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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

FEASIBILITY STUDY
ON
THE RESTORATION OF RURAL ROADS

FINAL REPORT

VOLUME V

RURAL ROAD RESTORATION MANUAL

JANUARY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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I N T R O D U C T I O N

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

The Feasibility Study on the Restoration of Rural Roads (hereinafter referred to as the Study) was carried out with the main objective of developing technology for restoration of rural roads damaged by disasters. The Study was outlined as follows:

- Three (3) provinces; Benguet, Batangas and Leyte, were selected as pilot provinces.
- A total of 226 disaster spots were identified along rural roads in the pilot provinces. Among them, 62 disaster spots were selected for feasibility study.
- Feasibility study was carried out for the selected disaster spots including traffic study, engineering survey, preliminary design, cost estimate and project evaluation.
- Implementation program for the rural road restoration project was prepared.

The feasibility study spots are as follows:

Type of Disaster	Number of Disaster Spots			
	Benguet	Batangas	Leyte	Total
Slope Damage	12	5	12	29
Debris Flow	4	0	1	5
Road Damage	1	3	2	6
Bridge Damage	2	6	6	14
Culvert Damage	2	2	2	6
Seawall Damage	0	2	0	2
T o t a l	21	18	23	62

This Manual was prepared on the basis of the findings from the Study, intending to be used as a reference for design and construction for restoration of damaged spots along rural roads.

1.2 LIMITATION OF THE MANUAL

The application of the Manual should be limited as follows:

1) Road Class

Since the Study covered national secondary roads, provincial roads and barangay roads, the Manual is preferably applied only to disasters on such classes of roads.

2) Exclusion of Preventive Measures

The Study dealt mainly with the restoration of the roads having been damaged by disasters, not prevention of road disaster, except for the case where presently there is no interference to traffic but progressive defect in road facilities is exposed to such extent that their collapse in near future is anticipated, as found in bridge foundation being scoured. Therefore, this Manual also deals with restoration measures for already damaged roads including above-mentioned exceptional case.

Regarding prevention of road disaster, "An Approach on Road Disaster Prevention, Volume V of the Final Report of the Feasibility Study of Philippine Road Disaster Prevention Project" is available.

3) Type of Disaster

This Manual covers only the following types of road disaster:

- Road slope damage including cut slope or mountain side natural slope failure, embankment slope or valley side natural slope failure, rock or debris fall, and landslide;
- Debris flow;
- Road damage including scour/washout of roadbed, and flooded/muddy road surface;
- Bridge damage including bridge washout, bridge approach washout, other bridge related damage like scour at pier/abutment/revetment and raise of riverbed, and spillway damage like scour/washout and debris clogging;
- Culvert damage; and
- Seawall damage

Other damages than above, for example, defects in bridge members like crack/spalling of beam/slab/substructure and deterioration of pavement and road accessories, are not covered by the Manual.

4) Scope of Restoration Measures

Restoration measures are divided into two; urgent restoration measures to open the road to traffic urgently and temporarily, and permanent restoration measures to restore the road completely and prevent the recurrence of disaster. Both are covered by the Manual.

The Manual deals with only those restoration measures that are to be taken as road project. Therefore, such works as river control and sabo work are not covered by the manual, except for the portions adjacent to the road under discussion.

Pavement or bridge construction is sometimes applied to restoration as a part or as a whole thereof. Description on these works are however omitted in this Manual, since many references are available.

1.3 ORGANIZATION OF THE MANUAL

This Manual is organized with six (6) chapters and three (3) appendices.

Chapter 1 gives the background, limitation and organization of the Manual.

Chapter 2 provides basic information on road disaster in the Philippines, including topography, geology, meteorology, road network, road disaster and disaster management system. This chapter also presents the classification of province in regard to disaster potential and type.

Chapter 3 shows the classification of road disaster according to portion of roadway damaged and nature of damage, giving the definition of each type of disaster.

In Chapters 4 to 6, discussions are made separately for urgent restoration measures and permanent restoration measures.

Chapter 4 presents the methodology of surveys to be conducted for design of restoration measures, showing survey items and their procedures by type of disaster.

Chapter 5 presents the design and construction methods of restoration measures covering 18 kinds of urgent restoration measures and 70 kinds of permanent restoration measures, which are applicable to rural road restoration.

Chapter 6 presents the criteria for selection of appropriate measures in the form of flow chart for each type of road disaster.

The practical use of the Manual will be as shown in Figure 1.3-1.

Appendix-1 shows detailed analysis methods including slope stability analysis, hydrological analysis for drainage, stability analysis for concrete retaining wall, grouted riprap retaining wall and gabion wall, and structural analysis for anchoring, rock shed and sabo dam, with example calculations as necessary.

Appendix-2 presents the standard drawings.

Appendix-3 compiles an example design for each type of road disaster.

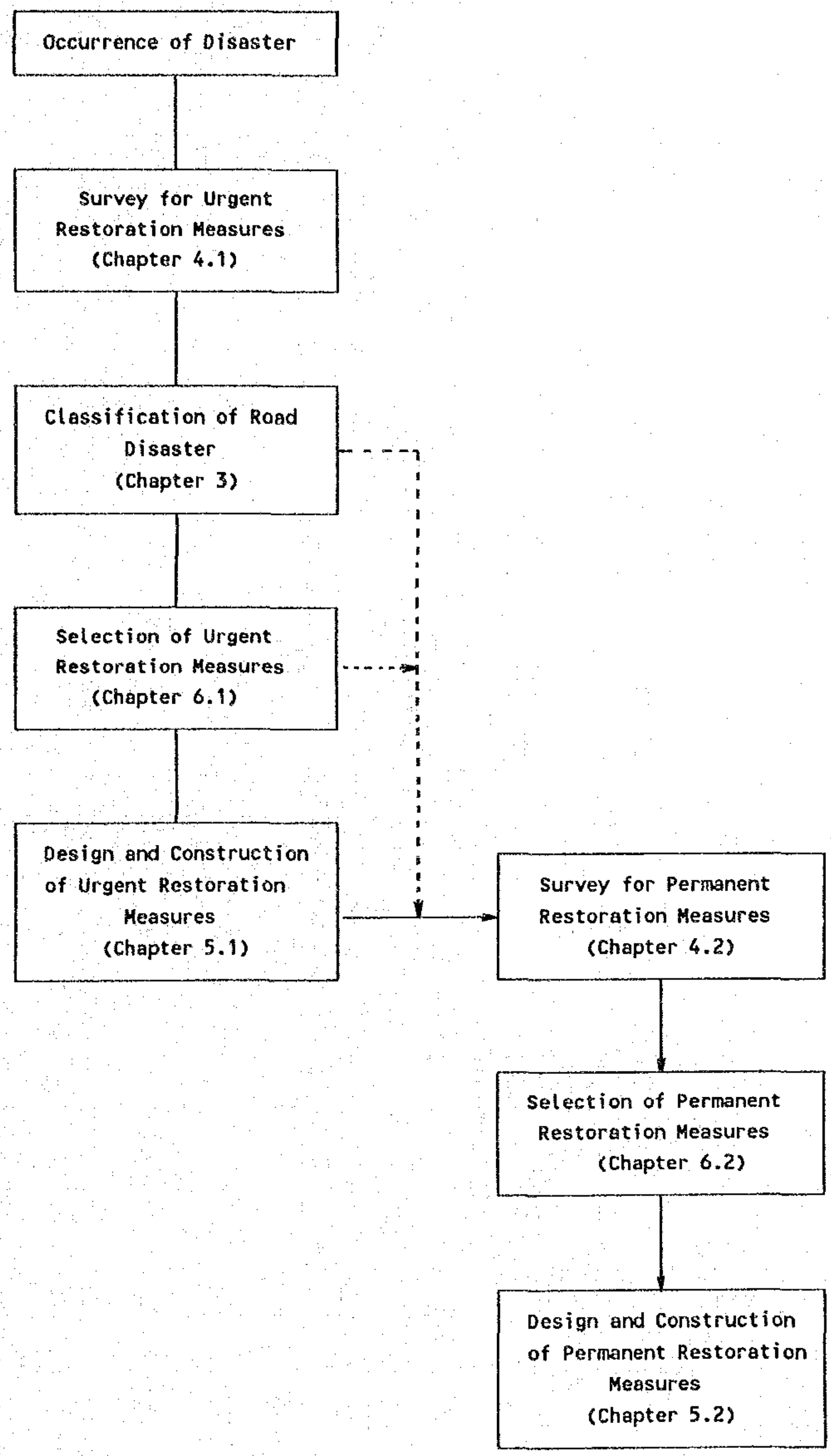


FIGURE 1.3-1 USAGE OF THE MANUAL

CHAPTER 2
ROAD DISASTER IN THE COUNTRY

CHAPTER 2
ROAD DISASTER IN THE COUNTRY

2.1 PHYSICAL CONDITION

2.1.1 Topography

The Philippines has a variety of topographical features from the low marsh a foot or so above high water at the head of Manila Bay to the high mountain masses, the highest peak being Mt. Apo in Mindanao with an elevation of approximately 2,953 meters. The largest mountainous areas and the most extensive plains are found in the island of Luzon (Figure 2.1-1).

The Cagayan Valley in northern Luzon, located southwest from Aparri, extends to a length of over 190 km with an average width of 64 km. The Cagayan River and its tributaries in this valley drains a basin of approximately 26,000 km^2. The Sierra Madre Mountains to the east rise steeply from both the Cagayan Valley and oceansides, and are largely unexplored, while the Cordillera Mountains lie west of this valley. Mt. Pulog, located in this general locality is the third highest peak in the archipelago with an elevation of 2,930 m. Among these mountain ranges are many fertile valleys several of which extend to the coastal plains along the north and west coasts of Luzon.

The Central Plain of Luzon is drained by the Agno River and its tributaries to Lingayen Gulf in the north and by the Pampanga River and with its tributaries to Manila Bay in the south. the depths of these rivers vary with the seasons, and at times the rivers are navigable only by small launches and bancas. This plain has an area of about 10,000 km^2 and is separated from the Cagayan Valley by the Caraballo Mountains. The Zambales Mountains lie to the west of the Central Plain of Luzon. Southeastern Luzon or Bicol Region has several plateaus and valleys of considerable size but has no river of importance. Mount Mayon which is located in this region is 2,432 m high, and is considered as an almost perfect volcanic cone.

Mindoro Island is mountainous and has coastal plains on the east and southwest sides where its towns and settlements are located, but its hinterlands have remained largely unexplored. Mindoro is considered to be a part of Southern Luzon.

The Visayan Islands are generally rugged with one or more mountain ranges and some coastal plains. Panay, one of its principal islands, has the largest area of level plains and rolling country, while Cebu Island has the least level lands. Negros has high mountains with most of its level lands in the west and northwest. Masbate, Samar, Leyte and Bohol are more in the nature of rolling terrain and high plateaus. These islands have no large rivers although some are wide and deep enough for navigation by launches and small boats.

Palawan Island consists mostly of high ridges and few level lands. It has no river of importance.

Mindanao Island has two large valleys: the Agusan Valley drained by the river of the same name with it sources in the comparatively low divide that separates this valley from the one extending north from Davao Gulf, and the Cotabato Valley drained by the Mindanao (Cotabato) River which empties into the Moro Gulf. The area of this valley excluding Lake Buluan and Liguasan Marsh is roughly 4,700 km^2. Cotabato Valley is separated from the valley to the north of Sarangani Bay by a low divide. Western and Eastern Mindanao are mountainous with narrow coastal plains.

The islands of Basilan, Jolo and Tawi-Tawi are comparatively rugged, while the rest of the Sulu Archipelago is composed mostly of relatively smaller islands.

Tables 2.1.1 and 2.1-2 show the area coverages by an elevation and by slope, respectively.

TABLE 2.1-1 AREA COVERAGE BY ELEVATION

Elevation	Area Coverage
0 m - 300 m	173,500 km^2 (57.8%)
300 m - 600 m	69,380 km^2 (23.1%)
600 m - 900 m	39,490 km^2 (13.2%)
900 m or above	17,630 km^2 (5.9%)
Total	300,000 km^2 (100.0%)

TABLE 2.1-2 AREA COVERAGE BY SLOPE

Slope	Area Coverage
0 - 8%	98,210 km^2 (32.7%)
8 - 18%	44,070 km^2 (14.7%)
18 - 30%	55,010 km^2 (18.3%)
30 - 50%	73,350 km^2 (24.5%)
50% or above	29,360 km^2 (9.8%)
Total	300,000 km^2 (100.0%)

Major river basins are listed in Table 2.1-3 and located as shown in Figure 2.1-2.

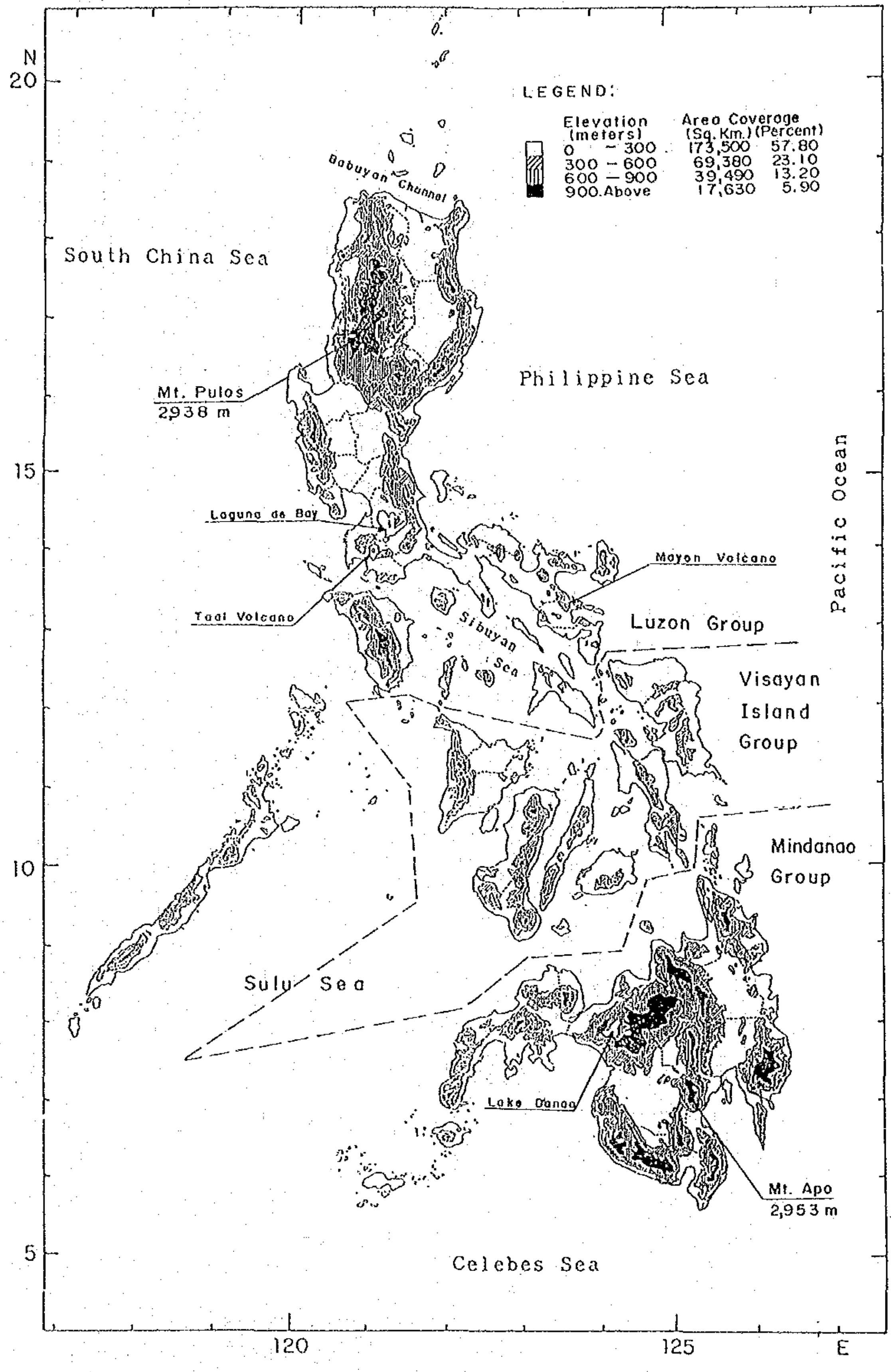
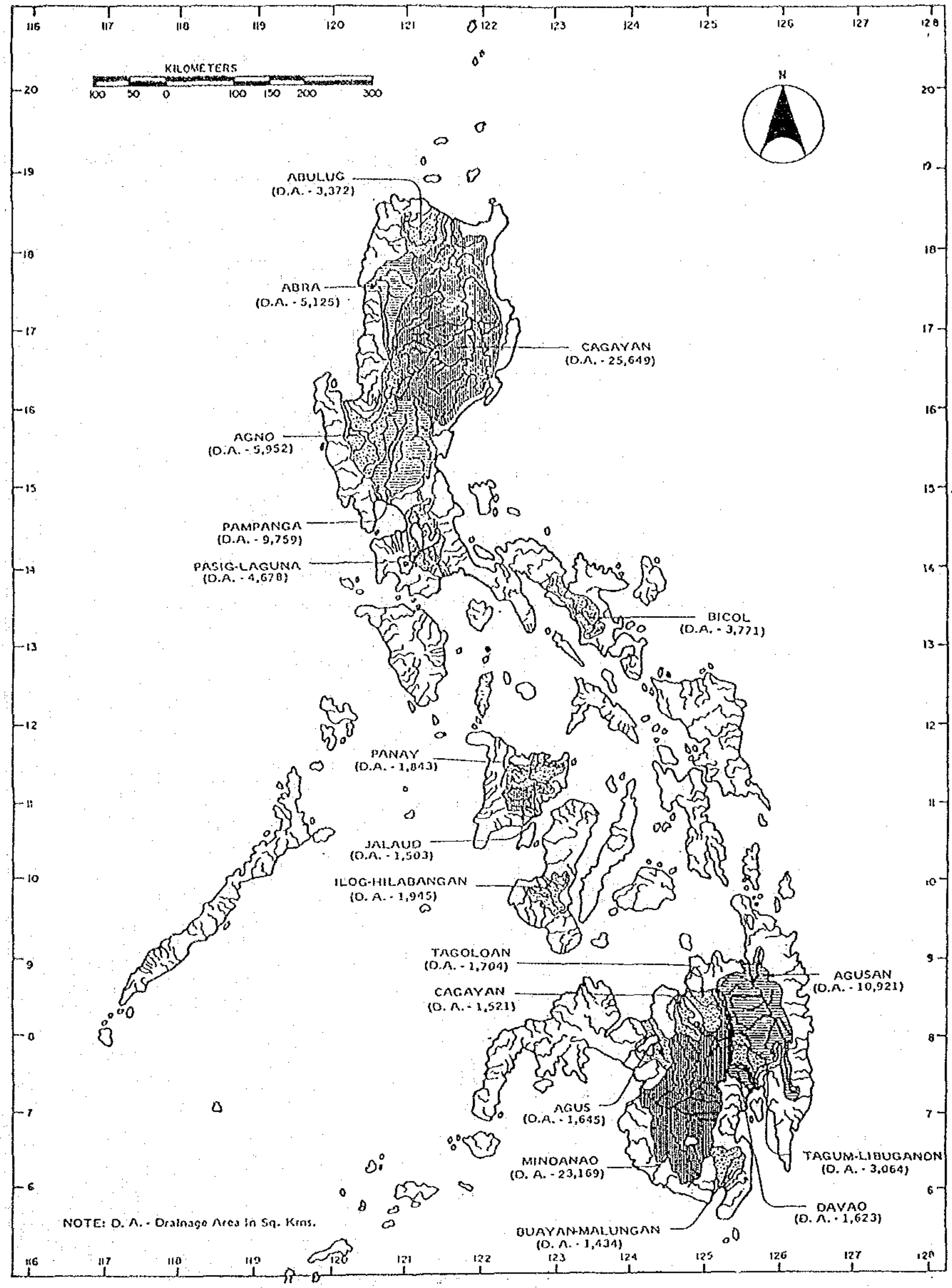


FIGURE 2.1-1 TOPOGRAPHIC MAP

TABLE 2.1-3 MAJOR RIVER BASINS

Rank	River Basin	Location	Drainage Area Km^2
1	Cagayan	Cagayan Valley	25,649
2	Mindanao	Southern Mindanao	23,169
3	Agusan	Northern Mindanao	10,921
4	Pampanga	Central Luzon	9,759
5	Agno	Central Luzon	5,952
6	Abra	Ilocos	5,125
7	Pasig-Laguna Bay	Southern Luzon	4,678
8	Bicol	Bicol	3,771
9	Abulug	Cagayan Valley	3,372
10	Tagum-Libuganon	Southeastern Mindanao	3,064
11	Ilog-Hilabangan	Western Visayas	1,945
12	Panay	Western Visayas	1,843
13	Tagoloan	Northern Mindanao	1,704
14	Agus	Southern Mindanao	1,645
15	Davao	Southeastern Mindanao	1,623
16	Cagayan	Northern Mindanao	1,521
17	Jalaud	Western Visayas	1,503
18	Buayan-Malungun	Southeastern Mindanao	1,434

Source: Principal River Basins of the Philippines, 1976



Source: Principal River Basins of the Philippines, 1976

FIGURE 2.1-2 MAJOR RIVER BASINS

2.1.2 Geology

1) Geological Formation

The geological formation of the Philippines is composed of various kinds of deposits and rocks as shown in Figure 2.1-3. The land area by geological category is shown in Table 2.1-4.

