REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

STUDY OF AGNO RIVER BASIN FLOOD CONTROL

FINAL REPORT

VOLUME [illegible]

MAIN REPORT
PART I MASTER PLAN

DECEMBER, [illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY

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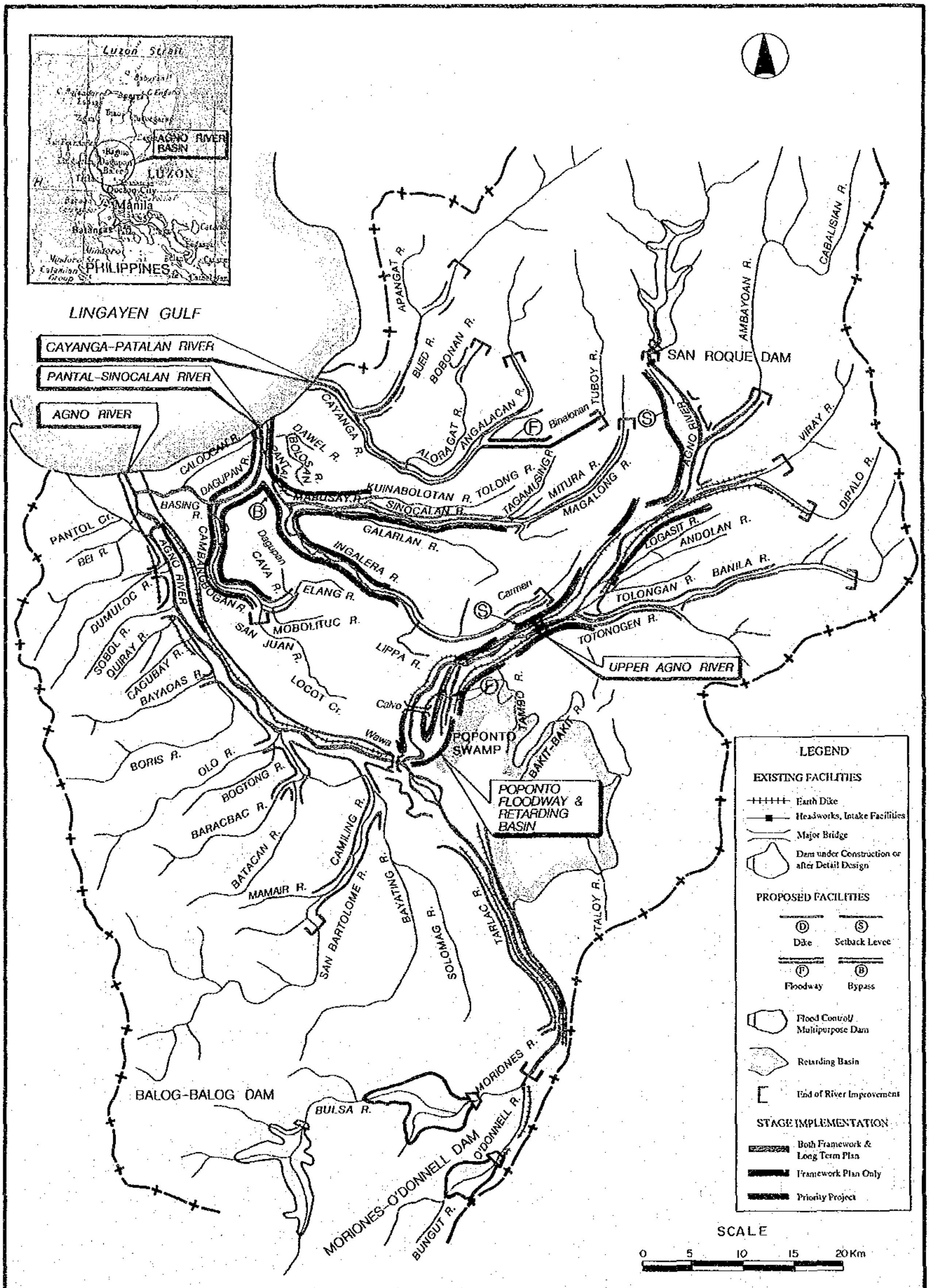
The report is published in six volumes under the following titles :

VOLUME I SUMMARY REPORT
II MAIN REPORT PART I MASTER PLAN
III MAIN REPORT PART II FEASIBILITY STUDY
IV SUPPORTING REPORT PART I MASTER PLAN
V SUPPORTING REPORT PART II FEASIBILITY STUDY
VI DATA BOOK



GENERAL PLAN OF FRAMEWORK PLAN AND LONG TERM PLAN

MAIN REPORT PART I MASTER PLAN

PRINCIPAL CONCLUSIONS

1. STUDY OBJECTIVES

The objectives of the Study as stipulated in the Implementation Arrangement of the Technical Cooperation between the Japan International Cooperation Agency (JICA) and Department of Public Works and Highways (DPWH) of the Government of the Philippines are :

1) To formulate a Master Plan for flood control in the Agno River Basin and identify the priority areas.

2) To conduct a Feasibility Study on the flood control projects in the identified priority areas.

This Part-1 of Main Report presents all the results of the Master Plan.

2. THE STUDY AREA

(1) The Master Plan Study Area covers three river systems and the vast alluvial plain called the Pangasinan plain in the western part of Central Luzon. The Study Area's drainage area totaling about 7,640 km^2, broken down into 5,907 km^2 for the Agno River basin, 1,115 km^2 for the Pantal-Sinocalan River, and 618 km^2 for the Cayanga-Patalan River. Aggregates of the Pantal-Sinocalan and Cayanga-Patalan Rivers are called together as the Allied Rivers.

The Master Plan Study Area straddle 9 provinces of the four Regions, Ilocos (Region I), Cordillera Autonomous Region (CAR), Cagayan Valley (Region II), and Central Luzon (Region III). These are Benguet, La Union, Pangasinan, Ifugao, Nueva Vizcaya, Nueva Ecija, Pampanga, Tarlac, and Zambales.

(2) The maximum inundation area in the Master Plan is estimated to be 2,465 km^2, largely covering the cultivated lands in the flood plains of the Agno River and the Allied Rivers in Pangasinan and Tarlac.

3. MASTER PLAN

3.1 Definition of Master Plan

(1) The Master Plan is composed of two stage plans, the Framework Plan and the Long Term Plan. The Framework Plan is defined as an ideal portrait of flood control plan which is to be achieved in the unspecified future. The Long Term Plan is defined as an stage development plan of the Framework Plan, the completion target year of which is set at the year 2010 (20 year - long term plan).

(2) The flood control target of the Framework Plan is set at a 100-year probable flood for the Main Agno River and the Tarlac River and at a 50-year probable flood for the other tributaries of Agno and the Allied Rivers. The flood control target of the Long Term Plan is set at a feasible scale during a project life of 50 years starting construction from 1995.

(3) Rivers subject to the study are :

Agno River	:	Main stream, Tarlac, Ambayoan, Viray-Dipalo, Banila, Camiling
Allied Rivers	:	The main stream of Cayanga-Patalan, Bued, Aloragat, Angalacan, The main stream of Pantal-Sinocalan, Tagamusing, Macalang, Ingalera, Dagupan

(4) The study focuses on the flood control plan but also studies the sediment control at a conceptual level only. The flood forecasting and warning system is studied as a part of the nonstructural measures.

3.2 Framework Plan

(1) The Framework Plan of the Agno River and its tributary the Tarlac River is composed of river improvements (stretch of 146.4 km), the Poponto floodway and natural retarding basin, and the Moriones-O'Donnel dam. Length of channel improvements including short cuts and length of dikes in both banks are 136.9 km and 258.1 km, respectively. The flood control effect of the San Roque dam (design was completed) is taken into account in the plan. The project economic cost is estimated to be 13,682 million pesos at 1989 price level. The principal features of the works are presented at the back of these sheets (refer to the general plan).

(2) For the four Agno River tributaries, Camiling, Banila, Viray-Dipalo and Ambayoan, the case of sole river improvement is adopted as the Framework Plan. The economic project cost is estimated to be 1,925 million pesos at 1989 price level. The principal features of the works are presented at the back of these sheets.

(3) A combination of river improvement and the Binalonan floodway is adopted as the Framework Plan for the Allied Rivers. The project economic costs of the Pantal-Sinocalan River and the Cayanga-Patalan River are estimated to be 2,553 million pesos and 1,246 million pesos respectively at 1989 price level. The principal features of the works are presented at the back of these sheets.

3.3 Long Term Plan

(1) The flood control scale and the financial project costs of the proposed Long Term Plan are as follows :

River/Region	Flood Control Scale	Financial Project Cost (million pesos)	EIRR (%)
Agno River and Tarlac River	25-year flood	11,048	16.6
Agno River Tributaries	25-year flood	1,640	15.5
Allied Rivers	10-year flood	3,286	33.8
Whole Study Area		15,974	20.5

(2) Although the Moriones - O'Donnell dam is included in the proposed Framework Plan, it is excluded from the Long Term Plan because of the expected issues of the land acquisition and resettlement in the reservoir areas. The reservoir areas are occupied by about 1,600 families, an agricultural land of about 40 km^2 (refer to the general plan).

(3) The proposed Long Term Plan (10-year flood) for the Allied Rivers is designed without the Binalonan floodway but takes into account the design flood distribution of the Framework Plan with the Binalonan floodway (50-year flood).

3.4 Implementation Schedule of Long Term Plan

The total project cost of the Long Term Plan is estimated to be 15,974 million pesos at 1989 constant price level. Since the amount of public funds required for the flood control works is very high if it is compared with the present level (some 0.5% of GRDP), a longer implementation schedule is formulated as an alternative. In this program the Long Term Plan can be achieved by the end of year 2020 with the public fund allocation of about 1.0% of Gross Regional Domestic Product (GRDP) of the Study Area.

3.5 Flood Forecasting and Warning System (FFWS)

(1) The FFWS Framework Plan aims to up-grade the existing ABC (Agno, Bicoland Cagayan Rivers) system and to achieve an integrated nation wide flood forecasting and warning system which fulfills the following objectives:

i) FFWS for resident's protection from flood incident

ii) FFWS for flood operation

iii) FFWS for basinwide flood management

(2) The proposed FFWS Framework Plan is composed of the system components listed below :

i) Hydrological observation network system

ii) Telemetering network system

iii) Flood forecasting system

iv) Flood warning network system

v) Monitoring system for flood operation

The total cost of the integrated FFWS in the Agno River basin is estimated at 796 million pesos at 1989 price level.

(3) The FFWS Long Term Plan is formulated as a part of a stagewise development plan which finally aims to set up the FFWS integrated system planning as the Framework Plan. Its objective is :

i) To improve the flood forecasting accuracy of the forecasting points in the existing Agno River FFWS.

ii) To carry out the effective flood warning activity in the Study Area.

The total project cost of the FFWS Long Term Plan is estimated at 281 million pesos at 1989 price level. The economic internal rate of return is expected to be 28.9%.

3.6 Sabo Works

(1) The average natural sediment yield of the mountainous areas is estimated to be about 7,800 $m^3/km^2/year$. Neither Sabo works, afforestation nor legal sediment control alone can control this large amount of sediment yield. Sabo Framework Plan is formulated as a part of sediment control, assuming that the sediment control plan will be proceeded in the future as described below :

a) Afforestation
Fifty percent of the sediment yield in the mountainous areas will be mitigated by afforestation/reforestation.

b) Sediment due to mine tailings, land slide and soil erosion due to road construction will be totally controlled.

(2) The Sabo Framework Plan is formulated for the project life of 20 years assuming that the excess sediment yield will be all stored inside the Sabo dam reservoirs. The required number of Sabo dams are 32 in addition to the

San Roque dam and the Moriones - o'Donnell dam. The Total construction cost is estimated at about 2.6 billion pesos at 1989 price level.

(3) If the project life is set at 50 years an additional 72 dams will be required each approximately 25m high. It is recommended to proceed with afforestation/reforestation simultaneously with Sabo dam construction instead of proceeding with Sabo dam construction only.

3.7 Identification of Priority Projects

(1) In the Master Plan the Upper Agno River and Pantal-Sinocalan River are identified as the Priority Project Areas subject to the Feasibility Study taking account of economic efficiency and regional significance of flood control.

A. Upper Agno River ; Bayambang stretch with Poponto retarding basin (AG180) to the San Manuel stretch (AG473); the stretch of 69 km between the Wawa bridge and the San Roque bridge in the Upper Agno River.

B. Pantal-Sinocalan River ; River mouth to the upstream to protect Dagupan city and towns of Calasiao and Santa Barbara; the downstream stretch of 27.5 km of the mainstream, 19.5 km of the Dagupan River and 10.7 km of the Ingalera River.

(2) Priority Projects are a step to the Long Term Plan with the flood protection level of 10-year design flood.

4. INITIAL ENVIRONMENTAL EXAMINATION

(1) Among the proposed schemes of the Framework Plan, the San Roque dam (assumed as existing), the Moriones-O'Donnell dam, provision of new dikes and the extension of Poponto retarding basin may have environmentally significant impacts, such as resettlement problems and encroachment of

agricultural lands. Thus, the most careful attention shall be paid to those prospective socio-economic impacts.

(2) As for the other environmental parameters, no significant environmental effects may be expected by both the Framework Plan and Long Term Plan. However, some natural environmental impacts having low or medium level of significance may be expected. Further environmental study shall, therefore, be required to visualize the expected impacts, and to find proper and possible countermeasures.

5. RECOMMENDATION

(1) The Long Term Plan is highly justifiable economically with sufficient EIRR. The project's financial costs are :

(price level on June 1989)

River/Region	Flood Control Scale	Financial Project Cost (million pesos)	EIRR (%)
Agno River and Tarlac River	25-year flood	11,048	16.6
Agno River Tributaries	25-year flood	1,640	15.5
Allied Rivers	10-year flood	3,286	33.8
Whole Study Area		15,974	20.5

The Long Term Plan is recommended to be implemented with the target commission year 2020. The total project cost is estimated to be 15,974 million pesos at 1989 constant price level.

(2) If the Study Area's flood control succeeds in containing damages with implementation of the proposed Long Term Plan, the basin economy of Pangasinan and Tarlac will become more productive. Flood protection allows the basin economy of Pangasinan and Tarlac to achieve its potential and this, in turn, makes it possible for the province to set a faster growth for the Region. The regional economy will then be able to meet, and perhaps even exceed, the projected GRDP growth.

PRINCIPAL FEATURES OF FLOOD CONTROL WORKS

1. FRAMEWORK PLAN

1.1 Project Economic Cost

Unit : Million Pesos (price level on June 1989)

. Agno River including Tarlac	13,682
. Agno Tributaries	
Camiling River	451
Banila River	1,023
Viray-Dipalo River	278
Ambayoan River	173
. Pantal-Sinocalan River	2,553
. Cayanga-Patalan River	1,246
Total	19,406

1.2 Design Flood Distribution

. Agno River including Tarlac, 100-year flood (refer to Figure 15.2.3)

River mouth	13,800 m^3/sec
Wawa bridge	11,200 m^3/sec
Confluence with Tarlac River	2,600 m^3/sec
Alcala	
for Poponto floodway	8,200 m^3/sec
for Bayambang stretch	1,000 m^3/sec
Ambayoan	6,400 m^3/sec

. Agno Tributaries, 50-year flood (refer to Figure 15.2.3)

Camiling River (confluence with Agno)	1,750 m^3/sec
Banila River (confluence with Agno)	1,400 m^3/sec
Viray-Dipalo River (confluence with Agno)	750 m^3/sec
Ambayoan River (confluence with Agno)	1,750 m^3/sec

. Pantal-Sinocalan River, 50-year flood (refer to Figure 10.2.2)

Main stream (river mouth)	2,900 m^3/sec
Dagupan River (confluence with Pantal)	2,700 m^3/sec
Ingalera River (confluence with Sinocalan)	600 m^3/sec

. Cayanga-Patalan River, 50 year flood (refer to Figure 10.2.2)

Main stream (river mouth)	3,100 m3/sec
Bued River (confluence with Cayanga)	1,300 m3/sec
Anglacan River (with Binalonan floodway)	1,250 m3/sec

1.3 Flood Control Works and Work Quantities

(1) Agno River

River Improvement Works and Flood Control Dam

Flood Control Works	Agno Main Stream	Tarlac River	Agno Tributaries
a) Length of River Improvement (km)	109.4	37.0	79.7
b) Channel Improvement Including Short Cut (km)	99.9	37.0	71.5
c) Diking System Including Back Water Stretch; both banks (km)	201.3	56.8	127.1
. new dikes	(87.0)	(1.3)	(90.1)
. heightening	(98.5)	(45.5)	(12.8)
. existing	(15.8)	(10.0)	(24.2)
d) Drainage Facilities	18	2	26
e) Bridge Reconstruction	5	3	14
f) Flood control dam	-	1 (Moriones-O'Donnell dam)	-

Work Quantities

Items	Unit	Main Agno	Tarlac River	Agno Tributaries
Excavation	1,000m3	28,875	4,300	2,083
Dredging	1,000m3	17,075	0	0
Embankment	1,000m3	20,370	1,355	3,370
Revetment	1,000m2	588	96	190
Groin	Pc.	958	244	1,070
Drainage facility	Pc.	18	2	26
Bridge	Pc.	5	3	14
Intake facility	Pc.	0	0	4
Flood control dam	Nos.	0	1	0

(2) Allied Rivers

River Improvement Works

Flood Control Works	Pantal-Sinocalan River	Cayanga-Patalan River
a) Length of River Improvement (km)	142.2	77.0
b) Channel Improvement Including Short Cut (km)	131.7	72.3
c) Diking System Including Back Water Stretch (km)	246.3	99.9
d) Drainage Facilities	41	22
e) Bridge Reconstruction	24	9

Work Quantities

Items	Unit	Pantal-Sinocalan River	Cayanga-Patalan River
Excavation	1,000m3	5,712	2,361
Dredging	1,000m3	38	440
Embankment	1,000m3	6,515	1,773
Revetment	1.000m2	470	194
Groin	Pc.	754	1,095
Drainage facility	Pc.	41	22
Bridge	Pc.	24	9
Intake facility	Pc.	4	0

2. LONG TERM PLAN

2.1 Project Cost and EIRR

(price level on June 1989)

River/Region	Flood Control Scale	Project Financial Cost (million pesos)	EIRR (%)
Agno River and Tarlac River	25-year flood	11,048	16.6
. Lower Agno River		6,296	
. Poponto Stretch		1,127	
. Upper Agno River		2,204	
. Tarlac River		1,421	
Agno River Tributaries	25-year flood	1,640	15.5
. Camiling River		387	
. Banila River		774	
. Viray-Dipalo River		300	
. Ambayoan River		179	
Allied Rivers	10-year flood	3,286	33.8
. Pantal-Sinocalan River		2,160	
. Cayanga-Patalan River		1,126	
Whole Study Area		15,974	20.5

2.2 Design Flood Distribution

. Agno River including Tarlac, 25-year flood (refer to Figure 15.2.4)

River mouth	10,100 m^3/sec
Wawa bridge	8,400 m^3/sec
Confluence with Tarlac River	2,600 m^3/sec
Alcala	
for Poponto floodway	5,200 m^3/sec
for Bayambang stretch	600 m^3/sec
Ambayoan	3,800 m^3/sec

. Agno Tributaries, 25-year flood (refer to Figure 15.2.4)

Camiling River (confluence with Agno)	1,650 m^3/sec
Banila River (confluence with Agno)	1,000 m^3/sec
Viray-Dipalo River (confluence with Agno)	550 m^3/sec
Ambayoan River (confluence with Agno)	1,350 m^3/sec

. Pantal-Sinocalan River, 10-year flood (refer to Figure 10.3.1)

Main stream (river mouth)	2,000 m^3/sec
Dagupan River (confluence with Pantal)	1,850 m^3/sec
Ingalera River (confluence with Sinocalan)	360 m^3/sec

. Cayanga-Patalan River, 10-year flood (refer to Figure 10.3.1)

Main stream (river mouth)	1,500 m^3/sec
Bued River (confluence with Cayanga)	750 m^3/sec
Anglacan River (with Binalonan floodway)	400 m^3/sec

2.3 Improvement Works and Work Quantities

(1) Agno River

River Improvement Works

Flood Control Works	Agno Main Stream	Tarlac River	Agno Tributaries
a) Length of River Improvement Including Poponto Floodway and Short Cut (km)	109.4	37.0	79.7
b) Channel Improvement Including Poponto Floodway and Short Cut (km)	99.9	37.0	71.5
c) Diking System Including Back Water Stretch (km)	201.3	56.8	126.7
. new dikes (km)	68.5	1.3	88.7
. heightening (km)	98.6	45.5	13.4
. existing (km)	34.2	10.0	24.6
d) Drainage Facilities	18	2	26
e) Bridge Reconstruction	5	3	14

Work Quantities

Items	Unit	Main Agno	Tarlac River	Agno Tributaries
Excavation	1,000m^3	24,673	4,300	1,200
Dredging	1,000m^3	13,027	0	0
Embankment	1,000m^3	15,269	1,355	2,581
Revetment	1,000m^2	514	96	190
Groin	Pc.	958	244	1,070
Drainage facility	Pc.	18	2	26
Bridge	Pc.	5	3	14
Fixed weir	Pc.	1	0	0
Intake facility	Pc.	0	0	4

(2) Allied Rivers

River Improvement Works

Flood Control Works	Pantal-Sinocalan River	Cayanga-Patalan River
a) Length of River Improvement (km)	129.6	77.0
c) Channel Improvement Including Short Cut (km)	119.1	72.3
d) Diking System Including Back Water Stretch (km)	210.2	99.7
. new dikes (km)	206.4	99.7
. heightening (km)	3.8	-
. existing (km)	-	-
e) Drainage Facilities	39	22
g) Bridge Reconstruction	22	9

Work Quantities

Items	Unit	Pantal-Sinocalan River	Cayanga-Patalan River
Excavation	$1,000m^3$	4,216	1,842
Dredging	$1,000m^3$	38	260
Embankment	$1,000m^3$	4,012	718
Revetment	$1,000m^2$	373	193
Groin	Pc.	952	1,095
Drainage facility	Pc.	39	22
Bridge	Pc.	22	9
Intake facility	Pc.	4	0

STUDY OF AGNO RIVER BASIN FLOOD CONTROL

MAIN REPORT

PART 1 MASTER PLAN

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ABBREVIATIONS

ADB	:	Asian Development Bank
AFCS	:	Agno Flood Control System
ARIS	:	Agno River Irrigation System
ARFFO	:	Agno River Flood Forecasting Office
ARFC	:	Agno River Flood Control
BP	:	Base Point
BUTEL	:	Bureau of Telecommunications
DAF	:	Department of Agriculture and Food
DENR	:	Department of Environment and Natural Resources
DOTC	:	Department of Transportation and Communication
DPWH	:	Department of Public Works and Highways
EIA	:	Environmental Impact Assessment
FFWS	:	Flood Forecasting and Warning System
FFWSDO	:	Flood Forecasting and Warning System for Dam Operation
GDP	:	Gross Domestic Product
GF	:	Growth Factor
GOJ	:	Government of Japan
GOP	:	Government of Philippines
GRDP	:	Gross Regional Domestic Product
IEE	:	Initial Environmental Examination
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Construction, Japan
LARIS		Lower Agno River Irrigation System
LATRIS	:	Lower Agno and Totonogen River Irrigation System
NAPOCOR	:	National Power Cooperation
NEDA	:	National Economic Development Authority
NFFO	:	National Flood Forecasting Office
NIA	:	National Irrigation Administration
NWRB	:	National Water Resources Board
OCD	:	Office of Civil Defense
OECF	:	Overseas Economic Cooperation Fund, Japan
PAGASA	:	Philippine Atmospheric Geophysical and Astronomical Services Administration
PM	:	Project Manager
PMO	:	Project Management Office
PNR	:	Philippine National Railways
SMORIS	:	San Miguel-O'Donnell River Irrigation System
UN	:	United Nations

ABBREVIATIONS OF MEASUREMENT

(Length)

mm	millimeter(s)
cm	centimeter(s)
m	meter(s)
km	kilometer(s)

(Area)

mm^2	square millimeter(s)
cm^2	square centimeter(s)
m^2	square meter(s)
km^2	square kilometer(s)
ha(has)	hectare(s)

(Volume)

cm^3	cubic centimeter(s)
m^3	cubic meter(s)
ltr	liter(s)

(Weight)

gr(grs)	gramme(s)
kg(kgs)	kilogramme(s)
ton(s)	ton(s), eq'vt to 1,000 kg

(Time)

sec	second(s)
min	minute(s)
hr(hrs)	hour(s)
dy(dys)	day(s)
mth(mths)	month(s)
yr(yrs)	year(s)

(Others)

%	percent(s)
o	degree(s)
10^3	thousand
10^6	million
10^9	billion

1. INTRODUCTION

1. INTRODUCTION

1.1 Objective of the Study

The Government of the Republic of the Philippines (GOP) has been making efforts for providing various kinds of flood control measures which are prerequisite to the economic development of the country. In spite of their efforts, however, flood damages have not been relieved completely due to insufficient provisions of facilities and progressive damage to the existing facilities.

Among the major rivers of the country, GOP places high priority to the implementation of the urgent rehabilitation and improvement works for flood control facilities in the Agro River and the Allied River basins. In response to GOP's request the Government of Japan (GOJ) decided to conduct the study of the Agno River Basin Flood Control (the Study) and entrusted the Study to the Japan International Cooperation Agency (JICA).

The objectives of the Study as stipulated in the Implementing Arrangement on the Technical Cooperation between JICA and the Department of Public Works and Highways (DPWH) are:

1) To formulate a Master Plan for flood control in the Agno River Basin and identify the priority areas.

2) To conduct a Feasibility Study on the flood control projects in the identified priority areas.

