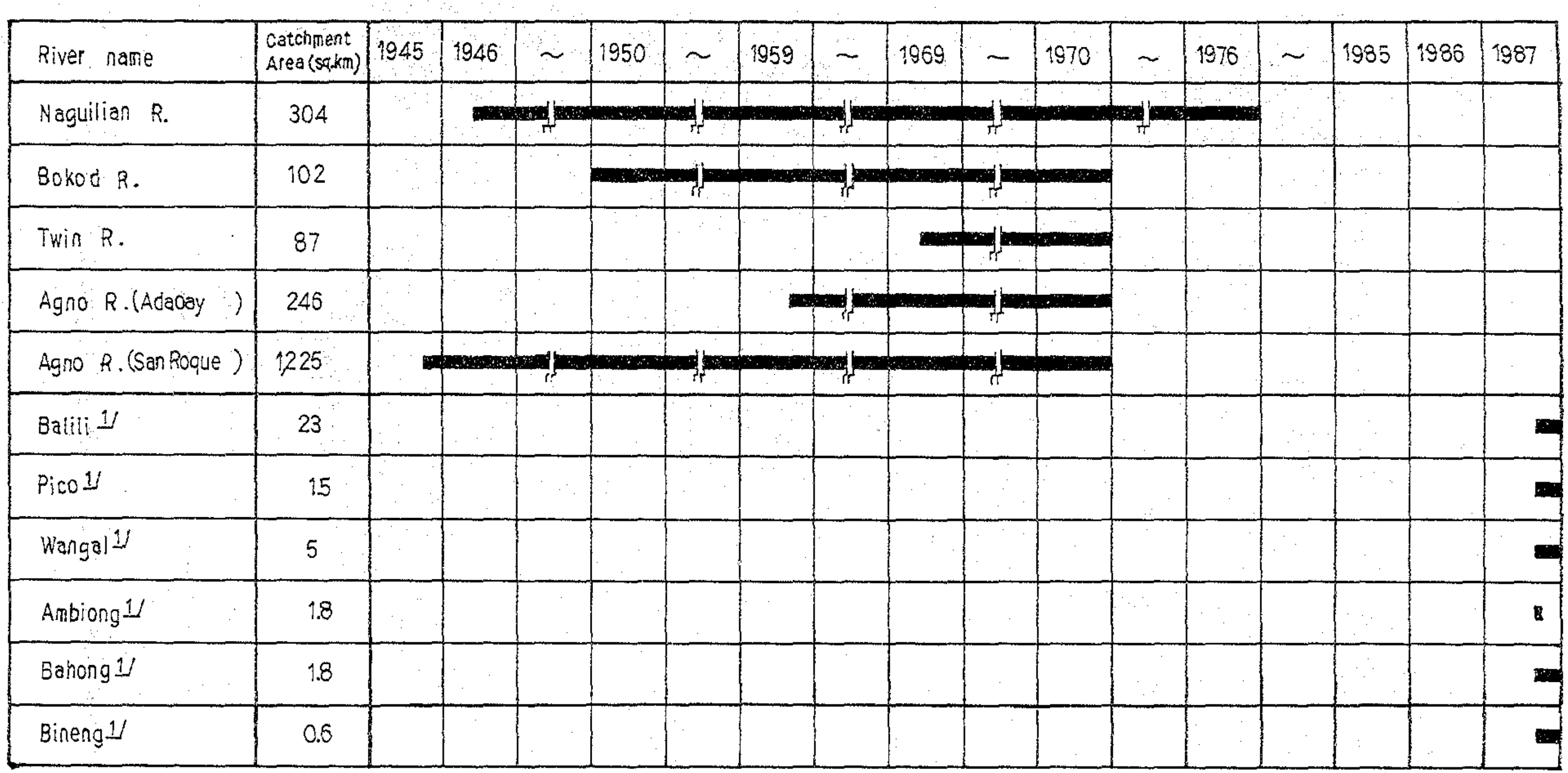
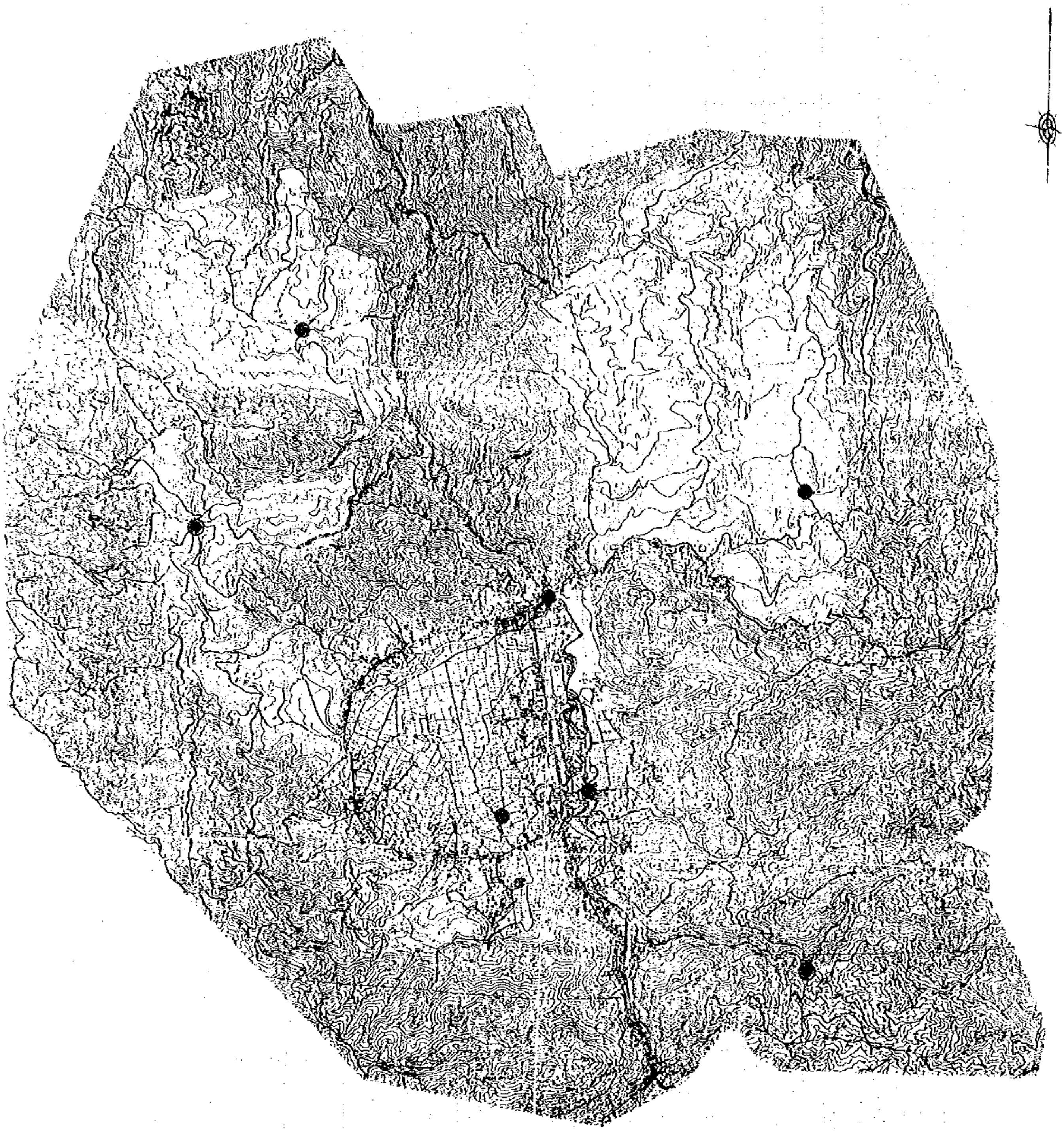


Fig.C.2.9 Tracks of Most Severe Typhoons in Last 10 Years



1/: Observed by JICA team

Fig. C.3.1 Collected Stream Flow Data

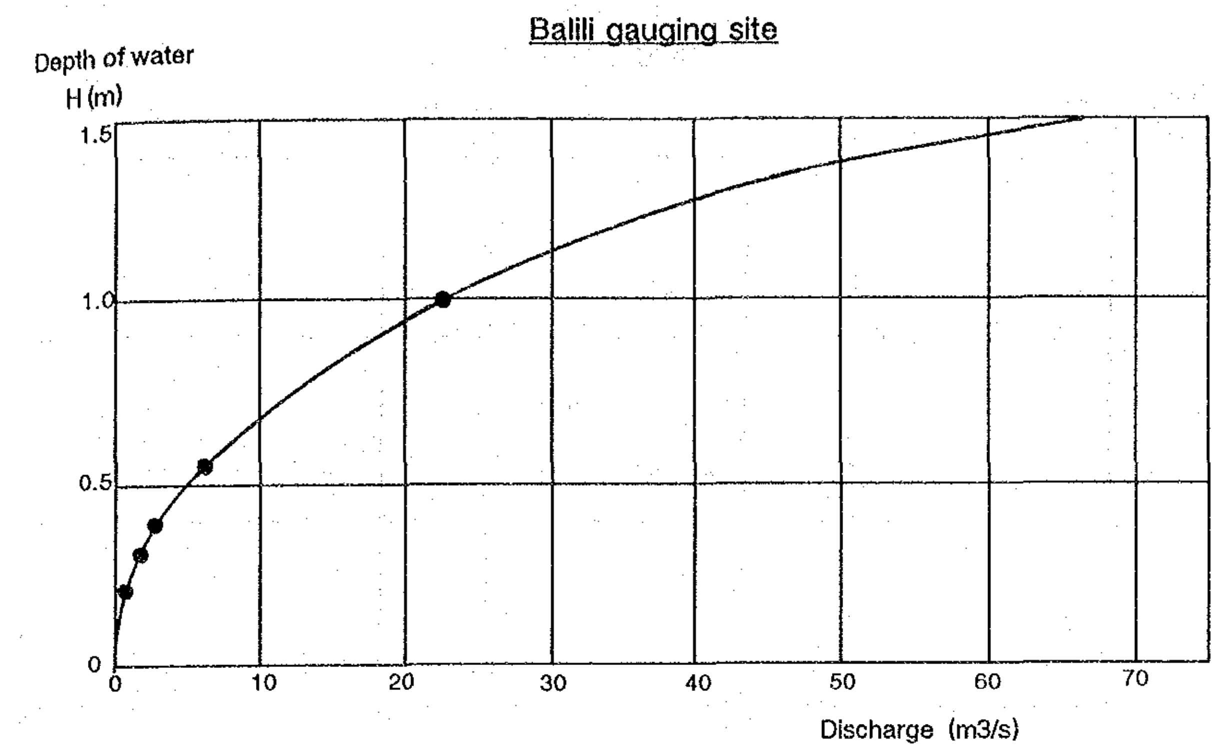


Automatic Water Level Gauge 2 points

Staff Gauge 5 points

Fig.C.3.2 Location Map of Gauging Sites

0 500 1000 m



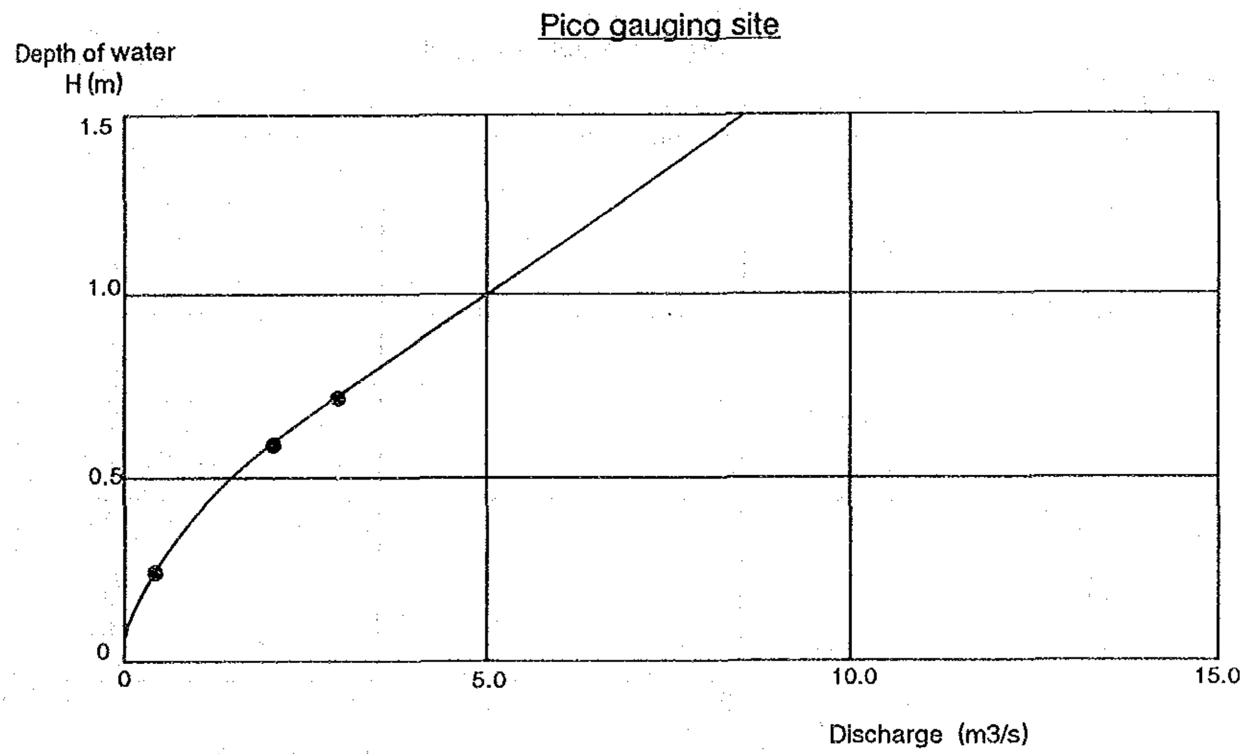
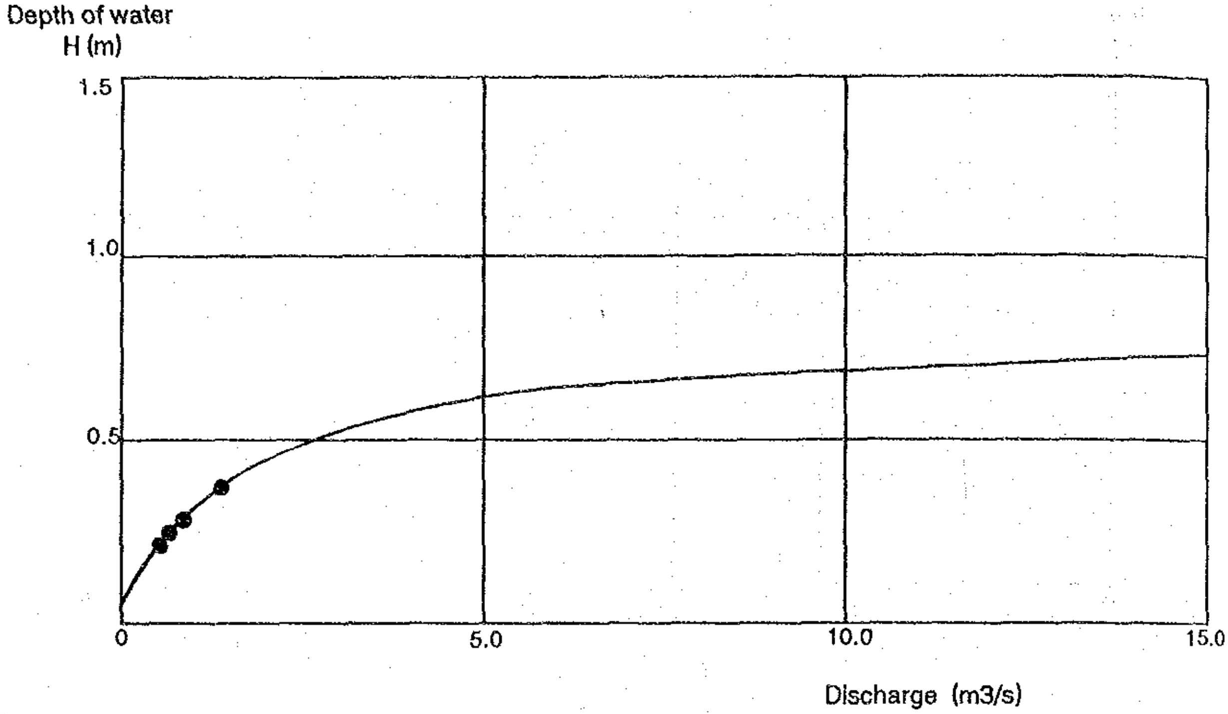


Fig. C.3.3 Rating Curve of Gauging Site in the Project Area (1/3)

