however, was not be represented in the simulation and inundation in the lowest reaches was not well simulated in the study.

12.5.4 POTENTIAL INUNDATION STUDY IN PASIG RIVER BASIN

Potential flood inundation over flood prone areas in the Pasig river basin was simulated under the following condition for 2 cases of probable flood hydroghaphs in different return periods which were given by the study of USACE. The flood runoff was input at the outlet of the Timbu river.

Topographic data	:	DTM produced by the 1995 simulation study	
	:	Area of analysis	27 km x 10 km
	:	Mesh size	100 m x 100 m

Hydrographs at Delta 5

Return period	Peak discharge (m^3/s)
20-year flood	430
100-year flood	490

Sediment concentration is given by Brown's equation for the initial discharge

The distribution of maximum water depth of every meshes is illustrated on topographic maps produced by GIS as shown in Figure 12.17 for 20 year flood and Figure 12.18 for 100 year flood.

The potential inundation areas estimated in this study are summarized as follows:

Inundation Area in Pasig river basin (unit: ha)

Water Depth	20-Year Flood	100-Year Flood
$0 < h < 0.2$	3,596	2,434
$0.2 < h < 1.0$	2,246	3,922
$1.0 < h$	224	487
Total	6,066	6,843

Total area of analysis : 27000 ha

12.6 FUTURE PROSPECT OF DISASTER MITIGATION MEASURE

12.6.1 High Risk Areas (See Figure 12.19)

(1) Lahar Avulsion into the Taug River

In June and early July 1995, the riverbed near Delta 5 aggraded by 2 to 3 m, then lahar avulsion into the Taug River was anticipated to extend the damage to Angeles City. During the 1995 rainy season channel down-cutting and widening proceeded in the whole stretch of the Pasig-Potrero River. As the active channel incised deeper, the natural ridge between the Pasig and Taug rivers became wider. This means that the width to be eroded also became wider. Thus, these channel development processes make avulsion beyond this ridge or lateral erosion to break through it less unlikely.

(2) Lahar Avulsion into the Porac River

Lahar avulsion into the Porac River has been anticipated since the beginning of the 1991 eruption. The possibility of lahar overtopping in the right bank into the Porac River becomes smaller because of the progressing channel incision. Although there is still some possibility of lahar intrusion into the Porac River by progressive meandering to break through the deposits and the terrace, the distance from the active channel to the Porac

River is more than 2 km as of now. The necessary measure to be taken in the 1996 rainy season is close monitoring regarding this matter.

(3) Lahar Overtopping around the Angeles-Porac Road

Most of the big-scale mudflows that reached to the Angeles-Porac road overtopped the left bank due to change of riverbed gradient. At present the prevailing active channel is more than 100 m wide and 20 m deep, and the flow capacity could be evaluated as corresponding to more than a 500-year flood if the riverbank was stable against flood runoff. In accordance with the reduction of frequency of mudflow occurrence, lahar overtopping in the left bank becomes more unlikely. On the other hand, the incised meander is progressing in the whole stretch, and there is some possibility of breaking the dike and overbanking onto the area in Porac and Bacolor. The necessary measure to be taken in the 1996 rainy season is also close monitoring regarding this matter.

(4) Dike Breach and Overbanking Floods along the Gugu Tertiary Dike

The major issue along the downstream reach of the Gugu tertiary dike is also dike breaching and overbanking floods caused by progressive incised meandering. Once flood water completely scours the base of the dike and reaches the low ground, it starts to rush toward the lower areas with new channeling and widely spreading out transported sediment as created in Bacolor from August to October 1995. Several critical portions were found along the old channel formed in August 1995. In order to prevent this type of flooding, construction of a protective structure with firm foundation is required at the diversion point and proper monitoring is necessary from the Angeles-Porac road to the diversion point.

(5) Dike Breach along the Right Tertiary Dike

If the diversion channel shifts toward the catch basin of the right tertiary dike, a disaster similar to the August-October 1995 events will likely happen to Santa Rita and Guagua. In order to prevent dike breaching and flooding with severe sediment deposition in Santa Rita and Guagua, the possible countermeasures are (1) construction of river training structure from the diversion point to the downstream end of the tertiary dike along the active channel, (2) construction of protective open levee with slope protection outside of the existing tertiary dike, and (3) continuous dredging and excavation in the center channel from the diversion point to the downstream end of the tertiary dike.

Combination of the protective open levee and channel excavation is deemed to be the most applicable countermeasure among the alternatives taking necessary maintenance and reliability of structures against anticipated riverbed fluctuation and meandering into consideration. It is required to connect the open levee to the right primary dike upstream of the Santa Barbara bridge for discharging overtopped flood water back to the Pasig-Potrero River, so as to prevent extending floods to the downstream areas.

(6) Flooding and Sediment Deposition along the Active Channel

Flooding and sediment deposition along the active channel on the lower reaches is the most serious and urgent problem in the whole stretch of the Pasig-Potrero River. The lower reaches have to receive muddy water even in a small amount of rain, and then transported sediment gradually accumulates over the ponding areas. The possible countermeasures are (1) construction of new channel and embankment along the active channel, (2) closing the active channel, and channel excavation along the primary dike between the diversion point and the confluence with the Guagua River, (3) construction of the protective ring dike with slope protection along the left bank of Palawe Creek connecting to the right dike of the San Fernando River, and (4) construction of the protective open levee with slope protection traversing from Dolores to Santa Barbara across the affected area.

Combination of the protective open levee and channel excavation is also deemed to be the most applicable countermeasure taking necessary land acquisition and necessary maintenance into consideration. It is required to connect the open levee to the left primary dike near the Santa Barbara bridge for discharging flood water back to the Pasig-Potrero main channel.

12.6.2 Basic Concept on Required Activities

During the 1995 rainy season, the Pasig River incised deeply on the pre-eruption alluvial deposit as well as the lahar deposit after the 1991 eruption, and the frequent and sharp meandering progressed in the whole stretch like a river course on the alluvial plain. The progress of meandering was observed to be very rapid because bank material of lahar deposit has a non-cohesive nature due to lack of clay particles. If this type of meander, incised and free meander, is planned to be controlled, bank protection work with deep foundation has to be made over the whole stretch because of the rapid progress of meandering. This type of measure is extremely costly, so that meandering which is now progressing on the Pasig River could be regarded as uncontrollable. Thus, continuous monitoring activity will play an important role to prevent serious flooding and sediment deposition, in particular, along the upper and middle reaches.

After every moderate-scale lahars and heavy rain shower, monitoring along the active channel should be conducted from Watch Point 5 to the downstream end of the tertiary dike. The major purposes of monitoring is inspecting the location and situation of the active river channel, clarifying the critical portions and their levels, and selecting the appropriate remedial measures.

Table 12.1 Major Lahar Events in Pasig-Potrero River in 1995

Lahar Event¹	Daily Rainfall (mm)	Range of Deposition Depth (m)	Volume of Deposits (million m^3)	Remarks
June 1 to 7	40 (Jun. 01) 13 (Jun. 02) 62 (Jun. 03) 17 (Jun. 04) 20 (Jun. 06) 16 (Jun. 07)	1.0	1	Typhoon Auring
July 7 to 11	61 (Jul. 07) 24 (Jul. 09) 27 (Jul. 10) 7 (Jul. 11)	Inner Area : 0.5-3.0 Outer Area : 0.8	5	
July 18	65 (Jul. 18)	0.2-1.0	2	
July 27 to 30	6 (Jul. 27) 68 (Jul. 28) 36 (Jul. 29) 109 (Jul. 30)	Inner Area : 0.6-2.6 Outer Area : 0.2-3.0	15	Typhoon Karing
August 15 to 19	44 (Aug. 15) 13 (Aug. 17) 46 (Aug. 18) 38 (Aug. 19)	Inner Area : 0.5-4.0 Outer Area : 1.0-1.8	14	
August 28 to September 3	25 (Aug. 28) 80 (Aug. 29) 49 (Aug. 30) 12 (Sep. 02) 69 (Sep. 03)	Inner Area : 0.2-4.0 Outer Area : 1.0-2.8	27	Typhoon Gening and Helming
September 30 to October 1	32 (Sep. 30) 251 (Oct. 01)	1.4-4.2	22	Typhoon Mameng
Total			86	

Note : 1) Daily rainfall indicates the data of Upper Sacobia Gauge observed by PHIVOLCS.
2) Inner area means the area between the tertiary dike system, while outer area means the area outside this system.
3) Volume of deposits indicates the volume of sediment accumulated since the earlier event.

Table 12.2 Estimate of Channel Erosion in 1995

Channel Segment	Average Eroded Area (m^2)	Active Channel Length (km)	Volume of Channel Erosion (million m^3)
Mouth of Timbu Creek - Delta 5	1,800	3.0	5.4
- Dike-Breach Point	2,400	6.4	15.4
- Diversion Point	1,500	6.2	9.3
- Downstream End of Dike System	570	18.6	10.6
Total			40.7

Note : Channel segment between diversion point and downstream end of dike system includes both the previously active and diversion channels.

Table 12.3 Summary of Secondary Explosion and Lahar Events

in 1992

Month	Rainfall (mm)	Frequency of Secondary Explosion H : Column Height in km				Frequency of Lahar in Number of Days					
						Sacobia River			Pasig River		
		H<1	1≤H<3	3≤H<5	5≤H	Small	Moderate	Big	Small	Moderate	Big
Jan.	0										
Feb.	0										
Mar.	0										
Apr.	2		1								
May	98		2								
Jun.	321	1	1								
Jul	527		5	1							
Aug	925	12	10	1	9						
Sep.	171	20	16		4						
Oct.	135	4	2		2						
Nov.	36	1	1								
Dec.	0										
Total	2215	38	38	2	15	-	-	-	-	-	-

Note : Monthly rainfall is referred to data observed at PI2
Lahar data is not compiled on the daily basis.

in 1993

Month	Rainfall (mm)	Frequency of Secondary Explosion H : Column Height in km				Frequency of Lahar in Number of Days					
						Sacobia River			Pasig River		
		H<1	1≤H<3	3≤H<5	5≤H	Small	Moderate	Big	Small	Moderate	Big
Jan.	0										
Feb.	0	1									
Mar.	0										
Apr.	0										
May	0										
Jun.	463	8	4			3	1			1	
Jul	349	10	9	1		2	3		2	1	
Aug	689	3	9	2	6	7	4		8	1	
Sep.	449		5	6		14	2		6		
Oct.	319	6	18	1		4	2	1	2	4	
Nov.	171	2	2	1					1	2	
Dec.	52		2								
Total	2492	30	49	11	6	30	12	1	19	9	0

Note : Monthly rainfall is referred to data observed at PI2

in 1994

Month	Rainfall (mm)	Frequency of Secondary Explosion H : Column Height in km				Frequency of Lahar in Number of Days					
						Sacobia River			Pasig River		
		H<1	1≤H<3	3≤H<5	5≤H	Small	Moderate	Big	Small	Moderate	Big
Jan.	21				1					1	
Feb.	59	1	4							1	1
Mar.	29	6	3							2	
Apr.	2	2	2		1				1	1	
May	28	14	5						6		
Jun.	120	3	4			5	1		3	2	
Jul	1086	4	11	3		12	2		3	5	3
Aug.	434	2	17	7	3	9	1		7	2	
Sep.	289	3	8	2	3	15	1		16	2	5
Oct	188	4	6	1	5	1	1		7		1
Nov.	0	1							3		
Dec.	13										
Total	2269	40	60	13	13	42	6	0	46	16	10

Note : Monthly rainfall is referred to data observed at UPPER-SACOBIA

in 1995

Month	Rainfall (mm)	Frequency of Secondary Explosion H : Column Height in km				Frequency of Lahar in Number of Days					
						Sacobia River			Pasig River		
		H<1	1≤H<3	3≤H<5	5≤H	Small	Moderate	Big	Small	Moderate	Big
Jan.	0										
Feb.	0										
Mar	19								1	1	
Apr.	0										
May	258		1			2			4	2	
Jun	211	2				2			2	3	1
Jul	508		2	1	2	4	1		5	6	3
Aug	501	3	2	2	1	1	2		4	4	1
Sep.	484	3	5			2	2		4	4	
Oct.	374	3	5	2			1		1	1	
Nov.											
Dec.											
Total	2355	11	15	5	3	11	6	0	21	21	5