1.2 Background of the Study

The Pangasinan plain is endowed with water resources which are essential for sustaining the region's human activities. However, the effects of seasonal variation of rainfall cause adverse economic dislocation at the national and regional levels. In particular, frequent recurrence of floods, which are caused by typhoons or tropical storms, has been inflicting serious damages to crops, properties and lives of inhabitants almost every year. In line with the national and regional development goals, it has been recognized quite important to accelerate various protective measures for relieving the inhabitants from damages to crops, properties and public facilities, and risk to their lives.

The Agno River basin and the Allied River basins are located in the western part of Central Luzon as shown in Figure 2.1.1. The Agno River has a catchment area of 5,910 km^2 and is the fifth largest river in the Philippines, while the Allied River basins have a total catchment area of 1,730 km^2. These basins and the adjacent Pampanga River basin cover a large part of the country's granary areas. This is one of the reasons why this area is regarded as one of the most important areas where flood control should be given priority attention.

It is estimated that a total area of 150,000 ha to 250,000 ha (depending on the flood's scale) is susceptible to inundation in the provinces of Pangasinan, Tarlac and Nueva Ecija in consequence of floods from the said river system. The population in this flood-prone area is estimated to be about 1.5 million. The Agno River basin experienced large floods in 1935, 1936, 1937, 1938, 1943, 1950, 1960, 1968, 1972, 1980, 1984, 1985, and 1986. The 1935 flood recorded the largest inundation area but had no damage record. The flood of 1972, the second largest record, inundated more than 80% of the flood-prone area mentioned above. The damages incurred by this flood amounted to ₱ 2 billion in Central Luzon.

The floods which occurred in September 1984 (typhoon Maring) and June 1986 (typhoon Gading) destroyed the existing earth dikes and bank protection structures over stretches of several kilometers, with estimated structural damages of about ₱ 64 million. The flood in 1986 inundated an area of about 200,000 ha and the damages caused by this flood amounted to about ₱ 134 million. It was reported that 69 people lost their lives in the Agno River basin due to floods and typhoons in the five-year period from 1982 to 1986. This frequent recurrence of floods and insufficient protective measures thus seriously hinders the economic development of the project area.

GOP started the implementation of flood protection measures in the Agno River in 1938. Based on the study conducted by the defunct Bureau of Public Works (BPW) in 1959, GOP carried out basic flood control measures such as straightening the river courses and constructing earth dikes in the Agno River basin. Some of these structures, however, had been damaged and the dikes had been breached or collapsed in many sections by rapid currents during the high flow periods.

At present, the Agno River basin and the Allied River basins are extensively utilized for irrigation and human settlement, making it now more susceptible to flood damages in economic terms. Urgent rehabilitation and improvement of the existing flood control facilities, including reconstruction and improvement of damaged dikes and augmentation of channel capacity and retarding basin, are of primary necessity.

Previously, the Nationwide Food Control Plan and River Dredging Program prepared in 1982 established the basic flood control plans for the major rivers of the Philippines including the Agno River.

1.3 Contents of the Report

The study outputs have been compiled in two parts; Part-1 for the Master Plan and Part-2 for the Feasibility Study. Each part is comprised of a main report and a supporting report. The main report presents all the study results while the supporting report describes the details of the respective sectoral studies. A summary report briefs both the Master Plan and Feasibility Study. A data book compiles the supporting data to these reports. The composition of the supporting report is as follows:

Sector		Part-1 Master Plan	Part-2 Feasibility Study
SE	Socio-Economy	*	*
HY	Hydrology	*	*
GL	Geology	*	*
LF	Liquefaction Study	out of scope	*
SR	Seismic Resistance Study	out of scope	*
SV	Survey	*	*
FD	Flood Damage	*	*
SD	Sediment Control Plan	*	*
RV	River Improvement Plan	*	*
DM	Dam and Retarding Basin Plan	*	*
FF	Flood Forecasting and Warning System	*	*
DS	Design of Structures	*	*
CP	Construction Plan and Cost Estimates	*	*
EI	Environmental Impact Assessment	*	*

The first half of this report, Chapters 2 - 7, summarizes the outputs of the basic sectoral studies which are required for the master plan formulation. The latter half, Chapters 8 - 14, presents the Master Plan and its evaluation including an initial environmental examination. Chapter 15 describes the modification of a part of the Master Plan and the background to why such a modification was required.

2. THE STUDY AREA

2. THE STUDY AREA

2.1 River Basins in the Study Area

The Study Area located in the western part of the Central Luzon covers the Agno River Basin and the Allied River Basins as delineated in Figure 2.1.1. The Study Area's drainage area totals about 7,640 km^2 divided into 5,910 km^2 in the Agno River Basin and 1,730 km^2 in the Allied River Basins.

The Agno River having a length of about 275 km is the fifth largest river in the Philippines. The river originates at a point 55 km north-east of Bagnio City and flows down the southern slopes of the Cordillera central mountains. It flows in a southerly course to Tayung where it veers southwest through Villasis and Bayambang into Poponto swamp. It then flows northeast, skirting the eastern slopes of the Zambales mountains and empties into the Lingayen Gulf. Its major tributaries are the Tarlac, Camiling, Ambayoan, Viray-Dipalo and Banila Rivers.

The Allied Rivers, consisting of a group of two medium size river systems, drain the runoff of the vast alluvial plain called the Pangasinan plain into the Lingayen Gulf. The drainage area of the Pantal-Sinocalan River is 1,115 km^2 (including the Dagupan River) while that of the Cayanga-Patalan River is 618 km^2 (including the Bued River).

These river basins provide an economic basis for fairly diversified agricultural production, mainly paddy and fish culture. However, their full potential cannot be exploited owing to recurrent damaging floods.

The water resources of the Agno River have been developed for power generation and irrigation purposes. There are two existing hydropower dams on the upstream reaches, namely the Ambuklao dam commissioned in December 1956 and the Binga dam commissioned in January 1960.

There are two existing irrigation intakes along the Agno River. One is the diversion weir for irrigating the Agno River Irrigation System (ARIS), located 7 km north of San Manuel or just 3 km downstream of the proposed site for the San Roque multipurpose dam project, and the other is the headwork for the Lower Agno River Irrigation System (LARIS), located downstream of Santa Maria.

ARIS was designed to irrigate an area of 18,500 ha in the Pangasinan province, though it has experienced a decrease in irrigateable area to 11,100 ha due to the decrease in the flow capacity of the canal system caused by heavy siltation of sandy deposits from the upstream stretches. LARIS was designed to irrigate some 8,000 ha.

The San Roque multipurpose dam project will involve constructing a fill dam 210 m in height (43 million m^3 of embankment volume) for power generation (390 MW), irrigation (70,800 ha), water quality control and flood control. The river drains an area of 1,250 km^2 at the proposed dam site where the annual mean runoff is estimated at 84.5 m^3/sec. The feasibility study of the project was completed in 1979 and its detailed engineering design was completed in 1982. The Balog-Balog dam in Tarlac province is under construction.

In the Agno River basin, a flood forecasting and warning system was established in 1982 as a non-structural measure to mitigate flood damages.

2.2 Socio-Economic Conditions in the Study Area

Administrative Region in the Study Area

The Study Area straddles nine provinces in Ilocos (Region I), Cordillera Autonomous Region (CAR), Cagayan Valley (Region II) and Central Luzon (Region III). These are Benguet, La Union, Pangasinan, Ifugao, Nueva Vizcaya, Nueva Ecija, Pampanga, Tarlac and Zambales as set out below:

Region		Province
I	:	Benguet, La Union, Pangasinan
II	:	Ifugao, Nueva Viscaya
III	:	Nueva Ecija, Pampanga, Tarlac, Zambales

It covers 83 out of the 189 municipalities in the 9 provinces as distributed below:

Province	Number of Municipalities in the Province	Number of Municipalities in the Study Area
Benguet	14	9
La Union	20	3
Pangasinan	48	40
Ifugao	7	3
Nueva Vizcaya	15	2
Nueva Ecija	32	5
Pampanga	22	1
Tarlac	17	15
Zambales	14	5
9	189	83

The regions, provinces, cities and municipalities covered by the Study Area are shown in Figure 2.2.1.

Socio-Economic Profile

The socio-economic profile of the Study Area is summarized in Table 2.2.1. The population in the Study Area increased from 1.72 million in 1970 to 2.05 million in 1980 with an average growth rate of 1.75% per year during this 10-year period.

This rate is similar to that of Region I (1.70%) but significantly lower than those of Region II (2.73%), Region III (2.88%) and the whole country (2.75%). This lower growth rate in the Study Area (hereinafter called the Area) may indicate that net out-migration was high in the Area from 1970 to 1980. The population in the Area was estimated at 2.324 million in 1987.

The population density in the Area was about 268 persons/km^2 in 1980 which was higher than the average density of 160 persons/km^2 for the whole country. The most densely populated municipalities with cultivated agricultural land are located in the flood plain of the Agno River and the Allied Rivers in Pangasinan and Tarlac.

The urban population in the Area, as defined by the National Statistics Office, was 529,000 in 1980 accounting for 26% of the total population. This was lower than the country's overall urbanization rate.

The working age population (15 years old and above) in the Area was 1.242 million or 60.7% of the total population in 1980, similar to the country's figure of 60.2%. Labor force in the Area totaled 694,000 persons or 55.9% of the working age population. This was lower than the country's 59.8% indicating that on a per capita basis there were fewer economically active persons in the Area than the national average.

The number of employed persons in the Area increased from 670,000 in 1980 to 800,000 in 1987. In 1987, the agriculture sector absorbed 405,000 workers or 50.6% of the total employment compared to 55.1% in 1980. During the same period, the service sector increased its share of total employment from 29.8% in 1980 to 34.3% in 1987. The employment share of the industry sector remained at 15.1%. Although mainly agricultural based, the structure of the Area's economy is shifting gradually towards a service sector oriented one. In 1987, the Area accounted for 4.1% of the country's agricultural workers, 4.0% of the country's industrial workers, and 3.5% of the country's service sector workers.

In 1987, the Gross Regional Domestic Product (GRDP) of the Area amounted to ₱17,500 million at current prices, accounting for 2.5% of the country's GDP. In real terms, the local economy grew at an average of 2.95% per year during the period 1980 to 1987 while the national economy grew at a slower rate of 0.44% per year during the same period. Per capita GRDP of the Area in 1987 was estimated at ₱7,539 comparatively lower than the national average per capita GDP of ₱12,300.

The population in the Area is projected by NEDA to be 2.450 million in 1990, 2.658 million in 1995, 2.857 million in 2000, 3.035 million in 2005, and 3.181 million in 2010. The corresponding average annual growth rates are 1.77%, 1.64%, 1.45%, 1.22% and 0.95%.

Table 2.2.1 SOCIO-ECONOMIC PROFILE OF THE STUDY AREA

Parameter	Unit	1980 Philippines	1980 Region I Ilocos	1980 Region II Cagayan Valley	1980 Region III Central Luzon	1980 Study Area Amount	1980 Study Area Share (%)	1987 Philippines	1987 Region I Ilocos	1987 Region II Cagayan Valley	1987 Region III Central Luzon	1987 Study Area Amount	1987 Study Area Share (%)
I. Population													
1. Total	Thousand	48,098	3,541	2,216	4,803	2,046	4.3	57,356	4,056	2,648	5,726	2,324	4.1
2. Rural Population	Thousand	30,155	2,699	1,872	2,794	1,517	5.0						
Percent of Total	%	62.7	76.2	84.5	58.2	74.1	-						
3. Population 15 yrs. old & over	Thousand	28,967	2,158	1,316	2,880	1,242	4.3	34,840	2,496	1,576	3,519	1,429	4.1
Percent of Total	%	60.2	60.9	59.4	60.0	60.7	-	60.7	61.5	59.5	61.5	61.5	-
4. Total Labor Force	Thousand	17,308	1,202	867	1,624	694	4.0	22,984	1,558	1,108	2,189	892	3.9
Percent of Pop. 15 yrs. old & over	%	59.8	55.7	65.9	56.4	55.9	-	65.7	62.4	70.3	62.2	62.4	-
5. Employed Persons (total)	Thousand	16,434	1,169	833	1,529	670	4.1	20,795	1,411	1,054	1,909	800	3.8
-Agriculture, Fishery & Forestry	Thousand	8,453	706	589	586	369	4.4	9,940	768	689	733	405	4.1
-Industry	Thousand	2,554	156	80	312	101	4.0	3,045	198	77	358	121	4.0
-Service	Thousand	5,427	307	164	631	200	3.7	7,810	445	288	818	274	3.5
Total	Thousand	16,434	1,169	833	1,529	670	4.1	20,795	1,410	1,055	1,909	800	3.8
Agriculture as Percent of Total	%	51.4	60.4	70.7	38.3	55.1	-	47.8	54.5	65.3	38.4	50.6	-
Employment Rate	%	95.0	97.3	96.1	94.2	96.5	-	90.5	90.5	95.2	87.2	89.7	-
II. GDP													
1. Total at Current Prices	Million P	264,652	10,706	7,567	24,456	6,181	2.3	705,467	30,577	16,152	62,638	17,521	2.5
at 1972 Constant Prices	Million P	92,568	3,500	2,606	7,644	2,021	2.2	95,434	4,323	2,301	7,665	2,477	2.6
2. Per Capita at Current Prices	P	5,477	3,021	3,397	5,067	3,021	-	12,300	7,539	6,100	10,939	7,539	-
at 1972 Constant Prices	P	1,916	988	1,170	1,584	988	-	1,664	1,066	869	1,339	1,066	-
3. Contribution to GDP at Current Prices													
-Agriculture	Million P	36,332						95,516	8,224	5,200	7,373		
Palay	Million P	9,080						24,028	2,453	2,854	4,649		
Corn	Million P	3,481						11,551	281	972	28		
Other crops	Million P	23,771						59,937	5,490	1,373	2,696		
-Livestock & Poultry	Million P	7,488						28,028	2,368	1,496	4,219		
-Fishery	Million P	11,198						36,319	598	159	1,569		
-Forestry	Million P	6,743						10,907	125	1,468	13		
Total Agri., Fishery & Forestry	Million P	61,761	3,255	3,244	4,713			170,770	11,315	8,323	13,174		
Percent of GDP	%	23.3	30.4	42.9	19.3			24.2	37.0	51.5	21.0		
-Industry	Million P	96,723	3,515	2,048	10,843			229,683	8,080	1,809	24,917		
Percent of GDP	%	36.6	32.8	27.1	44.3			32.6	26.4	11.2	39.8		
-Service	Million P	106,168	3,936	2,275	8,900			305,014	11,182	6,020	24,547		
Percent of GDP	%	40.1	36.8	30.0	36.4			43.2	36.6	37.3	39.2		
4. Labor Productivity													
-Agriculture	P	7,306	4,610	5,508	8,043			17,180	14,733	12,080	17,973		
-Industry	P	37,871	22,532	25,600	34,753			75,430	40,808	23,494	69,601		
-Service	P	19,563	12,821	13,872	14,105			39,054	25,128	20,903	30,009		
III. Land Use													
1. Total Area	km2	300,000	21,568	36,403	18,231	8,305	2.8						
2. Agricultural Land													
-Temporary crops	km2	43,652	3,086	4,157	4,445	2,029	4.6						
-Permanent crops	km2	34,890	200	380	138	96	0.3						
-Pasture	km2	5,300	504	956	171	159	3.0						
-Others	km2	13,409	499	897	266	198	1.5						
Total	km2	97,251	4,309	6,390	5,020	2,482	2.6						
Percent of Total Area	%	32.4	20.0	17.6	27.5	29.9	-						

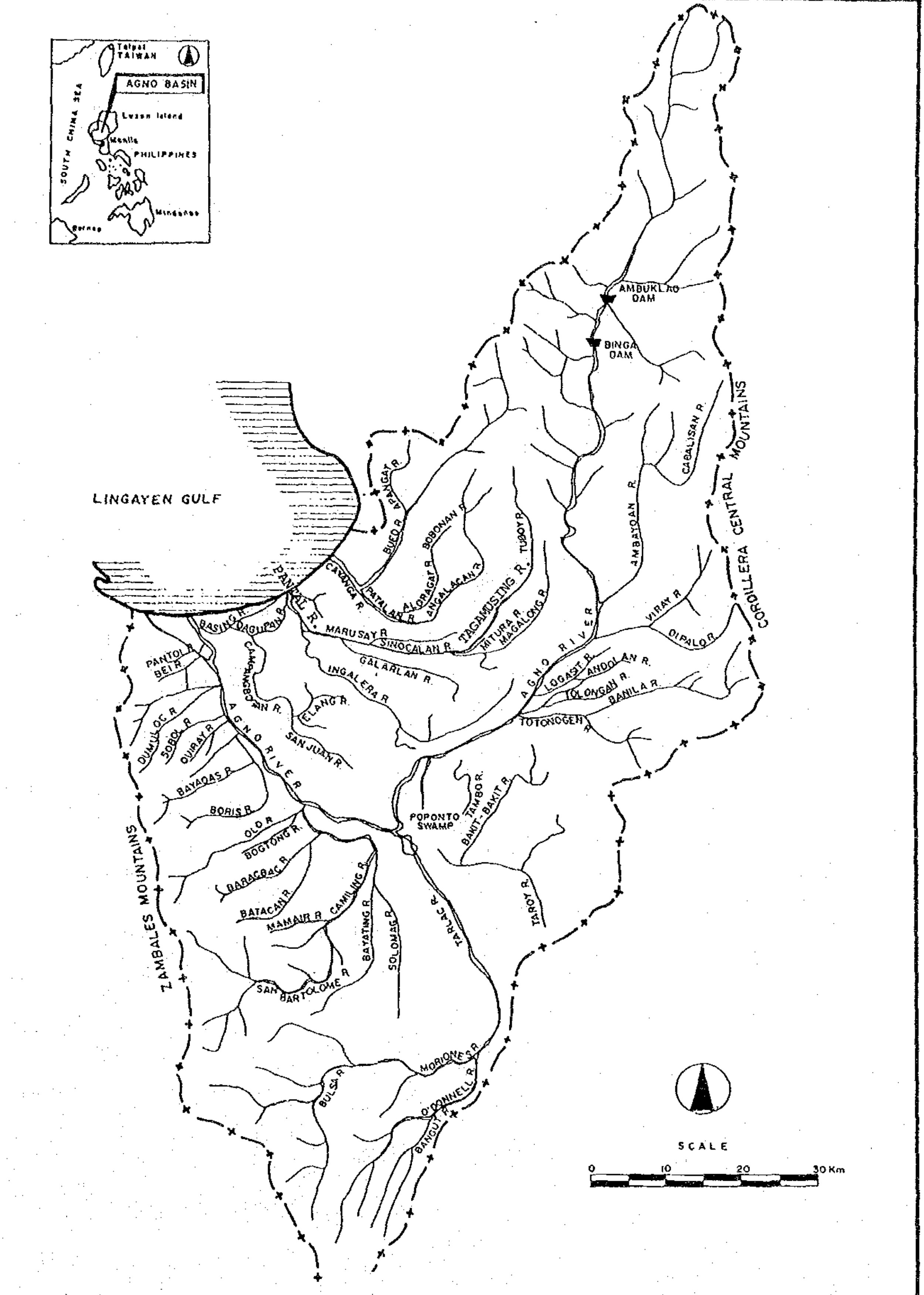


Fig. 2.1.1 LOCATION MAP OF THE STUDY AREA

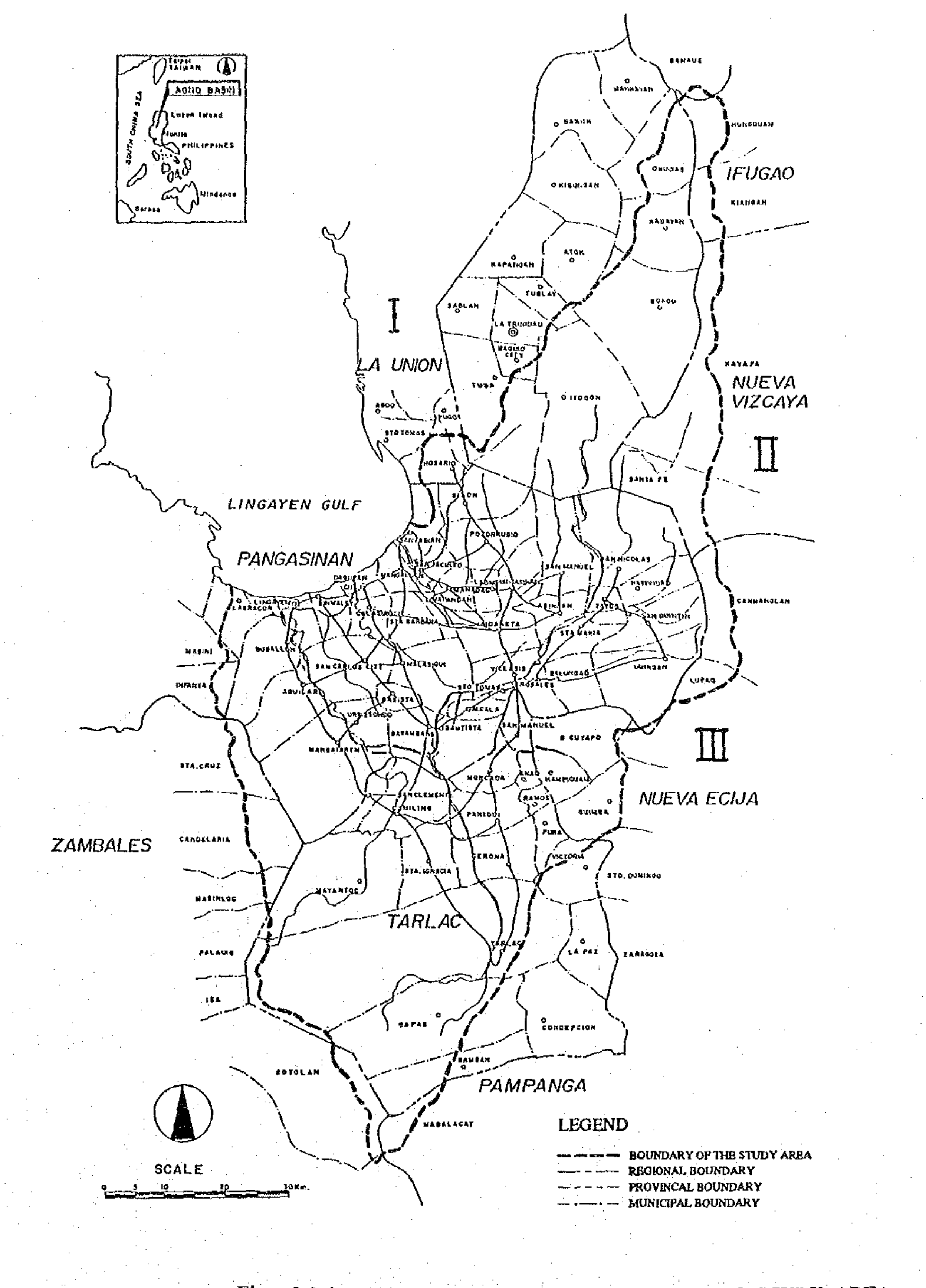


Fig. 2.2.1 ADMINISTRATIVE DIVISION IN THE STUDY AREA

3. PROFILE OF AGNO RIVER AND ALLIED RIVERS

3. PROFILE OF AGNO RIVER AND ALLIED RIVERS

3.1 Present River Conditions

3.1.1 River Systems

The Study Area is divided into three river systems; Agno River System (C.A.=5,907 km^2), Pantal-Sinocalan River System (C.A.=1,115 km^2) and Cayanga-Patalan River System (C.A.=618 km^2). The location map is shown in Figure 2.1.1. The river system diagram is shown in Figure 3.1.1.

3.1.2 Channel Conditions

The general features of the river channels of the Agno River main stream, its major tributaries, and the Allied Rivers are described as follows:

River	Stretch	River width (m)	Low Water width (m)	Channel depth (m)	River Bed Slope
Agno	(Mouth-Tarlac)	4,000-1,500	550-100	8.0-4.0	1/7,000-1,650
	(Tarlac-ARIS dam)	2,400-450	350- 75	5.5-3.0	1/1,650- 200
Tarlac	(8km Us.-Tarlac city)	1,500-600	550- 60	3.5-2.5	1/1,200- 750
Ambayoan	(Ds.end-9km Us.)	450-150	75- 60	2.5-1.5	1/200- 150
Viray-Dipalo	(Ds.end-8km Us.)	450-250	120- 60	4.0-3.0	1/400- 250
Banila	(Ds.end-30km Us.)	120- 30	120- 25	4.0-1.5	1/850- 100
Camiling	(Camiling-Mayantoc)	120- 50	120- 50	6.0-5.0	1/2,000- 250
Pantal-Sinocalan-Tagamusing		300- 35	160- 10	7.0-1.5	1/1,750- 70
Cayanga-Patalan-Angalacan		300- 35	170- 20	6.0-2.0	1/1,300- 140

Note Ds. : Downstream
Us. : Upstream

The longitudinal profiles and typical cross-sections of the existing river channels are presented for the Agno River, Tarlac River, Ambayoan River, and Viray-Dipalo River in Figures 3.1.2, 3.1.3, 3.1.4, and 3.1.5 respectively.

3.1.3 Historic Transformation of the River Course and River Bed

The historic transformation of the Agno River course is illustrated in Figure3.1.6.

As for the main stream of Agno River, the river stretch between San Roque and the confluence of the Viray-Dipalo River forms an alluvial fan and a braided river course. Downstream of the confluence of the Viray-Dipalo River, braiding and/or meandering river courses and alternating bars are actively developed. In the lower reaches from the Bayambang railway bridge, the main stream of the river course meanders about. As shown in Figure 3.1.6, straight river channels are found only in short stretches near the river mouth and in part of the improved short-cut channels. Thus, from a viewpoint of river morphology, the lower reaches of the Agno River are classified as a type of meandering river stretch.

The Tarlac River is also a meandering river with developed sand bars. In the lower reaches between the inlet (TA200) to the Poponto swamp and the confluence with the Agno River, river improvement works have not been done and flood water diverts naturally into the swamp while river improvement works were done in the upstream stretches from TA200.