Wangal gauging site



Ambiong gauging site

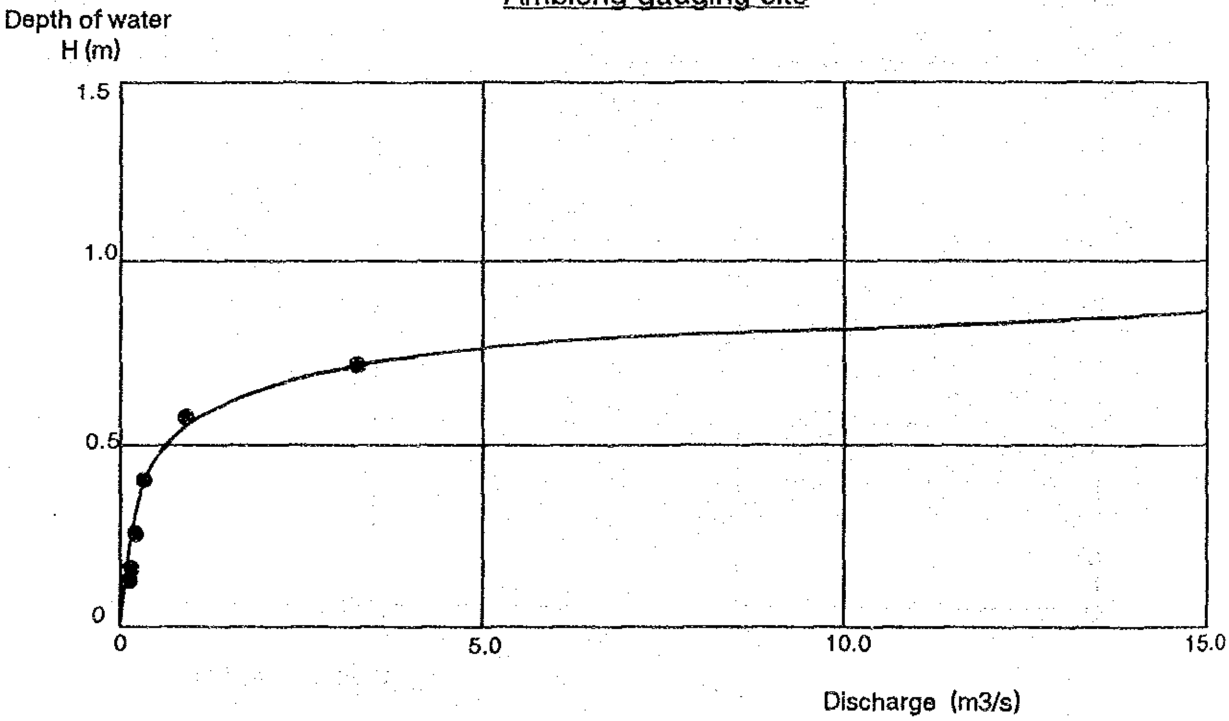
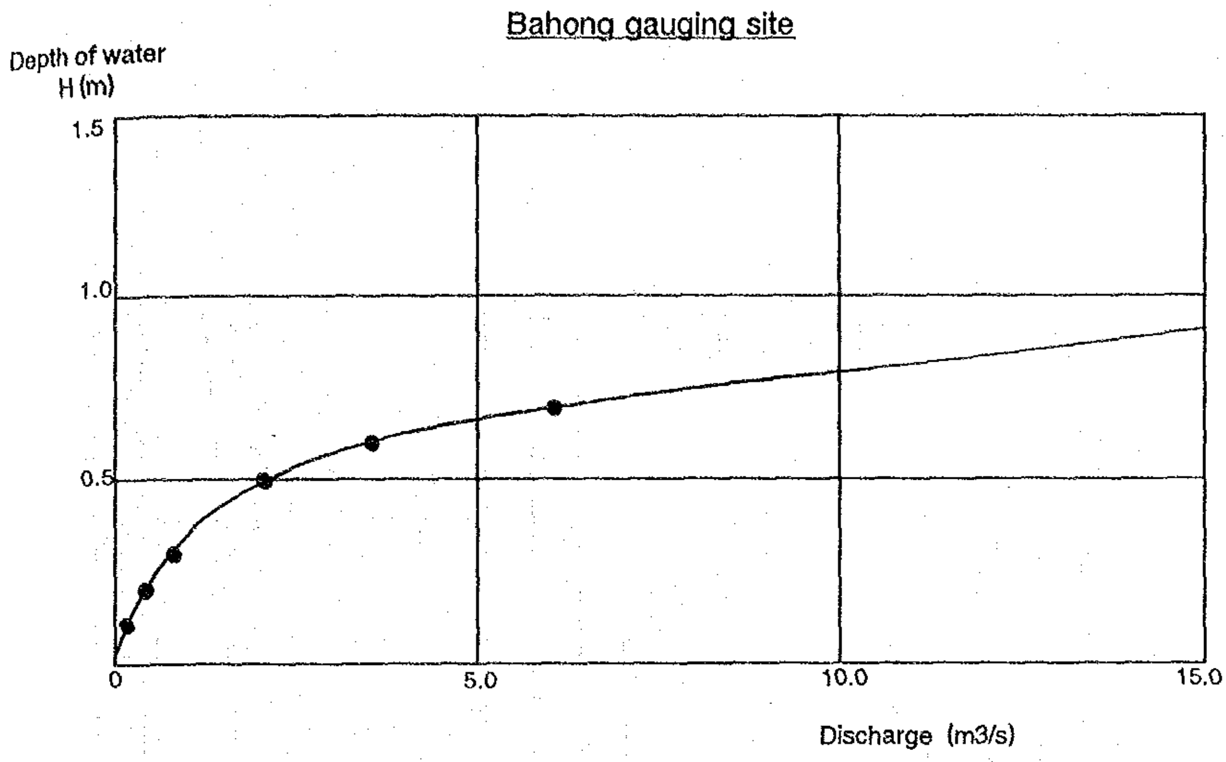


Fig. C.3.3 Rating Curve of Gauging Site in the Project Area (2/3)



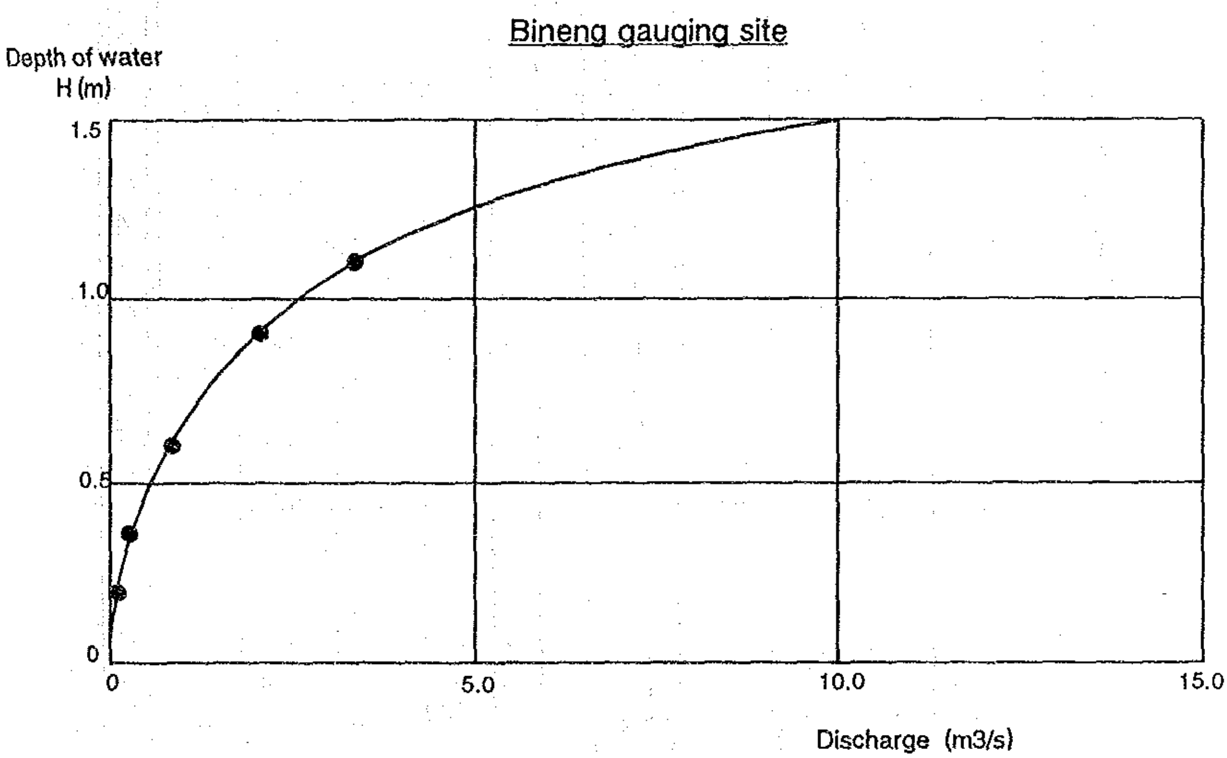


Fig. C.3.3 Rating Curve of Gauging Site in the Project Area (3/3)

Fig.C.3.4 Comparison of Estimate Runoff and Observed Runoff (1/5)

Gauging Site : Wangal, Catchment Area : 5.0 km^2

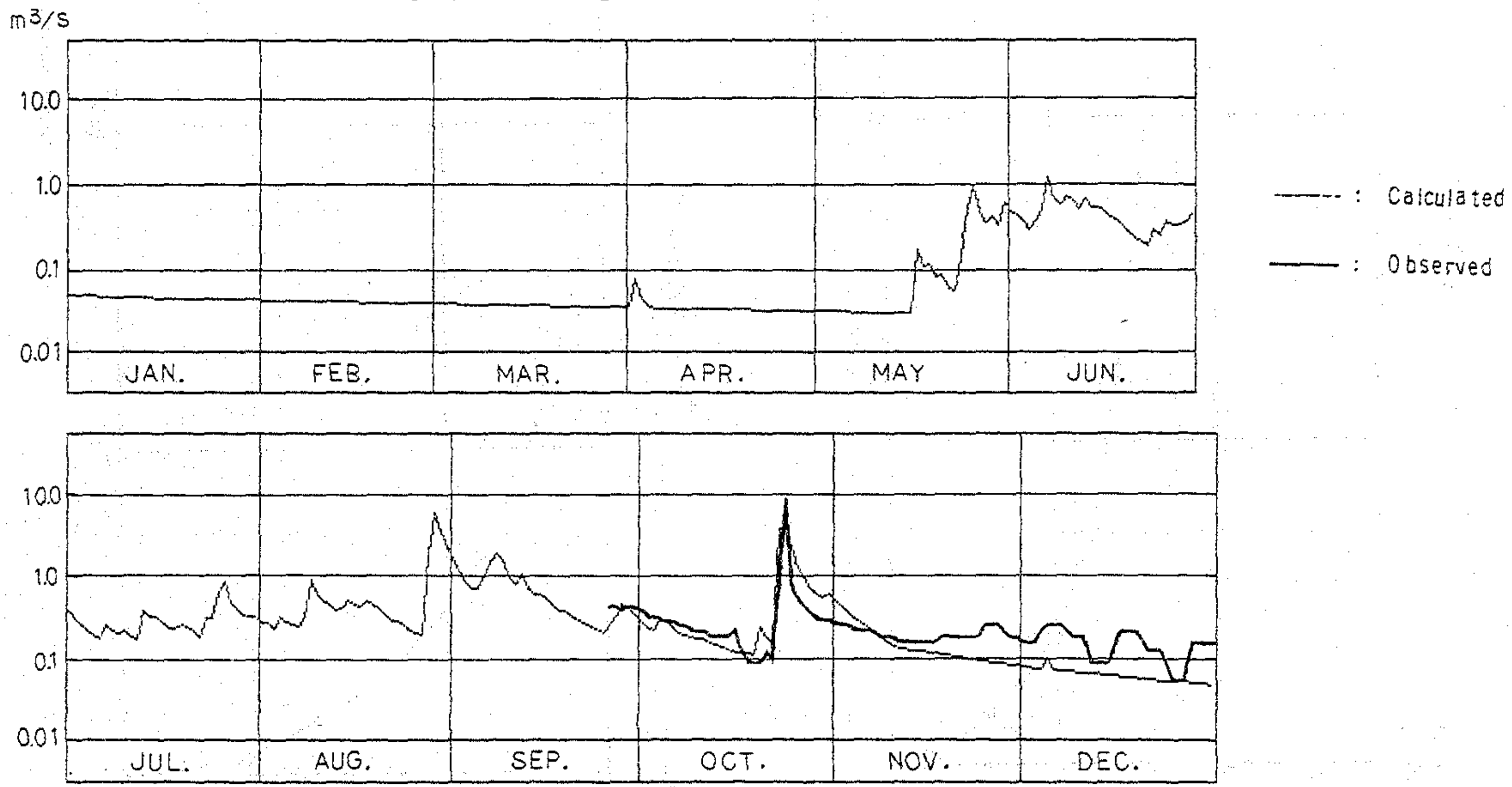


Fig.C.3.4 Comparison of Estimate Runoff and Observed Runoff (2/5)

Gauging Site : Balili, Catchment Area : 23.0 km^2

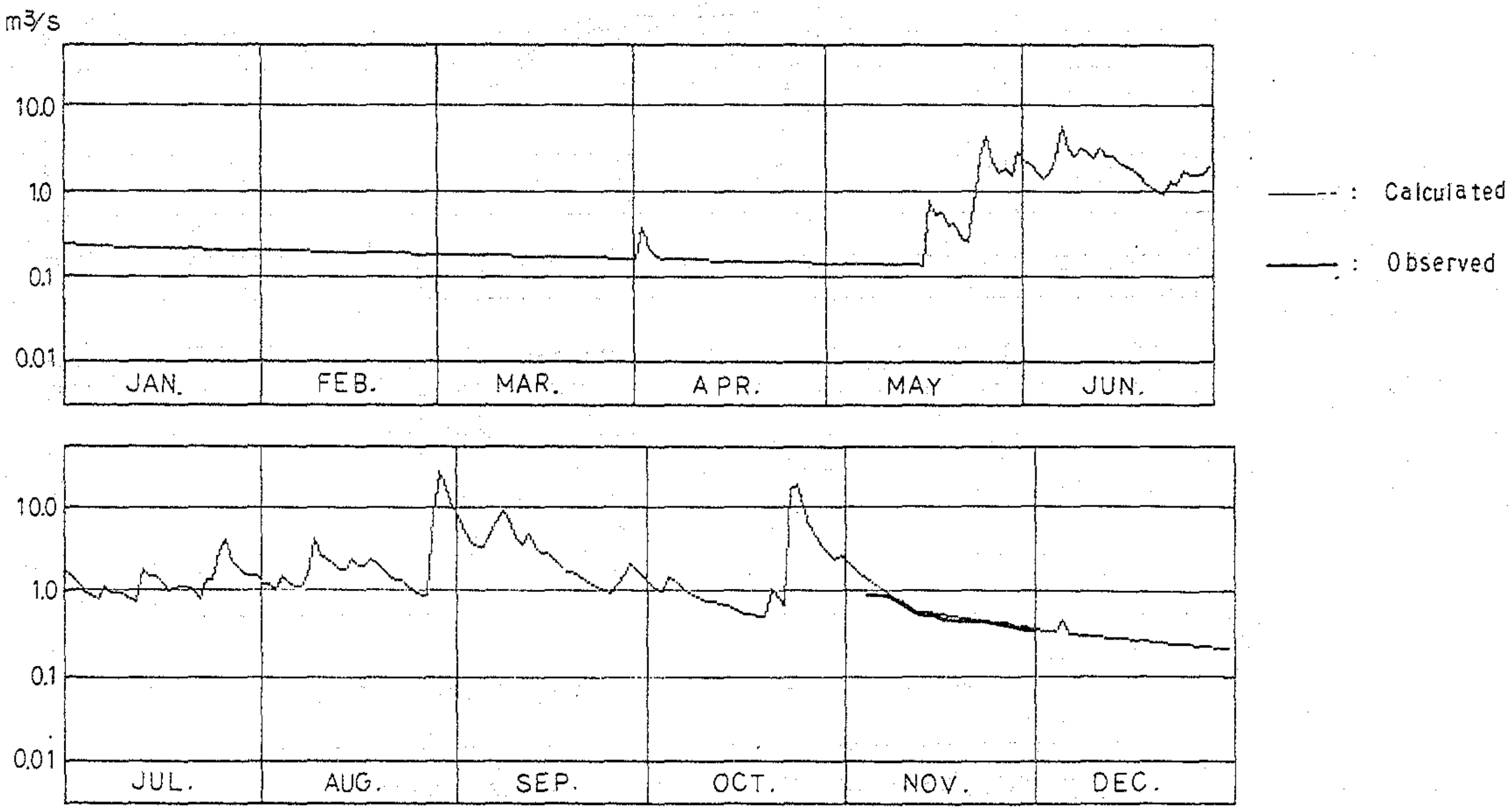


Fig.C.3.4 Comparison of Estimate Runoff and Observed Runoff (3/5)

Gauging Site : Bineng, Catchment Area : 0.6 km^2

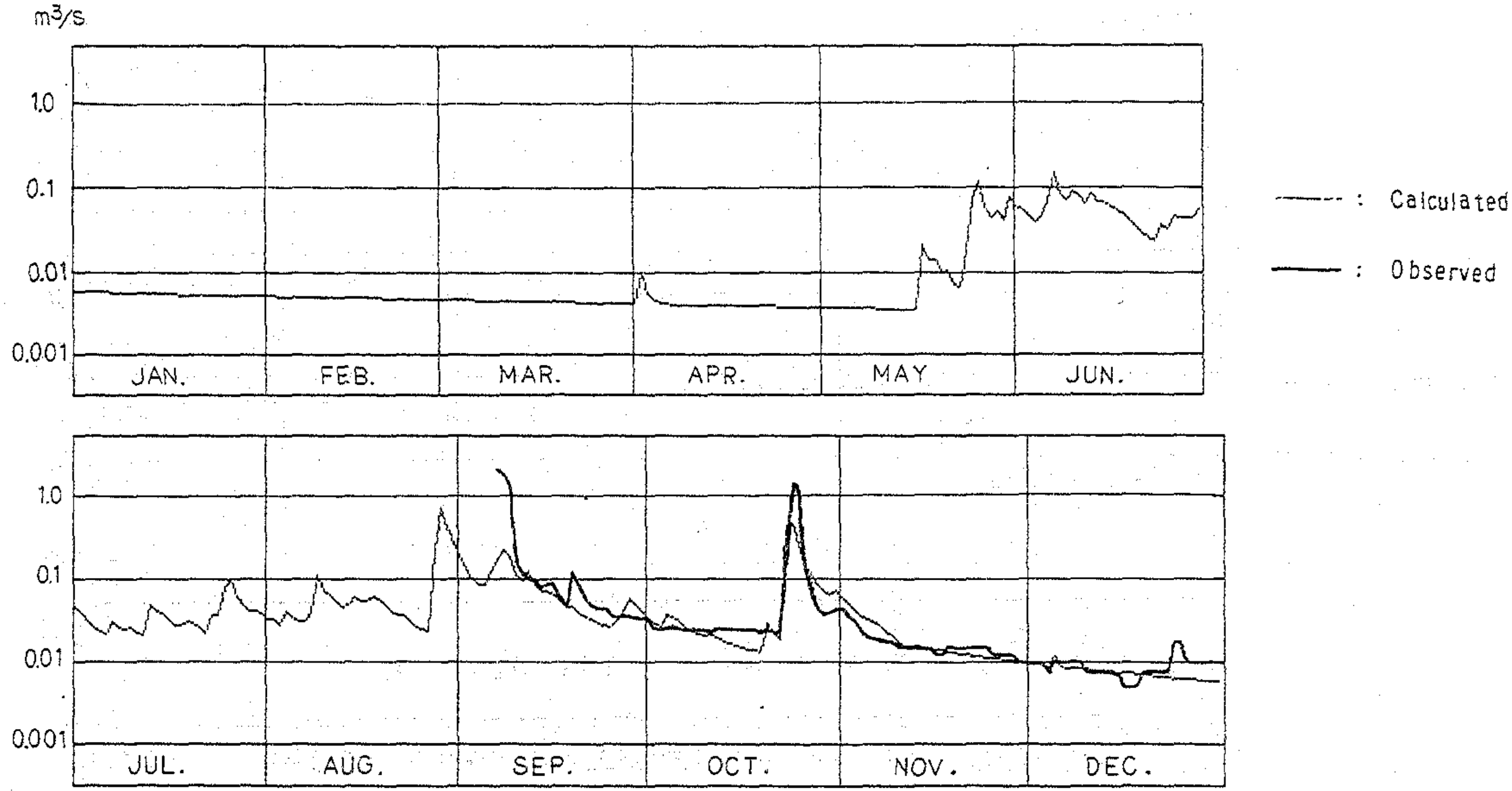


Fig.C.3.4 Comparison of Estimate Runoff and Observed Runoff (4/5)