Note : Monthly rainfall is referred to data observed at UPPER-SACOBIA

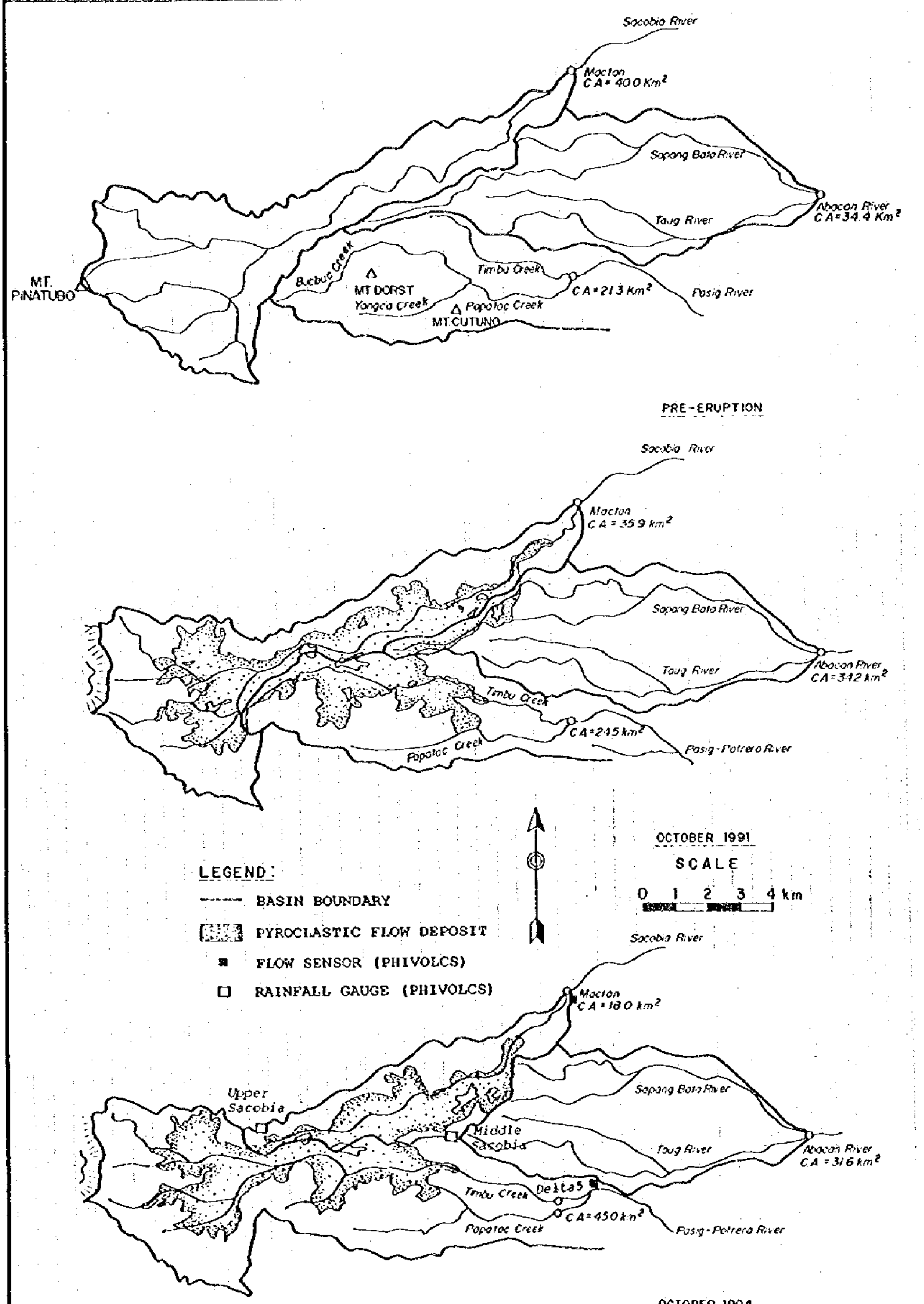


Figure 12.1

Chronological Changes of Sacobia-Abacan-Pasig Headwaters

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

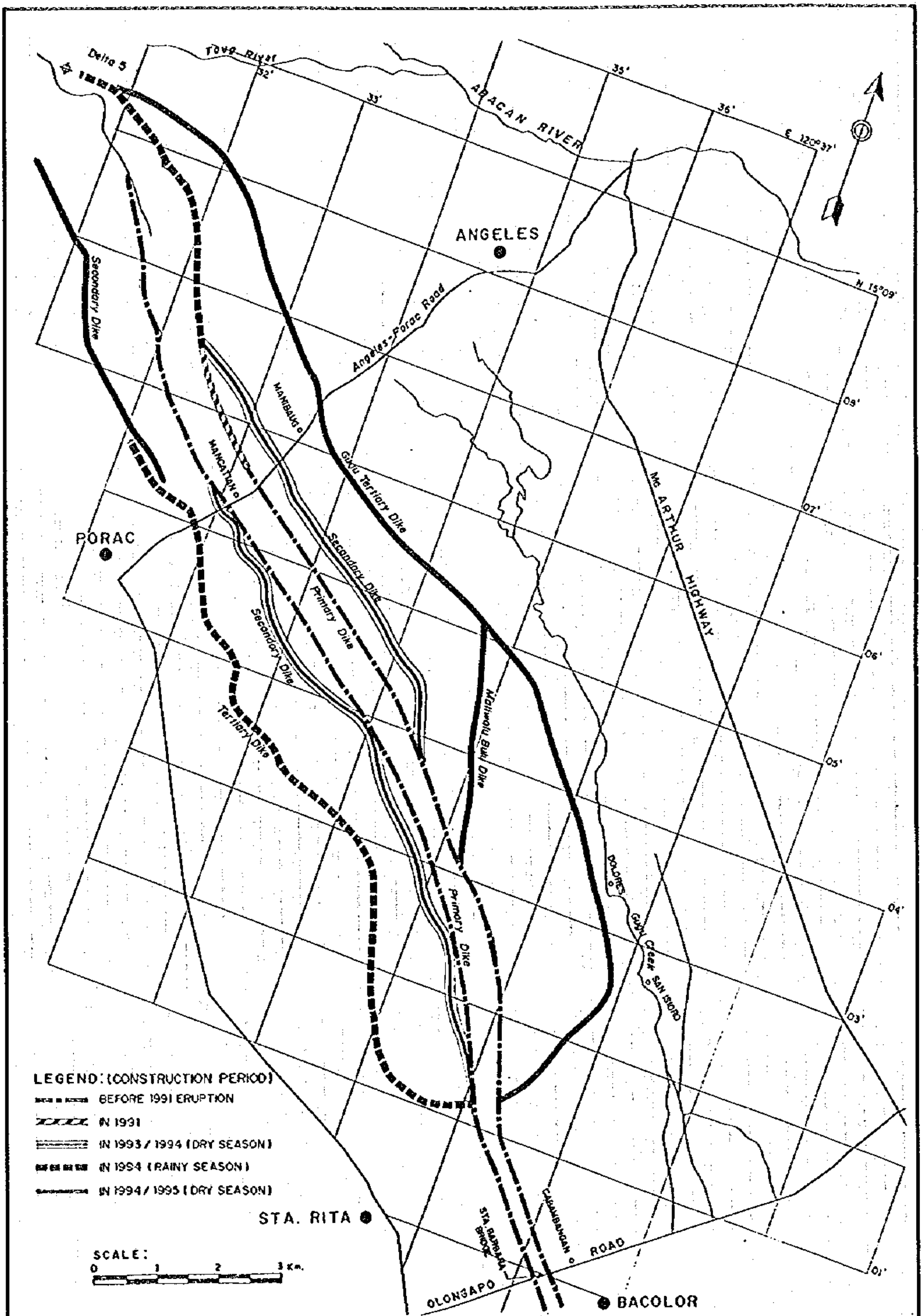
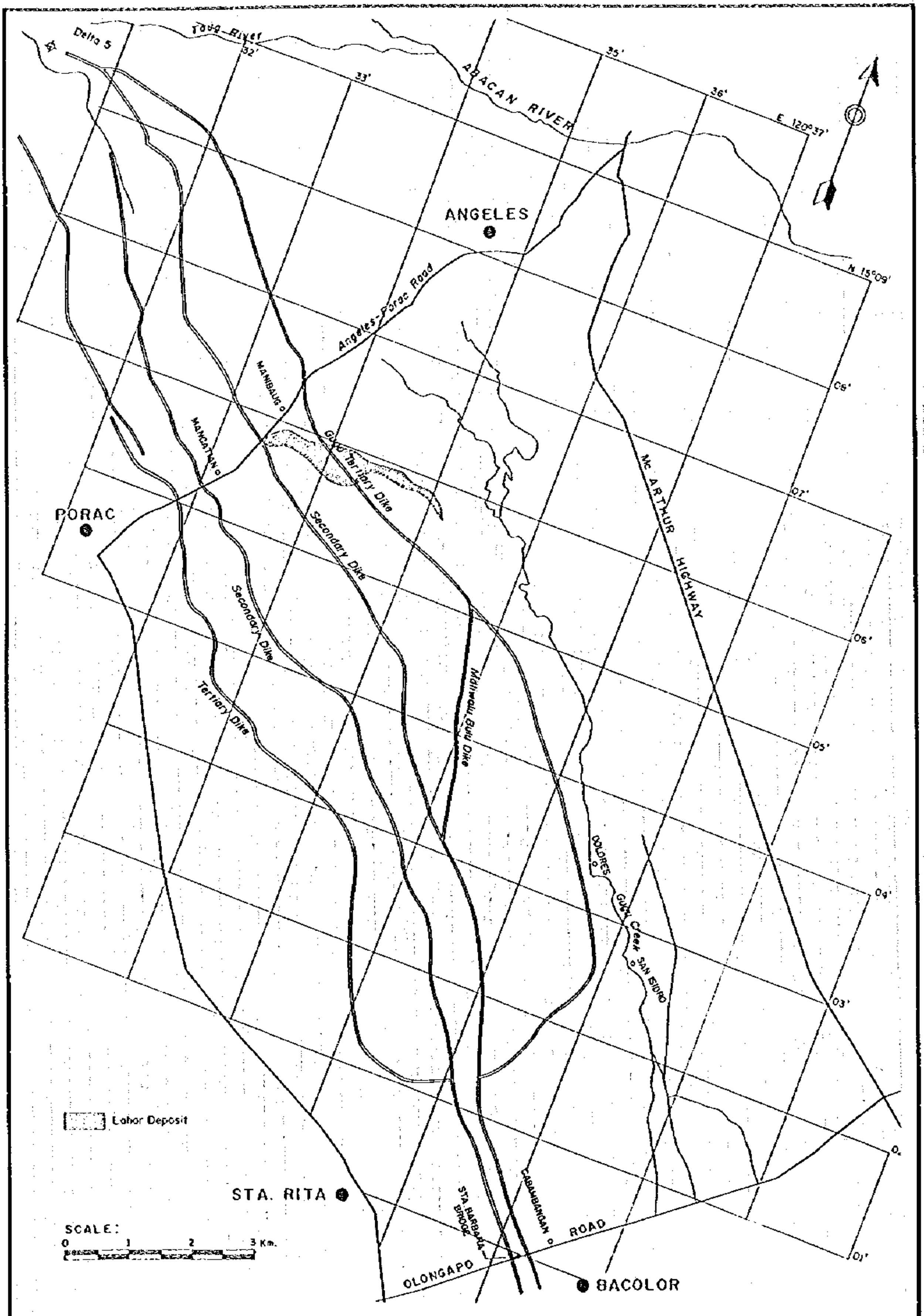