The river bed fluctuation of the main Agno and the Tarlac is analyzed by using the hydrological data at water-level gauging stations. The river stretch of the main Agno at Bayambang located about 10 km upstream of the confluence with the Tarlac River has experienced degradation of river bed for the past 10 years.

3.1.4 Carrying Capacity

The present river discharge capacity is estimated by a non-uniform flow calculation. The estimated capacity of the Agno main stream and its major tributaries is illustrated in Figure 3.1.7.

There is no dike in the 40 km section on the left bank from the mouth of the Agno River. The bankfull capacity of the stretch is estimated to be about equivalent to the peak flood discharge with a 1 to 2 year return period, while the carrying capacity of the river stretch near the river mouth is in the order of the peak flood discharge with a 2-3 year return period.

The average discharge carrying capacity of the dike stretch is estimated equal to the peak flood discharge with a 10-year return period. However, the carrying capacity fluctuates along the length of the river. Especially, the river stretch in Bayambang near the confluence of the Tarlac River and the Carmen bridge stretch are hydraulic bottle-neck points, where the carrying capacity is estimated to be equal to the peak flood discharge with a 5 year return period.

For the Allied Rivers, no significant river improvement works had been undertaken to increase the flow capacity of the channels. Therefore, the discharge carrying capacity depends on the ground level on both sides of the river. The area along the Sinocalan River from Santa Barbara to Calasiao is regularly inundated by the river overflow due to the shortage of flow capacity. Also, inundation due to local drainage problems annually occurred in the area.

3.2 Existing River Control Facilities and Structures

Existing facilities for flood control in the Agno and Allied Rivers are earth and concrete dikes, groins, revetments and diversion channels. The major river control facilities and structures are summarized in Table 3.2.1 and their locations are shown in Figure 3.1.8.

Diking systems are one of the most progressive flood control facilities in the Agno River. The lengths of existing dikes of the major rivers are summarized below:

River	Stretch	Length of diking system (km) Right bank	Left bank
Agno River			
Main Agno	River mouth-Bayambang (50km Upstream)	40.50	16.30
	Bayambang-ARIS Dam (99km Upstream)	47.80	28.80
Ambayoan	Confluence-8.7km Upstream	0.00	3.50
Viray-Dipalo	Confluence-8.5km Upstream	5.70	7.40
	Viray River stretch (L=3.9km)	3.30	7.00
	Dipalo River stretch (L=8.1km)	0.00	0.00
Banila	Confluence-30.9km Upstream	0.00	9.30
Tarlac	Confluence-TARIS Dam (37.0km Upstream)	29.60	25.50
Camiling	Confluence-Mayantoc (20.8km Upstream)	0.00	0.00
	Total	126.90	97.80
Allied Rivers			
Cayanga-Patalan	River mouth-37.5km Upstream	0.00	0.00
	Tributaries	0.00	0.00
Panto-Sinocalan	River mouth-49.4km Upstream	2.50	1.30
	Tributary	0.00	0.00
	Total	2.50	1.30

3.3 Previous River Control Works

As early as the 1930's the Government of the Philippines started a flood control study on the Pampanga and Agno River basins. Due to habitual flooding in the Agno River basin in the 1930's, construction of an earthdike was commenced in the downstream reaches of the Agno River in 1938. By 1960, construction of an earthdike of 100km in length, improvement works of 65km of river channels and 10km of revetment were completed. Tables 3.3.1 and 3.3.2 show the completed river control projects between 1968 and 1988, and the work quantities and construction costs since 1972 respectively.

3.4 On-going River Control Works and the Five-Year Program

The Major flood control plans under which river improvement works are being executed in the Agno River comprise:

(1) Master Plan of Agno Flood Control System
(2) Five-year DPWH Infrastructure Program
(3) Regular Infrastructure Program
(4) Rehabilitation Program

Despite these plans, a master plan with overall and long-term goals on the Agno River basin has not yet been established. It might be said at present that these plans mainly focus on rehabilitation and maintenance works of existing river facilities.

According to the Five-Year DPWH Infrastructure Program (1989-1993), 22 on-going river control works are planned in the Agno Rivers. Almost all of these projects are small-scale works to be implemented urgently, and mainly consist of bank protection works.

The proposed projects in the Five-Year DPWH Infrastructure Program are listed in Table 3.4.1.

Table 3.2.1 EXISTING RIVER CONTROL FACILITIES

PROJECT	EARTH-DIKE (km)	REVET./ GRAVITY WALL (km)	CUT-OFF CHANNEL /RIVER IMPV'T. (1968-88) (km)	REMARKS (Construction of Earthdike, 1968-88) (km)
1. AGNO RIVER CONTROL PROJECT				
(UPPER REACHES)				
Bayambang-Baby Dike Section	0.98 (R)	-	-	0.98
Bayambang-Villasis Earthdike Section	18.37 (R)	1.89	-	-
Villasis-Asingan Earthdike Section	12.00 (R)	0.40	-	12.00
Asingan-Sn. Manuel Earthdike Section	17.40 (R)	2.20	-	7.50
Anulid-Bautista Earthdike Section	5.80 (L)	-	-	5.80
Anulid-Poponto Earthdike/Flood Way	4.67 (L)	-	1.02 km(Spillway)	4.67
	6.03 (R)	-	10.85	6.03
Alcala-Sto. Tomas Dike Section	7.20 (L)	4.73	0.99	1.02
Rosales-Lagasit Dike Section	4.00 (L)	1.20	-	
Lagasit-Sta. Maria Section	12.06 (L)	-	-	
Sta. Maria-Tayug Section	- (L)	-	-	
(LOWER REACHES)				
Lingayen-Urbiztondo-Bayambang	40.50 (R)	-	-	8.50
Bugallon-Labrador Earth Section	0.53 (L)	-	-	0.53
Bugallon-Aguilar Earthdike Section	11.35 (L)	-	-	11.35
Cupang Parallel Earthdike Section	2.05 (L)	-	-	2.05
	1.84 (R)	-	-	1.84
Sobol Parallel Earthdike Section	1.60 (L)	-	-	1.60
	1.80 (R)	-	-	1.80
2. AMBAYOAN RIVER CONTROL PROJECT	2.50 (L)	-	-	2.50
3. VIRAY-DIPALO RIVER CONTROL PROJECT	14.44 (L)	-	8.80	14.44
	9.00 (R)	-	-	9.00
4. TOTONOGEN RIVER CONTROL PROJECT	2.50(L+R)	-	-	2.50
5. BANILA RIVER CONTROL PROJECT	9.33 (L)	-	-	9.33
6. TARLAC RIVER CONTROL PROJECT	22.54 (L)	3.00	-	22.54
	25.00 (R)	4.62	-	-
7. O'DONNELL RIVER CONTROL PROJECT	9.33 (R)	-	-	9.33
8. MORIONES RIVER CONTROL PROJECT	-	-	-	-
9. BATACAN RIVER CONTROL PROJECT	-	0.30	-	-
10. OLO RIVER CONTROL PROJECT	3.45	-	-	3.45
11. BAYAOAS RIVER CONTROL PROJECT	-	-	-	-
12. BEI RIVER CONTROL PROJECT	0.85	-	0.84	-
13. PANTAL RIVER CONTROL PROJECT	-	-	-	0.85
14. CAYANGA RIVER CONTROL PROJECT	-	1.10 (R)	-	-
		0.80 (R)	-	-
15. BUED RIVER CONTROL PROJECT	-	3.69 (R)	-	-
16. ANGALACAN RIVER CONTROL PROJECT	-	-	-	-
17. ALORAGAT RIVER CONTROL PROJECT	-	-	-	-
18. PANTO RIVER CONTROL PROJECT	-	-	-	-
19. MARUSAY RIVER CONTROL PROJECT	2.50 (R)	-	1.60	2.50
20. SINOCALAN RIVER CONTROL PROJECT	1.26	-	-	1.26
21. TAGAMUSING RIVER CONTROL PROJECT	-	0.78(L+R)	-	-
22. MITURA RIVER CONTROL PROJECT	-	0.22 (R)		-

Note ; R : Right Bank, L : Left Bank

Table 3.3.1 LIST OF COMPLETED RIVER CONTROL PROJECTS 1968-1988 (EARTHDIKE/CUT-OFF CHANNEL/RIVER IMPROVEMENT WORKS) (1/2)

PROJECT	LOCATION	YEAR	REMARKS
1 STO.TOMAS EARTHDIKE	Sta. 3.000-10.662	1968	
	Sta. 9.550- 9.745	1973	(Raising)
	Sta. 10.380-11.360	1973	(-ditto-)
2 ASINGAN-SAN MANUEL EARTHDIKE	Sta. 18.200-23.220	1978	
(SETBACK LEVEE)	Sta. 23.220-25.700	1982	
3 VILLASIS-ASINGAN SETBANK	Sta. 0.000-12.000	1973/74	
4 BAYAMBANG BABY DIKE	Sta. 19.400-20.383	1980/81	
5 STA.MARIA-TAYUG EARTHDIKE	Sta. 0.000-12.000	1975/76	
6 ALCALA EARTHDIKE	Sta. 10.662-11.680	1972	
7 ALCALA CUT-OFF CHANNEL	Sta. 0.000- 0.992	1981	
8 POPONT SWAMP FLOODWAY(SPILLWAY)	Sta. 0.000- 1.020	1977	
9 ANULID-POPONT PILOT CHANNEL	Sta. 0.000- 7.000	1978	
10 ANULID-POPONT RIGHT EARTHDIKE	Sta. 0.000- 4.780	1975/76	
	Sta. 4.780- 5.840	1983	
	Sta. 5.840- 6.025	1984	
11 ANULID-POPONT LEFT EARTHDIKE	Sta. 11.000-13.500	1975/76	
	Sta. 13.500-15.390	1978/79	
	Sta. 15.390-15.674	1988	
12 ANULID-BAUTISTA EARTHDIKE	Sta. 0.000- 4.920	1975/76	
	Sta. 5.120- 5.800	1978	
13 ROSARIO-LINGAYEN EARTHDIKE	Sta. 32.000-40.500	1973/74	
14 AGUILAR-BUGALLON EARTHDIKE	Sta. 0.000-11.355	1976/77	
15 SOBOL PARALLEL EARTHDIKE	Sta. 0.000- 1.600(L)	1979	
	Sta. 0.000- 1.800(R)	1979	
16 CUPANG PARALLEL EARTHDIKE	Sta. 0.000- 2.050	1980/81	
	Sta. 0.000- 1.840	1980/81	
17 BUGALLON-LABRADOR EARTHDIKE	Sta. 11.500-12.025	1979/80	
18 AMBAYOAN EARTHDIKE	Sta. 3.000- 3.400	1977/78	
19 VIRAY-DEPALO EARTHDIKE	Sta.(-)3.000-6.000(R)	1975/76	
	Sta.(-)2.840-6.930	1975/76	
20 VIRAY-DEPALO PILOT CHANNEL	Sta. 0.000- 6.800	1980	
21 SN.QUINTIN EARTHDIKE(DEPALO R.)	Sta.(-)3.340-(-)8.620(L)	1979/80	
22 SN.QUINTIN PILOT CHANNEL	Sta.(-)3.340-(-)5.340	1980	

SOURCE : YEAR-END REPORTS AND/OR LIST OF COMPLETED PROJECTS, AFCS OFFICE

Table 3.3.1 LIST OF COMPLETED RIVER CONTROL PROJECTS 1968-1988 (EARTHDIKE/CUT-OFF CHANNEL/RIVER IMPROVEMENT WORKS) (2/2)

PROJECT	LOCATION	YEAR	REMARKS
23 TOTONOGEN EARTHDIKE	Sta. 0.000- 1.150	1988	
	Sta. 0.000- 1.350	1988	
	Sta. 10.380-11.360	1973	
24 BANILA EARTHDIKE	Sta. 0.000- 9.332	1977/78	
25 TARLAC LEFT DIKE	Sta. 0.000- 1.350	1970	
	Sta. 1.350- 1.780	1972/73	
	Sta.(-)0.000-(-)2.000	-	
	Sta. 1.780- 5.000	-	
	Sta. 5.000- 8.000	1974	
	Sta.4.260-5.240/5.380-5.440/6.320-8.000	1982	(Raising)
	Sta. 8.000- 9.780	1982/83	
	Sta. 9.000-19.000	1988	
	Sta.(-)2.000-(-)3.355	1988	
25 ARMENIA EARTHDIKE(O'DONNELL R.)	Sta. 0.000- 5.530	1974	
	Sta. 5.530- 9.300	1988	
26 SAPANG PILOT CHANNEL	Sta. 0.000- 4.000	1977/78	
27 CALAPAN CUT-OFF CHANNEL	Sta. 0.000- 1.680	1979/80	
28 TABLANG-BACAO R.I.	Sta. 0.000- 4.000	1979/80	
29 CAMANGAAN-CALAPAN R.I.	Sta. 0.000- 5.080	1979/80	
30 CUT-OFF CHANNEL	Sta. 0.000- 0.560	1979/80	
31 OLO RIVER EARTHDIKE	Sta. 1.380- 2.160	1981	
	Sta. 0.000- 1.380	1982	(Raising)
	Sta. 1.160- 2.640	1981	
	Sta. 2.640- 3.450	1982	
32 BEI EARTHDIKE	Sta. 0.800- 1.650	1984/85	
33 BEI CUT-OFF CHANNEL	Sta. 0.420- 0.861	1988	
34 SOBOL CREEK EARTHDIKE	(L=2,170m)	1979	
35 QUIBAOL CUT OFF CHANNEL	Sta. 0.000- 1.750	1979/80	
36 MARUSAY EARTHDIKE	Sta. 0.000- 1.260	1983	
(STA.BARBARA-CALASIAO)	Sta. 1.260- 1.360	1984	
37 MARUSAY CUT-OFF CHANNEL	Sta. 4.740- 5.160	1982	
(CALASIAO)	Sta. 5.184- 5.470	1982	
	Sta. 7.620- 8.230	1983	
38 SINOCALAN EARTHDIKE	Sta. 0.000- 1.260	1983	
	Sta. 0.000- 0.400	1986	
	Sta. 0.400- 1.100	1988	

SOURCE : YEAR-END REPORTS AND/OR LIST OF COMPLETED PROJECTS, AFCS OFFICE

Table 3.3.2 SUMMARY OF ACCOMPLISHMENT OF RIVER CONTROL WORKS (1972-1988)

YEAR	EARTH DIKE (m)	W/BOULDER FACING/ APRON (m)	REVETMENT GRAVITY WALL (m)	BOULDER SPUR DIKE (UNIT)	BOULDER DIKE (m)	GRAVEL SUR-FACING (m)	CUT-OFF CHANNEL (m)	DRAINAGE GATE (UNIT)	SPILLWAY (m)	TOTAL COST (P)
1972	3,234	0	225	3	0	15,000	0	0	0	305,956
1973	3,322	0	-	155	0	0	0	0	0	12,186,174
1974	28,855	0	3,852	0	0	1,452	7,000	1	0	4,211,700
1975	69,915	0	2,765	1	0	10,248	460	2	0	22,006,479
1976	12,015	2,050	3,100	83	0	12,142	0	1	0	16,043,439
1977	12,607	0	75	26	0	0	3,500	1	1,020	19,157,660
1978	25,295	0	116	0	180	65,816	8,100	1	0	23,651,927
1979	20,631	0	0	29	720	0	0	4	0	9,099,154
1980	6,993	1,160	1,999	30	0	4,250	8,740	0	0	8,610,694
1981	10,805	0	843	0	0	0	992	0	0	8,492,994
1982	5,686	0	1,176	85	0	32,887	12,021	2	0	12,104,140
1983	10,484	0	856	138	0	280	9,599	0	0	15,859,494
1984	2,091	-	441	52	-	18,788	10,000	-	-	10,603,756
1985	1,304	194	2,458	64	-	0	7,426	0	0	11,583,600
1986	3,965	1,524	922	120	759	48,395	600	2	0	22,252,572
1987	7,750	3,633	1,910	182	686	-	4,703	2	0	33,933,000
1988	4,235	9,492	2,347	387	793	0	5,896	0	0	40,763,288
TOTAL	229,187	18,053	23,085	1,355	3,138	209,258	79,037	16	1,020	270,866,027

SOURCE: AGNO FLOOD CONTROL SYSTEM OFFICE, Rosales

Table 3.4.1 FIVE-YEAR INFRASTRUCTURE PROGRAM OF AGNO FLOOD CONTROL SYSTEM (1/2)

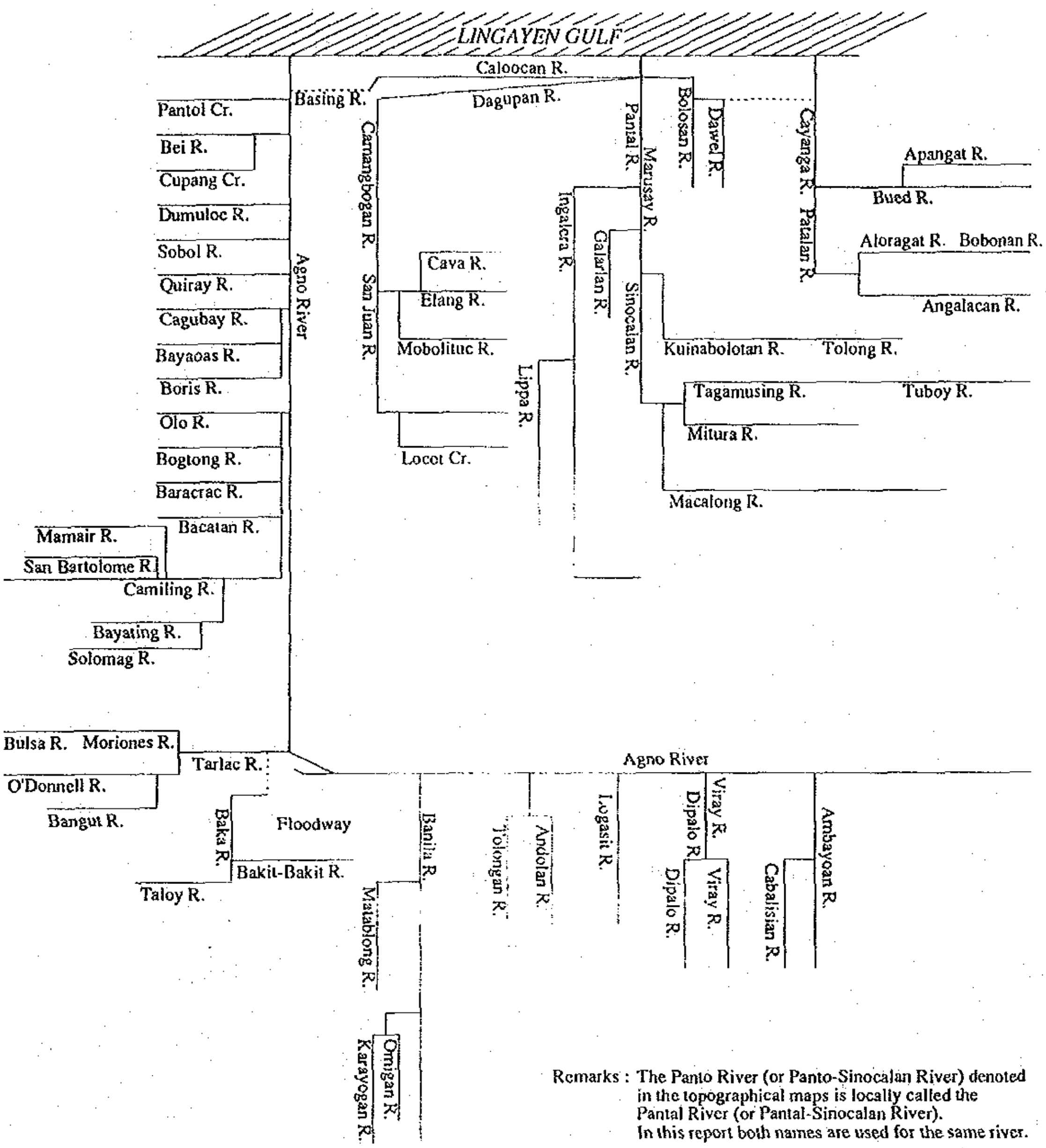
PROJECT LOCATION	SCOPE OF WORK AND PHYSICAL TARGET	STATUS	FUNDING REQUIREMENTS (10^6P) '89	'90	'91	'92	'93
AGNO RIVER CONTROL PROJECT							
1. Asingan-Sn. Manuel	Restoration of damaged dike Spur dike, apron	Const./Impv't./ Rehab.ON-GOING	4.75	5.00	5.40	5.60	5.90
2. Villasis	Spur dike, Revetment	-ditto-	1.20	1.30	1.90	1.20	1.50
3. Sto. Tomas	Restoration of boulder dike	-ditto-	1.20	1.20	2.10	2.40	2.50
	Bank protection, Spur dike	-ditto-	2.70	2.00	2.60	1.00	0.60
4. Alcala	Restoration of damaged dike Bank protection, Spur dike	-ditto-	2.70	2.00	2.60	1.00	0.60
5. Urbiztondo	Spur dike, Concrete revetment, River improvement	-ditto-	2.70	2.80	3.30	0.60	2.20
6. Brgy. Sanchez, Asingan	Earthdike, Spur dike	-ditto-	1.00	1.00	1.10	1.30	0.90
7. Alcala - Bayambang	Earthdike, Spur dike, Bank protection	-ditto-	0.90	-	1.20	1.30	1.30
8. Brgy. Daraoey, Bayambang	Spur dike, Drainage system, Bank protection	-ditto-	1.20	-	-	1.30	1.30
9. Brgy. Quibad, Bayambang	Cut-off channel (COC), Spur dike	Const./Impv't./ Rehab. NEW PROJECT	1.40	1.40	-	-	1.50
10. Brgy. Quibad, Lingayen	Spur dike, Channel impv't.	Const./Impv't./ Rehab. ON-GOING	2.90	2.00	2.00	2.30	2.30
11. Urbiztondo	Bank protection	-ditto-	-	2.00	-	-	2.00
12. San Carlos City	COC, Spur dike	-ditto-	1.00	1.00	1.00	1.00	1.50
13. Rosales-Sta. Maria	Protec. of damaged dike with boulder spur dike	-ditto-	1.20	1.30	1.30	1.40	-
14. Rosales	Spur dike	-ditto-	0.50	0.50	0.40	0.40	0.50
15. Sto. Tomas-Alcala	Spur dike, COC	-ditto-	1.20	1.40	1.50	1.50	-
16. Bautista	COC, Spur dike, Flood gate	-ditto-	0.90	2.90	2.20	2.30	2.50
17. Bugallon	Earthdike, COC, Flood gate	-ditto-	-	0.50	1.20	1.40	1.50
18. Bugallon-Labrador	Earthdike, Spur dike, Flood gate	-ditto-	1.20	1.20	-	1.40	1.60
19. Sta. Maria	Spur dike, Channel impv't.	-ditto-	-	1.20	-	1.00	1.20
20. Brgy. Pantal, Bugallon	Spur dike, Channel impv't.	-ditto-	-	1.00	-	1.00	1.20
21. Aguilar	COC, Spur dike	-ditto-	0.50	1.20	-	1.00	1.20
22. Brgy. Domalanoan, Lingayen	COC, Spur dike	-ditto-	-	0.80	1.50	-	1.80
		(Sub-Total)	29.15	33.70	31.30	30.40	35.60
AMBAYOAN R.C.P.							
23. Sn. Nicolas	Spur dike, Channel imprv't.	Const./Impv't./ Rehab. ON-GOING	1.00	1.00	1.00	1.20	1.20
VIRAY-DIPALO R.C.P.							
24. Tayug-Natividad	Restoration of damaged dike Spur dike, Channel impv't.	-ditto-	1.20	1.20	1.40	1.40	1.50
25. San Quintin	Rest. of damaged dike with Spur dike	-ditto-	1.20	1.20	1.20	1.40	1.50
		(Sub-Total)	2.40	2.40	2.60	2.80	3.00
TOTONOGEN R.C.P							
26. Rosales	Revetment, Spur dike	-ditto-	-	0.90	0.90	0.90	1.00
BANILA R.C.P.							
27. Umingan	Spur dike, Channel impv't.	-ditto-	0.50	0.40	0.50	0.60	0.70
28. Balungao	Bank protection, Spur dike, River impv't., Earthdike	-ditto-	1.00	1.00	1.00	1.00	1.00
		(Sub-Total)	1.50	1.40	1.50	1.60	1.70

Source : AGNO FLOOD CONTROL SYSTEM OFFICE, Rosales

Table 3.4.1 FIVE-YEAR INFRASTRUCTURE PROGRAM OF AGNO FLOOD CONTROL SYSTEM (2/2)

PROJECT LOCATION	SCOPE OF WORK AND PHYSICAL TARGET	STATUS	FUNDING REQUIREMENTS (10^6P) '89	'90	'91	'92	'93
TARLAC R.C.P.	Concrete revetment, floodgate boulder apron, earthdike		39.45	39.45	-	-	-
O'DONNEL R.C.P.	Earthdike, River impv't		8.66	8.30	-	-	-
MORIONES R.C.P.	Concrete revetment		3.50	3.50	-	-	-
OLO R.C.P.							
Mangatarem	Earthdike, River impv't.	-ditto-	1.50	-	-	1.00	1.00
BAYAOAS R.C.P.							
Aguilar	Concrete revetment with boulder apron	-ditto-	-	0.40	-	0.50	0.50
BEI R.C.P.							
Bugallon	Earthdike, Spur dike	-ditto-	0.20	0.20	-	0.30	0.50
CAYANGA R.C.P.							
Sn. Fabian	COC, Concrete revetment	Const./Impv't./ Rehab. ON-GOING	1.00	1.00	1.00	1.00	-
BUED R.C.P.							
Sison	Revetment	-ditto-	-	-	2.00	2.00	-
Sn. Fabian	Concrete revetment, Bank protec.	-ditto-	0.90	-	1.35	-	0.90
		(Sub-Total)	0.90	-	3.35	2.00	0.90
BUED-ALORAGAT R.C.P.							
-	Bank protection, Spur dike	-ditto-	0.50	0.50	0.50	1.20	1.30
ANGALACAN R.C.P.							
Mapandan	Spur dike, Bank protection	-ditto-	0.50	0.90	0.80	0.90	-
Mapandan	Spur dike, Concrete revetment	-ditto-	0.55	0.50	-	1.10	-
-	Spur dike, River impv't.	-ditto-	0.50	-	-	0.70	0.80
		(Sub-Total)	1.55	1.40	0.80	2.70	0.80
SINOCALAN R.C.P.							
Sta. Barbara-Urdaneta	Spur dike, COC	Const./Impv't./ Rehab. NEW PROJECT	1.00	-	1.50	2.00	-
MARUSAY R.C.P.							
Sta. Barbara	Earthdike, Spur dike, Bank protection	Const./Impv't./ Rehab. ON-GOING	-	1.00	2.10	2.20	-
TAGAMUSING R.C.P.							
Sumabnit	Spur dike, Revetment, River impv't.	-ditto-	-	1.20	-	1.10	-
Binalonan	Spur dike, Concrete revetment,	-ditto-	1.50	1.00	0.50	0.40	-
		(Sub-Total)	1.50	2.20	0.50	1.50	-
TOLONG-MITURA R.C.P.							
Urdaneta	Revetment, Spur dike	-ditto-	0.40	1.00	0.90	-	-
TUBOY R.C.P.							
San. Manuel	Spur dike	-ditto-	-	0.50	0.40	0.40	-
		(TOTAL)	94.21	98.85	48.35	51.70	47.50

Source : AGNO FLOOD CONTROL SYSTEM OFFICE, Rosales



Remarks : The Panto River (or Panto-Sinocalan River) denoted in the topographical maps is locally called the Pantal River (or Pantal-Sinocalan River).
In this report both names are used for the same river.