TABLE 2.1-4 LAND AREA BY GEOLOGIC CATEGORY

Geological Category	Area Coverage
Quatenary Deposit	91,820 km^2 (30.6%)
Neogene Deposit	37,100 km^2 (12.4%)
Palaogene Deposit	39,360 km^2 (13.1%)
Per-tertiary Deposit	30,610 km^2 (10.2%)
Intrusive Rock	19,140 km^2 (6.45)
Volcanic Rock	81,970 km^2 (27.3%)
T o t a l	300,000 km^2 (100.0%)

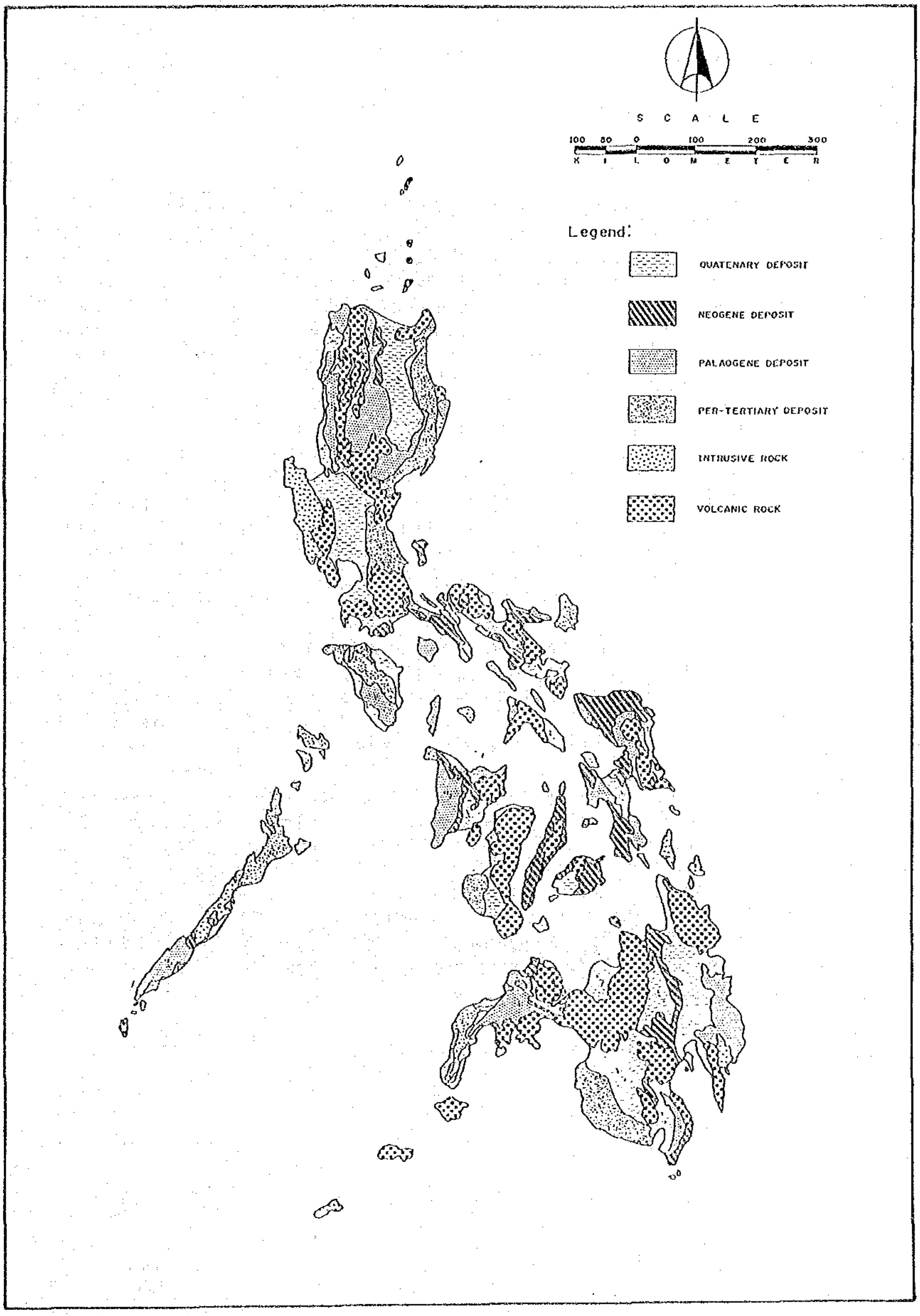


FIGURE 2.1-3 GEOLOGICAL FORMATION OF THE PHILIPPINES

2) Faults

Major coastal fractures in the Philippines are shown in Figure 2.1-4.

Transcurrent Fault

The Philippine Fault is the greatest transcurrent fault in the Philippines. It is traceable for about 1200 km. from Lingayen Gulf in the north, then along the southern border of Luzon Central Cordillera, Polillo Strait, Tayabas Isthmus, Masbate, Leyte, Agusan and into the Davao Gulf on the south. Recent study of the fault along the segment of the fault in the Tayabas Isthmus, Masbate and Northern Leyte indicated that the fault to be an oblique lateral fault with horizontal component of displacement being larger than the vertical component. Present movement of the fault is confirmed to be left lateral, displacing Neogene rocks in Northern Leyte for almsot 8 km. Activity in the fault appears to have been continuous since the Paleogene with apparently more intense activity in the past than at present.

Another major fault that is possible transcurrent is the Tablas Lineament. It is manifested by an almost linear physiographic feature traceable for about 350 km from the deep through west of Panay Island through the eastern edge of Tablas Island and then northward to Tayabas Isthmus, where it seems to merge with the Philippine Fault. It appears on-shore in northwest Panay where it is recognized as a great fault valley running meridionally from Nabas, Aklan on the north, to Pandan, Antique on the south.

Another major transcurrent fault is that across Ulugan Bay of Central Palawan. It trends almost N-S and is traceable for about 30 km across the whole width of Palawan Island. It apparently extends north and south following the abrupt physiographic break off-shore and marks the boundary between Carboniferous-Triassic terrain of northern Palawan and the ophiolitic terrain of southern Palawan.

There are probably many other major transcurrent faults that are not still recognized in the archipelago. Interpretation of Earth Resources Technology Satellites (ERTS) imagery reveal a number of major linear faults. One of them, the Bangui Fault in northwest Luzon, is undoubtedly a major transcurrent fault. It is almost parallel to the Luzon segment of the Philippine Fault and an interesting relation is observed between them. The Philippine Fault splits into several splices in the vicinity of Caraballo Mountains in Nueva Ecija. One splice, the Digdig Fault swerves northward and in flank of Luzon Central Cordillera. Both the Bangui and Philippine Faults die out after they intersect the Digdig Fault.

Normal Faults

Normal faults of varying magnitude are sporadically distributed throughout the archipelago. These faults are more easily observed in the field because they give rise to prominent fault scarpments. Although they do not appear to be structurally dominant as wrench and thrust faulting in the archipelago. Normal faults are commonly observed along flanks of major structural basins and actively rising mountain masses.

Among the more prominent ones in Luzon are the faults bounding the Laoag Plain in Ilocos Norte, the faults in the Cagayan Valley area, the well-known Marikina Fault. In the Bicol region, the most significant is a NW-trending fault in the central part of Camarines Sur.

The Mindoro Fault which runs across the northeastern side of the island of Mindanao is a normal fault which is observable from both topographics maps and aerial photographs.

Another fault of considerable extent is the Cotabato Fault along the eastern edge of Daguma Range in Cotabato.

Thrust Faults

Many thrust faults occur in the archipelago but most of them are minor. The more prominent ones are generally along the borders of the main Philippine arc and Sulu arc. Among the significant thrust faults are those along the western edges of Mindoro and Panay.

The thrust faults in the Bicol region are located in the northeastern parts of Camarines Norte, Camarines Sur and Catanduanes Island. In the Visayas, a number of thrust faults in the southwestern part of Samar islands.

In Mindanao, thrust faults of varying orientations are in Surigao del Sur, Central Mindanao, Davao Oriental and in some parts of Lanao and Cotabato and the Zamboanga area is a major thrusted zone.

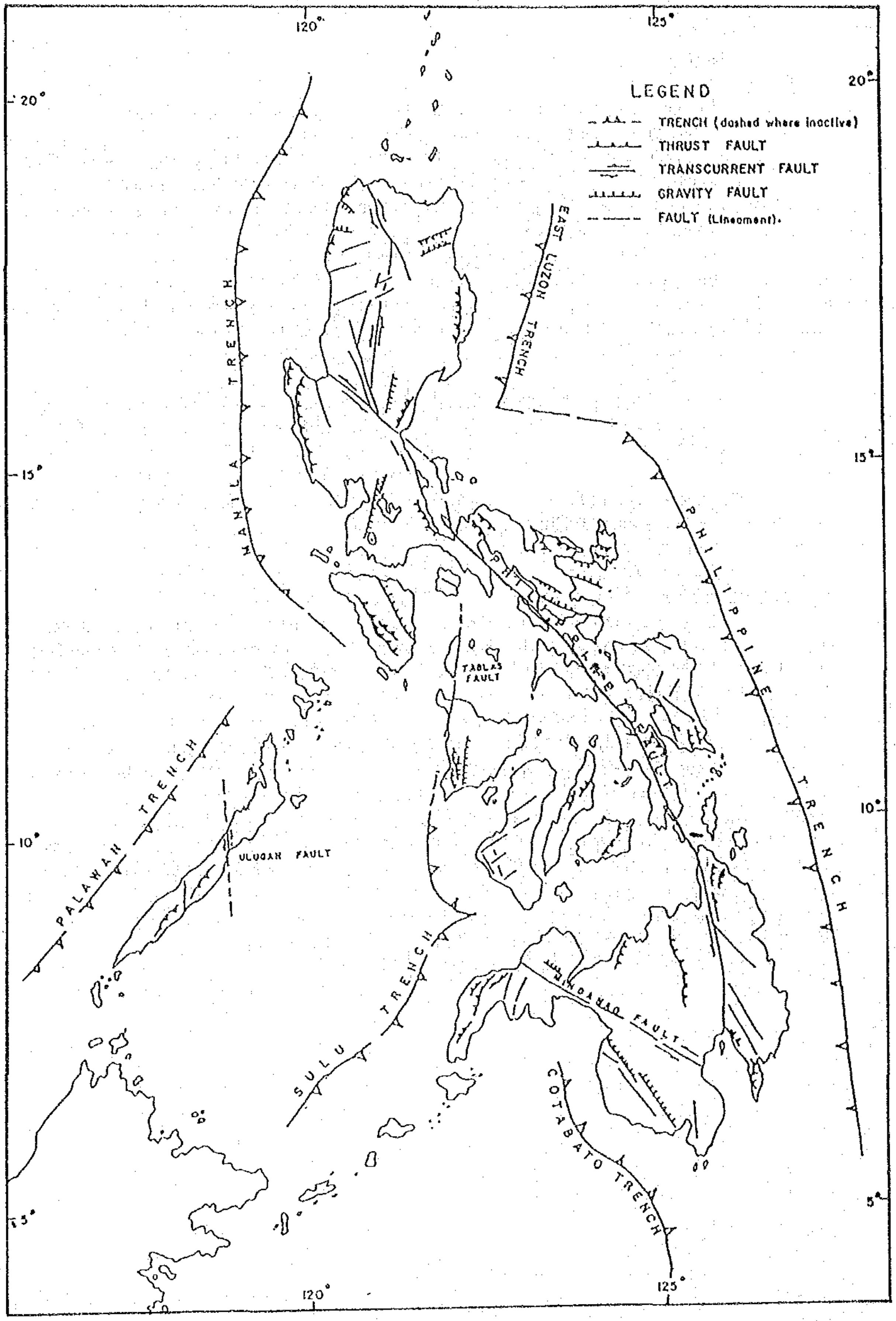


FIGURE 2.1-4 CYSTAL FRACTURES

Source: Geology and Resources of the Philippines

2.1.3 Meteorology

1) Rainfall

Table 2.1-5 shows the mean monthly and annual rainfall recorded by 59 PAGASA weather stations in the past 35 years from 1951 till 1985. Based thereon, the isohyet map is prepared as shown in Figure 2.1-5 for annual rainfall.

Annual Rainfall

The average annual rainfall in the Philippines is 2,405 mm. Luzon has an average of 2,572 mm, Visayas has 2,235 mm, and Mindanao has 2,090 mm.

The average annual rainfall varies from less than 1,000 mm to more than 5,000 mm.

Itbayat of Batanes Island, northermost of the Philippine Islands has the highest annual value of 5,237 mm, followed by Hinatuan along the coast of Surigao del Sur of Mindanao with a value of 4,328 mm.

General Santos, situated in a valley in southern Mindanao, has the lowest annual value of 955 mm followed by Zamboanga City with 1,212 mm.

Monthly Rainfall

Monthly rainfall distribution is quite different between eastern and western costs of the archipelago as follows:

- Two pronounced seasons; dry from November to April and wet during the rest of the year along western coasts.
- No dry season with a pronounced maximum rainfall from November to January along the eastern coasts.

They are affected strongly by the seasonal monsoons and tropical cyclones. See Figure 2.1-6.

2) Climate Type

The climate of the Philippines is classified into four (4) types by PAGASA following Modified Corona's Classification System (Figure 2.1-7).

Type I : Two pronounced seasons, dry in winter and spring, wet in summer and autumn. Maximum rain period is from June to September during the prevalence of the southwest monsoon. The dry season lasts from three to six or seven months.

Type II : No dry season with a very pronounced maximum rain period in winter. The maximum monthly rainfall generally occur in December and January. There is no single dry month. The minimum monthly rainfall occurs, in some places, in spring and in other places, in summer.

Type III : No very pronounced maximum rain period, with a short dry season lasting only from one to three months. This type is intermediate between the preceding two although it resembles the first type more closely since it has a short dry season. The short dry season is either in winter or spring.

Type IV : Rainfall is more or less evenly distributed throughout the year. This, also, is an intermediate between the first and second types, but it resembles the second more closely since it has no dry season.

TABLE 2.1-5 (1) MEAN MONTHLY AND ANNUAL RAINFALL

WEATHER STATION	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL RAINFALL	MONTHLY HIGHEST
Region: NCR														
1. NAIA (MIA)	12.3	3.6	13.4	15.9	109.4	253.6	332.6	417.0	308.7	180.3	116.7	54.1	1,817.6	417.0
2. Port Area	13.5	7.3	21.4	18.7	138.6	283.8	364.1	476.3	334.1	200.5	111.4	56.0	2,025.7	476.3
3. Science Garden	17.2	9.7	22.1	28.3	172.7	339.6	448.1	504.8	381.8	234.0	144.0	53.8	2,356.1	504.8
Region: CAR														
4. Baguio	12.1	35.8	55.9	102.9	331.1	480.6	670.8	847.9	582.3	262.4	152.3	28.8	3,562.9	847.9
Region: I														
5. Dagapan	6.2	6.2	17.6	73.2	216.1	346.6	462.1	608.4	324.8	158.5	63.1	13.8	2,296.6	608.4
6. Laoag	11.8	1.1	2.5	19.8	125.1	376.8	386.4	547.3	324.1	86.1	45.1	10.2	1,936.3	547.3
7. Vigan	2.3	3.3	5.0	17.4	145.9	404.3	483.3	738.9	355.7	112.5	35.1	9.1	2,312.8	738.9
Region II														
8. Aparri	141.1	76.0	45.6	35.4	100.6	184.1	183.2	225.5	274.7	343.0	396.0	208.7	2,213.9	396.0
9. Basco	183.9	126.1	102.6	83.1	138.4	278.3	259.2	43.0	370.1	330.1	317.1	259.9	2,491.8	370.1
10. Calayan	188.6	109.7	72.3	46.2	107.0	196.1	242.5	323.0	330.0	349.0	394.3	317.7	2,676.4	394.3
11. Itbayat	240.6	135.1	111.1	82.9	297.3	785.7	669.5	935.0	482.1	722.2	464.4	311.1	5,237.0	935.0
12. Tuguegarao	21.4	16.5	57.2	73.6	172.1	161.6	192.8	246.5	209.1	252.9	274.2	93.9	1,771.8	274.2
Region III														
13. Cabanatuan	7.5	4.9	16.4	19.7	150.1	267.6	340.8	395.8	305.2	190.8	134.8	39.9	1,873.5	395.8
14. Iba Zambales	3.0	2.7	12.1	28.8	280.7	579.0	763.1	1,105.9	615.8	203.9	80.9	25.6	3,701.5	1,105.9
15. Munoz	9.4	1.7	8.5	55.4	88.9	385.3	299.6	446.2	258.7	16.7	90.6	15.6	1,849.6	466.2
Region IV-A														
16. Alabat	250.8	133.5	99.3	81.5	109.5	200.2	226.4	174.9	253.4	510.1	530.9	571.4	3,141.9	571.4
17. Ambulog	22.1	9.9	16.3	37.4	105.3	237.5	289.9	323.7	259.7	234.1	156.6	97.6	1,790.1	323.7
18. Baler	193.1	150.8	213.1	232.4	301.4	272.3	240.5	218.6	300.6	416.0	444.4	327.9	3,311.1	444.4
19. Casiguran	217.2	157.5	192.8	138.9	236.6	237.9	261.2	238.2	296.9	412.3	601.7	437.2	3,427.4	601.7
20. Infanta	353.8	220.1	187.3	179.7	225.2	249.4	258.7	196.4	325.2	607.8	597.4	597.2	3,998.2	607.8
21. Lucena City	89.3	60.3	42.5	54.6	90.0	160.3	184.6	198.0	225.5	336.2	305.3	235.2	1,982.7	336.2
22. San Francisco	49.3	17.9	27.1	25.1	88.9	162.7	222.2	187.5	179.2	220.2	173.9	126.4	1,480.4	222.2
23. Sangley Pt.	25.3	2.1	7.4	13.6	102.2	259.3	259.5	460.5	243.8	185.6	91.7	32.8	1,683.8	460.5
24. Tayabas	155.1	72.3	72.3	103.2	227.5	257.9	260.6	172.6	316.1	512.7	519.9	413.7	3,083.9	519.9

TABLE 2.1-5 (2) MEAN MONTHLY AND ANNUAL RAINFALL

WEATHER STATION	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL RAINFALL	MONTHLY HIGHEST
Region: IV-B														
25. Calapan	91.4	54.8	52.7	90.2	159.2	200.9	183.4	199.5	189.9	298.3	237.5	172.4	1,930.4	298.3
26. Coron	25.7	8.0	5.7	30.4	184.4	378.6	480.1	551.4	436.6	288.9	135.2	82.1	2,607.1	551.4
27. Cuyo	13.2	2.5	8.2	44.1	187.3	376.2	437.7	409.7	375.0	272.1	148.2	55.1	2,329.3	437.7
28. Puerto Princesa	30.7	16.7	37.2	42.2	142.4	184.2	177.6	183.6	196.4	210.0	205.2	137.4	1,563.8	210.0
29. Romblon	114.4	48.3	48.3	71.4	125.4	205.7	249.5	227.9	252.4	323.1	234.3	204.6	2,105.3	323.1
30. San Jose	3.1	2.3	18.7	140.5	88.9	343.4	433.1	559.3	391.8	245.2	55.4	8.7	2,290.4	559.3
Region: V														
31. Daet	312.0	175.0	153.9	126.1	139.1	173.9	235.7	222.3	267.6	518.6	590.2	591.9	3,506.3	591.9
32. Legaspi	296.9	195.6	192.6	152.1	181.3	240.9	251.3	264.2	259.9	325.5	483.7	456.0	3,300.0	483.7
33. Masbate	163.2	80.3	65.5	54.9	134.0	153.4	191.2	180.3	218.8	212.8	232.7	257.1	1,949.2	257.1
34. Virac Radar	360.5	209.1	160.5	175.2	184.8	225.9	245.7	164.2	273.9	377.3	549.5	544.1	3,470.7	549.5
35. Virac	219.9	132.2	119.2	128.6	185.6	225.2	223.8	174.1	248.8	373.9	486.4	412.5	2,930.2	486.4
Luzon Average:													2,571.6	
Region: VI														
36. Iloilo City	42.8	25.3	34.3	52.4	115.1	271.6	300.8	348.0	276.4	251.1	179.7	96.9	1,994.4	348.0
37. Roxas City	115.9	50.4	56.7	57.7	146.2	253.0	246.9	232.6	240.4	321.6	225.0	172.4	2,118.8	321.6
Region: VII														
38. Cebu City	106.5	67.6	54.4	50.4	107.6	183.5	206.5	184.4	196.7	195.5	157.8	127.3	1,638.2	206.5
39. Dumaguete City	80.8	54.3	54.3	49.5	75.6	134.3	139.6	123.5	137.4	183.1	162.8	113.7	1,308.9	183.1
40. Mactan Airport	96.5	78.6	46.8	34.3	68.4	181.9	187.3	164.9	189.1	137.6	150.9	145.6	1,481.9	189.1
41. Tagbilaran city	105.0	78.5	71.8	57.8	80.3	131.0	134.8	107.8	136.0	212.8	190.5	117.2	1,423.5	212.8
Region: VIII														
42. Borongan	625.3	414.1	306.9	256.1	296.9	232.0	198.8	182.0	204.5	312.7	555.4	663.3	4,248.0	663.3
43. Catarman	417.4	250.8	215.2	146.7	149.8	179.3	208.8	157.8	212.0	372.5	525.8	493.0	3,329.1	525.8
44. Catbalogan	225.3	144.8	129.8	102.6	170.1	200.0	243.7	224.9	263.0	301.5	321.4	309.6	2,636.7	321.4
45. Guiuan	255.7	284.7	152.9	161.6	121.3	278.4	185.5	133.1	212.3	180.3	321.5	368.5	2,655.8	368.5
46. Maasin	186.5	145.4	109.9	60.3	64.9	108.5	170.3	161.5	163.8	202.4	168.2	230.7	1,772.4	230.7
47. Tacloban City	261.8	205.2	137.6	121.2	146.1	154.7	167.0	129.1	146.8	184.4	244.8	316.9	2,115.6	316.9
Visayas Average:													2,235.3	

TABLE 2.1-5 (3) MEAN MONTHLY AND ANNUAL RAINFALL

WEATHER STATION	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL RAINFALL	MONTHLY HIGHEST
Region: IX														
48. Cagayan de Sulu	194.4	118.1	23.3	50.1	103.7	215.9	267.6	192.2	242.8	300.2	305.1	272.8	2,286.2	305.1
49. Dipolog	158.8	72.2	75.7	97.9	185.0	254.1	239.8	225.8	234.1	297.2	356.1	280.8	2,477.5	356.1
50. Jolo	104.1	94.5	85.8	145.1	226.4	242.4	187.1	161.6	194.1	264.1	194.7	150.1	2,050.0	264.1
51. Zamboanga City	43.9	44.2	37.7	51.0	94.8	142.3	135.1	128.5	145.1	192.4	108.7	88.1	1,211.8	192.4
Region: X														
52. Butuan City	435.9	205.4	100.1	63.4	124.6	124.4	161.2	73.3	182.1	181.1	158.7	223.5	2,033.7	435.9
53. Cagayan de Oro	107.4	64.7	56.7	38.4	102.7	198.8	214.0	199.1	216.7	178.2	125.0	116.3	1,618.0	214.0
54. Lumbia Airport	93.7	62.4	29.8	24.6	98.5	209.0	230.5	221.4	181.2	206.9	91.0	100.0	1,549.0	230.5
55. Malaybalay	124.5	95.9	103.2	104.4	222.5	307.1	315.9	300.3	327.0	299.4	187.3	149.8	2,537.3	327.0
Region: XI														
56. Davao City	114.7	99.0	77.9	144.9	206.7	190.1	175.9	173.2	180.1	174.8	145.7	109.7	1,792.7	206.7
57. General Santos	64.1	73.2	39.5	50.5	87.5	112.5	104.3	87.2	80.6	94.4	87.0	74.1	954.9	112.5
58. Hinatuan	730.3	523.1	434.8	320.5	275.3	257.6	214.4	190.1	213.3	232.5	350.1	586.4	4,328.4	730.3
Region: XII														
59. Cotabato City	71.3	90.9	95.3	131.8	257.2	251.4	248.9	323.3	238.3	253.6	176.7	98.7	2,237.8	323.7
Mindanao Average:													2,089.8	
Total Average :													2,405.1	

Source: PAGASA (1951-1985)