Figure 12.2 Pasig-Potrero River Dike System

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



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

Figure 12.3

Lahar Deposit in June 1 to 7 Event, 1995

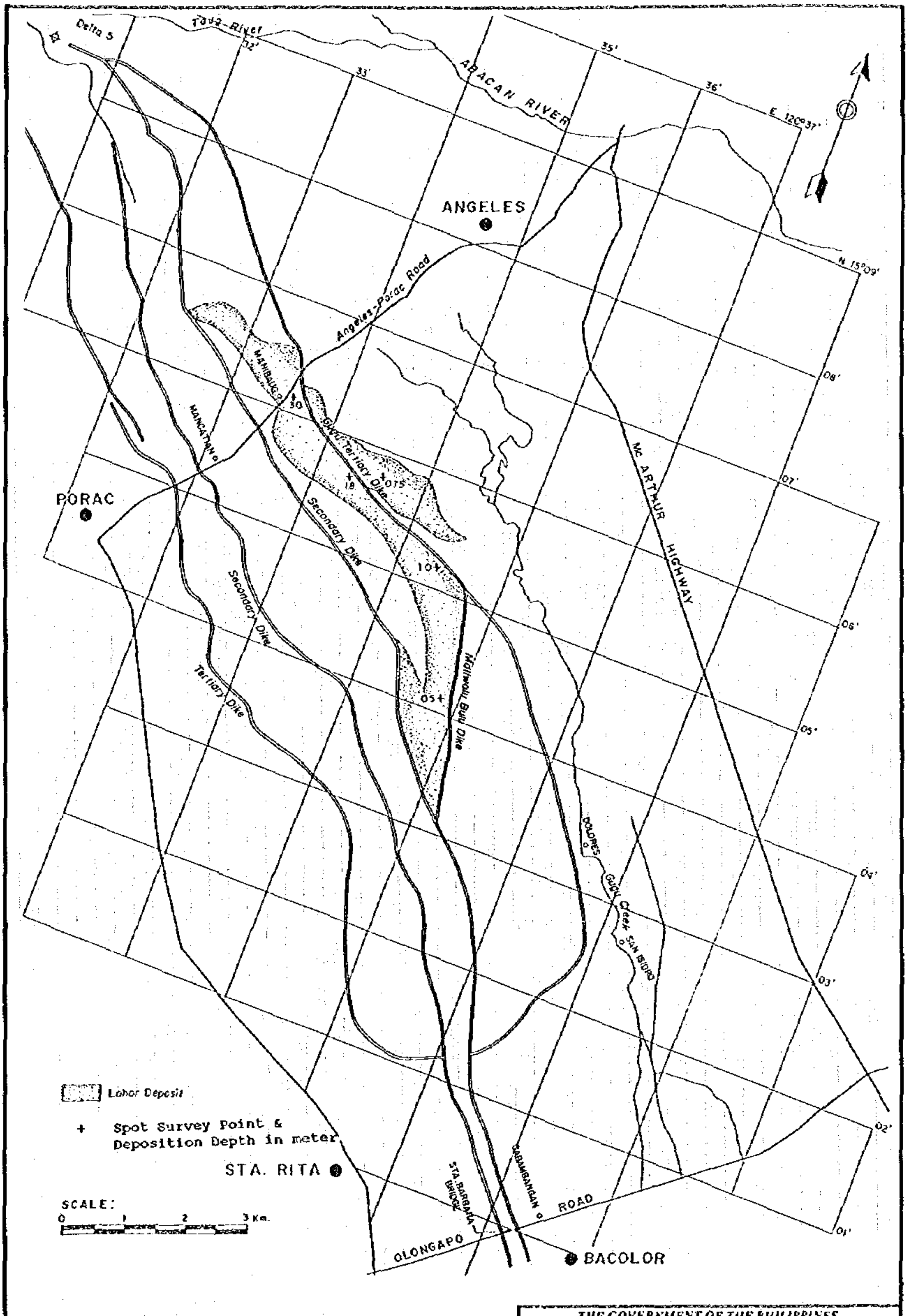


Figure 12.4
Lahar Deposit in July 7 to 11 Event, 1995

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

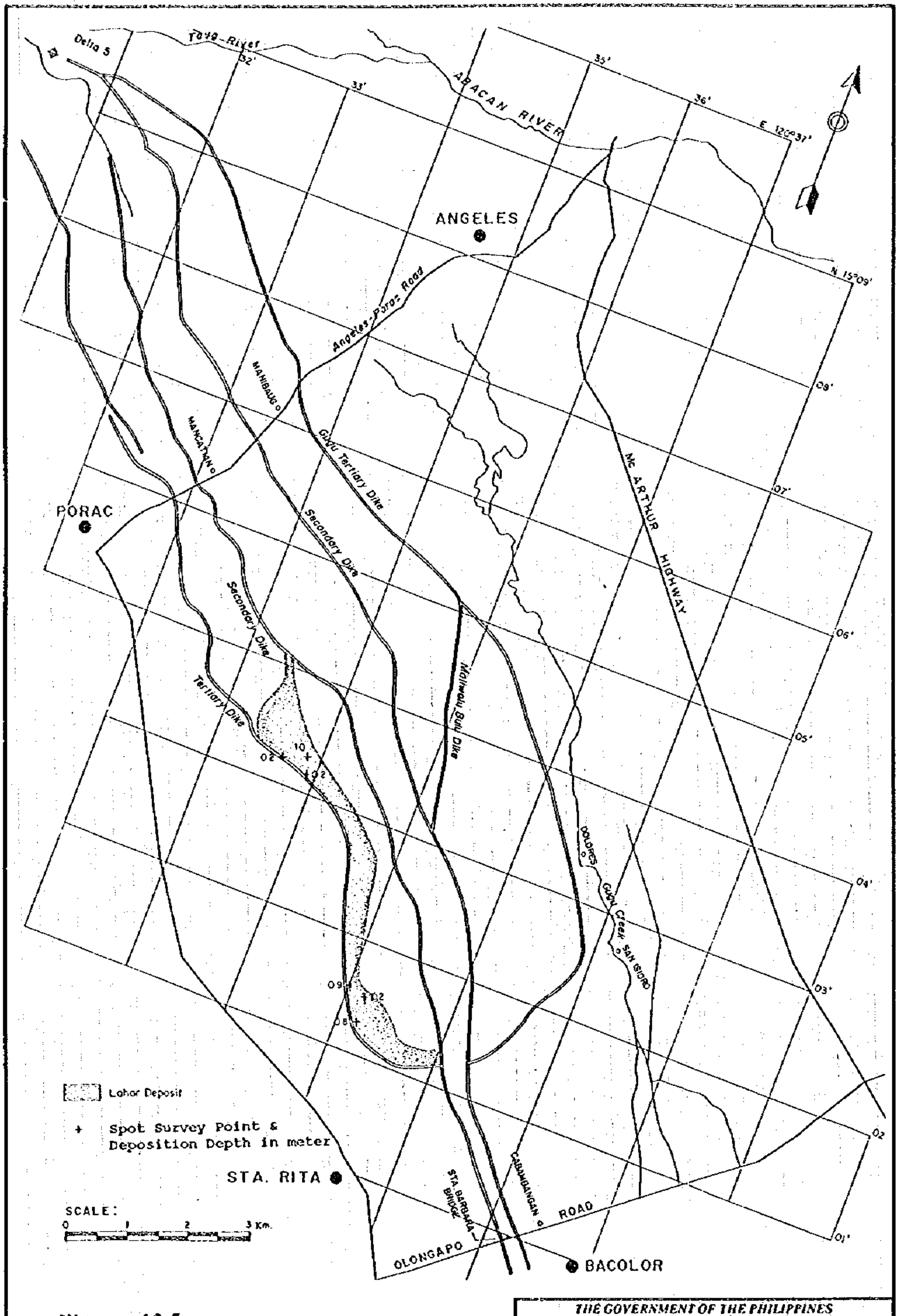


Figure 12.5

Lahar Deposit in July 18 Event, 1995

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

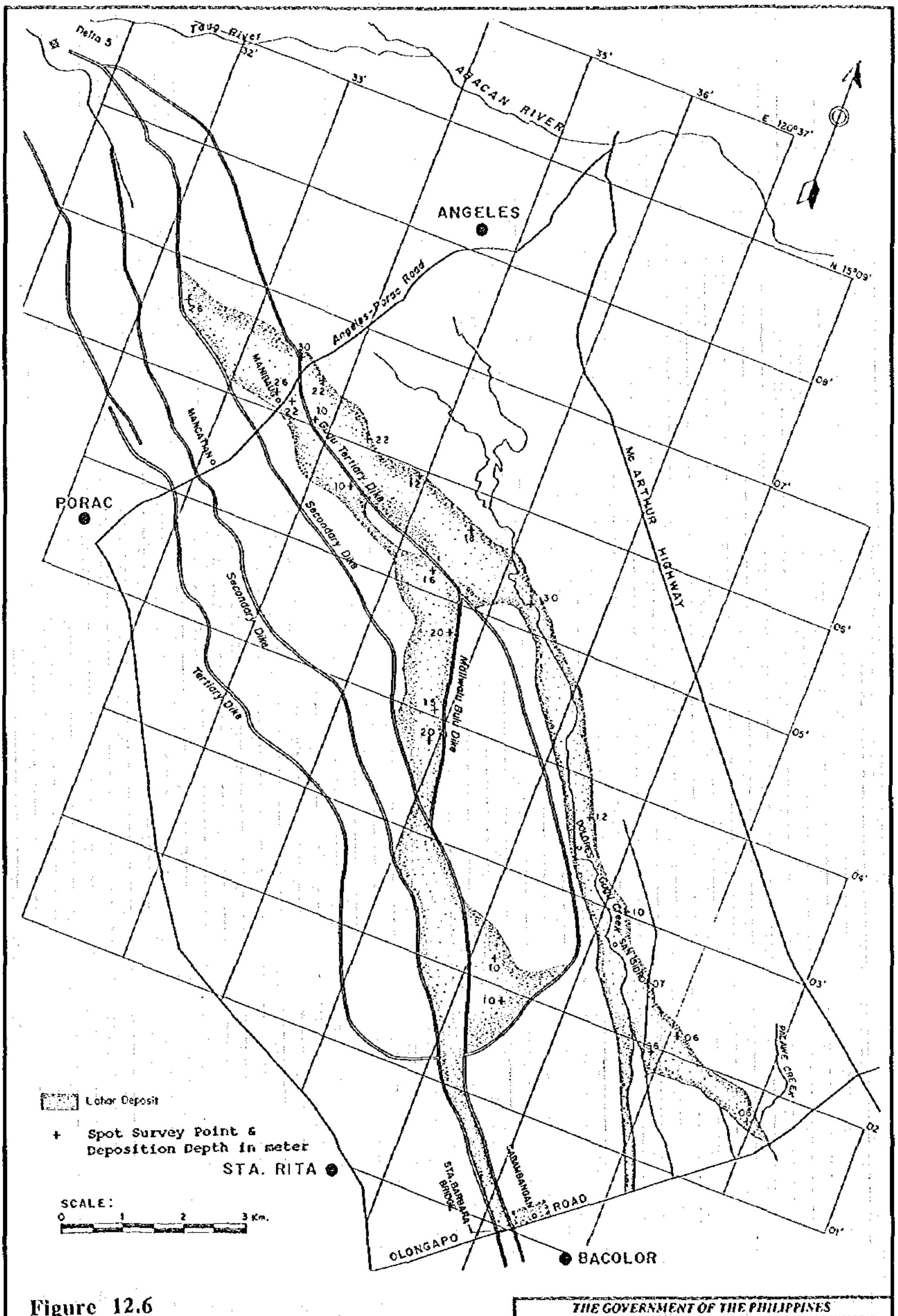


Figure 12.6
Lahar Deposit in July 27 to 30 Event, 1995

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

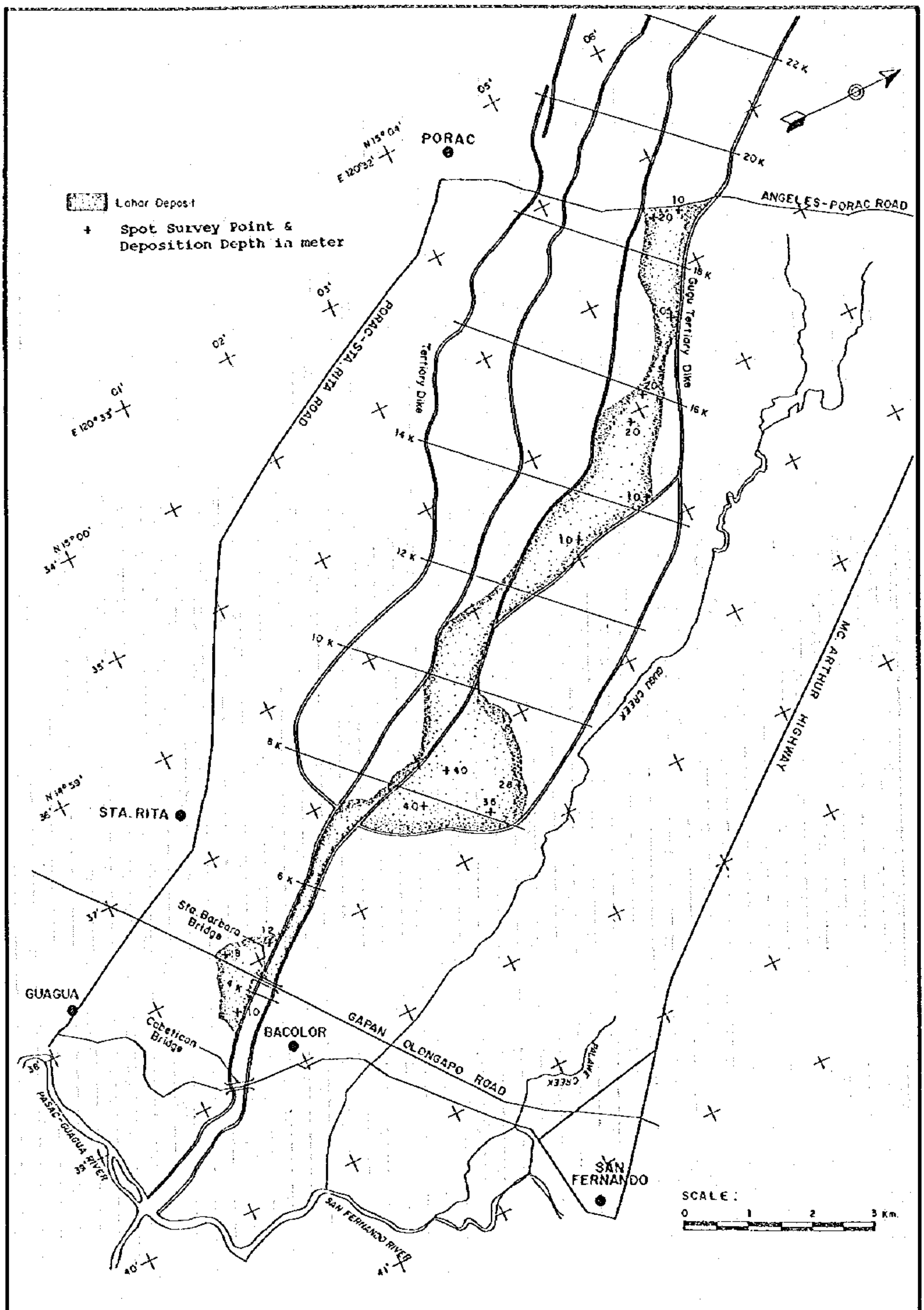


Figure 12.7

Lahar Deposit in August 15 to 19 Event, 1995

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