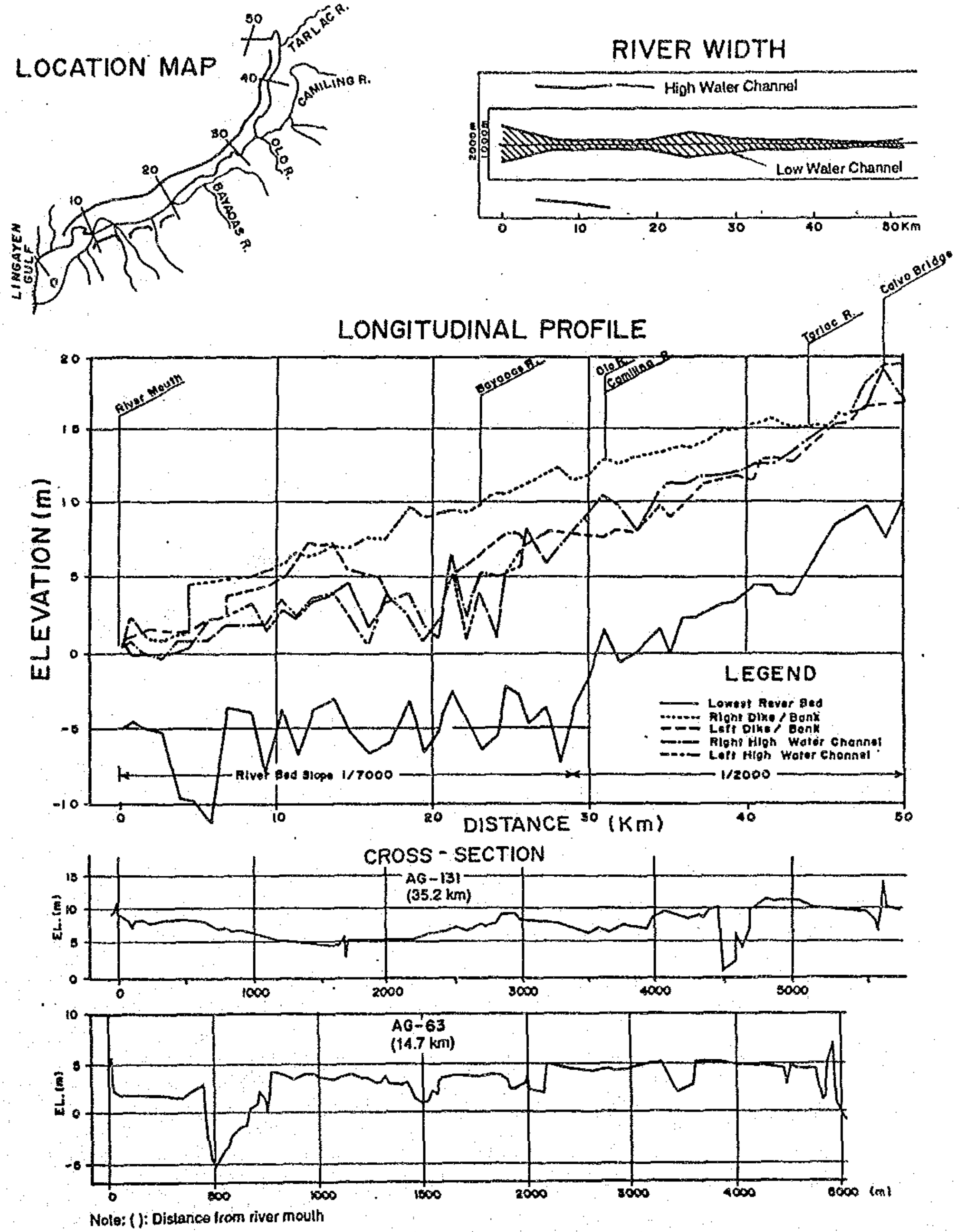
AGNO RIVER BASIN

River	Basin Area (km^2)	River Length (km)
Agno River		
Rivermouth	5,907	221.00
Floodway Site	2,477	165.00
Ambayoan River	367	62.20
Viray-Dipalo River	135	21.20
Banila River	309	39.00
Tarlac River	1,896	93.00
Camiling River	604	64.00

ALLIED RIVER BASIN

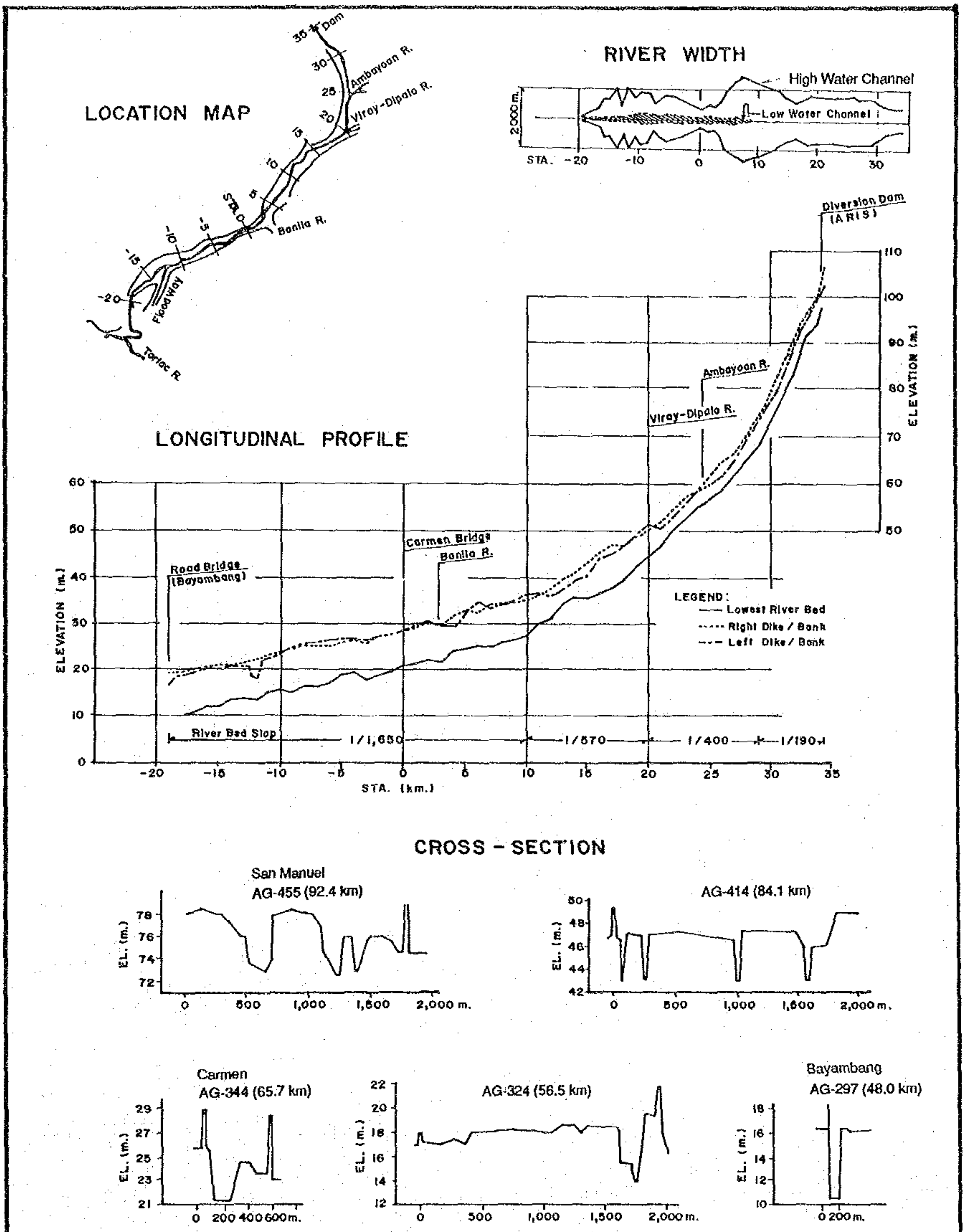
River	Basin Area (km^2)	River Length (km)
Cayanga-Patalan R.		
(whole)	618	61.00
Angalacan R.	144	25.50
Aloragat R.	116	31.00
Bued R.	286	54.00
Panto-Sinocalan R.		
(whole)	1,115	75.50
Tagumising R.	182	44.50
Mitura-Macalong R.	141	31.00
Ingalera R.	197	32.50
Dagupan R.	273	32.00

Fig. 3.1.1 RIVER SYSTEM DIAGRAM



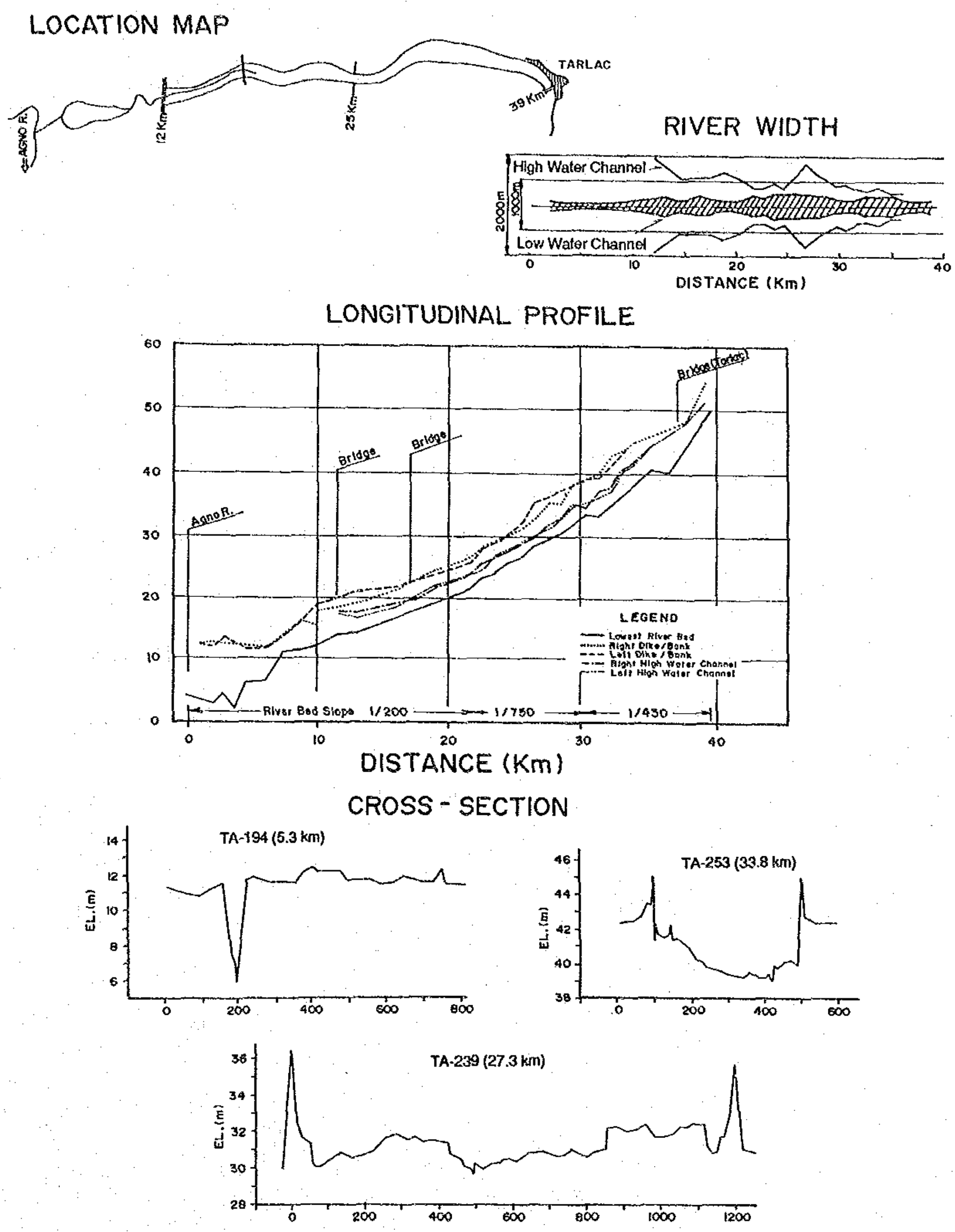
Note: ( ): Distance from river mouth

Fig. 3.1.2 CHANNEL FEATURES OF AGNO RIVER (1/2)



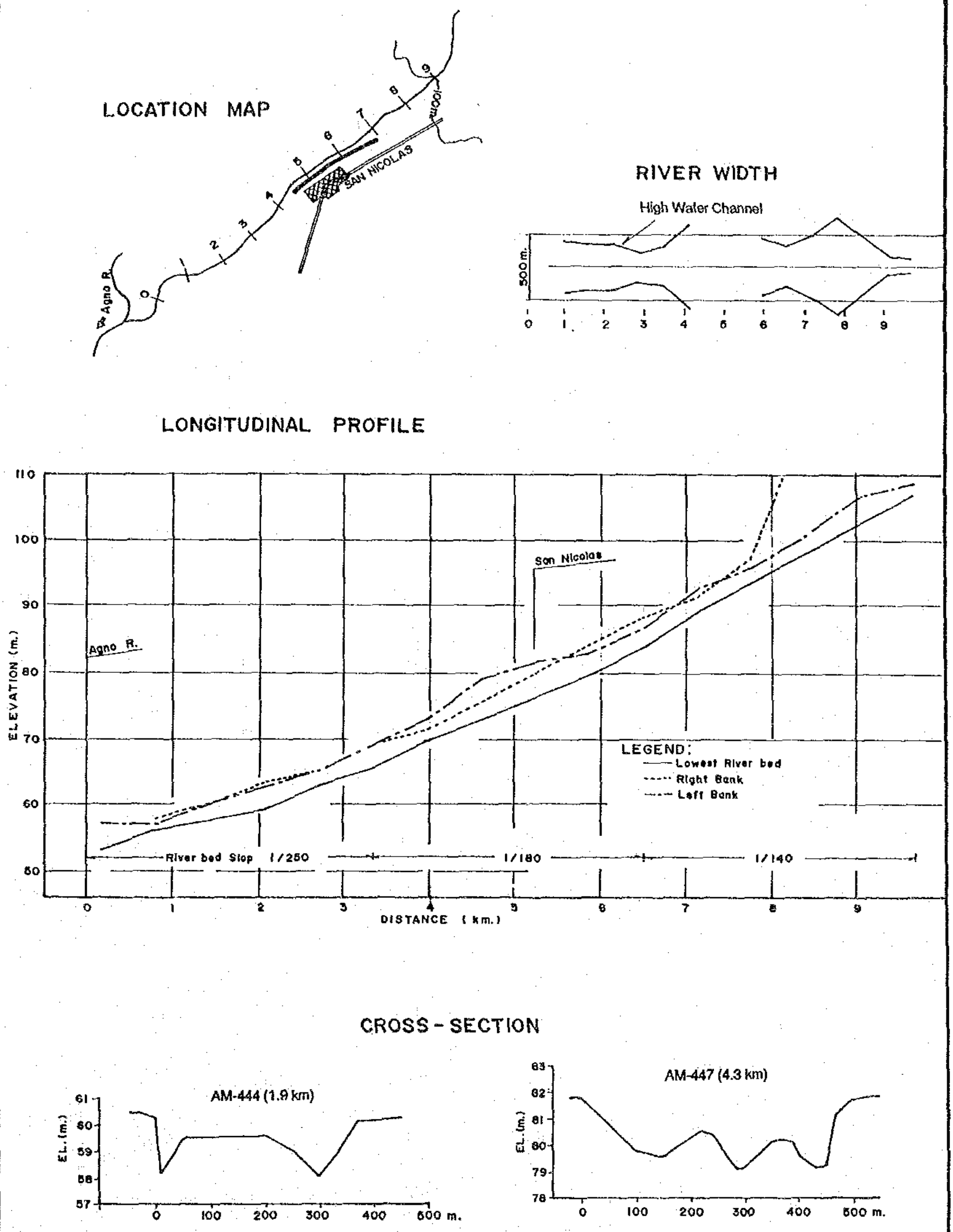
Note: ( ): Distance from river mouth

Fig. 3.1.2 CHANNEL FEATURES OF AGNO RIVER (2/2)