Gauging Site : Pico, Catchment Area : 1.5 km^2

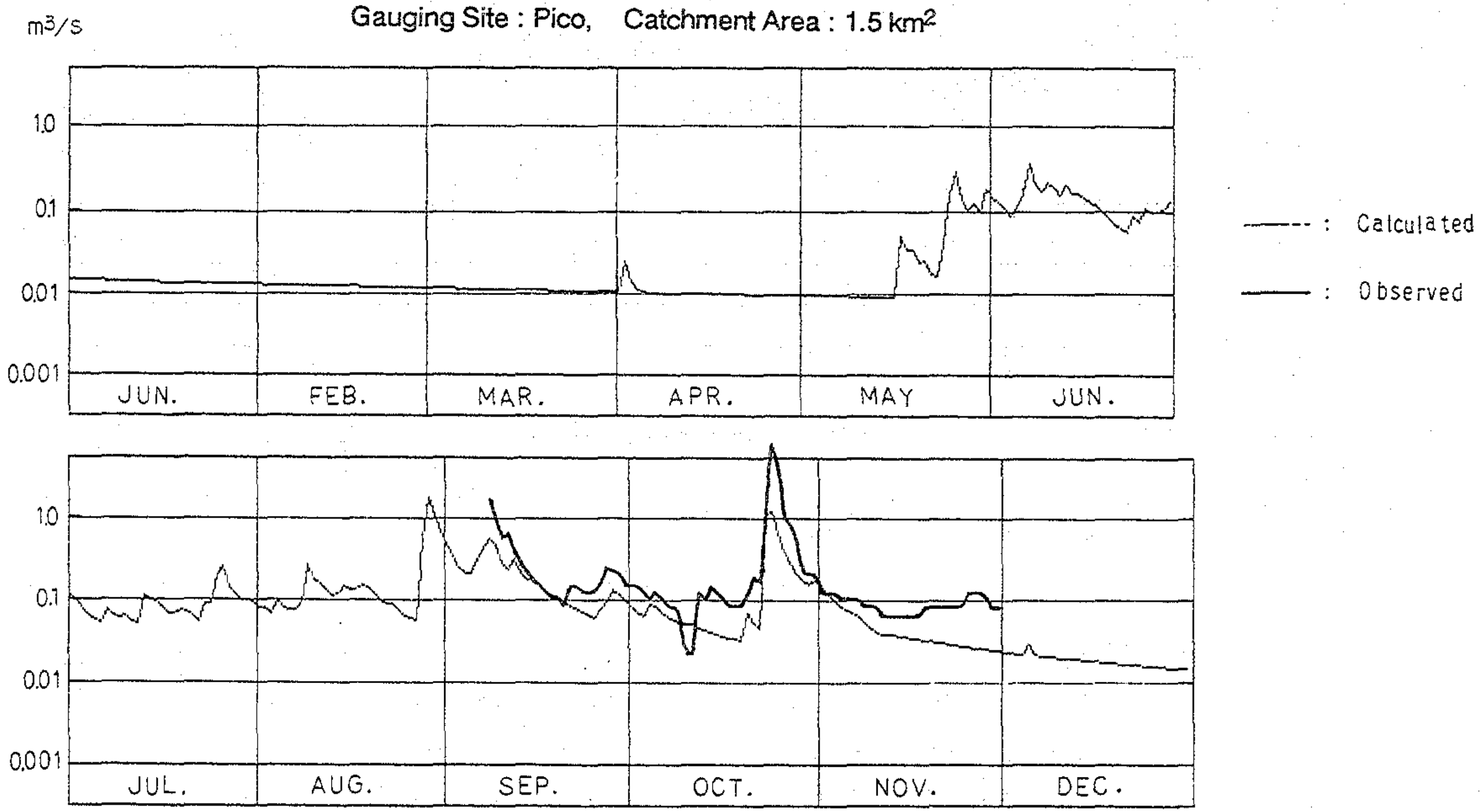
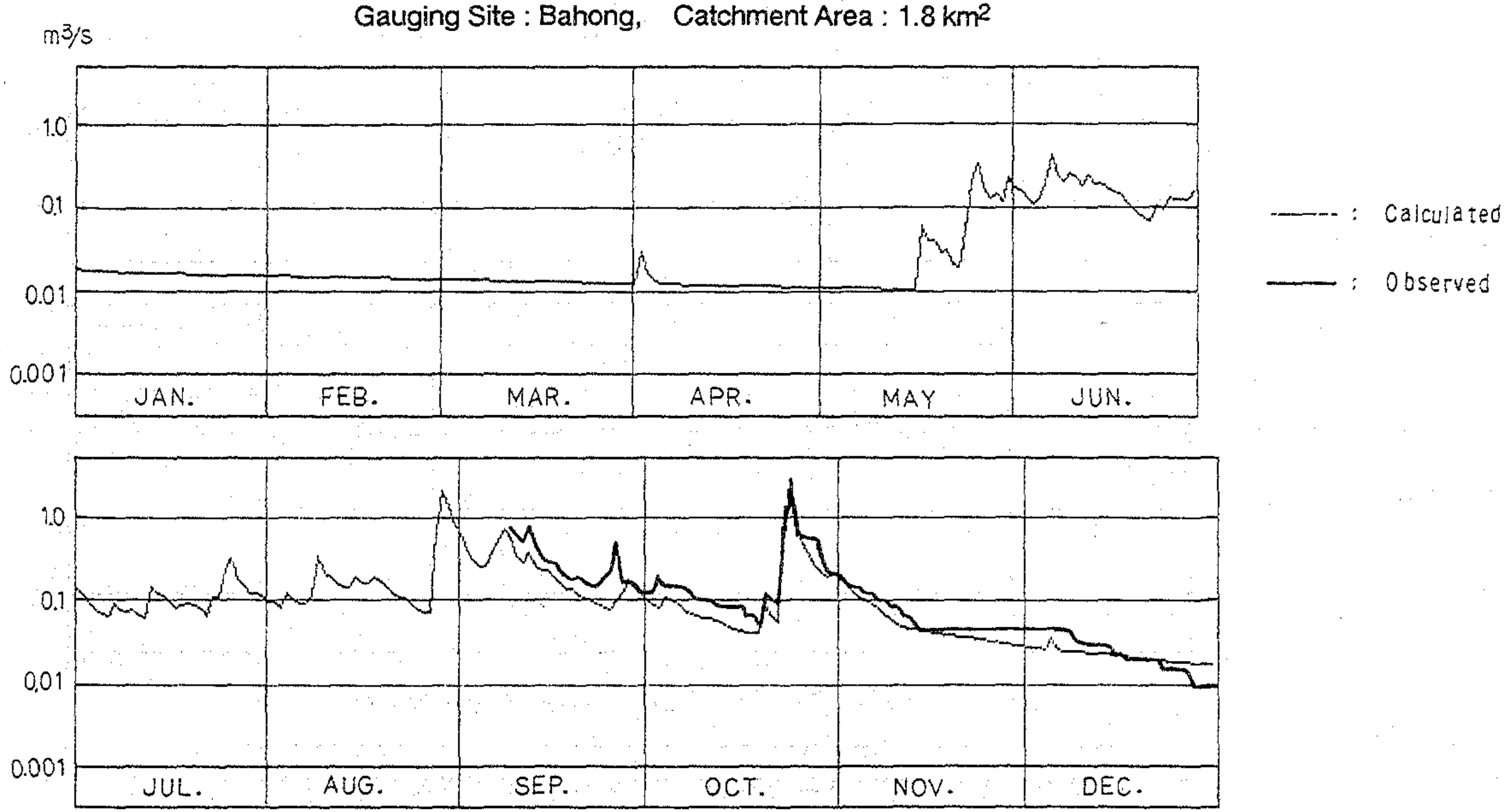


Fig.C.3.4 Comparison of Estimate Runoff and Observed Runoff (5/5)

Gauging Site : Bahong, Catchment Area : 1.8 km²



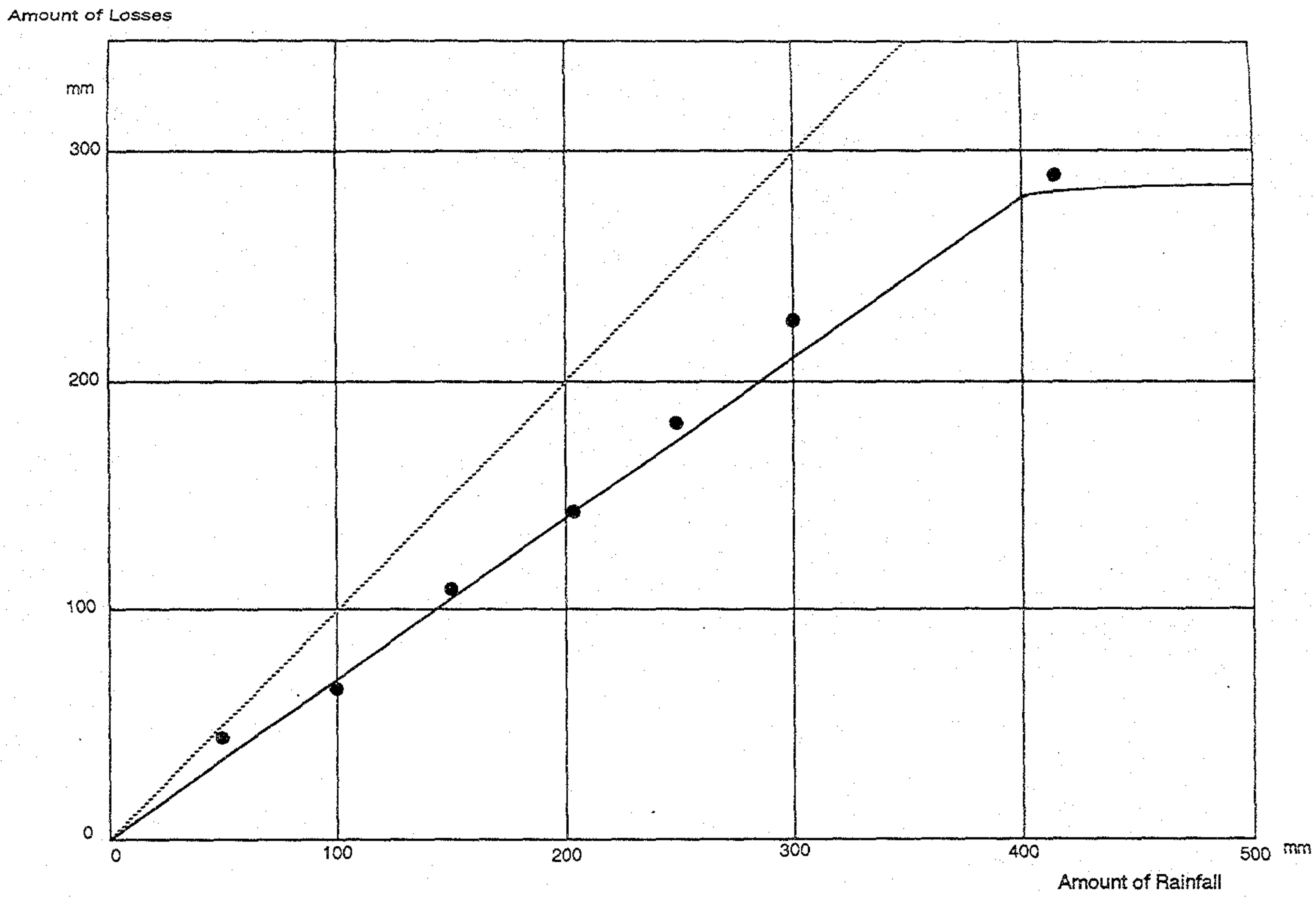


Fig. C.3.5 Actual Relation between Rainfall and Rainfall Losses at the Ambiong Gauging Site

APPENDIX D

GEOLOGY AND HYDROGEOLOGY

APPENDIX D GEOLOGY AND HYDROGEOLOGY

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APPENDIX D GEOLOGY AND HYDROGEOLOGY

1. GENERAL

The Project area of some 15 km^2 surface area lies in the southwestern part of the Central Cordillera mountain range in Northern Luzon. The Cordillera is flanked on the east by the Cagayan valley and Eastern Cordillera, and on the west by foothills which are the northern continuation of the Luzon Central valley.

South of La Trinidad, the Central Cordillera takes a southeasterly course. The central valley lies to the southwest of the Central Cordillera and is borders on the Sierra Madre in the east and on the Zambales Range in the west.

The Central Cordillera consists largely of early to middle Tertiary volcanic and platonic rock and early Tertiary or older metamorphic rock, all of which are known in great detail from the Baguio area, and Tertiary volcanic and sedimentary rocks.

There are no active volcanoes or confirmed volcanic landforms although Pliocence pyrociastics have been reported from the Guinaoang area, 50 km. north-northeast of Baguio.

2. GEOLOGY

2.1 Geological Components in the Project Area

The geology of the project area consists of quaternary and the tertiary sedimentation. The quaternary formations are divided into the alluvium of the Trinidad Valley and the Talus deposits presenting around the area with limestone formations.

The tertiary formations occupying most of the mountainous areas consist of the following:

- Tuffbreccia-Basalt
- Agglomerate-Lapilli Tuff
- Conglomerates
- Shale-Sandstone-Tuff
- Limestone
- Andesitic Sediment

Table D.2 gives a breakdown of these components in the Project area.

2.2. Quaternary Formation

2.2.1 Alluvium

This formation reaches a thickness of 14 m in the central part of the Trinidad Valley, more than 43 m along the national road at the northeast of Zone I, and 2 m of Stock Farm. The upper layer of this formation is of poorly sorted soil with a thickness of 1 to 2 m, and the lower layer is composed of well rounded silt and clay. Sandy soil of more than 2 m in thickness is distributed in the Alno Valley.

2.2.2 Limestone fragment

Limestone fragment is predominantly piled up at the foot of the steep cliffs in Zone II, and a part of the formation stretches into Sadag or Talingting.

This formation consists mainly of limestone boulder and reddish clay of terrestrial deposits. The formation is also observed at the foot of the Pico mountain and the Wangal creek.

2.3 Tertiary Formations

2.3.1 Tuffbreccia and Basalt

This formation consists of alternating beds of dark-greyey basalts and greenish-greyey tuffbreccia, and distributed in the downstream area of the Balili river.

This formation is supposed to be the oldest basement in the Baguio-Trinidad district.

2.3.2 Agglomerate-Lapilli Tuff

This formation occurs at the mountainside. Andesitic boulder is predominant at the top of the mountain.

This formation consists of granule to rounded cobble of andesite/tuff with a matrix of fine grades of the above, showing a reddish brown hue.

This formation is considered to be heterotopic faeces of conglomerate and shale-sandstone.

2.3.3 Conglomerates

This formation is widely distributed in the western part of the Project area. The formation consists of pebbles of andesite or granite and matrix of sandstone, and is almost jointless, hard to medium-hard.

Weathering residue 10 to 20 meters in thickness, is widely distributed in Puguis, in the Lower Wangal and Bineng. The formation dips to the north or to the west at angles generally ranging from 20 to 30 degrees.

2.3.4 Shale-Sandstone-Tuff

This formation is observed in Zone II, the upstream area of the Balili river and the peripheral area of the Trinidad Valley except at the eastern part of it. It has a gray, reddish brown and greenish gray color. Generally, it consists of soft to medium hard rocks with little fracture. Dipping angles of the formation range from 20 to 30 degrees to the north.

2.3.5 Limestone

Limestone occurs in the area from the back of Zone II through the Pico mountain. Basement rock of the Trinidad Valley consists of limestone stretching to the Westside of the Wangal creek.

It is of hard to medium-hard rock well jointed, showing grayish white color. The formation at the mountain ranges dips 30 to 40 degrees to the north-west, overlying the basal conglomerate. Thickness of the limestone layer in the Trinidad Valley is about 92 meters on the right bank, 40 meters on the left bank of the Balili river and 90 meters in the Stock farm area.

2.3.6 Andesitic sediment

Andesitic sediment is distributed in the mountain ranges at the back of Cruz through Alno, composing the mountain range.

This formation consists of andesite breccia, being hard and gray in color.

This Andesitic Sediment as well as Tuff mentioned in 2.3.4, are assumed to be a contributing factor to the formation of the Trinidad Valley and the Alno Valley.

3. HYDROGEOLOGY

3.1 General

The alluvium in the Trinidad Valley is generally water impermeable to semi-permeable as it consists of clayey sediment. But, in certain parts in the southern and western areas of the Trinidad Valley, the alluvium retains ground-water as it contains interbedded thin sandy layers.

There are several shallow wells of 10 to 20 meters depth and a static water level ranging from 3 to 7 meters. It is often the case that these shallow wells cannot be used in the dry season because of poor discharge from the wells and water contamination. This contamination is assumed to extend from the Balili river basin to the Bayabas creek basin.

Tertiary limestone interbedded with poorly cemented layer of coral fragments and loose soil of terrestrial deposits is an externally permeable layer because cracks along the bedding plane and joints are well developed in it. The mountain slope has no natural waterstops in the form of impervious rocks, so that no aquiferous strata are found here. A good aquifer does exist, however, in the Trinidad Valley.

On account of its high permeability in the Trinidad Valley, the aquifer found here is affected by the contamination from the Balili river.

3.2 Springs

Several springs are found in the mountainside areas consisting of limestone formations. Their occurrence suggests that the impervious shale or other tertiary rocks exist with the limestone formations.

Water from the Dinog cave contains lather, offensive odor, garbage and other wastes. The mains water is therefore assumed to come from the Balili river.

This indicates that the Bahong cave (Dinog Cave) is natural tunnel outlet connecting the downstream side (EL. 1,310 m) of the Balili river in Zone I and the Bahong spring (EL. 1,230 m). The length of this tunnel is about 1,500 meters.

The low quality of the water from the Bahong spring has a negative effect on the western side of sloping outlet downstream area, except Peril creek.

3.3 Groundwater

Groundwater in the tertiary rocks which generally form impermeable strata occurs as fissure water, while Puguis and Lower Wangal, mostly composed of weathered conglomerates, have phreatic ground water, with the rocks having a high water retention ratio.

In Longlong in the upstream area of the Wangal creek, groundwater may exist in the conglomerates as a confined water, with the conglomerates intercalated with loose and poorly graded layers along the accumulation surfaces.

As the thin layers of sandstone and coarse tuff in Zone II are rather loose, due to weathering, small but stable amount of groundwater discharge are obtained. Therefore, several shallow wells are exploited in the layers.

Rich aquifer is found in the hilly areas of Ambiong-Busal in Zone I, where boulders of agglomerates are concentrated.

4. ELECTRIC RESISTIVITY SURVEYS

Electric resistivity surveys of the rock strata are the most effective method of obtaining information about the hydrogeologic conditions.

The electric properties of most deposits and rocks vary over a wide range, depending upon the material, density, porosity, water content and quality, and the distribution of the water in the materials. Water saturated materials have lower resistivity than unsaturated and dry materials. The higher the porosity of the saturated materials, the lower their resistivity. The presence of clays and conductive minerals also reduces the resistivity of the materials.

Electric resistivity surveying is based on evaluating the apparent resistivity (Pa) of subsurface materials by passing a known electric current through the ground and measuring the potential difference between two points. The electric current is applied by using buried metal rods driven into the ground as the electrodes. The distance between the current electrodes depends on the desired range (depth) of observation. The potential difference is measured with two separate electrodes located symmetrically on a line between the current electrodes.

With the Wenner configuration, the distance between the voltage-applying electrodes (a) is one-third the distance between the current applying electrodes (L). Apparent resistivity (Pa) is calculated as

$$Pa = 2\pi a \frac{V}{I}$$

where V is the potential difference between the voltage electrodes, I is the total current in the electric field.

When the apparent resistivity (Pa) is plotted against the electrode spacing (a) for various spacing distances in a given site, the measurement points (coordinates) can be connected by a regular curve.