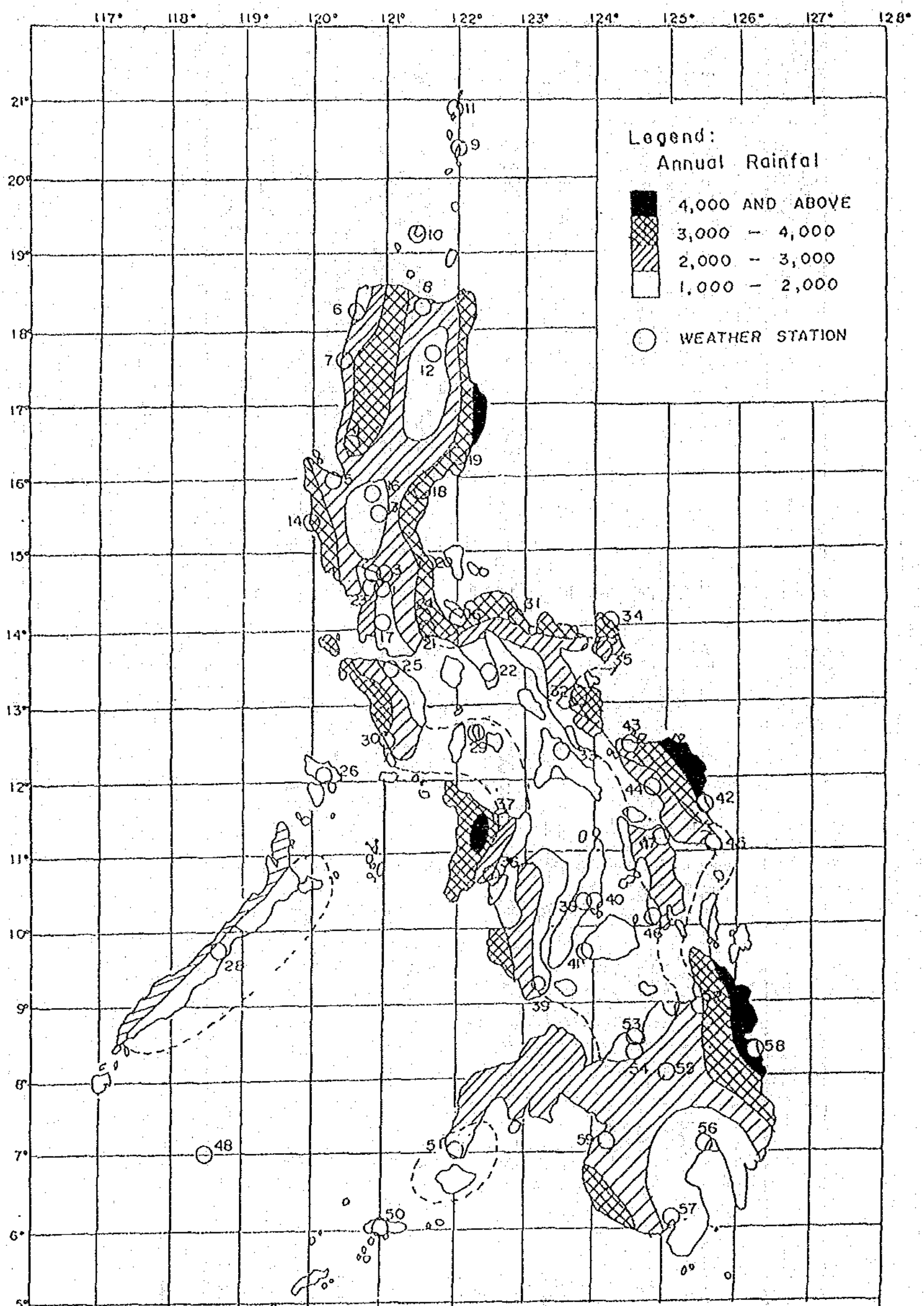


FIGURE 2.1-5 ISOHYET MAP

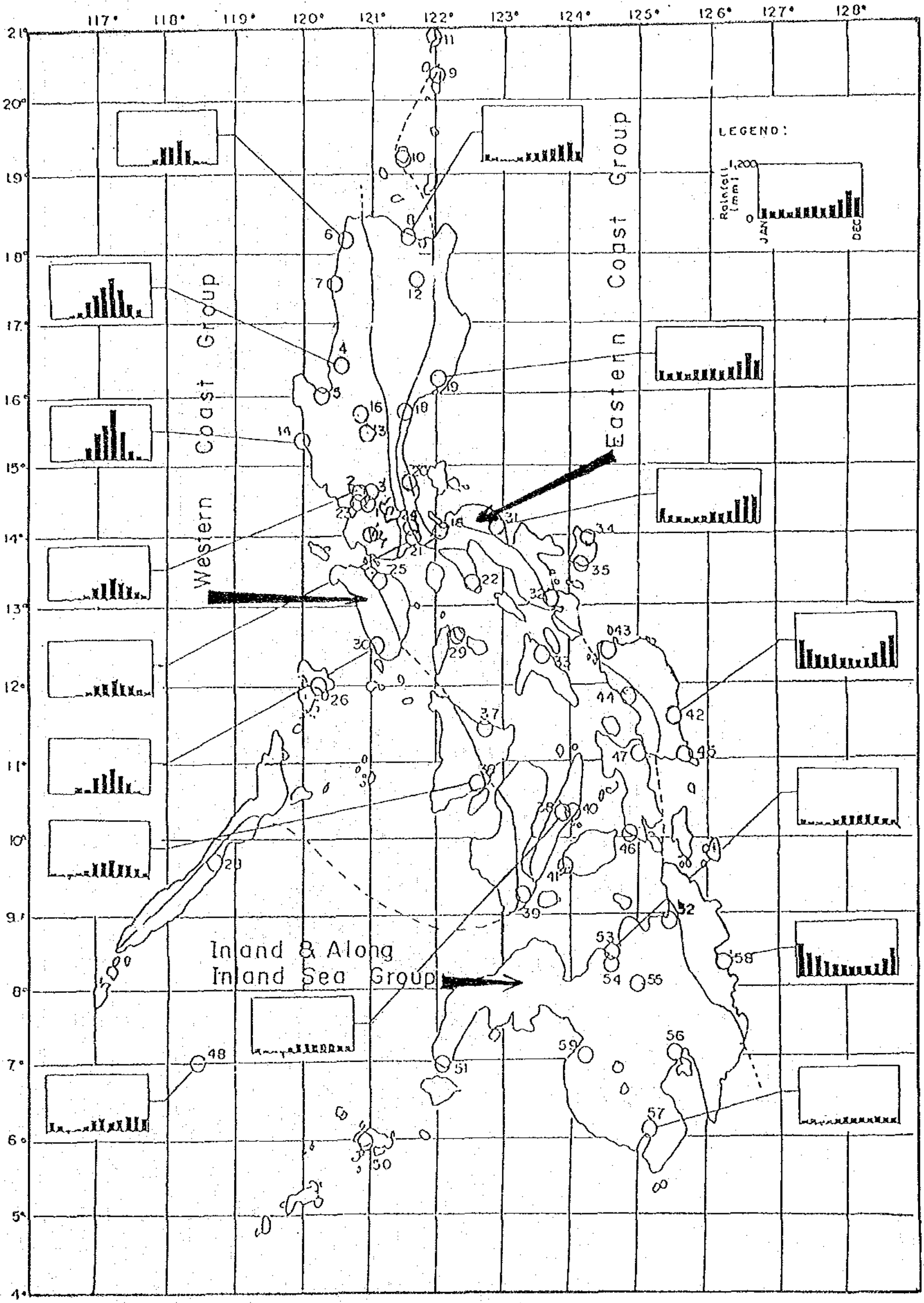


FIGURE 2.1-6 MONTHLY RAINFALL DISTRIBUTION

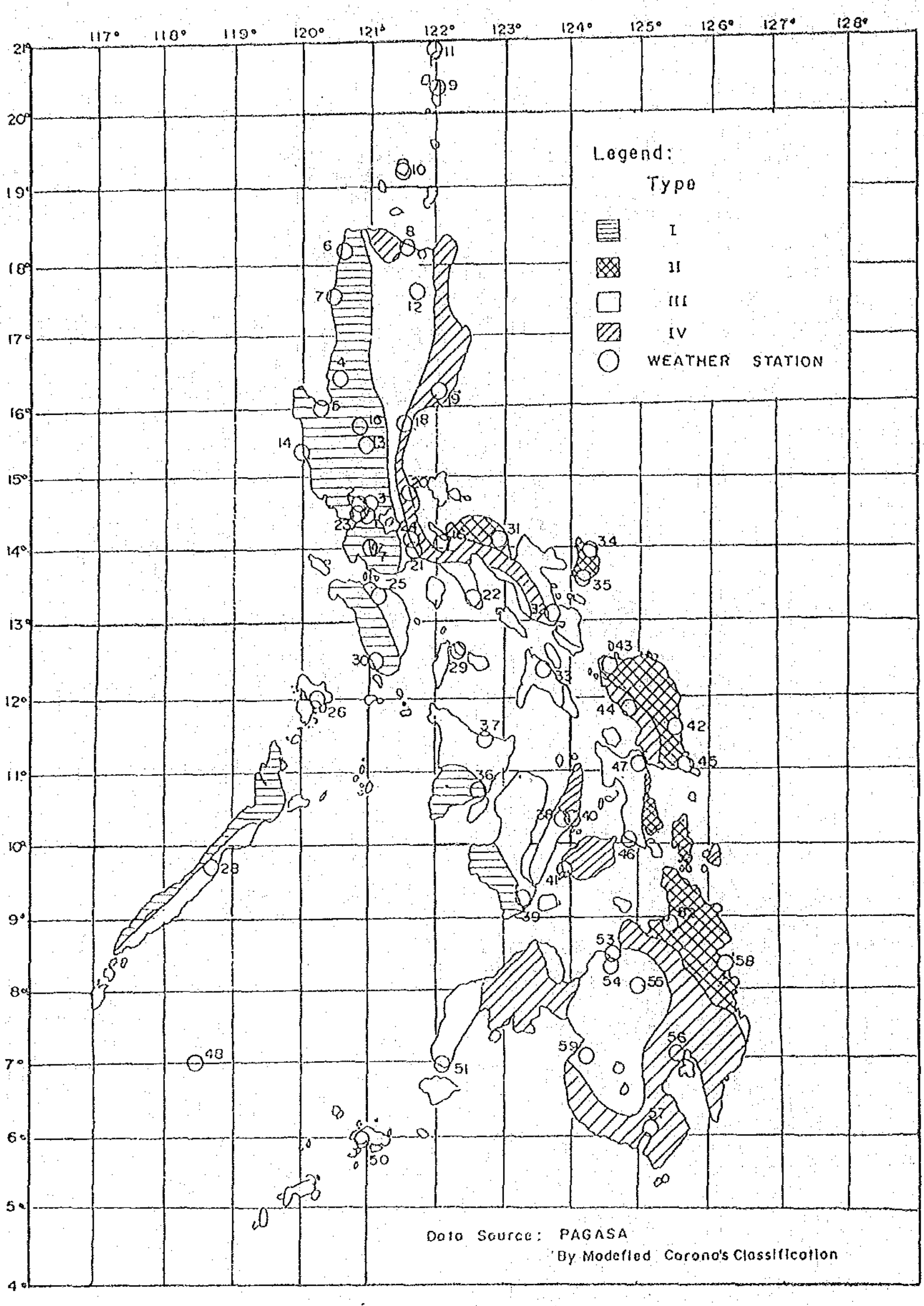


FIGURE 2.1-7 CLIMATE TYPE

2.2 NATURAL CALAMITIES

2.2.1 Volcanoes

The Philippines has 220 Quaternary volcanoes, 22 of which are considered active having erupted during historic times or within the last 600 years. Table 2.2-1 shows the volcanoes which have erupted in the 20th century.

Volcanic centers are divided into the following belts: Sta. Ana, Luzon Central Cordillera, Central Luzon, Bicol, Negros, Sulu, Lanao volcanic area, Mindanao Central Cordillera, Cotabato and Cuyo (Figure 2.2-1).

TABLE 2.2-1 VOLCANOES HAVING ERUPTED IN THE 20TH CENTURY

Name	Height (m)	Province/Island	Eruption
Mayon	2,462	Albay/Luzon	1988,1985,1984,1978 1977,1968,1947,1943 1941,1940,1938,1928 1902,1900,1893,1928 1971,1890,1989,1888 1987,1885,1882,1876 1873,1872,1862,1860 1859,1858,1845,1835 1828,1800,1776,1616
Taal	400	Batangas/Luzon	1977,1976,1990,1969 1968,1967,1966,1965 1911,1904,1878,1842 1825,1808,1754,1749 1716,1717,1709,1701 1591,1572
Canloan	2,465	Negros Occ. and Or./Negros	1988,1987,1986,1985 1980,1978,1969,1933 1927,1905,1904,1902 1893
Bulusan	1,559	Sorsogon/Luzon	1985,1984,1983,1981 1980,1979,1933,1928 1921,1919,1918,1894 1886,1852
Hibok-Hibok	1,332	Camiguin/Mindanao	1952,1951,1902,1871 1862,1852,1848,1827
Ragang	2,815	Lanao and Cotabato /Mindanao	1916,1873,1871,1858 1856,1840,1834,1756
Didicas	244	Batanes/Babuyan Island	1978,1969,1900,1860 1857,1773
Smith	688	Batanes/Babuyan Island	1924,1919,1917,1907 1652,1651
Pinatubo	1,780	Pampanga/Zambales and Tarlac/Luzon	1991
Cagua	1,158	Cagayan/Luzon	1907

Source: Philippine Almanac, 1990

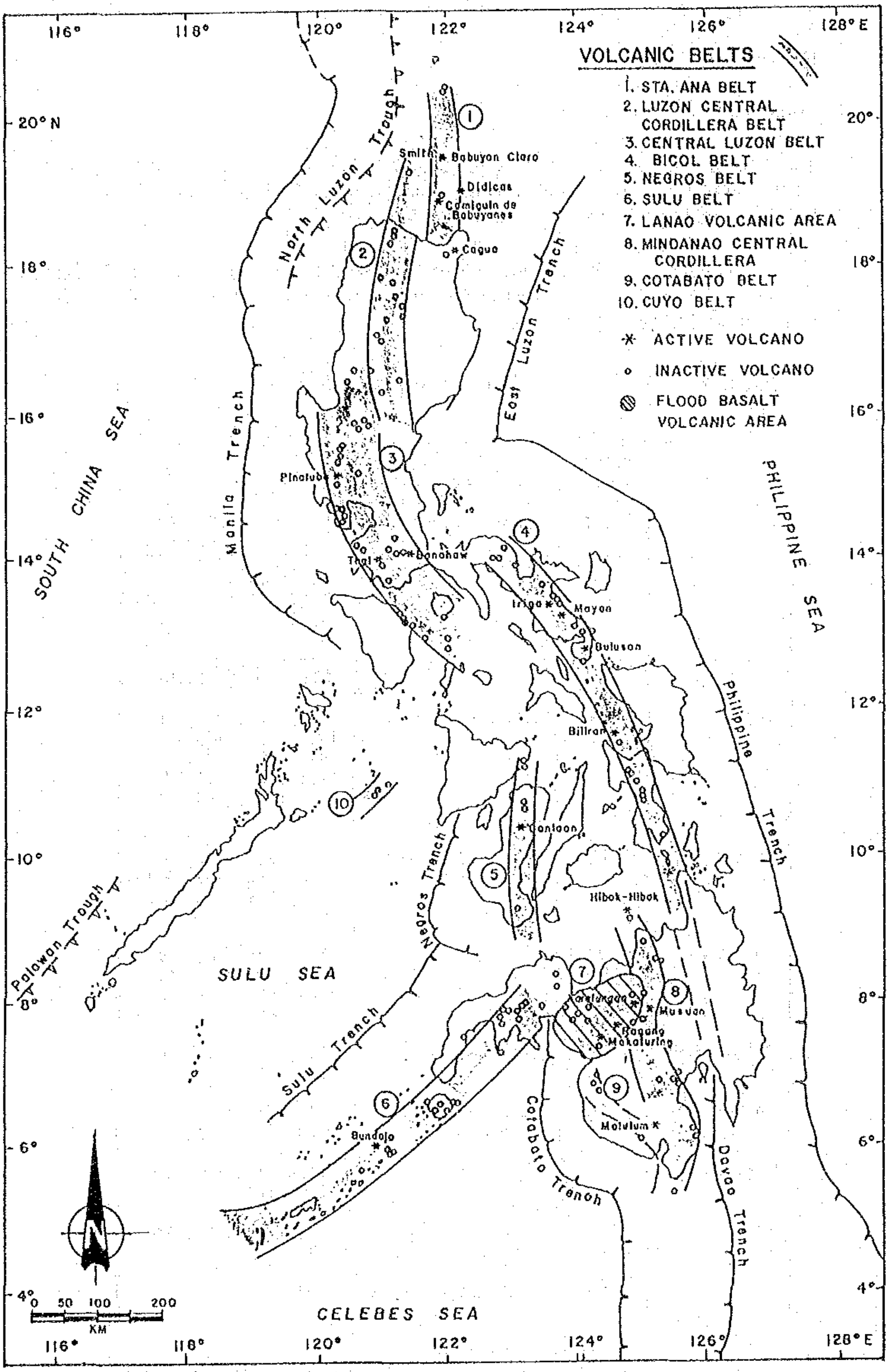


FIGURE 2.2-1 LOCATION OF VOLCANOES

Source: PAGASA Geologic Hazards and Disaster Preparedness, 1987
Note : Volcanic Belts Supplemented From "Geology and Mineral Resources", 1981

2.2.2 Earthquake

The Philippines, being situated within a Pan-Pacific Seismic Belt Zone have been very frequently shaken by an earthquake of various intensities.

According to the Philippine Institute of Volcanology and Seismology, 40 destructive earthquakes were experienced during 1599-1988 (Figure 2.2-2).

The earthquake hazard in the Philippines was analyzed by the Earthquake Hazard Mitigation Programme in Southeast Asia held in April 1986. The average return period for experiencing a site intensity of VII MM, population at risk, area and maximum observed intensity for each region are listed in Table 2.2-2 and illustrated in Figure 2.2-3.

TABLE 2.2-2 FREQUENCY OF EARTHQUAKE OCCURRENCE BY REGION

Region	Observation Period	Average Return Period (Years)	Population at Risk (x 10^6)	Area (10^3 KM^2)	Maximum MM Intensity (1589-1983)
I	1865-1983	1.2	3.903	21.6	X-XI
II	1850-1979	2.5	2.520	36.5	X
III	1850-1979	2.2	5.456	18.2	IX
IV	1850-1979	1.8	6.330	11.9	X
V	1860-1979	1.7	3.922	17.7	X
VI	1880-1979	4.4	5.092	20.2	X
VI	1860-1979	9.0	4.195	14.9	IX-X
VIII	1870-1979	1.9	3.073	21.5	IX
IX	1880-1979	3.0	2.863	18.7	X
X	1860-1979	1.4	3.179	28.4	X
XI	1860-1979	1.7	3.836	31.7	X
XII	1820-1976	3.0	2.598	23.2	X
NCR	1820-1976	4.6	6.942	0.636	X

Source: Earthquake Hazard Mitigation Programme in Southeast Asia

2.2.3 Tsunami

Tsunamis are giant sea waves generated by under-the-sea earthquakes and volcanic eruptions. Tsunamis in the Philippines had been recorded on several occasions affecting various coastal areas of the archipelago and their source regions ranging from as far as Alaska to Krakatau in Indonesia. Local earthquake events are also known to generate from the bottom of Celebes Sea (Figure 2.2-4).

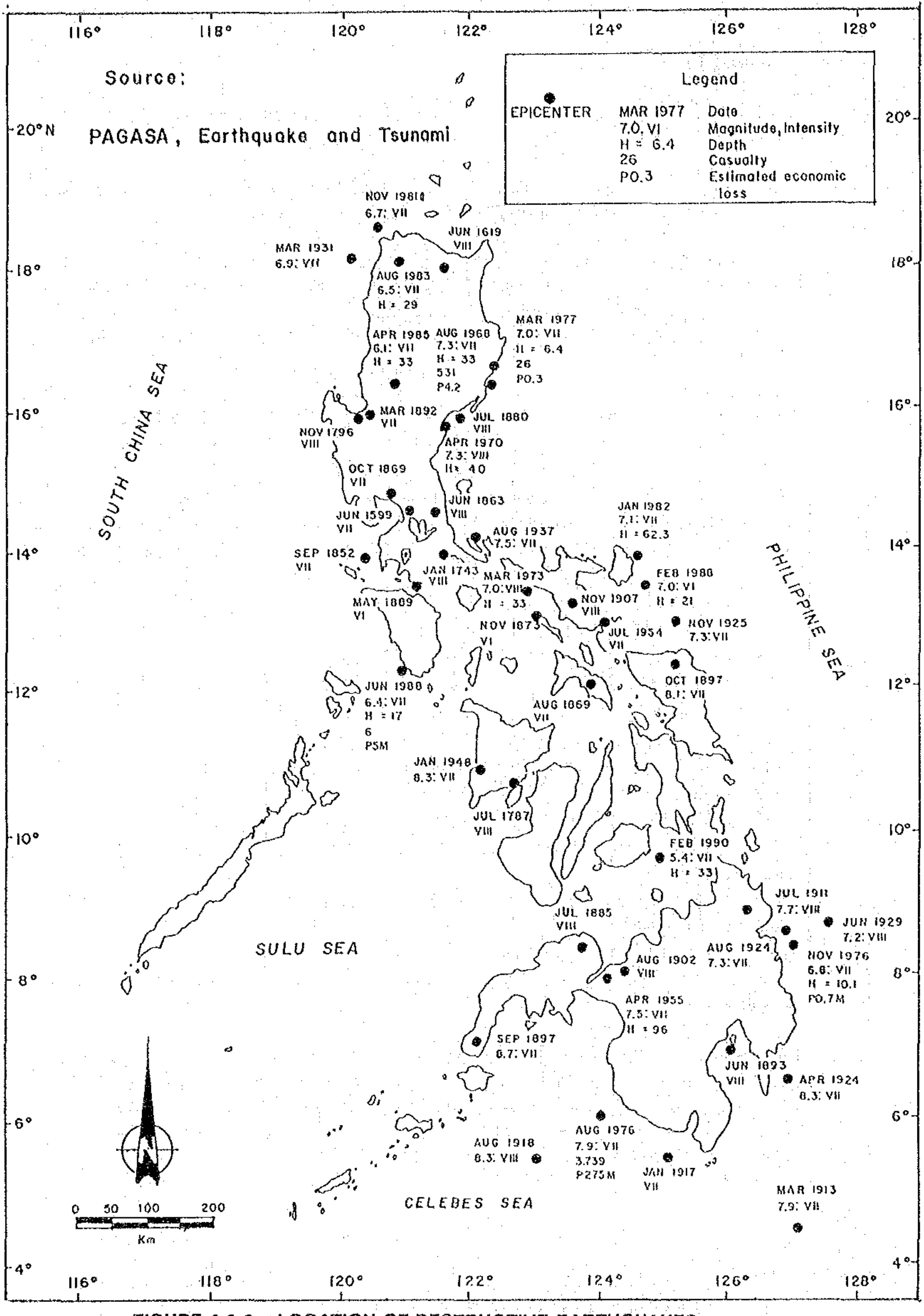


FIGURE 2.2-2 LOCATION OF DESTRUCTIVE EARTHQUAKES (1599-1988) (m>6.0 AND/OR INTENSITY>VI)