Note: ( ): Distance from the confluence with Agno River

Fig. 3.1.3 CHANNEL FEATURES OF TARLAC RIVER



Note: ( ): Distance from the confluence with Agno River

Fig. 3.1.4 CHANNEL FEATURES OF AMBAYOAN RIVER

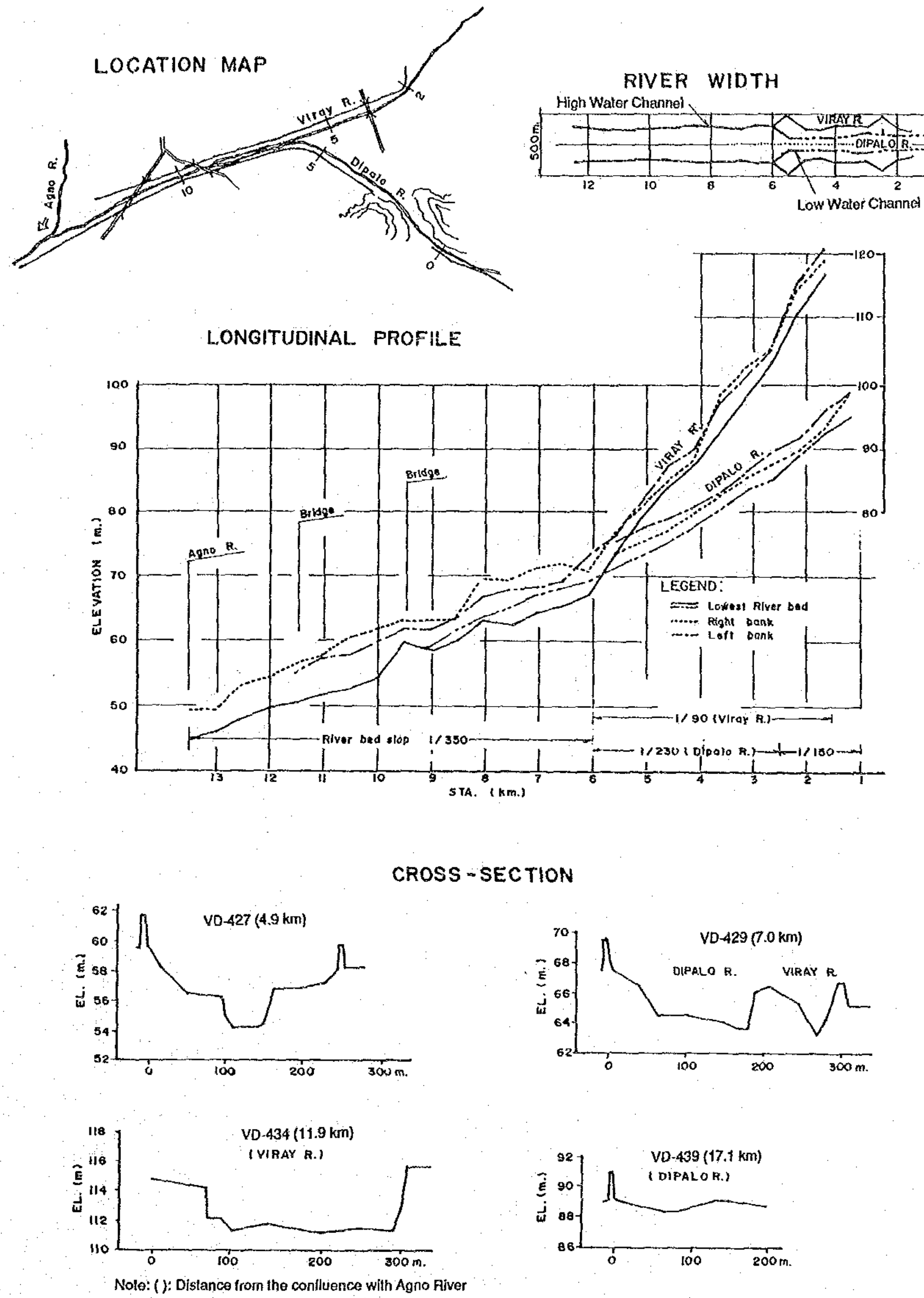


Fig. 3.1.5 CHANNEL FEATURES OF VIRAY-DIPALO RIVER

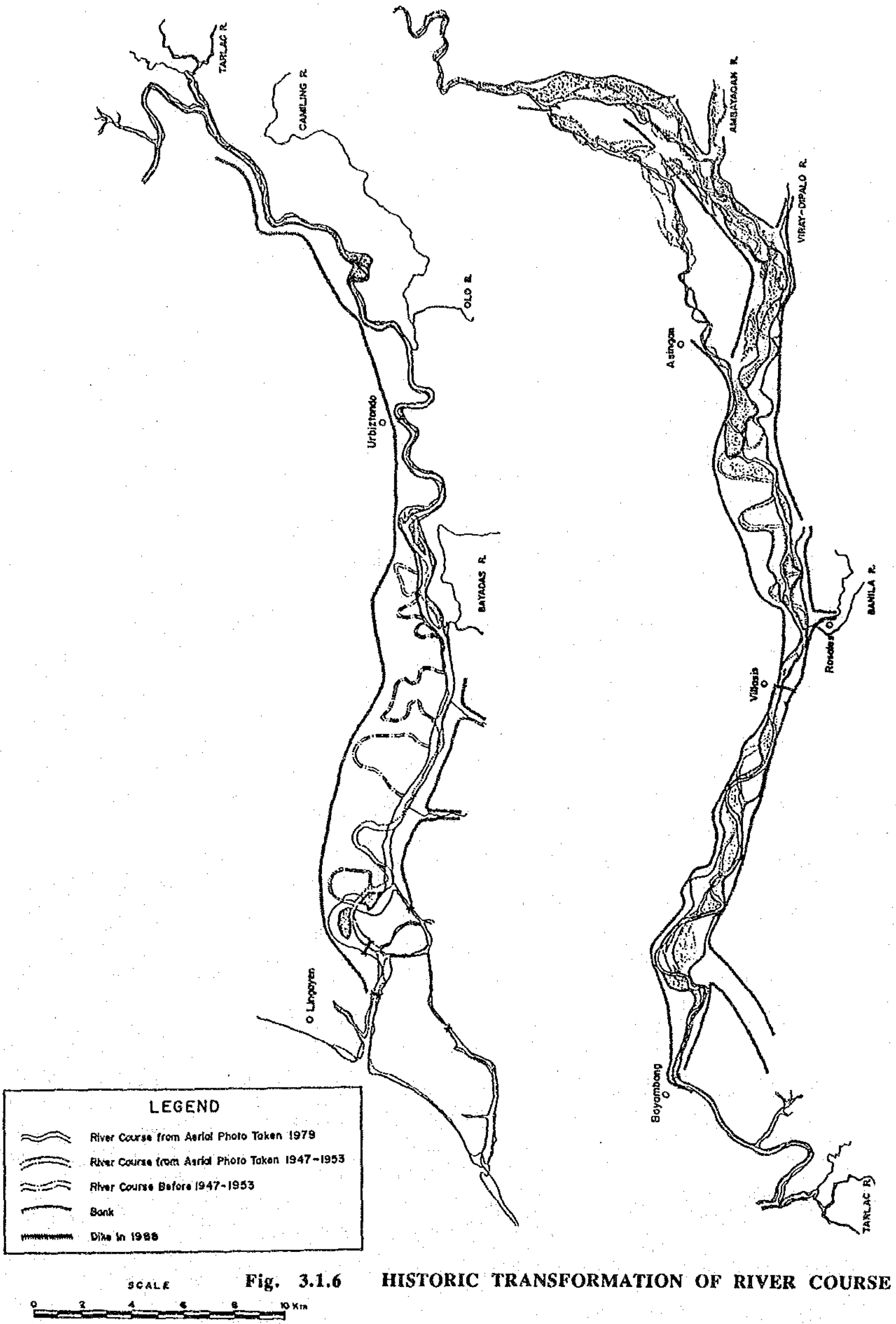


Fig. 3.1.6 HISTORIC TRANSFORMATION OF RIVER COURSE

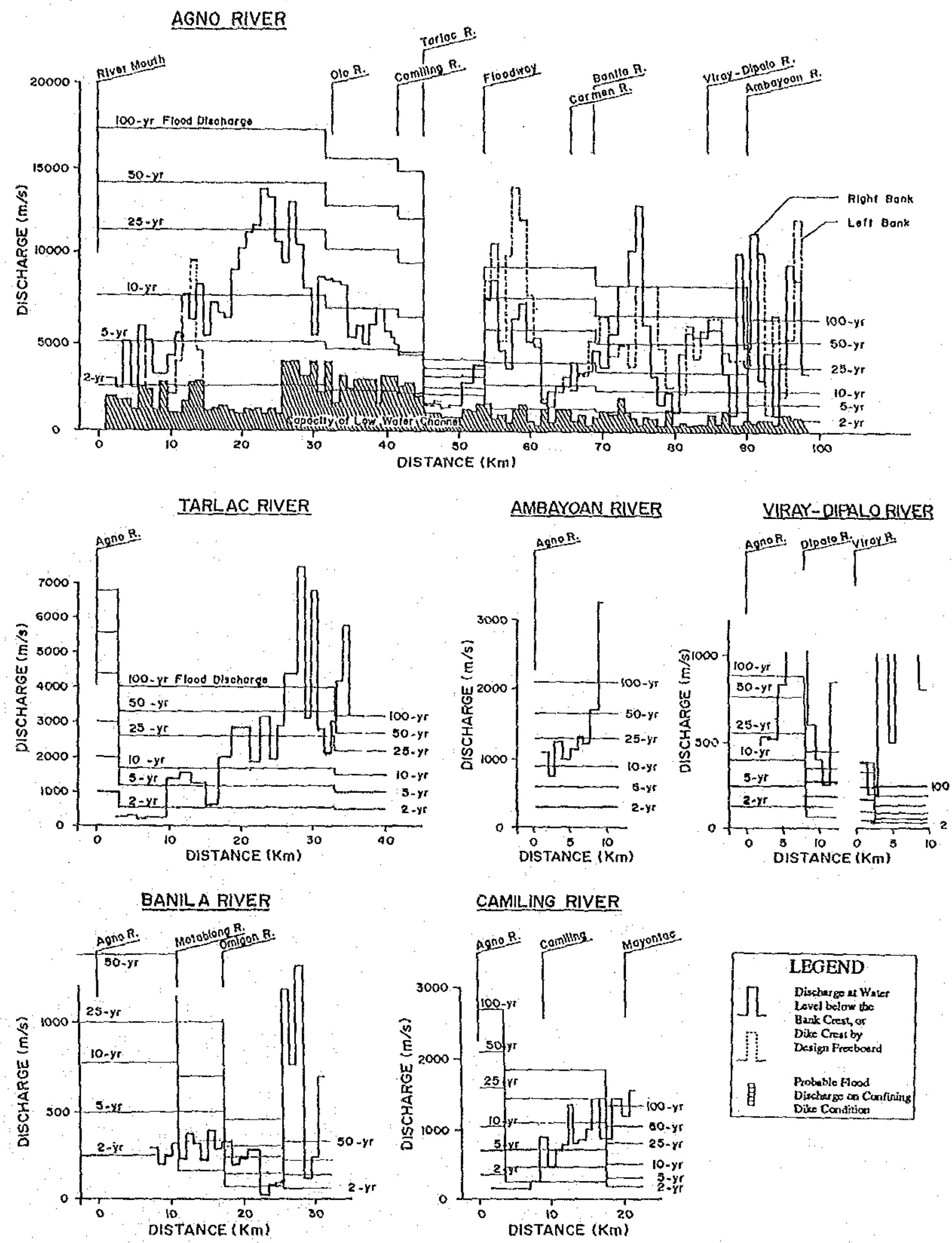


Fig. 3.1.7 EXISTING CARRYING CAPACITY OF AGNO RIVER

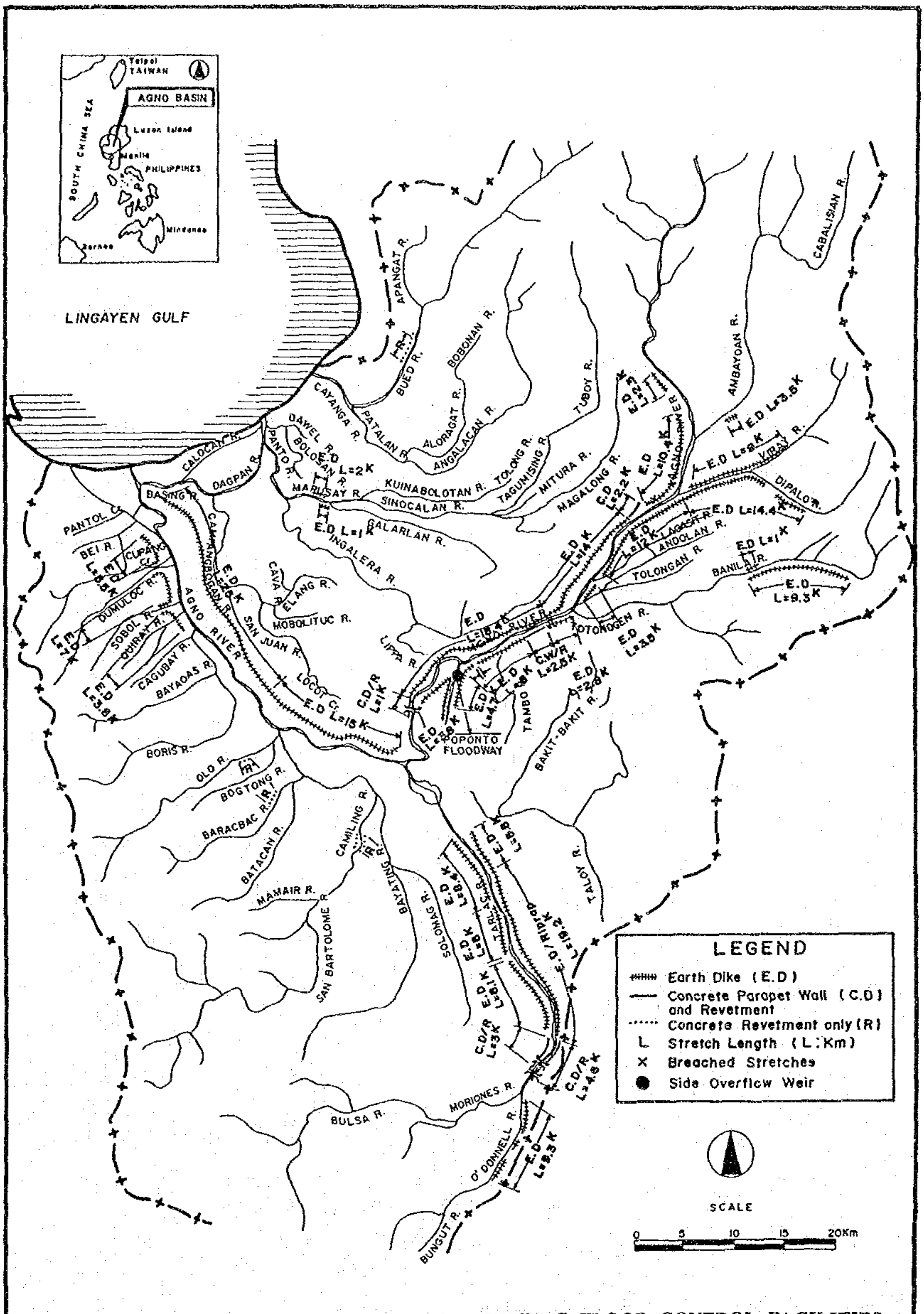


Fig. 3.1.8 LOCATION OF EXISTING FLOOD CONTROL FACILITIES

4. METEOROLOGY AND HYDROLOGY

4. METEOROLOGY AND HYDROLOGY

4.1 Climate

The climate in the Agno River basin is characterized by distinct dry and wet seasons. The dry season lasts usually from November to April and the wet season from May to October.

The annual rainfall varies from about 2,000 mm in the southeastern portion of the basin adjoining the Pampanga River basin to over 4,000 mm in the northern mountains as shown in the Isohyetal map of the Study Area (see Figure 4.1.1). This variation is mainly due to the topographical condition of the basin. More than 90% of the annual rainfall occurs in the six months of the wet season. The Agno River basin is often attacked by tropical typhoons and storms which bring about heavy rainfall causing harmful flooding.

The mean annual temperature is 28°C in Dagupan City located in the Pangasinan Plain in the Agno River basin and the mean monthly temperature varies from 23°C to 32°C. The relative humidity in Dagupan City is recorded at 77% on average annually. The month of April has the lowest at 70%, while the highest, 85%, occurs in August.

4.2 Flood Runoff Analysis

The flood runoff analysis for the Agno River basin including the Allied Rivers is performed under the following river conditions to prepare basic data required for the formulation of flood control alternatives.

- Under the present river condition
- Under the condition of planned river improvement

The flood runoff analysis under the present river condition is discussed in the succeeding Section 4.3.

<u>Base point</u>
Nine base points, the principal points for estimating the flood runoff distribution along the river course, are determined at confluences and rivermouths of main rivers and major tributaries. The selected base points are summarized below.

Base Point	Location	Basin Area (Km^2)
BP - 1	Rivermouth of Agno River	5,907
BP - 2	Agno River upstream of conf. of Camiling River	4,338
BP - 3	Agno River upstream of conf. of Tarlac River	2,441
BP - 4	Agno River at conf. of Ambayoan River	1,345
BP - 5	Camiling River at conf. of Agno River	604
BP - 6	Tarlac River at conf. of Agno River	1,896
BP - 7	Ambayoan River at conf. of Agno River	370
BP - 8	Rivermouth of Cayanga River	618
BP - 9	Rivermouth of Pantal River	1,115

The location of these points is shown in Figure 4.2.1.

<u>River system model</u>

The river system model is constructed as shown in Figure 4.2.1. The model comprises sub-basins, river channels and existing dams including those under construction and those identified through the Study.

<u>Design Rainfall</u>

The available rainfall data are analyzed to determine the design rainfall duration, probable basin mean rainfall and its hourly distribution. The rainfall duration is determined to be 4 days based on the major storm records. The probable basin mean rainfall with durations of 1,2,3 and 4 days is estimated at each base point as shown in Table 4.2.1. For estimating the basin mean rainfall, the Thiessen polygon method is applied using rainfall data at 17 stations.

The average 24-hour rainfall pattern is obtained from the accumulated rainfall curves of major storms as shown in the upper part of Figure 4.2.2 and the design rainfall distribution of 4-day duration is determined as follows:

1st day : Uniform distribution of R4-R3

2nd day : Uniform distribution of R2-R1

3rd day : Distribution of R1 by average rainfall pattern

4th day : Uniform distribution of R3-R2

Where, R1 : probable 1-day basin mean rainfall

R2 : probable 2-day basin mean rainfall

R3 : probable 3-day basin mean rainfall

R4 : probable 4-day basin mean rainfall

Typical hourly rainfall distribution of the design rainfall is illustrated in the lower part of Figure 4.2.2.

Condition for runoff calculation

The flood runoff calculation is carried out under the following conditions:

(1) River channel : A Confining dike system along the main Agno River and major tributaries

(2) Dam/reservoir : The existing Binga and Ambuklao dams have no flood control space in their reservoirs. Therefore, the outflow is assumed to be equal to the inflow. San Roque dam, for which detailed design has been completed and Balog-Balog dam, which is under construction, are to be incorporated. The reservoir operation proposed in their respective reports is being applied.

(3) Retarding area : Poponto swamp is not taken into account.

Probable peak flood distribution

Based on the above conditions, the flood runoff calculation is made with different return periods of 1.05, 2, 5, 10, 25, 50 and 100 years. The estimated flood peak distributions for the Agno River and Allied River basins are listed in Figures 4.2.3 and 4.2.4 respectively.

The specific discharge for the 100-year peak flood is shown in Figure 4.2.5. It varies from 3.0 $m^3/s/km^2$ to 6.2 $m^3/s/km^2$ in the Agno River basin and from 3.5 $m^3/s/km^2$ to 6.3 $m^3/s/km^2$ in the Allied River basins.

4.3 Flood Inundation Analysis

The flood inundation analysis aims at the following:

- Development of the flood simulation model to assess the hydrological characteristic under the present river condition.
- Estimate of probable flood water level and duration in inundation area with different recurrence intervals.

To meet the above requirements, the following simulation models are presented.

- Flood simulation model
- Flood inundation model

(1) Flood simulation model

This model is applied to simulate the flood runoff in the Agno River basin. The model comprises the following components:

- 58 sub-basins
- 31 river channels
- 1 retarding basin (Poponto swamp)
- 2 dams (Binga and Ambuklao)
- Camiling swamp as river channel

<u>Runoff from sub-basin</u>

Flood runoff from each sub-basin is calculated by means of the storage function method. Constants of storage function are estimated by empirical formula which is expressed by average river bed slope in a sub-basin.

<u>Flood routing in the river channel</u>

Flood routing in a river channel is calculated also by the storage function method. The storage function of a river channel is estimated based on the river cross-section data.

<u>Outflow from the dams</u>

Both of the existing Binga and Ambuklao dams are functional for hydropower generation but not for flood control. Therefore, the outflow from these reservoirs is assumed to be equal to the inflow for reservoir operation during floods.

Retarding basin

The Poponto swamp has a function to retard the flood peak discharge. The retarding basin model is constructed as shown in Figure 4.3.1.

Breached river stretch

In the area on the right bank of the Agno River main course, downstream of San Roque, there remain breached river sections of about 3 km in length. Thus, flood runoff from the upstream basin partly overflows into the Allied River basins.

The bankfull flow capacity at the said sections is estimated at about 1,200 m^3/sec. For flood runoff calculation, a flood discharge of over 1,200 m^3/sec is assumed to overflow into the Allied River basins.

Calibration of the simulation model

The simulation model is calibrated by using the records of the 1984 flood caused by typhoon Maring, which is selected among flood records observed by ARFFO. The mean rainfall with 4-day duration in the whole Agno River basin is estimated at 385 mm for calibration.

The simulated flood runoff hydrograph is compared with the observed discharge at 4 waterlevel stations and reservoir inflow at the Binga and Ambuklao dams as shown in Figure 4.3.2. These figures illustrate that the model simulates appropriately the recorded flood.

By the above simulation, the volume overflowing from the breached river stretch and the regulated volume in the Poponto swamp are estimated to be 233 x $10^6 m^3$ and 251 x $10^6 m^3$ respectively for the simulation period of about 10 days.

(2) Flood inundation model

The lowland area of the Allied River basins is characterized by wide-spread flooding due to the inadequate flow capacity of the river channels.

In addition, the flood inflow from the breached river stretch of the Agno River is incorporated in the flood from the upstream mountainous basin.

The sequential pond model is applied for the simulation of the above hydrological condition. The Allied Rivers are divided into 250 mesh blocks each with an area of 2 km x 2 km. This two dimensional model simulates the flood flow propagation for each mesh block in the probable inundation area by solving the kinematic and continuity equations under the given hydraulic condition.

Flood for calibration

The 1984 flood caused by typhoon Maring, which brought about wide-spread flood inundation, is selected for the calibration of the model.

Simulation result

As a result of simulation, the maximum inundation depth is estimated for each mesh block. The result is compared with the actual inundation as illustrated in Figure 4.3.3 map which was prepared through the interview survey. The area distribution of the maximum inundation depth in the inundation area is simulated fairly well.

(3) Probable inundation area

The inundation area and maximum inundated area in the lowland of the Allied River basins during occurrence of the probable 100-year flood are estimated by the simulation model. The calculated results are illustrated in Figure 4.3.4.

For the above simulation, the flood volume overflowing the dike of the Agno River is estimated based on the following hydrological conditions:

- The river dike is breached when the flood water level rises to the level corresponding to 50% of the free board.
- The flood runoff corresponding to the above water level is assumed to be the breach-starting discharge.
- The flood runoff over the breach-starting discharge is assumed to flow into the Allied River basins.
- The breach-starting discharge is determined for each river stretch based on the river cross section data as given below:

River stretches of the Agno River	Breach-starting discharge (m^3/s)
San Roque - Confluence with the Ambayoan R.	1,200
Conf. with the Ambayoan R. - Conf. with the Banila R.	5,470
Conf. with the Banila R. - Poponto floodway	3,130
Poponto floodway - Conf. with the Tarlac R.	1,230
Conf. with the Tarlac R. - Conf. with the Olo R.	10,200
Conf. with the Olo R. - Rivermouth	6,890

4.4 Low Flow Analysis

The objective of low flow analysis is to provide daily runoff data at arbitrary locations in the Agno River basin for a continuous period of more than 20 years.

Taking into account the available discharge and rainfall records, the runoff characteristic at San Roque is examined by applying the tank model method using daily runoff and rainfall records in the period of 1969-1971. Then, the daily runoff record at San Roque is supplemented by the runoff generated by the simulation model for the period of 1972-1986.

The daily runoff at Wawa and the rivermouth of the Agno River in the period of 1969-1986 is estimated based on the ratio of basin area and annual basin mean rainfall. The average flow duration curves are as shown in Figure 4.4.1.

4.5 Hydrological Observation

(1) Construction Progress of Hydrological Stations

Japan International Cooperation Agency (JICA) provided a set of hydrometeorological equipment including 4 automatic raingauges and 9 automatic water level gauges. The Department of Public Works and Highways (DPWH) constructed the gauging stations and installed these gauges.

The locations of the 4 automatic raingauge stations and 9 automatic water level stations were selected as shown in Figure 4.5.1. Installation of these automatic gauges was made according to the following schedule:

Station	Date of Completion	Elevation/Zero of Gauge (El.m)
Rainfall		
(1) Camp 4	Aug. 21, 1989	about 700
(2) Saytan	Aug. 21	about 190
(3) Sto. Domingo	Sept. 3	about 90
(4) Iba	Sept. 3	about 100
Water level		
(1) Poponto left dike	Sept. 28, 1989	18.325
(2) Poponto right dike	Oct. 5	12.669
(3) Conjuangco bridge	Nov. 23	14.500
(4) Camp 1	Dec. 4	178.600
(5) Aloragat	Oct. 23	44.000
(6) Angalacan	Oct. 17	10.300
(7) Tagamusing	Oct. 25	31.800
(8) Sinocalan	Oct. 20	9.200
(9) Ingalera	Dec. 15	2.700

(2) Hydrological Observation Works

The following observation works were carried out by DPWH under the supervision of a hydrological observation expert.

.Rainfall

Hourly observations by automatic raingauges.

.Water level

Hourly readings of staff gauges during flooding before completing the installation of the automatic water level gauges.

.Discharge Measurement

Discharge measurements to establish the discharge rate curve. Floats are to be used during a flood, while current meters are to be used during low flow.

.Sediment load

Sediment sampling at 10 sites and their laboratory testing.

.Water quality

Electric conductivity tests were in the dry season of 1990 to assess sea water intrusion into the Agno, Cayanga-Patalan and Panto-Sinocalan Rivers.

(3) Observation Record during Typhoon OPENG

From September 10 to 14, 1989, typhoon Openg, attacked the Agno River basin. Hydrological observation records during this typhoon are summarized below:

Rainfall

- Hourly rainfall was observed at four new stations.
- 3-hour rainfall was observed at the five stations in the Agno River FFWS.

Water Level

- Hourly water level was observed by staff gauge reading at four new stations, Cojuangco Bridge, Ingalera, Sinocalan and Tagamusing.

The observation records are shown in Figures 4.5.2 and 4.5.3. The water level hydrograph observation was started almost at the time of peak flooding because the typhoon hit the area during the weekend and dispatch of the observation crew was somehow delayed.

The mean 4-day rainfall in the basin is estimated at 431 mm. The rainfall isohyetal map shown in Figure 4.5.4 indicates that very heavy rainfall was experienced at the Bued River basin. The mean rainfall in the Allied River basins is estimated at 506 mm which corresponds to the 5-year probable rainfall. On the other hand, the mean rainfall in the Agno river basin is calculated at 253 mm, which is less than the probable rainfall with a 2-year return period.

Table 4.2.1 PROBABLE BASIN MEAN RAINFALL BY BASE POINT

(Unit:mm)

Base Point	Return Period (year)							
	1.05	2	5	10	25	50	100	200
1-Day								
BP-1	71	142	202	242	295	334	375	416
BP-2	71	148	214	260	319	364	411	458
BP-3	74	159	236	291	364	421	479	540
BP-4	68	158	251	323	425	510	603	704
BP-5	99	147	203	249	318	378	445	521
BP-6	64	140	208	256	320	369	420	473
BP-7	88	178	268	338	437	519	609	706
BP-8	90	176	246	294	355	401	447	494
BP-9	81	138	182	210	244	269	294	319
2-Day								
BP-1	96	216	326	405	509	590	674	761
BP-2	98	227	346	431	546	635	728	826
BP-3	112	251	376	465	583	675	770	868
BP-4	106	252	389	488	622	727	837	952
BP-5	130	221	325	410	537	648	774	917
BP-6	98	207	316	399	517	613	718	833
BP-7	124	277	415	513	643	745	849	958
BP-8	142	282	400	480	582	660	739	819
BP-9	116	227	319	381	460	519	579	640
3-Day								
BP-1	110	263	408	514	657	769	887	1,010
BP-2	118	277	426	533	678	792	910	1,034
BP-3	130	302	462	577	732	854	980	1,112
BP-4	133	308	471	588	746	869	997	1,131
BP-5	130	268	421	546	733	896	1,080	1,288
BP-6	116	252	397	512	681	825	984	1,162
BP-7	145	330	500	621	783	910	1,041	1,178
BP-8	168	337	478	574	697	791	886	983
BP-9	144	277	385	457	550	619	689	759
4-Day								
BP-1	126	301	466	586	747	875	1,008	1,147
BP-2	138	319	486	606	766	891	1,022	1,158
BP-3	157	344	511	629	784	904	1,028	1,156
BP-4	154	342	512	632	791	914	1,042	1,174
BP-5	147	305	482	629	849	1,041	1,259	1,506
BP-6	130	287	454	586	780	944	1,125	1,327
BP-7	177	374	545	664	818	927	1,059	1,183
BP-8	199	378	521	617	738	829	920	1,012
BP-9	157	308	433	517	625	707	789	873