The interpretation of such a resistivity-spacing(depth) curve in terms of the associated subsurface conditions is a complex problem. A measured apparent resistivity-depth curve is matched against the familiar standard theoretical curves (Sundberg and Hummel's curve) in order to determine the true resistivities of individual layers.

Electric resistivity surveys were carried out at 18 sites to make clear the hydrogeologic structure in Zone I, II and III. True resistivity values are given below.

Results of Electric Resistivity Surveys

True Resistivity Value (ohm - m)	Material	Geology	Permeability
0.2 | 15	Argillaceous	Alluvium (Clay - Silt), Shale, Tuff, Sandy Conglomerate	Impermeable Layer
15 | 40	Arenaceous	Sandy Clay - Sand, Sandy Rocks, Conglomerate	|
40 | 60	Sand or Gravel	Coarse Sandstone, Weathered Conglomerate, Limestone, Porous Rocks	Permeable Layer
200 |	Gravel	Limestone Fragment, Cracky Sandstone and Conglomerate, Jointful	

* 1,000 ohm-m in Alno is the unknown values.

Results of Pumping Tests of Deepwells

Well No. / Item	DZ-I (Stock Farm)	DZ-II (Bahong)	DZ-III (Bineng)	Remarks
Pumping Setting (m)	42.7	48.8	48.8	
Static water Level (m)	6.71	10.57	30.18	
0 - 21	0-1	0-8	Permeable layer : Ls.	
Talus deposits and Alluvial Sand	Talus deposit	Weathered conglomerates		
Lithologic Log (m)	21 - 87	1-33	8-76	Semipermeable layer :
Limestone and Sand	Limestone	Conglomerates	Sand, Sandstone, Conglomerates	
8- 112	33-100	76-80		
Marl	Sandstone, Shale,	Mudstone	Impermeable layer :	
112-120	Conglomerates	Marl, Tuff, Mudstone		
Tuff	and Tuff			
Thickness of the Aquifer M (m)	80.29	89.43{L.S. 22.43 S.Salt 67.0	45.82	Below the Static Water Level
Discharge Q (m^3/sec)	$4.4X10^{-3}$	$4.7X10^{-3}$	$4.4X10^{-3}$	Final
Drawdown s(m)	26.52	0.69	3.40	Maximum
Specific Capacity C (m^3/sec/m)	$1.6X10^{-4}$	$6.8X10^{-3}$	$1.3X10^{-3}$	$C = \frac{Q}{s}$
Transmissivity T (m^3/sec)				
Draw down TD				
by Yacob and Couper	$9.0X10^{-5}$	$5.1X10^{-3}$	$7.0X10^{-4}$	TR in DZ-II :
by Theis	$8.8X10^{-5}$	$5.6X10^{-3}$	$7.2X10^{-4}$	$1.1 X 10^{-2}$
by Chow	$1.1X10^{-4}$	$4.2X10^{-3}$	$5.9X10^{-4}$	TR in DZ-III:
by Yocob	$7.9X10^{-5}$	$4.7X10^{-3}$	7.0X10-4	$3.8 X 10^{-3}$
Recovery TR	$8.3X10^{-5}$	--	--	
Average	$9.0X10^{-5}$	$4.9X10^{-3}$	$6.8X10^{-4}$	
Hydraulic conductivity K (m/sec)	$1.1X10^{-6}$	$5.5X10^{-5}$	$1.5X10^{-5}$	$K = \frac{T}{M}$

5. DEEPWELL AND RESULT OF PUMPING TEST

5.1 General

Pumping tests for three deepwells were executed during the HIRDP survey period. The locations for each of the deepwells in the three zones were selected by taking into account the electric resistivity survey results and the estimation of the hydrogeological conditions.

Fig. D.5.2 gives the specifications of the deepwells for the pumping tests.

The pumping test resulted in an adequate and clean water discharge from the test wells. Table D.5.2 sums up the results while Table D.5.3 shows the corresponding hydrogeological conditions.

5.2 Pumping Capacity of Deepwells

Three (3) observation wells have been installed in appropriate locations on the inferred lineation along the fault line in the expectation that groundwater may exist in the cracks and fissures that have developed in the zigzag formation,

Hydraulic conductivity analyses have been carried out on the premise that there is a free groundwater surface. The results of the analysis are presented in Table D.5.4, the relationship between the specific capacity (C: m^3/sec/m) and the hydraulic conductivity (K: m/sec) in particular, was found to be as follows;

$$C \doteqdot 150K$$

(1) Zone I (DZ-I : Stock farm)

It can be inferred from the data of the pumping tests that groundwater near a well is possibly formed on a free groundwater surface. A slightly recovering tendency of groundwater level was observed during the pumping test period. This suggests a yield capacity in excess of the test results. Given that the permeability value of the limestone sand may be $K = 1.1 \times 10^{-6}$ m/sec, the design drawdown (s) value shall be less than 30 meters.

The results suggest that the design yield capacity of a well F = 250 mm reaches $Q = 4.8 \times 10^{-3}$ m^3/sec when the drawdown (s) is 30 meters.

In order to maximize groundwater utilization in Zone I, the installation of one more production well with a casing diameter = 200 to 300 mm might be effective at the promising site in Puguis in the Zigzag zone. Its pumping capacity may be in the same order as that of production wells such as DZ-II and DZ-III in the zigzag formation.

(2) Zone II (DZ -II Bahong)

Although a large specific capacity was recorded in the tests in the first half of the dry season, its value may decrease in progress of the groundwater level lowering to the end of the dry season. Since the groundwater level reaches a depth of 33 meters below the ground surface and since the permeability is $K = 5 \times 10^{-6}$ m/sec, the design yield capacity of one well $\Phi = 250$ mm becomes $Q = 7.5 \times 10^{-3}$ m^3/sec, when the drawdown (s) is 1.0 meters.

Six (6) wells have been designed to meet the water demand in Zone II at the location decided in the topography viewpoints, geology and the electrical exploration results with the expectation of the above capacity. More accurate estimates very difficult due to uncertainty of the lineament on the geographical map.

The depth of the production well at Tawang may be required to be more than 100 meters resulting from the thickness of the limestone at the high elevated land.

The depth of the other production well in Zone II may be 80 meters in consideration of the above conditions.

(3) Zone III (DZ-III Bineng)

According to the pumping test results, the existence of water-retaining fissure and leakable cracks has been observed, so that, it may be difficult to be successful in finding the aquifer at a different site.

Based on the analysis on DZ-III pumping test, the design yield capacity can be secured at a value of $Q = 1.3 \times 10^{-2}$ m^3/sec when the drawdown s=10 meters. Stable pumping-up is essential in the dry season so that the pump setting must be designed underneath the level of the possible leaking cracks. Its level may be about 59 meters in depth from the ground surface.

6. SOIL PROPERTY FOR PROPOSED PONDS

Soils in the foundations of the proposed ponds and proposed borrow pit areas can be classified into the following categories as their origin.

(1) Soils derived from limestone
(2) Soils derived from conglomerates
(3) Soils derived from shale, sandstone and tuff
(4) Alluvial clay

Soil derived from limestone is composed principally of talus deposits, weathered residual soil and reddish clay. Talus deposits and weathered residual soil contain fewer fine particles and have a high permeability.

Reddish clay indicates a high natural moisture content and may be considered to have poor workability characteristics.

Soils derived from conglomerates are mainly composed of talus deposits and weathered residual soil. They are widespread within areas as Puguis in Zone I, Alno in Zone II and elsewhere in Zone III. This kind of soil shows high shear strength and low compressibility and it is expected to be the most suitable for embankment materials and for foundation of embankment, except the soil extended at apart of Puguis in Zone I which has a possibility of depression of strength in water because it is composed of tuffaceous particles.

Soils derived from shale, sandstone and tuff are mainly composed of totally weathered residual soil and they are found widespread in Zone II. They have a high resistance against piping by have a water and are expected to be suitable for embankment materials and for embankment foundation.

Alluvial soils are found in the swamp area of Zone I. They are expected to show excessive settlement for embankment foundation and low strength for materials because their natural moisture content is higher than the liquid limit.

In addition, when the foundation is composed of limestone, it is necessary to take a countermeasures for the control of leakage.

7. GEOLOGY OF WANGAL DAMSITE

7.1 Geology

Three alternatives of the dam axes have been selected along the Wangal creek by considering the geological conditions as well as the specifications of damtype and required water capacity came from water demand.

Topographical and geological characteristics of the three alternatives are summarized as in Table.4.3.6.

There are topographical and geological limitations on the maximization of dams, i.e.:

-highest elevation of saddle having EL. 1,249.62 meters at the left bank of the Wangal creek, 350 m up-stream from No. 2 point.

-existing leaky limestone on EL. 1,260 meters height up-stream of the Wangal creek.

In case of an earth/rock fill type dam, impervious and rock materials for the embankment should be secured from the borrow pit consisting of totally weathered conglomerates in the Lower Wangal creek. The quarry site of medium hard conglomerates on the right bank of 200 meters up-stream site from No. 2, respectively.

In case of a concrete gravity dam, the most suitable site would be selected at 1.8 kms up-stream site from No. 2.

7.2 Test hole drilling

Test hole drilling specified in Table D.7.2 was executed at the No.2 point by the study team to obtain the geological informations for a dam foundations.

According to the results given in Table D.7.4, a low groundwater level is found left of the abutment, so that, curtain grouting would be required. Consolidation grouting would also be necessary for dam foundation to expect more increase of bearing capacity thereof.

Table D.2 Stratigraphic Classificatin

Period	Epoch	Geology
Quarternary	Recent	Alluvium
	Recent to Pleistocene	Limestone Fragment
Tertiary	Upper Miocene to Pliocene	Andesitic Sediment Limestone
	Early Middle Miocene	Shale - Sandstine - Tuff Conglomerates Agglomerates - Lapilli Tuff
	Upper Eocene	Tuff Breccia - Basalts

Table D.3.1 Available River Water on February

Geology	River	Water Source
(1) Limestone	Balili River Alapang Creek	(Baguio district), Pico Mountain, Trinidad Valley Tawang-Lubas Piedmont
(2) Conglomerates	Wangal River Bolo Creek Bedeweng Creek	Longlong-Timay-Sadiatan range Bineng Spring
(3) Agglomerates	Ambiong North Creek	Busol-Ambiong Mountainous
(4) Andesitic Sediment	Peril Creek	Bagto range

Table D.3.2 Classification of Spring Condition

Type	Location	Elevation (m)
(1) Piedmont lowland (Limestone)	East and South ends of Trinidad Valley ; Pico Spring, Balili Spring	1310 - 1320
(2) Bed on impervious rocks	Lubas Spring Bahong-Alapang Spring	1385 1200 - 1350
(3) Fissure	Conglomerates area Sadag-Alno	700 - 1400 980 - 1100

Table D.4 Results of Electric Resistivity Survey

True resistivity value (ohm-m)	Material	Geology	Permeability
0.2 | 15	argillaceous	Alluvium (clay - silt) shale, Tuff sound conglomerate	Impermeable layer
15 | 40	arenaceous	sandy clay - sand sandy rocks conglomerate	|
40 | 60	sand or granel	coarse sandstone wethered conglomerate limestone, porus rocks	Permeable layer
200 |	gravel	Limestone fragment cracky sandstone and conglomerate, jointful	

* 1000 ohm-m in Alno is the unknown values.

Table D.5.1 (1) Record of Pumping Test of Deep Well (DZ - I) (1/4)

WELL NO. ZONE I JICA - HIRDP BUYAGAN, LA TRINIDAD
DATE STARTED JAN. 24, 1988 STOPPED JAN. 26, 1988
PUMP TYPE SUBMERSIBLE TURBINE
PUMP SETTING 140 feet (42.67 m) STATIC WATER LEVEL 22 feet (6.7056 m)
REMARKES

r = 0.075 m

Time Clock	Time Elapsed	Pumping Water Level (feet)	Draw Down (feet)	Weir Level (feet)	Discharge (GPM)	Remarkes
10:00						
:01	01				80	
:02	02				80	
:03	03				80	
:04	04				80	Fast Drawdown No
:05	05				80	Reading Taken
:06	06				80	
:07	07				80	
:08	08				80	
:09	09				80	
:10	10				80	
:12	12				80	
:14	14				80	
:16	16				75	
:18	18				75	
:20	20				75	
:22	22				75	
:24	24				75	
:26	26				75	
:28	28				75	
:30	30				75	
:35	35				75	
:40	40	94'	72.0		75	
:45	45	95'44"	73.3		75	
:50	50	99'	77.0		75	
:55	55	100'3"	78.3		75	
11:00	60	101'5"	79.4		75	
:10	70	104'3"	82.3		75	
:20	80	104'7"	82.6		75	
:30	90	105'10"	83.8		75	
:40	100	106'10"	84.8		75	
:50	110	106'9"	84.8		75	
12:00	120	107'10"	85.8		75	
:20	140	107'7"	85.6		75	
:40	160	107'8"	85.7		70	
1:00	180	107'7"	85.0		70	

Table D.5.1 (1) Record of Pumping Test of Deep Well (DZ - I) (2/4)

WELL NO. ZONE I JICA - HIRDP BUYAGAN, LA TRINIDAD
DATE STARTED JAN. 24, 1988 STOPPED JAN. 26, 1988
PUMP TYPE SUBMERSIBLE TURBINE
PUMP SETTING 140 feet (42.67 m) STATIC WATER LEVEL 22 feet (6.7056 m)
REMARKES

r = 0.075 m

Time		Pumping Water	Draw Down	Weir Level	Discharge	Remarkes
Clock	Elapsed	Level (feet)	(feet)	(feet)	(GPM)	
2:00	240	107'5"	85.4		70	
3:00	300	108'6"	86.5		70	
4:00	360	109'0"	87.0		70	
5:00	420	109'0"	87.0		70	
6:00	480	108'7"	86.6		70	
7:00	540	108'5"	86.4		70	
8:00	600	108'5"	86.4		70	
9:00	660	108'5"	86.4		70	
10:00	720	108'4"	86.3		70	
11:00	780	108'4"	86.3		70	
12:00	840	108'5"	86.4		70	
1:00	900	108'5"	86.4		70	
2:00	960	108'5"	86.4		70	
3:00	1020	108'4"	86.3		70	
4:00	1080	108'5"	86.4		70	
5:00	1140	108'6"	86.5		70	
6:00	1200	108'6"	86.5		70	
7:00	1260	108'8"	86.6		70	
8:00	1320	108'6"	86.5		70	
9:00	1380	108'6"	86.5		70	
10:00	1440	108'7"	86.6		70	
11:00	1500	108'5"	86.4		70	
12:00	1560	108'7"	86.6		70	
1:00	1620	108'6"	86.5		70	
2:00	1680	108'7"	86.6		70	
3:00	1740	108'7"	86.6		70	
4:00	1800	108'7"	86.6		70	
5:00	1860	108'5"	86.4		70	
6:00	1920	108'6"	86.5		70	
7:00	1980	108'6"	86.5		70	
8:00	2040	108'8"	86.7		70	
9:00	2100	108'6"	86.5		70	
10:00	2160	108'7"	86.6		70	
11:00	2220	108'6"	86.5		70	
12:00	2280	108'6"	86.5		70	

Table D.5.1 (1) Record of Pumping Test of Deep Well (DZ - I) (3/4)

WELL NO. ZONE I JICA - HIRDP BUYAGAN, LA TRINIDAD
DATE STARTED JAN. 24, 1988 STOPPED JAN. 26, 1988
PUMP TYPE SUBMERSIBLE TURBINE
PUMP SETTING 140 feet (42.67 m) STATIC WATER LEVEL 22 feet (6.7056 m)
REMARKES

r = 0.075 m

Time		Pumping Water	Draw Down	Weir Level	Discharge	Remarkes
Clock	Elapsed	Level (feet)	(feet)	(feet)	(GPM)	
1:00	2340	108'5"	86.4		70	
2:00	2400	108'4"	86.3		70	
3:00	2460	108'4"	86.3		70	
4:00	2520	108'4"	86.2		70	
5:00	2580	108'3"	86.2		70	
6:00	2640	108'1"	86.1		70	
7:00	2700	108'0"	86.0		70	
8:00	2760	108'2"	86.2		70	
9:00	2820	108'1"	86.0		70	
10:00	2880	108'0"	86.0		70	

Table D.5.1 (1) Record of Pumping Test of Deep Well (DZ - I) (4/4)

WELL NO. ZONE I JICA - HIRDP BUYAGAN, LA TRINIDAD
DATE STARTED JAN. 28, 1988 STOPPED JAN. 28, 1988
AVERAGE PUMPING RATE 70 GPM (264.95 l/min)
STATIC WATER LEVEL 22 feet (6.7056 m)
REMARKES

Clock Time	Time since Pumping Started t (min)	Stopped t' (min)	Ratio t / t'	Weir Level (feet)	Residual Drawdown (feet)	Remarkes
10:01	2881	1	2881			
:02	2882	2	1441			
:03	2883	3	961			
:04	2884	4	721			
:05	2885	5	577			
:06	2886	6	481			
:07	2887	7	412			
:08	2888	8	361			
:09	2889	9	321			
:10	2890	10	289			
:12	2892	12	241			
:14	2894	14	207			
:16	2896	16	181	55	33	
:18	2898	18	161	50	28	
:20	2900	20	145	49	27	
:25	2905	25	116	46	24	
:30	2910	30	97	42	20	
:40	2920	40	73	39	17	
:50	2930	50	59	36	14	
11:00	2940	60	49	34	12	
:10	2950	70	42	32	10	
:20	2960	80	37	30	8	
:30	2970	90	33	28.5	6.5	
:50	2990	110	27	26	4	
12:10	3010	130	23	25.7	3.7	
:30	3030	150	20	23.7	1.7	
1:30	3090	210	15	22.9	0.9	
2:30	3150	270	12	22.7	0.7	

Table D.5.1 (2) Record of Pumping Test of Deep Well (DZ - II) (1/3)

WELL NO. ZONE II JICA - HIRDP BAHONG, LA TRINIDAD
DATE STARTED JAN. 20, 1988. 8:00 A.M. STOPPED JAN. 26, 1988. 8:00 A.M.
PUMP TYPE SUBMERSIBLE 5 HP MOTER
PUMP SETTING 160 feet (48.77 m) STATIC WATER LEVEL 34.8 feet (10.5664 m)
REMARKES

r = 0.075 m

Time		Pumping Water	Draw Down	Weir Level	Discharge	Remarkes
Clock	Elapsed	Level (feet)	(feet)	(feet)	(GPM)	
8:01	01					
:02	02	35'8"	1'0"		75	Cloudy Discharge
:03	03	35'8"	1'0"		75	
:04	04	35'8"	1'0"		75	
:05	05	35'8.5"	1'0.5"		75	
:06	06	35'8.5"	1'0.5"		75	
:07	07	35'8.5"	1'0.5"		75	
:08	08	35'8.5"	1'0.5"		75	
:09	09	35'9"	1'1"		75	
:10	10	35'9"	1'1"		75	
:12	12	35'9"	1'1"		75	
:14	14	35'9"	1'1"		75	
:16	16	35'9.5"	1'1.5"		75	
:18	18	35'9.5"	1'1.5"		75	
:20	20	35'10"	1'2"		75	
:25	25	35'11"	1'3"		75	
:30	30	36'00"	1'4"		75	
:35	35	36'00"	1'4"		75	
:40	40	36'00"	1'4"		75	
9:00	60	36'01"	1'5"		75	
:20	80	36'2.5"	1'6.5"		75	
:40	100	36'3"	1'7"		75	
10:00	120	36'4"	1'8"		75	Clearer Water
11:00	180	36'5"	1'9"		75	
12:00	240	36'5"	1'9"		75	
1:00	300	36'5.5"	1'9.5"		75	
2:00	360	36'6"	1'10"		75	
3:00	420	36'7"	1'11"		75	
4:00	480	36'9"	2'1"		75	
5:00	540	36'10"	2'2"		75	
6:00	600	36'10"	2'2"		75	
7:00	660	36'10"	2'2"		75	
8:00	720	36'10"	2'2"		75	
9:00	780	36'10"	2'2"		75	
10:00	840	36'10"	2'2"		75	
11:00	900	36'10"	2'2"		75	
12:00	960	36'10"	2'2"		75	