Source: NEDA, Reconstruction and Development Program, November 1990

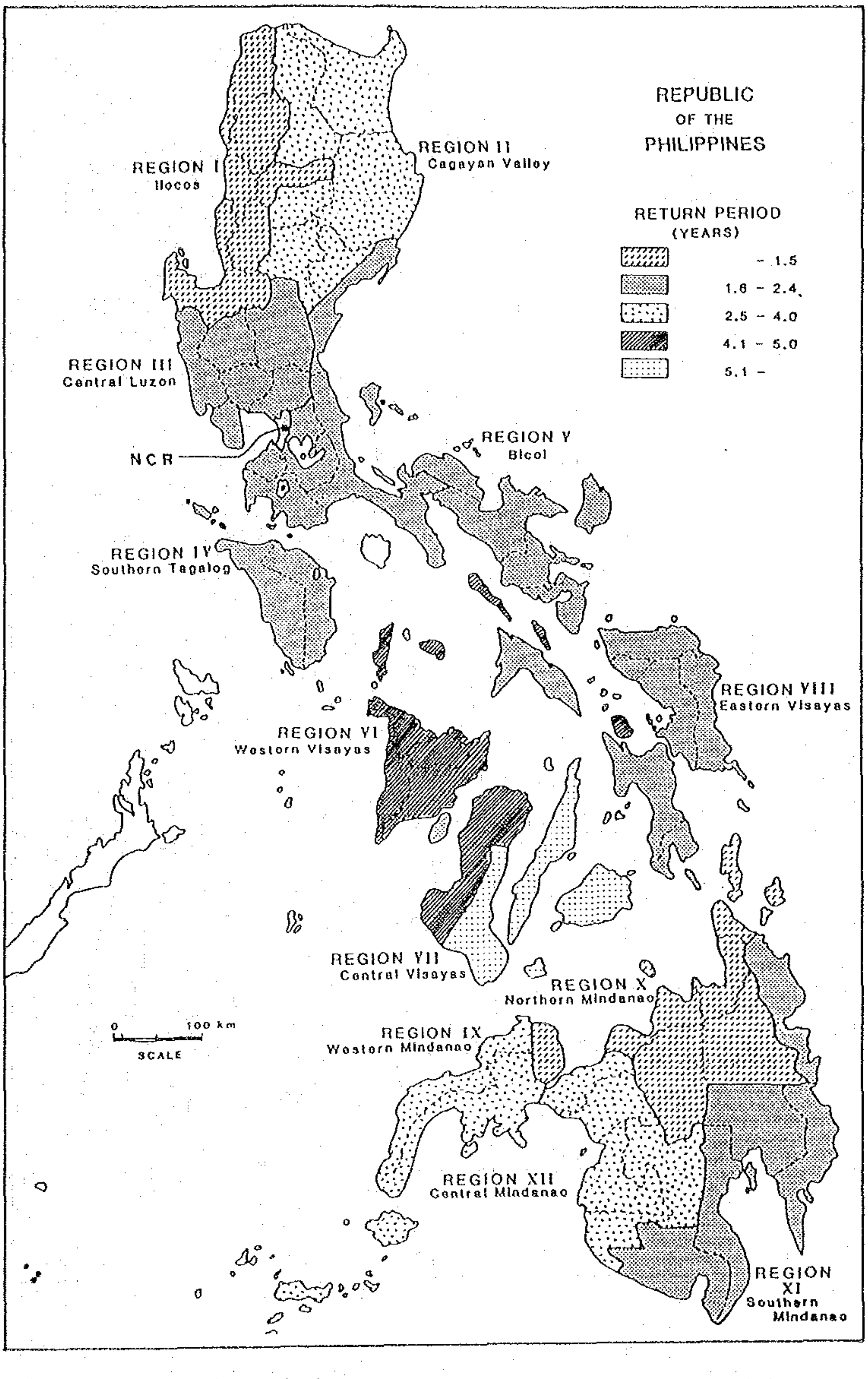


FIGURE 2.2-3 FREQUENCY OF EARTHQUAKE OCCURRENCE BY REGION (SITE INTENSITY VIII AND ABOVE)

Source: Southeast Asia and Assoiciation of Seismology and Earthquake Engineering: Series of Seismology Vol. I, Earthquake Hazard Mitigation Programme in Southeast Asia, April 1986

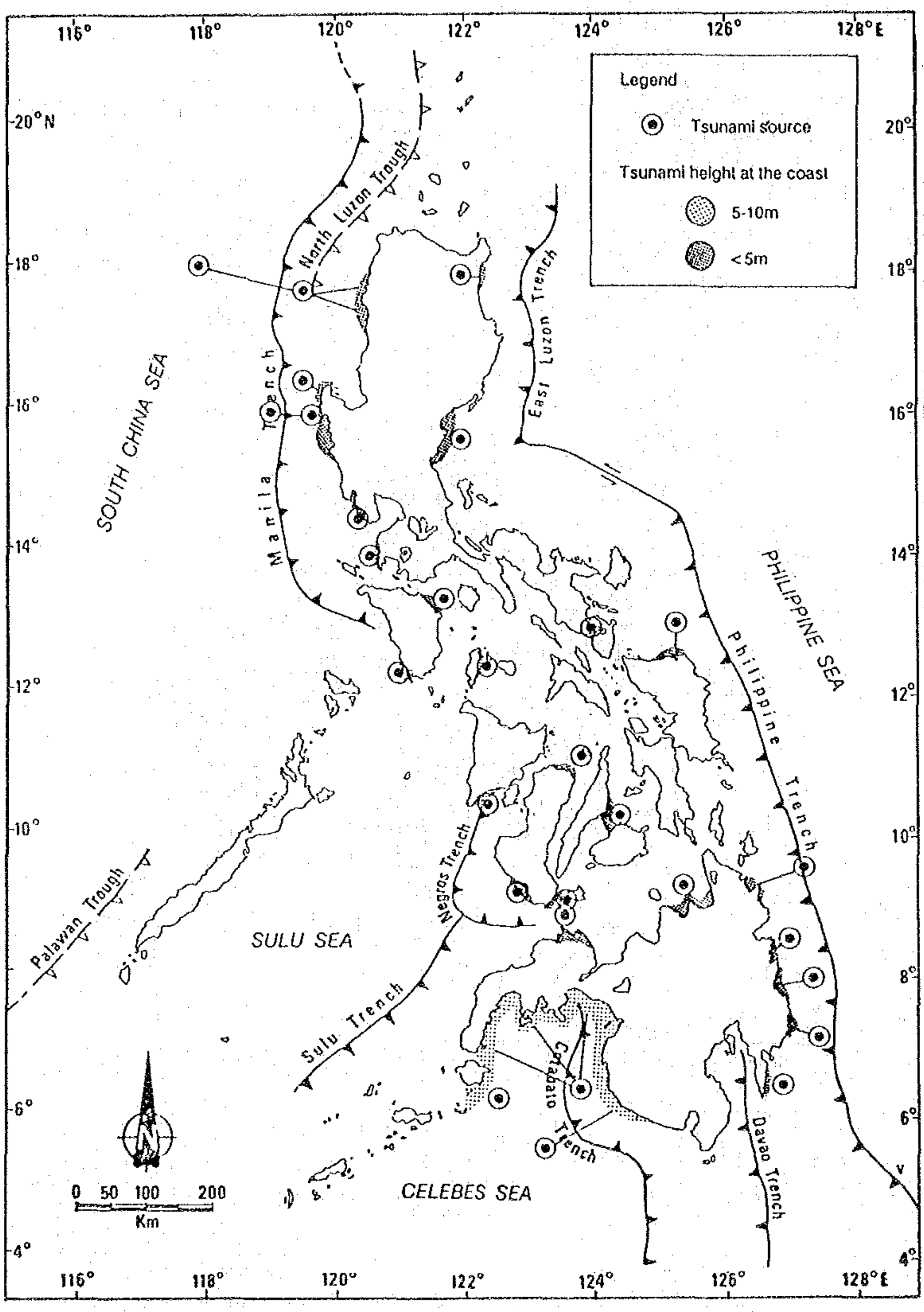


FIGURE 2.2-4 PAST TSUNAMI AREA

Source: PAGASA, Earthquake and Tsunami

2.2.4 Tropical Cyclones

A tropical cyclone is characterized by a low pressure center and cloud band spiralling inward in counterclockwise direction from all sides in the northern hemisphere. Intense tropical cyclones are the most impressive phenomena of the tropical regions. The Philippines is prone to such natural disaster agents as tropical cyclones and the accompanying destructive winds, floods and storm surgess.

The tropical cyclone season in the Philippines is from June to December, with an average monthly frequency of more than one tropical cyclone. The period of the rest months, however, is not free from tropical cyclones.

A total of 690 tropical cyclones of all intensities during 35- year period or an average of 19.7 cyclones per year crossed the Philippine Area of Responsibility (PAR). See Table 2.2-3.

By PAGASA, 5-year average frequency of passage of tropical cyclone's center for the period from 1884 to 1975 (91 years) is presented as in Figure 2.2-5. An average of 22 tropical cyclones form annually in the northwest Pacific Ocean, about 19 of which enter the Philippine Area of Responsibility (PAR) and about 9 of them cross the country per year.

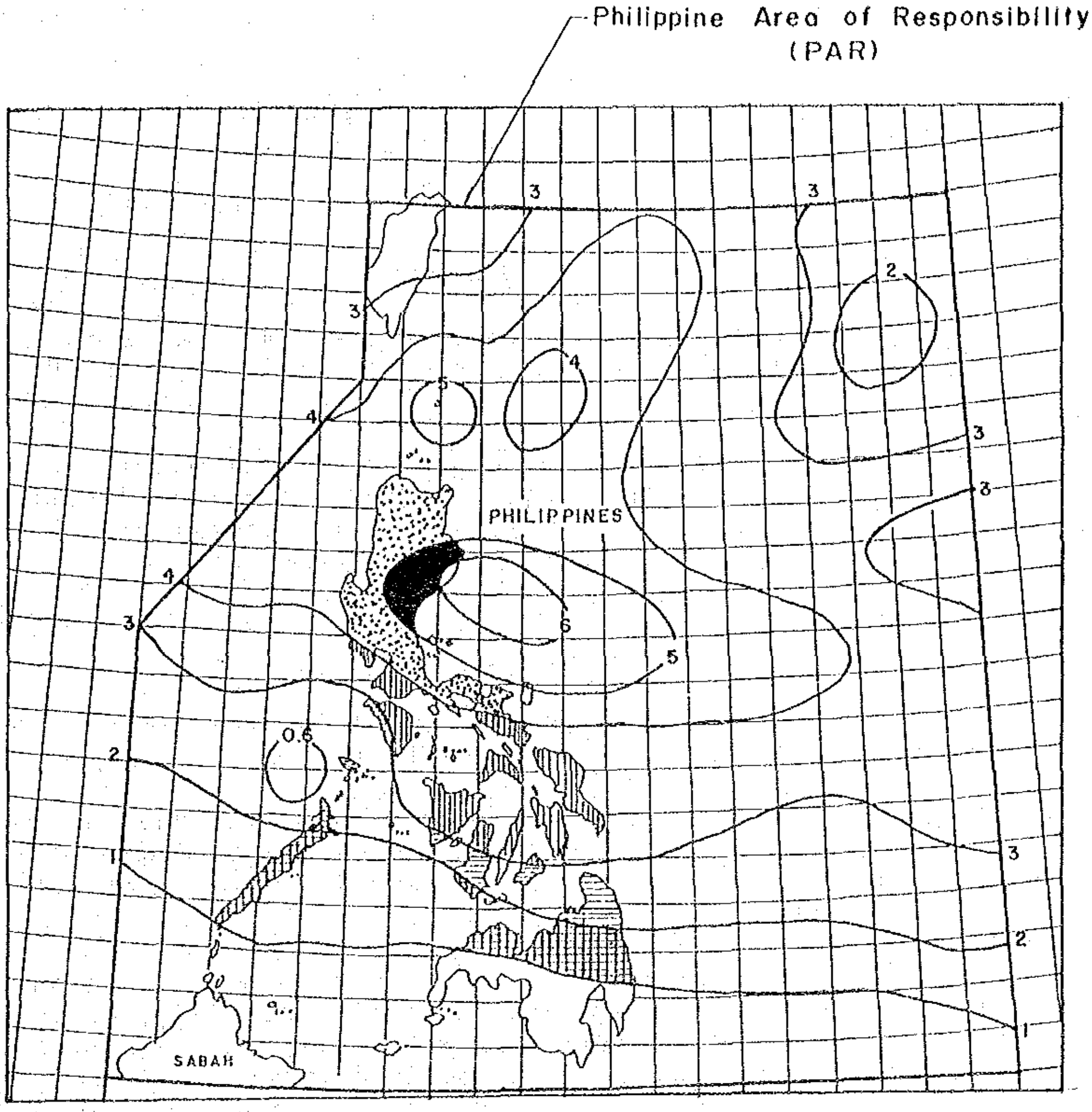
A great part of damage by natural calamities are caused by typhoons and floods, because they are annual occurrence in the Philippines and affect wide area.

TABLE 2.2-3 TROPICAL CYCLONES ENTERING THE PAR

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
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	2	16
1964	0	0	0	0	2	1	9	5	5	3	3	1	29
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	3	2	2	21
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	83	77	49	690
Average	0.5	0.3	0.3	0.5	0.8	1.6	3.3	3.3	3.1	2.4	2.2	1.4	19.7

Note : Area of Responsibility during the 35-year period (1948-1982)

Source: PAGASA



LEGEND:

(solid black)	5 ~ 6
(dotted)	4 ~ 5
(vertical hatching)	3 ~ 4
(horizontal hatching)	2 ~ 3
(cross hatching)	1 ~ 2

FIGURE 2.2-5 5-YEAR AVERAGE FREQUENCY OF TROPICAL CYCLONE PASSAGE

Source: PAGASA, 1987

2.3 ROAD NETWORK

The public road network system in the Philippines consists of:

- National Roads
- Provincial Roads
- City Roads
- Municipal Roads
- Barangay Roads

National Roads are all roads that form part of the main trunkline system continuous in extent; all roads leading to national airports, national seaports, national parks or coast-to-coast roads.

Provincial Roads are those roads connecting one municipality with another, the termini to be public plazas; all roads extending from a municipality or from a provincial or national road to a public wharf or railway station; and any other road to be designated as such by the Sangguniang Panlalawigan.

City Roads are those roads/streets within the urban area of the city to be designated as such by the Sangguniang Panglungsod.

Municipal Roads are those roads/streets within the poblacion area of a municipality to be designated as such by the Sangguniang Bayan.

Barangay Roads are rural roads located either outside the urban area of a city or outside industrial, commercial or residential subdivisions which act as feeder or farm-to-market roads, and which are not otherwise classified as national, provincial, city or municipal roads.

Responsibility for planning, construction and maintenance of national roads and barangay roads is with the Department of Public Works and Highways (DPWH). The provincial, city and municipal government units, all under the general supervision of the Department of Interior and Local Government (DILG), are responsible for provincial, city and municipal roads in their areas, through the Provincial, City and Municipal Engineer's Offices, respectively.

As of 1987, the Philippines has a road network of some 157,800 km, consisting of 26,100 km of national, 28,900 km of provincial, 4,000 km of city, 12,900 km of municipal and 85,900 km of barangay roads.

Table 2.3-1 shows the road length and road density by province, wherein two kinds of the road density are defined as follows:

1) Road Density = $L/\sqrt{AP}$

where, L = road length, in km
A = land area, in km^2
P = population, in 1,000

2) Road Density = $L'/\sqrt{AP}$

where, L'	=	fair condition road length
	=	$\alpha \cdot L_{pcc} + \beta \cdot L_{AC} + \Gamma \cdot L_{GR} + \delta \cdot L_{ET}$
L_{pcc}, L_{AC}, L_{GR}, L_{ET}	=	length of PCC, AC, gravel and earth roads, respectively, in km.
α, β, Γ, δ	=	ratio of road length in acceptable condition of each type of of road (assumed as $\alpha = 1.0$, $\beta = 0.6$, $\Gamma = 0.15$ for barangay roads and 0.30 for other roads, and $\delta = 0$)

TABLE 2.3-1 ROAD DENSITY (1/2)

	Land Area (km2) A	1987 Population P	1987 Road Length (km) National	Provinc'l	City	Municipal	Barangay	Total L	Road Density $L/\sqrt{AP/1000}$	Road Density $L'/\sqrt{AP/1000}$
All Philippines	300,000.2	57,356,069	26,081.9	28,927.8	3,984.4	12,875.3	85,940.8	157,810.2	1.203	0.322
NCR	636.0	7,354,177	882.1	--	1,273.8	554.4	271.2	2,981.5	1.379	0.94
CAR	18,293.7	1,077,532	1,613.2	1,402.0	142.2	429.1	3,499.9	7,086.4	1.596	0.358
Abra	3,975.6	183,757	179.1	479.9	-	252.0	1,309.6	2,220.6	2.598	0.469
Benguet	2,655.4	431,260	467.1	321.1	142.2	35.6	791.2	1,757.2	1.642	0.485
Mountain Province	2,097.3	112,863	316.1	272.8	-	37.3	172.9	799.1	1.642	0.404
Ifugao	2,517.8	127,803	252.6	154.4	-	18.4	557.8	983.2	1.733	0.370
Kalinga-Apayao	7,047.6	221,849	398.3	173.8	-	85.8	668.4	1,326.3	1.061	0.212
Region I	12,840.2	3,327,781	1,428.8	1,783.6	167.7	1,079.8	7,716.1	12,176.0	1.863	0.477
Ilocos Norte	3,399.3	440,087	356.7	422.2	130.9	294.8	1,867.1	3,071.7	2.511	0.647
Ilocos Sur	2,579.6	508,274	370.1	263.1	-	245.5	1,933.5	2,812.2	2.456	0.527
La Union	1,493.1	532,118	216.0	251.9	-	121.6	638.9	1,228.4	1.378	0.435
Pangasinan	5,368.2	1,847,302	486.0	846.4	36.8	417.9	3,276.6	5,063.7	1.608	0.425
Region II	26,837.7	2,298,163	1,650.9	1,644.1	-	1,037.5	6,228.1	10,560.6	1.345	0.331
Batanes	209.3	13,395	65.7	64.6	-	30.5	116.4	277.2	5.235	1.306
Cagayan	9,002.7	829,709	592.0	527.0	-	202.6	2,135.2	3,456.8	1.265	0.331
Isabela	10,664.6	1,052,180	421.5	580.2	-	430.4	2,318.9	3,751.0	1.120	0.279
Nueva Vizcaya	3,903.9	295,246	313.2	369.7	-	285.7	1,434.4	2,403.0	2.238	0.481
Quirino	3,057.2	107,633	258.5	102.6	-	88.3	223.2	672.6	1.173	0.306
Region III	18,230.8	5,725,563	1,692.2	2,364.0	258.5	1,036.8	7,725.0	13,076.5	1.280	0.394
Bataan	1,373.0	411,539	295.9	225.2	-	52.5	501.1	1,074.7	1.430	0.563
Bulacan	2,625.0	1,334,696	257.7	352.2	-	245.0	1,689.7	2,544.6	1.359	0.497
Nueva Ecija	5,284.3	1,245,862	427.3	697.6	39.6	324.3	1,739.5	3,228.3	1.258	0.359
Pampanga	2,180.7	1,415,226	279.7	321.5	128.4	118.0	1,532.2	2,379.8	1.355	0.394
Tarlac	3,053.4	785,271	209.6	552.3	-	132.7	1,661.6	2,556.2	1.651	0.420
Zambales	3,714.4	532,969	222.0	215.2	90.5	164.3	600.9	1,292.9	0.919	0.291
Region IV	46,924.1	7,488,360	4,028.5	3,866.4	292.7	1,380.9	8,788.0	18,356.5	0.979	0.296
Aurora	3,239.5	137,174	218.4	115.9	-	55.1	241.3	630.7	0.946	0.237
Batangas	3,165.8	1,372,047	507.5	637.0	37.3	237.1	2,234.7	3,653.6	1.753	0.525
Cavite	1,287.6	1,003,900	302.0	429.5	91.6	67.9	717.3	1,608.3	1.415	0.508
Laguna	1,759.7	1,215,027	346.3	252.1	79.8	146.8	645.3	1,470.3	1.006	0.463
Marinduque	959.2	199,133	217.9	173.3	-	135.1	138.8	665.1	1.522	0.452
Occidental Mindoro	5,879.8	269,305	358.9	321.8	-	131.6	794.2	1,606.5	1.277	0.284
Oriental Mindoro	4,364.7	546,107	276.7	734.7	-	66.5	242.5	1,320.4	0.855	0.263
Palawan	14,896.3	464,815	551.4	504.2	66.7	109.1	1,386.6	2,618.0	0.995	0.214
Quezon	8,706.7	1,346,948	720.1	368.4	17.3	214.1	793.6	2,113.5	0.617	0.213
Rizal	1,308.9	719,413	244.2	66.8	-	143.4	782.8	1,237.2	1.275	0.478
Romblon	1,355.9	214,491	285.1	262.7	-	74.2	810.9	1,432.9	2.657	0.585
Region V	17,632.5	4,104,522	1,936.8	1,796.6	245.3	781.6	3,851.3	8,611.6	1.012	0.321
Albay	2,552.6	945,248	385.4	374.7	26.9	166.6	684.0	1,637.6	1.054	0.385
Camarines Norte	2,112.5	370,364	185.0	134.8	-	86.2	320.7	726.7	0.822	0.338
Camarines Sur	5,266.8	1,308,911	457.4	695.3	218.4	243.2	1,815.2	3,429.5	1.306	0.375
Catanduanes	1,511.5	200,277	252.4	223.6	-	71.7	240.3	788.0	1.432	0.378
Masbate	4,047.7	685,483	359.0	117.8	-	86.6	441.0	1,004.4	0.603	0.155
Sorsogon	2,141.4	594,239	297.6	250.4	-	127.3	350.1	1,025.4	0.909	0.340

TABLE 2.3-1 ROAD DENSITY (2/2)