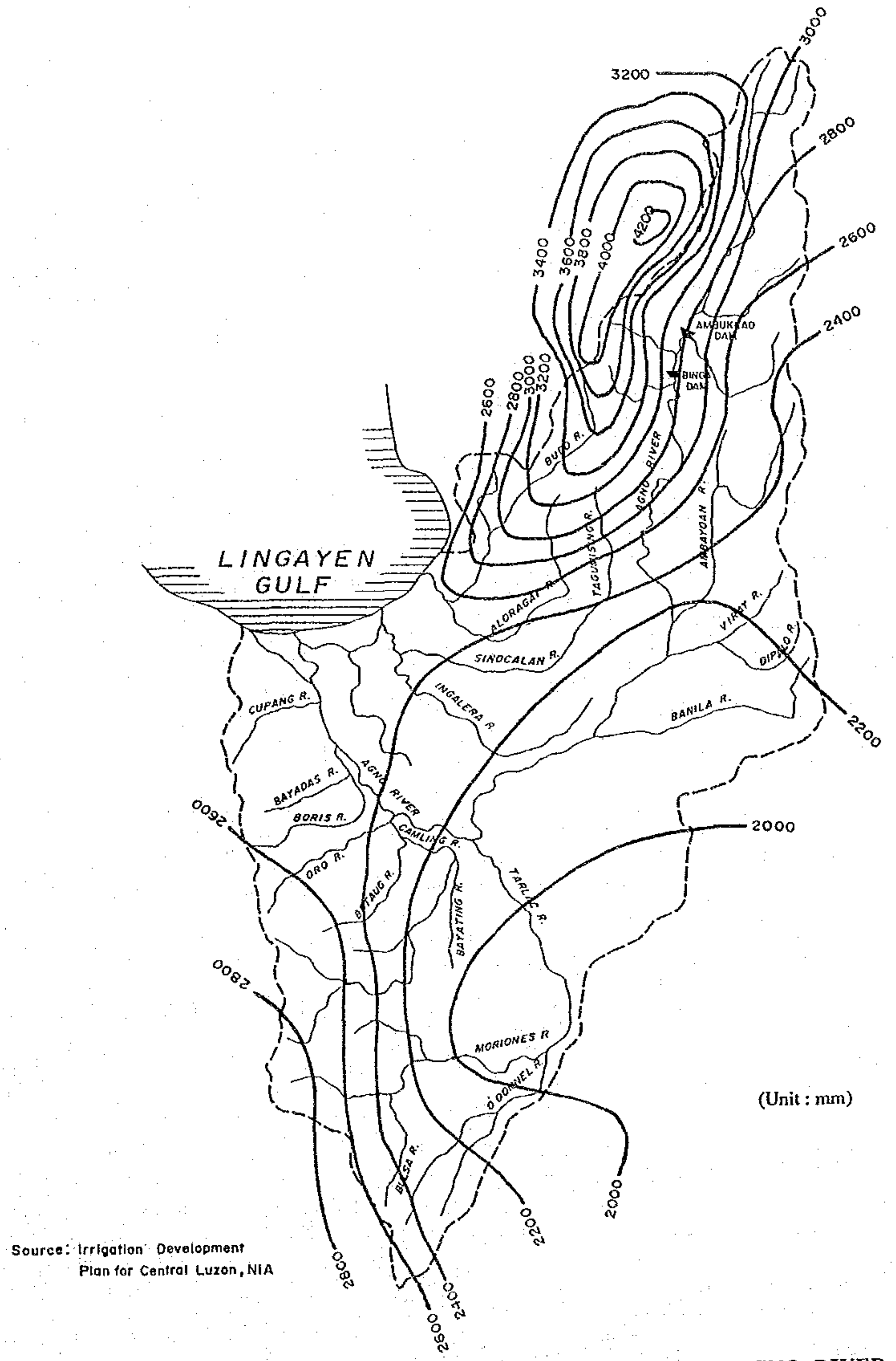


Fig. 4.1.1 ISOHYETAL MAP OF AGNO RIVER BASIN

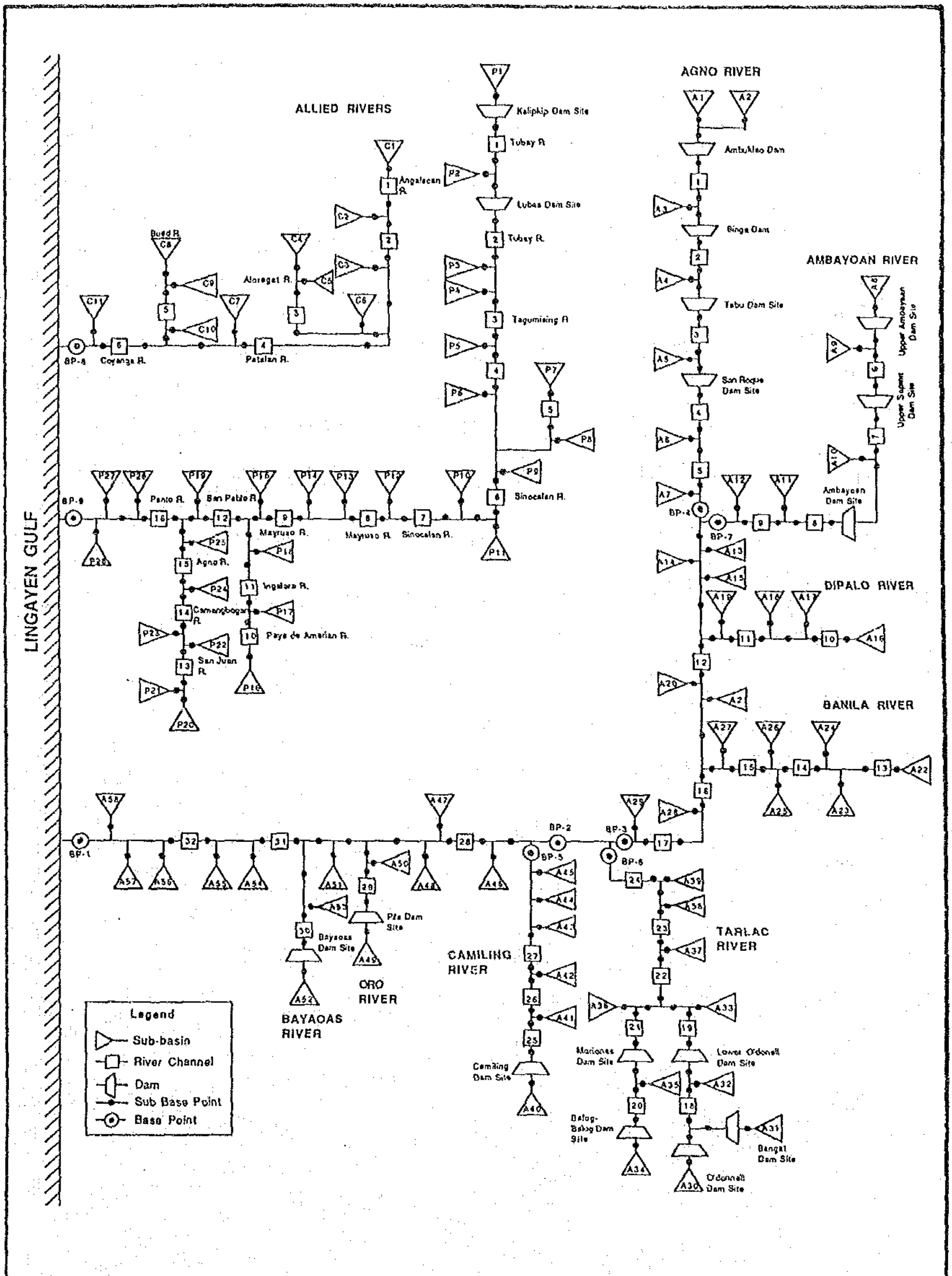
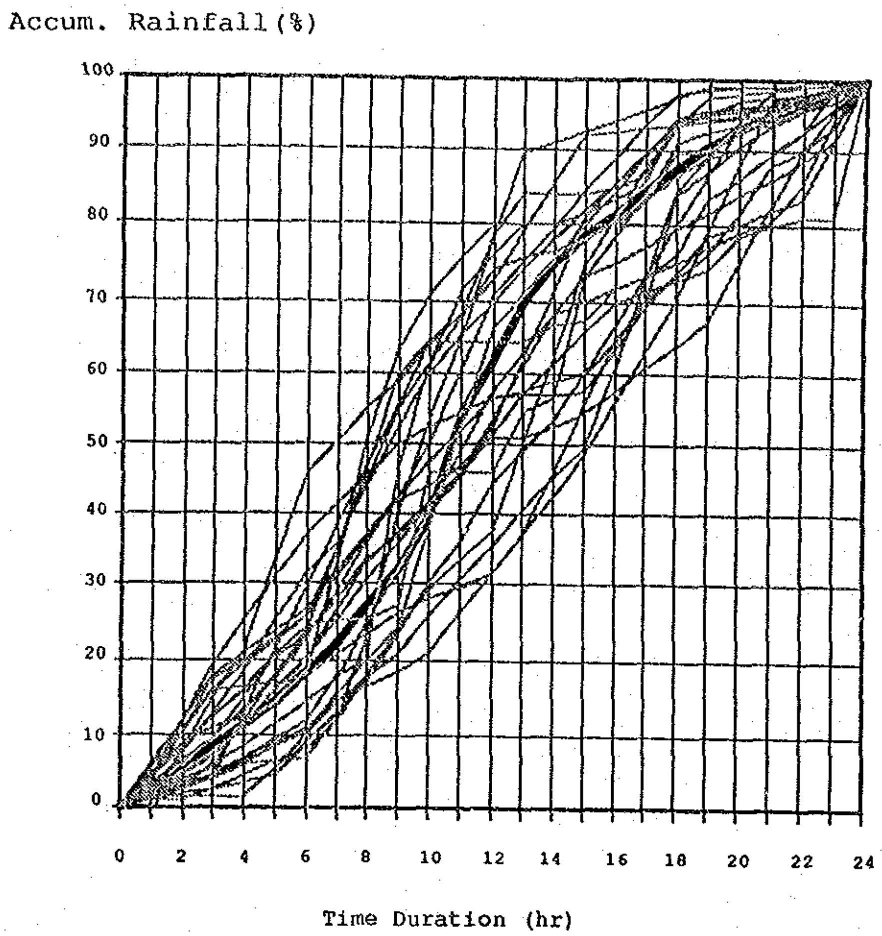


Fig. 4.2.1 RIVER SYSTEM MODEL OF AGNO RIVER AND ALLIED RIVERS FOR FLOOD RUNOFF ANALYSIS



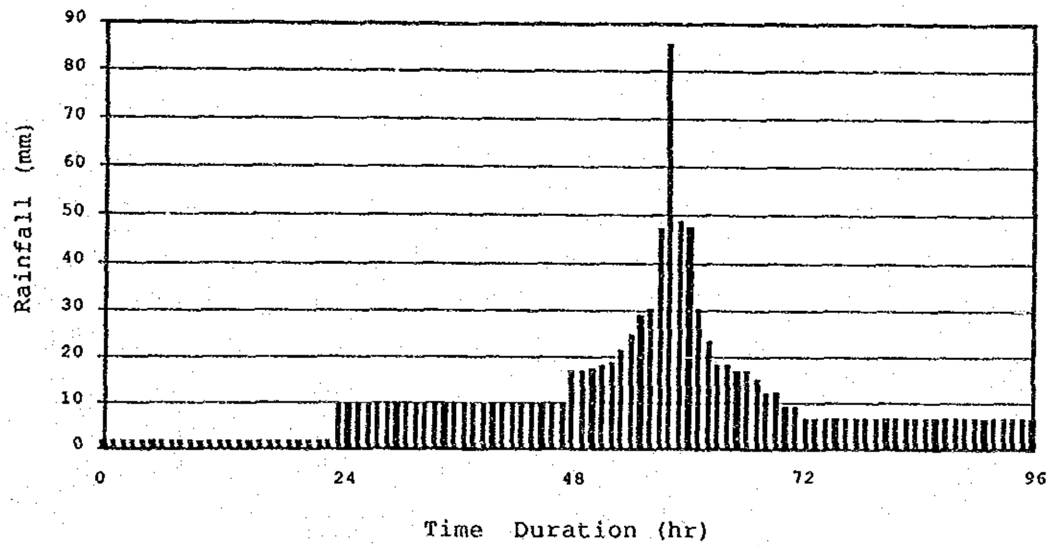
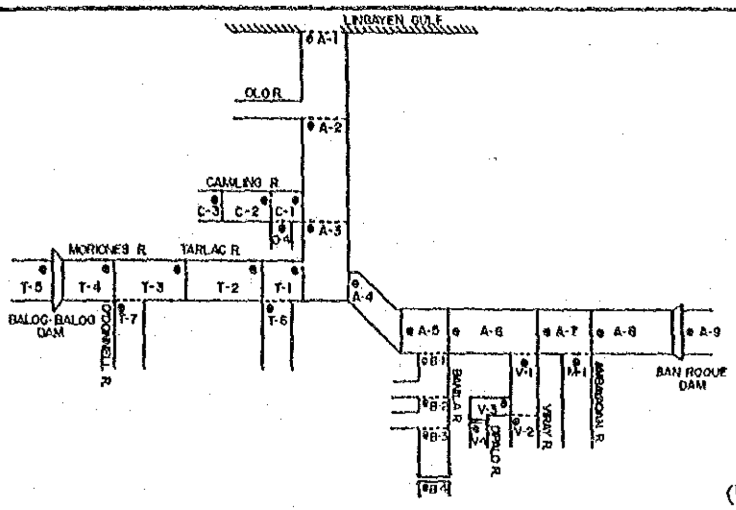


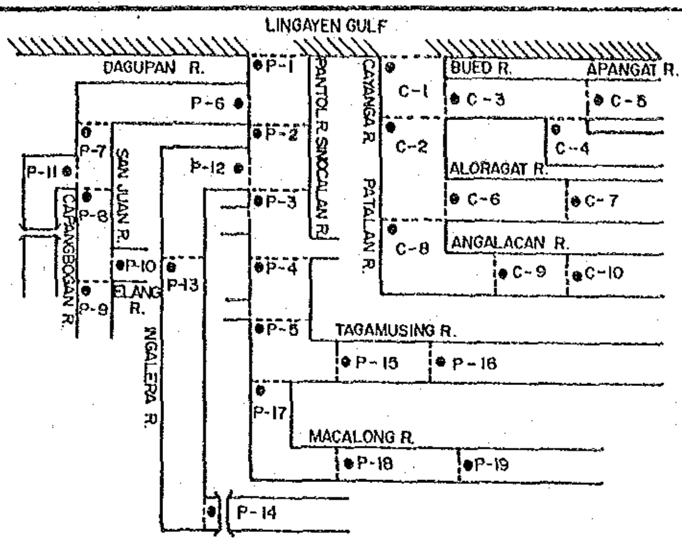
Fig. 4.2.2 DESIGN HOURLY RAINFALL DISTRIBUTION



(Unit : m³/sec)

River/Stretch	Location No.	Return Period (year) 1.05	2	5	10	25	50	100
1. Main Agno River								
Rivermouth	A-1	1160	2510	5100	7610	11220	14170	17310
Before Junction with Olo R.	A-2	990	2250	4700	6910	10140	12730	15680
Before Junction with Camiling R.	A-3	880	2100	4350	6410	9330	11960	14020
Before Junction with Tarlac R.	A-4	500	1330	2690	3980	5760	7460	9210
Upstream of Poponto Floodway	A-5	490	1320	2680	3960	5730	7430	9190
Before Junction with Banila R.	A-6	410	1140	2330	3470	5020	6570	8140
Before Junction with Viray-Dipalo R.	A-7	360	970	2050	3010	4380	5930	7280
Before Junction with Ambayoan R.	A-8	260	700	1530	2340	3780	5120	6370
San Roque Dam	A-9	320	830	1710	2600	3950	5060	6260
2. Tarlac River								
Junction with Agno R.	T-1	460	960	2000	2930	4350	5510	6720
Before Junction of Baka R.	T-2	240	550	1140	1690	2640	3230	3940
Tarlac	T-3	180	430	870	1340	2020	2580	3180
Baka R. + Sub Basin	T-6	260	530	1000	1490	2150	2640	3150
Moriones R.	T-4	110	280	570	860	1270	1610	1950
O'Donnell R.	T-7	70	170	310	490	760	1000	1230
Balog-Balog	T-5	80	160	300	430	610	760	900
3. Camiling River								
Junction with Agno R.	C-1	200	360	660	1020	1630	2170	2660
Before Junction with Bayating R.	C-2	130	240	450	700	1140	1520	1850
Before Junction with Hamair R.	C-3	90	170	310	480	850	1130	1380
Bayating R.	C-4	70	120	210	320	500	660	800
4. Banila River								
Junction with Agno R.	B-1	110	250	510	740	990	1380	1610
Before Junction with Matablong R.	B-2	60	160	320	470	650	950	1100
Before Junction with Karayoga R.	B-3	30	70	150	220	300	440	510
Bridge	B-4	20	60	110	160	230	330	390
5. Viray-Dipalo River								
Junction with Agno R.	V-1	50	120	240	380	530	730	840
Viray R.	V-2	20	60	130	190	270	370	420
Dipalo R. (Down stream of San Pedro)	V-3	20	60	110	170	250	350	400
(Upstream of San Pedro)	V-4	10	30	70	100	150	210	240
6. Ambayoan River								
Junction with Agno R.	M-1	110	300	590	880	1310	1730	2090

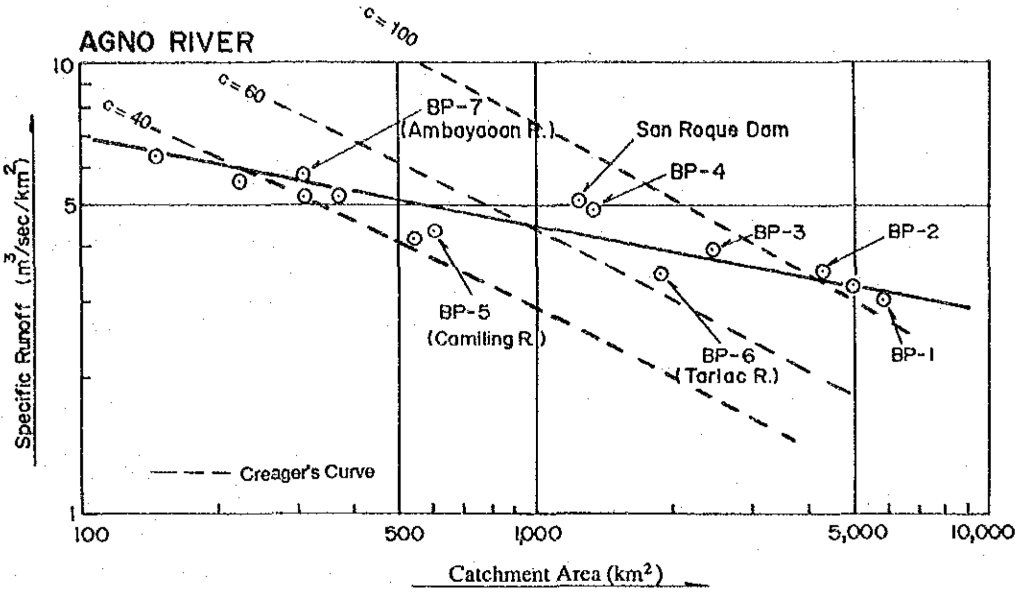
Fig. 4.2.3 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF AGNO RIVER UNDER CONFINING DIKE CONDITION (WITH SAN ROQUE DAM)



(Unit : m³/sec)

River/Stretch	Location No.	1.05	2	5	10	25	50	100
1.1 Cayanga/Patalan Rivers								
Rivermouth	C-1	270	500	1070	1490	2080	2560	3030
Before Junction with Bued R.	C-2	140	300	550	770	1060	1310	1550
1.2 Bued River								
Junction with Cayanga R.	C-3	130	290	520	730	1040	1290	1550
Before Junction with Apangat R.	C-4	90	200	340	500	750	950	1170
Apangat R.	C-5	30	60	120	160	220	260	300
1.3 Aloragat River								
Junction with Patalan R.	C-6	50	110	210	280	380	470	550
Amagbagan	C-7	30	60	100	140	200	240	290
1.4 Angalacan River								
Junction with Patalan R.	C-8	70	150	280	400	670	710	840
Maraboc	C-9	50	110	190	270	400	510	620
Killo	C-10	30	80	130	190	290	370	460
2.1 Panto/Sinocalan River								
Rivermouth	P-1	430	810	1340	1900	2710	3260	4000
Before Junction with Dagupan R.	P-2	280	540	850	1220	1740	2220	2670
Before Junction with Ingalera R.	P-3	190	380	600	860	1260	1640	2000
Before Junction with Quinabolotan R.	P-4	140	280	430	620	950	1250	1530
Catablan	P-5	120	250	370	540	850	1120	1380
2.2 Dagupan City								
Junction with Panto R.	P-6	170	300	480	690	950	1110	1260
Before Junction with Basing R.	P-7	130	240	380	540	740	870	990
Lower San Juan R.	P-8	100	170	270	390	540	630	720
Upper San Juan R.	P-9	50	90	150	200	280	330	380
Elang R.	P-10	50	80	120	190	260	310	350
Campangbogan R.	P-11	30	50	80	120	170	190	220
2.3 Ingalera River								
Junction with Sinocalan R.	P-12	80	150	250	360	500	600	670
Talospatang	P-13	60	120	180	260	370	450	540
San Nicolas	P-14	20	40	50	80	120	150	180
2.4 Tagumising/Tuboy River								
Junction with Sinocalan R.	P-15	80	170	250	350	580	790	990
Yatyat	P-16	70	150	230	330	540	730	910
2.5 Macalong River								
Junction with Sinocalan R.	P-17	40	90	130	190	270	330	390
Urdaneta	P-18	30	60	80	120	190	240	280
San Manuel	P-19	20	30	50	70	100	140	160

Fig. 4.2.4 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF ALLIED RIVERS UNDER CONFINING DIKE CONDITION



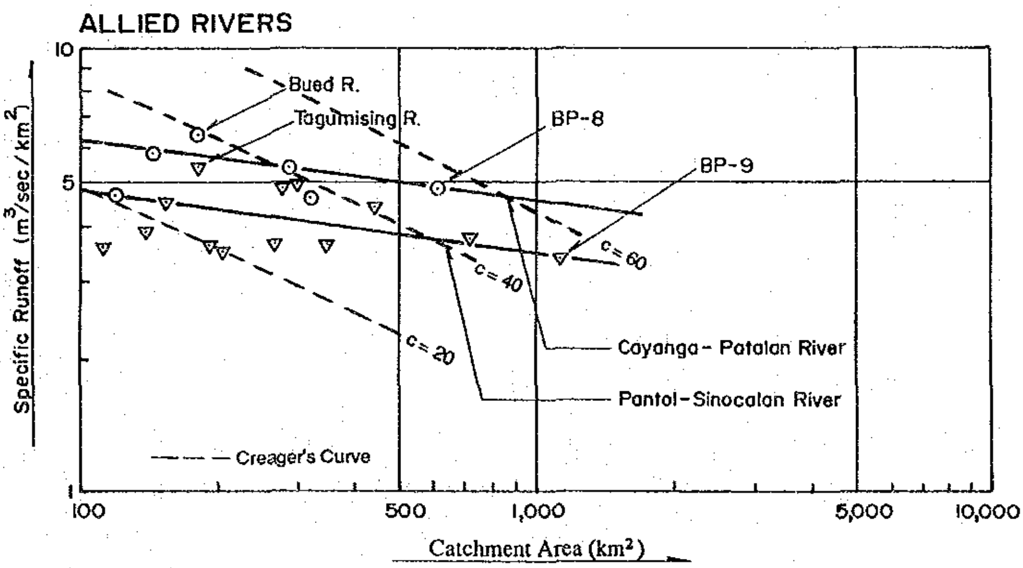
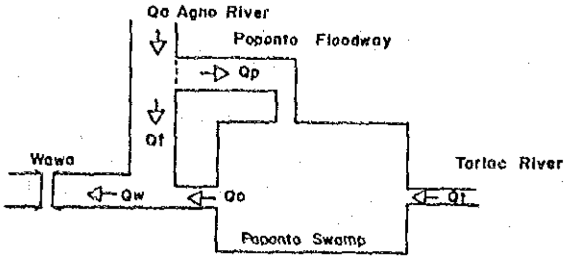


Fig. 4.2.5 RELATIONSHIP BETWEEN SPECIFIC RUNOFF OF 100-YEAR FLOOD AND CATCHMENT AREA

(1) Model Diagram



$$\begin{cases} Qa = Qp + Qf \\ Qw = Qf + Qo \\ Qi = Qp + Qt \quad \text{(Inflow to Swamp)} \end{cases}$$

(2) Hydraulic Equations in Swamp

Equation of Continuity : $Qi - Qo = \frac{dS}{dt}$

(S : Storage volume in swamp)

Equation of Movement : $Qo = C\sqrt{2g} \cdot A \cdot |Hp - Hw|^{1/2}$

(C : Runoff Coeffient
A : Flow Area
Hp : Water level at Swamp
Hw : Water level at Wawa)

(3) Calculation Procedure

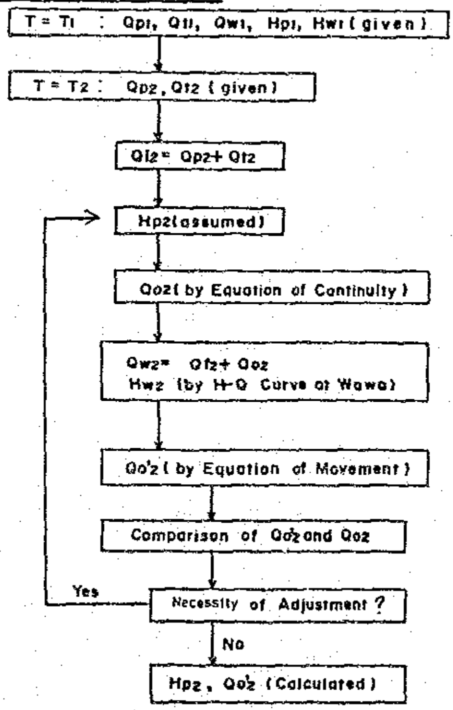


Fig. 4.3.1 ILLUSTRATION OF HYDRAULIC MODEL FOR POPONTO SWAMP

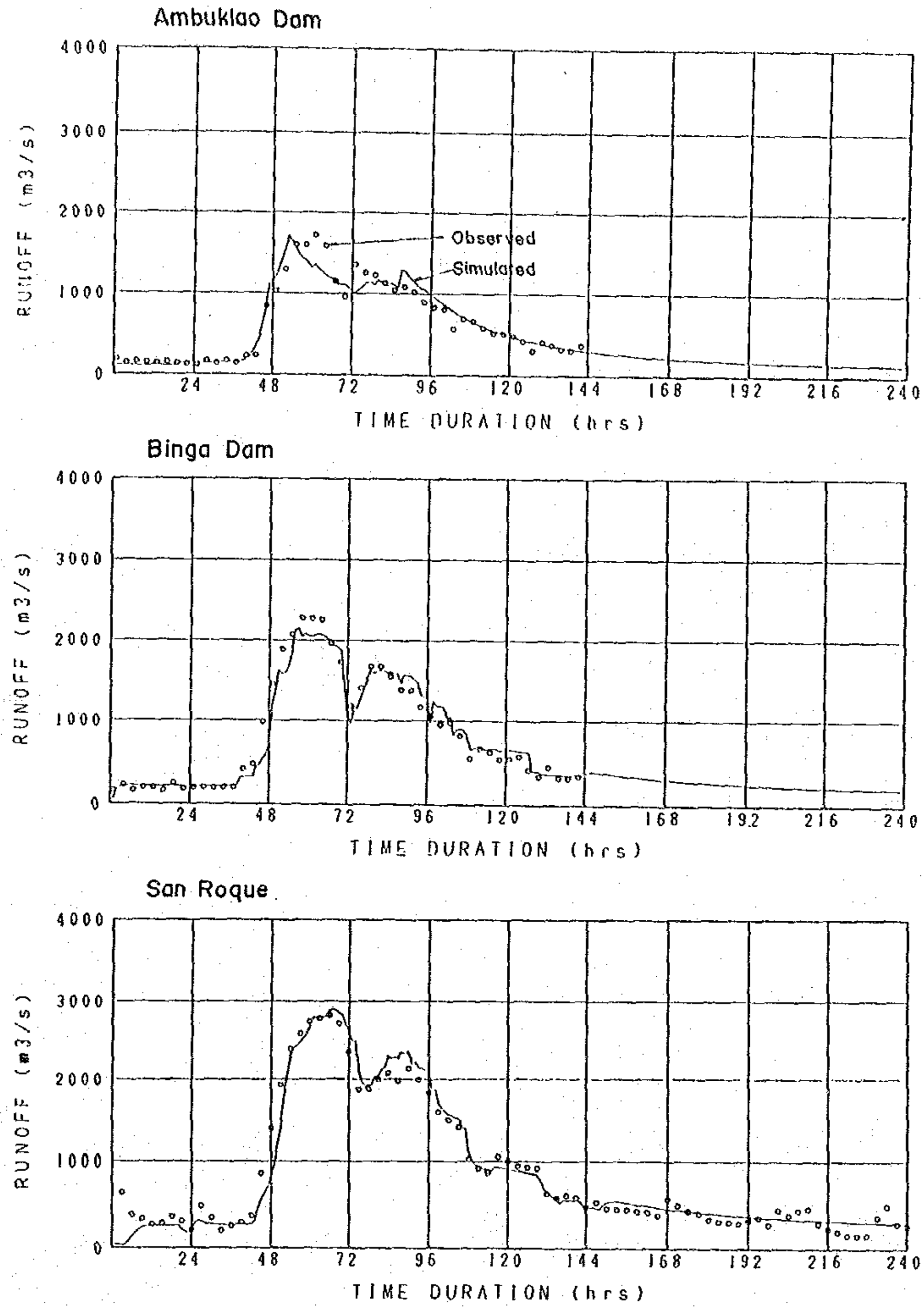


Fig. 4.3.2 OBSERVED AND SIMULATED FLOOD HYDROGRAPHS DURING TYPHOON MARING IN 1984 (1/2)