Table D.5.1 (2) Record of Pumping Test of Deep Well (DZ - II) (2/3)

WELL NO. ZONE II JICA - HIRDP BAHONG, LA TRINIDAD
DATE STARTED JAN. 20, 1988. 8:00 A.M. STOPPED JAN. 26, 1988. 8:00 A.M.
PUMP TYPE SUBMERSIBLE 5 HP MOTER
PUMP SETTING 160 feet (48.77 m) STATIC WATER LEVEL 34.8 feet (10.5664 m)
REMARKES

r = 0.075 m

Time Clock	Time Elapsed	Pumping Water Level (feet)	Draw Down (feet)	Weir Level (feet)	Discharge (GPM)	Remarkes
1:00	1020	36'10"	2'2"		75	
2:00	1080	36'10"	2'2"		75	
3:00	1140	36'10"	2'2"		75	
4:00	1200	36'10"	2'2"		75	
5:00	1260	36'10"	2'2.5"		75	
6:00	1320	36'10.5"	2'2.5"		75	
7:00	1380	36'10.5"	2'2"		75	
8:00	1440	36'10"	2'2"		75	
9:00	1500	36'10"	2'2.5"		75	
10:00	1560	36'10.5"	2'2.5"		75	
11:00	1620	36'10.5"	2'2.5"		75	
12:00	1680	36'10.5"	2'2.5"		75	
1:00	1740	36'10.5"	2'2.5"		75	
2:00	1800	36'10.5"	2'2.5"		75	
3:00	1860	36'10.5"	2'2.5"		75	
4:00	1920	36'10.5"	2'2.5"		75	
5:00	1980	36'10.5"	2'2.5"		75	
6:00	2040	36'10.5"	2'2.5"		75	
7:00	2100	36'10.5"	2'2.5"		75	
8:00	2160	36'10.5"	2'2.5"		75	
9:00	2220	36'10.5"	2'2.5"		75	
10:00	2280	36'11"	2'3"		75	
11:00	2340	36'11"	2'3"		75	
12:00	2400	36'11"	2'3"		75	
1:00	2460	36'11"	2'3"		75	
2:00	2520	36'11"	2'3"		75	
3:00	2580	36'11"	2'3"		75	
4:00	2640	36'11"	2'3"		75	
5:00	2700	36'11"	2'3"		75	
6:00	2760	36'11"	2'3"		75	
7:00	2820	36'11"	2'3"		75	
8:00	2880	36'11"	2'3"		75	

Table D.5.1 (2) Record of Pumping Test of Deep Well (DZ - II) (3/3)

WELL NO. ZONE II JICA - HIRDP BAHONG, LA TRINIDAD
DATE STARTED JAN. 22, 1988. 8:00 A.M. STOPPED JAN. 22, 1988. 12:00 P.M.
AVERAGE PUMPING RATE 75 GPM (238.875 l/min)
STATIC WATER LAVEL 34.8 feet (10.5664 m)
REMARKES

Clock Time	Time since Pumping Started t (min)	Stopped t' (min)	Ratio t / t'	Weir Level (feet)	Residual Drawdown (feet)	Remarkes
8:01	2881	1	2881	36'2"	1'6"	
:02	2882	2	1441	36'1"	1'5"	
:03	2883	3	961	36'1"	1'5"	
:04	2884	4	721	36'1"	1'5"	
:05	2885	5	577	36'1'	1'5"	
:06	2886	6	481	36'0.5"	1'0.5"	
:07	2887	7	412	36'0.5"	1'4.5"	
:08	2888	8	361	36'0.5"	1'4.5"	
:09	2889	9	321	36'0"	1'4"	
:10	2890	10	289	36'0"	1'4"	
:12	2892	12	241	36'0"	1'4"	
:14	2894	14	207	36'0"	1'4"	
:16	2896	16	181	35'11.5"	1'3.5"	
:18	2898	18	161	35'11"	1'3"	
:20	2900	20	145	35'11"	1'3"	
:25	2905	25	116	35'11"	1'3"	
:30	2910	30	97	35'11"	1'3"	
:35	2915	35	82	35'11"	1'3"	
:40	2920	40	73	35'10.5"	1'2.5"	
:50	2930	50	58	35'10"	1'2"	
9:00	2940	60	49	35'10"	1'2"	
:10	2950	70	42	35'9.5"	1'1.5"	
:20	2960	80	37	35'9"	1'1"	
:30	2970	90	33	35'8.5"	1'0.5"	
:40	2980	100	29	35'8"	1'0"	
10:00	3000	120	25	35'8"	1'0"	
:30	3030	150	20	35'8"	1'0"	
11:00	3060	180	17	35'7.5"	11'0.5"	
11:30	3090	210	15	35'7"	11"	
12:00	3120	240	13	35'7"	11"	

Table D.5.1 (3) Record of Pumping Test of Deep Well (DZ - III) (1/4)

WELL NO. ZONE III JICA - HIRDP BINENG, LA TRINIDAD
DATE STARTED JAN. 29, 1988. 2:00 P.M. STOPPED JAN. 31, 1988.
PUMP TYPE SUBMERSIBLE TURBINE
PUMP SETTING 160 feet (48.768 m) STATIC WATER LEVEL 99 feet (30.1752 m)
REMARKES

r = 0.075 m

Time Clock	Time Elapsed	Pumping Water Level (feet)	Draw Down (feet)	Weir Level (feet)	Discharge (GPM)	Remarkes
2:01	01	99				
:02	02					
:03	03	106.6	7.5		76	Cloudy Water
:04	04				76	
:05	05	107.3	8.3		76	
:06	06				76	
:07	07	107.9	8.8		76	
:08	08				76	
:09	09				76	
:10	10				76	
:12	12	108.6	9.5		76	
:14	14	108.8	9.7		76	
:16	16	109.2	10.2		76	
:18	18	109.5	10.4		76	
:20	20	109.8	10.7		76	
:22	22	109.9	10.8		76	
:24	24	110.2	11.2		76	
:26	26	110.2	11.2		76	
:28	28	110.2	11.2		76	
:30	30	110.2	11.2		76	
:35	35	110.2	11.2		76	Clearer Water
:40	40	110.2	11.2		76	
:45	45	110.2	11.2		76	
:50	50	110.2	11.2		76	
:55	55	110.2	11.2		76	
3:00	60	110.2	11.2		70	
:10	70	110.2	11.2		70	
:20	80	110.2	11.2		70	
:30	90	110.2	11.2		70	
:40	100	110.2	11.2		70	
:50	110	110.2	11.2		70	
4:00	120	110.2	11.2		70	
:15	135	110.2	11.2		70	
:30	150	110.2	11.2		70	
:45	165	110.2	11.2		70	
5:00	180	110.2	11.2		70	

Table D.5.1 (3) Record of Pumping Test of Deep Well (DZ - III) (2/4)

WELL NO. ZONE III JICA - HIRDP BINENG, LA TRINIDAD
DATE STARTED JAN. 29, 1988. 2:00 P.M. STOPPED JAN. 31, 1988.
PUMP TYPE SUBMERSIBLE TURBINE
PUMP SETTING 160 feet (48.768 m) STATIC WATER LEVEL 99 feet (30.1752 m)
REMARKES

r = 0.075 m

Time		Pumping Water	Draw Down	Weir Level	Discharge	Remarkes
Clock	Elapsed	Level (feet)	(feet)	(feet)	(GPM)	
5:20	200	110.2	11.2		70	
:40	220	110.2	11.2		70	
6:00	240	110.2	11.2		70	
:30	270	110.2	11.2		70	
7:00	300	110.2	11.2		70	
:30	330	110.2	11.2		70	
8:00	360	110.2	11.2		70	
:30	390	110.2	11.2		70	
9:00	420	110.2	11.2		70	
:30	450	110.2	11.2		70	
10:00	480	110.2	11.2		70	
11:00	540	110.2	11.2		70	
12:00	600	110.2	11.2		70	
1:00	660	110.2	11.2		70	
2:00	720	110.2	11.2		70	
3:00	780	110.2	11.2		70	
4:00	840	110.2	11.2		70	
5:00	900	110.2	11.2		70	
6:00	960	110.2	11.2		70	
7:00	1020	110.2	11.2		70	
8:00	1080	110.2	11.2		70	
9:00	1140	110.2	11.2		70	
10:00	1200	110.2	11.2		70	
11:00	1260	110.2	11.2		70	
12:00	1320	110.2	11.2		70	
1:00	1380	110.2	11.2		70	
2:00	1440	110.2	11.2		70	
3:00	1500	110.2	11.2		70	
4:00	1560	110.2	11.2		70	
5:00	1620	110.2	11.2		70	
6:00	1680	110.2	11.2		70	
7:00	1740	110.2	11.2		70	
8:00	1800	110.2	11.2		70	
9:00	1860	110.2	11.2		70	
10:00	1920	110.2	11.2		70	
11:00	1980	110.2	11.2		70	
12:00	2040	110.2	11.2		70	

Table D.5.1 (3) Record of Pumping Test of Deep Well (DZ - III) (3/4)

WELL NO. ZONE III JICA - HIRDP BINENG, LA TRINIDAD
DATE STARTED JAN. 29, 1988. 2:00 P.M. STOPPED JAN. 31, 1988.
PUMP TYPE SUBMERSIBLE TURBINE
PUMP SETTING 160 feet (48.768 m) STATIC WATER LEVEL 99 feet (30.1752 m)
REMARKES

r = 0.075 m

Time		Pumping Water	Draw Down	Weir Level	Discharge	Remarkes
Clock	Elapsed	Level (feet)	(feet)	(feet)	(GPM)	
1:00	2100	110.2	11.2		70	
2:00	2160	110.2	11.2		70	
3:00	2220	110.2	11.2		70	
4:00	2280	110.2	11.2		70	
5:00	2340	110.2	11.2		70	
6:00	2400	110.2	11.2		70	
7:00	2460	110.2	11.2		70	
8:00	2520	110.2	11.2		70	
9:00	2580	110.2	11.2		70	
10:00	2640	110.2	11.2		70	
11:00	2700	110.2	11.2		70	
12:00	2760	110.2	11.2		70	
1:00	2820	110.2	11.2		70	
2:00	2880	110.2	11.2		70	

Table D.5.1 (3) Record of Pumping Test of Deep Well (DZ - III) (4/4)

WELL NO. ZONE III JICA - HIRDP BINENG, LA TRINIDAD
DATE STARTED JAN. 31, 1988. 2:00 P.M. STOPPED JAN. 31, 1988.
AVERAGE PUMPING RATE 70 GPM (264.95 l/min)
STATIC WATER LAVEL 99 feet (30.1752 m)
REMARKES

Clock Time	Time since Pumping Started t (min)	Stopped t' (min)	Ratio t /t'	Weir Level (feet)	Residual Drawdown (feet)	Remarkes
2:00	2880			110.2	11.2	
:01	2881	1	2881			
:02	2882	2	1441	100	1.0	
:03	2883	3	961	99.8	0.8	
:04	2884	4	721	99.8	0.8	
:05	2885	5	577			
:06	2886	6	481			
:07	2887	7	412	99.5	0.5	
:08	2888	8	361			
:09	2889	9	321			
:10	2890	10	289	99.4	0.4	
:12	2892	12	241	99.3	0.3	
:14	2894	14	207	99.3	0.3	
:16	2896	16	181	99.3	0.3	
:18	2898	18	161			
:20	2900	20	145			
:30	2910	30	97			
:40	2920	40	73			
:50	2930	50	58			
3:00	2940	60	49	99.3	0.3	
:30	2970	90	33	99.2	0.2	
4:00	3000	120	25	99.2	0.2	
5:00	3060	180	17	99.2	0.2	
6:00	3120	240	13	99.2	0.2	

Table D.5.2 Results of Pumping Test on the Deep Wells

No. of Deep Well	Location	Collar Elevation (m)	Depth (m)	Static Water level (m)	Discharge	Drawdown (m)
DZ−I	Zone I (Stockfarm)	1314.60	122	6.70	70G.P.M	26.20
DZ−II	Zone II (Bahong)	1257.00	100	10.60	75G.P.M	0.69
DZ−III	Zone III (Bineng)	981.50	83	30.20	70G.P.M	3.40

Table D.5.3 Geology of Deep Wells

No. of Well	Depth−Geology
DZ−I	0m− Alluvial deposit reddish brown in color 21 m− Limestone 87 m− Marl 112 m− Tuff
DZ−II	0m− Talus deposit 1m− Limestone 33m− Alternation of tuff, shale & sandstone including conglomerates
DZ−III	0m− Weathered conglomerates 8m− Conglomerates 76m− Mudstone

Table D.5.4 Results of Deep Wells Analysis

Casing dia. 152mm January, 1988

Well No. / Item	DZ－I (Stock farm)	DZ－II (Bahong)	DZ－III (Bineng)	Remarks
Pumping setting (m)	42.7	48.8	48.8	
Staticwater level(m)	6.71	10.57	30.18	
Lithologic log (m)	0 ~21 Talus deposits and Alluvial sand 21 ~87 Limestone and sand 8~112 Marl 112~120 Tuff	0 ~ 1 Talus deposit 1 ~33 Limestone 33~100 Sandstone, Shale, Conglomerates and Tuff	0 ~8 Weathered conglomerates 8 ~76 Conglomerates 76 ~80 Mudstone	· permeable layer : Ls. · semipermeable layer : Sand, Sandstone, Conglomerates · Impermeable layer : marl, tuff, mudstone.
Thickness of the aquifer M (m)	80.29	89.43(L.S. 22.43 S.S.alt 67.0	45.82	below the static water level
Discharge Q(m³/sec)	4.4×10^{-3}	4.7×10^{-3}	4.4×10^{-3}	final
Drawdown s (m)	26.52	0.69	3.40	maximum
Specific capacity C (m³/sec/m)	1.6×10^{-4}	6.8×10^{-3}	1.3×10^{-3}	$C=\frac{Q}{s}$
Transmissivity T(m³/sec)				
· draw down TD				TR in DZ－II : 1.1×10^{-2}
by Yacob and Couper	9.0×10^{-5}	5.1×10^{-3}	7.0×10^{-4}	
by Theis	8.8×10^{-5}	5.6×10^{-3}	7.2×10^{-4}	
by Chow	1.1×10^{-4}	4.2×10^{-3}	5.9×10^{-4}	TR in DZ－III : 3.8×10^{-3}
by Yocob	7.9×10^{-5}	4.7×10^{-3}	7.0×10^{-4}	
· recovery TR	8.3×10^{-5}	——	——	
· average	9.0×10^{-5}	4.9×10^{-3}	6.8×10^{-4}	
Hydraulic conductivity k(m/sec)	1.1×10^{-6}	5.5×10^{-5}	1.5×10^{-5}	$K=\frac{T}{M}$

Table D.5.5 Water Well Data

WELL NUMBER	LOCATION	DRILLING DEPTH (m)	ACTUAL CAPACITY (m³/sec)	SPECIFIC CAPACITY (m³/sec/ m)	STATIC WATER LEVEL (mbgs)	DRAWDOWN (m)	Remarks
BPW 36-61-12	Bayabas	17.6	7.6×10^{-4}	1.206×10^{-2}	1.52	0.06	by National Water Resources Council, May 1982
BPW 18903	Pico Elem. School	21.3	3.2×10^{-4}	8.0×10^{-5}	2.44	4.00	do
BPW 18904	Pico	26.8	6.3×10^{-4}	4.1×10^{-4}	4.27	1.53	do
BPW 36-61-11 (LWUA No.136)	KM.6 Betag	42.6	6.3×10^{-4}	4.1×10-4	4.57	1.53 (6.00)	do
BPW 36-61-15	Buyagan	20.4	6.3×10^{-4}	2.1×10^{-4}	Ground Level	3.00	do
LWUA No. 142	DANGWA TRANS. CO.	152.0	1.3×10^{-2}	6.0×10^{-4}	2.90	22.10	by Baguin city Nov. 1983
LWUA No. 151	Balili	(230.0)	ND	ND	45	(30)	on going construction as of JAN. 1981, Abandoned
LTWD	Balili	145.0	1.26×10^{-2}	ND	ND	——	Existing
private well	Puguis	122.0	ND	ND	ND	——	Existing
DZ-1	Stockfarm	120.0	4.4×10^{-3}	1.6×10^{-4}	6.71	26.52	JAN. 1983 by JICA

mbgs : meter below ground surface
ND — No Data

Table D.7.1 Comparison of Proposed Wangal Damsite

Damsite	Landform	Geology	Proposable scale of Dam	Dam type
No.1 Up-Stream site	lowlying terrace floor in riverbed, hill at the right abutment	deeply weathered conglomerates at the right abutment.	small	earth & rock fill type (Fill type)
No.2 Middle site	lowlying terrace floor in left, steep slope at both abutments	exposure of medium weathered conglomerates at both abutments	medium	Fill type/concrete gravity type
No.3 Down-Stream site	gentle slope in part at the middle of both abutment	weathered tuff at the right abutment more than 1250 meters in elevation, inferring fault at about 20 meters higher than riverbed at the right bank	medium	Fill type/con gravity type

Table D.7.2 Quantity on Drilling Works

Drilling No.	Location	Collar elevation	Depth	Diameter	Water pressure test	Rock test
V－I	leftbank at No.2 Gayasey	1246.90m	50m	75mm	10 times	3pieces

Table D.7.3 Result of Test Hole Drilling

Depth (m)	Classification and Physical Condition	Permeability (Lugeon)
0 - 12.7	weathered zone, poor core recovery	less than 2
12.7 - 30.0	sound zone, medium hard to hard, greenish gray in color conglomerates consisting of subrounded Andesite ranging from 2 cm to 10 cm in diameter and graded sand	5 - 10
30.0 - 40.0	fractured zone, friable and slightly hard rock	17 - 23
40.0 - 50.0	sound zone, medium hard to hard, jointed gray in color	4 - 10

Table D.7.4 Drilling Record and Log (V-1)