	Land Area (km2) A	1987 Population P	1987 Road Length (km) National	Provinc'l	City	Municipal	Barangay	Total L	Road Density $L/\sqrt{AP/1000}$	Road Density $L/\sqrt{AP/1000}$
Region VI	20,223.2	5,322,784	2,632.8	2,453.1	297.3	696.6	7,902.1	13,981.9	1.348	0.370
Aklan	1,817.9	379,063	141.9	286.1	-	80.3	623.1	1,131.4	1.363	0.364
Antique	2,522.0	405,994	362.8	96.7	-	97.1	753.6	1,310.2	1.295	0.334
Capiz	2,633.2	585,938	306.1	365.5	27.8	81.4	877.4	1,658.2	1.335	0.348
Iloilo	5,324.0	1,660,767	949.3	814.8	31.8	224.8	2,332.8	4,353.5	1.464	0.422
Negros Occidental	7,926.1	2,291,022	872.7	890.0	237.7	213.0	3,315.2	5,528.6	1.297	0.356
Region VII	14,951.5	4,362,062	1,666.7	2,336.7	315.2	908.7	5,485.5	10,712.8	1.327	0.353
Bohol	4,117.3	899,732	585.3	922.2	65.4	288.3	2,666.3	4,527.5	2.352	0.535
Cebu	5,088.4	2,426,444	623.4	930.1	189.3	403.3	1,630.1	3,776.2	1.075	0.333
Negros Oriental	5,402.3	957,509	382.4	299.6	60.5	196.5	1,108.7	2,047.7	0.900	0.240
Siquijor	343.5	78,377	75.6	184.8	-	20.6	80.4	361.4	2.203	0.664
Region VIII	21,431.7	3,185,293	1,963.5	1,403.7	70.6	713.9	4,319.6	8,471.3	1.025	0.314
Leyte	6,268.3	1,478,953	959.0	520.6	60.5	351.5	1,913.1	3,804.7	1.250	0.386
Southern Leyte	1,734.8	350,971	265.4	350.8	-	81.2	661.4	1,358.8	1.741	0.588
Eastern Samar	4,339.6	373,825	258.7	250.5	-	135.3	968.8	1,613.3	1.267	0.287
Northern Samar	3,498.0	451,989	248.1	146.7	10.1	89.4	446.3	940.6	0.748	0.233
Samar	5,591.0	529,555	232.3	135.1	-	56.5	330.0	753.9	0.438	0.178
Region IX	18,685.0	2,994,373	1,019.1	2,094.8	121.5	836.6	5,438.1	9,510.1	1.271	0.281
Basilan	1,327.2	241,370	62.1	229.1	-	47.9	332.0	671.1	1.186	0.239
* Sulu	1,600.4	421,073	134.8	217.3	-	19.4	481.8	853.3	1.039	0.258
* Tawi-Tawi	1,087.4	227,913	92.8	29.9	-	25.0	184.7	332.4	0.668	0.141
Zamboanga del Norte	6,618.1	688,006	260.1	807.8	46.6	344.8	1,710.0	3,169.3	1.485	0.329
Zamboanga del Sur	8,051.9	1,416,011	469.3	810.7	74.9	399.5	2,729.6	4,484.0	1.328	0.291
Region X	28,327.8	3,350,016	2,151.7	2,751.6	217.4	1,210.6	8,578.1	14,909.4	1.530	0.361
Agusan del Norte	2,590.3	442,313	215.1	232.9	66.0	91.3	597.6	1,202.9	1.124	0.357
Agusan del Sur	8,965.5	329,572	300.1	266.9	-	161.9	766.4	1,495.3	0.870	0.239
Bukidnon	8,293.8	766,149	613.3	787.1	-	400.9	2,899.3	4,700.6	1.865	0.364
Camiguin	229.8	61,904	63.5	94.5	-	28.0	160.0	346.0	2.901	0.752
Misamis Occidental	1,939.3	451,601	199.4	507.9	71.4	170.1	1,398.4	2,347.2	2.508	0.522
Misamis Oriental	3,570.1	855,759	417.5	501.5	63.5	158.9	2,060.1	3,201.5	1.832	0.464
Surigao del Norte	2,739.0	442,718	342.8	360.8	16.5	199.5	696.3	1,615.9	1.467	0.378
Region XI	31,692.9	4,032,431	1,954.2	3,009.4	453.7	1,261.2	8,769.4	15,447.9	1.366	0.296
Davao del Norte	8,129.8	853,452	351.5	743.7	-	305.1	1,641.1	3,041.4	1.155	0.294
Davao del Sur	6,377.6	1,388,733	513.2	425.7	267.9	257.8	2,521.0	3,985.6	1.339	0.298
Davao Oriental	5,164.5	406,202	308.3	548.9	-	73.8	418.2	1,349.2	0.932	0.217
South Cotabato	7,468.8	925,887	464.8	1,012.5	185.8	512.1	3,379.1	5,554.3	2.112	0.383
Surigao del Sur	4,552.2	458,157	316.4	278.6	-	112.4	810.0	1,517.4	1.051	0.252
Region XII	23,293.1	2,733,012	1,461.4	2,021.8	128.5	947.6	7,368.4	11,927.7	1.495	0.293
Lanao del Norte	3,092.0	559,392	224.5	201.3	67.9	229.7	1,047.5	1,770.9	1.347	0.335
* Lanao del Sur	3,872.9	465,386	281.6	416.6	27.3	244.6	3,456.3	4,426.4	3.297	0.537
* Maguindanao	5,474.1	631,301	248.4	341.8	33.3	108.6	1,057.5	1,789.6	0.963	0.200
North Cotabato	6,565.9	693,716	555.0	447.8	-	249.6	778.7	2,031.1	0.952	0.218
Sultan Kudarat	4,288.2	383,217	151.9	614.3	-	115.1	1,028.4	1,909.7	1.490	0.262

* ARMM (Autonomous Region of Muslim Mindanao)

2.4 ROAD DISASTER

2.4.1 Road Damage By Typhoon

Among various kinds of calamities, the typhoon calamities are most frequent and causing huge amount of damages to agricultural products, houses, infrastructures, etc. every year.

Table 2.4-1 shows estimated cost of damages to infrastructure and roads/bridges caused by typhoons for the past ten (10) years, which is summarized as follows:

	Average of the past 10 years
• Number of typhoons affected	6 times a year
• Estimated cost of damages to all infrastructure (in 1989 prices)	1,025 million pesos per annum
• Estimated cost of damages to roads/bridges only (in 1989 prices)	463 million pesos per annum

Annual average costs of damages to all infrastructure and roads/bridges alone in 1989 prices were 1,025 million pesos and 463 million pesos, respectively. About 20 to 30% of calamity fund was appropriated for aid and relief operation, therefore, capital outlay for repair and reconstruction of damaged infrastructure was not always enough for restoration works, thus many damaged infrastructures were left without having been restored.

TABLE 2.4-1 TYPHOON DAMAGES FOR THE PAST TEN YEARS

Year	No. of Typhoons Entering the PAR[1]	No. of Typhoons Affecting the Country	Estimated Cost of Damage[2] (Million Peso)						Calamity Fund[3] (Million Peso)	
			Total		All Infrastructure		Roads and Bridges			
			Current Price	1989 Price	Current Price	1989 Price	Current Price	1989 Price	Current Price	1989 Price
1980	23	9	1,465.2	4,634.4	366.4	1,158.9	78.9	249.6	300.0	948.9
1981	21	7	1,274.5	3,564.8	361.6	1,011.4	71.5	200.0	400.0	1,118.8
1982	23	8	1,659.4	4,209.8	58.7	148.9	32.9	83.5	600.0	1,522.2
1983	14	4	522.1	1,204.5	142.1	327.8	48.4	111.7	600.0	1,384.2
1984	20	4	5,869.3	9,003.4	1,850.9	2,839.2	1,099.7	1,686.9	1,500.0	2,301.0
1985	17	4	2,724.7	3,395.0	316.1	393.9	123.8	154.3	1,500.0	1,869.0
1986	21	6	1,776.8	2,197.9	526.0	650.7	330.6	409.0	1,000.0	1,237.0
1987	16	6	4,083.0	4,866.9	970.0	1,156.2	411.4	490.4	442.7	527.7
1988	20	5	8,675.6	9,508.5	1,224.9	1,342.5	589.1	645.7	442.7	485.2
1989	19	7	4,494.4	4,494.4	1,221.0	1,221.0	598.5	598.5	1,000.0	1,000.0
Total	194	60	32,545.0	47,079.6	7,037.7	10,250.5	3,384.8	4,629.6	7,785.4	12,394.0
Average	19.4	6	3,254.5	4,708.0	703.8	1,025.1	338.5	463.0	778.5	1,239.4

Note: 1) PAR = Philippine Area of Responsibility
2) Source: Asean Natural Disaster Center, Department of National Defense
3) Source: General Appropriations Act (Released amount is not available.)

2.4.2 Classification of Province

According to disaster potential and topography, provinces are classified as shown in Figure 2.4-1 and Table 2.4-2. In Figure 2.4-1, average slope, meteorological effect index damage rate and disaster type are defined as follows:

1) Average Slope (%) $= 4xA_1 + 13xA_2 + 24xA_3 + 40xA_4 + 64xA_5$

where, A_1, A_2, A_3, A_4 and A_5 = ratio o f land area with slope 0 - 8%, 8 - 18%,18 - 30%, 30 - 50%, and 50% or more, respectively

2) Meteorological Effect Index = N_t + Rn/900

where, N_t = average number of typhoons per year
R_m = maximum monthly rainfall, in mm

3) Damage Rate = D/L

where, D = total amount of road damage by typhoon for 10 years from 1980 to 1989, in P1,000.
L = total length of road, in Km.

4) Disaster Type

In the classification of road damage by typhoon into 3 categories: road damage, bridge damage and slope damage,

Type A: Mostly road damage (road damage more than 80%)
Type B: Road damage and bridge damage combined (bridge drainage more than 20%)
Type C: Remarkably slope damage (slope damage more than 40%)
Type D: All categories of damage combined (each more than 10%)

Note: % in terms of amount of damage by typhoon for 2 years (1988 and 1989).

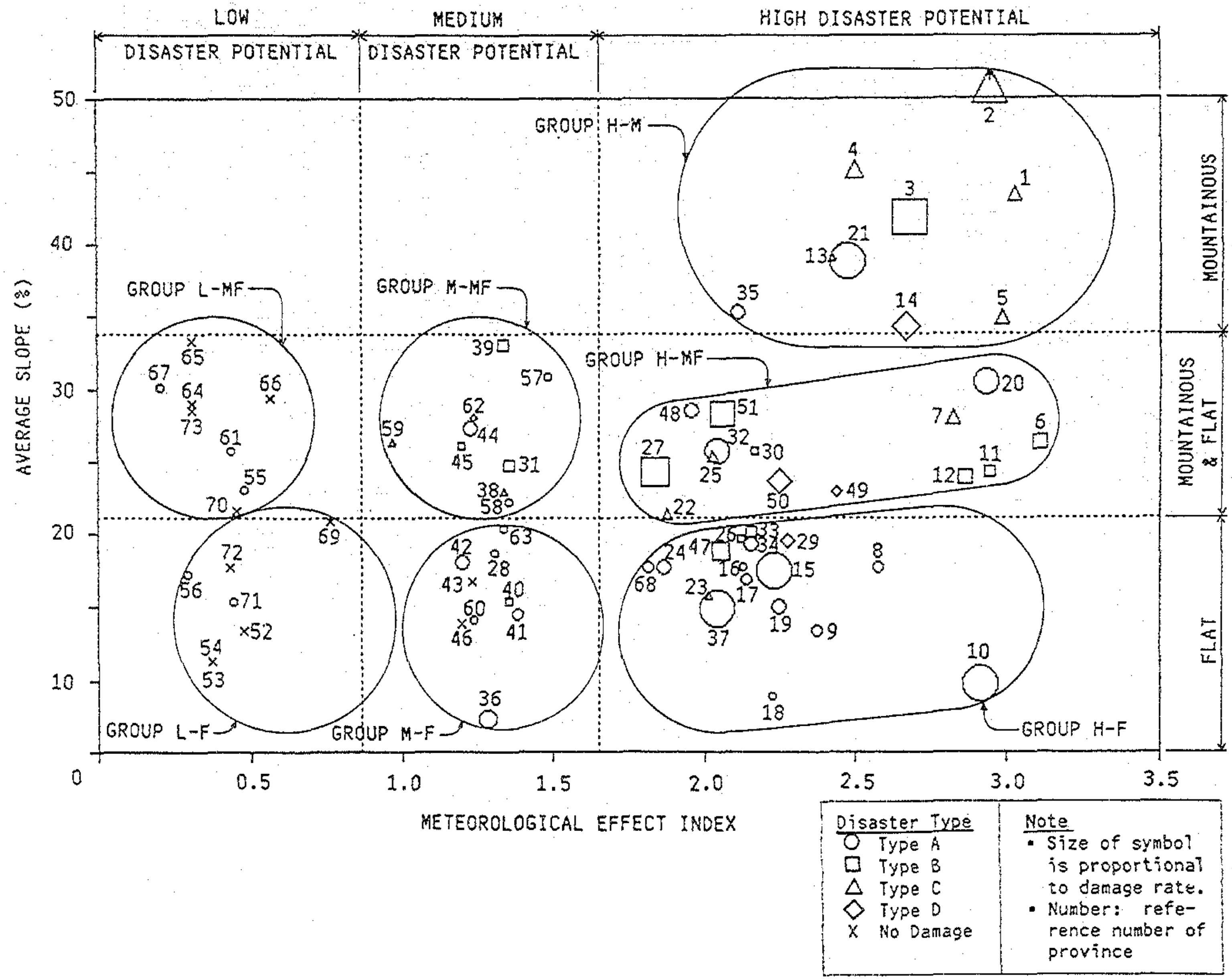


FIGURE 2.4-1 AVERAGE SLOPE VS. METEOROLOGICAL EFFECT INDEX

TABLE 2.4-2 CLASSIFICATION OF PROVINCE

		DISASTER POTENTIAL		
		L (LOW)	M (MEDIUM)	H (HIGH)
Topo-graphy	M (Mountainous)			Group H-M (CAR) Benguet 2 (CAR) Ifugao 4 (CAR) Abra 1 (CAR) Mountain Province 3 (2) Nueva Vizcaya 13 (4) Aurora 21 (5) Catanduanes 35 (CAR) Kalinga-Apayao 5 (2) Quirino 14
	MF (Mountainous and Flat)	Group L-MF (11) Davao del Sur 65 (11) South Cotabato 67 (11) Davao Oriental 66 (11) Davao del Norte 64 (12) Sultan Kudarat 73 (10) Misamis Occidental 61 (9) Zamboanga del Norte 55 (12) Lanao del Sur 70	Group M-MF (6) Antique 39 (10) Agusan del Norte 57 (10) Misamis Oriental 62 (7) Cebu 44 (10) Bukidnon 59 (7) Negros Oriental 45 (4) Romblon 31 (6) Aklan 38 (10) Agusan del Sur 58	Group H-MF (3) Zambales 20 (8) Southern Leyte 48 (8) Samar 51 (1) Ilocos Sur 7 (1) Ilocos Norte 6 (4) Rizal 30 (5) Albay 32 (4) Marinduque 25 (4) Oriental Mindoro 27 (2) Cagayan 11 (2) Isabela 12 (8) Northern Samar 50 (8) Eastern Samar 49 (4) Batangas 22
	F (Flat)	Group L-F (12) *Lanao del Norte* 69 (12) North Cotabato 72 (9) Zamboanga del Sur 56 (12) Maguindanao 71 (9) Basilan 52 (9) Tawi-Tawi 54 (9) Sulu 53	Group M-F (10) *Surigao del Norte* 63 (4) Palawan 28 (6) Negros Occidental 42 (7) Bohol 43 (6) Capiz 40 (6) Iloilo 41 (10) Camiguin 60 (7) Siquijor 46 (5) Masbate 36	Group H-F (5) *Camarines Norte* 33 (4) Occidental Mindoro 26 (4) Quezon 29 (5) Camarines Sur 34 (8) Leyte 47 (1) La Union 8 (3) Bulacan 16 (11) Surigao del Sur 68 (4) Laguna 24 (3) Bataan 15 (3) Nueva Ecija 17 (4) Cavite 23 (3) Tarlac 19 (5) Sorsogon 37 (1) Pangasinan 9 (2) Batanes 10 (3) Pampanga 18

NOTE: ( ): Region Number
Number at the end of province name: reference number of province

2.5 DISASTER MANAGEMENT SYSTEM

2.5.1 Organization for Disaster Management

1) Overall Organization

Under direction and control of the National Disaster Coordinating Council (NDCC), all emergency operations are exercised by the all concerned Departments, local government units, as well as non- government organizations and private sectors. Overall organization for disaster management is shown in Figure 2.5-1.

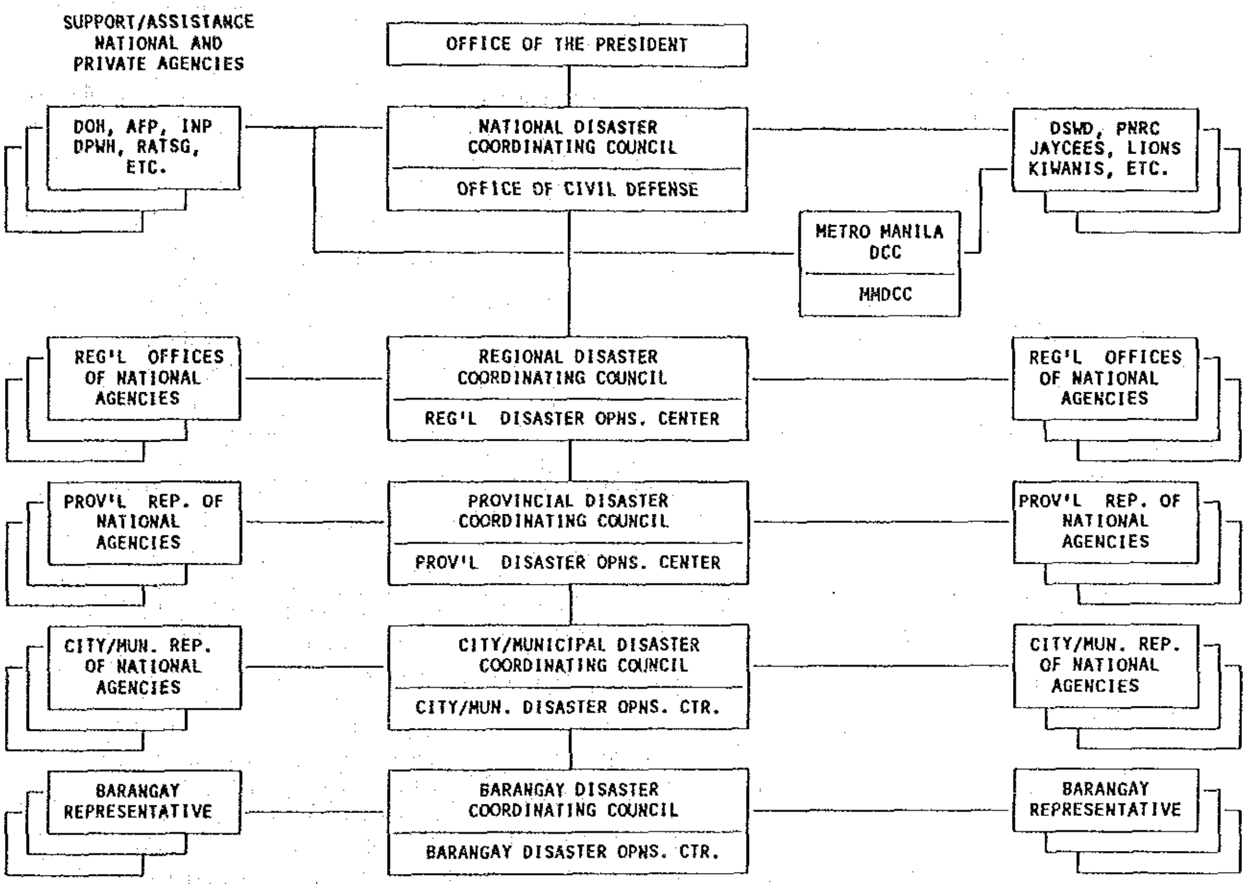


FIGURE 2.5-1 OVERALL ORGANIZATION FOR DISASTER MANAGEMENT

2) National Disaster Coordinating Council (NDCC)

Member of NDCC

Secretary, Department of National Defense	- Chairman
Secretary, Department of Public Works and Highways	- Member
Secretary, Department of Transportation and Communication	- Member
Secretary, Department of Social Welfare Development	- Member
Secretary, Department of Agriculture	- Member
Secretary, Department of Education, Culture and Sports	- Member
Secretary, Department of Finance	- Member
Secretary, Department of Labor and Employment	- Member
Secretary, Department of Trade and Industry	- Member
Secretary, Department of Health	- Member
Secretary, Department of Environment and Natural Resources	- Member
Secretary, Department of Local Government	- Member
Secretary, Department of Budget and Management	- Member
Secretary, Department of Justice	- Member
Director, Philippine Information Agency	- Member
Chief of Staff, Armed Forces of the Philippines	- Member
Secretary-General, Philippine National Red Cross	- Member
Administrator, Office of Civil Defense	- Member and Executive

Tasks of NDCC

- Advises the President on the status of disaster preparedness programs, disaster operations and rehabilitation efforts undertaken by the government and the private sector;
- Establishes policy guidelines on emergency preparedness and disaster operations involving rescue, relief and rehabilitation;
- Establishes priorities in the allocation of funds, services, disaster equipment and relief supplies;
- *Advises the lower-level Disaster Coordinating Councils through the Office of Civil* Defense in accordance with the guidelines on disaster management;
- Recommends to the President the declaration of a state of calamity in areas extensively damage; and submits proposals to re store normalcy in the affected areas;
- Creates an Action Group composed of permanent representatives from the member-departments and other government agencies with the Executive Officer as head; and
- Utilizes the facilities and services of the Office of Civil Defense in Camp Aguinaldo, Quezon City, in discharging its functions.

2.5.2 DPWH Standard Operation Procedure

1) DPWH Disaster Coordination Body

The Department of Public Works and Highways (DPWH) organizes the Disaster Coordinating Body at the Central Office as well as field office from Regional down to District/City levels. Standard organization of the Disaster Coordination Body is shown in Figure 2.5-2.

Major tasks of DPWH in the overall context of disaster operation are as follows:

- Restores destroyed public works such as flood control, water works, roads, bridges, and other vertical and horizontal facilities/structures;
- Provides heavy and light equipment for rescue and recovery operations;
- Makes available existing communications facilities for disaster operations
- Assists in providing transportation facilities to transport relief supplies, personnel and disaster victims;
- Provides warning to the public of impending releases of water from dams under its control; and
- Organizes reaction teams in the department proper as well as in all bureaus and offices under it.

Functions of the staff and teams in the Disaster Coordinating Body are as follows:

Administrative Staff

- Provide the administrative supports (personnel acquisition, clerical, reporting, recording, financials, etc.) and supplies including equipment.

Communication Staff

- Provide networks in telephone, telegram, radio system, courier and postal service for DPWH Disaster Preparedness and Control Units, and DPWH assistance to other Government Agencies and Disaster Coordinating Council.

Transportation Staff

- Provide transport assistance to DPWH units and Councils/Agencies that need assistance.

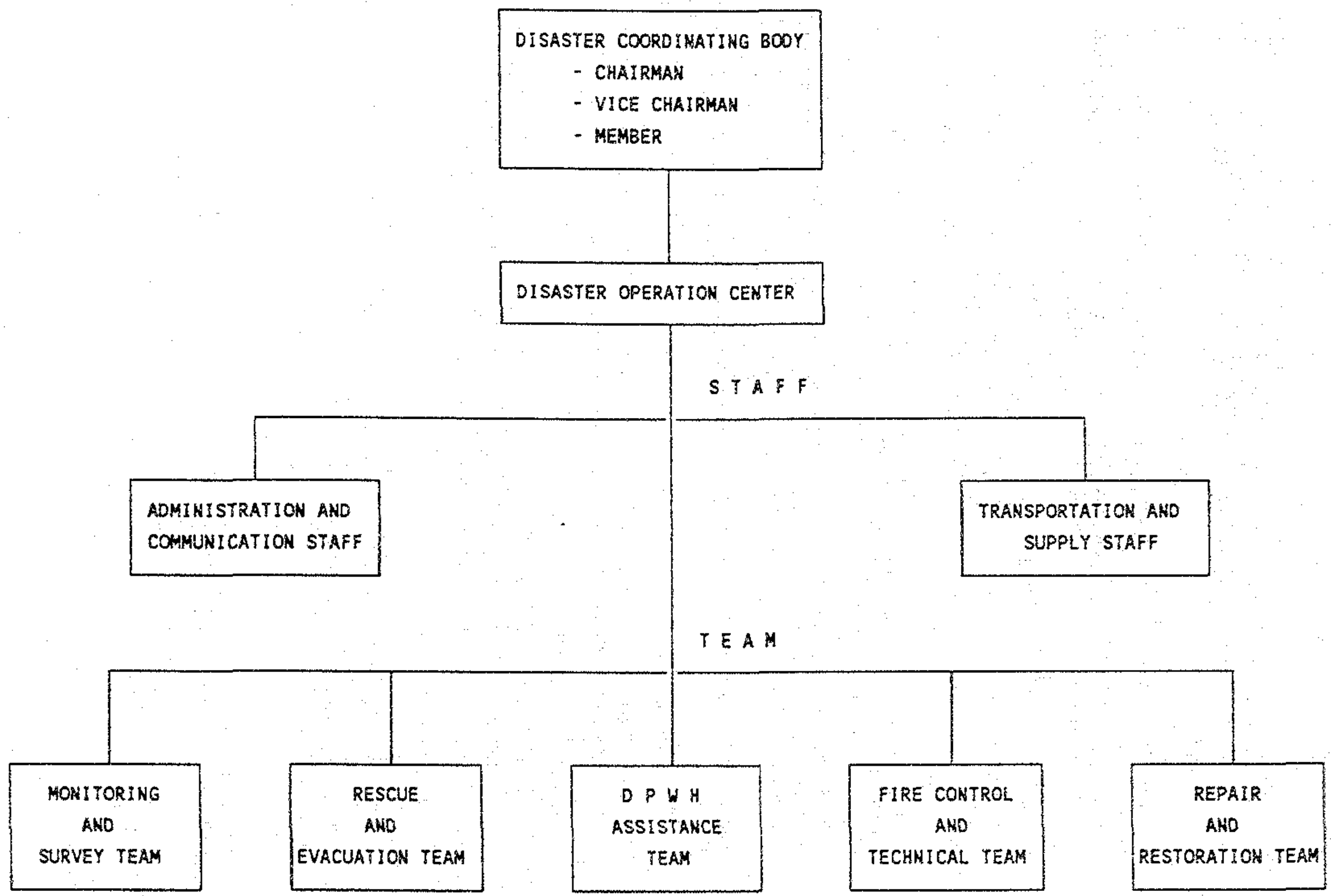


FIGURE 2.5-2 STANDARD DPWH DISASTER COORDINATING BODY

Monitoring and Survey Team

- Monitors impending disasters, and at the first sign of disaster, sound alarm to activate appropriate Teams.
- Surveys damages to infrastructure and transmit relevant reports to DPWH Manila within 24 hours.
- Monitors all emergency and post emergency activities of various Teams, particularly the Repair and Restoration Team, and prepare/submit corresponding reports.

