APPENDIX 8.1

RESULTS OF RIVER CONDITION

APPENDIX 8.1 PRESENT RIVER CONDITION

(1) River System

The river basins located in the Central part of Luzon, occupy a big portion in the provinces of Ilocos Sur, La Union, Pangasinan, Pampanga and a smaller portion of Bulacan. The basin is surrounded by the Cordillera Mountains on the north and on the east by the Sierra Madre Mountains. Independent rivers such as Canayon river, Sta. Maria river, Bauang river are located in the southern north of Ilocos region and La Union. While the river basin in the southwest portion is bounded by the adjoining Agno river basin and Pampanga river basin. Also included in the river basin is the flow that comes from the northern slope of Zambales Mountain, thus, all the flow discharges in Lingayen Gulf to South China Sea. There are also some other rivers not contributing to Agno river, they are the Patalan-Angalacan, Sinocalan, Bued, and Calamay-Dagupan rivers. Labangan river which is located at the southeast portion of Pampanga river discharges directly to Sta. Cruz river to Manila Bay.

The Cagayan river basin, located in the northern part of Luzon Island, is the largest basin in the Philippines. The basin originates from the Caraballo Mountains in the south near the provincial boundary of Nueva Vizcaya and Nueva Ecija. The river drains into Babuyan channel in the northern extremity of Luzon Island. The eastern central portion of the basin originates in the western slopes of the Sierra Madre Range and by Cordillera Mountains in the west.

The Cagayan river basin so called Cagayan valley is a feather shaped one surrounded by the mountains. The principal tributaries of the Cagayan river includes Magat, Ilagan, Siffu and Chico Rivers. Tributaries on the right side of the river are relatively steep with smaller basin areas, since the Cagayan river takes its route closer to the Sierra Madre Mountain. The flat plains extend mainly to the left side of the river. Other river basins excluded in the principal tributaries of Cagayan river are Pared river, Balasig river and Pinacanauan de Tuguegarao river which are located in Cagayan and Isabela provinces.

The Bicol river which is the main drainageway of the Bicol basin starts from Lake Bato and discharges at San Miguel Bay. The river basin is located in the southeastern part of Luzon Island. The basin lies mainly within the provinces of Albay and Camarines Sur and small portion of Camarines Norte. The Bicol river follows a general northerly direction from Lake Bato up to Naga City, where it swerves at a right angle towards the west for a distance of 10 km. At a little distance downstream of the upperend of cut off channel, it again assumes a northerly course until it reaches San Miguel Bay.

Further downstream to Lake Bato, the largest stream in the upper reach is called the Quinali river, where small rivers discharge into it. Among them are Cabilogan, San Francisco, and Nasisi rivers, all of which head from the western slopes of either Mayon Volcano or Mt. Masaraga.

Other river basin such as Basiad and Palsabangon rivers discharge directly to Basiad Bay to Calauag Bay and Pagbilao Bay to Tayabas Bay located less than 10 km away.

In Samar Island, the headwater originates in the south eastern tip of the basin and flows in a southwest direction and finally discharge into the west side of Samar Sea. The river basin is surrounded by numerous bays, islands and channels. Waters from these streams presumably disperse and join the adjoining Samar Sea and Philippine Sea in the north and east side of the river basin.

The basin map of the selected bridge, its river profile and cross section are shown in AP. 8.1.1, AP. 8.1.2 and AP. 8.1.3 respectively.

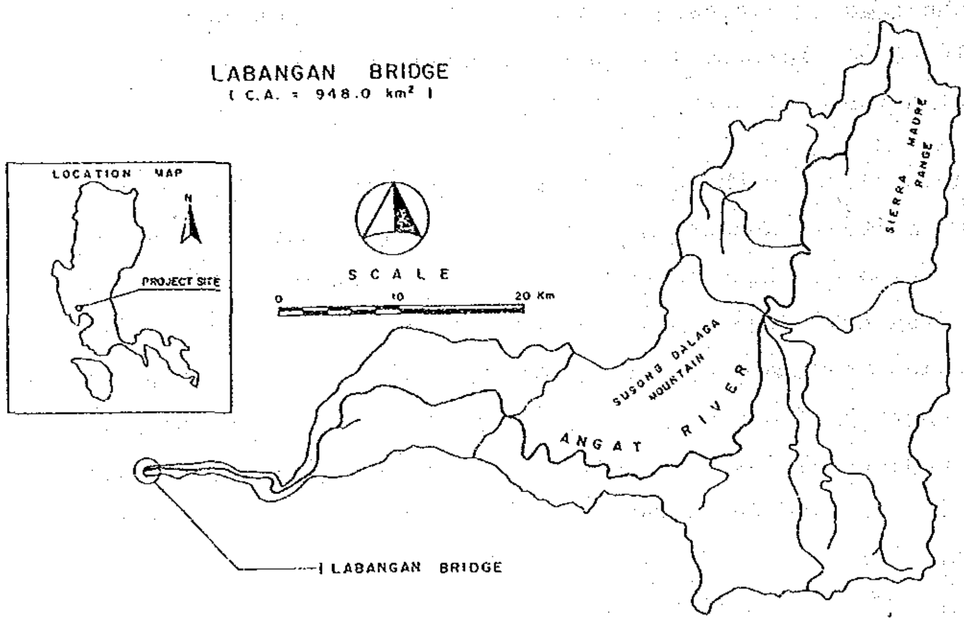
(2) Flood Damages in the Basin

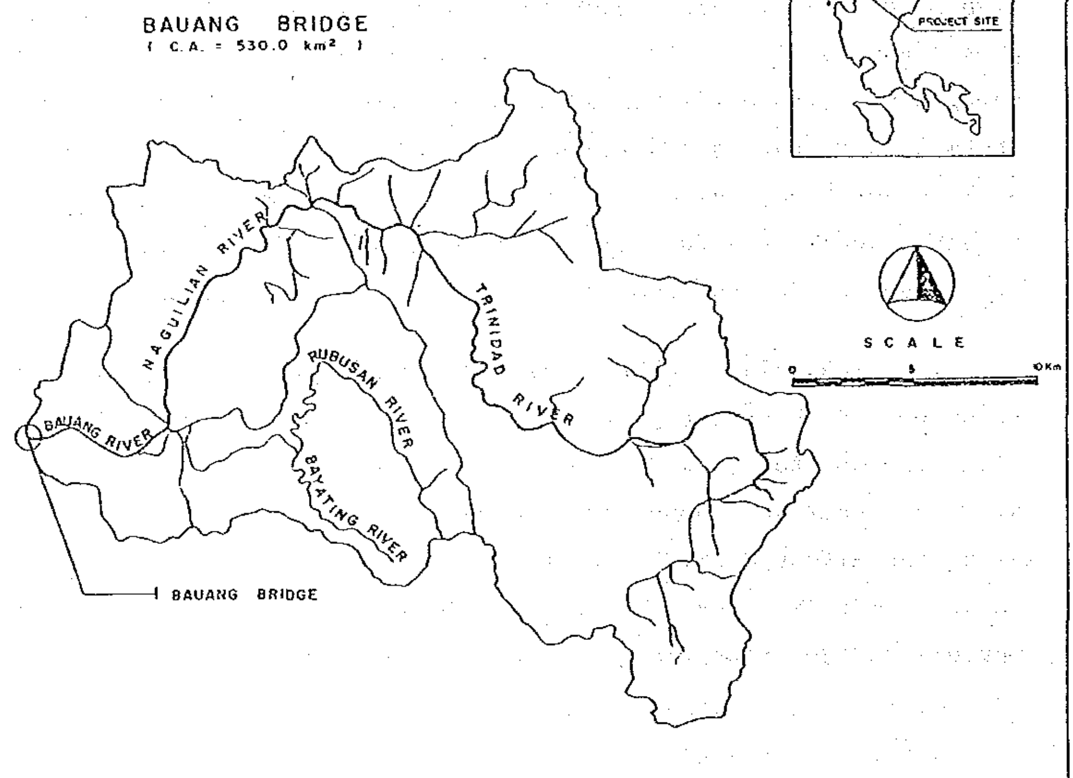
The river basins that form the Central Luzon basin, experienced several historical big floods in 1935, 1936, 1937, 1972, and 1980. Among them, the flood of 1972 submerged the entire flat basin. In Labangan bridge, Sta. Cruz bridge, and Sta. Maria bridge, the duration of flood takes several days if rain is continuous. This causes severe damages such as bank erosion and scouring of pier foundation. Other bridges like Tagamusing bridge and Bued bridge suffered serious deterioration of beams and other members of bridge. The inundations are also caused by overbanking and breaching of the existing dikes due to side erosion and shortage of channel capacity which are brought about by excessive siltation. The flood prone area covers highly productive agricultural lands and plantation areas.

The Cagayan river which is the largest river in the country has suffered from habitual inundations and bank erosions that require an immediate execution of flood control works. The recurrent floods have relegated the region to one of the least developed area in the country. Batu bridge which has a strong current velocity during flood, experienced erosion and scouring of abutment. Serious erosion around the pier and on the river bank were also observed in some bridges like Pinacanauan bridge, Naguilian bridge and Balasing bridge. Design flood water profile is shown in AP. 8.1.4.

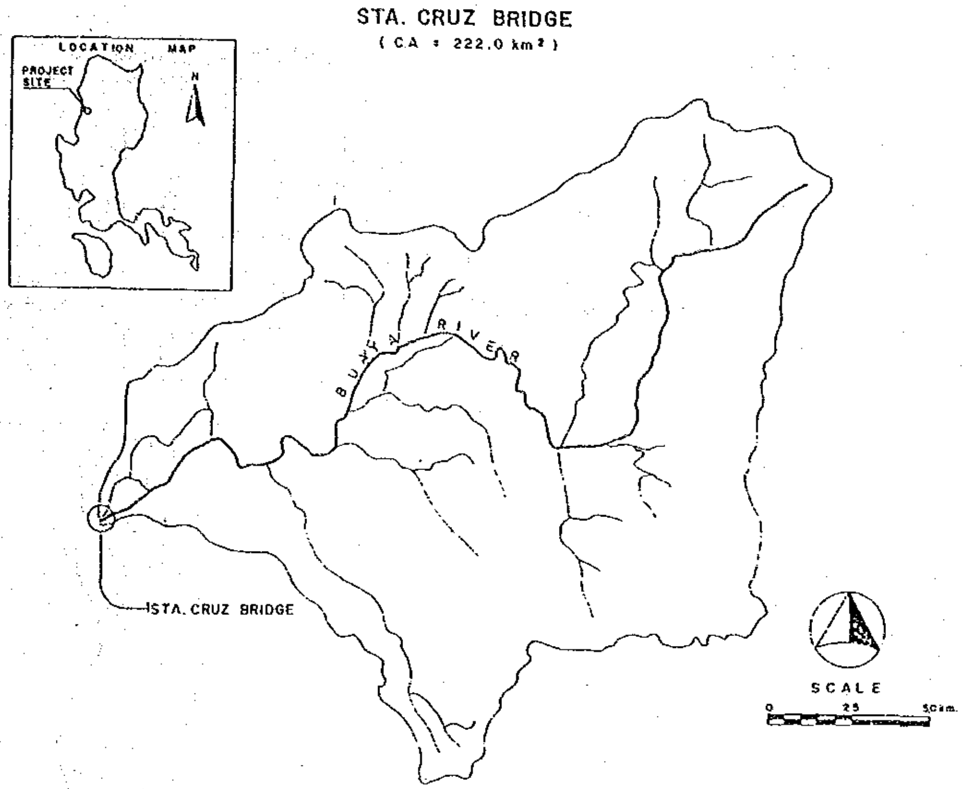
Located in the southern part of Luzon Island, is the Bicol basin which has a floodable area comprising mainly of agricultural lands of high productivity. The inhabitants susceptible to floods are less those in Cagayan and in the Central Luzon basin. Some of the noticeable damages were found in Guinobatan bridge where slope protection and abutment were partly destroyed. Also in upstream portion where the river bank is very low, the water over flows into the houses during flood season. There is also a slow recession of flood waters which cause a prolonged inundations that usually last for several weeks.

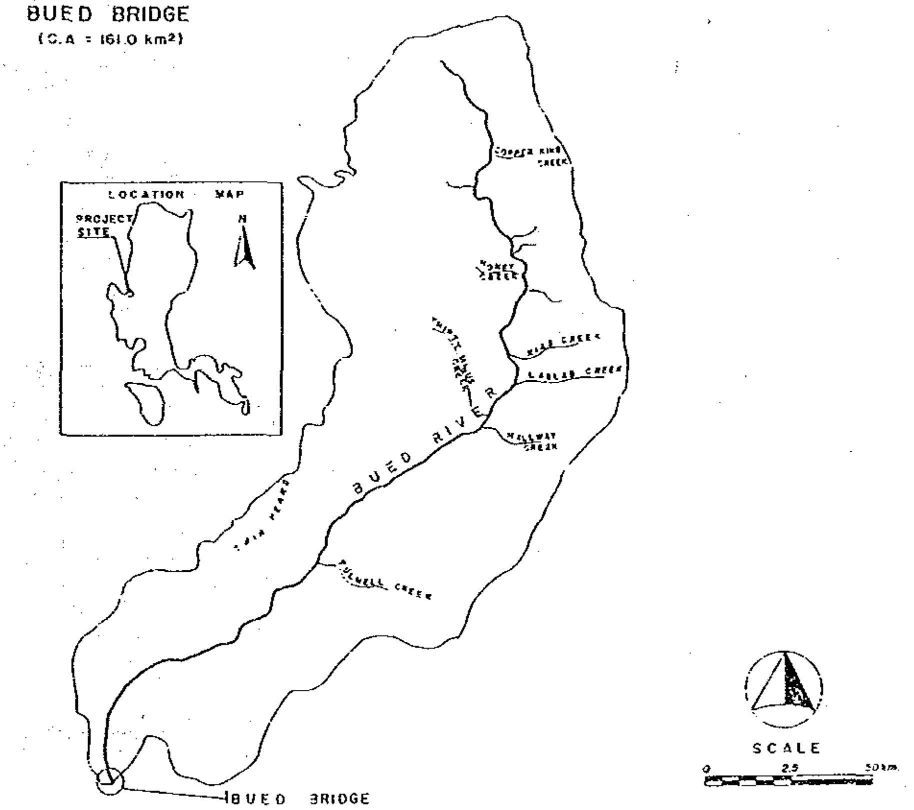
The flood plain in Samar Island has suffered from habitual inundations due to the shortage of channel capacity. Within the plain, lands along the coastal area are most severely affected, thus, suffering from deep and recurrent inundation because of inherent low-lying lands. Among the affected bridges, Jiabong, Hinogbongan and Jubasan bridges, suffered from serious erosions for abutment, corrosion for all structural members and deterioration at concrete slab and beams.



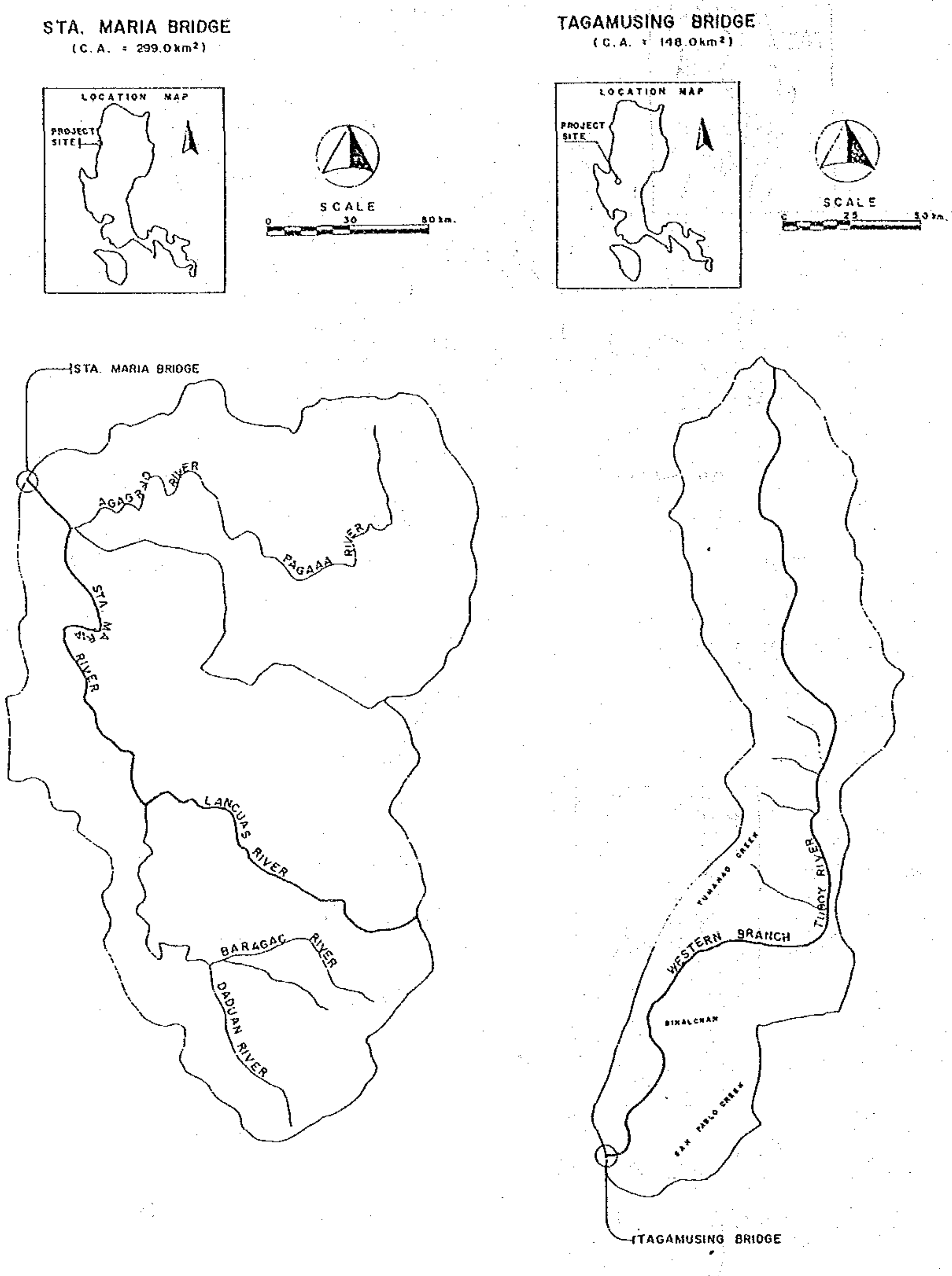


AP.8.1.1 BASIN MAP OF THE SELECTED BRIDGE (1/6)