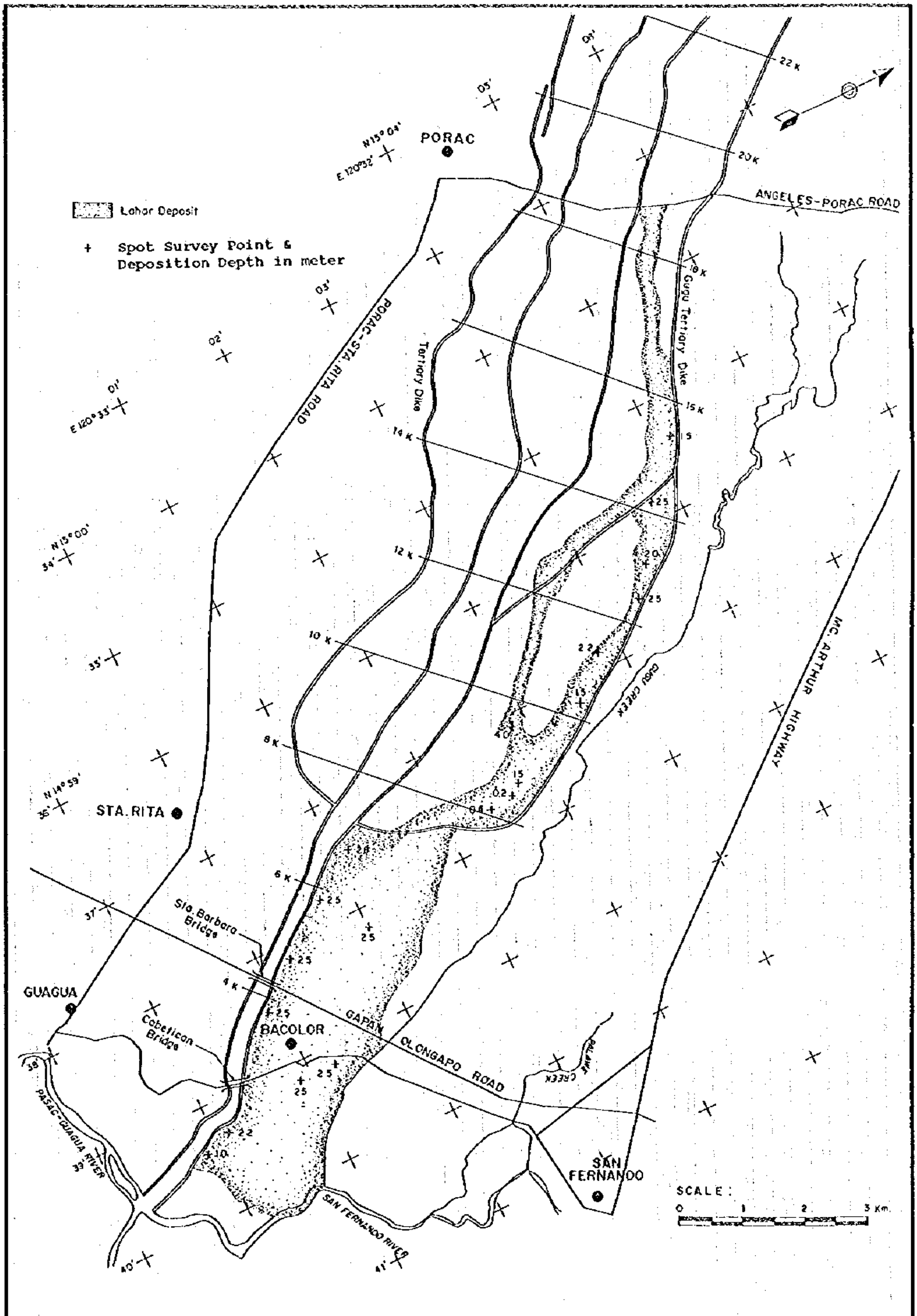


Figure 12.8

Lahar Deposit in August 28 to September 3 Event, 1995

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

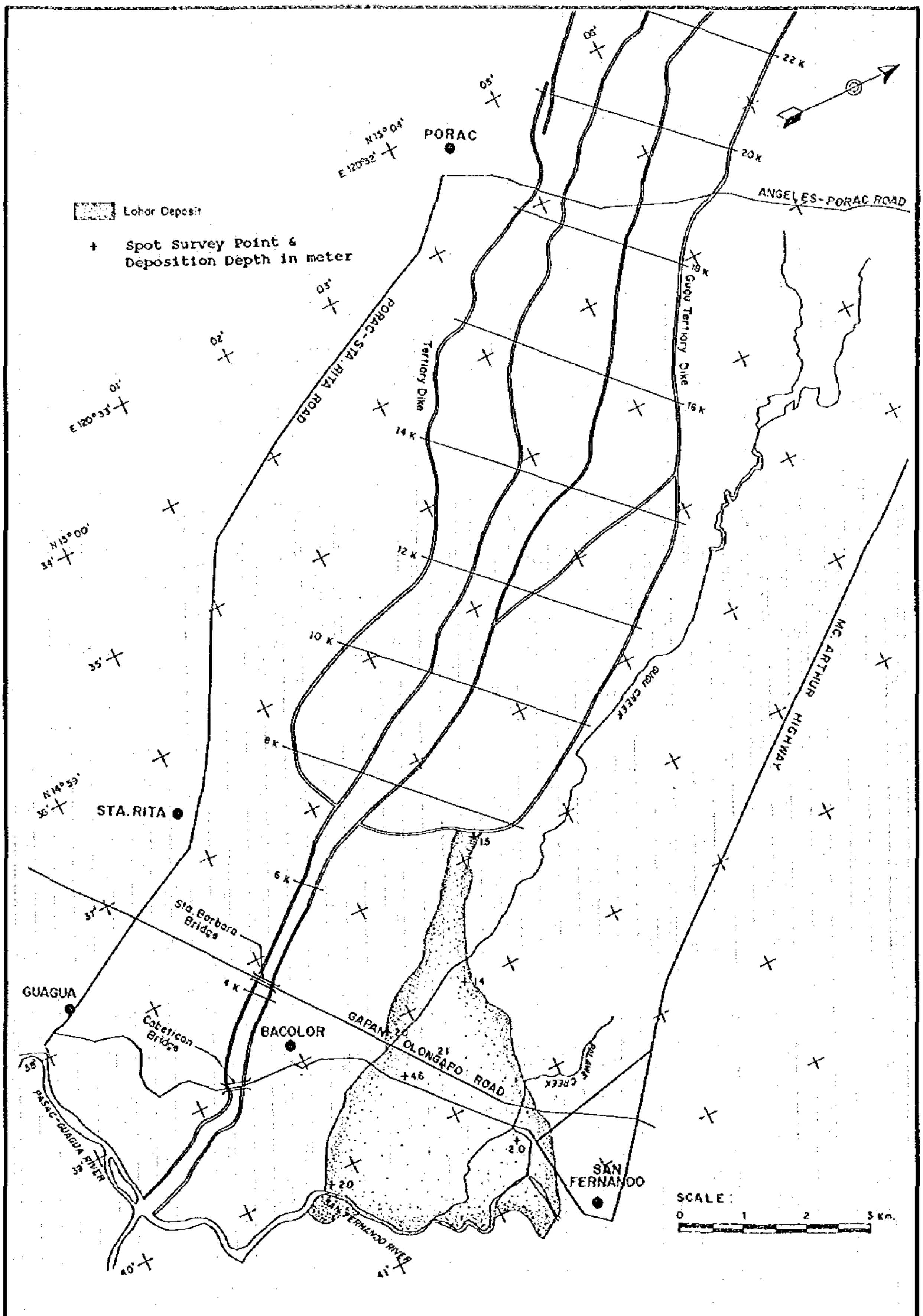


Figure 12.9

Lahar Deposit in September 30 to October 1 Event, 1995

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

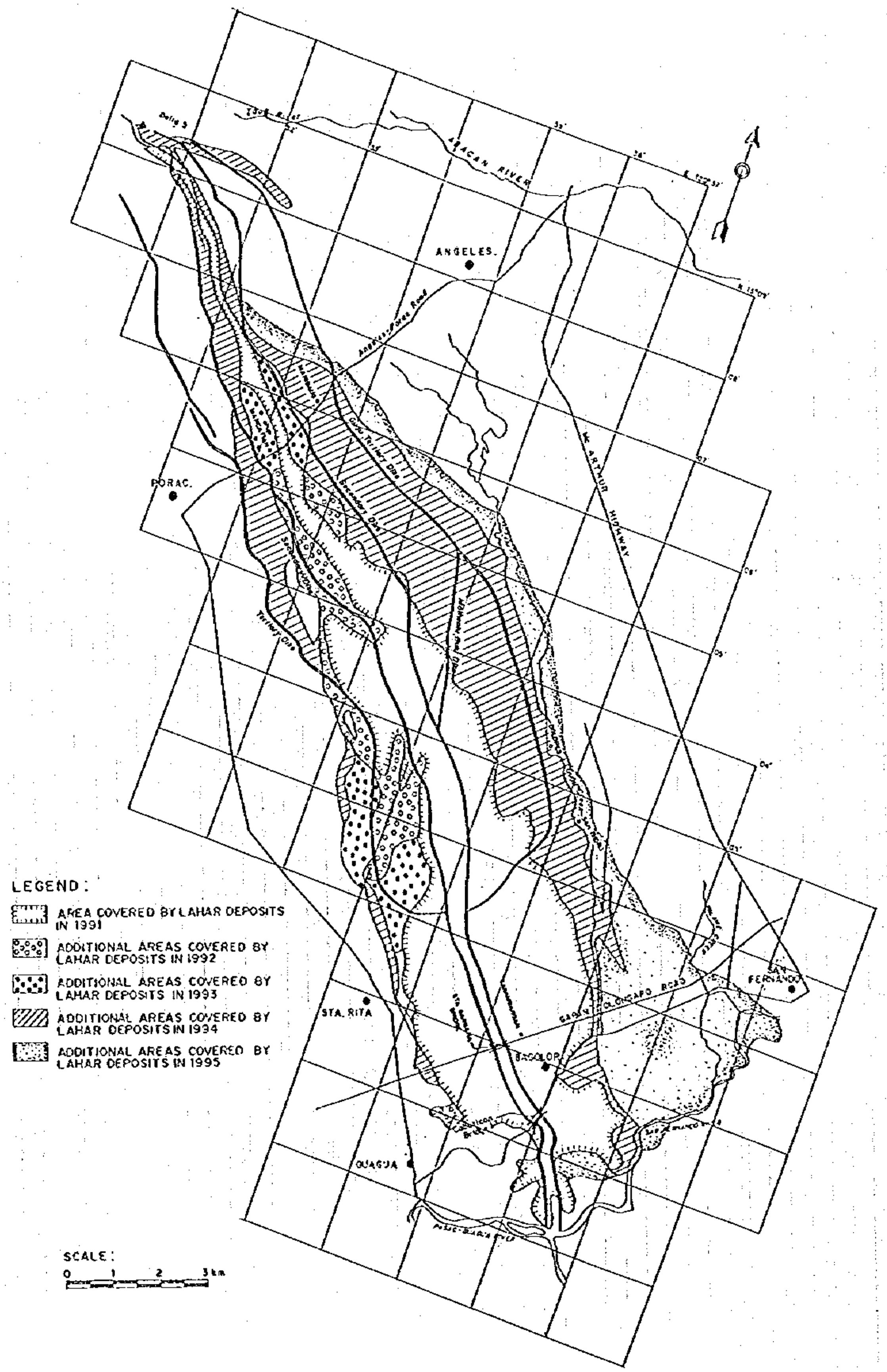
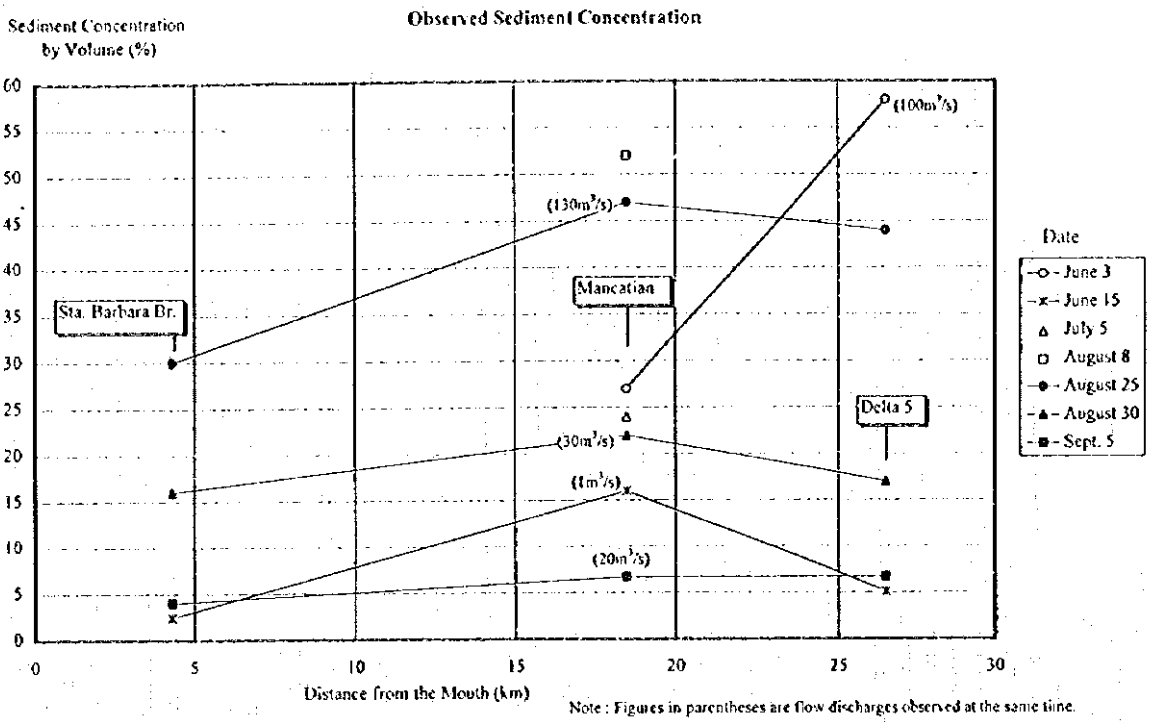


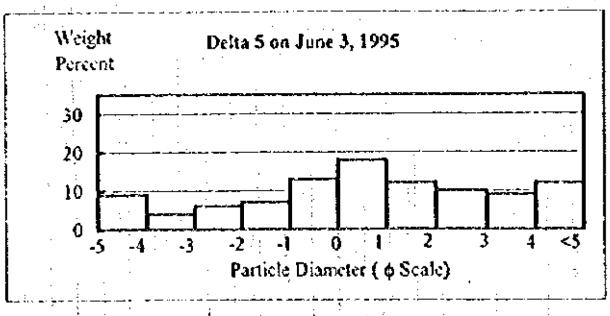
Figure 12.10

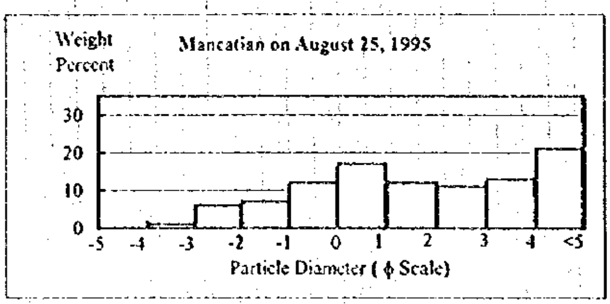
Lahar Deposits after 1991 Mt. Pinatubo Eruption

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



Note : Figures in parentheses are flow discharges observed at the same time.





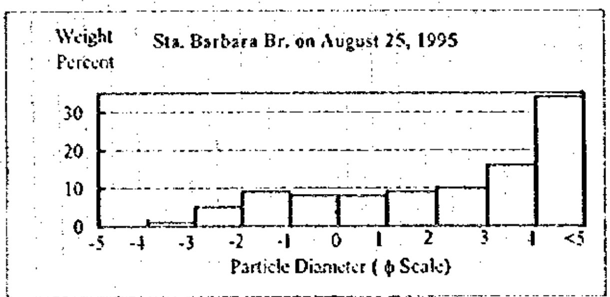
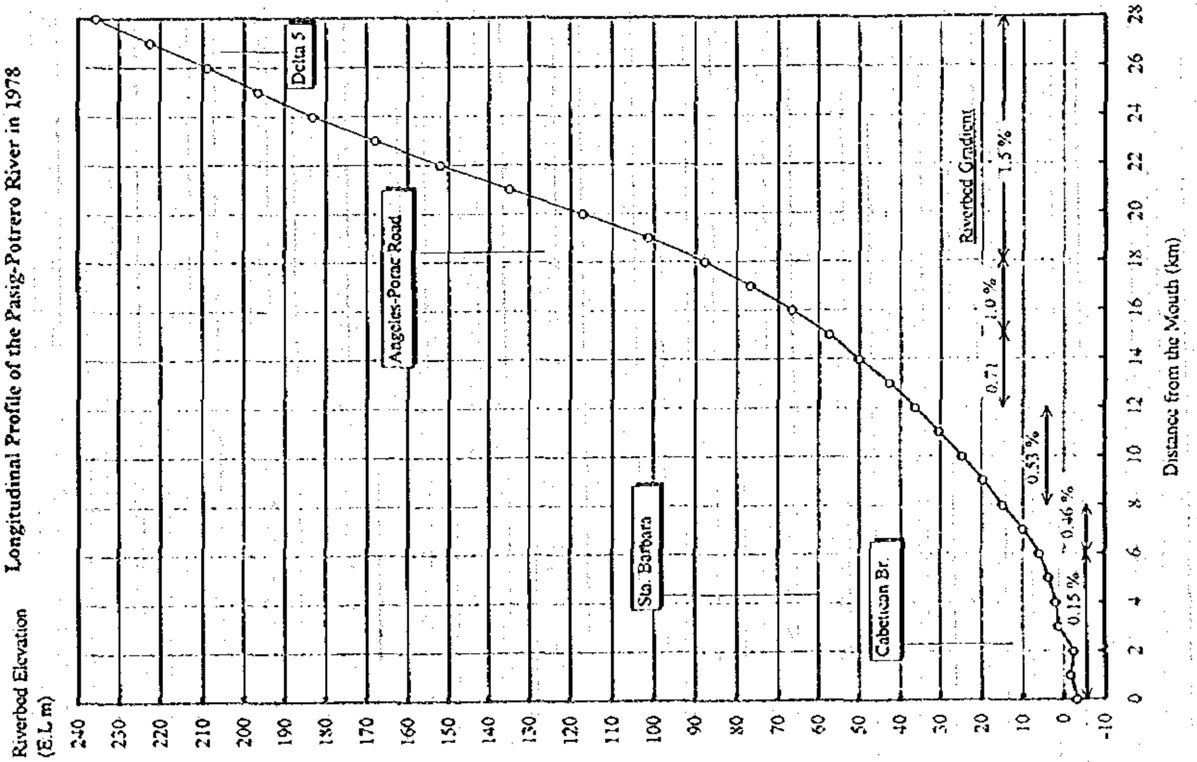