HOLE No. : V-1 SITE : WANGAL HOLE COLLAR ELEVATION : 1246.9MATERS HOLE INCLINATION : VERTICAL

DRILLING RECORD

NOTE : CORE BARREL LENGTH =3.97M; DRILL MACHINE : LONGYEAR34

DATE	No. OF RODS (PC)	STRING OF RODS (M)	STICK-UP (M)	DEPTH (M)	RUN (M)	CORE LENGTH	CORE (%) RECOVERY	RQD (%)	ROCK SP. gr
01-28-88	2	7.02	4.02	3.00	3.00	0.05	1.66	0 / 0 / 0	
	3	10.07	4.02	6.05	3.05	0.12	3.93	0 / 0 / 0	
01-29-88	4	13.12	3.12	10.00	3.95	0.00	0.00	0 / 0 / 0 / 0	
02-12-88	5	16.17	3.12	13.05	3.05	0.75	24.59	0 / 20 / 25	
02-12-88	6	19.22	4.22	15.00	1.95	1.70	87.17	70 / 75	2.55
02-13-88	7	22.27	4.22	18.05	3.05	3.05	100.00	30 / 75 / 50	
02-13-88	7	22.27	2.27	20.00	1.95	1.95	100.00	33 / 71	
02-15-88	8	25.32	2.27	23.05	3.05	3.05	100.00	87 / 58 / 76	2.43
02-15-88	9	28.37	3.37	25.00	1.95	1.95	100.00	81 / 84	
02-16-88	10	31.42	3.37	28.05	3.05	3.05	100.00	77 / 93 / 73	
02-16-88	11	34.47	4.47	30.00	1.95	1.95	100.00	62 / 100	
02-17-88	12	37.52	4.47	33.05	3.05	3.05	100.00	39 / 21 / 21	
02-17-88	12	37.52	2.57	35.00	1.95	1.95	100.00	62 / 69	
02-18-88	13	40.57	2.57	38.05	3.05	3.05	100.00	64 / 66 / 29	
02-18-88	14	43.67	3.62	40.00	1.95	1.95	100.00	54 / 16	
02-19-88	15	46.67	3.62	43.05	3.05	3.05	100.00	72 / 82 / 66	
02-19-88	15	48.67	1.67	45.00	1.95	1.95	100.00	48 / 67	
02-20-88	16	49.72	1.67	48.05	3.05	3.05	100.00	81 / 55 / 52	
02-20-88	17	52.77	2.73	50.04	1.99	1.96	98.99	55 / 100	2.66

DRILLING LOG

WATER LEVEL	LUGEON UNIT (Lu)	DEPTH (M)	LITHOLOGY	ROCK HARDNESS	ROCK COLOR	ROCK FACIES NAME	ROCK FACIES SYMBOL	DESCRIPTION
3.0	1.39@ 10kg/cm²	05		SOFT	LIGHT BROWN SAND	CONGLOMERATE	Cgl	FINE-GRAINED SLUDGE. 2.95-3.00, BROKEN Cgl PEBBLES. (WEATHERED CONGLOMERATE) 4.88-3.00, BROKEN Cgl PEBBLES.
8.0	0.604 @ 10kg/cm²	10		SOFT	LIGHT BROWN SAND	CONGLOMERATE	Cgl	5-8, MEDIUM-GRAINED SLUDGE. 8-10, FINE-GRAINED SLUDGE.
12.0	8.63@ 3kg/cm² max			SOFT	LIGHT BROWN	CONGLOMERATE	Cgl	10-11.7, FINE GRAINED SLUDGE
		15		MED. HARD	LIGHT GRAY	CONGLOMERATE	Cgl	11.7-13.0, SLIGHTLY WEATHERED WITH PROMINENT FRACTURES DIPPING 40° TO 80°, PARTIALLY FILLED FRACTURES WITH BROWN MAT.
15.70	3.80@ 7kg/cm² MAX.	20		MED. HARD	LIGHT GRAY TO GREENISH	CONGLOMERATE	Cgl	15.25-15.70, MODERATELY BROKEN W/26° DIP OPEN FRACTURS. 18.2-18.8, HIGHLY BROKEN.
15.70	4.36@ 10kg/cm² MAX.	25		MED. HARD	LIGHT GRAY	CONGLOMERATE	Cgl	MODERATELY MASSIVE. PROMINENT CEMENTING MATERIAL (MATRIX)ARE CALCITE AND MAGNETITE.
9.65	4.86 10kg/cm² MAX.	30		MED. HARD	LIGHT GRAY	CONGLOMERATE	Cgl	SAME AS 20 TO 25.
9.65	13.6 @ 4kg/cm² MAX.	35		SLIGHTLY HARD / MED. HARD	LIGHT GRAY W/ BROWNISH TINTS.	CONGLOMERATE	Cgl	MATRIX IS TUFFACEOUS AND CLAYEY(30 TO 40M). 33.55 TO 33.88, BROKEN 31.5-32.0, BROKEN
34.40	14.4 @ 4kg/cm² MAX.	40		SLIGHTLY HARD	LIGHT GRAY W/ BROWNISH TINTS.	CONGLOMERATE	Cgl	34.30-34.6, MODERATELY BROKEN 38.39-38.84, HIGHLY BROKEN 39.0-39.84, HIGHLY FRACTURED, PROMINENT FRACTURE PLAUE 35° DIP WITH BROWN STAINS.
38.55	3.25@ 10kg/cm² MAX.	45		MED. HARD	LIGHT GRAY	CONGLOMERATE	Cgl	AT 43.7M CALCITE FILLED FRACTURE DIPPING 76°
47.50	5.65@ 7kg/cm² MAX.	50		MED. HARD	LIGHT GRAY	CONGLOMERATE	Cgl	AT 45.05 SLICKENSIDED SHEAR FRACTURE PLANE 40° DIP. 46.6-46.85, HIGHLY FRACTURED 47.5-47.85, BROKEN 48.3-48.5, BROKEN

PROJECT : WANGAL CORE DRILLING

Table D.7.5 Results of Water Pressure Test for Test Hole Drilling

DATA : WATER PRESSURE TEST

(1/2)

DATE	DEPTH M-M	L (cm)	r (cm)	PRESSURE (kg/cm²)	HEAD(A) (cm)	HEAD(B) (cm)	H=A+B+C (cm)	(q) L/Min	(Q) cm³/Min	K cm/sec	Lu Lugeon Unit
FEB. 9. 1988	2.50-5.00	250.00	3.83	1.0	1,000.00	312.50	1,322.50	0.185	0.185×10^3	6.20205×10^{-6}	0.5595463
	2.50-5.00	250.00	3.83	4.0	4,000.00	312.50	4,322.50	0.975	0.975×10^3	1.00006×10^{-5}	0.9022556
	2.50-5.00	250.00	3.83	7.0	7,000.00	312.50	7,322.50	0.218 ×10	0.218×10^4	1.31994×10^{-5}	1.1908500
	2.50-5.00	250.00	3.83	10.0	10,000.00	312.50	10,322.50	3.595	3.596×10^3	1.54409×10^{-5}	1.3930734
	2.50-5.00	250.00	3.80	7.0	7,000.00	312.50	7,322.50	2.155	2.155×10^3	1.30480×10^{-5}	1.1771900
	2.50-5.00	250.00	3.83	4.0	4,000.00	312.50	4,322.50	0.980	0.980×10^3	1.00519×10^{-5}	0.9068825
	2.50-5.00	250.00	3.83	1.0	1,000.00	312.50	1,322.50	0.480	0.480×10^3	1.60918×10^{-5}	1.4517900
FEB. 11. 1988											
	5.00-10.0	500.00	3.83	1.0	1,000.00	650.00	11,660.00	0.431	0.431×10^3	2.10815×10^{-5}	0.5192771
	5.00-10.0	500.00	3.83	4.0	4,000.00	650.00	4,660.00	1.535	1.535×10^3	8.51345×10^{-6}	0.6587982
	5.00-10.0	500.00	3.83	7.0	7,000.00	650.00	7,660.00	2.540	2.540×10^3	8.57014×10^{-6}	0.6631853
	5.00-10.0	500.00	3.83	10.0	10,000.00	650.00	10,660.00	3.220	3.220×10^3	7.80695×10^{-6}	0.6041270
	5.00-10.0	500.00	3.83	7.0	7,000.00	650.00	7,660.00	2.450	2.450×10^3	8.26647×10^{-6}	0.6396860
	5.00-10.0	500.00	3.83	4.0	4,000.00	650.00	4,660.00	2.420	2.420×10^3	1.34218×10^{-5}	1.0386200
	5.00-10.0	500.00	3.83	1.0	1,000.00	650.00	1,660.00	1.096	1.096×10^3	1.70641×10^{-5}	1.3204819
FEB. 13. 1988											
	10.0-15.0	500	3.83	1.0	1,000.00	3,100.00	2,110.00	12.530	12.530×10^3	2.94402×10^{-4}	11.876777
	10.0-15.0	500	3.83	3.0	3,000.00	1,100.00	4,110.00	17.740	17.740×10^3	1.11556×10^{-4}	8.6326034
	10.0-15.0	500	3.83	1.0	1,000.00	1,100.00	2,110.00	13.281	13.281×10^3	1.62679×10^{-4}	12.588626
FEB. 14. 1988											
	15.0-20.0	500	3.83	1.0	1,000.00	1,535.00	2,545.00	3.570	3.57×10^3	3.62546×10^{-5}	2.805501
	15.0-20.0	500	3.83	4.0	4,000.00	1,535.00	5,545.00	9.280	9.28×10^3	4.32543×10^{-5}	3.3471596
	15.0-20.0	500	3.83	7.0	7,000.00	1,535.00	8,545.00	16.276	16.276×10^3	4.92287×10^{-5}	3.8094792
	15.0-20.0	500	3.83	4.0	4,000.00	1,535.00	5,545.00	8.86	8.86×10^3	4.12967×10^{-5}	3.1956718
	15.0-20.0	500	3.83	1.0	1,000.00	1,535.00	2,545.00	3.505	3.505×10^3	3.55945×10^{-5}	2.7544204
FEB. 15. 1988											
	20.00-25.0	500	3.83	1.0	1,000.00	1,570.00	2,580.00	4.745	4.745×10^3	4.753×10^{-5}	3.678000
	20.00-25.0	500	3.83	4.0	4,000.00	1,570.00	5,580.00	16.795	16.795×10^3	7.779×10^{-5}	6.012500
	20.00-25.0	500	3.83	7.0	7,000.00	1,570.00	8,580.00	20.906	20.906×10^3	6.297×10^{-5}	4.873000
	20.00-25.0	500	3.83	10.0	10,000.00	1,570.00	11,580.00	25.250	25.25×10^3	5.635×10^{-5}	4.361000
	20.00-25.0	500	3.83	7.0	7,000.00	1,570.00	8,580.00	20.620	20.62×10^3	6.211×10^{-5}	4.806500
	20.00-25.0	500	3.83	4.0	4,000.00	1,570.00	5,580.00	16.57	16.57×10^3	7.674×10^{-5}	5.939000
	20.00-25.0	500	3.83	1.0	1,000.00	1,570.00	2,580.00	4.40	4.40×10^3	4.967×10^{-5}	3.410000

PROJECT : WANGAL CORE DRILLING

DATA : WATER PRESSURE TEST

Table D.7.5 Results of Water Pressure Test for Test Hole Drilling

(2/2)

DATE	DEPTH M-M	L (cm)	r (cm)	PRESSURE (kg/cm²)	HEAD(A) (cm)	S.W.L.(B) (cm)	H=A+B+C (cm)	(q) L/Min	(Q) cm³/Min	K cm/sec	Lu Lugeon Unit
FEB. 17. 1988	25.0-30.0	500	3.83	1.0	1,000.00	965.00	1,975.00	4.750	4.75 $\times10^3$	6.2159 $\times10^{-5}$	4.810
	25.0-30.0	500	3.83	4.0	4,000.00	965.00	4,975.00	16.685	16.68 $\times10^3$	8.667 $\times10^{-5}$	6.707
	25.0-30.0	500	3.83	7.0	7,000.00	965.00	7,975.00	20.86	20.86 $\times10^4$	6.760 $\times10^{-5}$	5.231
	25.0-30.0	500	3.83	10.0	10,000.00	965.00	10,975.00	26.70	26.70 $\times10^3$	6.287 $\times10^{-5}$	4.865
	25.0-30.0	500	3.80	7.0	7,000.00	965.00	7,975.00	21.13	21.13 $\times10^3$	6.8478 $\times10^{-5}$	5.299
	25.0-30.0	500	3.83	4.0	4,000.00	965.00	4,975.00	17.105	17.105 $\times10^3$	8.886 $\times10^{-5}$	6.876
	25.0-30.0	500	3.83	1.0	1,000.00	965.00	1,975.00	5.475	5.475 $\times10^3$	7.1647 $\times10^{-5}$	5.540
FEB. 18. 1988											
	30.0-35.0	500	3.83	1.0	1,000.00	965.00	1,975.00	29.36	29.36 $\times10^3$	3.8400 $\times10^{-5}$	29.7316
	30.0-35.0	500	3.83	4.0	4,000.00	965.00	4,975.00	33.98	33.98 $\times10^3$	1.7650 $\times10^{-4}$	13.6600
	30.0-35.0	500	3.83	4.0	4,000.00	965.00	4,975.00	33.925	33.925 $\times10^3$	1.7624 $\times10^{-4}$	13.6380
	30.0-35.0	500	3.83	1.0	1,000.00	965.00	1,975.00	30.375	30.370 $\times10^3$	3.97495 $\times10^{-4}$	30.7590
FEB. 19. 1988											
	35.0-40.0	500	3.83	1.0	1,000.00	3,440.00	4,450.00	32.160	32.16 $\times10^3$	1.8678 $\times10^{-4}$	14.4539
	35.0-40.0	500	3.83	4.0	4,000.00	3,440.00	7,450.00	46.605	46.60 $\times10^3$	1.6194 $\times10^{-4}$	12.5110
	35.0-40.0	500	3.83	4.0	4,000.00	3,440.00	7,450.00	46.510	46.51 $\times10^3$	1.8630 $\times10^{-4}$	14.4179
	35.0-40.0	500	3.83	1.0	1,000.00	3,440.00	4,450.00	32.800	32.80 $\times10^3$	1.6135 $\times10^{-4}$	12.5110
FEB. 19. 1988											
	40.0-45.0	500	3.83	1.0	1,000.00	3,855.00	4,865.00	2.860	2.86 $\times10^3$	1.5034 $\times10^{-5}$	1.1757
	40.0-45.0	500	3.83	4.0	4,000.00	3,855.00	7,865.00	9.535	9.535 $\times10^3$	9.5350 $\times10^{-5}$	2.4246
	40.0-45.0	500	3.83	7.0	7,000.00	3,855.00	10,853.00	15.853	15.853 $\times10^3$	3.7710 $\times10^{-5}$	2.9181
	40.0-45.0	500	3.83	10.0	10,000.00	3,855.00	13,865.00	22.540	22.54 $\times10^3$	4.2016 $\times10^{-5}$	3.2513
	40.0-45.0	500	3.83	7.0	7,000.00	3,855.00	10,853.00	15.815	15.815 $\times10^3$	3.7661 $\times10^{-5}$	2.9144
	40.0-45.0	500	3.83	4.0	4,000.00	3,855.00	7,865.00	9.880	9.880 $\times10^3$	3.24669 $\times10^{-5}$	2.51239
	40.0-45.0	500	3.83	1.0	1,000.00	3,855.00	4,865.00	2.980	2.980 $\times10^3$	1.58313 $\times10^{-5}$	1.22507
FEB. 20. 1988											
	45.0-50.0	500	3.83	1.0	1,000.00	4,625.00	5,635.00	4.530	4.530 $\times10^3$	2.0777 $\times10^{-5}$	1.60780
	45.0-50.0	500	3.83	4.0	4,000.00	4,625.00	8,635.00	19.685	19.685 $\times10^3$	5.8919 $\times10^{-5}$	4.55935
	45.0-50.0	500	3.83	7.0	7,000.00	4,625.00	11,635.00	32.920	32.920 $\times10^3$	7.3126 $\times10^{-5}$	5.65878
	45.0-50.0	500	3.83	4.0	4,000.00	4,625.00	8,635.00	20.820	20.820 $\times10^3$	6.23163 $\times10^{-5}$	4.82223
	45.0-50.0	500	3.83	1.0	1,000.00	4,625.00	5,635.00	4.930	4.930 $\times10^3$	2.26318 $\times10^{-5}$	1.7497

Table D.7.6 (1) Results of Rock Test of Drilling Core Sample (S-1)

MATERIALS DESCRIPTION: CONGLOMERATE

SPECIMEN SUBMITTED: CORE SAMPLES , 2" φ NOMINAL DIAMETER

A. SPECIFIC GRAVITY TEST

TEST METHOD: VOLLY BALANCE METHOD SAMPLE NO.: S-1

DATE OF TEST: FEB. 27, 1988 REFERENCE LOCATION: @ DEPTH 13.60 −13.75

TRIAL	1	2	3
WEIGHT IN AIR; WA	4.2	2.62	1.76
WEIGHT LOSS IN WATER; WL	1.77	0.96	0.69
APPARENT S.G. = WA/WL	2.373	2.729	2.551
MEAN SPECIFIC GRAVITY	S.G. = 2.551		

B. ABSORPTION TEST

SAMPLE NO. S-1 REFERENCE LOCATION: @ DEPTH 13.60 −13.75

TRIAL	1	2
CONTAINER + SATURATED SAMPLE, Wwet	10.90	9.55
CONTAINER + DRY SAMPLE, Wdry	10.80	9.45
CONTAINER , We	6.75	5.85
ABSORBED WATER, W1 = Ww = Wd	0.10	0.10
DRY WEIGHT, W2 = Wd = We	4.05	3.60
% ABSORPTION = W1 / W2	2.469	2.778
AVERAGE ABSORPTION	2.6235 %	

C. UNCONFINED COMPRESSION TEST

DATE OF TEST: FEB. 27, 1988

LOAD PACER, RPM: 0.5

RANGE SELECTOR: 10

SAMPLE DIAMETOR, CM: 4.75

SAMPLE AREA, CM2 17.72

MAXIMUM LOAD, Kg: 2230

UNCONFINED COMPRESSIVE STRENGTH, Kg/CM2= 125.84

SKETCH AT FAILURE

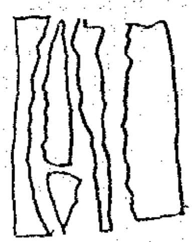


Table D.7.6 (2) Results of Rock Test of Drilling Core Sample (S-2)

MATERIALS DESCRIPTION: CONGLOMERATE

SPECIMEN SUBMITTED: CORE SAMPLES , 2" Φ NOMINAL DIAMETER

A. SPECIFIC GRAVITY TEST

TEST METHOD: VOLLY BALANCE METHOD SAMPLE NO.: S-2

DATE OF TEST: FEB, 27, 1988 REFERENCE LOCATION: @ DEPTH 21.35 -21.71

TRIAL	1	2	3
WEIGHT IN AIR; WA	4.3	2.62	1.96
WEIGHT LOSS IN WATER; WL	1.76	1.10	0.79
APPARENT S.G. = WA/WL	2.443	2.382	2.481
MEAN SPECIFIC GRAVITY	S.G. =	2.435	