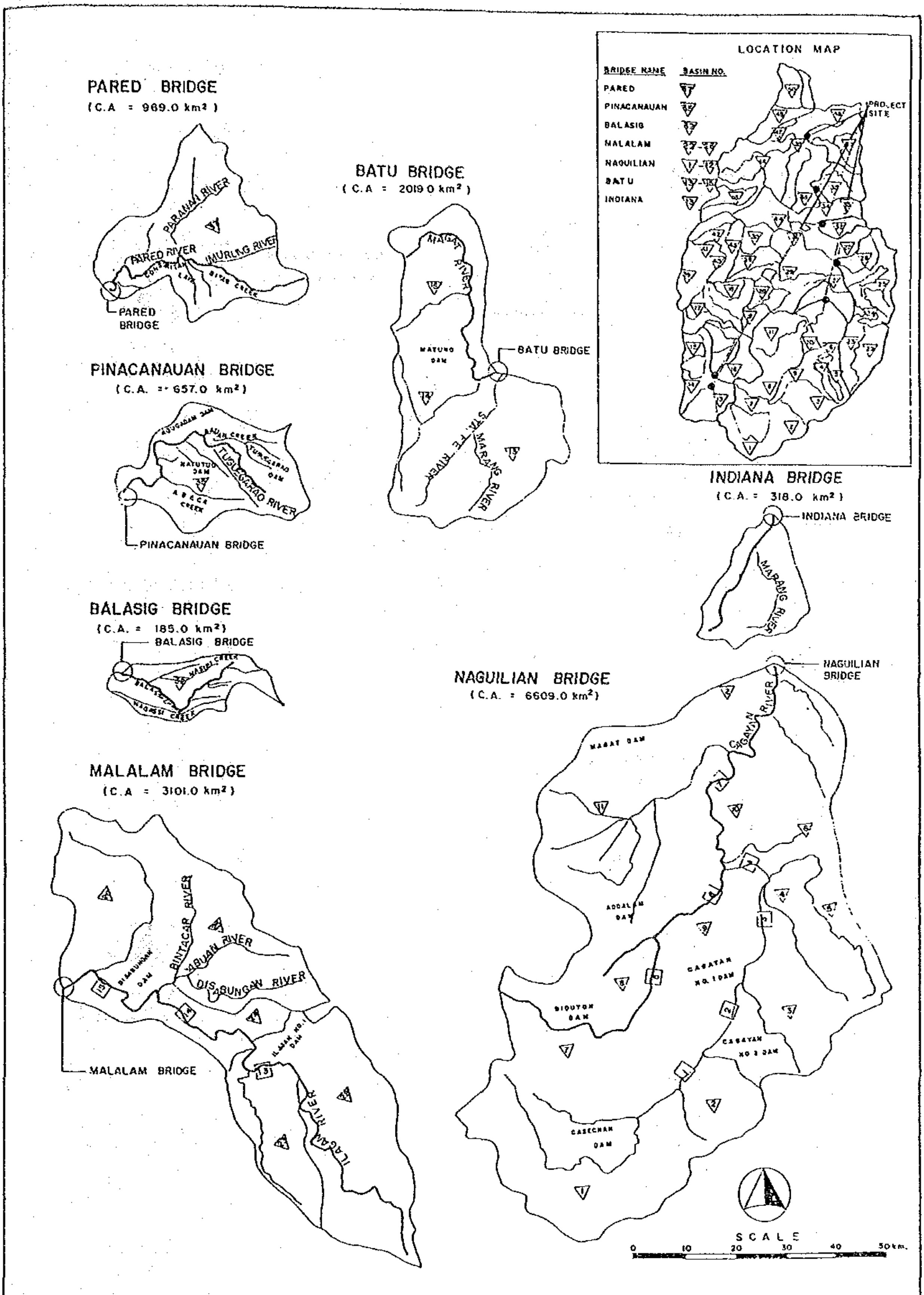




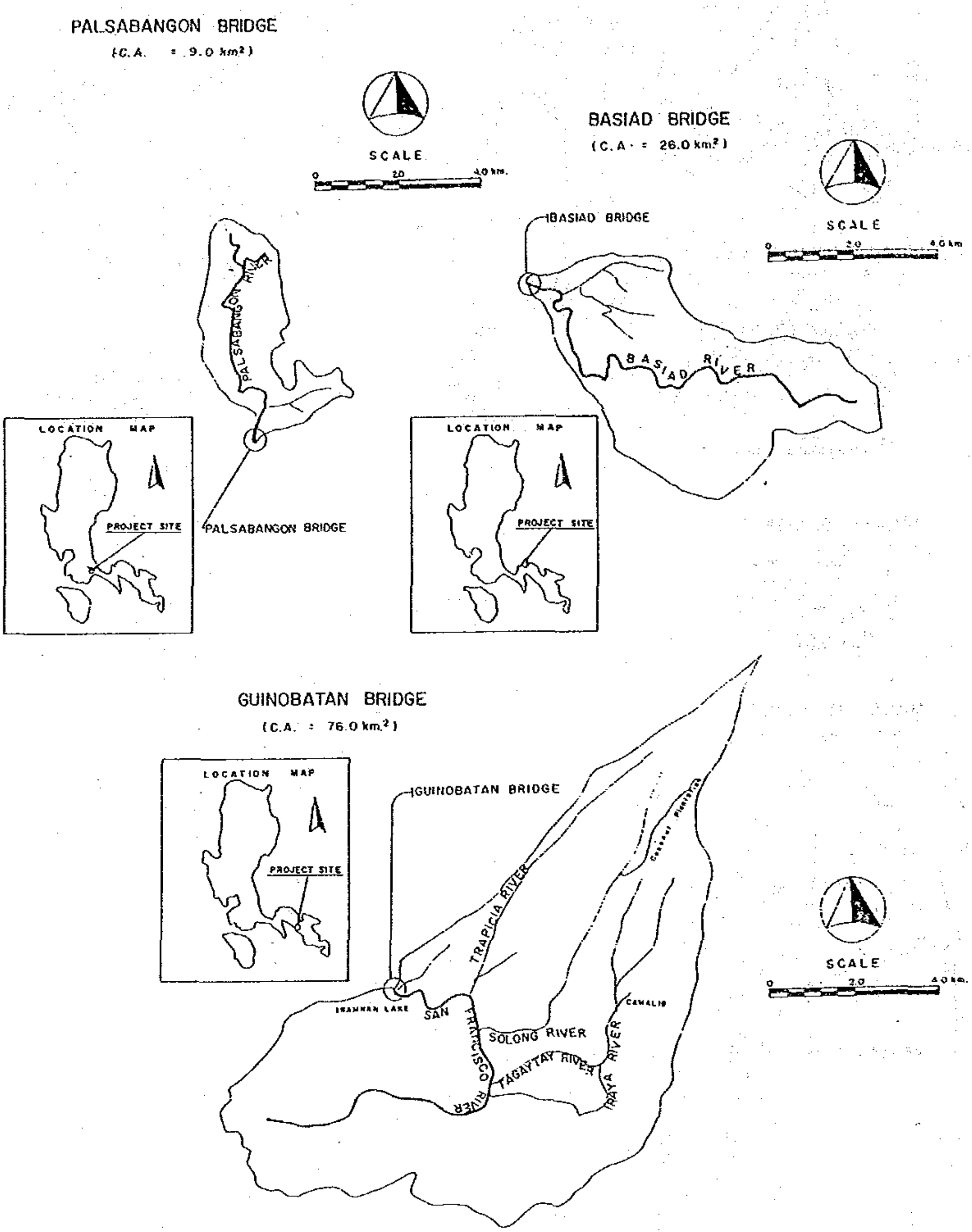
AP.8.1.1 BASIN MAP OF THE SELECTED BRIDGE (2/6)



AP.8.1.1 BASIN MAP OF THE SELECTED BRIDGE (3/6)

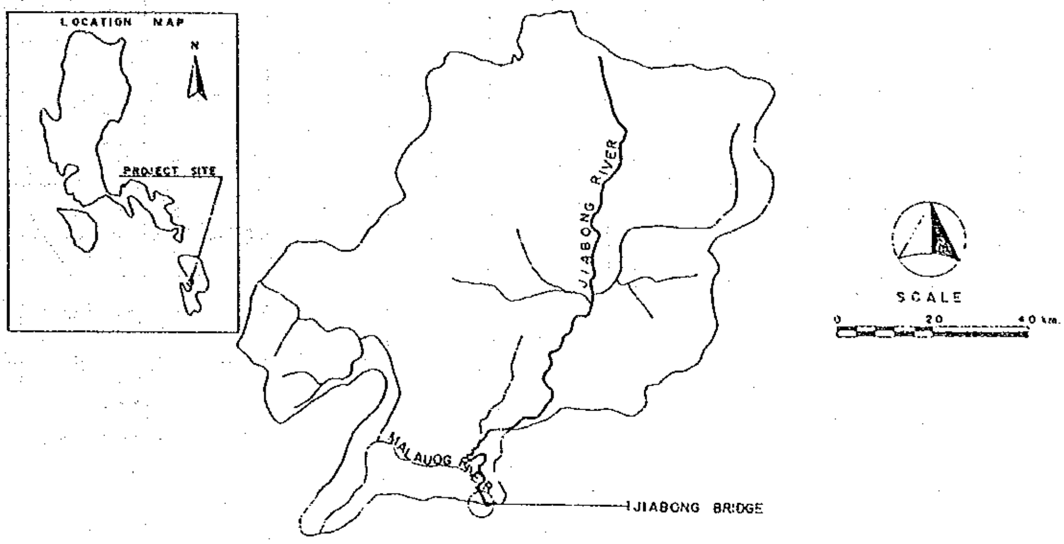


AP.8.1.1 BASIN MAP OF THE SELECTED BRIDGE (4/6)

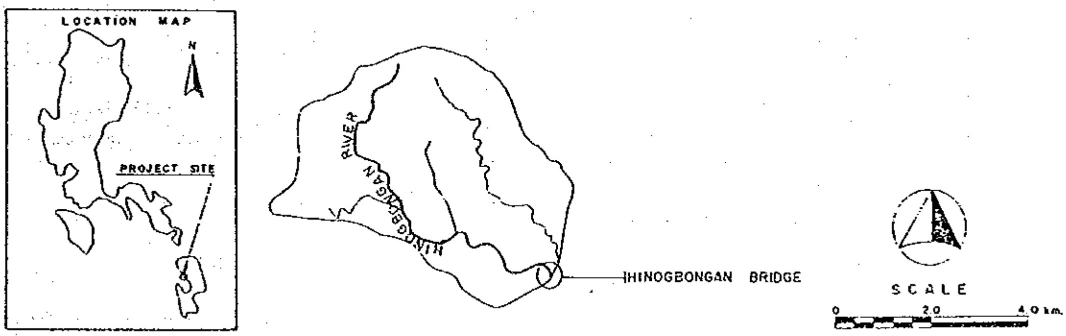


AP.8.1.1 BASIN MAP OF THE SELECTED BRIDGE (5/6)

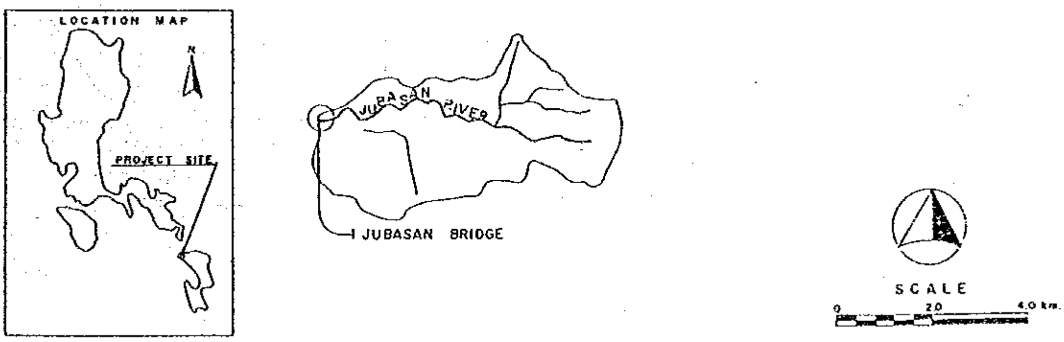
JIABONG BRIDGE
(C.A. = 670 km²)



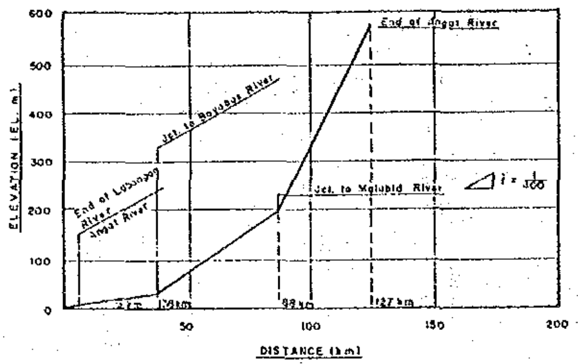
HINOGBONGAN BRIDGE
(C.A. = 13.0 km²)



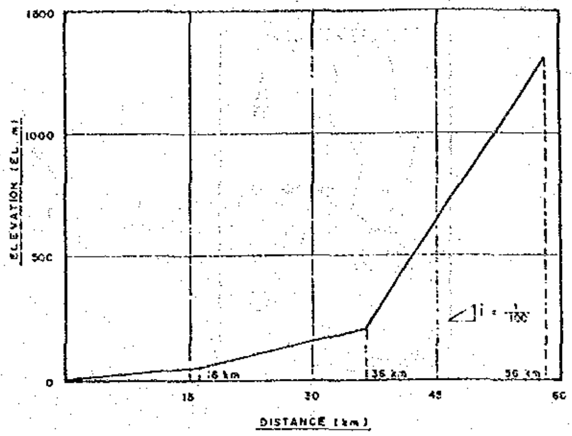
JUBASAN BRIDGE
(C.A. = 13.0 km²)



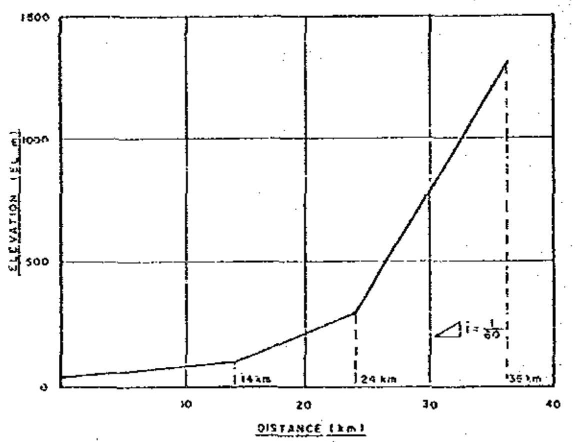
AP.8.1.1 BASIN MAP OF THE SELECTED BRIDGE (6/6)



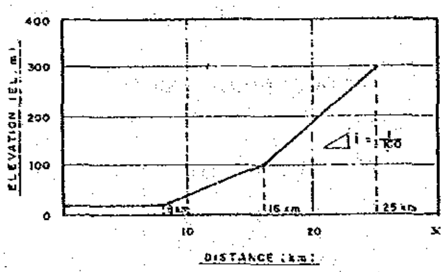
PROFILE OF LABANGAN RIVER



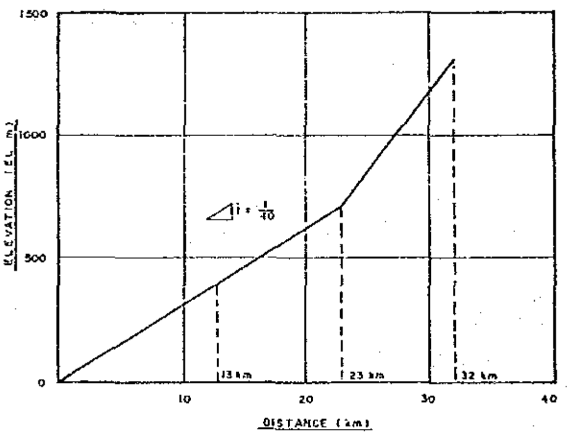
PROFILE OF BAUANG RIVER



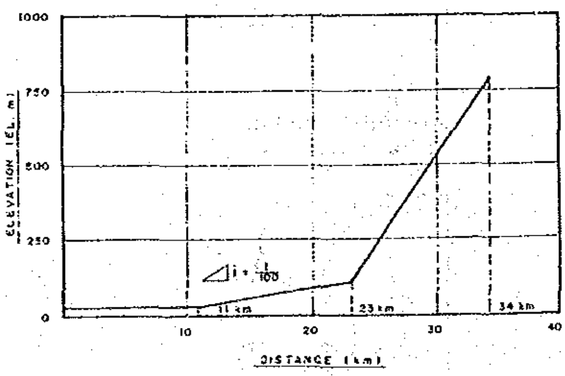
PROFILE OF TAGAMUSING RIVER



PROFILE OF STA. MARIA RIVER

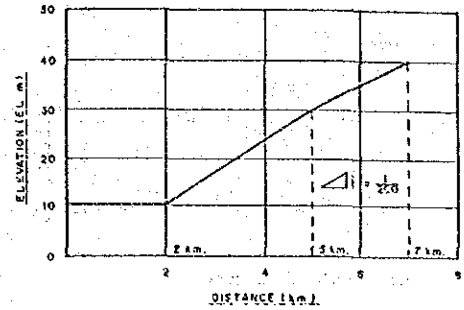


PROFILE OF BUED RIVER

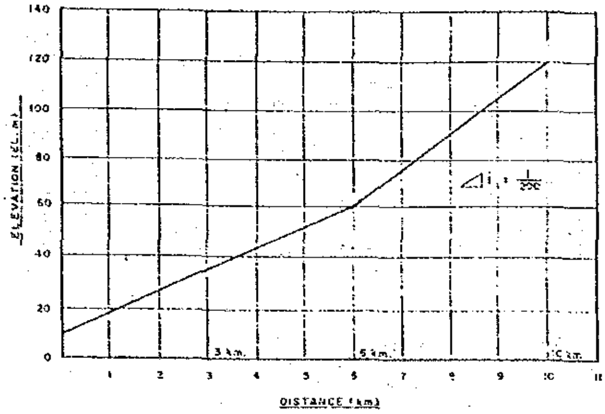


PROFILE OF BUAYA RIVER

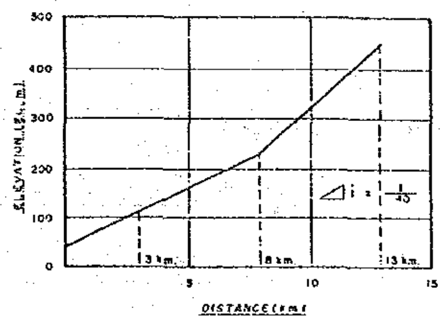
AP.8.1.2 RIVER PROFILE (1/2)



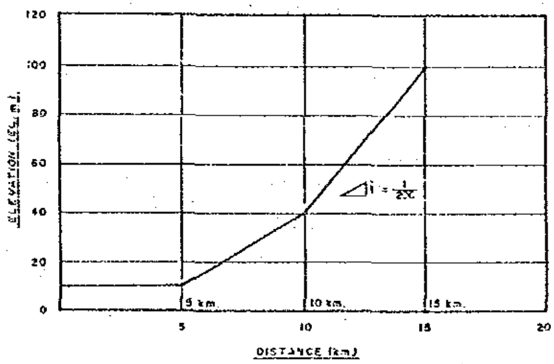
PROFILE OF PALSABANGON RIVER



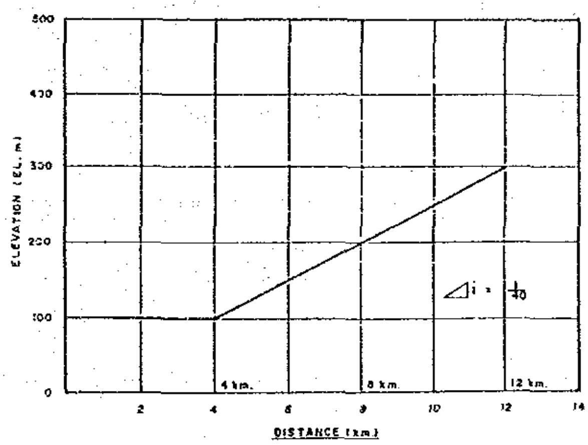
PROFILE OF JUBASAN RIVER



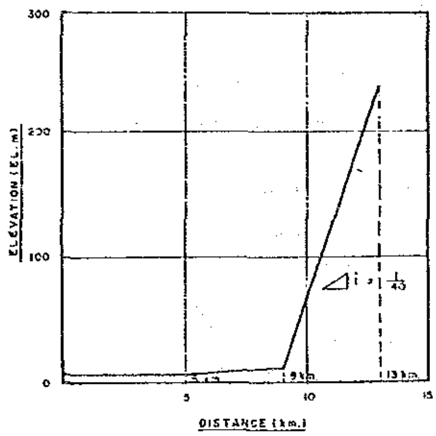
PROFILE OF BASIAD RIVER



PROFILE OF HINOGBONGAN RIVER



PROFILE OF SAN FRANCISCO RIVER

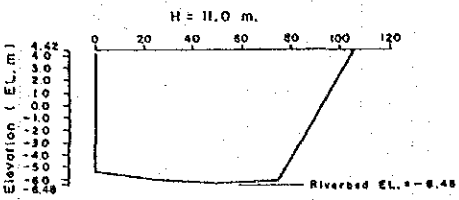


PROFILE OF JIABONG RIVER

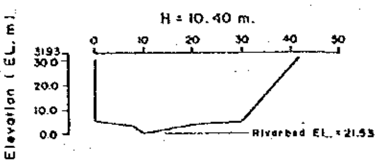
AP.8.1.2 RIVER PROFILE (2/2)

MANILA - LAOAG SECTION

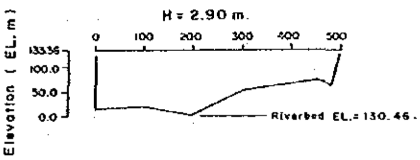
1.) Labangan River



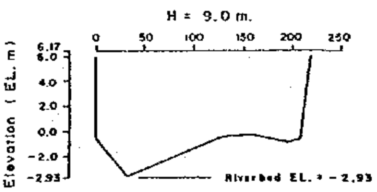
2.) Tagamusing River



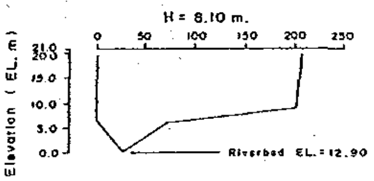
3.) Bued River



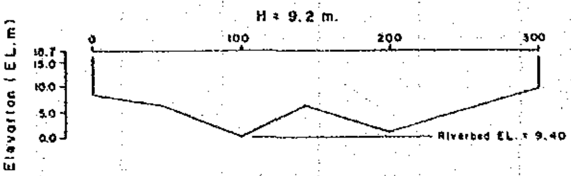
4.) Bauang River



5.) Buaya River (Sta. Cruz Bridge)

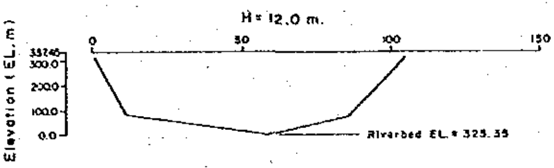


6.) Sta. Maria River

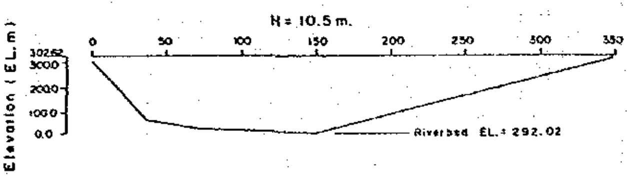


MANILA - ALLACAPAN SECTION

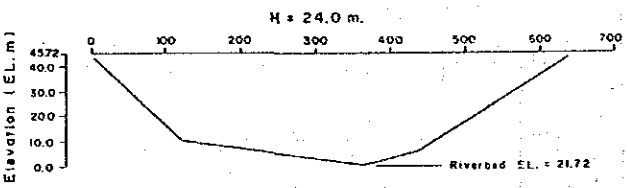
7.) Sta Fe River (Indiana Bridge)