Rescue and Evacuation Team

When requested during emergencies by appropriate agencies thru the DPWH Coordination Body, shall assist in the:

- Rescue operations in locating injured or trapped persons and moving them to places where they can be cared for.
- Evacuation operations by providing available personnel and equipment to expedite controlled movement of evacuees.

DPWH Assistance Team

When requested thru the DPWH Coordinating Body by appropriate agencies during emergencies, shall assist in the:

- Dismantling/demolitions of obstructions to rescue operations specially related to the fire and earthquakes.
- Relief operations of Red Cross/Social Services by providing vehicles and personnel.
- Salvage and Recovery Operations in coordination with other agencies by providing vehicles and personnel.

Fire Control and Technical Team

- Controls fire in office building or assist in controlling fire in adjoining buildings.
- Controls and maintain operation of essential utilities such as water and power supply. Also provides cooperation to technical experts in disarming explosive devices, minimizing the effects of both natural and man-made disasters through physical, chemical, biological and radiological counter or preventive measures.

Restoration and Repair Team

- Repairs and restore damaged roads, bridges and other public infrastructure within the area of jurisdiction.

2) DPWH Standard Operation Procedure

Standard operation procedure before, during and after the calamity is summarized in Table 2.5-1.

At the first sign or warning of typhoon or other calamity, the Operation Centers at the Central and respective field office are activated and placed on 24 hours operation by three (3) shifts until after the calamity.

DPWH Field Offices in the calamity stricken area shall undertake the following:

Before Typhoon or Any Other Calamity

1) Road Sections prone to damages caused by calamities are identified.

2) Permanent inspectors who are capable of assessing damages and estimating with a high degree of accuracy the cost of restoration work are assigned to identified disaster prone road sections.

3) At the warning or indication of an impending typhoon or calamity, the designated inspectors proceed to their assigned section.

4) Undertake preparatory work to mitigate effects of calamity.

During Typhoon or Any Other Calamity

1) Undertake emergency work

2) Prepare situational reports and submit them to District/City Engineer, Regional Director and the Secretary by the fastest means of communication. The situational report shall include the following:

- Type/nature, location and extent of damage
- Where traffic is disrupted, possible detour routes
- What restoration activities are being done
- Estimated date for opening to traffic
- Rough estimate of costs of restoration
- Request and nature of assistance if warranted

3) Provide relief and information to the public.

4) Request DPWH Central Office for disaster-related assistance.

5) Implement orders, directives and instructions from DPWH Central Office.

TABLE 2.5-1 STANDARD PROCEDURE BEFORE, DURING AND AFTER CALAMITY

	DPWH Central Office Operation Center for Disaster	DPWH Regional/District/City Offices Operation Center for Disaster
Before typhoon or other calamity	· Team Leader assembles the Team for a pre-disaster conference and strategy. · Alert thru telex Regional Directors and advise them to activate Operation Center and Disaster Crews.	· Identify road disaster-prone sections and assign permanent inspectors to these sections. · Activate Operation Center and Disaster Crews. · Designated inspectors proceed to assigned sections. · Undertake preparatory work to mitigate effects. · Anticipate relief action needed and information to Central Office.
During typhoon or other calamity	· Receive situational reports from field offices. · Receive request for disaster-related assistance from NDCC or other government agencies including DPWH field offices. · Transmit orders, directives, instructions of National Disaster Coordinating Body of DPWH to field Disaster Coordinating Bodies. · Coordinate with Public Affairs Office for dissemination of relevant disaster related information to Media. · Prepare memorandum for the Secretary 2 or 3 times during the 24-hour period to appraise him of the situational reports.	· Undertake emergency work. · Provide relief and information to the public. · Prepare situational reports. · Request DPWH Central Office Operation Center for disaster-related assistance. · Implement orders, directives, instructions from DPWH Central Office Operation Center.
After typhoon or other calamity	· Consolidates the Initial Damage Assessment Report and submit to the Secretary. Upon approval by the Secretary, Quick Response Fund is released. · Within 2 weeks consolidates the Final Detailed Report and submit to the National Disaster Coordinating Council. · Request of release of Calamity Fund is submitted to the President for approval thru National Disaster Coordinating Council.	· Within 24-hours, undertake an initial damage assessment of at least Priority I group and report them to District Engineer. · Within 48-hours, District Engineer transmit the initial report to the Secretary thru BOM covering at least Priority I Group. · Within 5 days, the District Engineer submits to the Regional Director the Final Detailed Report on the damages for all 3 Priority groups including realistic cost estimates. · Within 2 days after receipt of the District Reports, the Regional Director reviews and validates the damages covered by the Final Report and submits the summarized reports to the Secretary thru BOM.

After Typhoon or Any Other Calamity

1) Immediately assess the damages. Damages shall be categorized into three (3) priority groups as follows:

Priority I: Involves the immediate rehabilitation of collapsed bridges, cut road sections, breached seawalls and dikes to quickly restore mobility and ensure safety of the affected areas.

Priority II: Involves the ordinary repair works such as patching potholes, resurfacing of washed-out roads and slightly destroyed flood control.

Priority III: Involves minor repair work and/or improvement to prevent further deterioration such as repair of road section.

2) Within 24 hours, the initial assessment report covering at least Priority I group of damages is prepared and submitted to District/City Engineers.

3) Within 48 hours, the District/City Engineer transmits the initial assessment report to the Secretary of DPWH thru the Bureau of Maintenance by the fastest means of communication.

4) Within 5 days, the District/City Engineer submits to the Regional Director the final detailed report on the damages covering all three (3) Priority groups with pictures and the realistic cost estimates for the restoration of the damaged facilities.

5) Within 2 days after receipt of the District/City Engineer's report, the Regional Director reviews and validates the damages reported and submits the summarized report to the Secretary of DPWH thru the Bureau of Maintenance.

The Central Office of DPWH undertakes the following:

1) Consolidates the initial assessment report and submit it to the Secretary. Upon approval of the report by the Secretary, Quick Response Fund is released.

2) Within 2 weeks after receipt, consolidates the final detailed report and submit it to the Secretary of DPWH and the National Disaster Coordinating Council.

3) Prepare a letter requesting release of Calamity Fund and submit it to the President for approval thru the National Disaster Coordinating Council.

2.5.3 Calamity Fund

Calamity Fund is appropriated by the General Appropriations Fund and is utilized for the following purposes:

- For maintenance and other operating expenses, particularly for aid, relief and rehabilitation services to people/areas affected by calamity.
- For capital outlays to repair, restore and reconstruct damaged structures.

Fund will be directly appropriated to implementing agencies in accordance with the recommendation of the National Disaster Coordinating Committee upon approval of the President.

To effect timely and expeditious response for the immediate repair/restoration of calamity damaged infrastructure facilities. "Quick Response Fund" which represents twenty percent (20%) of capital outlay is authorized under Calamity Fund and is immediately released to DPWH.

Guidelines for releasing, utilizing the monitoring Quick Response Fund are prescribed as follows:

1) Priority in the release of the Quick Response Fund is for the emergency repair/restoration of critically damaged infrastructure facilities to restore mobility and ensure safety in the affected areas, such as:
   - Cut or closed road section
   - Collapsed bridges and washout approaches
   - Breached river control and shore protection
   - Unroofed school buildings and other public buildings
2) The District/City Engineers shall submit thru the Regional Director and the Director of Bureau of Maintenance to the Secretary, the calamity damaged report within two (2) days after the occurence of the calamity which should incorporate the following:
   - Brief description and location
   - Extent of damage
   - Pictures
   - Programs of work with detailed estimate
3) The Regional Director shall review and validate the damage reports and submit to the Secretary his recommendation within two (2) days after receipt of the reports from the District/City Engineers which will be the basis in the release of Quick Response Fund.
4) The Regional Director and District/City Engineers shall be held responsible for the integrity, validity and accuracy of the reports.
5) The District/City Engineers shall submit thru the Regional Director and then the Director of Bureau of Maintenance to the Secretary, the monthly accomplishment report including statements on utilization of the "Quick Response Fund" until completion of the projects.
6) The Director of Bureau of Maintenance shall compile and collate all monthly progress reports for submittal by the Secretary to the National Disaster Coordinating Council.

CHAPTER 3
CLASSIFICATION OF ROAD DISASTER

CHAPTER 3
CLASSIFICATION OF ROAD DISASTER

3.1 CLASSIFICATION OF ROAD DISASTER

Road disasters are broadly classified into six (6) categories based on the portion (or location) of roadway damaged or failed as follows:

I. Slope Damage
II. Debris Flow
III. Road Damage
IV. Bridge Damage
V. Culvert Damage
VI. Seawall Damage

Above mentioned are further classified into a total of 16 categories based on type of damage or failure as summarized in Table 3.1-1.

Definitions of respective categories of road disaster are presented in Table 3.1-2 (1) to 3.1-2 (16).

TABLE 3.1-1 CLASSIFICATION OF ROAD DISASTER

Classification by Portion of Roadway Damaged	Classification by Type of Damages or Failure	Abbrevia-tion	Remarks
I. Slope Damage	1. Cut Slope Failure	C-F	Includes failures of cut slope and mountainside natural slope.
	2. Embankment Slope Failure	E-F	Includes failures of embankment slope and valley side natural slope.
	3. Rock Fall/Debris Fall	FALL	Includes rock fall and debris fall.
	4. Landslide	L-SL	
II. Debris Flow	5. Debris Flow	D-FL	Includes debris flow and mud flow.
III. Road Damage	6. Scour/Washout of Road-bed	Rd-D	Includes damages caused by river current or wave action.
	7. Flooded/Muddy Road Surface	FM-Rd	Includes flooded and/or muddy section during/after rainfall.
IV. Bridge Damage	8. Permanent Bridge Washout	PBr-W	
	9. Permanent Bridge Approach Washout	PBr-A	
	10. Permanent Bridge Other Damages	PBr-D	Includes scouring of abutment, piers and approaches, and all other damages related to permanent bridge.
	11. Temporary Bridge Washout	TBr-W	
	12. Temporary Bridge Approach Washout	TBr-A	
	13. Temporary Bridge Other Damages	TBr-D	Includes scouring of abutment, piers and approaches, and all other damages related to temporary bridge.
	14. Spillway Damage	SPW-D	Includes all kinds of damage related to a spillway or its approaches.
V. Culvert Damage	15. Culvert Damage	CLV-D	Includes culvert damage and other damages related to culvert such as embankment slope damage or flooding of road surface due to non-functioning culvert, etc.
VI. Seawall Damage	16. Seawall Damage	SW-D	Includes seawall washout or other damages and its related damages such as scouring of shoulders.

TABLE 3.1-2 (1) DEFINITION OF CUT SLOPE FAILURE (C-F)

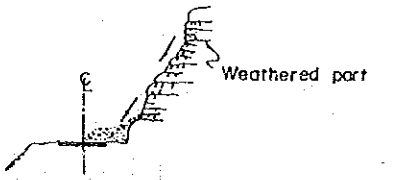
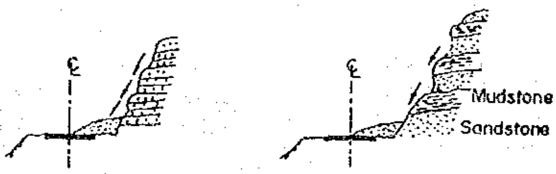
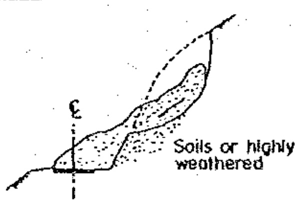
Sub-Classi-fication	Definition	Illustration	Soils/Rocks susceptible to Failure
Surface Failure	· Shallow failure of slope surface caused by erosion. · Erosion is due to heavy rainfall which often forms gullies on slope surface. · Erosion occurs mainly on bare slope without vegetation. · If left as is, may develop to large scale failure.		· Surface soils, volcanic ash soils, sand and gravel. · Volcaniclastic material, tuff, weathered shale and chert, agglomerate, etc.
	· Shallow failure of weathered surface of slope.		· Soft rocks, and easily weathered rocks. · Mudstone, tuff, weathered shale and and schist, etc.
	· Shallow failure caused by structural weakness, such as developed cracks, joints, bedding faults, and border planes in alternate strata of soft rocks.		· Schist, diabase, serpentinites, granite, andesite, quartz, porphyrites sandstones, etc. · Alternate strata of sandstone and mudstone.
Deep Failure	· Deep failure caused by scouring. · Scouring is due to concentration of surface water on slope.		· Soil and all kinds of soft rocks.
	· Rotational failure · Failure occurs along circular slide plane of slope with weak shear strength.		· Sandy soil, clayey, soil, talus, and metamorphic rocks.

TABLE 3.1-2 (2) DEFINITION OF EMBANKMENT SLOPE FAILURE (E-F)

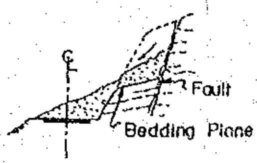
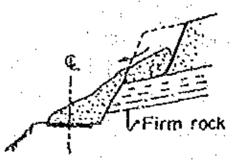
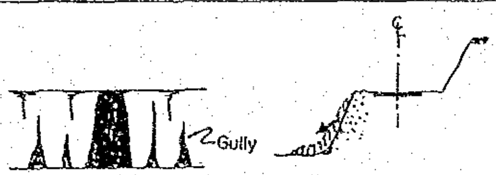
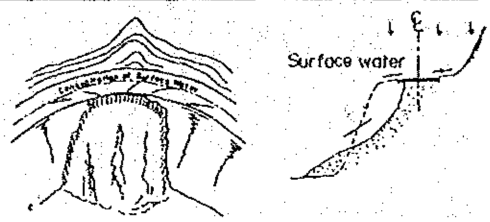
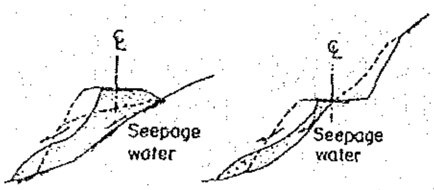
Sub-Classi-fication	Definition	Illustration	Soils/Rocks susceptible to Failure
Deep Failure	· Translational failure. · Failure occurs along the structural weakness of slope such as faults bedding planes, and border planes between firm bedrock and over-laying detritis or soil		· Sandstone, mudstone, slate, alternate strata of above rocks, granites, porphyry, etc.
			· Talus, sand and gravel, volcanic ash soil, etc. on bedrock.
Surface Failure	· Shallow failure due to erosion by surface water, which often forms gullies on slope surface.		· Sandy soil.
Deep Failure	· Deep failure caused by scouring or water saturation in embankment. · Scouring usually caused concentration of surface water at curved or sagged section.		
	· Deep failure caused by saturation of water due to seepage of surface or ground water into embankment. · Mainly occurs in embankment constructed on inclined ground or cut/embankment section.		

TABLE 3.1-2 (3) DEFINITION OF ROCK FALL/DEBRIS FALL (FALL)

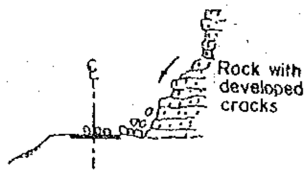
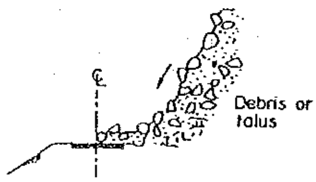
Sub-Classification	Definition	Illustration	Soils/Rocks susceptible to Failure
Rock Fall	· Free fall of detached rocks from a surface of slope of bedrocks with developed cracks, joints, and beddings.		· All kinds of rocks with developed cracks, joints, and beddings.
Debris Fall	· Free fall of unsupported pebbles, cobbles and boulders from a surface of slope of debris or talus.		· Talus, volcaniclastic materials.

TABLE 3.1-2 (4) DEFINITION OF LANDSLIDE (L-SL)

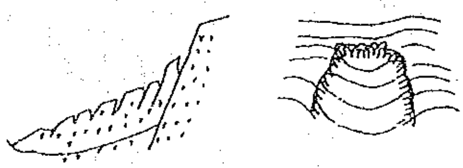
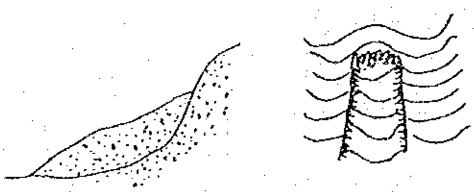
Sub-Classification	Definition	Illustration	Soils/Rocks susceptible to Failure
Rock Landslide	· Movement of huge mass which occurs along structural weakness in rock or in weathered rock of weak shear strength. · Speed of movement is usually moderate and sometimes rapid in which case it is difficult to foresee. · Landslide in weathered rock shows intermittent movement.		· Neogene, crystalline, schist, etc. · Mainly in fault fracture zone.
Soil Landslide	· Movement of huge mass which occurs of colluvial soil and clayey soil or along border plane between firm rock and the said soils. · Speed of movement is slow and continuous.		· Colluvial soil, clayey soil, and said soils with gravel.

TABLE 3.1-2 (5) DEFINITION OF DEBRIS FLOW (D-FL)

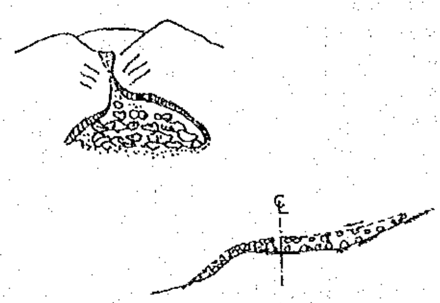
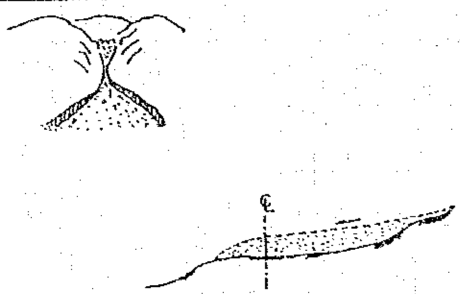
Sub-Classi-fication	Definition	Illustration	Soils/Rocks Susceptible to Failure
Debris Flow	· Flow movement of deposit with large stones on the stream bed. · Flow movement resembles those of viscous fluids in distribution of velocies.		· Fault fracture zone. · Neogene, weathered granite, volcaniclastic, etc.
Mud Flow	· Same as above except deposit materials which are soils and muds without large stones.		

TABLE 3.1-2 (6) DEFINITION OF SCOUR/WASHOUT OF ROADBED (Rd-D)

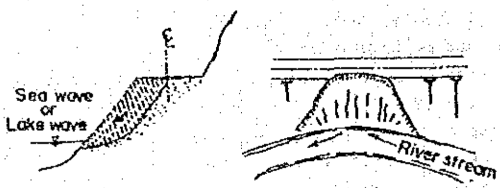
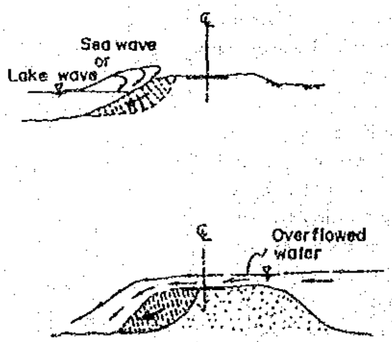
Sub-Classi-fication	Definition	Illustration
Scour or Washout of Roadbed	· Washout or scouring of roadbed due to effect of river stream, wave action or overflowing water.	
Scour or Washout of Shoulder	· Same as above, however, damage is extended only to shoulder.	

TABLE 3.1-2 (7) DEFINITION OF FLOODED/MUDDY ROAD SURFACE (FM-Rd)

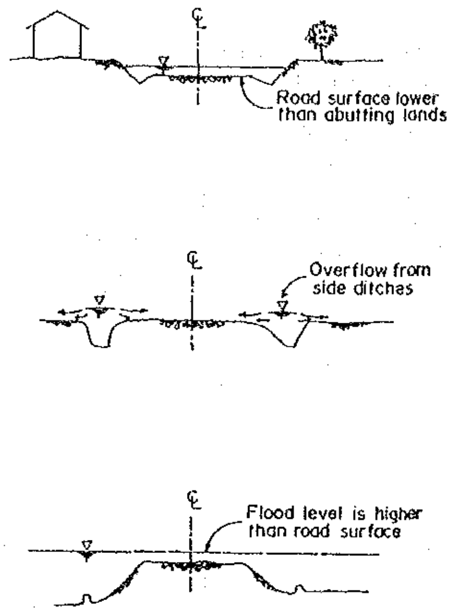
Sub-Classi-fication	Definition	Illustration
Flooded and/or Muddy Road Surface	· Road surface is flooded and/or muddy due to lower road surface than abutting lands or insufficient capacity of side ditches or lower road surface than flood level.	

TABLE 3.1-2 (8) DEFINITION OF PERMANENT BRIDGE WASHOUT (PBr-W)

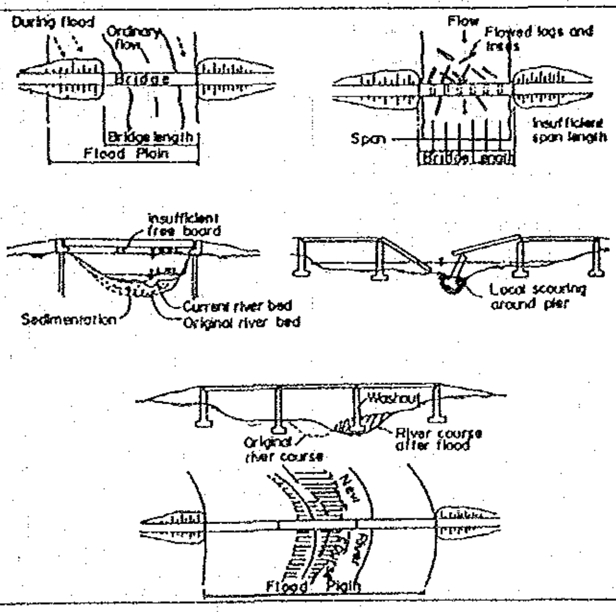
Sub-Classi-fication	Definition	Illustration
Permanent Bridge Washout	· Washout of permanent bridge due to insufficient length of bridge, too short span length between piers, insufficient free board, collapse of piers due to scouring, changed river course, etc.	