Figure 12.11

Observed Sediment Concentration and Transported Material in Pasig-Potrero River

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



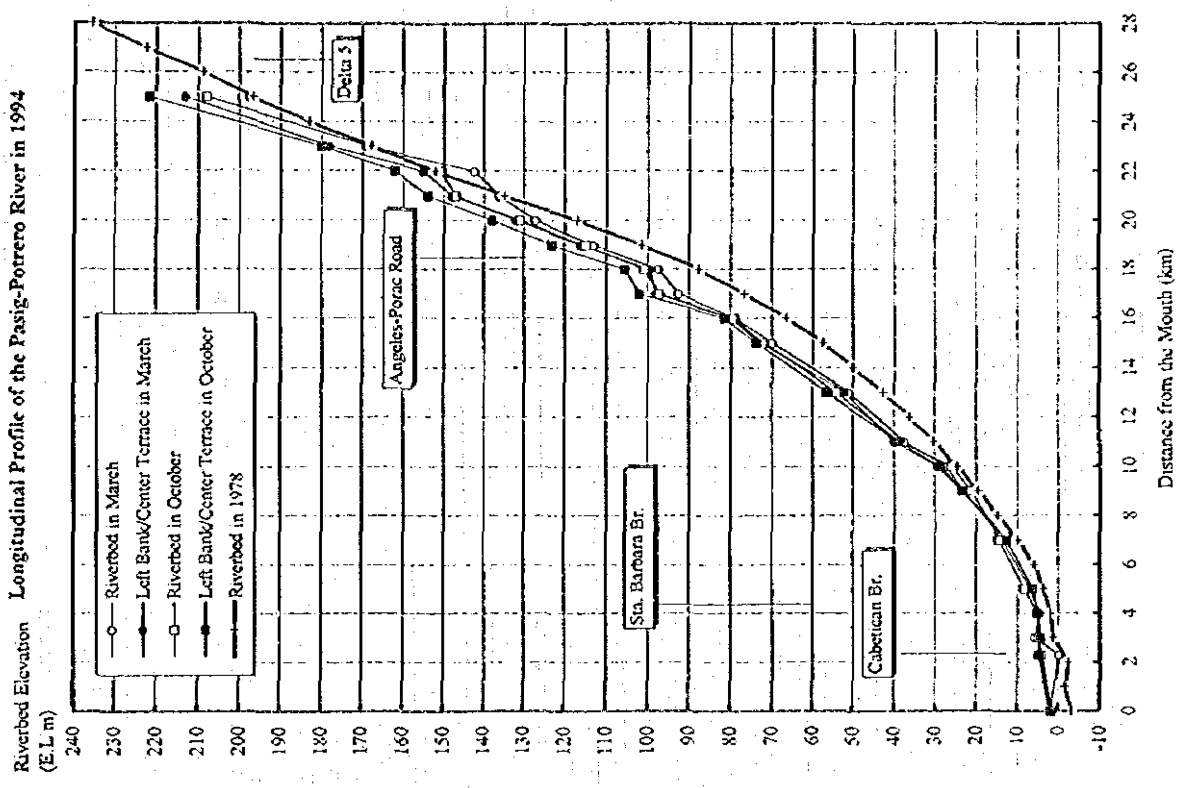
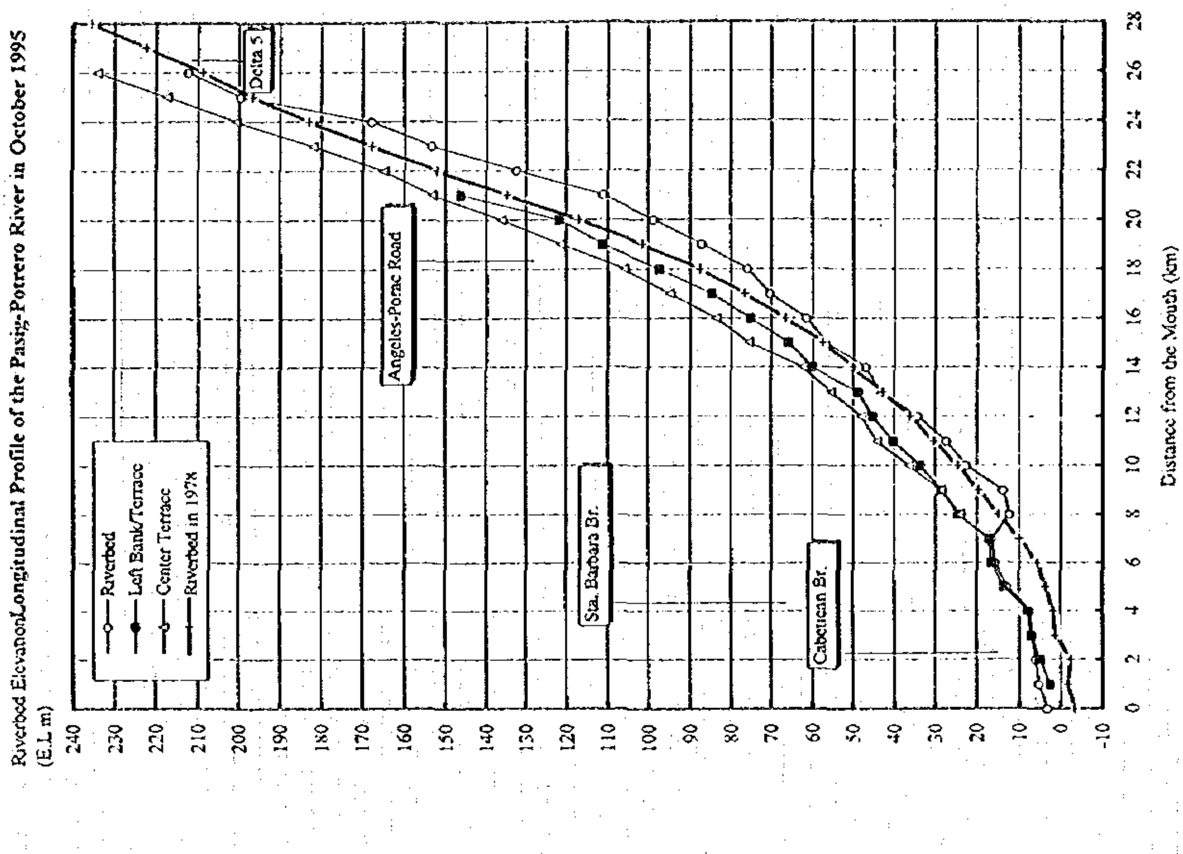


Figure 12.12 (1/2)

Changes of Longitudinal Profile of Pasig-Potrero River

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



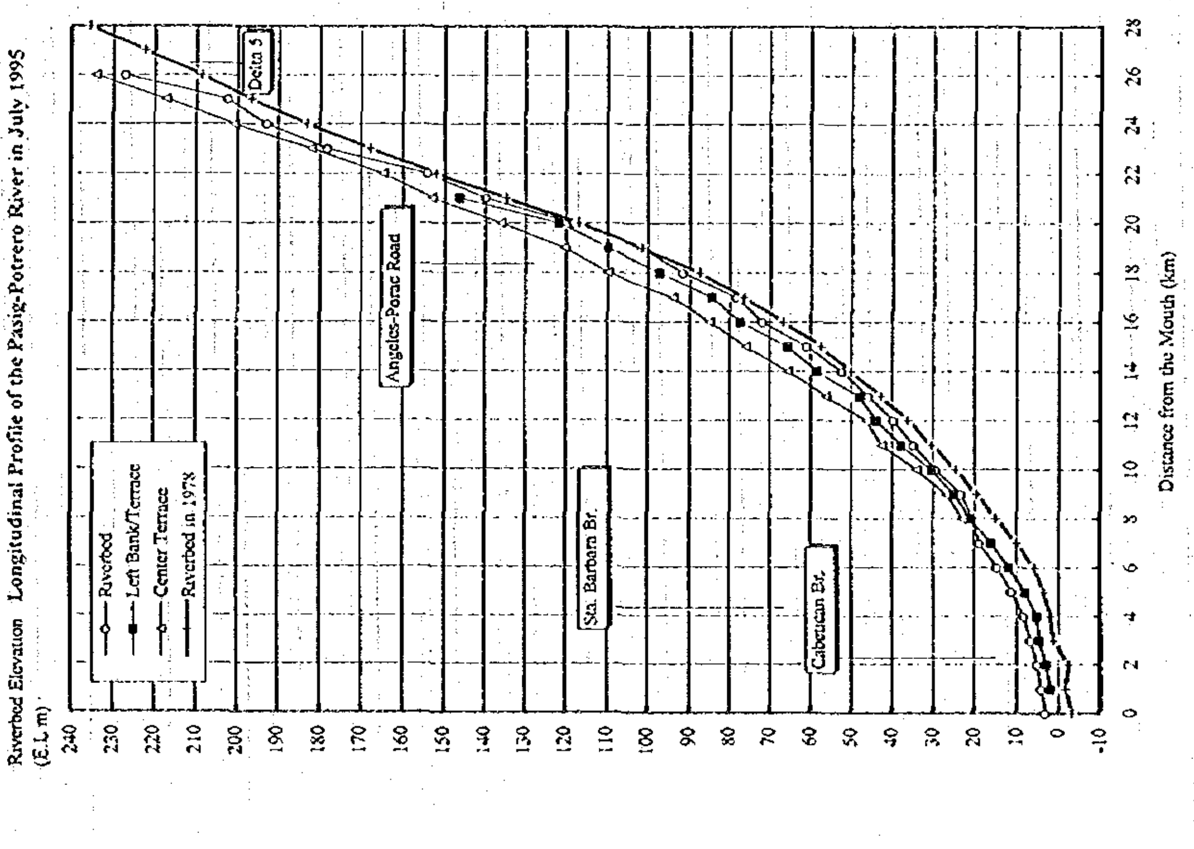


Figure 12.12 (2/2)

Changes of Longitudinal Profile of Pasig-Potrero River

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

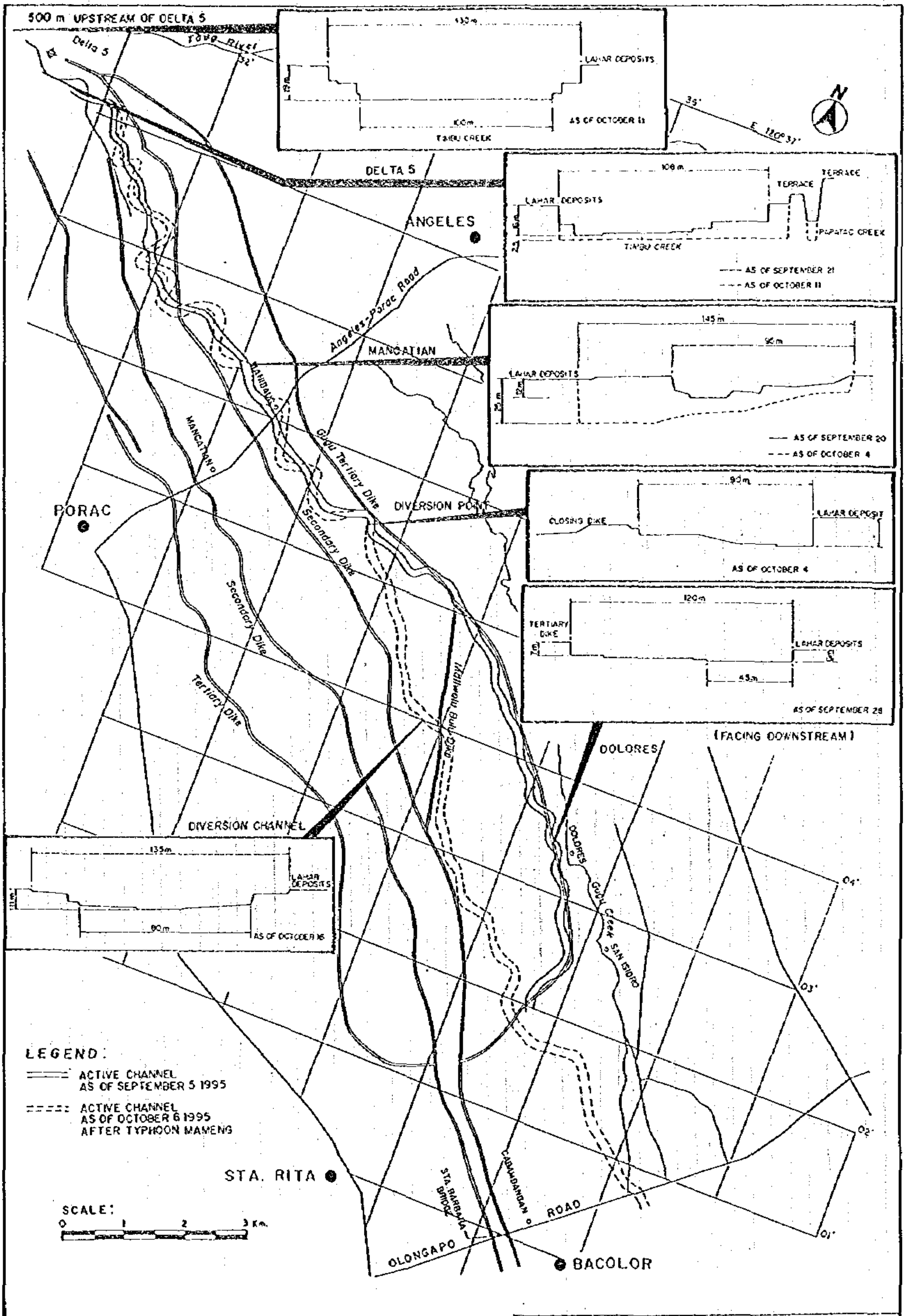
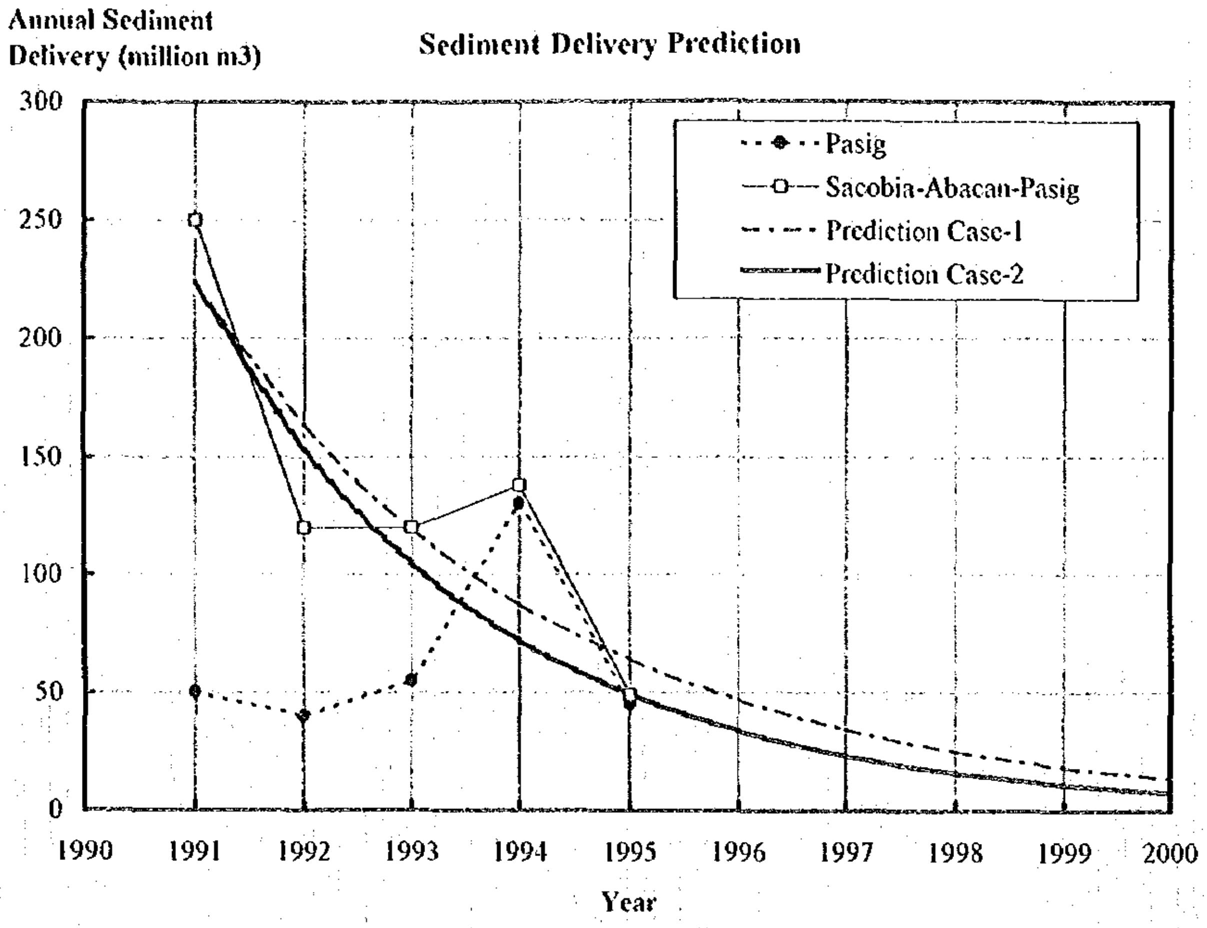