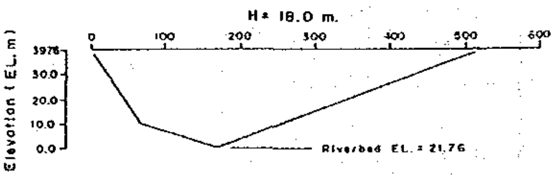
8.) Magat River (Batu Bridge)



9.) Cagayan River (Naguilian Bridge)



10.) Ilagan River (Malalam Bridge)

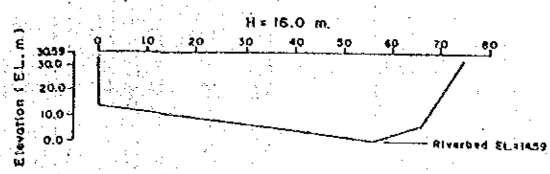


NOTE:

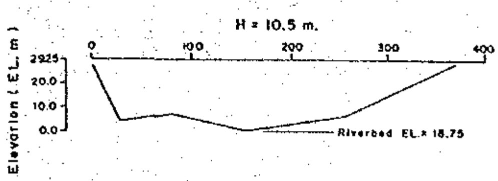
* H = Distance from riverbed to lowest girder of bridge

AP.8.1.3 RIVER CROSS SECTION (1/2)

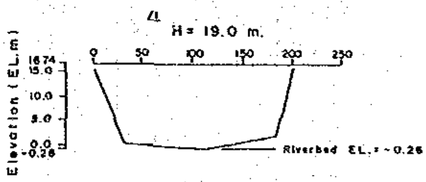
11.) Balasig Creek



12.) Tuguegarao River (Pinacanauan Bridge)

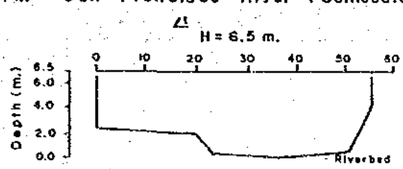


13.) Pared River

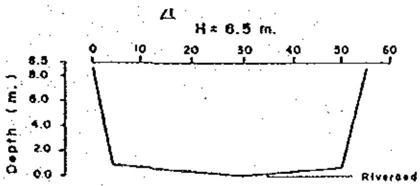


MATNOG – MANILA SECTION

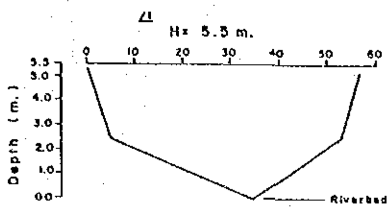
14.) San Francisco River (Guinobatan Div. Bridge)



15.) Baslad River

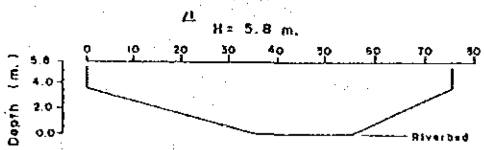


16.) Palsabangon River

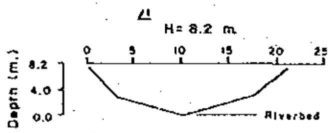


LILOAN – ALLEN SECTION

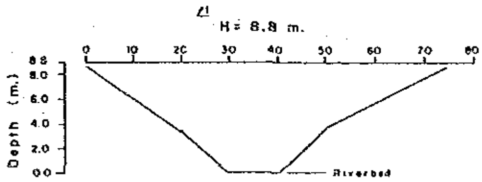
17.) Jiabong River



18.) Hinogbongan River

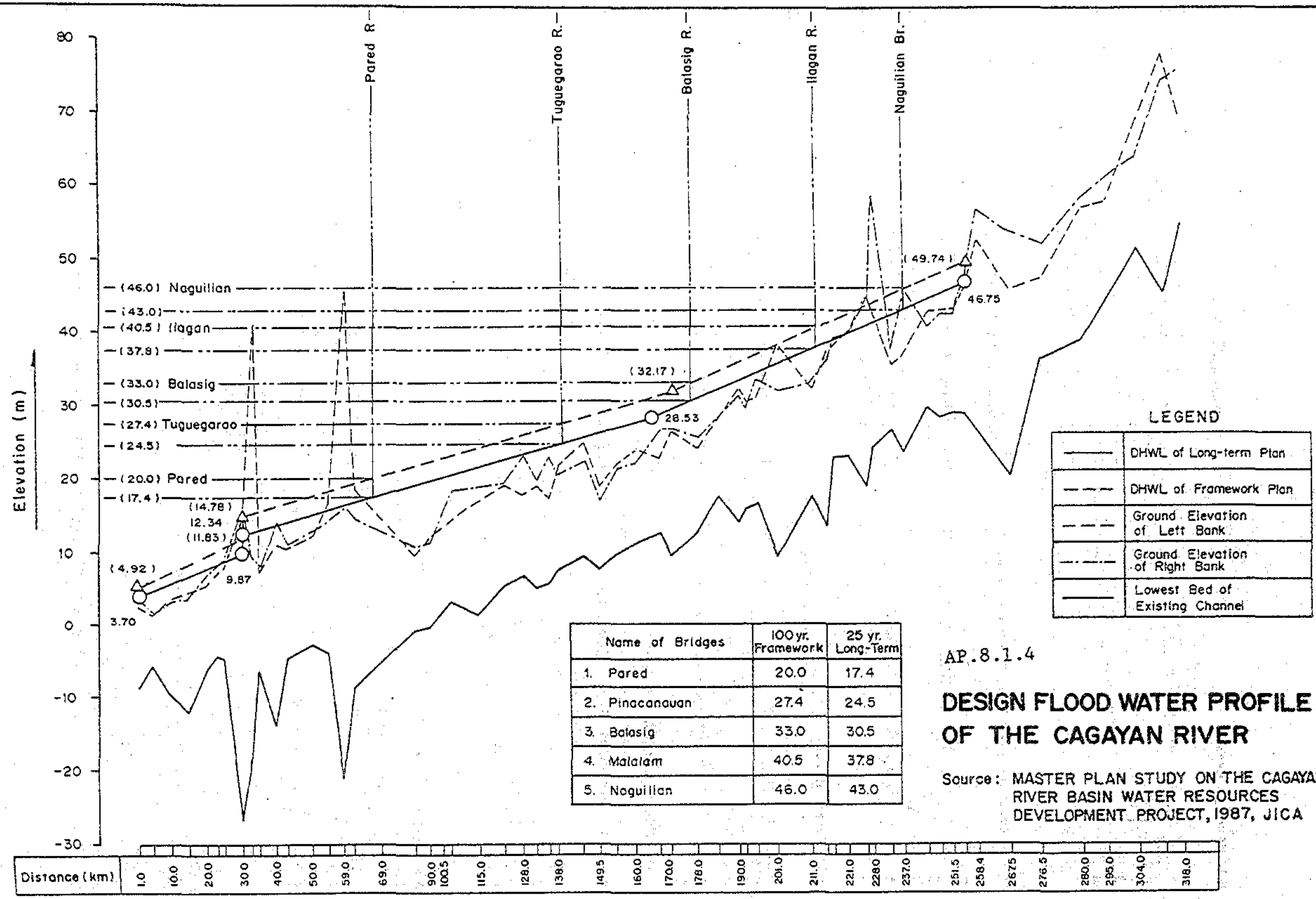


19.) Jubasan River



NOTE: ⊿ ; Elevation data are not available at the bridge sites in the Matnog – Manila and Liloan – Allen Sections.
H in the figures means the distance from riverbed to lowest girder of bridge.

AP.8.1.3 RIVER CROSS SECTION (2/2)



Name of Bridges	100 yr. Framework	25 yr. Long-Term
1. Pared	20.0	17.4
2. Pinacanauan	27.4	24.5
3. Balasig	33.0	30.5
4. Malalam	40.5	37.8
5. Naguilian	46.0	43.0

AP.8.1.4

DESIGN FLOOD WATER PROFILE OF THE CAGAYAN RIVER

Source: MASTER PLAN STUDY ON THE CAGAYAN RIVER BASIN WATER RESOURCES DEVELOPMENT PROJECT, 1987, JICA

APPENDIX 8.2

METEOROLOGICAL FEATURES

APPENDIX 8.2 METEOROLOGICAL FEATURES

(1) Typhoon and Monsoon

PA. 8.2.1 shows the tracks of tropical cyclones affecting the Philippines. The cyclones deposit large amount of rainfall while passing over the land where their energy is gradually dissipated.

During the past 34 years (1948 - 82), a total of 693 tropical cyclones occured in the Philippine Area of Responsibility (PAR). It averages 19.8 cyclones a year. A maximum number of 30 tropical cyclones for a single year occured in 1964 and a minimum number of 12 cyclones in 1973. The number of tropical cyclones which occured in the Philippine Area of Responsibility (PAR) during the same period is shown in AP. 8.2.2.

(2) Rainfall

Rainfall data used in this study comes from PAGASA. They have been observing rainfall in the country since 1902. Rainfall extreme value in terms of intensity, duration and frequency is one of the most important hydrometeorological informations often required in the feasibility study, planning and design of hydrological and related projects.

The monthly and annual mean rainfalls of selected stations are summarized in AP. 8.2.3. Location map of hydrological stations are shown in AP. 8.2.4.

(3) Temperature

The Philippines, situated in the tropics and in a region of high isolation, surrounded by warm seas, and with warm air currents flowing over them, is expected to have generally high temperature.

The monthly and annual mean temperature at selected stations are shown in AP. 8.2.5.

(4) Humidity

Throughout the Philippines the relative humidity is rather high. This condition is mainly a result of extensive evaporation from the seas surrounding the country, the rich vegetation, the moist air stream affecting the Philippines, and the large amount of rainfall.

AP. 8.2.6 shows the monthly and annual mean relative humidity recorded at selected stations.

(5) Evaporation

The monthly mean and annual mean evaporation used in this study comes from the recorded data of PAGASA and National Irrigation Administration (NIA) evaporation stations.

The monthly and annual mean evaporation at selected stations are shown in AP. 8.2.7.

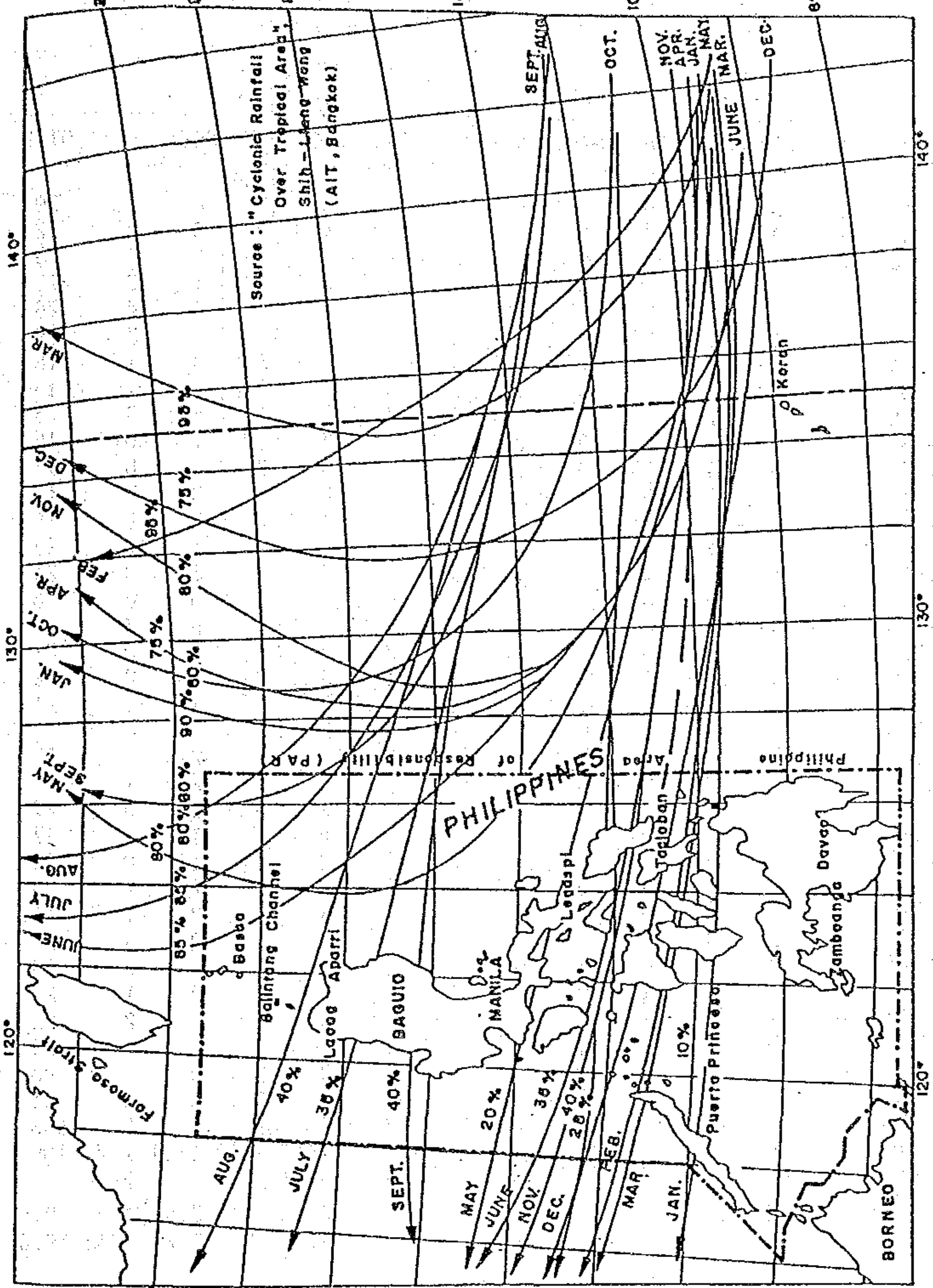
(6) Wind Volocity and Direction

The annual average wind speed in the Philippines is e.0 m/sec, about 10 km/hr. Wind speed during the passage of a tropical storm over a place especially on the exposed eastern coastal areas occasionally exceeds 50 m/sec.

The wind speeds may also increase considerably above the average during surges or intensifications of the monsoons. Values exceeding 15 m/sec are observed during severe thunderstorm.

AP. 8.2.8 and AP. 8.2.9 show the monthly and annual wind velocity and wind direction respectively.

AP. 8.2.10 shows the annual surface air flow in the Philippines.



AP.8.2.1 MEAN MONTHLY TRACKS OF TROPICAL CYCLONES AFFECTING THE PHILIPPINES

AP.8.2.2 FREQUENCY OF TROPICAL CYCLONES
(1948 TO 1982 - 32 YEAR PERIOD)

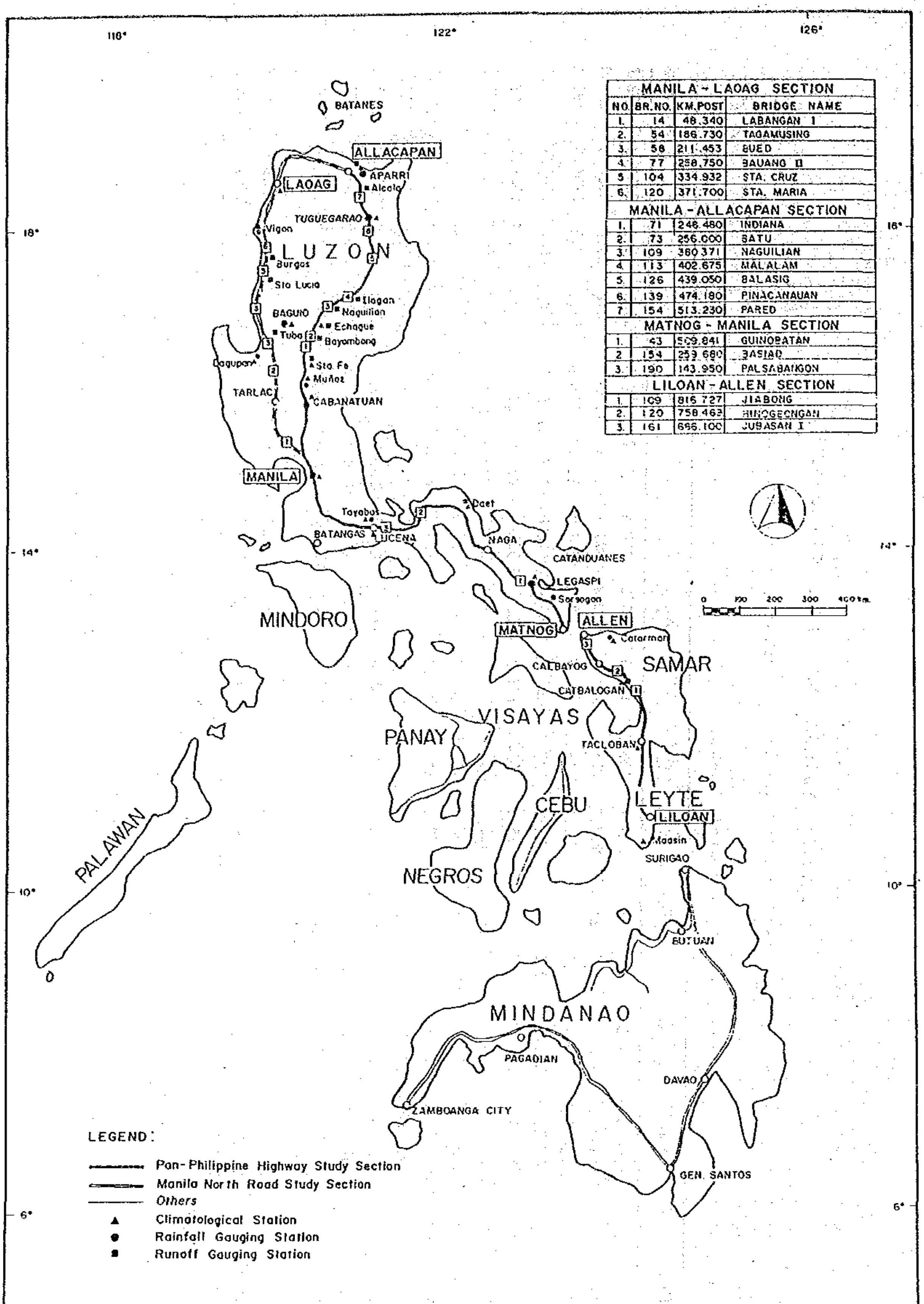
YEAR :	JAN:	FEB:	MAR:	APR:	MAY:	JUN:	JUL:	AUG:	SEP:	OCT:	NOV:	DEC:	TOTAL
1948	1	0	0	0	1	0	3	1	3	2	6	3	20
1949	1	0	0	0	0	2	5	2	4	3	3	2	22
1950	0	0	0	0	0	2	2	1	3	2	2	1	13
1951	0	0	0	1	0	1	1	4	2	1	1	2	13
1952	0	0	0	0	0	5	2	3	4	4	4	4	26
1953	1	1	0	0	1	2	0	5	2	2	3	2	19
1954	0	0	1	0	1	0	1	6	2	3	3	1	18
1955	1	1	0	1	0	0	2	3	1	4	1	1	15
1956	0	0	1	2	0	0	4	4	5	1	5	3	25
1957	2	0	0	1	0	2	1	2	3	3	1	0	15
1958	1	0	0	0	0	1	4	2	4	2	3	0	17
1959	0	1	1	0	0	0	1	4	2	4	3	2	18
1960	1	0	0	1	1	2	2	6	1	3	0	2	19
1961	1	1	1	0	1	3	4	4	4	1	1	2	23
1962	0	1	0	0	2	0	4	6	4	1	3	0	21
1963	0	0	0	0	1	3	4	2	3	1	0	0	16
1964	0	0	0	0	2	1	9	5	5	3	5	2	30
1965	2	1	1	0	2	2	6	2	3	1	1	0	21
1966	0	0	0	1	3	1	7	1	3	2	2	2	22
1967	0	1	1	1	1	2	4	5	0	2	3	1	21
1968	0	1	0	0	0	2	2	3	3	1	3	0	15
1969	0	0	0	1	1	0	4	2	4	1	2	0	15
1970	0	1	0	0	0	3	2	4	4	4	2	1	21
1971	1	0	1	3	3	2	5	2	3	5	2	0	27
1972	2	0	0	0	0	2	4	2	4	1	1	1	17
1973	0	0	0	0	0	1	2	3	2	3	1	0	12
1974	1	0	0	0	0	3	4	4	2	5	2	2	23
1975	1	0	0	0	0	0	1	3	3	3	2	1	14
1976	1	1	0	1	1	3	3	3	4	0	2	3	22
1977	1	0	0	0	1	1	4	2	4	2	2	2	19
1978	0	0	0	1	0	3	1	7	6	4	2	1	25
1979	0	0	1	1	2	1	3	3	3	4	2	2	22
1980	0	1	1	1	3	2	4	3	2	2	3	1	23
1981	0	1	0	0	0	3	5	4	3	2	3	2	23
1982	0	0	2	0	1	0	5	4	4	3	0	2	21
TOTAL	18	12	11	16	28	55	115	117	109	85	77	50	693
%TOTAL	2.6	1.7	1.6	2.3	4.0	7.9	16.6	16.9	15.7	12.3	11.1	7.2	100
RANK	9	11	12	10	8	6	2	1	3	4	5	7	
MEDIAN						3	4.5	4	3.5	3	3.5	3	19.5
AVERAGE	0.5	0.34	0.3	0.5	0.8	1.6	3.3	3.33	3.1	2.4	2.2	1.43	19.8