TABLE 3.1-2 (9) DEFINITION OF PERMANENT BRIDGE APPROACH WASHOUT (PBr-A)

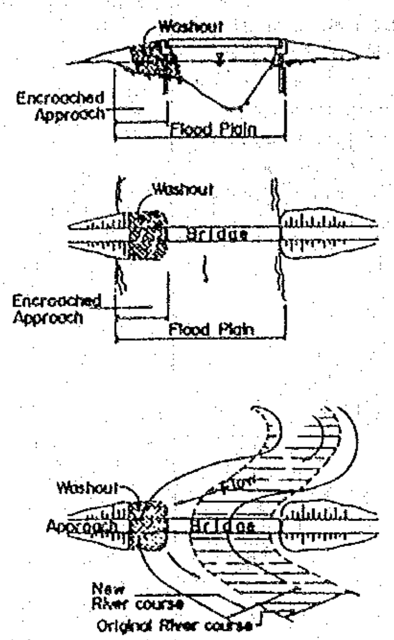
<table>
<tr><th>Sub-Classi-fication</th><th>Definition</th><th>Illustration</th></tr>
<tr><td>Permanent Bridge Approach Washout</td><td>· Partial or total wash-out of approach of permanent bridge due to encroachment of approach on the flood plain, meandering of stream, washout of rivetment or riprap around abutment due to scouring, etc.</td><td>
</td></tr>
</table>

TABLE 3.1-2 (10) DEFINITION OF PERMANENT BRIDGE OTHER DAMAGE (PBr-D)

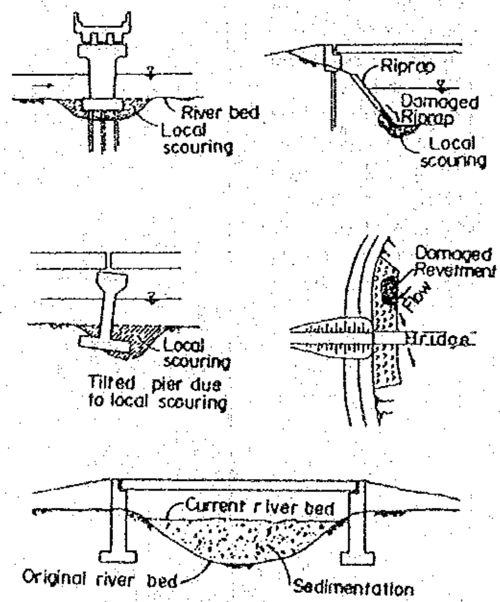
<table>
<tr><th>Sub-Classi-fication</th><th>Definition</th><th>Illustration</th></tr>
<tr><td>Permanent Bridge Other Damages</td><td>· Other damages include local scouring at pier, local scouring and damages of riprap or stone masonry around abutment, tilting of pier, local scouring of rivetment near abutment raising of river bed elevation due to sedimentation, etc.</td><td>
</td></tr>
</table>

TABLE 3.1-2 (11) DEFINITION OF TEMPORARY BRIDGE WASHOUT (TBr-W)

Sub-Classi-fication	Definition	Illustration
Temporary Bridge Washout	· Washout of temporary bridge due to reasons mentioned in Table 6.1-2 (8)	· Refer to Table 6.1-2 (8)

TABLE 3.1-2 (12) DEFINITION OF TEMPORARY BRIDGE APPROACH WASHOUT (TBr-A)

Sub-Classi-fication	Definition	Illustration
Temporary Bridge Approach Washout	· Washout of temporary bridge approach due to reasons mentioned in Table 6.1-2 (9).	· Refer to Table 6.1-2 (9)

TABLE 3.1-2 (13) DEFINITION OF TEMPORARY BRIDGE OTHER DAMAGE (TBr-D)

Sub-Classi-fication	Definition	Illustration
Temporary Bridge Other Damages	· Other damages include those mentioned in Table 6.1-2 (10).	· Refer to Table 6.1-2 (10)

TABLE 3.1-2 (14) DEFINITION OF SPILLWAY DAMAGE (SPW-D)

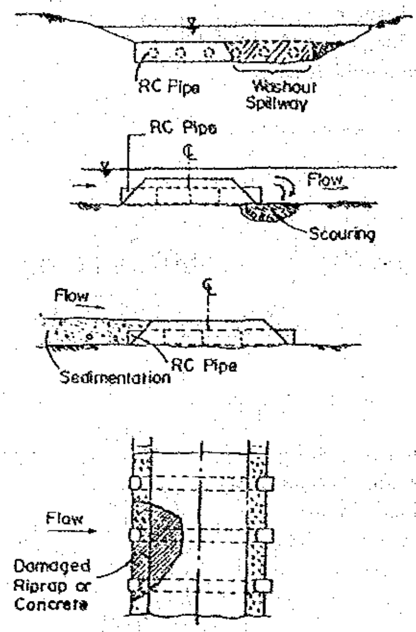
Sub-Classification	Definition	Illustration
Spillway Damage	· Washout of spillway due to scouring, collapse of riprap and/or surface concrete, washout of approach, clogged pipes, etc. · Damages include partial washout of spillway, damages of pipes and riprap, approach damages, etc.	

TABLE 3.1-2 (15) DEFINITION OF CULVERT DAMAGE (CLV-D)

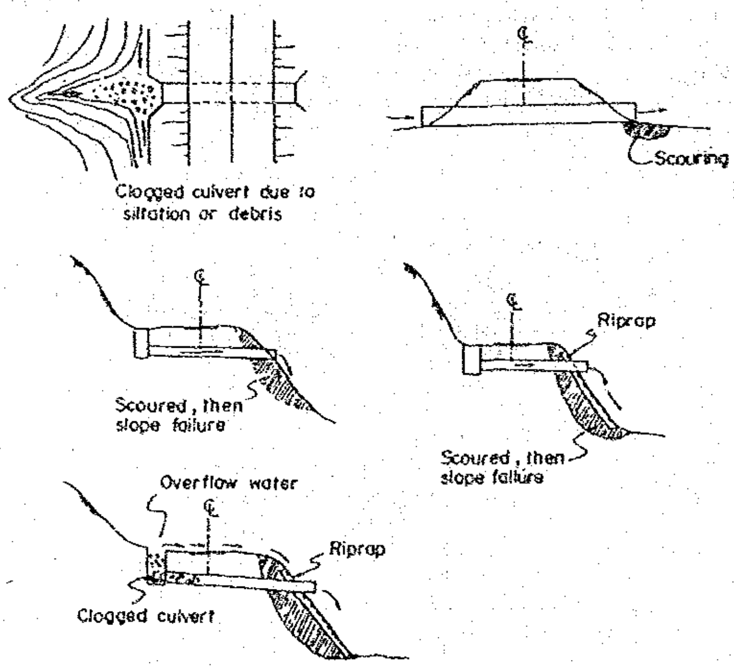
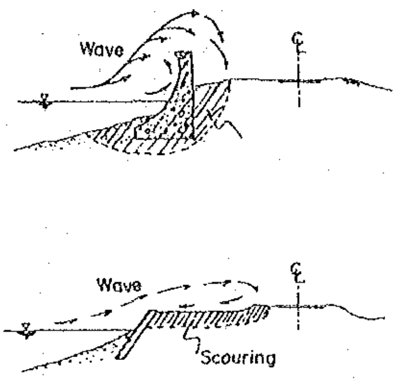
Sub-Classification	Definition	Illustration
Culvert Damage	· Culvert damage includes clogging of culvert due to siltation or debris, scouring at outlet, etc · Culvert related damages include embankment slope failure caused by scouring at culvert outlet, flooding of road surface due to non-functioning culvert etc.	

TABLE 3.1-2 (16) DEFINITION OF SEAWALL DAMAGE (SW-D)

Sub-Classi-fication	Definition	Illustration
Seawall Damage	· Seawall washout or damages due to wave action. · Damage includes scouring of shoulder due to wave action.	

CHAPTER 4
S U R V E Y S

CHAPTER 4

SURVEYS

Road disaster surveys are usually conducted in two different stages:

- Initial survey which is conducted immediately after the occurrence of road disaster for getting information necessary to take proper urgent measures; and
- Detailed survey which is conducted for getting necessary information/data for detailed design and construction of permanent restoration measures.

In this Manual, the former is called survey for urgent restoration measures, while the latter survey for permanent restoration measures.

4.1 SURVEY FOR URGENT RESTORATION MEASURES

Survey for urgent restoration measures is an initial survey which is conducted immediately after the occurrence of road disaster is reported, with the following objectives:

- To grasp the situation of road disaster on type/nature, location and extent;
- To assess the cause of disaster;
- To get the information necessary for deciding the urgent restoration measures to be taken; and
- To get the information necessary for planning the survey for permanent restoration measures.

The survey is conducted by field reconnaissance.

Based on the field reconnaissance, type of disaster is determined in accordance with the definitions described in Chapter 3. The cause of disaster is assessed by visual inspection, wherein Table 4.1-1 may serve as reference.

To decide the urgent restoration measures to be taken, the following information/assessment are necessary:

- Site conditions including topography, geology and water condition;
- Type, extent and cause of road disaster;
- Impact on traffic;
- Presence of materials endangering traffic, like unstable stones on slope suspicious to fall down; and
- Possibility of prompt progress of damage.

The information/assessment based on the field reconnaissance should be properly recorded together with sketch and photographs to supplement the record. The proposed recording forms are presented in Tables 4.1-3 (1) to (8), one of which is selected depending on the type of road disaster as shown in Table 4.1-2.

Procedures for making a sketch are as follows:

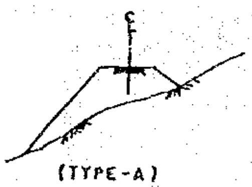
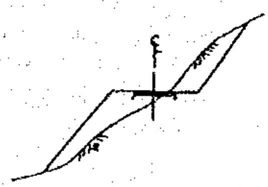
Procedure For Sketching Plans

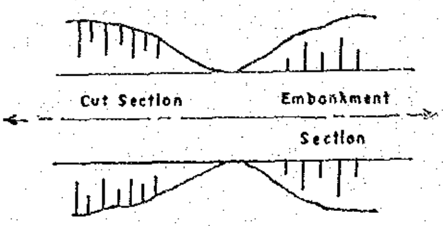
1. Draw road centerline alignment.
2. Draw pavement edge lines, shoulder lines and side ditches. When there is no side-ditch, describe "no side ditch" on the plan.
3. Indicate on the plan an approximate vertical grades in %.
4. Indicate damaged portion. Length, width, height, etc. shall be noted on the plan.
5. *Topographic characteristics shall be indicated by contour lines. If steep slopes, dense* contour line interval will be used.
6. Indicate all existing structures such as ripraps, cross drainages, wing walls, inlet/outlet of drainage facilities, houses, etc. Location, dimensions, depth from road surface, etc. shall be indicated on the plan.
7. Conditions such as existence of gulley, flow of surface water, sedimentary condition, clogged pipes, etc. which suggest potential causes shall be noted on the plan.
8. For bridge/spillway spots, river conditions such as listed in Table 4.1-1 shall be *indicated on the plan.*
9. Indicate locations of cross sections measured.

Procedure for Sketching Cross Sections

1. Select locations of cross sections to be measured (probably 2- 3 cross sections per spot will be required).
2. Measure distances from the centerline and height/depth from road surface.
3. Draw cross sections and indicate distance and height/depth.

TABLE 4.1-1 CHECKLIST AND GENERAL POTENTIAL CAUSES

Type of Disaster	Check Items	General Potential Causes
1. Cut Slope Failure (C-F)	1) Surface water condition - Existence of gulley, sag portion of a slope which causes concentration of surface water 2) Sub-surface water condition - Existence of seepage water, etc. 3) Top soil layer depth 4) Rock formation and condition - One kind of rock of several layers of different rocks - Condition of weathering, cracks and joints	· Unstable slope gradient (too steep and too high) · Surface water runs slope surface with high velocity due to bare and steep gradient · A slope has irregular surface and water concentrates at sagged portion causing erosion · Top soils on the inclined hard layer slides due to saturated water in top soils · Weathered rocks slide due to rainfall · Rotational failure along circular slide plane with weak shear strength · Translational failure which occurs along structural weakness such as faults, bedding planes and border planes between firm bedrock and overlying detritus or soils
2. Embankment Slope Failure (E-F)	1) Horizontal alignment of the road 2) Vertical alignment of the road 3) Super-elevation of the road 4) Type and width of pavement 5) Existence of side ditches and type, dimension and sedimentation of side ditches 6) Topography of mountain side slope particularly existence of stream or valley or sagged topography 7) River current directly hits the embankment (in this case, classify as Rd-D) 8) Type of cross-section  (TYPE-A)  (TYPE-B)	· Unstable slope gradient · Concentration of surface water · Failure caused by water saturation in embankment · Failure caused by saturation of water due to seepage of surface or underground water (cross section Type-A or Type-B) · Same as above, but at the boundary between cut section and embankment section (Type-C) · Slope with no vegetation and berms on which water runs with high velocity

Type of Disaster	Check Items	General Potential Causes
(EF)	9) No cross-drainage, where it should have been provided (in this case, classify as CLV-D) 10) Existence of riprap/stone masonry protection - Height, thickness, etc. 11) Damaged riprap/stone masonry - Grouted or not - Existence of foundation and depth of foundation embedment - Existence of weep holes and whether they are functioning or not - Back filling is compacted enough or not, and material used 12) Whether it is located at the boundary between cut section and embankment section  (TYPE-C)	
3. Rock Fall/ Debris Fall (FALL)	1) Rock fall or debris fall 2) Rock formation and condition - one kind of rock or several layers of different rocks - condition of weathering, cracks and joints 3) Concentration of surface water - Existence of gulley, sag portion 4) Seepage of water from slope surface	· Rocks with highly weathered or developed cracks/joints · In case of debris falls, same causes as cut slope failure
4. Land-slide (L-SL)	1) Existence of cliff in a slope 2) Irregularity of road surface (sinking road surface or horizontal slide of road surface) 3) Seepage of water from a slope 4) Existence of tension cracks on a slope	· Rock landslide occurs along structural weakness in rock or in weathered rock of weak · Shear strength · Soil landslide occurs along sliding plane of colluvial soil or clayey soil or along border plane between firm rock and soils

Type of Disaster	Check Items	General Potential Causes
5. Debris Flow (D-FL)	1) Identify location of spot on 1/50,000 topo map. (Area of basin will be determined and plan will be also developed based on 1/50,000 top map at an appropriate scale) 2) Existence of deposits on the stream bed 3) Vegetation of slopes at both sides of a stream (slopes easily eroded or not)	· Deposits on stream bed made by - accumulated soils and gravels brought from further upstream - materials brought by erosion of devastated slopes - failures of slopes on one or both sides of a stream
6. Scour/Wash-out of Road-bed (Rd-D)	1) Direction of river stream 2) High water level of a river which is obtained by interviewing local officials or nearby residents 3) Sea wave height 4) Riprap/stone masonry/sea wall (same information mentioned in E-F) 5) Flood level (how many cm from road surface)	· Meandering river frequently changes its course and river stream hits the embankment directly · Overflowing water on a road surface scoures shoulder/road bed · No protection against sea wave is provided · Improperly constructed protections
7. Flooded/Muddy Road Surface (FM-Rd)	1) Road surface elevation vs. abutting land 2) Existence of side ditches 3) Dimension of side ditches 4) Flood level above road surface 5) Road surface material	· No proper drainage facilities · Improper road elevation · Improper material of road surface
8. Permanent Bridge Wash-out (PBr-W)	1) Bridge length (Distance between abutments) 2) Span length (Distance between piers) 3) Scouring depth at abutment, piers and river-bank protection 4) River condition - Width of flood plane - General direction of river course changes - Past history of river course changes - Flood water level - River bed deposit (max and mean size of gravel/cobbles) - Tendency of river bed (rising or lowering) - Clearance between flood water level and bridge	· Too short bridge length, thus insufficient opening at bridge site, and flood discharge cannot be accomodated. Usually bridge approach encroach flood plain · Too short span length between piers which causes accumulation of trees and logs flowed from upstream · Insufficient free board which causes accumulation of trees and logs. Insufficient free board may be due to sedimentation or design errors · Local scouring at abutments, piers, approach protections and river bank protections · Insufficient embedment of foundation or improper type of foundation · Meandering river usually changes its river course, resulting in deep local scouring of unexpected portion
9.(PBr-A) 10.(PBr-D) 11.(TBr-W) 12.(TBr-A) 13.(TBr-D)	· Same check items as 8. PBr-W	· Same causes as 8. PBr-W

Type of Disaster	Check Items	General Potential Causes
14. Spill-way Damage (SPW-D)	1) Vertical alignment along road center line 2) Damaged length and width 3) Materials used for spillway - Concrete - Riprap - RCP (Diameter) 4) Length of spillway 5) River condition - Same as 8. PBr-W 6) Scouring depth 7) Condition of sedimentation 8) Cross section of spillway	· Deep local scouring at downstream side which leads to collapse of spillway · Too short spillway, thus scouring/washout of approach, then washout of spillway · Improper materials and/or construction · Cracks of spillway surface due to axle load which leads to washout of materials under spillway surface · Sedimentation at upstream side due to which function is lost
15. Cul-vert Damage (CLV-D)	1) Horizontal and vertical alignment of the road 2) Super-elevation of the road 3) Type and width of pavement 4) Existence of side ditches, type, dimension and sedimentation of side ditches 5) Topography of mountain side slope 6) Type, dimension and condition of cross-drainage facility 7) Inlet and outlet facilities and their condi-tions 8) Damaged condition of slopes near the cross-drainage 9) River or stream condition for both upstream and downstream sides	· Clogged culvert or insufficient capacity of culvert causes over flow of concentrated surface water over road surface and damaging embankment slopes · No outlet drainage facilities or insufficient length of apron are provided, thus water runs directly on a slope, causing deep scouring · Riprap around a culvert and a slope is poorly constructed, thus easily damaged by drained water · At curved or sagged section where surface water concentrate no drainage facilities are provided
16. Sea-wall Damage (SW-D)	1) Distance from seawall to seashore and distance from seawall to a road centerline 2) Type and width of road pavement and shoulder 3) Type of seawall 4) Damaged condition - Grouting was properly done or not - Foundation was properly constructed or not - Others 5) Wave height during typhoon (by interviewing local officials and/or nearby residents)	· Poorly constructed seawall, and is not water-tight structure · Insufficient height of seawall · Foundation embedment is not sufficient and scoured

TABLE 4.1-2 INSPECTION SHEETS AND THEIR APPLICATION

FORM NO. AND TITLE	TYPE OF ROAD DISASTER
Form-1: Cut Slope Failure Inspection Sheet	Cut Slope Failure
Form-2: Embankment Slope Failure Inspection Sheet	Embankment Slope Failure
Form-3: Fall Inspection Sheet	Rock Fall/Debris Fall
Form-4: Landslide Inspection Sheet	Landslide
Form-5: Debris Flow Inspection Sheet	Debris Flow
Form-6: Road Damage Inspection Sheet	Scour/Washout of Roadbed, Flooded/Muddy Road Surface, and Seawall Damage
Form-7: Bridge Damage Inspection Sheet	Permanent Bridge Washout, Permanent Bridge Approach Washout, Permanent Bridge Other Damage, Temporary Bridge Washout, Temporary Bridge Approach Washout, Temporary Bridge Other Damage, and Spillway Damage
Form-8: Culvert Damage Inspection Sheet	Culvert Damage

TABLE 4.1-3 (1) FIELD INSPECTION SHEET FORM-1

FORM-1

CUT SLOPE FAILURE
INSPECTION SHEET

SPOT NO.	
NAME OF PROVINCE	

NAME OF ROAD (Road No.)			
CLASSIFICATION OF ROAD			(1) NATIONAL ROAD (2) PROVINCIAL ROAD (3) BARANGAY ROAD
LOCATION OF SPOT			
NO. OF LANES AND ROADWAY WIDTH			(1)1-LANE (2)2-LANE TOTAL WIDTH: PAVE.WIDTH:
SURFACE TYPE			(1)PCC (2)AC (3)GRAVEL (4)EARTH
EVIDENCE OF FAILURE	1	TYPE OF SLOPE	(1)CUT SLOPE (2)NATURAL SLOPE (3)( )
	2	KIND OF FAILURE	(1)SURFACE FAILURE (2)DEEP FAILURE (3)( )
	3	SIZE OF FAILURE	(1)WIDTH(m): (2)HEIGHT(m):
	4	DATE OCCURED	/ / 19 ___
	5	TRAFFIC INTERRUPTION PERIOD	(1)1 DAY > (2)1 DAY - 7 DAYS (3)7 DAYS <
	6	COUNTERMEASURE	(1)STRUCTURE( )(2)REMOVAL OF SLIDE MATERIALS (3)
	7	RAINFALL INTENSITY (mm/day)	(1)100 > (2)100-200 (3)200-300 (4)300 <
EXISTING SLOPE CONDITION	8	HEIGHT	(1)10 m > (2)10-30 m (3)30-50 m (4)50 m <
	9	GRADIENT	(1) 45°> (2)45°-60° (3)60°< (4)OVERHANG
	10	BERM	(1)NONE (2)EXISTING NUMBER( )(3)WIDTH( )
	11	PROTECTION	(1)NONE (2)VEGETATION (3)STRUCTURE( )
GEOLOGICAL CONDITION — ROCK	12	HARDNESS	(1)HARD ROCK (2)SOFT ROCK (3)( )
	13	ROCK NAME (INDICATE SAMPLE NO. IF ANY)	(1)GRANITE (2)DIORITE (3)DIABASE (4)ANDESITE (5)DIACITE (6)SCHIST (7)STATE (8)LIMESTONE (9)SCHALTEN (10)TUFF (11)TUFFBRECCIA (12)SANDSTONE (13)SHALE (14)MUDSTONE (15)CONGLOMERATE (16)MASS (17)VOLCANICLATIOS SAMPLE NO.
	14	WEATHERING CONDITION	(1)FRESH (2)SLIGHTLY WEATHERED (3)HIGHLY WEATHERED (4)NEARLY SOIL
	15	CONDITION OF CRACK	(1)SPARSE (2)REGULAR (3)DEVELOPED (4)OPENING CRACK.
	16	DIRECTION OF CRACK	(1)INCLINED TO MOUNTAIN (2)INCLINED TO SLOPE (3)IRREGULAR INCLINATION
GEOLOGICAL CONDITION — SOIL	17	THICKNESS	(1)1 m (2)1-5 m (3)5-10 m (4)10-20 m (5)20 m <
	18	COMPACTNESS	(1)TIGHT (2)SLIGHTLY LOOSE (3)LOOSE
WATER CONDITION	19	DEGREE OF SATURATION	(1)DRY (2)WET (3)SEEPAGE (4)SPRING
	20	SURFACE WATER CONCENTRATION	(1)NONE (2)LOW (3)HIGH
	21	DRAINAGE FACILITIES	(1)EXISTING( ) (2)NOTHING
ENGINEERING JUDGEMENT	22	IMPACT TO ROAD	(1)LOW (2)MEDIUM (3)HIGH
	23	CAUSE OF DAMAGE	(1)SEEPAGE WATER (2)SEISMIC (3)( )
	24	COUNTERMEASURE	
	25	DETOUR ROAD	(1)NONE (2)AVAILABLE