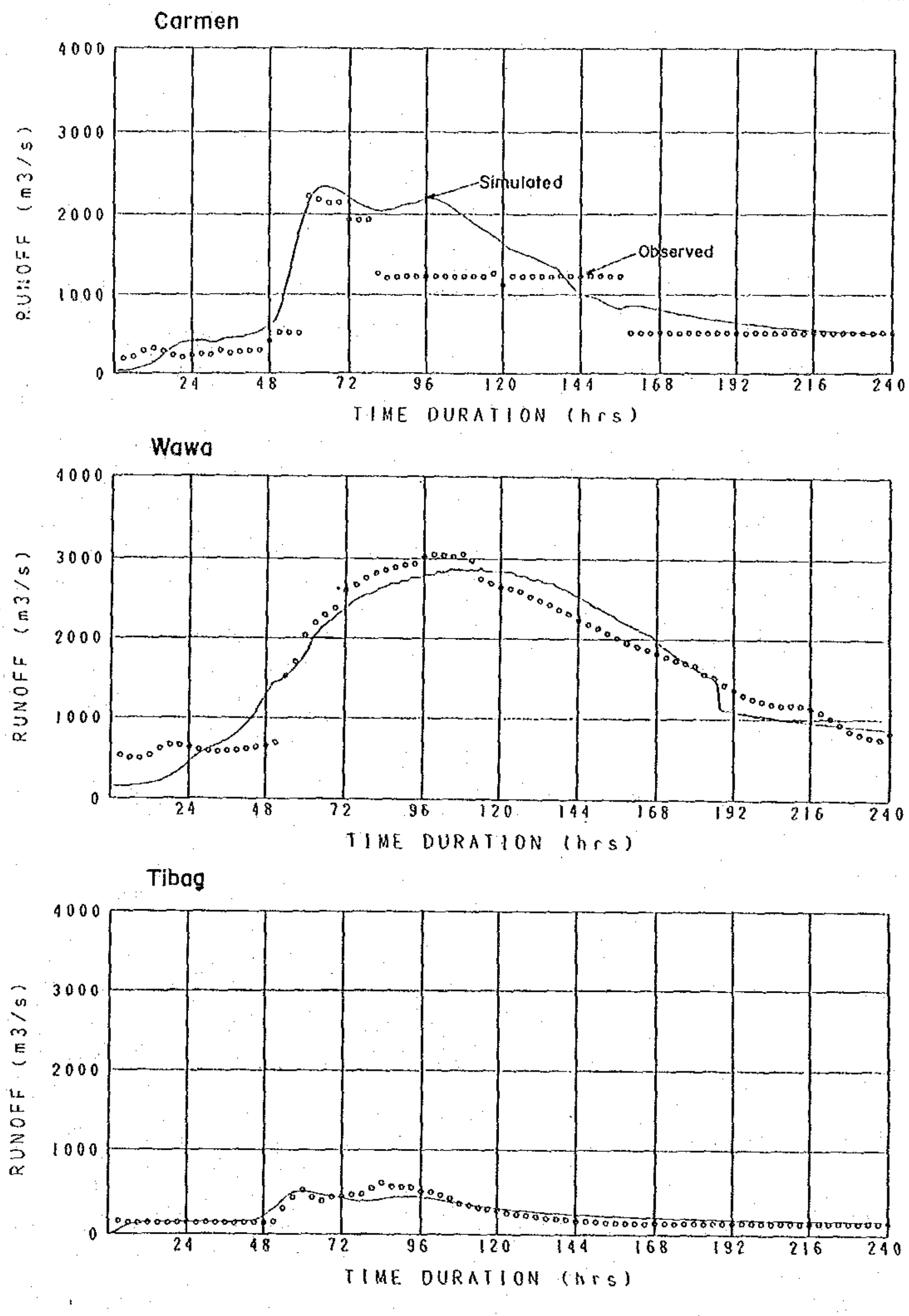


Fig. 4.3.2 OBSERVED AND SIMULATED FLOOD HYDROGRAPHS DURING TYPHOON MARING IN 1984 (2/2)