AP.8.2.3 MONTHLY AND ANNUAL MEAN RAINFALL

Unit : mm

STATION	PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL	MEAN
VIGAN	1951-1985	2.3	3.3	5.0	17.4	145.9	404.3	483.3	738.9	355.7	112.5	35.1	9.1	2312.8	192.7
BAGUIO CITY	1951-1985	12.1	35.0	55.9	102.9	331.1	480.6	670.8	847.9	262.4	152.3	28.8	28.8	3562.9	296.9
DAGUPAN CITY	1951-1985	6.2	6.2	17.6	73.2	216.1	346.6	462.1	608.4	324.8	158.5	63.1	13.8	2296.6	191.4
TAYABAS	1970-1985	155.1	72.3	72.3	103.2	227.5	257.9	260.6	172.6	316.1	151.7	159.9	413.7	3083.9	257.0
DAET	1951-1985	312.0	175.0	153.9	126.1	139.1	173.9	235.7	222.3	267.6	518.6	590.2	591.9	3506.3	292.2
LEGASPI CITY	1951-1985	296.9	195.6	192.6	152.1	181.3	240.9	251.3	264.2	259.9	325.5	483.7	456.0	3300.0	275.0
CATARMAN	1951-1985	417.4	250.8	215.2	146.7	140.8	179.3	208.8	157.8	212.0	372.5	525.8	493.0	3329.1	277.4
CATBALOGAN	1951-1985	225.3	144.8	129.8	102.6	170.1	200.0	243.7	224.9	263.0	301.5	321.4	309.6	2636.7	219.7
APARRI	1951-1985	141.1	76.0	45.6	35.4	100.6	184.1	183.2	225.5	274.7	343.0	396.0	208.7	2213.9	184.5
TUGUEGARAO	1981-1985	21.4	16.5	57.2	73.6	172.1	161.6	192.8	246.5	209.1	252.9	274.2	93.9	1771.8	147.6
MUÑOZ, N.E.	1981-1985	9.5	1.7	8.5	55.4	88.9	385.3	299.6	466.2	258.7	169.7	90.6	15.6	1849.6	154.1
CABANATUAN	1951-1976	7.5	4.9	16.4	19.7	150.1	267.6	340.8	336.8	305.2	190.8	134.8	39.9	1873.5	156.1
MANILA :															
MIA	1951-1985	12.3	3.6	13.4	15.9	109.4	258.6	332.6	417.0	308.7	180.5	116.7	54.1	1822.8	151.9
SCIENCE GARDEN	1951-1985	17.2	9.7	22.1	28.3	172.7	339.6	448.1	504.8	381.8	234.0	144.0	53.8	2356.1	196.3

SOURCE : PAGASA



NO.	BR. NO.	KM. POST	BRIDGE NAME
MANILA - LAOAG SECTION			
1.	14	48.340	LABANGAN I
2.	54	186.730	TAGAMUSING
3.	58	211.453	BUED
4.	77	258.750	BAUANG II
5	104	334.932	STA. CRUZ
6.	120	371.700	STA. MARIA
MANILA - ALLACAPAN SECTION			
1.	71	246.480	INDIANA
2.	73	256.000	BATU
3.	109	360.371	NAGUILIAN
4.	113	402.675	MALALAM
5.	126	439.050	BALASIG
6.	139	474.180	PINACANAUAN
7.	154	513.230	PARED
MATNOG - MANILA SECTION			
1.	43	509.841	GUINOBATAN
2	154	259.680	BASIAD
3.	190	143.950	PALSABANGON
LILOAN - ALLEN SECTION			
1.	109	816.727	JIABONG
2.	120	758.463	HINOGECNGAN
3.	161	666.100	JUBASAN I

AP.8.2.4 LOCATION MAP OF HYDROLOGICAL STATIONS

AP.8.2.5 MONTHLY AND ANNUAL MEAN TEMPERATURE

Unit : °C

STATION	PERIOD		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
VIGAN	1951-1985	MAX	29.7	30.1	31.3	32.5	32.8	31.4	30.7	30.0	30.3	31.1	30.9	30.4	
		MIN	21.0	21.5	22.9	24.3	24.0	24.0	23.8	23.4	23.5	23.4	22.9	22.0	
		MEAN	25.3	25.8	27.1	28.4	20.8	27.7	27.2	26.7	26.9	27.2	20.9	26.2	27.0
BAGUIO CITY	1951-1985	MAX	22.6	23.6	24.7	25.1	24.6	23.6	23.0	22.0	22.9	23.5	23.2	22.8	
		MIN	12.9	13.1	14.3	15.5	16.2	16.2	16.0	15.9	15.7	15.4	14.8	14.0	
		MEAN	17.01	18.4	19.6	20.4	20.5	20.0	19.6	18.9	19.3	19.5	19.0	18.4	19.3
DAGUPAN CITY	1951-1985	MAX	30.9	31.8	33.5	34.9	34.3	32.9	32.0	31.1	31.7	32.2	31.7	31.2	
		MIN	20.9	21.4	22.7	24.2	24.6	24.4	24.2	24.0	24.1	23.8	22.8	21.7	
		MEAN	25.9	26.6	28.1	29.5	29.4	28.6	28.1	27.5	27.9	28.0	27.2	26.4	27.8
TAYABAS CITY	1970-1985	MAX	27.2	27.7	29.2	30.9	31.8	31.2	30.7	30.0	30.6	29.6	28.7	27.5	
		MIN	21.4	21.6	22.2	23.3	23.7	23.6	23.1	23.0	22.7	23.1	22.8	22.2	
		MEAN	24.3	24.6	25.7	27.1	27.7	27.4	26.9	26.9	26.6	26.3	25.7	24.8	26.2
DAET		MAX	28.8	28.9	30.0	31.4	32.8	32.8	32.2	32.1	31.8	30.9	29.9	28.7	
		MIN	22.3	22.3	22.6	23.5	24.0	24.0	23.9	24.0	23.6	23.5	23.6	23.1	
		MEAN	25.5	25.6	26.3	27.4	28.4	28.4	28.0	28.0	27.7	27.2	26.7	25.9	27.1
LEGASPI CITY	1951-1985	MAX	28.6	29.1	29.9	31.1	32.1	32.2	31.8	31.6	31.5	31.1	30.1	29.0	
		MIN	22.1	22.2	22.8	23.5	24.1	24.0	23.7	23.7	23.5	23.3	23.1	22.9	
		MEAN	25.3	25.6	26.3	27.3	28.1	28.1	27.3	27.6	27.5	27.2	26.6	25.9	26.9
CATARMAN	1951-1985	MAX	28.4	28.8	29.8	30.9	31.9	32.1	31.6	32.0	31.6	30.7	29.9	28.8	
		MIN	22.1	21.8	22.0	22.4	23.0	23.3	23.4	23.6	23.2	23.0	22.9	22.7	
		MEAN	25.2	25.3	25.9	26.6	27.4	27.7	27.5	27.8	27.4	26.8	26.4	25.7	26.6
CATBALOGAN	1951-1985	MAX	30.1	30.6	31.6	32.7	33.1	32.7	32.1	32.3	32.1	31.7	31.1	30.3	
		MIN	21.9	21.8	22.2	23.2	24.1	24.1	24.1	24.4	24.1	23.5	23.0	22.5	
		MEAN	26.0	26.2	26.9	27.9	28.6	28.4	28.1	28.3	28.1	27.6	27.0	26.4	27.5
APARRI	1951-1985	MAX	26.4	27.6	29.5	31.6	33.3	33.5	32.9	32.4	31.6	30.2	28.2	26.8	
		MIN	20.4	20.7	22.0	23.6	24.6	24.8	24.8	24.6	24.3	23.7	22.8	21.4	
		MEAN	23.4	24.1	25.7	27.6	29.0	29.2	28.9	28.5	27.9	26.9	25.5	24.1	26.3
TUGUEGARAO	1951-1985	MAX	29.1	31.3	33.7	35.9	36.7	35.6	34.8	34.1	33.6	32.2	30.1	28.8	
		MIN	19.3	19.4	20.8	22.6	23.7	23.8	23.6	23.6	23.3	22.6	21.6	20.2	
		MEAN	24.3	25.4	27.3	29.3	30.3	29.7	29.2	28.9	28.5	27.4	25.9	24.5	27.6
MUNOZ, N.E.	1981-1985	MAX	30.2	30.9	32.1	32.6	35.0	33.6	31.9	30.6	31.7	31.8	31.6	30.9	
		MIN	21.4	21.3	21.8	23.1	23.8	23.6	23.4	23.2	23.1	22.2	21.9	21.1	
		MEAN	25.8	26.1	26.9	28.3	29.4	28.1	27.6	26.9	27.4	27.0	26.7	26.0	27.2
CABANATUAN	1951-1976	MAX	31.5	32.6	34.0	35.5	35.3	33.4	32.4	31.5	31.9	32.5	31.8	31.9	
		MIN	20.0	20.1	21.1	22.8	23.7	23.6	23.4	23.4	23.3	22.8	21.9	20.9	
MANILA:		MEAN	25.8	26.4	21.1	20.8	29.5	26.5	27.9	27.5	27.3	27.8	26.9	30.9	27.6
MIA	1951-1985	MAX	30.2	31.3	32.8	34.2	34.2	32.5	31.3	30.7	30.9	31.1	30.7	30.2	
		MIN	30.7	20.9	22.0	23.7	24.6	24.3	24.0	23.9	23.8	23.3	22.5	21.3	
		MEAN	25.5	26.1	27.4	28.9	29.4	28.4	27.6	27.3	27.3	27.2	26.6	25.7	27.0
SCIENCE GARDEN	1961-1985	MAX	29.9	21.2	33.0	34.6	34.2	32.2	31.1	30.5	30.9	31.0	30.7	30.2	
		MIN	20.0	20.0	21.3	22.9	23.8	23.7	23.4	23.4	23.2	22.6	21.7	20.8	
		MEAN	25.1	25.6	27.2	28.0	29.0	28.0	27.2	27.0	27.1	26.8	26.2	25.5	27.0

SOURCE : PAGASA

AP.8.2.6 MONTHLY AND ANNUAL MEAN RELATIVE HUMIDITY

Unit : %

STATION	PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
		MONTH												
VIGAN	1951-1985	77	77	76	76	79	83	85	87	86	82	87	78	81
BAGUIO CITY	1951-1985	80	78	78	80	86	88	90	92	90	87	83	80	84
DAGUPAN CITY	1951-1985	74	72	70	70	73	80	82	85	84	80	77	75	77
TAYABAS	1970-1985	85	86	81	81	82	84	95	86	97	87	87	89	87
DAET	1951-1985	84	82	80	81	80	80	83	82	84	86	85	85	83
LEGASPI CITY	1951-1985	84	82	82	81	81	82	84	84	85	84	85	85	83
CATARMAN	1951-1985	87	85	84	85	84	84	84	82	84	86	88	88	85
CATBALOGAN	1951-1985	82	81	78	78	78	80	80	79	83	83	84	84	81
APARRI	1951-1985	84	83	82	80	79	80	81	82	84	83	86	87	83
TUGUEGARAO	1951-1985	80	76	71	68	69	73	76	78	79	80	83	84	76
MUÑOZ,N.E.	1981-1985	73	72	73	72	72	80	84	85	84	82	76	71	77
CABANATUAN	1951-1976	72	69	66	64	71	80	84	86	85	81	78	74	76
MANILA :														
MIA	1951-1985	75	70	67	65	70	78	81	82	83	81	80	78	76
SCIENCE GARDEN	1961-1985	75	70	67	65	72	81	84	85	86	86	82	78	77

SOURCE : PAGASA

AP.8.2.7 MONTHLY AND ANNUAL MEAN EVAPORATION

STATION	PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
MMSU, Batac Ilocos Sur	1976-1987	48.8	57.2	64.3	59.7	64.2	54.0	50.9	40.5	44.5	40.9	38.8	39.2	603.0
MSAC, La Trinidad Baguio	1977-1987	35.1	37.1	34.6	33.1	30.7	29.4	22.4	17.3	22.0	23.3	30.2	34.2	349.4
Hacienda Luisita Concepcion, Tarlac	1970-1982	56.4	68.7	87.2	94.2	74.1	55.4	48.4	41.7	45.3	49.2	55.1	55.7	731.4
CAO, Science Garden Quezon City	1971-1987	34.1	46.1	60.9	56.9	58.4	41.7	35.9	42.0	28.3	26.0	28.3	17.9	476.5
Cuyambay , Tanay Rizal	1970-1980	38.7	47.4	53.8	63.1	50.5	38.9	30.7	23.5	28.6	31.1	30.5	35.0	471.8
NAS-UPLB Los Baños, Laguna	1977-1987	38.9	47.5	66.8	66.8	57.3	46.6	40.2	39.3	29.0	31.3	30.0	29.9	523.6
ISU, Echague Isabela	1976-1985	21.5	35.6	48.2	43.9	42.1	44.1	35.4	35.7	37.8	30.2	25.1	25.6	425.2
CSLU, Muñoz Nueva Ecija	1975-1987	75.0	80.7	80.5	87.6	64.9	51.8	45.4	34.9	32.6	46.6	40.6	40.4	681.0
CSAC, Pili Camarines Sur	1975-1986	42.0	49.1	59.8	62.5	59.1	48.5	43.0	38.7	41.8	33.9	26.8	30.7	535.9
Malinao, Albay	1972-1985	24.3	33.5	43.1	50.5	49.1	32.8	42.2	41.5	41.1	33.5	27.6	24.7	443.9
UEP, Catarman Northern Samar	1975-1986	34.3	38.4	51.8	45.7	47.0	37.0	43.9	40.4	34.7	31.1	26.5	27.2	458.0

Source : PAGASA

AP.8.2.8 MONTHLY AND ANNUAL MEAN WIND VELOCITY

Unit : mps

STATION	PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
VIGAN	1951-1985	4	4	3	3	3	3	3	3	3	3	4	3	3
BAGUIO CITY	1951-1985	2	3	3	3	3	3	3	3	2	3	3	2	2
DAGUPAN CITY	1951-1985	3	3	4	4	3	3	3	3	3	3	3	3	3
TAYABAS	1970-1985	3	3	3	2	2	1	1	2	1	2	3	3	2
DAET	1951-1985	3	3	3	3	2	2	2	2	2	2	4	4	3
LEGASPI CITY	1951-1985	4	4	4	4	3	3	3	3	3	3	4	4	4
CATARMAN	1951-1985	3	3	3	2	2	2	2	2	2	2	3	3	2
CATBALOGAN	1951-1985	2	2	2	2	2	2	2	2	2	2	1	2	2
APARRI	1951-1985	4	4	3	3	3	3	3	3	3	4	4	4	3
TUGUEGARAO	1951-1985	2	2	2	2	2	2	2	2	2	2	2	2	2
MUÑOZ, N.E.	1981-1985	4	4	3	3	2	2	2	2	2	3	3	3	3
CABANATUAN	1951-1976	2	2	2	2	2	1	2	2	1	2	2	2	2
MANILA :														
MIA	1951-1985	3	4	4	4	4	3	3	3	3	2	2	3	3
SCIENCE GARDEN	1961-1985	2	2	2	2	2	2	2	2	2	2	2	2	2

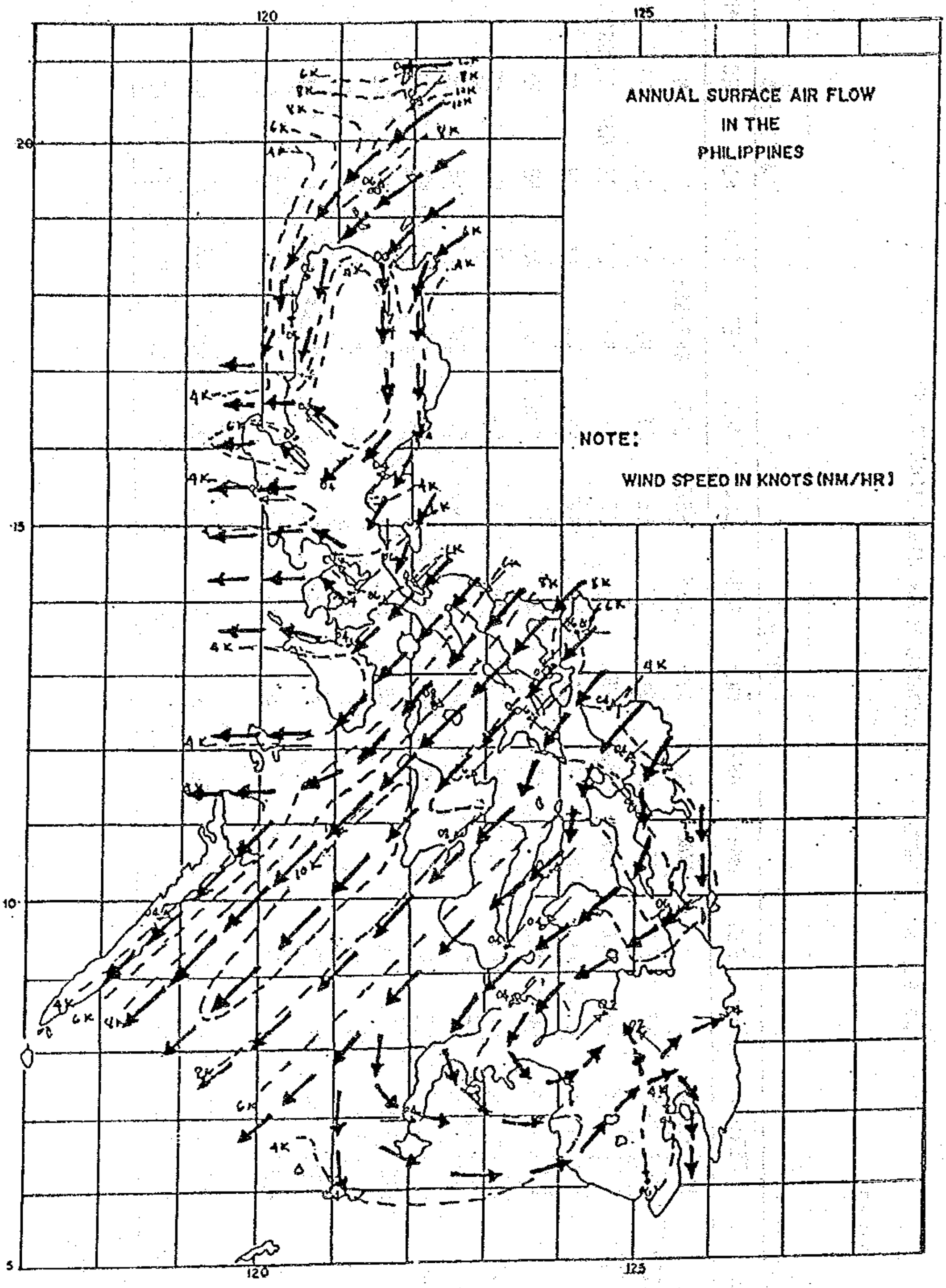
SOURCE : PAGASA

AP.8.2.9 MONTHLY AND ANNUAL MEAN WIND DIRECTION

Unit : %

STATION	PERIOD	JAN	FEB	MAR.	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
		MONTH												
VIGAN	1951-1985	N	N	NNW	N	VAR	SSE	SSE	SSE	SSE/SSE	N	N	N	N
BAGUIO CITY	1951-1985	SE	SE	SE	SE	SE	SE	SE	SE	NW	SE	SE	SE	SE
DAGUPAN CITY	1951-1985	NNW	SSE	NNW	NNW	SE	SE	SE	SE	SE	SE	SE/NNW	SE/SSE	SE
TAYABAS	1970-1985	N/NE	NE	NE	NE	NE	SW	SW	SW	SW	NE	NE	NE	NE
DAET	1951-1985	NE	NE	NE	NE	ENE	S	S	S/SSW	NE	NE	NE	NE	NE
LEGASPI CITY	1951-1985	NE	NE	NE	NE	NE	NE	SW	SW	W	NE	NE	NE	NE
CATARMAN	1951-1985	NE	NE	NE	NE	NE	NE	SW	SW	SW	NE	NE	NE	NE
CATBALOGAN	1951-1985	NE	NE	NE	NE	NE	SW	SW	SW	SW	N/VAR	NE	NE	NE
APARRI	1951-1985	NE	NE	NE	NE	NE	S	S	S	NE	NE	NE	NE	NE
TUGUEGARAO	1951-1985	N	N	N	N	S	S	S	S	N	N	N	N	N
MUÑOZ,N.E.	1981-1985	NE	ENE	ENE	E	E	VRBL	S	S	E/ENE	ENE	NE	NE	ENE
CABANATUAN	1951-1976	NE	NE	SE	SE	SE	SE	SW	S	VAR	NE	NE	NE	NE
MANILA :														
MIA	1951-1985	SE	SE	SE	SE	SE	SE	SW	SW	SW	SE	E	SE	SE
SCIENCE GARDEN	1961-1985	NE	NE	SE	SE	VRBL	SW	SW	SW	SW	NE	NE	NE	NE