Figure 12.13
River Course Meandering and Cross-Sectional Changes along Pasig-Potrero River in 1995

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



Annual Sediment Delivery

Year	Actual		Prediction	
	Pasig	Sacobia-Abacan-Pasig	Case-1	Case-2
1991	50	250	223	223
1992	40	120	163	153
1993	55	120	119	105
1994	130	138	87	72
1995	45	49	64	49
1996			47	34
1997			34	23
1998			25	16
1999			18	11
2000			13	7

Note: 1) Case-1 is predicted using all actual data of Sacobia-Abacan-Pasig from 1991 to 1995.
2) Case-2 is predicted excluding the 1994 data as a extraordinary value.
3) Regression lines are as folows;
Case-1 : Y=304.6Exp(-0.312T) Correlation Coefficient = 0.846
Case-2 : Y=325.1Exp(-0.377T) Correlation Coefficient = 0.966

Figure 12.14 Sediment Delivery Prediction

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

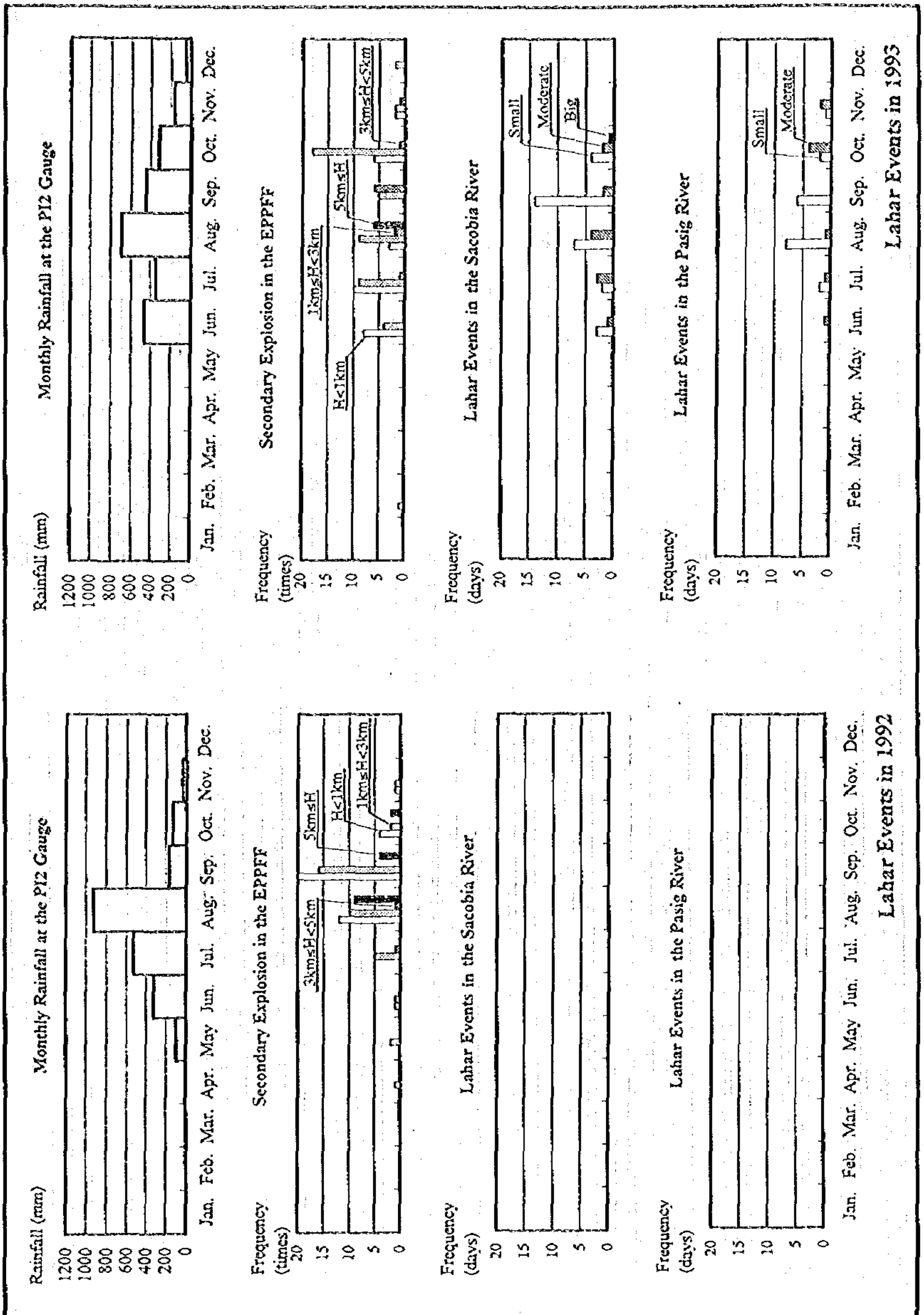


Figure 12.15 (1/2)
Summary of Lahar Events, 1992-1995

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

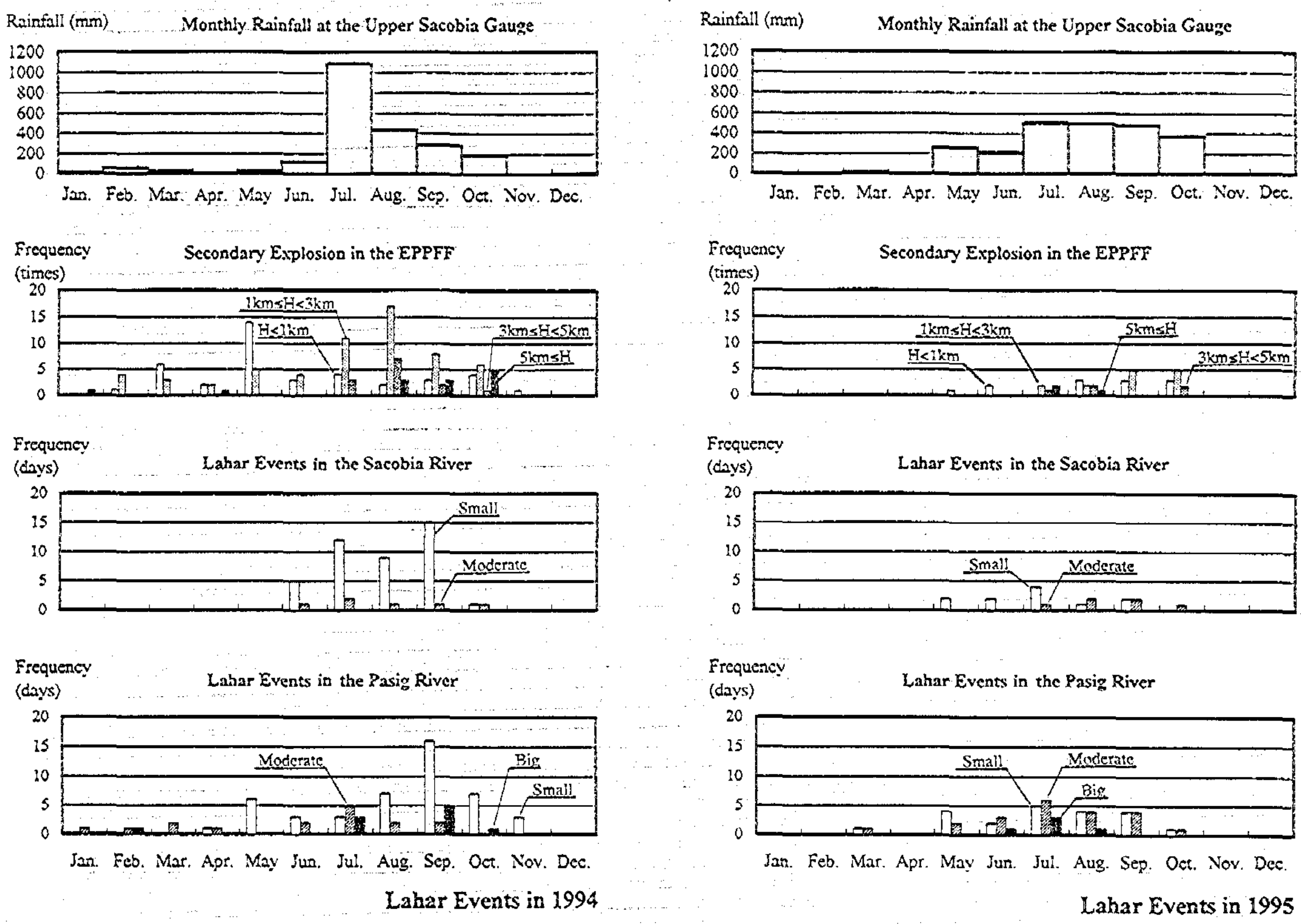


Figure 12.15 (2/2)

Summary of Lahar Events, 1992-1995

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

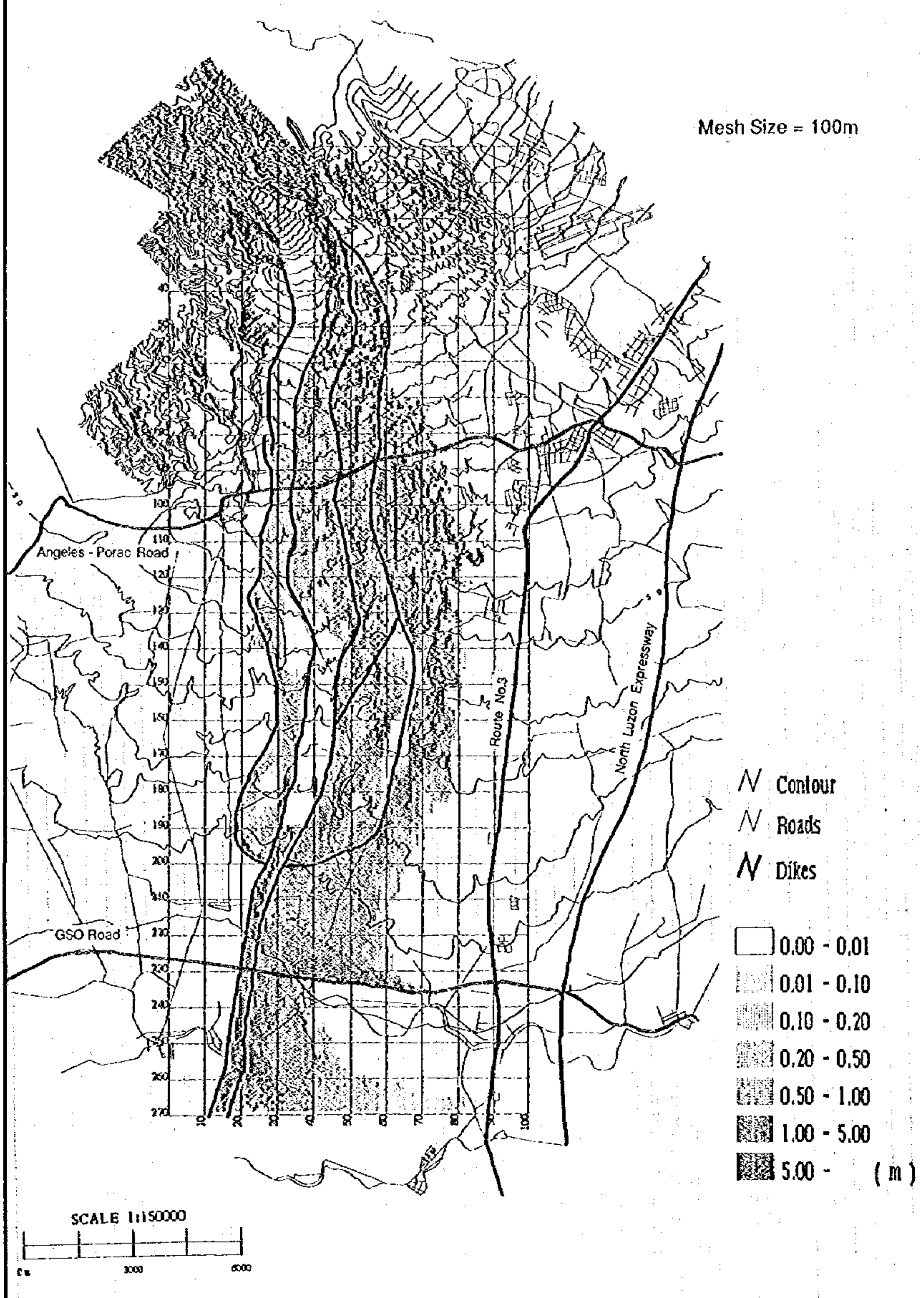


Figure 12.16
Flood and Mudflow Inundation in Pasig River in 1995 on DTM

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

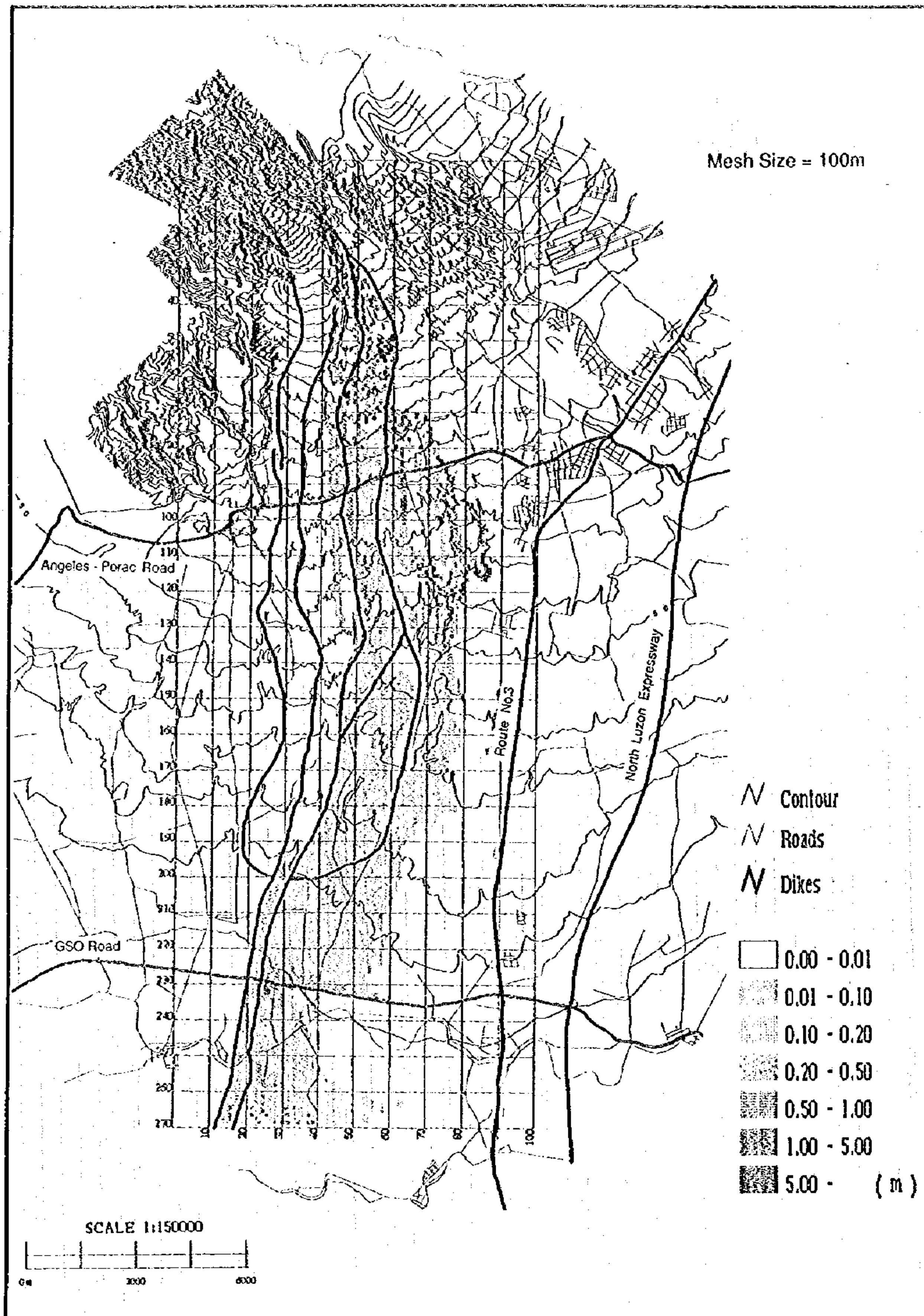


Figure 12.17
Flood and Mudflow Inundation in Pasig River due to 20-year flood on DTM