B. ABSORPTION TEST

SAMPLE NO. S-2 REFERENCE LOCATION: @ DEPTH 21.35 -21.71

TRIAL	1	2
CONTAINER + SATURATED SAMPLE, Wwet	10.85	12.55
CONTAINER + DRY SAMPLE, Wdry	10.75	12.40
CONTAINER , We	6.60	6.75
ABSORBED WATER, W1 = Ww = Wd	0.10	0.15
DRY WEIGHT, W2 = Wd = We	4.15	5.65
% ABSORPTION = W1 / W2	2.41	2.65
AVERAGE ABSORPTION	2.53 %	

C. UNCONFINED COMPRESSION TEST

DATE OF TEST: FEB, 27, 1988

LOAD PACER, RPM: 0.5

RANGE SELECTOR: 10

SAMPLE DIAMETOR, CM: 4.7

SAMPLE AREA, CM2 17.349

MAXIMUM LOAD, Kg: 2180

UNCONFINED COMPRESSIVE STRENGTH, Kg/CM2= 125.65

SKETCH AT FAILURE

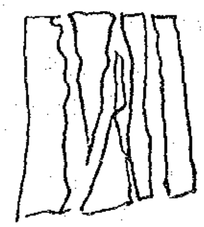


Table D.7.6 (3) Results of Rock Test of Drilling Core Sample (S-3)

MATERIALS DESCRIPTION: CONGLOMERATE

SPECIMEN SUBMITTED: CORE SAMPLES , 2" φ NOMINAL DIAMETER

A. SPECIFIC GRAVITY TEST

TEST METHOD: VOLLY BALANCE METHOD SAMPLE NO.: S-3 (①&②)

DATE OF TEST: FEB, 27, 1988 REFERENCE LOCATION: @ DEPTH 49.60

TRIAL	1	2	3
WEIGHT IN AIR; WA	8.52	0.91	0.85
WEIGHT LOSS IN WATER; WL	3.30	0.36	0.30
APPARENT S.G. = WA/WL	2.582	2.578	2.833
MEAN SPECIFIC GRAVITY	S.G. =	2.664	

B. ABSORPTION TEST

SAMPLE NO. S-3 REFERENCE LOCATION: @ DEPTH 49.60

TRIAL	1	2
CONTAINER + SATURATED SAMPLE, Wwet	11.65	10.60
CONTAINER + DRY SAMPLE, Wdry	11.50	10.45
CONTAINER , We	6.80	6.55
ABSORBED WATER, W1 = Ww = Wd	0.15	0.15
DRY WEIGHT, W2 = Wd = We	4.30	3.90
% ABSORPTION = W1 / W2	3.19	3.84
AVERAGE ABSORPTION	3.515%	

C. UNCONFINED COMPRESSION TEST

DATE OF TEST: FEB, 27, 1988

LOAD PACER, RPM: 0.5

RANGE SELECTOR: 10.0

SAMPLE DIAMETOR, CM: ① 4.7 | ② 4.7

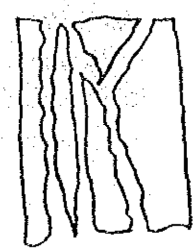
SAMPLE AREA, CM2 17.349 | 17.349

MAXIMUM LOAD, Kg: 2740 | 2540

UNCONFINED COMPRESSIVE STRENGTH, Kg/CM2= 146.40 — 157.93

SKETCH AT FAILURE

TYPICAL FAILURE FOR SAMPLE ①&②



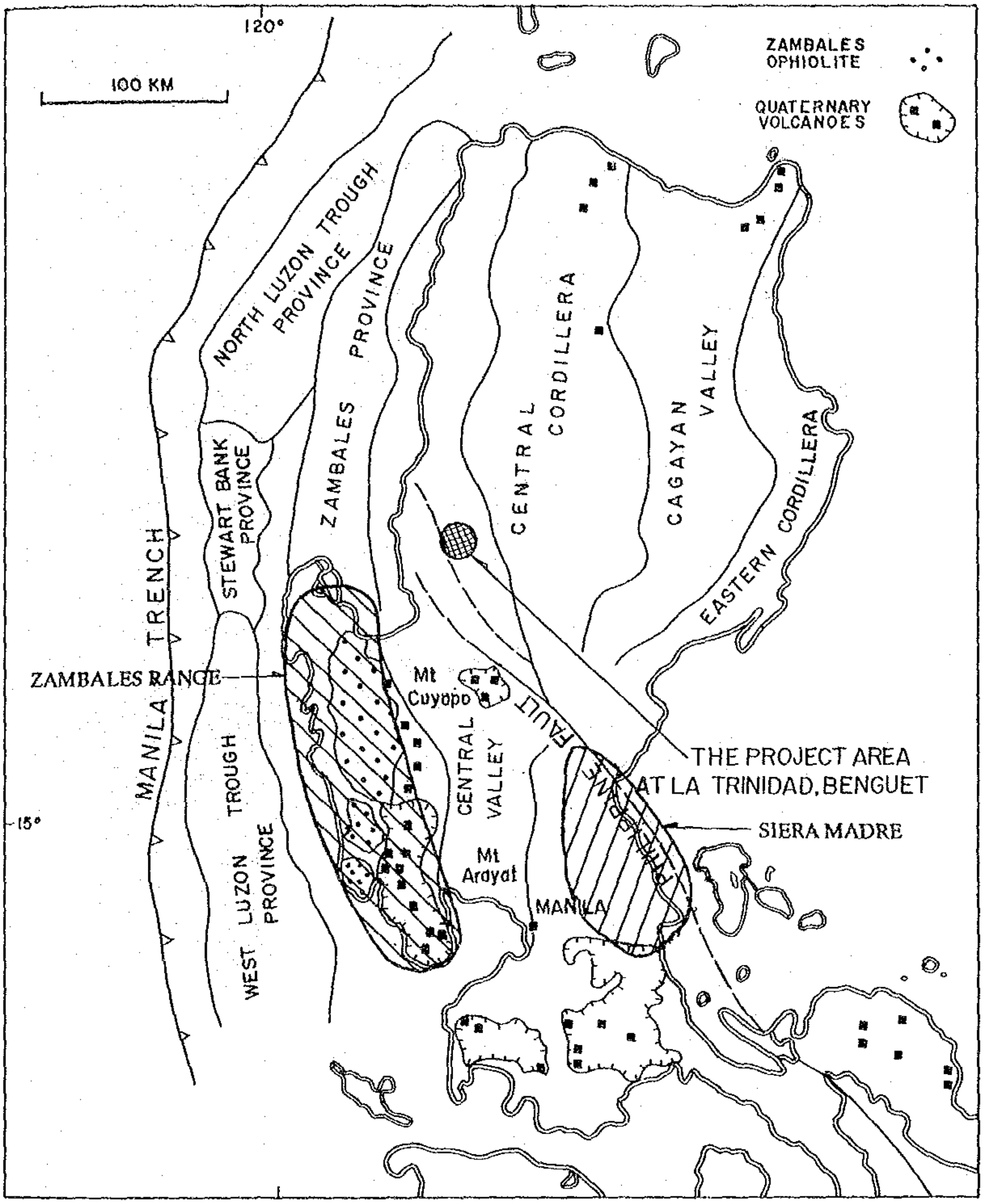


Fig. D.1 Regional Tectonic Setting

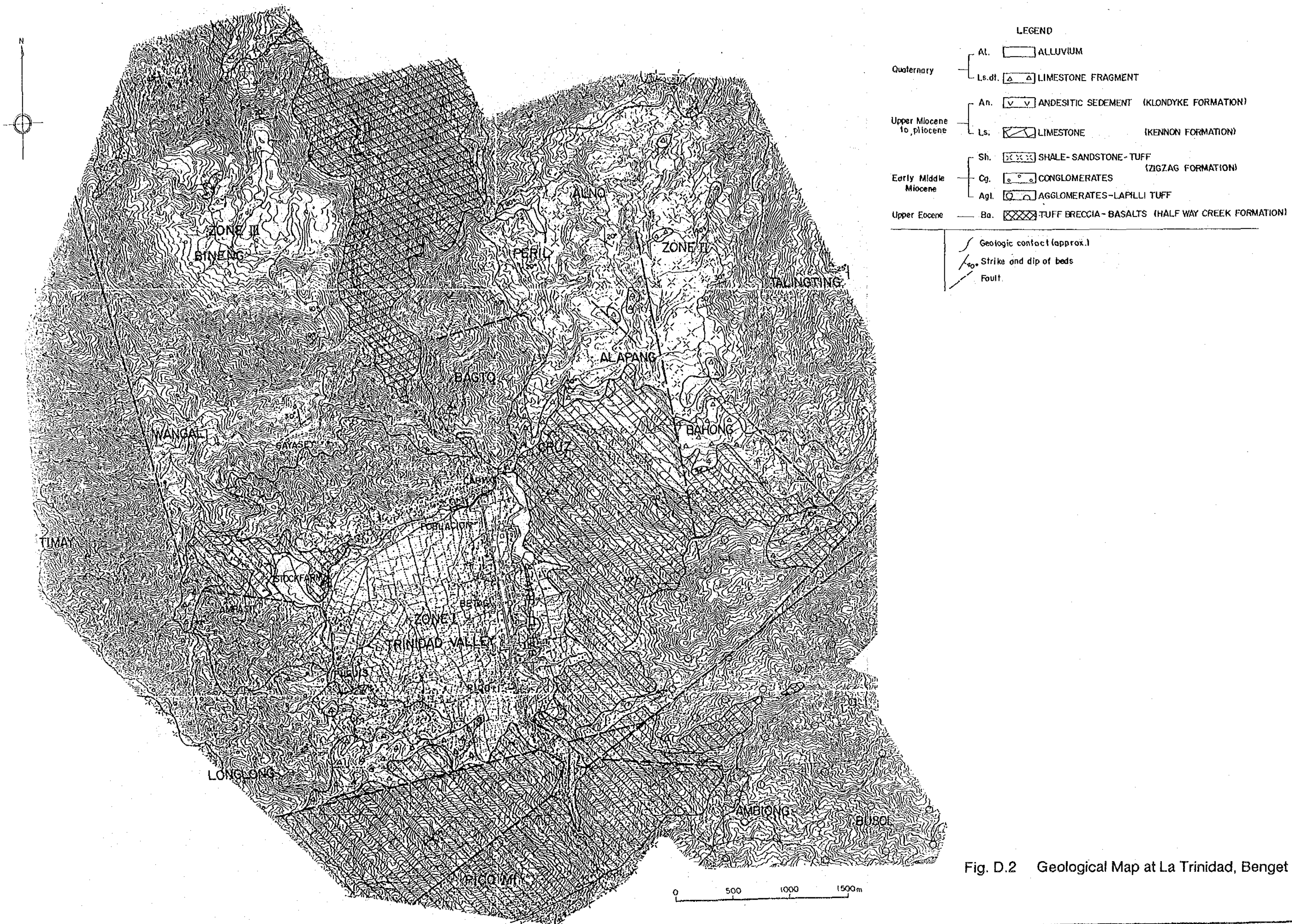


Fig. D.2 Geological Map at La Trinidad, Benget

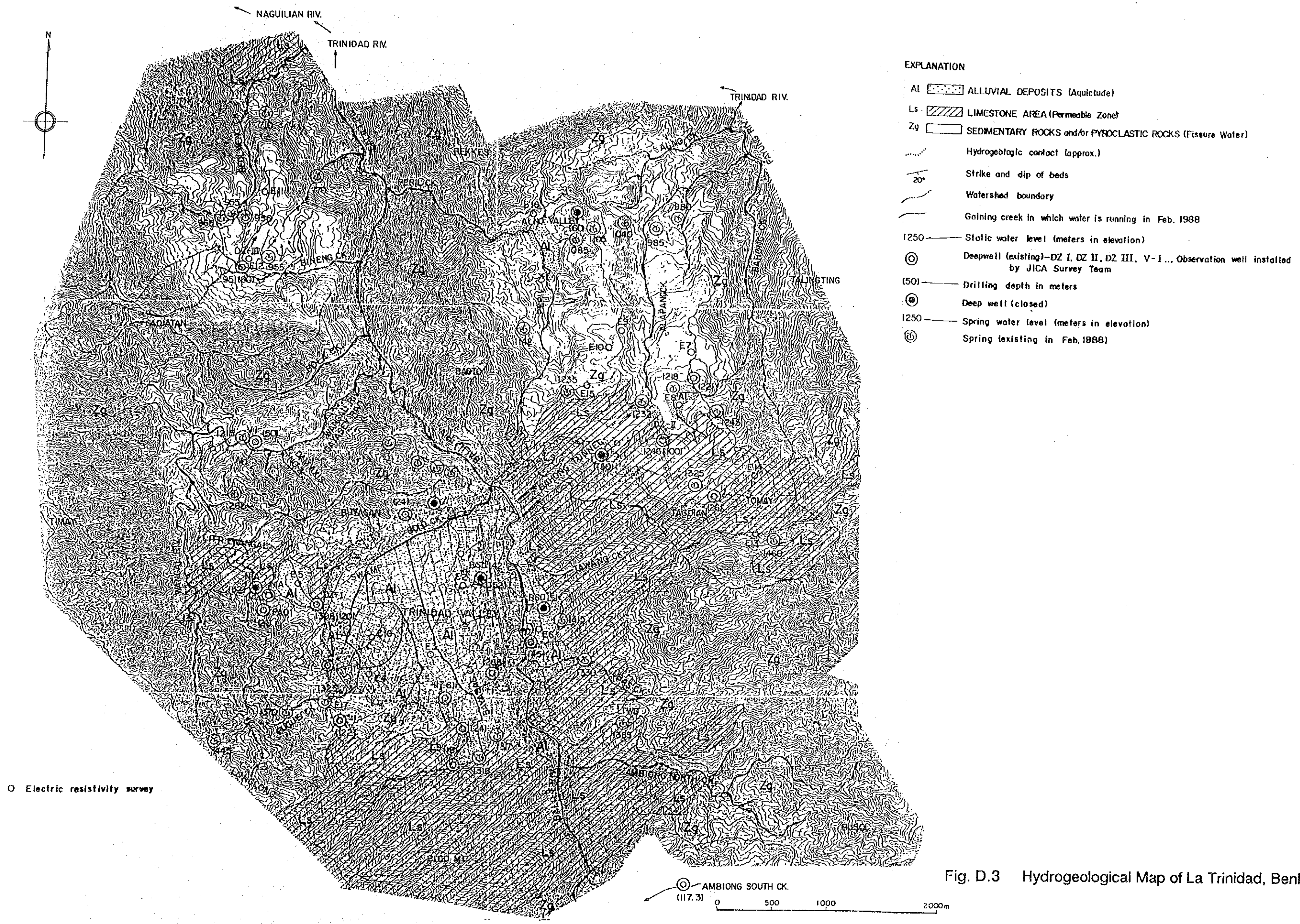


Fig. D.3 Hydrogeological Map of La Trinidad, Benbuet

The apparent resistivity (ρ) - depth (a) curve
ρ: apparent resistivity (ohm-m)
a : depth (m)

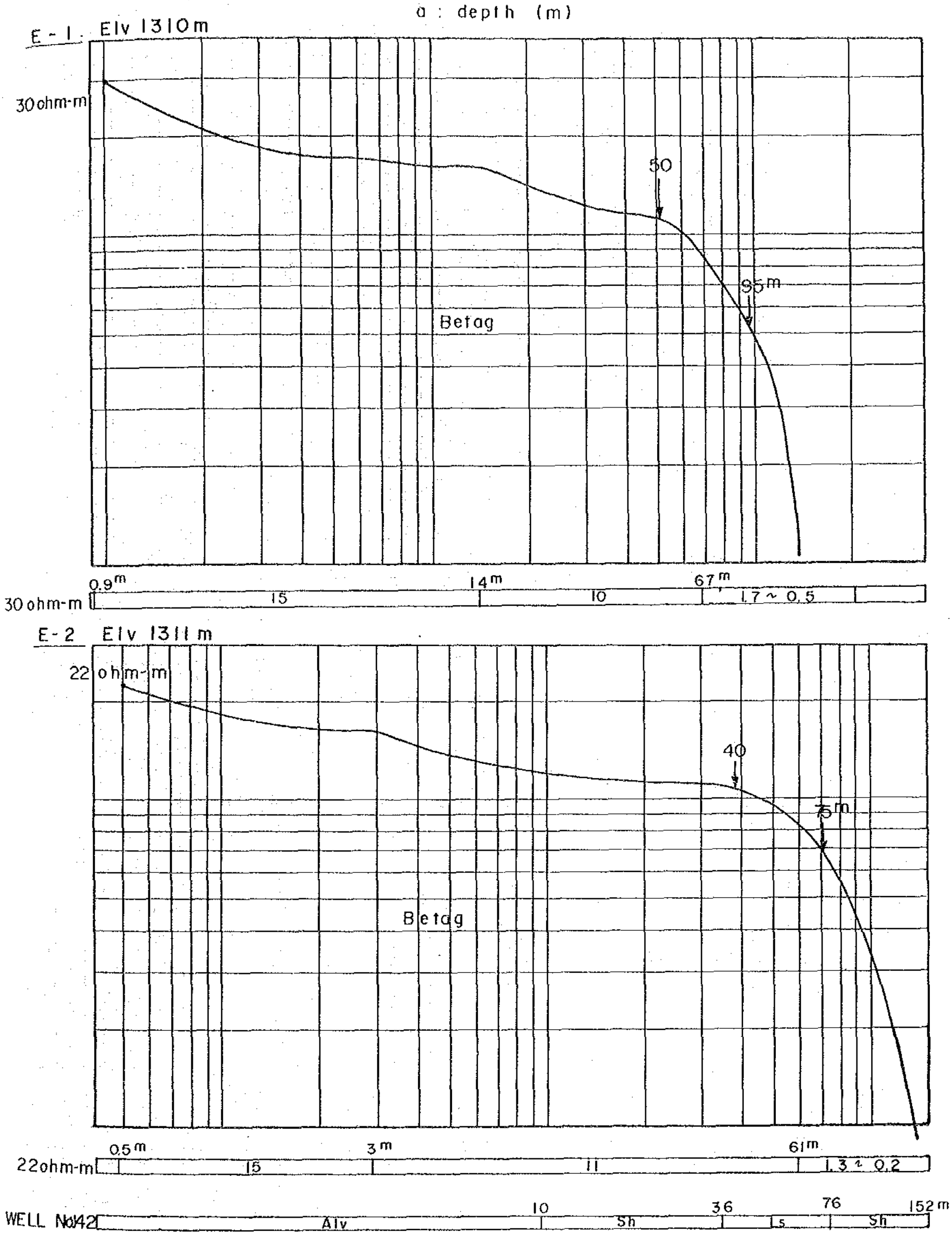
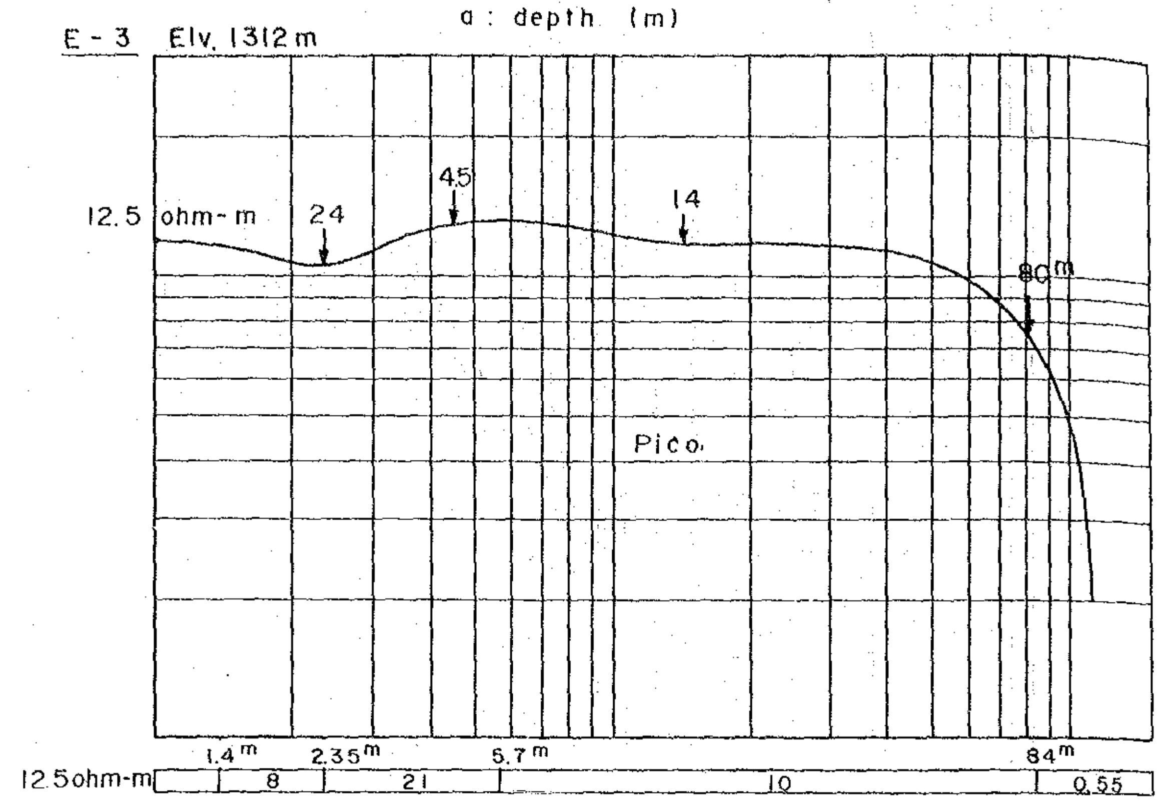