SOURCE : PAGASA



AP.8.2.10 ANNUAL SURFACE AIR FLOW IN
IN THE PHILIPPINES

APPENDIX 8.3

RAINFALL ANALYSIS

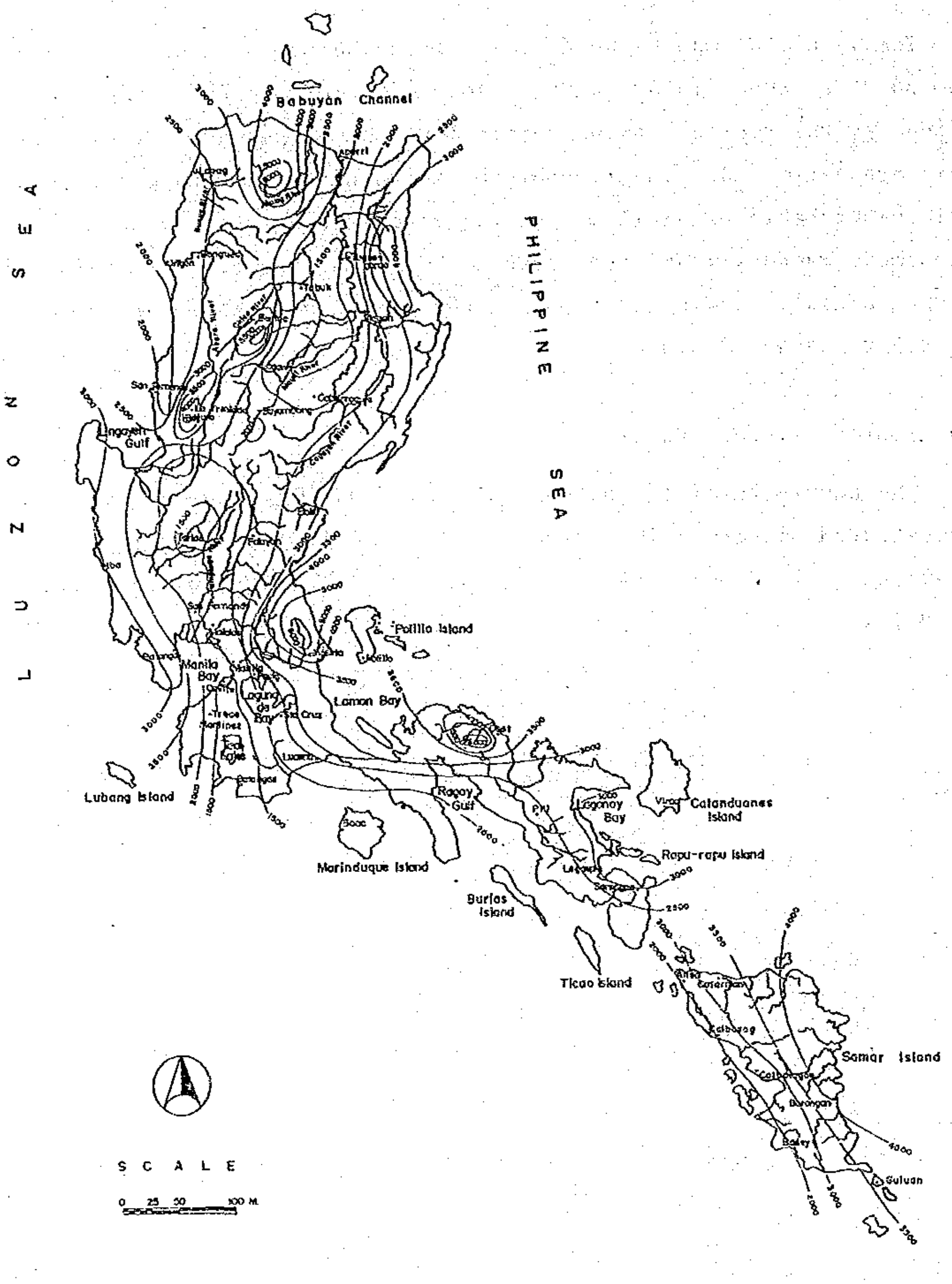
APPENDIX 8.3 RAINFALL ANALYSIS

(1) Probable Basin Rainfall

The isohyetal map is used to estimate the probable basin rainfall from point as shown in AP. 8.3.1. The adjustment factors which are defined as the ratios between rainfall at the gauge and that of bridge basin are estimated. The probable basin rainfall is thus calculated from the probable rainfall at the rainfall gauging station and the adjustment factors mentioned above. The calculated probable rainfall at the rainfall gauging station and the bridge site basin are shown in AP. 8.3.2 and AP. 8.3.3.

(2) Hourly Rainfall Pattern

The hourly rainfall pattern is assumed from records to be a center-concentrated pattern. The percentage of each hourly rainfall to total 1-day rainfall is estimated by the rainfall intensity curve as shown in AP. 8.3.4.



AP.8.3.1 ISOHYETAL MAP

AP.8.3.2 PROBABLE 1-DAY RAINFALL AT THE GAUGE

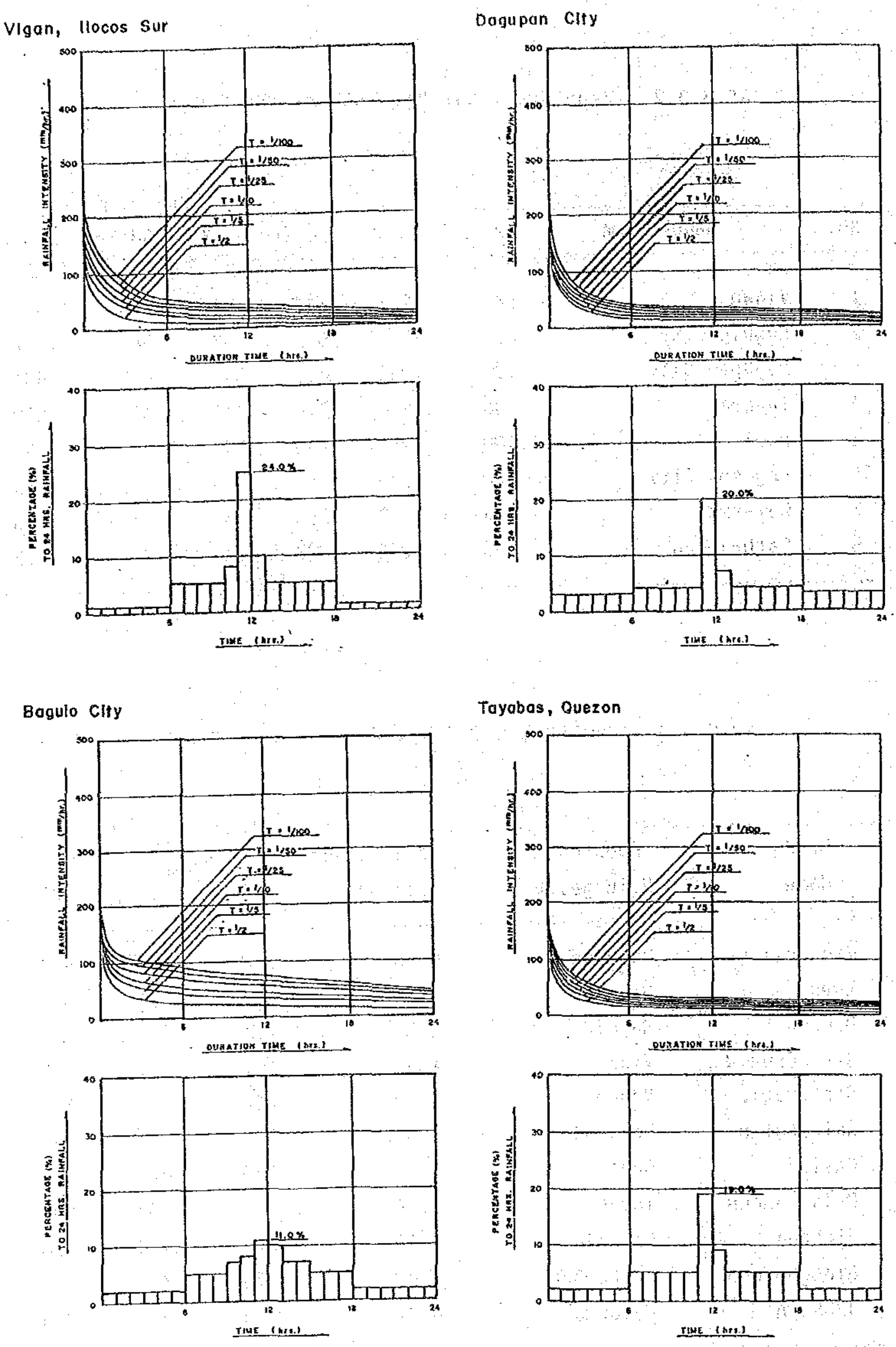
Unit : mm

No.	Gauge Name	2 Yr	5 Yr	10 Yr	25 Yr	50 Yr	100 Yr
1	Vigan	127	257	344	453	534	614
2	Baguio City	319	532	674	852	985	1117
3	Dagupan City	193	293	359	443	505	567
4	Tayabas	138	243	313	401	467	532
5	Daet	182	250	295	352	394	436
6	Legaspi City	178	279	342	424	485	545
7	Catarman	131	213	266	334	385	435
8	Catbalogan	143	236	297	375	433	490

AP.8.3.3 PROBABLE 1-DAY RAINFALL IN THE BRIDGE SITE BASIN

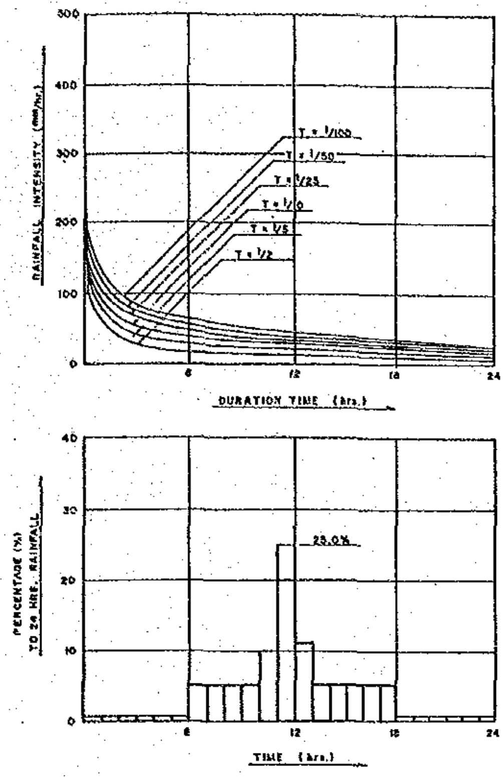
Unit : mm

Bridge Name	Adopted Rain gauge	Adjustment Factor	Return Period		
			25 Yr	50 Yr	100 Yr
Tagamusing	Dagupan	0.90	398	454	510
Bued	Baguio	0.60	511	591	670
Bauang I	Baguio	0.55	469	542	614
Sta. Cruz I	Vigan	1.00	453	534	614
Sta. Maria	Vigan	1.10	498	587	675
Guinobatan	Legaspi	0.80	339	388	436
Basiad	Daet	0.90	316	345	392
Palsabangon	Tayabas	1.00	401	467	532
Jiabong	Catbalogan	1.00	375	433	490
Hinogbongon	Catbalogan	1.00	375	433	490
Jubasan I	Catarman	0.80	268	307	348

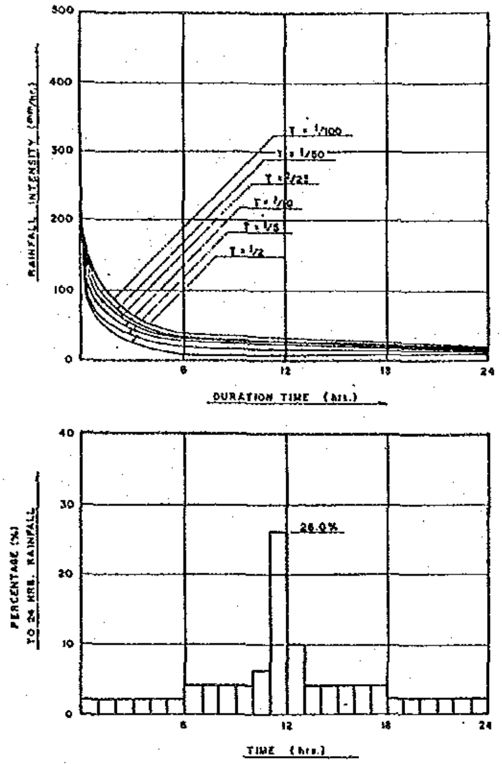


AP.8.3.4 RAINFALL INTENSITY CURVE AND HOURLY DISTRIBUTION (1/2)

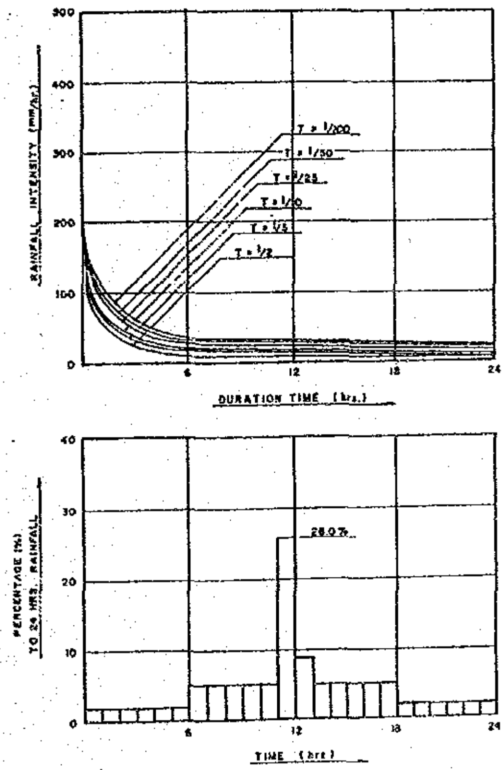
Legaspi City



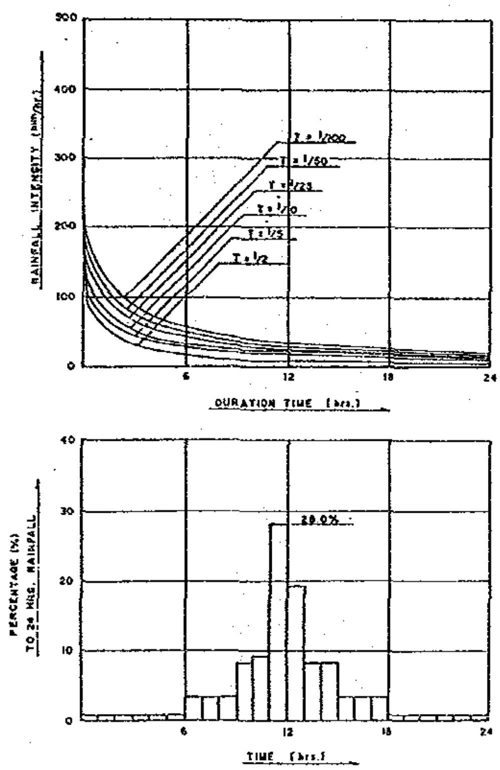
Daet, Camarines Norte



Catbalogan, Samar



Catarman, Samar



AP.8.3.4 **RAINFALL INTENSITY CURVE AND HOURLY DISTRIBUTION (2/2)**

APPENDIX 8.4

FLOOD RUNOFF ANALYSIS

APPENDIX 8.4 FLOOD RUNOFF ANALYSIS

(1) Flood Runoff Model

The storage function is applied as the flood runoff model in this study. The basin model is shown in AP. 8.4.1. The coefficient of the storage function and lag time for subbasins are estimated by the formulas, which are well known as Tone River Formulas and applies for many rivers in Japan.

The estimated coefficient of storage function K, P and T are listed in AP. 8.4.2 and AP. 8.4.3. The primary runoff coefficient (f_1) and saturated rainfall (Rsa) are assumed to be 0.5 and 150 mm and the specific baseflow is adopted to be 0.04 $m^3/sec/km^2$ in this study.

(2) Probable Flood Runoff

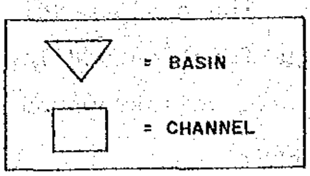
The probable flood runoff is estimated at each bridge site. The flood hydrograph at the bridge sites are shown in AP. 8.4.4 and the specific flood runoff curves are presented in AP. 8.4.5.

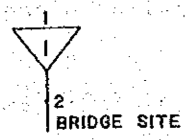
(3) Design Flood Water Level

The levels are converted from probable flood runoff by Non-uniform or Uniform flow calculation methods. The initial water level in the sea to be used in Non-uniform flow calculation are summarized in AP. 8.4.6.

TYPE 1; SUBBASIN NUMBER = 1

	C. A. (km²)
1) TAGAMUSING	148
2) BUED	161
3) STA. CRUZ	222
4) GUINOBATAN	76
5) BASIAD	26
6) PALSABANGON	9
7) JIABONG	67
8) HINOGBONGAN	20
9) JUBASAN I	13



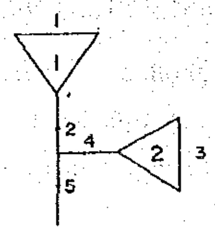


(TYPE 1)

TYPE 2; SUBBASIN NUMBER = 2

1) STA. MARIA

SUBBASIN	C. A. (km²)
1	108
2	191
TOTAL	299

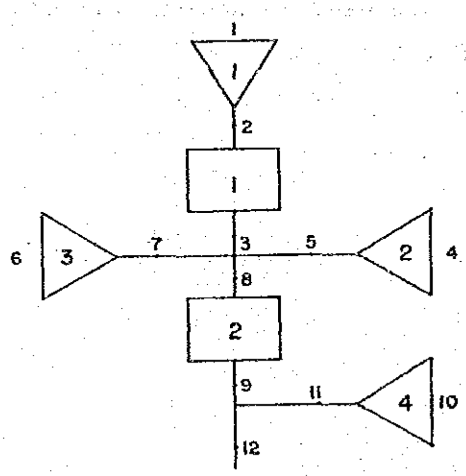


(TYPE 2)

TYPE 3; SUBBASIN NUMBER = 4
(CHANNEL NUMBER = 2)

1) BAUANG II

SUBBASIN	C. A. (km²)
1	302
2	96
3	94
4	38
TOTAL	530



(TYPE 3)

AP.8.4.1 BASIN AND RIVER MODEL FOR STORAGE FUNCTION

AP.8.4.2 STORAGE FUNCTION OF SUBBASIN

No.	Br. Name	Basin No.	A (Km^2)	L (Km)	Basin Slope (I)	K	P	Tl (Hrs.)
1	Tagamusing	1	148	36.0	1/60	34.8	0.45	1.1
2	Bued	1	161	32.0	1/40	39.3	0.42	0.9
3	Bauang I	1	302	56.0	1/100	29.8	0.52	1.9
		2	96	23.0	1/100	29.8	0.52	0.5
		3	94	26.0	1/30	42.7	0.39	0.6
		4	38	7.0	1/400	19.6	0.72	0.0
4	Sta. Cruz I	1	222	34.0	1/100	29.9	0.52	1.0
5	Sta. Maria	1	108	25.0	1/90	30.7	0.50	0.6
		2	191	29.0	1/100	29.8	0.52	0.7
6	Guinobatan	1	76	12.0	1/40	39.3	0.42	0.0
7	Basiad	1	26	13.0	1/40	39.3	0.42	0.1
8	Palsabangon	1	9	7.0	1/200	24.2	0.61	0.0
9	Jiabong	1	67	13.0	1/40	39.3	0.42	0.1
10	Hinogbongan	1	20	15.0	1/200	24.2	0.61	0.1
11	Jubasan I	1	13	10.0	1/200	24.2	0.61	0.0