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

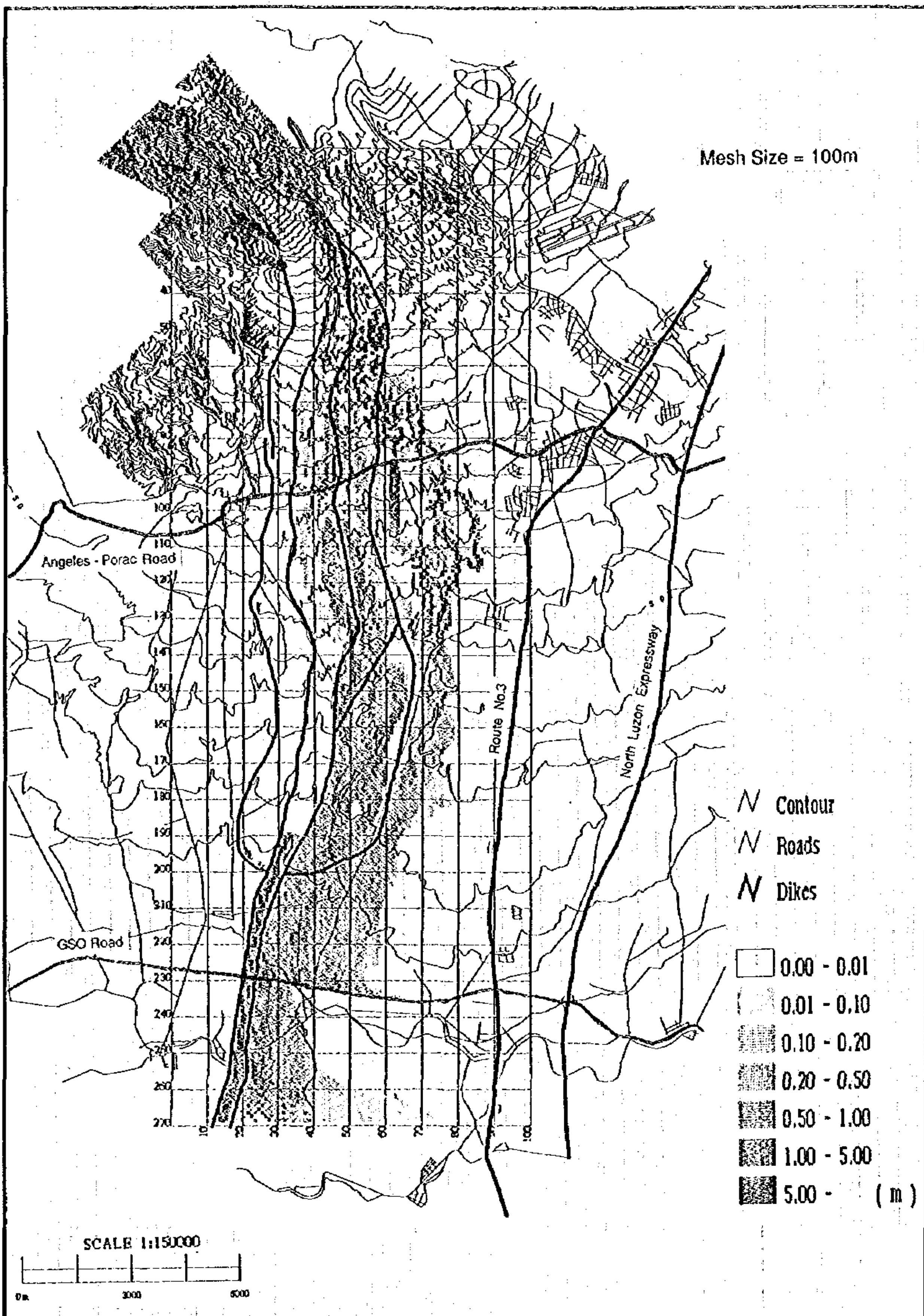
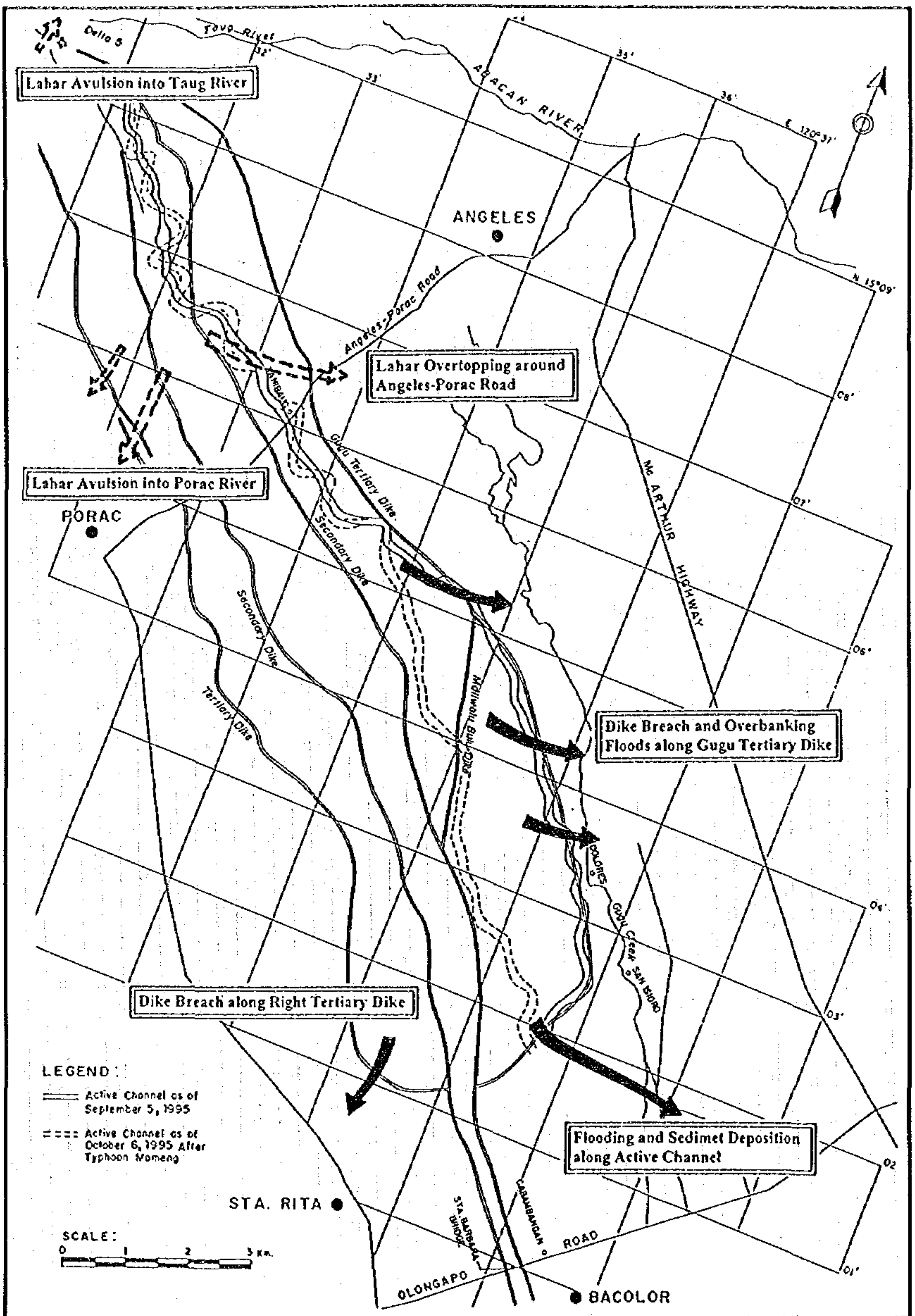


Figure 12.18

Flood and Mudflow Inundation in Pasig River due to 100-year flood on DTM

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



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

Figure 12.19

Critical Portions along Pasig-Potrero River Course

REFERENCES

REFERENCES

CHAPTER 1 SCOPE OF STUDY

Ref.1.1 JICA, "Incepcion Report, the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River draining from Mt.Pinatubo", November 1993

Ref.1.2 JICA, "Progress Report (No.1), the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River draining from Mt.Pinatubo", March 1994

Ref.1.3 JICA, "Interim Report (No.1), the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River draining from Mt.Pinatubo", June 1994

Ref.1.4 JICA, "Progress Report (No.2), the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River draining from Mt.Pinatubo", December 1994

Ref.1.5 JICA, "Interim Report (No.2), the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River draining from Mt.Pinatubo", March 1995

Ref.1.6 JICA, "Progress Report (No.3), the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River draining from Mt.Pinatubo", October 1995

Ref.1.7 JICA, "Draft Final Report, the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River draining from Mt.Pinatubo", March 1996

CHAPTER 2 PRE-ERUPTION NATURAL CONDITION

Ref.2.1 T.C.Pierson, R.J.Janda, J.V.Umbal and A.S.Daag, "Immediate and Long-term Hazards from Lahars and Excess Sedimentation in Rivers Draining Mt. Pinatubo, Philippines", USGS

Ref.2.2 JICA,"Feasibility Study on the Pampanga Delta Development Project (Flood Control Component)", 1982

Ref.2.3 Dr.L.Kitanaar, "Climate of the Philippines", 1989

Ref.2.4 JICA,"Feasibility Study on the Pampanga Delta Development Project (Irrigation Component)", 1982

Ref.2.5 BSWM,"Soils/Land Resources Evaluation Project - Physical, Agro-Socio-Economics and Land Evaluation, Province of Tarlac", 1986

Ref.2.6 BSWM,"The Physical Environment and Agro-Socio Economics and Land Evaluation, Province of Pampanga", 1986

Ref.2.7 Bureau of Soils,"Soil Survey of Pampanga Province", 1956

Ref.2.8 Bureau of Soils,"Soil Survey of Tarlac Province", 1940

CHAPTER 3 MT.PINATUBO ERUPTION

Ref.3.1 PHIVOLS/USGE, "Serious but Rapidly Diminishing Hazards at Mount Pinatubo", August 1994

Ref.3.2 Scott K.M. et al, "Channel and Sedimantation Responses to Large Volumes of 1991 Volcanic Deposits on the East Flank of Mount Pinatubo", Attachment I of Ref.3.1.

Ref.3.3 T.Koyaguchi, "Volume Estimation of the Ejecta of Pinatubo 1991 Eruption by Means of Fluid Dynamics Model and Geological Methods (special report for Mt.Pinatubo)", 1993

Ref.3.4 Janda R.J. et al, "Assessment and Response to Lahar Hazard around Mount Pinatubo, 1991 to 1993", Attachment B of Ref.3.1.

Ref.3.5 PHIVOLCS/UNESCO, "Lahar Studies", 1994

Ref.3.6 BSWM, "Physico-Chemical Mineralogical and Hydrological Characterization of Volcanic Ash and Lahar and their Utilization and Management for Agricultural Crops", 1992

Ref.3.7 USACE, "Mount Pinatubo Long Term Action Report, Eight River Basins, Republic of the Philippines, Volume-II Thechnical Appendices, Appendix E : Engineering Analysis of Potential Measures and Developed Alternatives", March 1994

Ref.3.8 N.M.Tungol and M.M.Regalado (PHIVOLCS), "Calibrartion of the Sacobia Acoustic Flow Monitor and Correlation of Rainfall with Lahars along the Sacobia River in 1992 (DRAFT)"

Ref.3.9 Punongbayang, R.S., "Eruption Hazard Assessments and Warnings", Attachment A of Ref.3.1.

Ref.3.10 National Statistics Office (NSO), "1990 Census of Population and Housing, Pampanga and Tarlac Provinces", June 1992

Ref.3.11 USAID,"Preliminary Report for the Master Plan Study for the Areas of Central Luzon affected by the Eruption of Mt.Pinatubo", October 1993

Ref.3.12 Asisn Development Bank (ADB),"Report and Recommendation for the Mt.Pinatubo Damage Rehabilitation Project", March 1992

Ref.3.13 ADB,"Philippine Country Operational Program Paper 1993-96", April 1993

Ref.3.14 NSCB,"1993 Philippine Statistical Yearbook", January 1994

Ref.3.15 NSO,"1991 Family Income and Expenditures Survey" Vol.1 and Vol.2, January 1994

Ref.3.16 "Population Projections by single year of age and by sex: 1990-2000-High Assumption" NSO

Ref.3.17 Provincial Planning and Development Office,"Pampanga and Tarlac Provinces, Annual Accomplishment Report CY 1992", May 1993

Ref.3.18 President Task Force on Mt.Pinatubo,"Terminal Report : Mt.Pinatubo Rehabilitation and Reconstruction Program", November 1992

Ref.3.19 NEDA Region III Office,"Socio-economic Impacts of Mt.Pinatubo Eruption"

Ref.3.20 Tarlac Province,"Medium Term Development Plan for Tarlac 1994-98" (Working Draft), October 14 1993

Ref.3.21 JICA,"Mapping and Agricultural Potential Study for the Integrated Development Program in Pampanga", November 1992

Ref.3.22 Philippine Business for Social Progress (PBSP), "In Search of Alternatives : Rehabilitation Options and Alternatives for the Mt.Pinatubo Victims", July 1993

Ref.3.23 DPWH, "Surface Water Supply Bulletine", 1982

CHAPTER 4 BASIC CONCEPT OF THE STUDY

Ref.4.1 A Special Report of a Newspaper "Manila Standard", "Philippine 2000", July 21 1993

Ref.4.2 NEDA, "Medium Term Philippine Development Plan 1993-98", December 1992

Ref.4.3 Provincial Planning and Development Office (PPDO), Pampanga Province, "Annual Development and Investment Plan1993, Province of Pampanga"

Ref.4.4 PPDO Pampanga Province, "Socio-economic Profile 1989 Pampanga Province"