Fig.D.4 Results of the Electrical Resistivity Survey (1/9)

The apparent resistivity (ρ) - depth (a) curve
ρ : apparent resistivity (ohm-m)
a : depth (m)



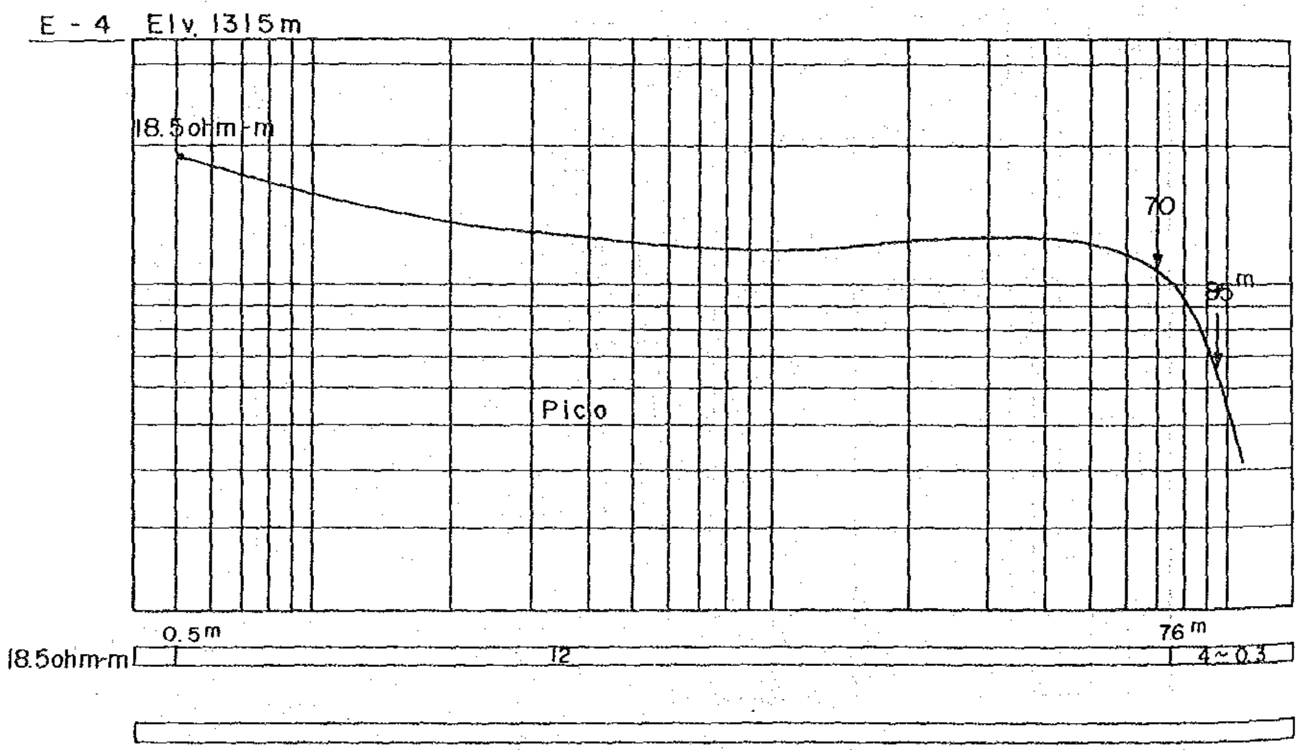
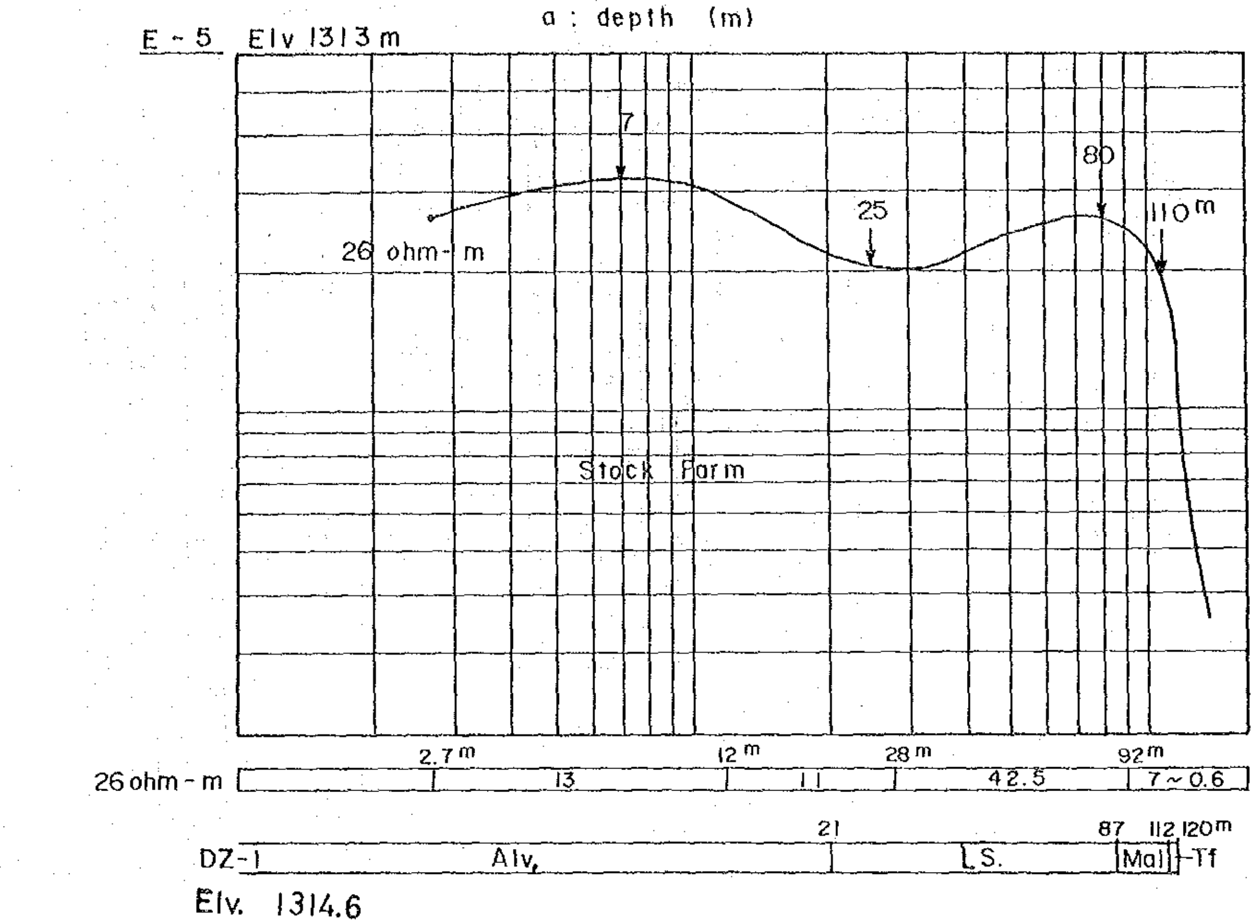


Fig. D.4 Results of the Electrical Resistivity Survey (2/9)

The apparent resistivity (ρ) – depth (a) curve
ρ: apparent resistivity (ohm-m)
a : depth (m)



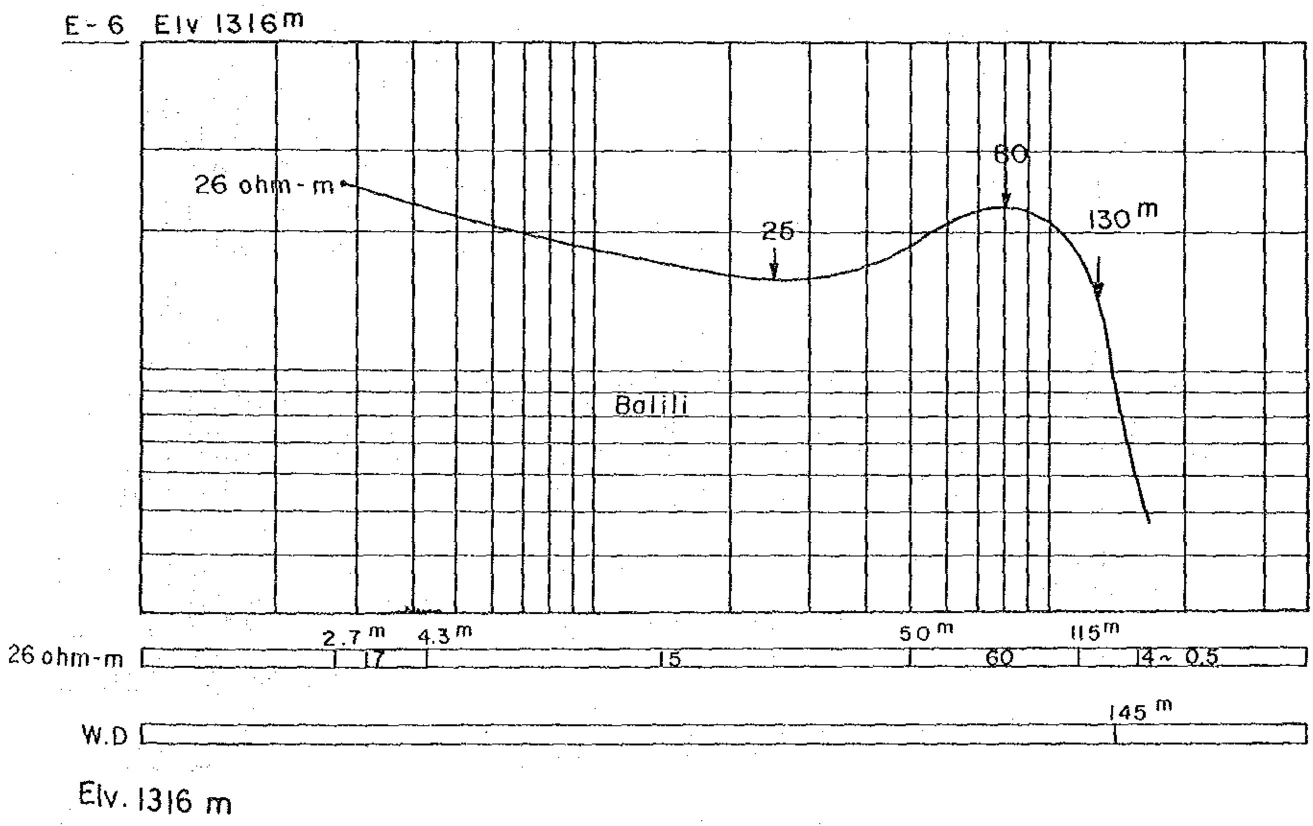
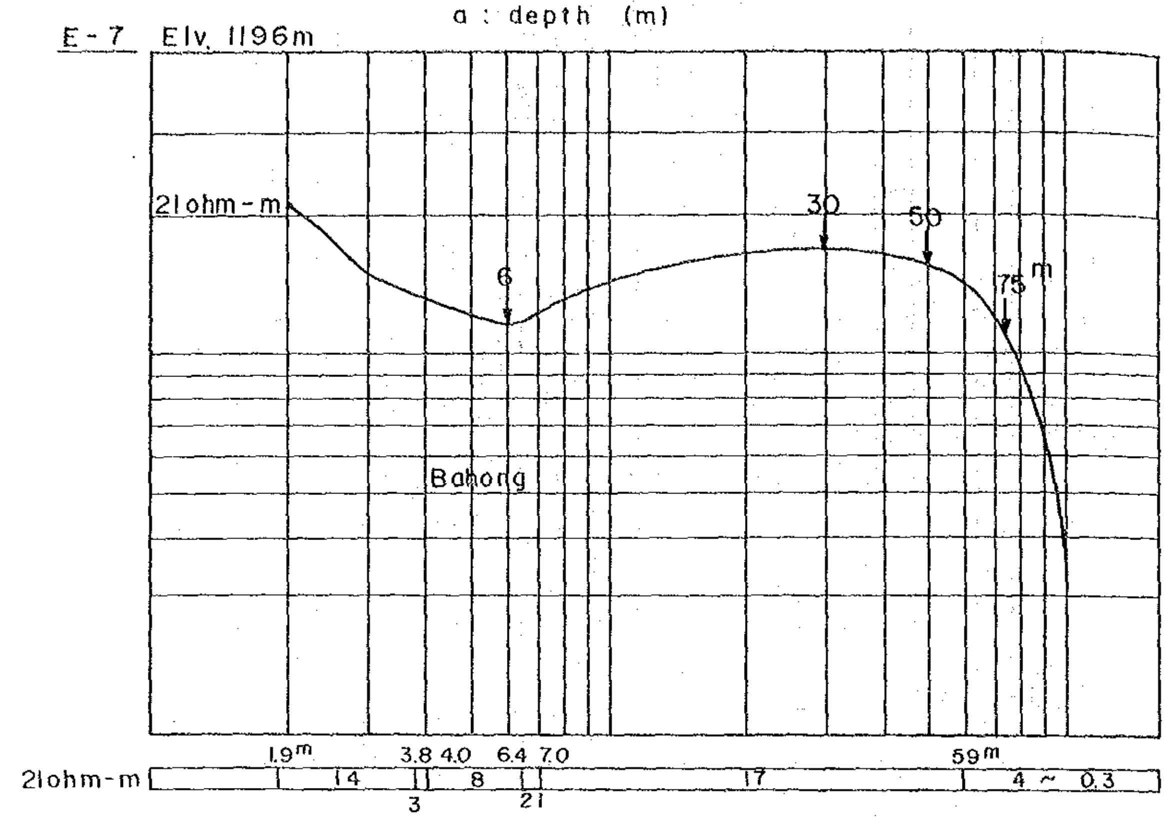


Fig.D.4 Results of the Electrical Resistivity Survey (3/9)

The apparent resistivity (ρ) - depth (a) curve

ρ: apparent resistivity (ohm-m)

a : depth (m)



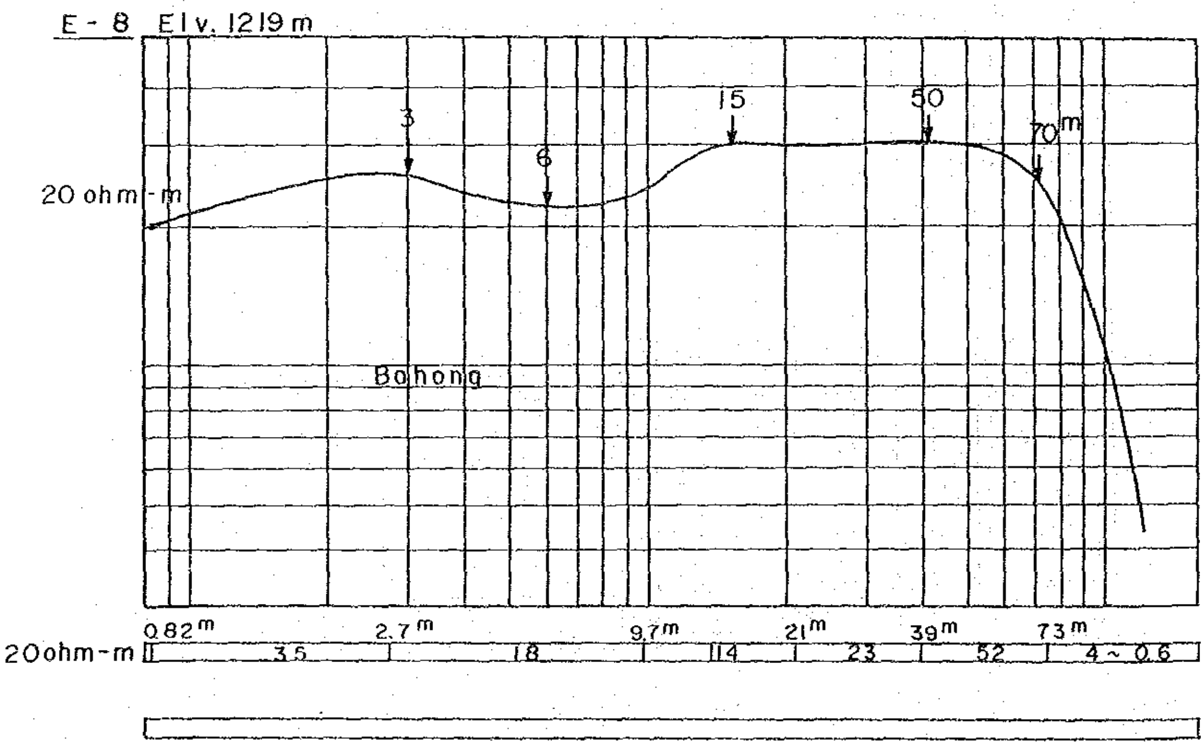


Fig. D.4 Results of the Electrical Resistivity Survey (4/9)