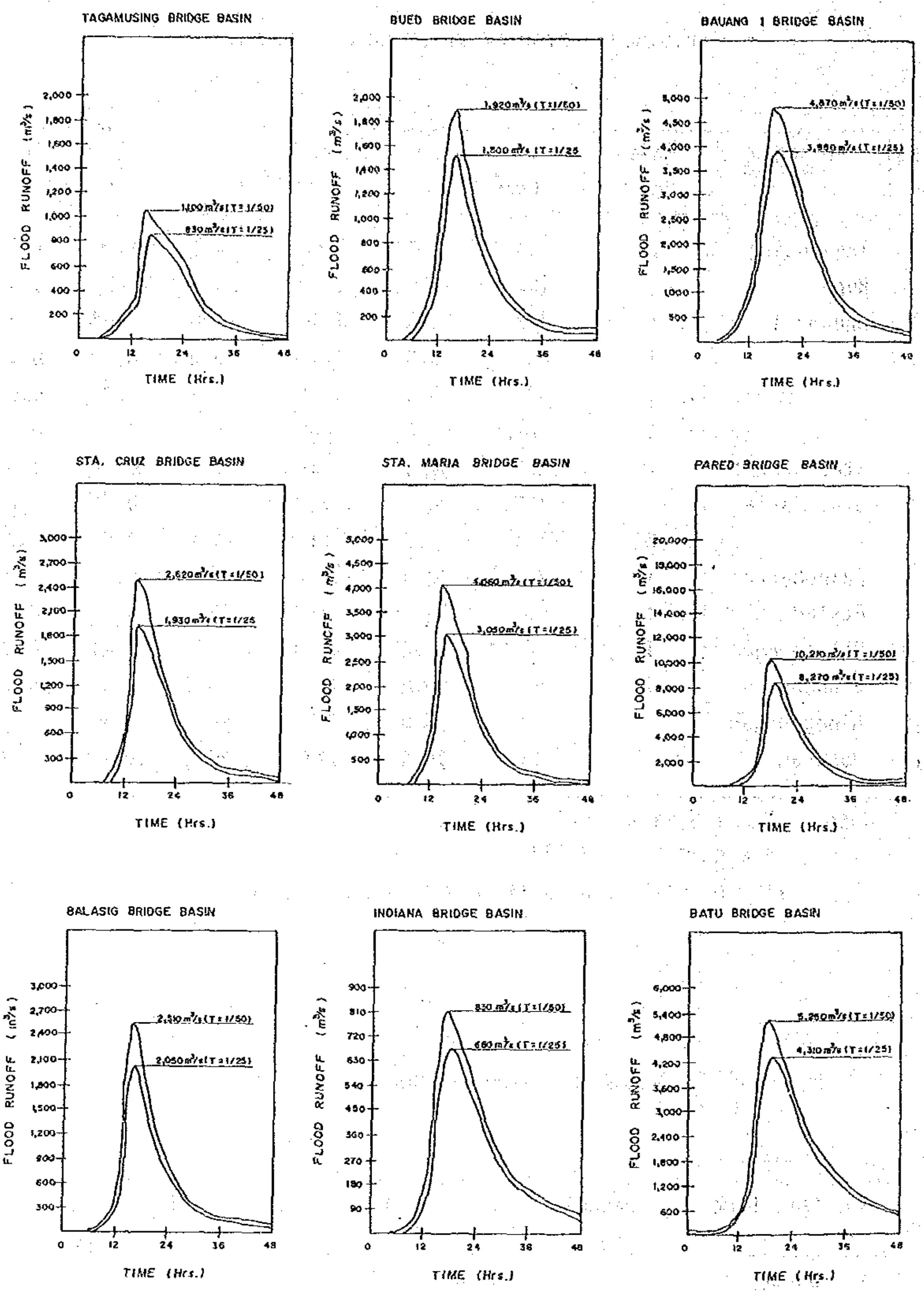
Note: $K = 118.54 \times I^{0.3}$

$P = 0.175 \times I^{-0.235}$

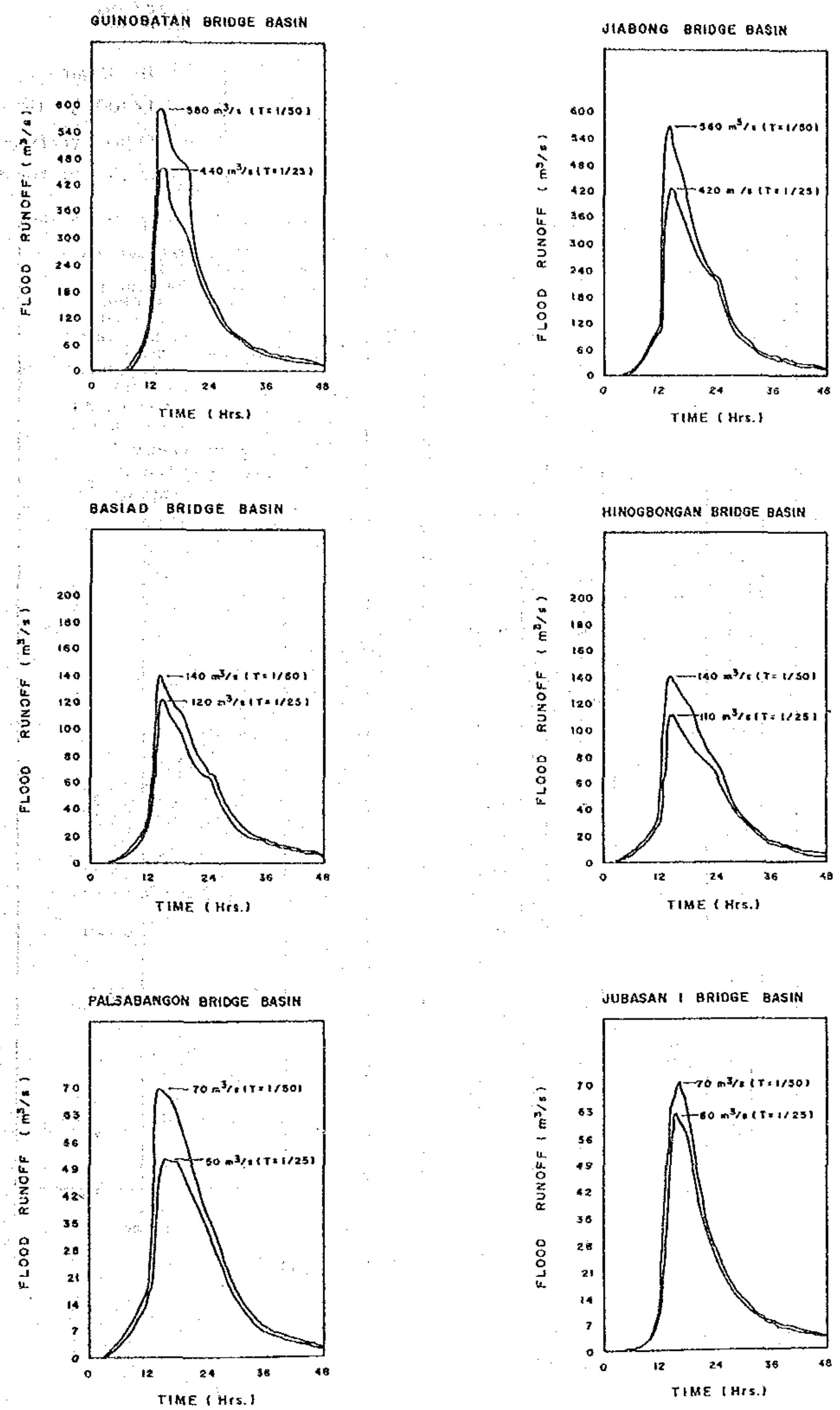
$Tl = 0..047 L - 0.56$ (if $L < 11.9$ km then $Tl = 0$)

AP.8.4.3 STORAGE FUNCTION OF CHANNEL

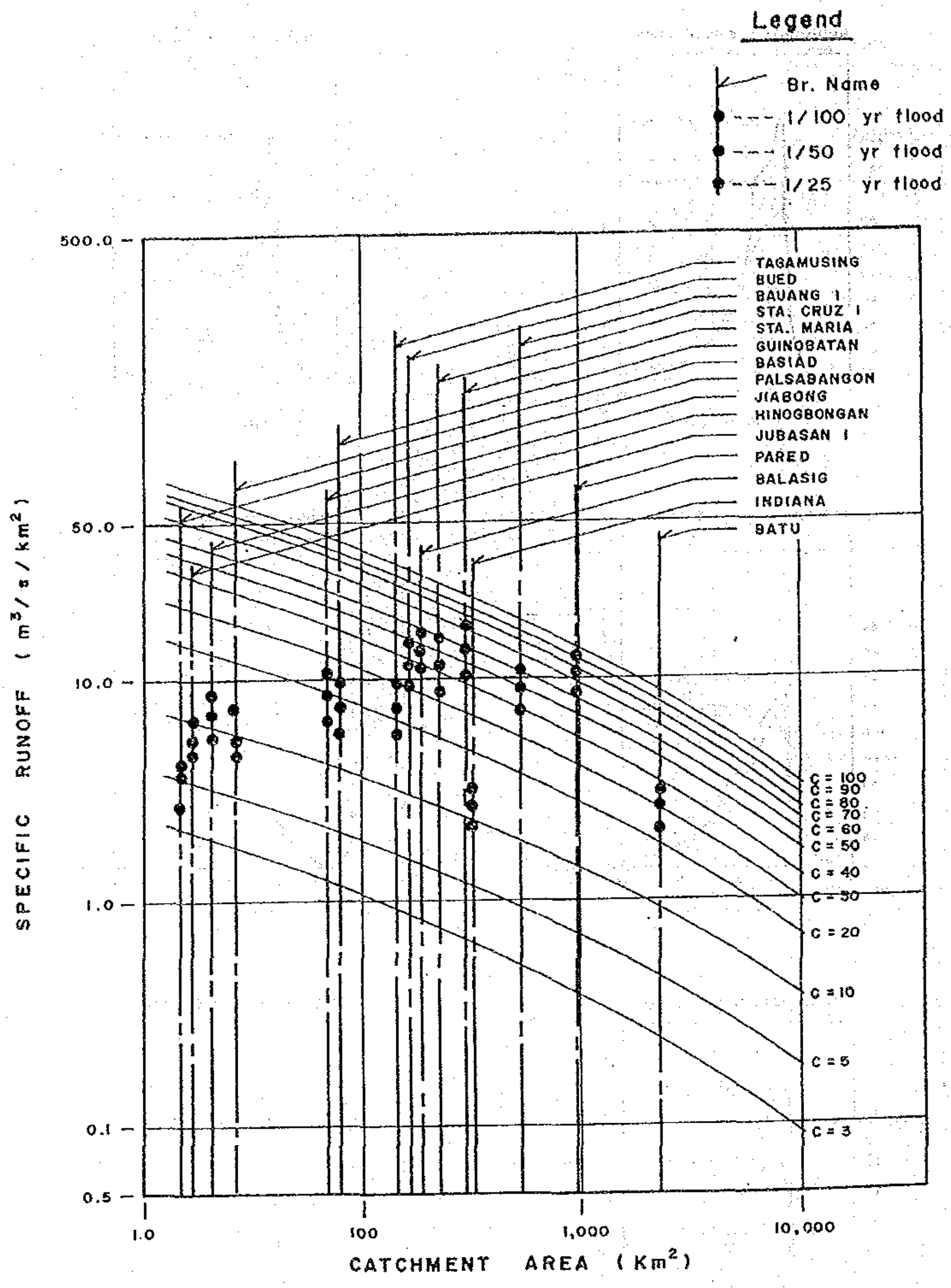
No.	Br. Name	Channel No.	L (KM)	I	K	P	Tl (Hrs.)
1	Bauang I	1	23.0	1/100	-	-	0.5
		2	7.0	1/400	-	-	0.0



AP.8.4.4 FLOOD HYDROGRAPH (1/2)



AP.8.4.4 FLOOD HYDROGRAPH (2/2)



Note: Creager's formula

$$q = C \times A^{(A^{-0.05} - 1)}$$

where, q = Specific runoff peak
A = Catchment area
C = Creager's coefficient

AP.8.4.5 SPECIFIC RUNOFF PEAK

AP.8.4.6 HIGHEST HIGH WATER LEVEL (HHWL)

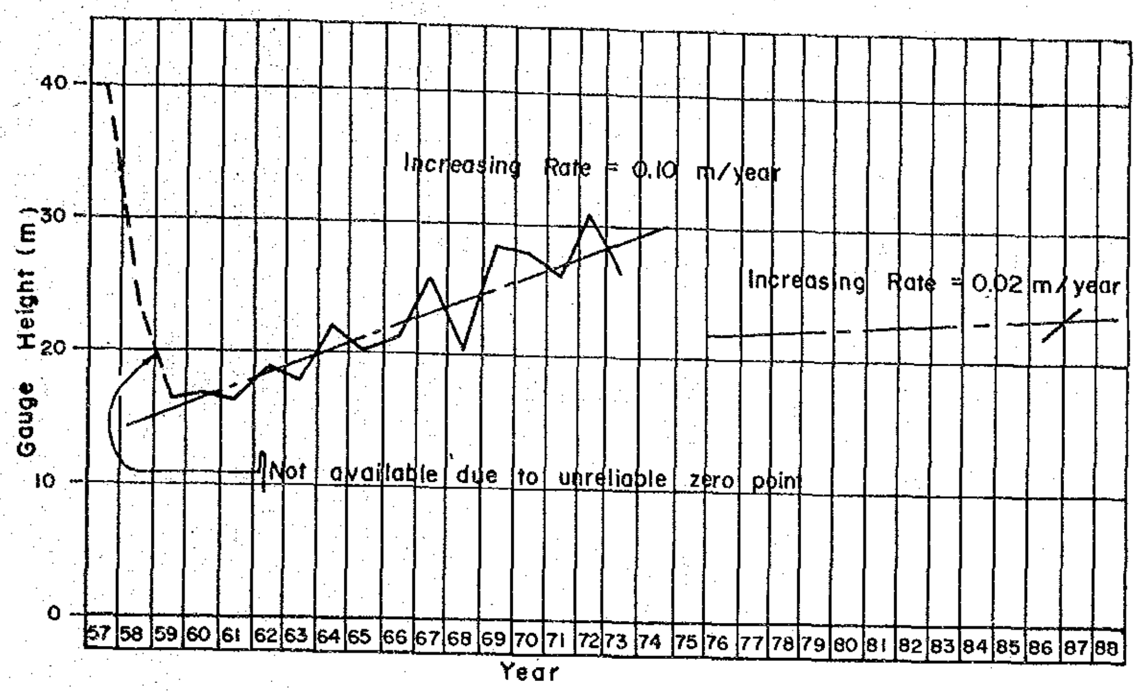
Bridge Name	Tidal Station Name	Tidal Difference HWL (m)	Reference Station		Adjusted HHWL (m)
			Name	HHWL (m)	
Bauang I	Sto.Tomas,Lingayen Gulf	+0.09	San Fernando	0.086	0.776
Sta. Cruz I	Sta.Cruz,Ilocos Sur	*0.82	San Fernando	0.086	0.562
Sta. Maria	Sta. Cruz, Ilocos Sur	*0.82	San Fernando	0.086	0.562
Basiad	Capalonga, Lamon Bay	+0.09	San Fernando	0.086	1.492
Palsabangon	Atimonan, Lamon Bay	+0.21	San Fernando	0.086	1.612
Jiabong	Catbalogan, Samar	+0.06	Cebu	1.530	1.590
Hinogbongan	Calbayog, N. Samar	*0.46	Cebu	1.530	0.704
Jubasan I	Catarman River Entrance	*0.93	Cebu	1.530	1.423

Note : * Ratio of rise. Multiply heights at reference station by this ratio.

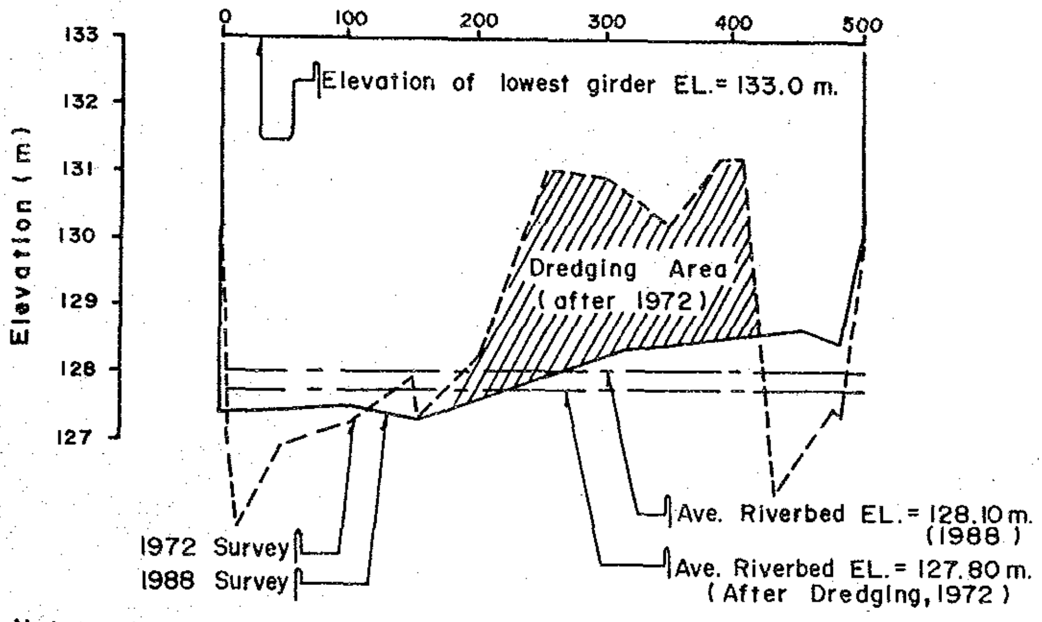
APPENDIX 8.5

RIVERBED FLUCTUATION OF THE BUED RIVER

Riverbed Fluctuation of Bued River



2.) Comparison of River Cross Section in 1972 and in 1988 (Bued River)



Note:

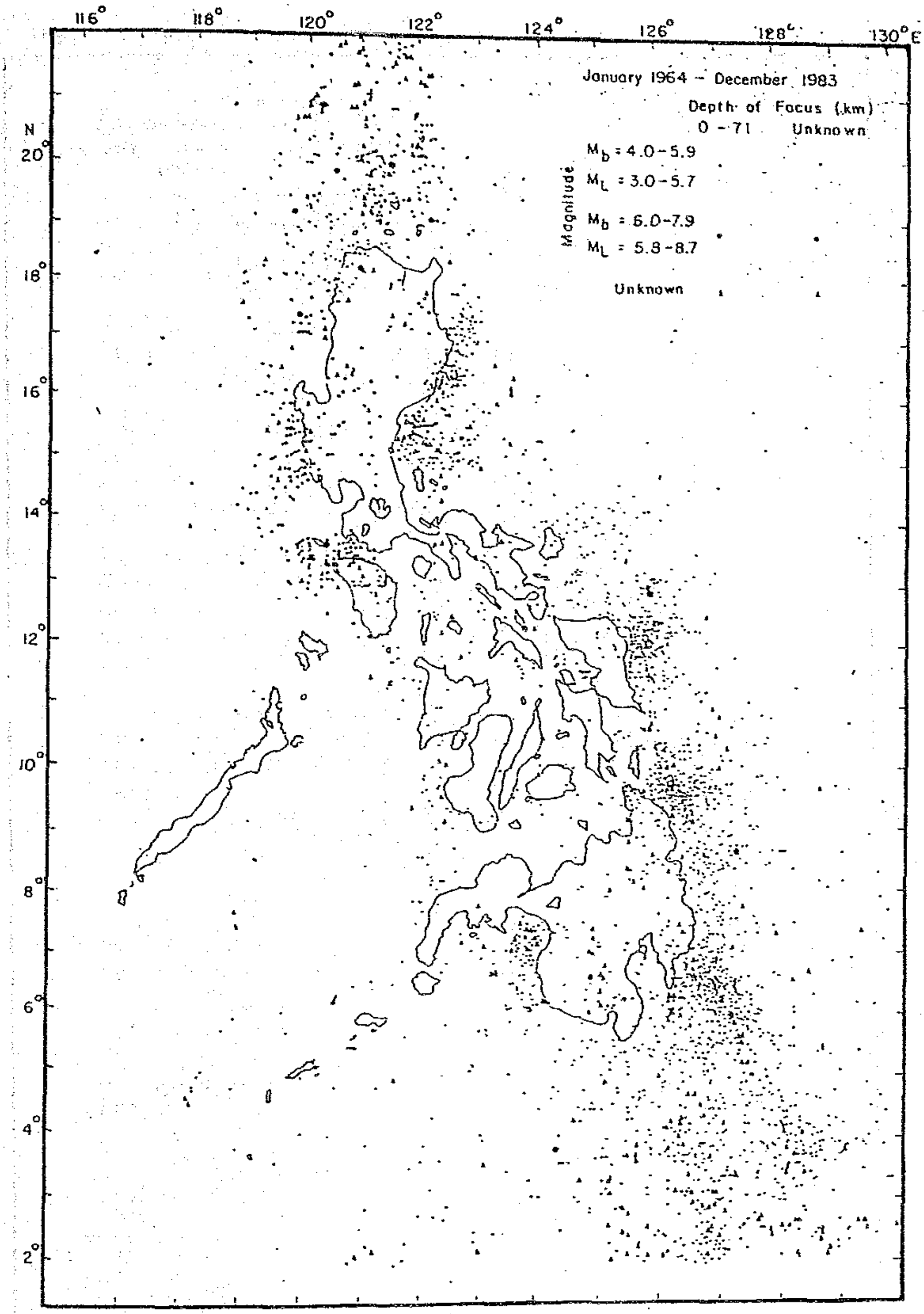
1.) River Cross Section in 1972 is referred from the "Proposed 2nd IBRD Highway Project (BPH, EDCOP, LBI)".