Ref.4.5 USACE, "Physical Parameters Package for Long Term Alternatives-being considered in the Mt.Pinatubo Recovery Action Plan-Basin Cost Summaries", December 1993

Ref.4.6 USACE and USAID, "Mt.Pinatubo Recovery Action Plan-Interim Report of the Pasig-Potrero River Basin", October 1992

Ref.4.7 US Geological Survey, "Immediate and Long-term Hazards from Lahars and Excess Sedimentation in Rivers draining Mt.Pinatubo, Philippines", 1992

Ref.4.8 JICA, "The Master Plan Study for West Central Luzon Development Program, Progress Report I", March 1994

Ref.4.9 NEDA Region III Office, " Socio-Economic Impacts of Mount Pinatubo Eruption", 1993

Ref.4.10 Mount Pinatubo Commission (MPC), Office of the President, "1993 Year-End Report to the President", January 1994

Ref.4.11 MPC, "1994 Work and Financial Plan", 1995

Ref.4.12 MPR-PMO, DPWH, "Progress Report as of January 1994", February 1994

Ref.4.13 Center for Research and Communication, "Business and Socio-Economic Prospects in Angeles City : With or Without Clark Air Base :1947-2006", October 1989-March 1990

Ref.4.14 JICA, "Master Plan Study on Luzon Island Strategic Road Network Development Project", July 1993

Ref.4.15 Province of Tarlac, "Master Plan on Mount Pinatubo Development Programs", September 1993

CHAPTER 5 GEOMORPHOLOGIC CHANGES

Ref.5.1 T.C.Pierson, A.S.Daag, P.J.D.Reyes, T.Regalado, R.Solidum, and B.Tubianosa, "Flow and Deposition of Post-eruption Hot Lahars on the East Side of Mt. Pinatubo, July - October, 1991 (DRAFT)", PHIVOLCS

Ref.5.2 K.S.Rodolfo, et al. "Two Years of Lahars on the Western Plank of Mt.Pinatubo, Philippine: Initiation, Flow Processes, Deposits, and Attendant Geomorphic and Hydraulic Changes", 1992

Ref.5.3 R.Torres, S.Self, M.Martinez, "Secondary Pyroclastic Flows from the 15 June 1991 Ignimbrite of Mount Pinatubo (DRAFT)", PHIVOLCS

Ref.5.4 R.A.Arboleda, A.S.Daag, P.J.D.Reyes, M.L.Martinez, T.M.Regalado, "1993 lahars on the Eastside Drainages of Pinatubo Volcano: An Overview (DRAFT)", PHIVOLCS

Ref.5.5 Major, J.J., et al, "Watershed Disturbance and Lahars on the East Side of Mount Pinatubo during the Mid-June 1991 Eruptions", Attachment L of Ref.3.1.

Ref.5.6 Umbal J.V., el al, "The 1991 Lahars of Southwestern Mount Pinatubo and Evolution of the Lahar-Dammed Mapanuepe Lake", Attachment J of Ref.3.1.

Ref.5.7 Tokudome, et al, "Extent and Some Properties of Mt.Pinatubo's ashfall Over Agricultural Land (JICA Technical report on the Soil Research and Development Center Project, BSWM)", 1994

Ref.5.8 Pierson, T.C., et al, "Immediate and Long-Term Hazards from Lahars and Excess Sedimentation in Rivers draining Mt.Pinatubo, Philippines", copy from US Geological Survey, Books and Open-File Reports Federal Center.

Ref.5.9 Torres, R., " Secondary Pyroclastic Flows from June 1991 Ignimbrite of Mount Pinatubo",PHIVOLS's Library

Ref.5.10 PHIVOLCS, "Pinatubo Volcano: Past Events and Future Outlook", Proceeding of Mount Pinatubo Congress held by MPC in Manila on December 8 1993.

Ref.5.11 Arboleda, R.A., "Report of Investigation of the Typhhon Kadiang- & Epang-Generated Lahar Events at the East Side Drainages of Mt.Pinatubo October 11 1993", PHIVOLCS's library

Ref.5.12 Rodolfo, K.S., " Two Years of Lahars on the Western Flank of Mount Pinatubo, Philippines: Initiation, Flow Process, Deposits, and Attendant Geomorphorphic and Hydraulic Changes", Attachment K of Ref.3.1.

CHAPTER 6 SEDIMENT BALANCE

Ref.6.1 PHIVOLCS and UNESCO, "Lahar Studies", 1994

Ref.6.2 PHIVOLCS and USGS, "Serious but Rapidly Diminishing Hazards at Mount Pinatubo", August 1994

Ref.6.3 Thomas C. Pierson and Richard J. Janda, USGS, and Jesse V. Umbal and Arturo S. Daag, PHIVOLCS, "Immediate and Long-Term Hazards from Lahars and Excess Sedimentation in Rivers Draining Mt. Pinatubo, Philippines", 1992

Ref.6.4 Thomas C. Pierson, Arturo S. Daag, Perla J. Delos Reyes, Theresa Regalado, Renato Solidum, and Bella Tubianosa, "Flow and Deposition of Post-Eruption Hot Lahars on the East Side of Mt. Pinatubo, July-October, 1991"

Ref.6.5 PHIVOLCS, "Pinatubo Volcano, Update, July-October 15,1992", 1992

Ref.6.6 Norman M. Tungol and Ma. Theresa M. Regalado, "Calibration of the Sacobia Acoustic Flow Monitor and Correlation of Rainfall with Lahars along the Sacobia River in 1992", 1992

Ref.6.7 NIA (PDDP-IC Office), "Updated Report of the Effects of Mt. Pinatubo Eruption on PDDP-IC", December 1993

Ref.6.8 Japan Society of Civil Engineers, "Manual of Hydraulic Engineering", 1971

Ref.6.9 US Army Corps of Engineers, "Mount Pinatubo Recovery Action Plan, Long Term Report, Eight River Basins", March 1994

Ref.6.10 R. Torres, S. Self, M. Martinez, "Secondary Pyroclastic Flows from the 15 June 1991 Ignimbrite of Mount Pinatubo", 1992

CHAPTER 7 POTENTIAL HAZARD AREA

Ref.7.1 Swiss Disaster Relief, "Lahars in the O'Donnell river system, Mt.Pinatubo, Philippines, Final Report", January 1994

Ref.7.2 PHIVOLCS-USGS, Progress Report of Joint PHIVOLCS-USGS collaboration, 1992 through mid-1994, Serious but Rapidly Diminishing Hazards at Mount Pinatubo, August, 1994

Ref.7.3 T.C.Pierson, R.J.Janda, J.V.Umbal and A.S.Daag, PHIVOLCS-USGS, Immediate and long-term hazards from lahars and excess sedimentation in rivers draining Mt.Pinatubo, Philippines, 1992

Ref.7.4 US Army Corps of Engineers, Mount Pinatubo Recovery Action Plan Long Term Report, Eight River Basins Republic of the Philippines, March 1994

CHAPTER 8 STRUCTURAL MEASURE IN SACOBIA-BAMBAN RIVER BASIN

Ref.8.1 USACE, "Mount Pinatubo Long Term Action Report, Eight River Basins, Republic of the Philippines, Volume-II Thechnical Appendices, Appendix A : Hydrology", March 1994

Ref.8.2 NIA (PDDP-IC Office), "Updated reports of the Effects of Mt.Pinatubo Eruption on PDDP-IC", December 1993

Ref.8.3 Pierson, T.C., et al, "Immediate and Long-Term Hazards from Lahars and Excess Sedimentation in Rivers draining Mt.Pinatubo, Philippines", copy from US Geological Survey, Books and Open-File Reports Federal Center.

Ref.8.4 T.C.Pierson, A.S.Daag, P.J.D.Reyes, T.Regalado, R.Solidum, and B.Tubianosa, "Flow and Deposition of Post-eruption Hot Lahars on the East Side of Mt. Pinatubo, July - October, 1991 (DRAFT)", PHIVOLCS

Ref.8.5 MPC, "Integrated Plan for the Mount Pinatubo Affecetd Areas, Main Text", July 1994

Ref.8.6 USACE, "Mount Pinatubo Recovery Action Plan, Basin Cost Summaries", December 1993.

Ref.8.7 Japan Society of Civil Engineers, "Manual of Hydraulic Engineering", 1971

Ref.8.8 USACE, "Mount Pinatubo Long Term Action Report, Eight River Basins, Republic of the Philippines, Main Report", March 1994

Ref.8.9 Provincial Planning and Development Office "Socio-economic Profile of Pampanga Province 1989", 1990

Ref.8.10 Provincial Planning and Development Office, "Socio-economic Profile of Tarlac Province 1990", 1991

Ref.8.11 "Development Plan of City and Municipalities:

- Angeles City	"Socio-economic and Physical Profile 1993"
- Arayat	"Comprehensive Development Plan, Arayat 1992-96"
- Mabalacat	"Socio-economic Profile 1989"
	"Comprehensive Develop't Plan and Zoning Ordinance
- Magalang	"Socio-economic Profile 1993"
	"Development Investment Plan 1994-98"
- Mexico	"Socio-economic Profile 1991"
- Santa Ana	"Socio-economic Profile 1990(?)"(simple one)
- Bamban	"Socio-economic Profile 1990 and 1992"
	"Barangay Profiles"(After Pinatubo)
- Capas	"Barangay Data 1987 (simple)
- Concepcion	"Socio-economic Profile 1980 and 1993"

Ref.8.12 "Pampanga Province : Annual Accomplishment Report 1992"

Ref.8.13 "Pampanga Province : Annual Development and Investment Plan 1993"

Ref.8.14 BSWD and JICA,"Disaster Planning and Management for Agriculture", March 1992

Ref.8.15 Philippine Business for Social Progress,"1993 Annual Report", 1994

Ref.8.16 USAID, "Preliminary Report for the Master Plan Study for Pinatubo affected Areas", October 1993

Ref.8.17 USAID, "Master Plan for the Areas of Central Luzon affected by the Eruption of Mt.Pinatubo, Final Report", July 1994

Ref.8.18 MPC, "Integrated Plan for the Mt.Pinatubo affected Areas", July 1994

Ref.8.19 "Medium Term Development Plan for the Province of Tarlac 1994-1998" Working Draft, October 1993

Ref.8.20 NEDA, "Medium-Term Central Luzon Regional Development Plan 1993-1998"

Ref.8.21 JICA, "The Master Plan Study for Central Luzon Development Program" Final Report, September 1995

Ref.8.22 JICA,"Study of Agno River Basin Flood Control" Final Report,Vol.III Main Report Part II Feasibility Study, and Vol.IV Supporting Report Part I Master Plan", December 1991

CHAPTER 9 STRUCTURAL MEASURE IN ABACAN RIVER BASIN

Ref.9.1 T.Kaki, "Sabo Works Planning (Japanese Edition)", 1986

Other references are the same as Chapter 8.

CHAPTER 10 NON-STRUCTURAL MEASURE

Ref.10.1 OCD, "The Philippine Disaster Management System".

Ref.10.2 Punongbayang, R.S., "Eruption Hazard Assessments and Warnings", Attachment A of Ref.3.1.

Ref.10.3 Janda R.J. et al, "Assessment and Response to Lahar Hazard around Mount Pinatubo, 1991 to 1993", Attachment B of Ref.3.1.

Ref.10.4 PHIVOLCS/UNESCO, "Lahar Studies", 1994

CHAPTER 11 ENVIRONMENTAL CONDITION

Ref.11.1 Campita, N.R.,"Crateer Lake and Post-eruption Hydrothermal Activity of Pinatubo Volcano", International Scientific Conference on Mt.Pinatubo' 1992

Ref.11.2 Grifal, R., "Physico-chemical, Mineralogical and Hydrological Characterization of Volcanic Ash and Lahar and their Utilization and Management for Agricultural Crops", Proceedings of Symposium on Sustainable Agricultural Development of Mt.Pinatubo Affected Areas, Biotech.UPLB, November 5-6, 1992

Ref.11.3 Mt.Pinatubo Groundwater Survey Team,"Assessment of the Effects of the Mt.Pinatubo Eruption on the Groundwater System, Progress Report", September 30 to October 29, 1991

Ref.11.4 Suyat, M.N., et al.,"Adaptability Test of Different Field Crops under Lahar-Laden Soils", Proceedings of Symposium on Sustainable Agricultural Development of Mt.Pinatubo Affected Areas, Biotech.UPLB, November 5-6, 1992

Ref.11.5 Dickinson, E.H., et.al.,"Birds of the Philippines", British Ornithological Union, Herts 1-23 6 AP, U.K, 1991

Ref.11.6 Du Pont, "Philippine Birds Monograph Series 2", Delaware Museum of National History, Greenville, Delaware, 1971

Ref.11.7 Generators Integrated Resource Development Inc. (GIRD), "EIA Report : Environmental Assessment of Clark Access Highway: 0-21 km.: Bamban to Flora, October 1981", 1981

Ref.11.8 McClure, H.E.,"Migration and Survival of Birds of Asia", U.S.Army Med. Comp. SEATO Medical Project, Bangkok, Thailand, 1974

Ref.11.9 City of Angeles, "Angeles City Comprehensive Land USe Plan", 1995

Ref.11.10 ASEAN-US Watershed Project,"Manual on Watershed Management Project Planning, Monitoring and Evaluation", 1990

Ref.11.11 DENR,"Master Plan for Forestry Development", 1990

Ref.11.12 IFC,"Master Plan for Mt.Makaling Watershed", 1995

Ref.11.13 PCARRD,"Philippine Recommends for Watershed Management", 1990

Environmental-related regulations of the Government of the Philippines were attached in Appendix D of Volume II.

CHAPTER 12 SEDIMENT MONITORING IN PASIG RIVER

Ref.12.1 PHIVOLCS and UNESCO, "Lahar Studies", 1994

Ref.12.2 PHIVOLCS and USGS, "Serious but Rapidly Diminishing Hazards at Mount Pinatubo", August 1994

Ref.12.3 Thomas C. Pierson and Richard J. Janda, USGS, and Jesse V. Umbal and Arturo S. Daag, PHIVOLCS, "Immediate and Long-Term Hazards from Lahars and Excess Sedimentation in Rivers Draining Mt. Pinatubo, Philippines", 1992

Ref.12.4 Thomas C. Pierson, Arturo S. Daag, Perla J. Delos Reyes, Theresa Regalado, Renato Solidum, and Bella Tubianosa, "Flow and Deposition of Post-Eruption Hot Lahars on the East Side of Mt. Pinatubo, July-October, 1991"

Ref.12.5 PHIVOLCS, "Pinatubo Volcano, Update, July-October 15,1992", 1992

Ref.12.6 K.Yamamoto, "Alluvial River Morphology", 1994

Ref.12.7 Norman M. Tungol and Ma. Theresa M. Regalado, "Calibration of the Sacobia Acoustic Flow Monitor and Correlation of Rainfall with Lahars along the Sacobia River in 1992", 1992

Ref.12.8 US Army Corps of Engineers, "Mount Pinatubo Recovery Action Plan, Long Term Report, Eight River Basins", March 1994

Ref.12.9 R. Torres, S. Self, M. Martinez, "Secondary Pyroclastic Flows from the 15 June 1991 Ignimbrite of Mount Pinatubo", 1992