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

TABLE 4.1-3 (2) FIELD INSPECTION SHEET FORM-2

FORM-2

EMBANKMENT SLOPE FAILURE
INSPECTION SHEET

SPOT NO.	
NAME OF PROVINCE	

NAME OF ROAD (Road No.)			
CLASSIFICATION OF ROAD			(1) NATIONAL ROAD (2) PROVINCIAL ROAD (3) BARANGAY ROAD
LOCATION OF SPOT			
NO. OF LANES AND ROADWAY WIDTH			(1)1-LANE (2)2-LANE TOTAL WIDTH: PAVE.WIDTH:
SURFACE TYPE			(1)PCC (2)AC (3)GRAVEL (4)EARTH
EVIDENCE OF FAILURE	1	TYPE OF SLOPE	(1)EMBANKMENT (2)NATURAL (3)BRIDGE APPROACH
	2	LOCATION	(1)INSIDE OF CURVE (2)ADJACENT TO RIVER/SEA (3)BRIDGE APPROACH (4)( )
	3	SIZE OF FAILURE	(1)WIDTH(m): (2)HEIGHT(m):
	4	DATE OCCURED	/ / 19 ___
	5	TRAFFIC INTERRUPTION PERIOD	(1)1 DAY > (2)1 DAY - 7 DAYS (3)7 DAYS <
	6	COUNTERMEASURE	(1)ONLY FILL (2)RIPRAP (3)STRUCTURE ( ) (4) ( )
	7	RAINFALL INTENSITY (mm/day)	(1)100 > (2)100-200 (3)200-300 (4)300 <
EXISTING SLOPE CONDITION	8	HEIGHT	(1) 5 m > (2) 5-10 m (3)10 m <
	9	GRADIENT	(1) 45°> (2)45°-60° (3)60°<
	10	PROTECTION	(1)NONE (2)VEGETATION (3)RIPRAP (4)STRUCTURE( )
	11	SURFACE WATER CONCENTRATION	(1)NONE (2)LOW (3)HIGH ( )
	12	DRAINAGE FACILITIES	(1)EXISTING ( ) (2)NOTHING
ENGINEERING JUDGEMENT	13	IMPACT TO ROAD	(1)LOW (2)MEDIUM (3)HIGH
	14	CAUSE OF DAMAGE	(1)CONCENTRATION OF SURFACE WATER (2)RIVER STREAM (3)SEA WAVE (4)( )
	15	COUNTERMEASURE	
	16	DETOUR ROAD	(1)NONE (2)AVAILABLE

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

TABLE 4.1-3 (3) FIELD INSPECTION SHEET FORM-3

FORM-3

FALL INSPECTION SHEET

SPOT NO.	
NAME OF PROVINCE	

NAME OF ROAD (Road No.)			
CLASSIFICATION OF ROAD			(1) NATIONAL ROAD (2) PROVINCIAL ROAD (3) BARANGAY ROAD
LOCATION OF SPOT			
NO. OF LANES AND ROADWAY WIDTH			(1)1-LANE (2)2-LANE TOTAL WIDTH: PAVE.WIDTH:
SURFACE TYPE			(1)PCC (2)AC (3)GRAVEL (4)EARTH
EVIDENCE OF FALL	1	TYPE OF SLOPE	(1)CUT SLOPE (2)NATURAL SLOPE (3)( )
	2	TYPE OF FALL	(1)DEBRIS FALL (2)ROCK FALL (3)( )
	3	FALLEN ROCK SIZE	(1)20(cm)> (20-50(cm) (3)50(cm)
	4	DATE OCCURED	/ / 19 ___
	5	TRAFFIC INTERRUPTION PERIOD	(1)1 DAY > (2)1 DAY - 7 DAYS (3)7 DAYS <
	6	COUNTERMEASURE	(1)STRUCTURE( )(2)REMOVAL OF FALLEN ROCK (3)( )
	7	RAINFALL INTENSITY (mm/day)	(1)100 > (2)100-200 (3)200-300 (4)300 <
EXISTING SLOPE CONDITION	8	HEIGHT	(1)10 m > (2)10-30 m (3)30-50 m (4)50 m <
	9	GRADIENT	(1) 45°> (2)45°-60° (3)60°< (4)OVERHANG
	10	DEGREE OF SATURATION	(1)DRY (2)WET (3)SEEPAGE (4)SPRING
	11	SURFACE WATER CONCEN-TRATION	(1)NONE (2)LOW (3)HIGH))
	12	BERM	(1)NONE (2)EXISTING NUMBER ( ) WIDTH ( )
	13	SLOPE PROTECTION	(1)NONE (2)VEGETATION (3)STRUCTURE ( )
	14	DRAINAGE FACILITIES	(1)NONE (2)EXISTING ( )
GEOLOGICAL CONDITION — DEBRIS FALL	15	MATRIX CONDITION	(1)HARD (2)SOFT (3)LOOSE (4)LOOSE WITH DETACHED COBBLE
	16	GULLY	(1)RARE (2)COMMON (3)FREQUENTLY
	17	DETACHED ROCK & COBBLE	(1)NOTHING (2)SUPPORTED STABLY (3)SUPPORTED UNSTABLY
GEOLOGICAL CONDITION — ROCK FALL	18	ROCK NAME	(1)GRANITE (2)DIORITE (3)DIABASE (4)ANDESITE (5)DICITE (6)SCHIST (7)SLATE (8)LIMESTONE (9)SCHALSTONE (10)TUFF (11)TUFFBRECCIA (12)SANDSTONE (13)SHALE (14)MUDSTONE (15)CONGLOMERATE (16)MASA (17)VOLCANICLASTIES
	19	WEATHERING CONDITION	(1)FRESH (2)SLIGHTLY WEATHERED (3)HIGHLY WEATHERED
	20	CONDITION OF CRACK	(1)SPARSE (2)REGULAR (3)DEVELOPED
	21	DIRECTION OF CRACK	(1)INCLINED MOUNTAIN (2)IRREGULAR INCLINATION (3)INCLINED SLOPE
ENGINEERING JUDGEMENT	22	IMPACT TO ROAD	(1)LOW (2)MEDIUM (3)HIGH
	23	CAUSE OF FALL	
	24	COUNTERMEASURE	
	25	DETOUR ROAD	(1)NONE (2)AVAILABLE

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

TABLE 4.1-3 (4) FIELD INSPECTION SHEET FORM-4

FORM-4

LANDSLIDE INSPECTION SHEET

			SPOT NO.
		NAME OF PROVINCE	

NAME OF ROAD (Road No.)			
CLASSIFICATION OF ROAD			(1) NATIONAL ROAD (2) PROVINCIAL ROAD (3) BARANGAY ROAD
LOCATION OF SPOT			
NO. OF LANES AND ROADWAY WIDTH			(1)1-LANE (2)2-LANE TOTAL WIDTH: PAVE.WIDTH:
SURFACE TYPE			(1)PCC (2)AC (3)GRAVEL (4)EARTH
EVIDENCE OF FAILURE	1	TYPE OF SLOPE	(1)CUT SLOPE (2)NATURAL SLOPE
	2	TYPE OF LANDSLIDE	(1)ROCK (2)TALUS (3)SOIL
	3	SIZE OF LANDSLIDE	(1)WIDTH ( ) (2)HEIGHT ( )
	4	DATE OCCURED	/ / 19 ___
	5	TRAFFIC INTERRUPTION PERIOD	(1)1 DAY > (2)1 DAY - 7 DAYS (3)7 DAYS <
	6	RAINFALL INTENSITY (mm/day)	(1)100 > (2)100-200 (3)200-300 (4)300 <
TOPO-GRAPHICAL AND GEOLOGICAL CONDITION	7	EXISTING OF IRREGULAR SURFACE WITH STEPS, SHARP CLIFF AND PUDDLES	(1)UNNOTICED (2)MEDIUM (3)REMARKABLE (4)( )
	8	GEOLOGY	(1)SEDIMENTARY ROCK (2)HIGHLY WEATHERED SEDIMENTARY ROCK OR TALUS OR SOIL (3)OTHERS
OTHER CONDITION	9	DEGREE OF SATURATION	(1)DRY (2)WET (3)SEEPAGE (4)SPRING
	10	GRADIENT OF SLIDE PLAN	(1)10°> (2)10°-20° (3)20°<
	11	CONTINUITY OF SLIDE MOVEMENT	(1)UNNOTICED (2)MEDIUM (3)REMARKABLE
ENGINEERING JUDGEMENT	12	IMPACT TO ROAD	(1)LOW (2)MEDIUM (3)HIGH
	13	CAUSE OF LANDSLIDE	
	14	COUNTERMEASURE	
	15	DETOUR ROAD	(1)NONE (2)AVAILABLE

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

TABLE 4.1-3 (5) FIELD INSPECTION SHEET FORM-5

FORM-5

DEBRIS FLOW INSPECTION SHEET

SPOT NO.	
NAME OF PROVINCE	

NAME OF ROAD (Road No.)			
CLASSIFICATION OF ROAD			(1) NATIONAL ROAD (2) PROVINCIAL ROAD (3) BARANGAY ROAD
LOCATION OF SPOT			
NO. OF LANES AND ROADWAY WIDTH			(1)1-LANE (2)2-LANE TOTAL WIDTH: PAVE.WIDTH:
SURFACE TYPE			(1)PCC (2)AC (3)GRAVEL (4)EARTH
EVIDENCE OF DEBRIS FLOW	1	EXISTING OF DEPOSITIONAL TOE	(1)EXISTING (2)NOTHING (3) ( )
	2	SIZE OF DAMAGE	(1)WIDTH( ) (2)LENGTH ( )
	3	DATE OCCURED	/ / 19 ___
	4	TRAFFIC INTERRUPTION PERIOD	(1)1 DAY > (2)1 DAY - 7 DAYS (3)7 DAYS <
	5	RAINFALL INTENSITY (mm/day)	(1)100 > (2)100-200 (3)200-300 (4)300 <
EXISTING FLOW CONDITION	7	AVERAGE GRADIENT	(1)20°> (2)20°-30° (3)30°<
	8	AREA OF BASIN	(1)50000m2 (2)50000-200000m2 (3)200000m2 <
	9	DEPOSIT ON RIVERBED	(1)NONE (2)RARE (3)ABUNDANCE
	10	VEGETATION	(1)COVERING RATE OF BARE LAND OR THIN FOREST: 50% > OR 50<
ENGINEERING JUDGEMENT	11	IMPACT TO TRAFFIC	(1)LOW (2)MEDIUM (3)HIGH
	12	CAUSE OF DAMAGE	
	13	COUNTERMEASURE	
	14	DETOUR ROAD	(1)NONE (2)AVAILABLE

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

TABLE 4.1-3 (6) FIELD INSPECTION SHEET FORM-6

FORM-6

ROAD DAMAGE INSPECTION SHEET

SPOT NO.	
NAME OF PROVINCE	

NAME OF ROAD (Road No.)			
CLASSIFICATION OF ROAD			(1) NATIONAL ROAD (2) PROVINCIAL ROAD (3) BARANGAY ROAD
LOCATION OF SPOT			
NO. OF LANES AND ROADWAY WIDTH			(1)1-LANE (2)2-LANE TOTAL WIDTH: PAVE.WIDTH:
SURFACE TYPE			(1)PCC (2)AC (3)GRAVEL (4)EARTH
GENERAL INFORMATION	1	TERRAIN	(1)FLAT (2)ROLLING (3)MOUNTAINOUS
	2	CROSS-SECTION	(1)FILL (2)CUT (3)CUT/FILL (4)FLAT
	3	ROADBED MATERIAL	(1)GRAINED (2)GRAVEL (3)COMMON (4)
EVIDENCE OF DAMAGE	4	TYPE OF DAMAGE	(1)WASHOUT/SCOURING OF ROADBED (2)SCOURING OF SHOULDER (3)FLOODING/MUDDY SURFACE (4)SEAWALL DAMAGE/WASHOUT
	5	LENGTH OF DAMAGE	
	6	DATE OCCURED	/ / 19__
	7	TRAFFIC INTERRUPTION PERIOD	(1)1 DAY > (2)1 DAY - 7 DAYS (3)7 DAYS <
	8	RAINFALL INTENSITY (mm/day)	(1)100 > (2)100-200 (3)200-300 (4)300 <
	9	COUNTERMEASURE	
EXISTING ROAD CONDITION	10	SURFACE CONDITION	(1)FAIR (2)BAD (3)VERY BAD (4)IMPASSABLE
	11	DRAINAGE FACILITIES	(1)EXISTING ( ) (2)NONE
	12	DRAINAGE CONDITOIN	
ENGINEERING JUDGEMENT	13	IMPACT TO TRAFFIC	(1)LOW (2)MEDIUM (3)HIGH
	14	CAUSE OF DAMAGE	(1)CONCENTRATION OF SURFACE WATER (2)FLOOD (3)RIVER STREAM (4)SEA WAVE (5)
	15	COUNTERMEASURE	
	16	DETOUR ROAD	(1)NONE (2)AVAILABLE

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

TABLE 4.1-3 (7) FIELD INSPECTION SHEET FORM-7

FORM-7

BRIDGE DAMAGE INSPECTION SHEET

SPOT NO.	
NAME OF PROVINCE	

NAME OF ROAD (Road No.)				
CLASSIFICATION OF ROAD				(1) NATIONAL ROAD (2) PROVINCIAL ROAD (3) BARANGAY ROAD
LOCATION OF SPOT				
NAME OF BRIDGE				
NO. OF LANES AND ROADWAY WIDTH				(1)1-LANE (2)2-LANE | TOTAL WIDTH: | PAVE.WIDTH:
SURFACE TYPE				(1)PCC (2)AC (3)GRAVEL (4)EARTH
TYPE OF BRIDGE				(1)PERMANENT (2)TEMPORARY (3)SPILLWAY
GENERAL INFORMATION	1	BRIDGE LENGTH (SPAN LENGTH) (m)		
	2	BRIDGE WIDTH (m)		
	3	TYPE OF SUPERSTRUCTURE		
	4	TYPE OF ABUTMENT		
	5	TYPE OF PIER		
	6	TYPE OF FOUNDATION		
DAMAGE	7	SUPERSTRUCTURE		
	8	SUB-STRUCT-TURE	ABUTMENT	
	9		PIER	
	10		OTHERS	
	11	MOVEMENT		(1)SCOUR (2)TILTING (3)SETTLEMENT (4)SLIDING (5) ( )
	12	APPROACH ROAD		
	13	RIVER CONDITION		
	14	DATE OCCURED		/ / 19__
	15	TRAFFIC INTERRUPTION PERIOD		(1)1 DAY > (2)1 DAY - 7 DAYS (3)7 DAYS <
ENGINEERING JUDGEMENT	16	IMPACT TO ROAD		(1)LOW (2)MEDIUM (3)HIGH
	17	CAUSE OF DAMAGE		
	18	COUNTERMEASURE		
	19	DETOUR ROAD		(1)NONE (2)AVAILABLE

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

TABLE 4.1-3 (8) FIELD INSPECTION SHEET FORM-8

FORM-8

CULVERT AND ITS RELATED DAMAGE
INSPECTION SHEET

SPOT NO.	
NAME OF PROVINCE	

NAME OF ROAD (Road No.)							
CLASSIFICATION OF ROAD			(1) NATIONAL ROAD		(2) PROVINCIAL ROAD		(3) BARANGAY ROAD
LOCATION OF SPOT							
NO. OF LANES AND ROADWAY WIDTH			(1)1-LANE	(2)2-LANE	TOTAL WIDTH:		PAVE.WIDTH:
SURFACE TYPE			(1)PCC	(2)AC	(3)GRAVEL		(4)EARTH
GENERAL INFORMATION	1	TERRAIN	(1)FLAT		(2)ROLLING		(3)MOUNTAINOUS
	2	CROSS-SECTION	(1)FILL	(2)CUT	(3)CUT/FILL		(4)FLAT
	3	LOATION	(1)TANGENT SECTION		(2)CURVED SECTION		
	4	TYPE AND DIMENSION	(1)PIPE CULVERT (φ		) (2)BOX CULVERT (		m x m)
CULVERT DAMAGE	5	SILTED/BLOCKED					
	6	SCOUR					
	7	STRUCTURAL DAMAGE					
	8	OTHERS					
	9	DATE OCCURED	/ / 19___				
RELATED DAMAGE	10	DAMAGED PORTION	(1)EMBANKMENT SLOPE		(2)CUT SLOPE		(3)
	11	CAUSES OF DAMAGE					
	12	DATE OCCURED	/ / 19___				
	13	TRAFFIC INTERRUPTION PERIOD	(1)1 DAY >		(2)1 DAY - 7 DAYS		(3)7 DAYS <
ENGINEERING JUDGEMENT	14	IMPACT TO ROAD	(1)LOW		(2)MEDIUM		(3)HIGH
	15	CAUSE OF DAMAGE					
	16	COUNTERMEASURE					
	17	DETOUR ROAD	(1)NONE		(2)AVAILABLE		

TYPICAL PHOTO

DATE OF INSPECTION		INSPECTOR	

4.2 SURVEY FOR PERMANENT RESTORATION MEASURES

Survey for permanent restoration measures is a detailed survey which is carried out to investigate in detail the cause and extent of road disaster and to get information/data necessary for detailed design and construction of permanent restoration measures.

4.2.1 Kinds of Survey

Kinds of survey are as follows:

- Collection of relevant data;
- Field reconnaissance;
- Topographic survey;
- Geotechnical and hydrological survey; and
- Material survey.

1) Collection of Relevant Data

In general, the following data are collected:

- Topographic map;
- Landuse map;
- Geological map;
- Precipitation data including hourly rate, daily rate, monthly rate and annual rate;
- Hyrdologic data/information including drainage area, river characteristics and flood/highwater information;
- As-built drawings and construction records; and
- Past disaster records.

Above data are used for the following purposes:

- Grasp of situation of disaster spot;
- Input data for hydrological analysis;
- History of change in local condition; and
- Problems in original design/construction.

2) Field Reconnaissance

Field reconnaissance is conducted on the following points:

- Surface and groundwater conditions;
- Formation of soil/rock and their local conditions;
- Details of damaged portion; and
- Others

Inspection requirements depend on the type of disaster.

3) Topographic Survey

Topographic survey is conducted covering the whole area related to the damage and restoration measures to be taken. Generally, area coverage of topographic survey for this purpose is relatively small but more detailed survey is required.

4) Geotechnical and Hyrdrological Survey

Geotechnical survey includes boring, auger boring, test pit, sounding, laboratory test, seismic prospecting, etc.

In addition to the above, groundwater survey is required for landslide area or portion with spring/seepage water, and movement survey is required for large-scale landslide area to determine the sliding plane.

Survey items in relation to survey methods are shown in Table 4.2-1.

5) Material Survey

Material survey is conducted to identify sources of borrow, aggregates and other materials necessary for construction and to confirm their quantities and qualities.

TABLE 4.2-1 APPLICATION OF GEOTECHNICAL AND HYDROLOGICAL SURVEYS

Survey Item \ Survey Method		Field Reconnaissance	Seismic Prospecting	Boring	Anger Boring	Test Pit	Sounding	Soil Test	Rock Test	Groundwater Survey	Movement Survey
Soil/Rock Properties		◎	△	◎	○	○	△	◎	◎		
Geological Structure	Stratification Structure, Fault, Fracture Zone, etc	◎	◎	○							
	Crack, Joint	○	○	◎		○			○		
	Weathering	△	○	◎	△	○			△		
	Thickness of Top Soil	○	○	◎	◎	◎	○				
	Unconformity, Discontinuity	○	◎	◎		○	○				
Strength of Ground			△	○		○	○	◎	◎		
Strength of Embankment Material								◎			
Properties of Embankment Material		△		○	○	○		◎			
Deformation of Slope		◎									
Condition of Groundwater/ Seepage Level		○		○	△	○				◎	
Groundwater Level				○						◎	
Landslide	Location of Sliding Plane	△		○		○	○				◎
	Direction and Amount of Movement	△									◎
	Prediction of Movement	△									◎
	Properties of Groundwater									◎	
	Trace of Groundwater Flowing									◎	
	Groundwater Level									◎	

Note: ◎ Most Applicable
○ Applicable
△ Supplemental

4.2.2 Survey Items Requried for Each Type of Disaster

1) Survey for Cut Slope Failure (C-F)

- Deformation, crack, joint, bulge, etc. of slope should be carefully observed.
- Water conditions such as concentrations of surface water from rainfall runoff, seeps, and springs should be carefully observed.
- In order to examine slope stability, the following items should be investigated by boring/laboratory test as necessary:
  - Groundwater level;
  - Thickness of top soil;
  - Properties of top soil and base rock; and
  - State of stratification.

2) Survey for Embankment Slope Failure (E-F)

- Water conditions should be carefully observed, especially on path of surface water from rainfall runoff, and spring/seep of water which permeates from ground surface into embankment slope.
- Conditions of groundwater should be investigated particularly for the embankment on inclined ground, on the following items:
  - Distribution of groundwater;
  - Composition of permeable/impermeable layers; and
  - Direction of groundwater flow, water vein and water source.
- Properties of embankment material should be examined as necessary.

3) Survey for Rock Fall/Debris Fall (FALL)

- Presence of materials suspicious to fall should be carefully examined. The following slopes are susceptible to fall:
  - Slopes of rocks with developed cracks, joints, bedding planes, etcl; and
  - Slopes of debris or talus with matrix which is easily eroded or scoured, such as colluvial deposits, terrace gravel, volcaniclastics, etc.
- To select an appropriate measure, the following items should be examined:
  - Size of rocks anticipated to fall and their location;
  - Condition of the slope on which rocks will pass (gradient, hardness, irregularity, vegetation, etc.); and
  - Space between carriageway and slope toe.

4) Survey for Landslide (L-SL)

In order to investigate the cause of landslide and to determine the rang of landslide movement, the following surveys are conducted as well as collection of data on past landslide movements, field reconnaissance and topographic survey:

- *Geotechnical Survey*

  Landslides mainly occur along the specific slide planes, such as faults, bedding planes and border planes between firm bed rocks and overlying detritus or soil. Therefore, geotechnical survey should be carried out to investigate location, shape, extent, and soil mechanical characteristics of the slide plane. Beside this, to obtain the overall information of landslide, strength of rocks, degree of weathering, strike and inclination of stratum, conditions of faults and fractured zone, degree of cracks and joints, etc. should be surveyed.

  Boring is mainly applied to the said survey. In order to determine the location and strength of the slide plane, sounding survey is also carried out. At least four borings should be done: three on the sliding block and one on the upper part of the block. Borehole should be drilled at least 5.0 m into the firm bedrock to recognize the slide plane. Where landslide area is wide and bedrock is unconformable, seismic prospecting is usually applied with boring to sound shape of extended bedrock.

- Groundwater Survey

  It is well known that landslide frequently occurs after heavy rain and that its movement becomes active as the groundwater level rises. In order to clarify the mechanism of the landslide, the groundwater conditions such as location, fluctuation of the level, flow, runoff path, current speed, quality and temperature etc. should be investigated. Groundwater surveys can be generally classified into groundwater distribution survey and groundwater pressure survey. The contents of each survey are shown in Figure 4.2-1.