2.) River Cross Section in 1988 is measured by the team.

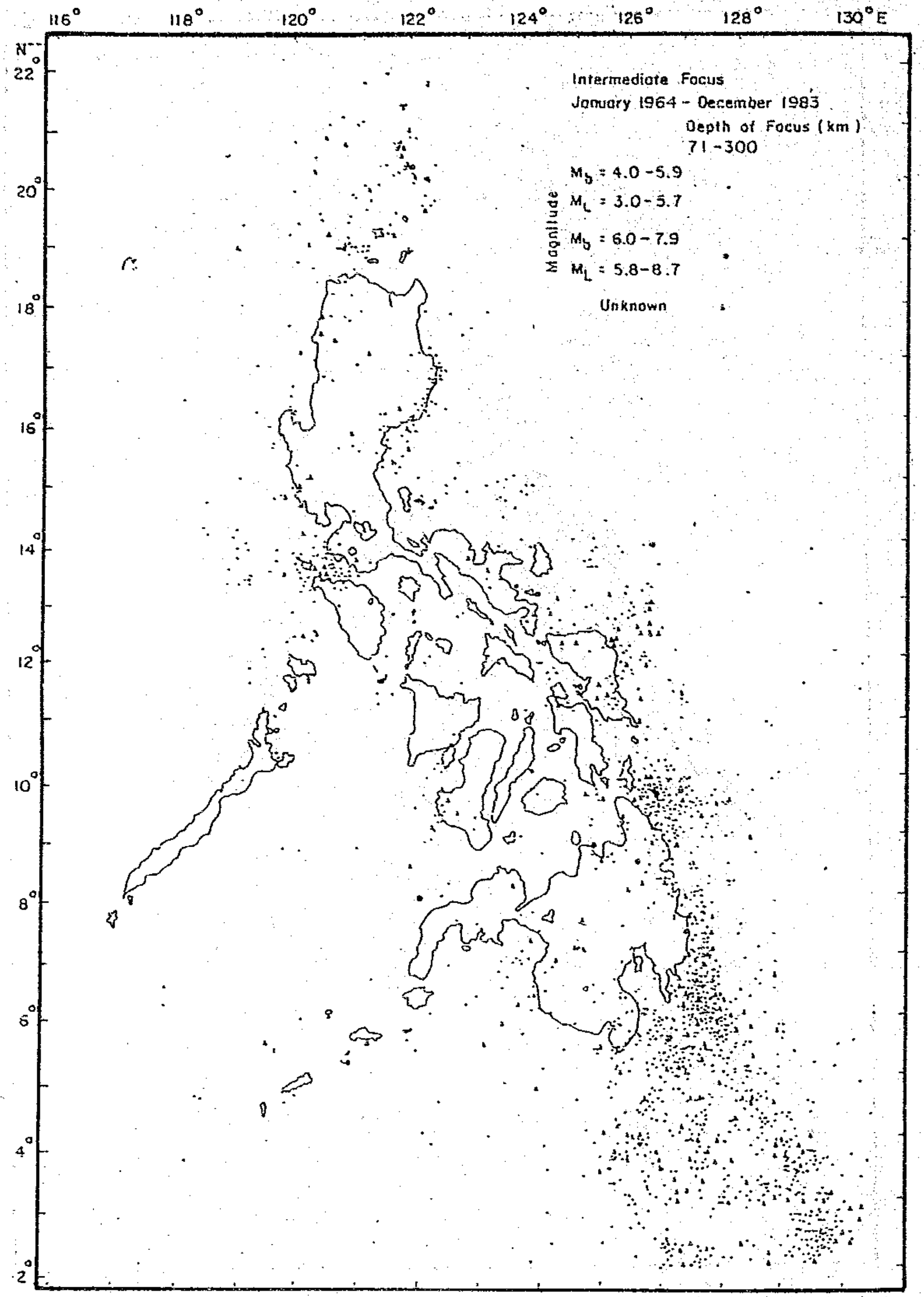
3.) Riverbed elevation went up by 0.3 m. (128.10 m. - 127.80 m.) Annual increasing rate 0.019 m/year.

APPENDIX 10.1

SEISMIC DATA



SEISMICITY MAP (DEPTH = 0 - 70 KM, 1964-1983)



SEISMICITY MAP (DEPTH = 71 - 300 KM, 1964-1983)

ROSSI-FOREL-SCALE OF EARTHQUAKE INTENSITIES (Adapted)

I. Hardly Perceptible Shock.
Felt only by an experienced observer under favorable conditions.

II. Extremely Feeble Shock.
Felt by a small number of persons at rest.

III. Very Feeble Shock.
Felt by several persons at rest. Duration and direction may be perceptible. Sometimes dizziness or nausea experienced.

IV. Feeble Shock.
Felt generally indoors, outdoors by a few. Hanging objects swing slightly. Swealing of frames of houses.

V. Shock of Moderate Intensity.
Felt generally by everyone. Hanging objects swing freely. Overturn of all vases and unstable objects Light sleepers awaken.

VI. Fairly Strong Shock.
General awakening of those asleep. Some frightened persons leave their houses. Stopping of pendulum clocks. Oscillation of hanging lamps. Slight damage in very old or poorly-built structures.

VII. Strong Shock.
Overturn of movable objects. General alarm, all run outdoors. Damage slight in well-built houses, considerable in old or poorly-built structures, old walls, etc. Some landslides from hills and steep banks. Cracks in road surfaces.

VIII. Very Strong Shock.
People panicky. Trees shaken strongly. Changes in the flow of springs and wells. Sand and mud ejected from fissures in soft ground. Small landslides.

IX. Extremely Strong Shock.
Panic general. Partial or total destruction of some buildings. Fissures in ground. Landslides and roof falls.

DESCRIPTION OF THE RICHLER MAGNITUDE SCALE

1. Earthquakes with M over 9 have never occurred since the data based on the seismographic observations become available.

2. Earthquakes with M8 to 9 are the "great earthquakes" occuring once or twice a year. When they occur in land areas, damages occur over wide areas. When they occur under the sea, considerable tsunamis are produced. Many aftershocks occur in areas approximately 100 to 1000 kilometers in diameter.

3. Earthquake with M7 to 8 are the "major earthquakes" and can cause considerable damages near the epicenters. In case of earthquakes occuring under the sea they produce small tsunamis.

4. Earthquakes with M6 to 7 are the "strong earthquakes" and are accompanied by local damages near the epicenter. First class seismological stations can observe them wherever they occur within the earth.

5. Earthquakes with M5 to 6 are the "earthquakes of moderate strength" and are felt over wide areas; some of them cause small local damages near the epicenter.

6. Earthquakes with M4 to 5 are the "feeble shocks" where damages are not usually reported.

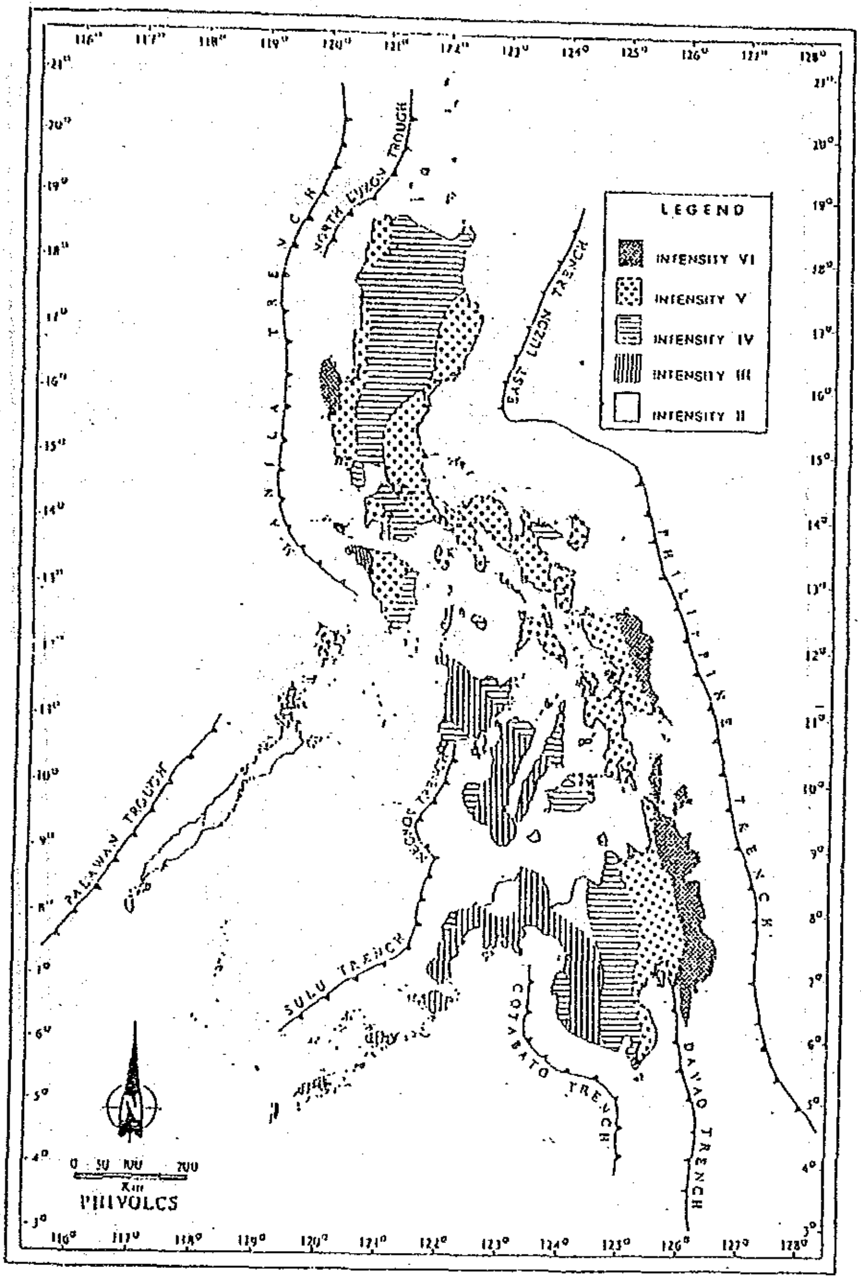
7. Earthquakes with M3 to 4 are the "very feeble shocks" and only felt near the epicenters.

8. Most earthquakes with M below 3 are the "hardly perceptible shocks" and are not felt. They are only recorded by seismographs of near-by stations.

9. Earthquakes with M below 1 are only detectable when an ultrasensitive seismometer is operated under favorable conditions.

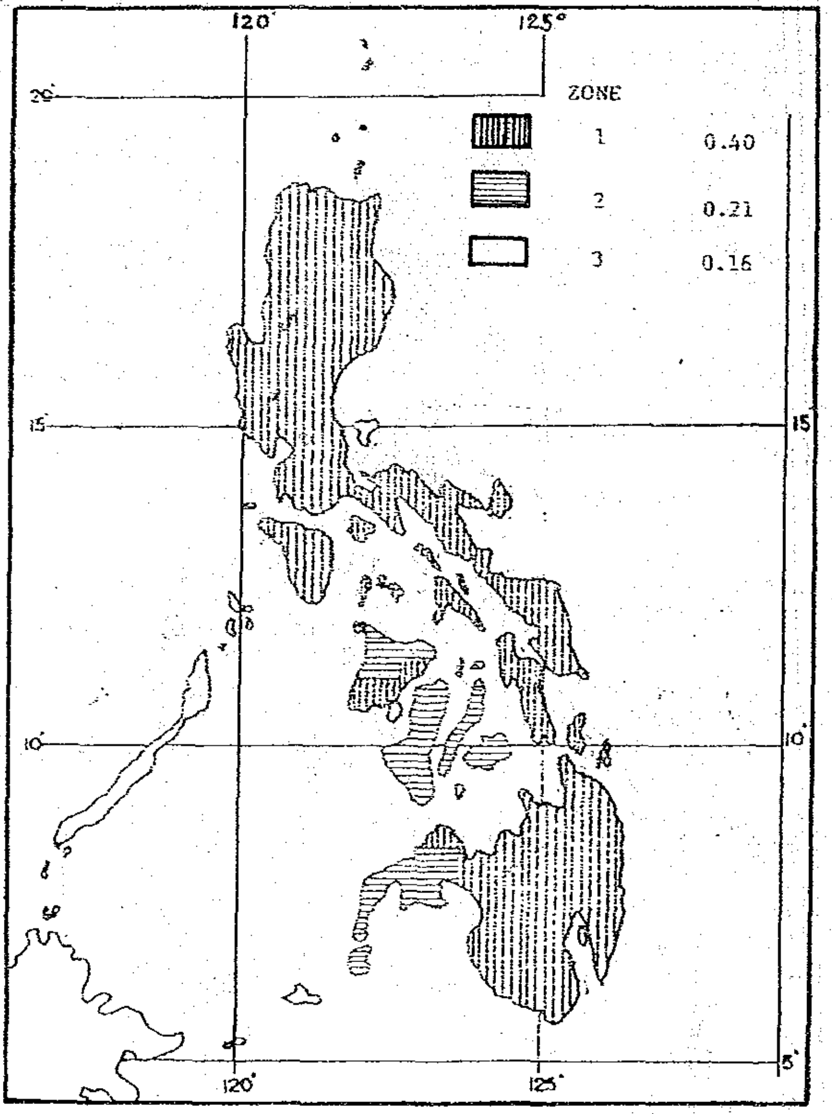
REMARKS: For deep-focus earthquakes the above descriptions are not applicable.

EARTHQUAKE PRONE AREAS

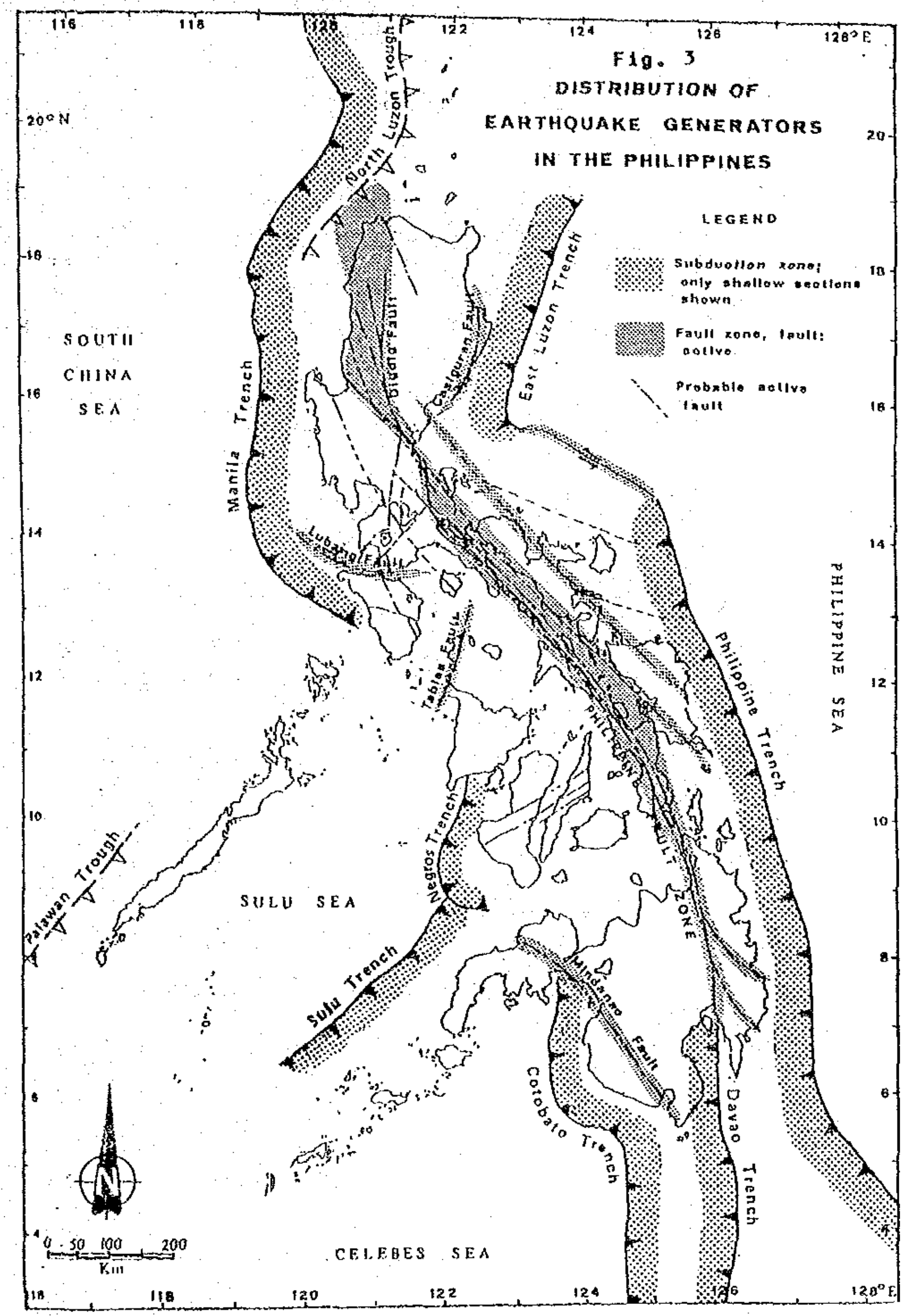


Earthquake Prone Areas

ACCELERATION COEFFICIENT



DISTRIBUTION OF EARTHQUAKE GENERATORS
IN THE PHILIPPINES



APPENDIX 10.2

DESIGN CRITERIA

1. General

2. Geometric Design Standard (Highway Design Guideline)

3. Clearance for Bridges (NSCP, 2.23)

4. Bridge Width

5. Free Board

6. Types of Loads (NSCP, Part A)

   6.1 Dead Load (NSCP, 3.3)
   6.2 Live Loads (NSCP, 3.4)
   6.3 Application of Live Loads (Study Team)
   6.4 Impact (NSCP, 3.8)
   6.5 Longitudinal Forces (NSCP, 3.9)
   6.6 Application of Live Load (NSCP, 3.11)
   6.7 Sidewalk Loading (NSCP, 3.14)
   6.8 Wind Load (NSCP, 3.14)
   6.9 Force of Stream Current on Piers (NSCP, 3.18)
   6.10 Bouyancy (NSCP, 3.19)
   6.11 Earth Pressure (NSCP, 3.20)

7. Combination of Loads (NSCP, 3.22)

8. Earthquake (NSCP, 3.21)

8.1 Earthquake Design Method (NSCP, 3.21.1)
8.2 Application of Earthquake Design (Study Team)
8.3 Minimum Support Length (NSCP, Appendix E and Japanese Spec. -V)

9. Selection of Design Method

10. Superstructure Design

11. Substructure Design

11.1 Pier Spacing Orientation and Type (NSCP, 7.1)
11.2 Pier (NSCP, 7.2)
11.3 Abutment (NSCP, 7.4)
11.4 Foundation (NSCP 4)

12. Material and Allowable Stress

12.1 Concrete
12.2 Reinforcing Steel
12.3 Structural Steel (NSCP, 10.32.1)
12.4 Pre-Stressed Concrete (NSCP, 9.15)

13. Design Standard

1. General

The historical background of bridge design in the Philippines is in the commentaries of the first edition of the NSCP, Vol. II by Mr. Roberto P. Bernardo, Chairman of Committee on NSCP Vol. II Bridges.

Traditionally, bridges designed by engineers in the Philippines follow the procedures presented in American technical books and manuals. Likewise, standards and guidelines that have been set by government agencies for the approval and implementation of infrastructure projects are patterned after these procedures. Since most existing bridge structures were found to have performed satisfactorily, the ASEP National Structural Code of the Philippines Committee on Bridges has decided to essentially adopt the ASSHTO 1983 edition as the basis of the NSCP Volume II with slight modifications to suit local conditions. Also incorporated are design methods which are not explicitly in AASHTO, but resulted in satisfactory performance of numerous local bridge projects.

The design criteria to be applied to the preliminary design of this feasibility study are based on the above NSCP, and were determined after carefully reviewing and studying the related articles. So these design criteria consist of the modification of and excerpts from the NSCP. Vol. II Bridge, December 1987, issued by Association of Structural Engineers of the Philippines (ASEP), in case it is not specified in the design criteria, it is precisely based on the NSCP.

The design criteria involves the following.

- Geometric Design Standard
- Clearances for Bridges
- Bridge Width
- Loads
- Earthquakes
- Design method
- Materials and Allowable Stress
- Superstructure Design
- Substructure Design
- Design Standards
- Unit Conversion

2. Geometric Design Standard (Highway Design Guideline)

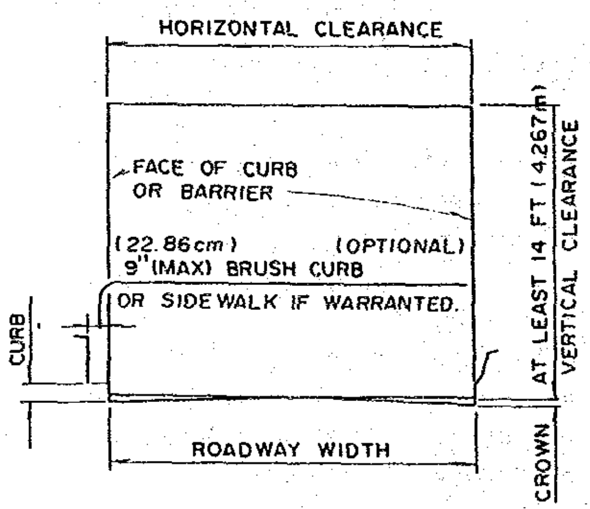
The geometric design standards being applied to this feasibility study are derived from the Highway Design Guidelines, DPWH, 1984 as tabulated as follows:

(1)	Design Speed	* 40 - 90 KPH
(2)	Lane Width for two lanes	6.1 m, 6.7 m, 7.32 m, 8.0 m
(3)	Shoulder	0.31 m
(4)	Sidewalk	0.76 (0.46 m)
(5)	Vertical Clearance	4.80 m
(6)	Crossfall	1.5%
(7)	Superelevation (max.)	0.10 m/m
(8)	Horizontal Curvalture (min.)	* 50 m
(9)	Vertical Gradient	* 6%
(10)	Length of Vertical Curves	60 m

Note: ( ): The figures in the bracket are subject to the existing bridge requirement.
* : to be based on the minimum geometric standards in the planning conditions.

3. Clearance for Bridges (NSCP, 2.2.3)

The standard vertical clearance shall be 4.80 m while the horizontal clearance shall be the roadway width which shall generally equal the width of the approach roadway section including the shoulder as illustrated below.



Clearance diagram for bridges.

4. Bridge Width

The hierarchy classification of bridge width shall be based on the following.

	Type of Highway	Roadway Width (m)	Remarks
(1)	Main Highways	0.31+7.32+0.31	AADT2000 ≥ 10,000
(2)	Rural Highways	0.31+6.70+0.31	10,000 > AADT2000 > 5,000

5. Free Board

The elevation of the lower end of bridge girder shall be designed not to be lower than that of design flood water level with addition of free board. The free board is designed to be 1.5 m for streams carrying debris and 1.00 m for others based on the Design Guidelines Criteria and Standards by Bureau of Design in DPWH.

In this study, the standard of free board shall be set up as follows taking into consideration the Guidelines and Standard above.

<u>Free Board</u>	<u>Applied River</u>
1.0 m	Small river, Design flood less than 500 m^3/S
1.2 m	Medium river, Design Flood less than 500-2,000 m^3/S
1.5 m	Big/Debris river, Design flood more than 2,000 m^3/S

6. Types of Loads (NSCP, PART A)

Structure shall be designed to carry loads such as Dead Load, Live Load, Impact or Dynamic Effect of the Live Load, Wind Loads and other forces, namely, Longitudinal Forces, Centrifugal Force, Thermal Forces, Earth Pressure, Buoyancy, Shrinkage Stresses, Rib Shortening, Erection Stresses, Current Pressure and Earthquake Stresses.

6.1 Dead Load (NSCP, 3.3)

The following weights are to be used in computing the dead load:

	kg/m³	KN/m³
Steel or cast steel	7850	77.0
Cast iron	7210	70.7
Aluminum alloys	2800	27.4
Timber (treated or untreated)	800	7.8
Concrete, plain or reinforced	2400	23.5
Compacted sand, earth, gravel or ballast	1900	18.6
Loose sand, earth, and gravel	1600	15.7
Macadam or gravel, rolled	2200	21.5
cinder filling	960	9.4
Pavement, other than wood block	2400	23.5
Railway rails, guard rails, and fastenings (per linear foot or track)	3200	31.4
Stone masonry	2700	26.5
Asphalt plank, 1 in. thick	44 kg/m²	0.43

6.2 Live Loads (NSCP, 3.4)

The loads being adopted on this feasibility study are from the National Structural Code of the Philippines, Vol. II, Dec., 1987 as follows.

(1) Standard Truck and Lane Loads

The highway live loadings on the roadways of bridges or incidental structures shall consist of standard trucks or lane loads that are equivalent to truck trains. Two systems of loading are provided, the M loadings and the MS loadings the MS loadings being heavier than the corresponding M loadings.

Each lane load shall consist of a uniform load per linear meter of traffic lane combined with a single concentrated load (or two concentrated loads in the case of continuous spans) so placed on the span as to produce maximum stress. The concentrated load and uniform load shall be considered as uniformly distributed over a 3.05 m width on a line normal to the centerline of the lane.

(2) Classes of Loading

There are four standard classes of highway loading: M 18, M 13.5, MS 18 and MS 13.5. Loading M 13.5 is 75 percent of loading M 18. Loading MS 13.5 is 75 percent of Loading MS 18. If loadings other than those designated are desired, they shall be obtained by proportionately changing the weights shown for both the standard truck and the corresponding lane loads.

(3) Minimum Live Load

For truck highways, or for other highways that carry, or may carry, heavy truck traffic, the minimum live load shall be the MS 13.5 designated herein.

(4) M Loading

The M loading consist of a two-axle truck or the corresponding lane loading as illustrated in Figs. 10.1 and 10.2. The M loadings are designated M followed by a number indicating the gross weight in tons of the standard truck.

Fig. 10.1 STANDARD MS TRUCKS

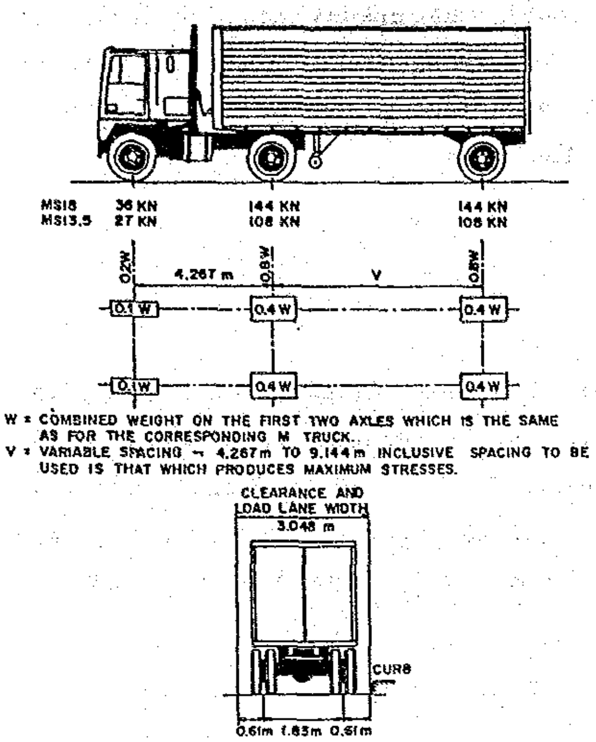


Fig. 10.2 STANDARD M TRUCKS

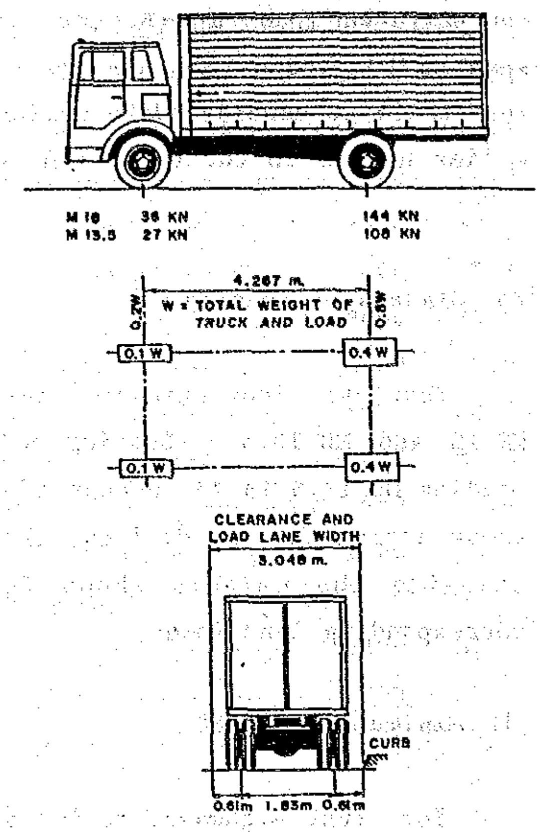
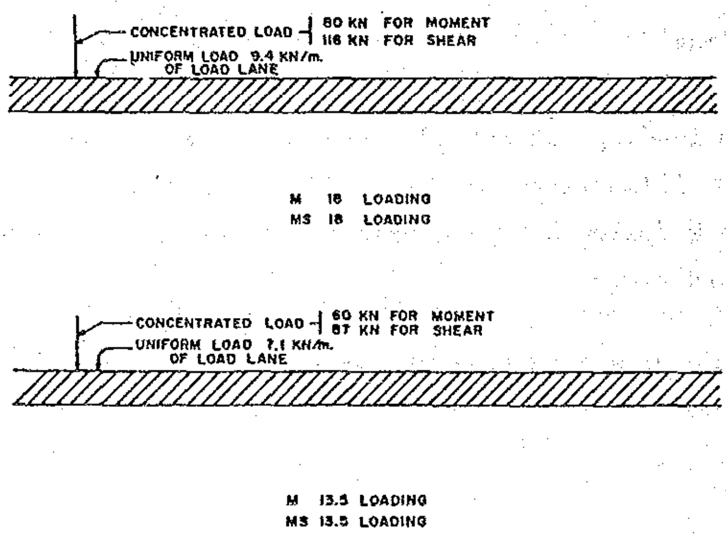


Fig. 10.3 M LANE AND MS LANE LOADING



(5) MS Loading

The MS loading consist of a tractor truck with semi-trailer or the corresponding lane load as illustrated in Fig. 10.3. The MS loadings are designated by the letters MS followed by a number indicating the gross weight in tons of the tractor truck. The variable axle spacing has been introduced in order that the spacing of axles may approximate more closely the tractor trailers in use. The variable spacing also provides a more satisfactory loading for continuous spans, in that heavy axle loads may be so placed in adjoining spans as to produce maximum negative moments.

6.3 Application of Live Loads (Study Team)

The live loads being applied to the preliminary design are classified corresponding to the rehabilitation methods such as new-construction, reconstruction and repair. (Refer to Table 10.3)

Kind of Loading	Reconstruction / Replacement		Repair	
	Deck Slab	Girder/Beam	Deck Slab	Girder/Beam
Standard HS Trucks				
MS 18	adopted	adopted	adopted	-
MS 13.5	-	-	-	-
Standard H Trucks				
M 18	adopted	adopted	adopted	adopted*-1
M 13.5	-	-	-	adopted*-1
Lane Loading				
MS 18, M18	-	adopted	-	adopted*-2
MS 13.5, M 13.5	-	-	-	adopted*-2

Note: - : Non loading is adopted .

*-1: to be subject to the sections divided by AADT (2000).

*-2: to be equivalent to Standard H Trucks M 18 or M 13.5.

Table 10.3 APPLICATION OF DESIGN LIVE LOAD

SECTIONS	AADT 2000	Reconstruction / Replacement		REPAIR		REMARKS
		DECK SLAB	GIRDER/BEAM	DECK SLAB	GIRDER/BEAM*	
(1) Manila - Rosario	> 20,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(2) Rosario - San Fernando	> 10,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(3) San Fernando - Laoag	> 5,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
Pan-Philippine Highway						
(1) Manila - Santa Fe	> 20,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(2) Santa Fe - Santiago	> 10,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(3) Santiago - Allacapan	< 5,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(4) Manila - Calamba	> 20,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(5) Calamba - Calauag	> 10,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(6) Calaug - Sipocot	> 5,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(7) Sipocot - Sorsogon	> 10,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(8) Sorsogon - Matnog	< 5,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(9) Allen - Tacloban	< 5,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(10) Tacloban - Mac Arthur	> 10,000	MS 18	MS 18	MS 18	M 13.5 or M 18	
(11) Mac Arthur - Liloan	< 5,000	MS 18	MS 18	MS 18	M 13.5 or M 18	

MS 18 = MS 18 TRUCKS OR MS 18 LANE LOADING
M 18 = M 18 OR M 18 LANE LOADING
MS 13,5 = MS 13.5 TRUCKS OR MS 13.5 LANE LOADING

* : M 18 or M 13.5 is to be selected in accordance with loading capability which is determined by the structural properties of the existing bridges.

6.4 Impact (NSCP, 3.8)

Live load stress produced by M or MS loading shall be increased by applying the following impact formula.

$$I = \frac{15.24}{L + 38}$$

in which

I = impact fraction (maximum 30 percent)

L = length in meters of the portion of the span that is loaded to produce the maximum stress in the manner.

6.5 Longitudinal Forces (NSCP, 3.9)

Provision shall be made for the effect of a longitudinal force of 5 percent of the live load in all lanes carrying traffic headed in the same direction. The center of gravity of the longitudinal force shall be assumed to be located 1.83 m above the floor slab and to be transmitted to the substructure through the superstructure.

6.6 Application of Live Load (NSCP, 3.11)

The application of live load shall be based on the articles prescribed in 3.11 APPLICATION OF LIVE LOAD, NSCP, i.e. Traffic Lane Unit, Number and Position of Traffic Lane Unit, Lane Loads on Continuous Spans, Loading for Maximum Stress, Reduction in Load Intensity.

6.7 Sidewalk Loading (NSCP, 3.14)

Sidewalk floors, stringers and their immediate supports, shall be designed for a live load of 85 pounds per square foot of sidewalk area. Girders, trusses, arches, and other members shall be designed for the following sidewalk live loads:

Spans 0 to 7.62 m in length ---------------- 4070 Pa

Spans 7.92 to 30.5 m in length -------------- 2870 Pa

Spans over 30.5 m in length according to the formula

$$P = (1{,}435 + \frac{43{,}800}{L}) \frac{(16.7 - W)}{15.2}$$

in which

P = live load in Pa max. 2870 Pa

L = loaded length of sidewalk in meters

W = width of sidewalk in meters

6.8 Wind Load (NSCP, 3.15)

Group II and Group V Loadings

A wind load of the following intensity shall be applied horizontally at right angles to the longitudinal axis of the structure:

For trusses and arches	3590 Pa
For girders and beams	2390 Pa

The total force shall not be less than 4380 N/m in the plane of the windward chord and 2190 N/m in the plane of the leeward chord on truss spans, and not less than 4380 on girders spans.

Group III and Group VI Loadings

Group III and Group VI loadings shall comprise the loads used for Group II and Group V loadings reduced by 70 percent and a load of 1460 N/m applied at right angles to the longitudinal exist of the structure and 1.83 m above the deck as a wind load on a moving live load.

6.9 Force of Stream Current on Piers (NSCP, 3.18)

The effect of flowing water on piers shall be calculated by the formula:

$$P = 515\ KV^2$$

where:

P = pressure in Pascal Pa

V = velocity of water in m/s

K = a constant, being 1 3/8 for square ends, 1/2 for angle ends where the angle is 30 degrees or less, and 2/3 for circular piers.

6.10 Buoyancy (NSCP, 3.19)

Buoyancy shall be considered where it affects the design of either substructure, including piling, or the superstructure.

6.11 Earth Pressure (NSCP, 3.20)

Structures which retain fills shall be proportioned to withstand pressure as given by Rankine's formula; provided, however, that no structure shall be designed for less than an equivalent fluid weight (mass) of 480 kg/m^3

7. Combinations of Loads (NSCP, 3.22)

The following Groups represent various combinations of loads and forces to which a structure may be subjected. Each component of the structure, or the foundation on which it rests, shall be proportioned to withstand safely all group combinations of these forces that are applicable to the particular site or type. Group loading combinations for the Service Load Design and Load Factor Design are given by: (Refer Table 10.4)

$$\text{Group (N)} = t[\beta_D - D + \beta_L (L + I) + \beta_C CF + \beta_E E$$

$$+ \beta_B B + \beta_S SF + \beta_W W + \beta_{WL} WL$$

$$+ \beta_L - LF + \beta_R (R + S + T) + \beta_{EQ} EQ]$$

where

N = group number

t = load factor

ß = coefficient

D = dead load

L = live load

I = live load impact

E = earth pressure

B = buoyancy

W = wind load on structure

WL = wind load on live load - 1460 N/m

LF = longitudinal force from live load

CF = centrifugal force

R = rib shortening

S = shrinkage

T = temperature

EQ = earthquake

SF = stream flow pressure

Table 10.4 TABLE OF COEFFICIENT r AND β

Col.No.	1	2	3	3A	4	5	6	7	8	9	10	11	12	13	14	
	FACTORS															
GROUP	γ	D	(L+I)n	(L+I)p	CF	E	β	SF	W	WL	LF	R+S+T	EQ	ICE	%	
SERVICE LOAD																
I	1.0	1	1	0	1	βE	1	1	0	0	0	0	0	0	100	
IA	1.0	1	2	0	0	0	0	0	0	0	0	0	0	0	150	
IB	1.0	1	0	1	1	βE	1	1	0	0	0	0	0	0	**	
II	1.0	1	0	0	0	1	1	1	1	0	0	0	0	0	125	
III	1.0	1	1	0	1	βE	1	1	0.3	1	1	0	0	0	125	
IV	1.0	1	1	0	1	βE	1	1	0	0	0	1	0	0	125	
V	1.0	1	0	0	0	1	1	1	1	0	0	1	0	0	140	
VI	1.0	1	1	0	1	βE	1	1	0.3	1	1	1	0	0	140	
VII	1.0	1	0	0	0	1	1	1	0	0	0	0	1	0	133	
VIII	1.0	1	1	0	1	1	1	1	0	0	0	0	0	1	140	
IX	1.0	1	0	0	0	1	1	1	1	0	0	0	0	1	150	
X	1.0	1	1	0	0	βE	0	0	0	0	0	0	0	0	100	Culvert
LOAD FACTOR DESIGN																
I	1.3	βD	1.67	0	1.0	βE	1	1	0	0	0	0	0	0		
IA	1.3	βD	2.20	0	0	0	0	0	0	0	0	0	0	0		
IB	1.3	βD	0	1	1.0	βE	1	1	0	0	0	0	0	0		
II	1.3	βD	0	0	0	βE	1	1	1	0	0	0	0	0	not Applicable	
III	1.3	βD	1	0	1	βE	1	1	0.3	1	1	0	0	0		
IV	1.3	βD	1	0	1	βE	1	1	0	0	0	1	0	0		
V	1.25	βD	0	0	0	βE	1	1	1	0	0	1	0	0		
VI	1.25	βD	1	0	1	βE	1	1	0.3	1	1	1	0	0		
VII	1.3	βD	0	0	0	βE	1	1	0	0	0	0	1	0		
VIII	1.3	βD	1	0	1	βE	1	1	0	0	0	0	0	1		
IX	1.20	βD	0	0	0	βE	1	1	1	0	0	0	0	1		
X	1.30	1	1.67	0	0	E	0	0	0	0	0	0	0	0		Culbert

$(L + I)_n$ - Live load plus impact for AASHTO Highway M or Ms loading

$(L + I)_p$ - Live load plus impact consistent with the overload criteria of the operation agency.

*1.25 may be used for design of outside roadway beam when combination of sidewalk live load as well as traffic live load plus impact governs the design, but the capacity of the section should not be less than required for highway traffic live load only using a beat factor of 1.67. 1.00 may be used for design of deck slab with combination of loads as described in Article 3.24.2.2.

$$\beta_{Percentage} = \frac{\text{Maximum Unit Stress (Operating Rating)}}{\text{Allowable Basic Unit Stress}} \times 100$$

For Service Load Design

% (Column 14) Percentage of Basic Unit Stress

No increase in allowable unit stresses shall be permitted for members or connections carrying wind loads only.

β_E = 0.70 for vertical loads on Reinforced Concrete Boxes.

β_E = 1.0 for lateral loads on Reinforced concrete Boxes.

β_E = 1.0 for vertical and lateral loads on all other culverts.

8. Earthquake (NSCP, 3.21)

8.1 Earthquakes Design Method (NSCP, 3.21.1)

The earthquakes force is estimated in accordance with NSCP in which the Equivalent Static Force Method consisting of the following two principal formula is considered by reason of practicality.

Formula (1):	EQ = C.F.W.	for superstructure
Formula (2):	EW = 0.10 (W + L/2)	- do -
Formula (3):	H = 0.1 x W	for substructure

Where:

EQ = equivalent static horizontal force applied at the center of gravity of the structure;

F = Framing factor;

F = 1.0 for structures where single columns or piers resists the horizontal forces;

F = 0.8 for structures where continuous frames resist horizontal forces applied along the frame;

W = total deal weight of the structure in KN.

$C = A \cdot R \cdot S / Z$

C = response coefficient (the calculated coefficient C shall not be less than 0.10) for various depths of alluvium to rocklike material given in Figures 3.2.1: 1A,B,C, and D;

A = maximum expected acceleration of bedrock at the site 0.5 g. More exact peak rock acceleration values should be used in. areas where "Maximum Expected Rock Acceleration" maps are available.