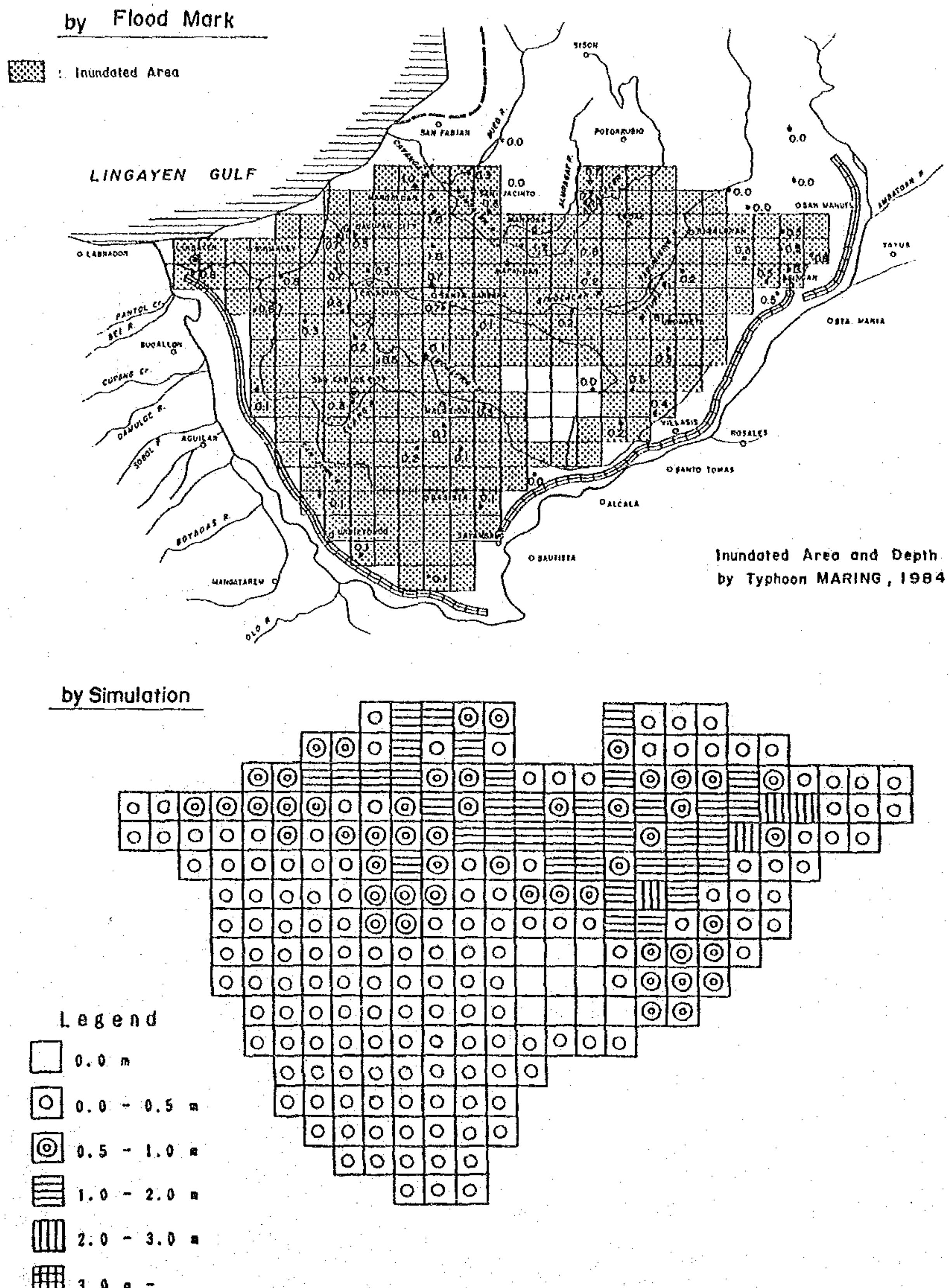


Fig. 4.3.3 COMPARISON OF INUNDATED AREA AND MAXIMUM DEPTH OF TYPHOON MARING IN 1984

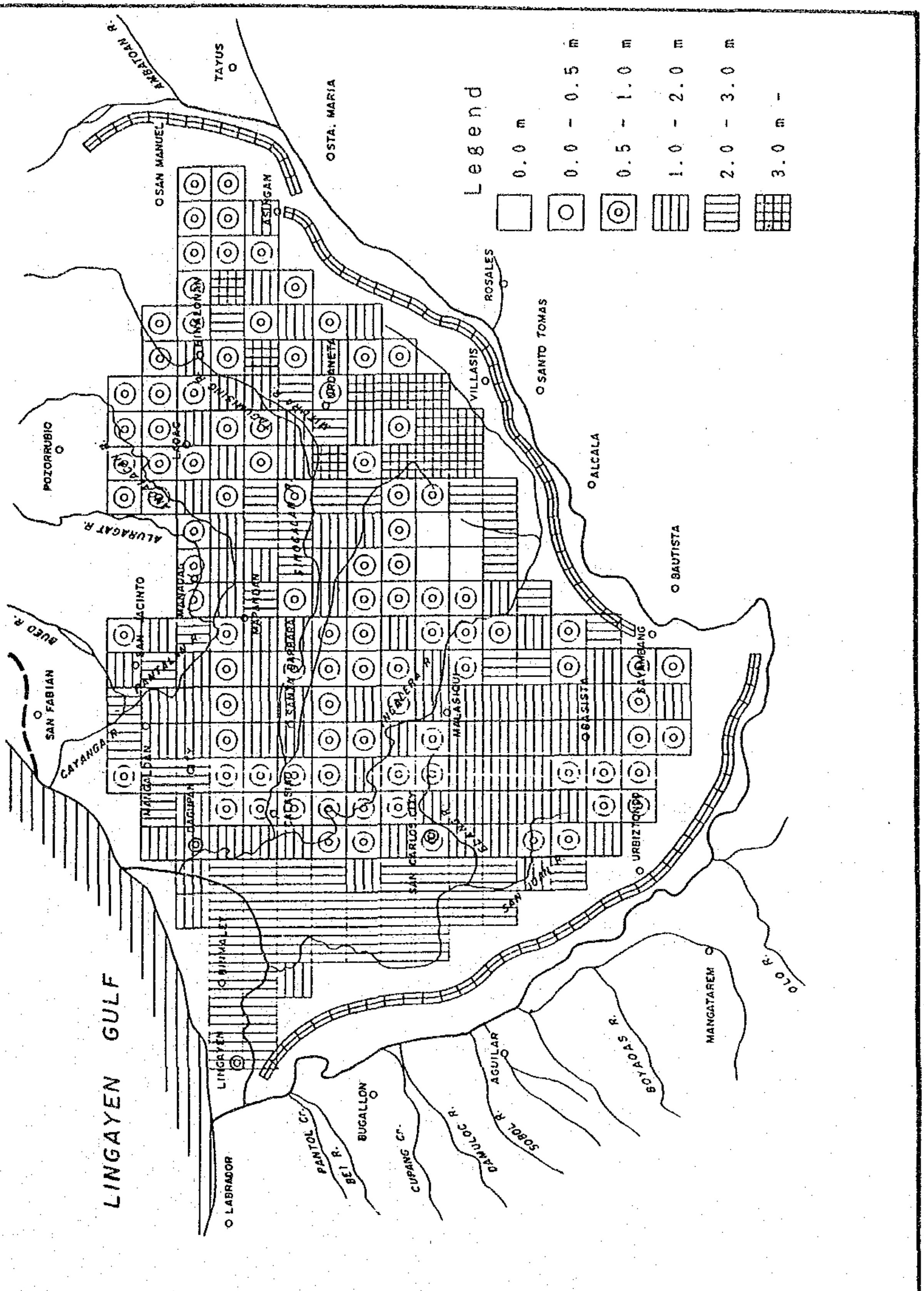


Fig. 4.3.4 MAXIMUM INUNDATION DEPTH OF 100-YEAR PROBABLE FLOOD

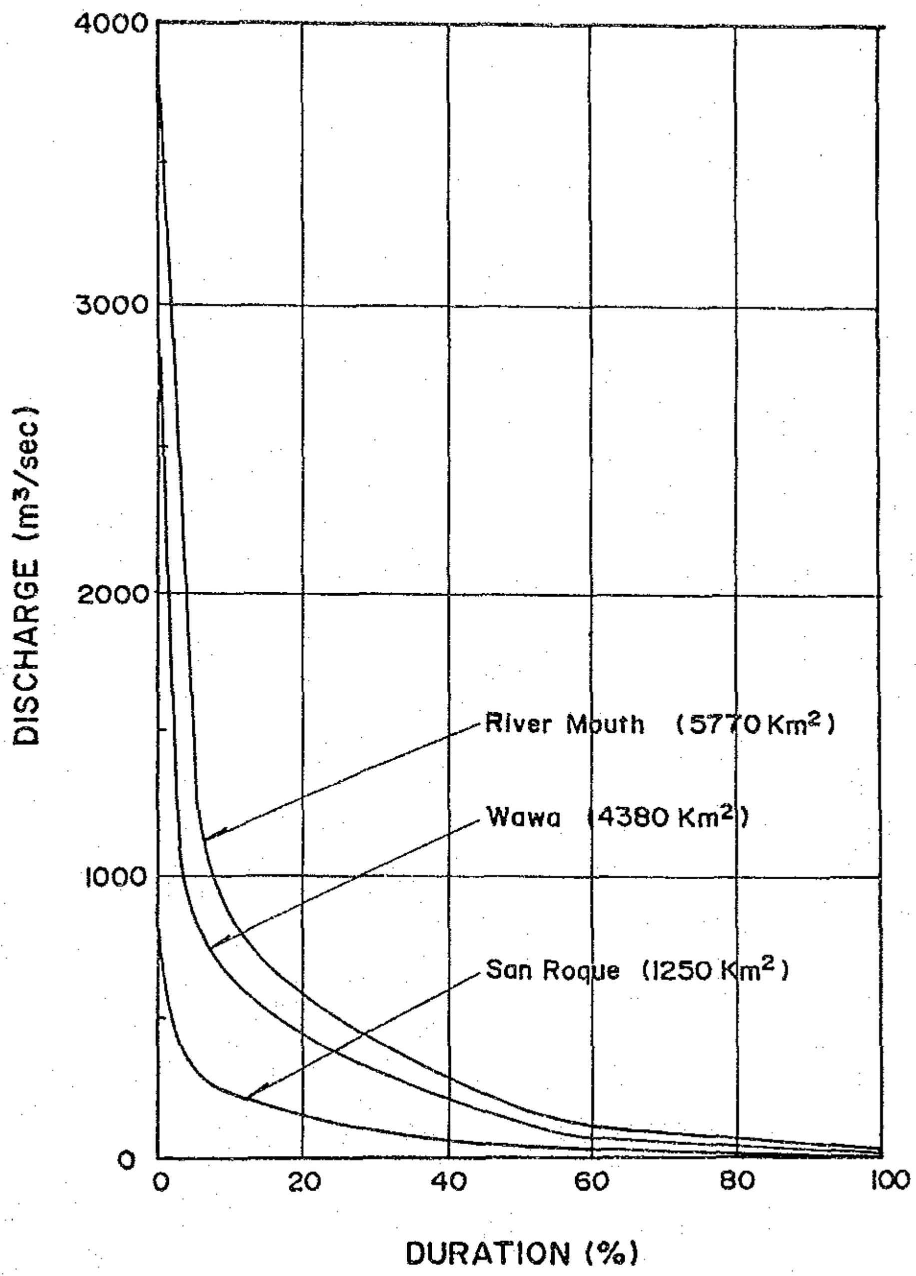


Fig. 4.4.1 FLOW DURATION CURVES

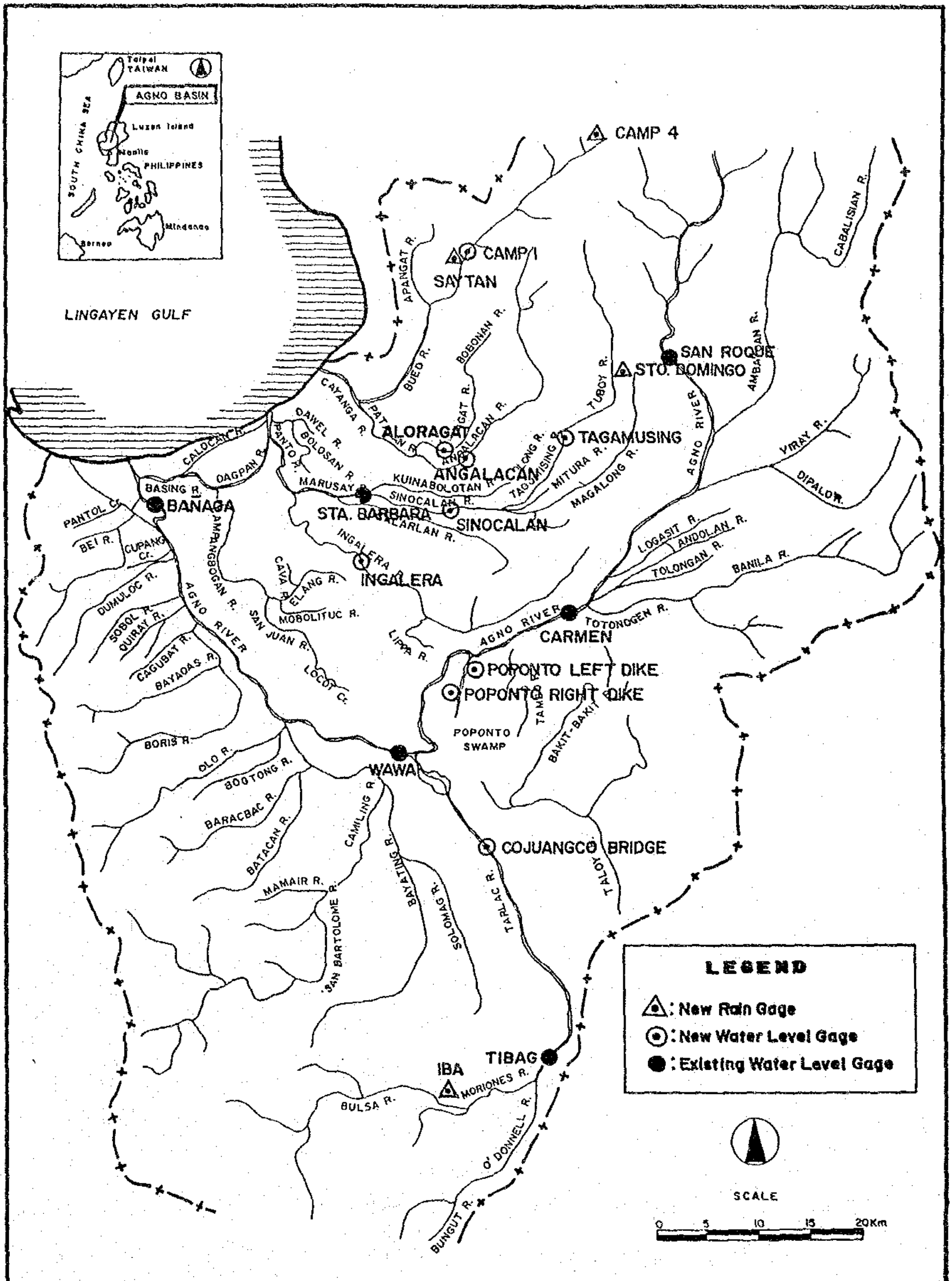


Fig. 4.5.1 LOCATION MAP OF NEW RAIN GAGES AND WATER LEVEL GAGES

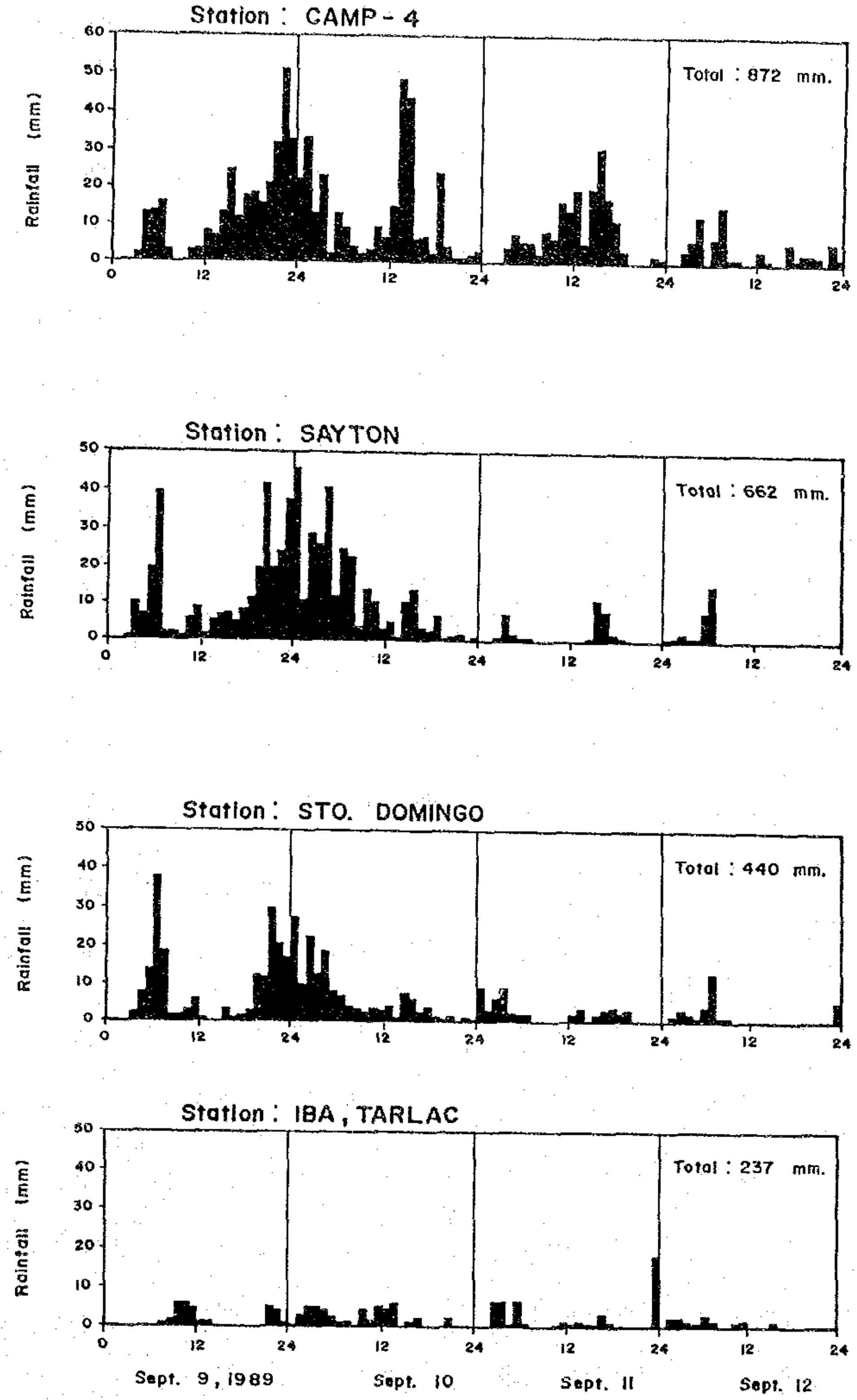


Fig. 4.5.2 OBSERVED RAINFALL HYETOGRAPHS DURING TYPHOON OPENG

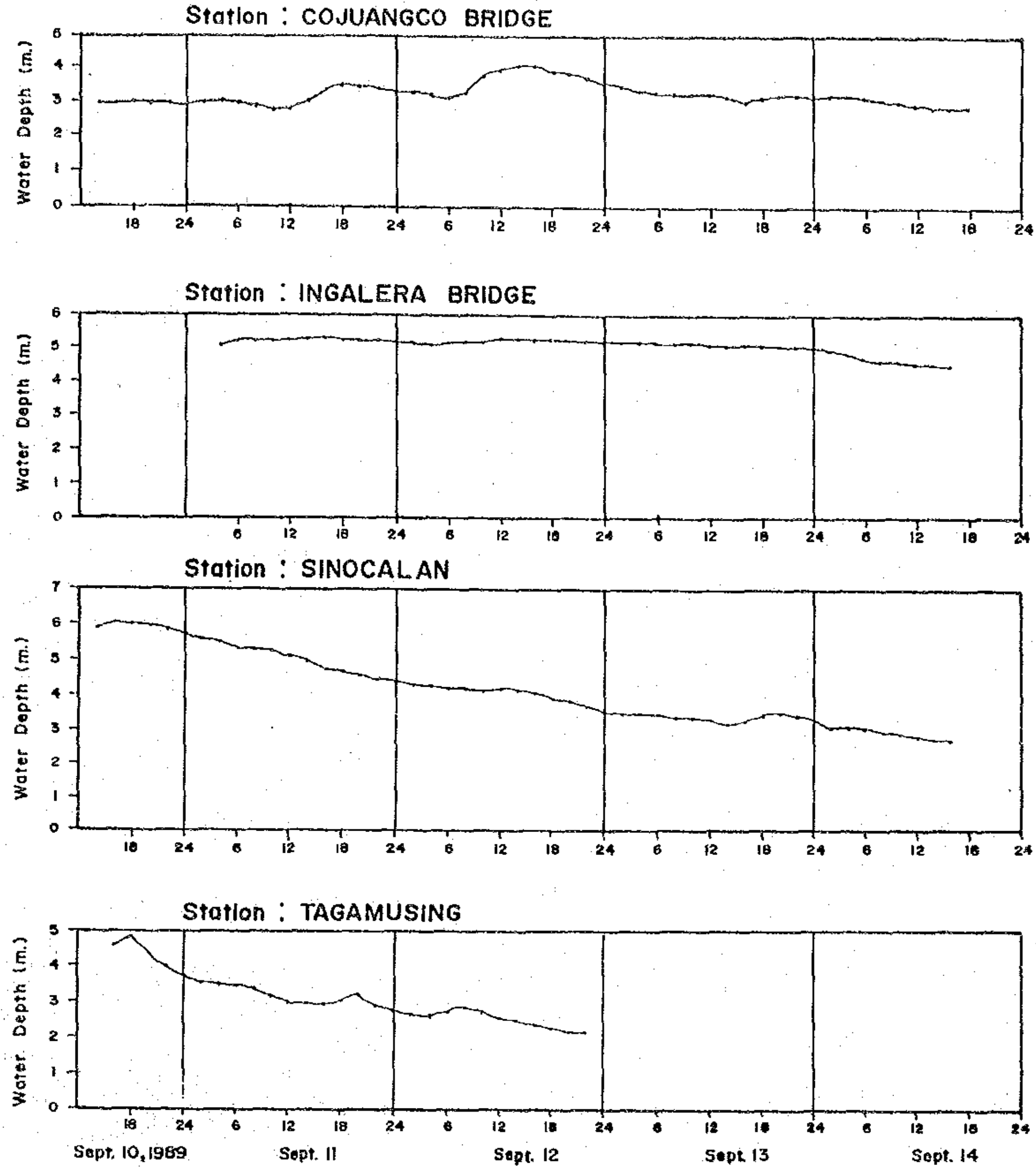


Fig. 4.5.3 OBSERVED WATER LEVEL HYDROGRAPHS DURING TYPHOON OPENG

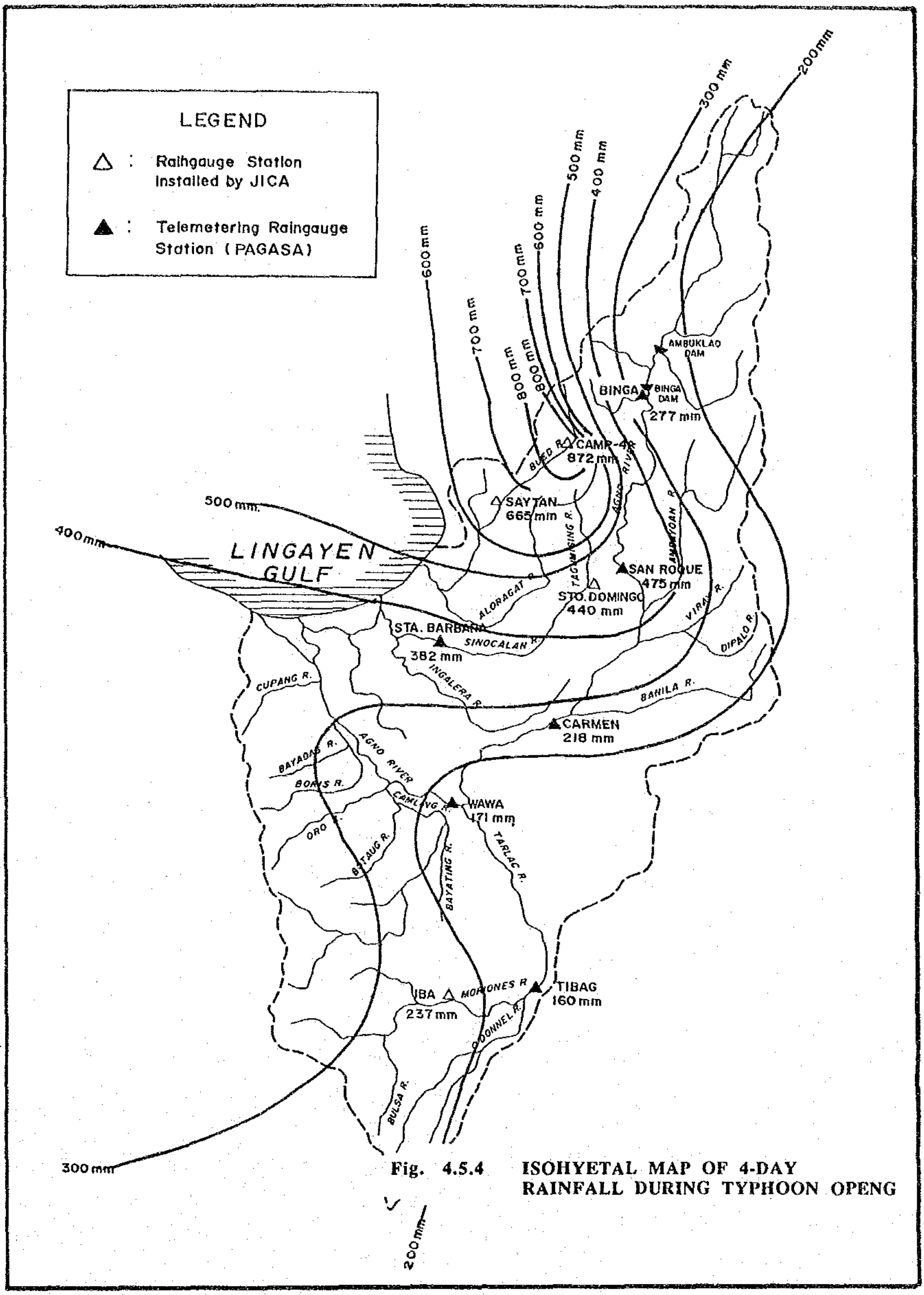


Fig. 4.5.4 ISOHYETAL MAP OF 4-DAY RAINFALL DURING TYPHOON OPENG

5. FLOOD DAMAGE ANALYSIS

5. FLOOD DAMAGE ANALYSIS

5.1 Flood Damage Records

5.1.1 Flood Records

Typhoons prevail in the rainy season, usually in the months of May to October and yield more than 90% of the annual average rainfall of 3000 mm in the basin. The downpour during this period causes habitual flooding in the Pangasinan plain area, causing flood damages almost every year.

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) and the Office of Civil Defense (OCD) have carried out surveys on each large typhoon and flood in the basin since 1962. Table 5.1.1 lists past destructive typhoons as well as 4-day rainfalls and their recurrence intervals observed at the mouth of the Agno River. In the last two decades, the severest flood, with a recurrence interval of 10 years occurred in 1972. More recent floods occurred in August, 1984 and July, 1986 with recurrence intervals of some 4 and 7 years, respectively.

A rainstorm occurred in September, 1989 and caused an overflow of the Sinocalan river and its tributaries in the Allied River basins. The recurrence interval of this flood is estimated at some 5 years in the entire Allied River basins. Calasiao town and Dagupan city, which are located in the downstream coastal area of the Sinocalan river, were inundated with water depths reaching 1 m in low-lying areas.

As an example of major past flood maps, a flood inundation map of typhoon Maring in 1984 is shown in Figure 5.1.1.

Flood years and flood inundation areas measured from the recorded flood maps are described as follows:

Flood Year	Inundation Area(km^2)	Recurrence Interval (year)
1935	2,100	no hydrological data
1972	2,040	10-year
1973	900	-
1980	1,550	-
1984	1,670	4-year

5.1.2 Flood Damage Records

Records on past large floods have been compiled by OCD since 1972, including information on the number of affected people and houses, and damages to crop, livestock, fish culture, and infrastructures. Of the major flood damage records, those of 1972, 1984 and 1986 are compiled in Table 5.1.2.

According to the damage records in Pangasinan Province, during the 1972 flood which was of the largest magnitude in the last two decades, 530,000 inhabitants (about 43% of the estimated population of 1,250,000 in 1972) suffered from flooding including 460,000 evacuated persons. On the other hand, in the recent large floods of 1984 (typhoon Maring) and 1986 (typhoon Gading), the number of affected people was reported to be 300,000 and 160,000 respectively. The corresponding share is about 20% and 10% of the estimated population of 1,500,000 in 1984 and 1,550,000 in 1986, respectively. The damages from the 1984 flood and the 1986 flood were estimated at about 99 and 134 million pesos at the price level in the corresponding year, respectively.

5.2 Estimation of Maximum Inundation Areas

A flood mark survey for confirming the extent of inundation area as well as water depth and duration of the floods of 1972, 1984, and 1986 was carried out at 240 sites in the flood prone area. Major items were water depth, duration of flooding and direction of flood flow, sedimentation depth, and damage. The results of the survey are compared with flood inundation analysis in hydrological studies for estimating probable flood damages. Figure 5.2.1 shows the maximum envelope of flood inundation area which was prepared the results of the flood mark survey and also with reference to available flood maps of past floods and topographic maps on 1 to 50,000 scale. The envelope confines the maximum extent of recorded flood inundation area in the Study Area; that is, the maximum extent of inundation area is defined as the probable maximum inundation area for the flood damage analysis. The maximum inundation area is 2,465 km^2. The affected administrative division in the area is shown in Figure 5.2.2.

5.3 Estimation Procedure for Probable Damage from Flooding and Sedimentation

Assets which are vulnerable to flooding and sedimentation in the Study Area are identified based on past damage records and if they are located in the probable inundation area. Damages to assets are classified into two; direct damage and indirect damage. The detailed constitution of these damages is illustrated in Figure 5.3.1.

Direct damage is one which is directly imposed on assets due to flooding and sedimentation, while indirect damage is a loss due to the suspension of economic activity, extra transportation costs required to change traffic routes and costs for rescue and relief activities.

The direct damage due to flooding consists of agricultural damage to crops, livestocks and fish cultures including pond facilities, and non-agricultural damage to houses, buildings and infrastructures. The direct damage due to sedimentation also consists of agricultural and non-agricultural damages. Areas subject to damages due to sedimentation are identified in two places; the portion downstream of San Roque on the right side of the Agno River and the portion of the Poponto Swamp near the downstream end of river dikes of the Tarlac River.

The probable flood and sedimentation damages with return periods of 1.05, 2, 5, 10, 25, 50 and 100 years are estimated on the basis of the damage classification mentioned above. The probable flood damages are assessed by multiplying the value of assets by the damage rate in the inundation area. For estimating the annual average probable flood damage, the portion of probable damage risk due to an event larger than a 100-year flood is assumed to be negligible.

5.4 Probable Flood Damages

The flood damages under the condition without project works are estimated for each of the 2,465 mesh blocks shown in Figure 5.4.1 by using the inundation water depth and duration of floods with frequencies of 1.05 years to 100 years computed by the flood inundation simulation model (see Section 4.3). Table 5.4.1 shows the probable direct and indirect damages, affected people and area in the Study Area estimated for various flood return periods. The components of indirect damage are shown in Table 5.4.2. The ratio of indirect damage to direct damage is estimated to be about 10% to 35%. The Study Area's probable damages are summarized below:

unit : million pesos

Return Period (Year)	2	5	10	50	100
Inundation Area (km2)	1,448	1,665	2,038	2,183	2,465
Affected Inhabitants (million persons)	1.05	1.17	1.37	1.44	1.56
Direct Damage	956	1,512	1,970	3,001	3,493
- Agricultural	315	486	586	762	877
- Non-agricultural	516	739	908	1,382	1,558
- Infrastructures	125	287	476	857	1,058
Indirect Damage	114	299	489	966	1,208
(% ratio)	(11.9)	(19.8)	(24.8)	(32.2)	(34.6)
Total Damage	1,070	1,811	2,458	3,968	4,700

Figure 5.4.1 illustrates regional distribution of direct flood damage in the Study Area in an event of a 100 year flood.

The flood damages of each mesh block are summed in 18 sub-basins shown in Figure 5.4.2. The cumulative annual average probable flood damage up to the 100-year flood is about 1,262 million pesos at 1989 price level in the whole Study Area as indicated in Table 5.4.3. The regional damage distribution at the sub-basin level is set out below:

Sub-basin No.	Annual Average Flood Damage (Million Pesos)	Sub-basin No.	Annual Average Flood Damage (Million Pesos)
1	7.5	10	2.4
2	92.8	11	10.8
3	16.4	12	89.7
4	22.5	13	39.1
5	180.0	14	148.9
6	127.7	15	18.5
7	261.9	16	17.8
8	100.3	17	58.1
9	10.1	18	57.4
		Total	1,261.8 Million Pesos

5.5 Assessment of Flood Damages on River Facilities

5.5.1 Records of Flood Damages on River Facilities and Structures

Records of flood damages to flood control facilities and related structures by major floods in recent years are shown in Tables 5.5.1 and Figure 5.5.1.

5.5.2 Analysis of Damage Causes

Most of the damages caused by floods were found on dikes, eroded banks and groins.

Restoration and damage prevention works have been undertaken repeatedly. Figure 5.5.3 shows the typical cross sections of dikes at the locations shown in Figure 5.5.2. These sections are presently adopted in the Study Area.

On the basis of analysis of bank failure sites caused by recent floods (refer to Figure 5.5.1), it is realized that the upper area of Agno River, the left bank of its middle reaches and the Dipalo River which is a tributary of the main Agno River have been damaged almost every year.

Since both dikes and groins are damaged in these areas, it is considered that the main causes of bank failure are scouring due to dike materials of silty sand and the strong tractive force on the existing dry masonry groins. On the other hand, the degree of dike failure depends on the quality of restoration works, such as the condition of compaction at contact portions between existing dikes and newly constructed ones.

The causes of bridge damage are considered as follows.

- Shortage of clearance
- Drift current by constriction of flow area
- Unsuitable location of abutment
- No existing revetment and foot protection around abutment to prevent dike failure due to scouring

The mechanism of bridge failure is explained below.

The destruction of a bridge due to a shortage of clearance occurs when the flood water level rises up to the level of the superstructure and strong dynamic loads are applied directly to the superstructure from floating matters such as drift timber. When the flood overflows the superstructure, the latter is washed away due to the flood flow (refer to No. 1 in Figure 5.5.4).

When abutment is placed in the river side as shown in No. 2 of Figure 5.5.4, overflow of the flood due to the decrease of flow area causes destruction of bridge, and scouring of dike is triggered off by drift currents due to constriction.

Destruction around an abutment occurs with scouring of the dike by the flood flow due to an unsuitable location of the abutment as shown in No. 3 of Figure 5.5.4.

Destruction of dikes, which consist of silty sand, occurs easily if no revetment and foot protection are provided around the existing abutment as shown in No. 4 of Figure 5.5.4.

5.5.3 Sedimentation Damage to Irrigation System

NIA has eight irrigation systems including ARIS and LATRIS in the probable inundation area. All of these irrigation systems have sedimentation problems. Sediment carried by irrigation water is deposited in the canal and the original design flow capacity cannot be maintained during irrigation.

NIA estimates this annual average sedimentation damage to be about 81 million pesos as follows:

- Rice yield reduction	17,900 ha	77.7 million pesos
- Desilting cost	355,000 m^3	5.7 million pesos
Total annual average damage		83.4 million pesos

Table 5.1.1 LIST OF DESTRUCTIVE TYPHOONS RECORDED IN THE AGNO RIVER BASIN (1962-1988)

No.	Calender Year	Name of Tyhoon	Date	4-day Rainfall at Agno River Mouth (mm)	Remarks/ Return Period (year)
1	1962	KATE	Jul.18-27		
2		WANDA	Aug.25-Sept.3		
3		AMY	Sept.3-Sept.8		
4	1963	DIDING	Jun.24-30		
5	1964	SENIANG	Aug.2-11		
6		ARING	Sept.3-13		
7	1965	MILING	Jul.10-18		
8	1966				No Flood
9	1967	TRINING	Oct.14-20		
10	1968	DIDANG	Jul.23-29		
11		HUANING	Aug.18-25		
12		LUCING	Sept.2-8		
13		NITANG	Sept.26-Oct.2		
14	1969				No Flood
15	1970				No Flood
16	1971	ROSING	Jul.18-21	175	1.2-year return period
17		KRISING	Oct.9-12	261	1.8-year return period
18	1972	KORDING	Jun.26-27	27	
19			July 17-20	601	10-year Return Period
20	1973	LUMING	Oct.2-9		
21	1974	ILING	Jul.18-21		
22		SUSANG	Oct.8-12		
23		TERING	Oct.14-17		
24		WENING	Oct.25-29		
25		ANING	Nov.4-8		
26		BIDING	Nov.24-29		
27	1975	AURING	Jun.22-26		
28	1976	HUANING	Jun.27-Jul.30	370	4-year return period
29	1977	UNDING	Nov.10-17		
30	1978	KIDING	Aug.18-26		
31		KADING	Oct.25-27	152 (3-day)	1.1-year return period
32	1979	MAMANG	Aug.9-15		
33	1980	GLORING	May 22-26		
34		NITING	Jul.18-21	178	1.1-year return period
35		ARING	Nov.1-7		
36	1981	ANDING	Nov.22-25	168	1.1-year return period
37	1982	EMANG	Jul.12-16		
38		NORMING	Aug.30-Sept.3	82	1.01-year return period
39	1983	BEBENG	Jul.12-16		
40	1984	MARING	Aug.27-30	400	4-year return period
41	1985	KURING	Jun.20-23	389	4-year return period
42		DALING	Jun.26-29	195	1.2-year return period
43		SALING	Oct.15-20	-	
44	1986	GADING	Jul.7-10	479	7-year return period
45		MIDING	Aug.24-Sept.4		
46	1987	ISING	Aug.12-19		
47	1988	UNSANG	Oct.21-24		

Source: OCD, PAGASA

Table 5.1.2 DAMAGE RECORDS BY TYPHOONS

Unit : Million Pesos

Items	1972 Typhoon			1984 Typhoon-Maring			1986 Typhoon-Gading		
	Pangasinan	Tarlac	Nueva Ecija	Pangasinan	Tarlac	Nueva Ecija	Pangasinan	Tarlac	Nueva Ecija
Casualities (number of habitants)									
Affected	524,391	273,448	173,905	296,628	34,175	44,630	152,041	58,057	68,248
Evacuated	461,971	232,430	94,488	12,512	-	10,156	-	-	-
Dead	-	-	-	21	-	-	7	-	-
Injured	-	-	-	3	-	-	2	-	-
Missing	-	-	-	6	-	-	5	-	-
Affected house/building (number of bilds.)									
Totally	-	-	-	173	-	-	336	-	-
Partially	-	-	-	379	-	-	1,076	-	-
Direct Damage									
Agriculture									
Crops	0.6	-	-	6.4	27.3	18.1	51.2	7.1	0.6
Padday									
Corn	-	-	-	-	-	-	-	-	-
Sugarcane	-	-	-	-	-	-	-	-	
Legume	-	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-
Livestocks	-	-	-	0.4	-	-	1.9	-	0.1
Fishpond	-	-	-	21.3	-	-	24.1	-	21.6
Sub-total	0.6	-	-	28.1	27.3	18.1	77.2	7.1	22.3
Non-agriculture									
House/Building									
Residential	-	-	-	-	-	-	-	-	-
Non-residential	-	-	-	-	-	-	-	-	-
Infrastructures									
Road/Bridge	-	-	-	3.5	-	-	2.5	-	-
Railways	2.8	-	-	5.0	-	-	-	-	-
Irrigation facility	-	-	-	-	-	-	-	-	-
River facility	-	-	-	65.7	-	-	54.8	-	-
Water supply facility	-	-	-	-	-	-	-	-	-
Telecom. facility	-	-	-	4.3	-	-	4.3	-	-
Sub-total	2.8	-	-	78.5	5.0	3.7	61.6	15.2	9.9
Total	3.4	-	-	106.6	32.3	21.8	138.8	22.3	32.2
Indirect Damage									
Rescue & Relief Services	0.2	-	0.3	-	-	-	2.1	2.4	-
Total	0.2	-	0.3	-	-	-	2.1	2.4	-
Grand Total	3.6	-	0.3	106.6	32.3	21.8	140.9	24.7	32.2

Sources: DND, Ocd, Quezon City
DA, Central Office, Pangasinan, Tarlac
PNRC, National Headquaters, Tarlac, Manila
BFAR, DAF, Pangasinan
PMP-AFCS, DPWH

Note: Damage values shown in the above table are indicated at the price level of each year.

Table 5.4.1 PROBABLE FLOOD DAMAGE

Unit : Million Pesos

Item	Return Period (Year)						
	1.05	2	5	10	25	50	100
1. Casualities							
Affected People(1000 person)	938	1,056	1,175	1,370	1,406	1,435	1,457
Affected Area (km2)	1,213	1,448	1,665	2,038	2,122	2,183	2,465
2. Direct Damage							
(1) Agricultural Damage							
- Crops	236	269	321	388	437	467	545
- Livestocks	17	19	22	27	31	33	38
- Fishpond	4	27	143	171	217	262	293
Sub-total	257	315	486	586	684	762	877
(2) Non-agricultural Damage							
- Residential Bldg.	317	433	598	731	946	1,086	1,220
- Non-residential Bldg.	49	83	141	177	251	296	338
Sub-total	366	516	739	908	1,197	1,382	1,558
-Infrastructures							
- Road/Bridge	6	35	93	175	245	334	419
- Railways	2	10	23	40	63	77	104
- Irrigation Facility	4	8	16	27	34	45	52
- River Facility	8	52	92	135	175	221	259
- Water Supply Facility	3	18	61	96	148	175	216
- Telecommunication	0	1	3	4	5	6	8
Sub-total	23	125	287	476	669	857	1,058
Total	646	956	1,512	1,970	2,550	3,001	3,492
3. Indirect Damage	63	114	299	489	750	966	1,208
Grand Total	709	1,070	1,811	2,458	3,299	3,968	4,700

Note: The probable flood damage shown above is estimated for the entire Agno River Basin.

Table 5.4.2 PROBABLE INDIRECT FLOOD DAMAGE

Probable Indirect Damage (1000 Pesos)

Damage Item							
Return period (year)	1.05	2	5	10	25	50	100
Economic suspension period (days)	1	2	6	9	14	18	21
Traffic suspension period (days)	1	2	6	9	14	18	21
1. Loss due to suspension of Economic Activity (GRDP in the Inundation Area)	29,609	66,676	222,780	389,344	622,014	816,228	1,033,225
2. Extra Transportation Cost due to Change of Traffic Routes	590	590	590	590	590	590	590
3. Cost due to Rescue Services (5% of Probable Direct Damage)	32,320	48,982	75,600	98,492	127,491	150,071	174,619
Total	62,519	116,248	298,970	488,425	750,095	966,889	1,208,434

Remarks :

Total probable flood damage (1000 pesos)	708,913	1,095,895	1,810,967	2,458,259	3,299,915	3,968,310	4,700,814
GRDP per capita in 1989 (pesos)	9,480	9,480	9,480	9,480	9,480	9,480	9,480
Economic activity days a year	300	300	300	300	300	300	300
Inundation area (km2)	1,213	1,448	1,665	2,038	2,122	2,183	2,465
Affected people (1000 persons)	937	1,055	1,175	1,369	1,406	1,435	1,557
Probable direct damage (1000 pesos)	646,394	979,647	1,511,997	1,969,834	2,549,820	3,001,421	3,492,380
Indirect damage/Direct damage (%)	9.7	11.9	19.8	24.8	29.4	32.2	34.6

Note : The suspension days for economic activities and traffic are assumed based on the interviews with AFCS, DPWH and site-interviews.

Table 5.4.3 PROBABLE ANNUAL AVERAGE FLOOD DAMAGES BY SUB-BASIN

Unit : Million Pesos

Sub-basin No.	Return Period (year)						
	1.05	2	5	10	25	50	100
1	0.0	1.8	4.1	5.6	6.8	7.2	7.5
2	0.0	31.7	62.0	75.7	86.1	90.3	92.8
3	0.0	5.5	10.8	13.3	15.1	15.9	16.4
4	0.0	8.2	15.5	18.7	21.0	21.9	22.5
5	0.0	51.2	111.4	141.0	164.2	174.1	180.0
6	0.0	43.5	84.4	103.2	117.9	124.2	127.7
7	0.0	69.9	158.9	203.8	239.1	253.6	261.9
8	0.0	34.8	67.2	81.6	93.0	97.7	100.3
9	0.0	3.5	7.2	8.6	9.5	9.9	10.1
10	0.0	0.7	1.6	2.0	2.2	2.3	2.4
11	0.0	4.0	7.2	8.7	10.0	10.5	10.8
12	0.0	28.1	54.7	68.8	81.3	86.6	89.7
13	0.0	13.1	25.6	31.3	36.0	37.9	39.1
14	0.0	42.8	88.5	111.5	132.3	142.0	148.9
15	0.0	0.0	0.0	6.3	14.2	17.0	18.5
16	0.0	1.3	5.3	9.3	14.0	16.4	17.8
17	0.0	13.7	33.1	43.8	52.6	56.1	58.1
18	0.0	7.7	27.5	39.7	50.4	54.9	57.4
Total	0.0	361.8	765.0	973.0	1,145.8	1,218.4	1,261.8

Note : The entire Agno River Basin and Allied River Basins.

Table 5.5.1 SUMMARY OF FLOOD CONTROL FACILITIES DAMAGED BY FLOODS

River (Reaches)	Damage Type		1984-Flood Aug. 28-30 ("Maring")		1985-Flood Jun.22-24 ("Kuring") Jun. 28-30 ("Daling")		1986-Flood July 9-11 ("Gading") Aug.30-Sep.5 ("Meding")	
Agno River (Upper)	Earthdike/Revet.	(Site, m)	8	2,760	8	2,290	10	5,340
	Breaches/Gaps	(P:1,000)		52,972		17,888		55,402
	Scoured	(Site, m)	0	0	0	0	3	2,900
		(P:1,000)		0		0		2,750
	Damaged Spurdike	(Site, Unit)	2	56	0	0	7	188
		(P:1,000)		1,400		0		3,812
Agno River (Lower)	Earthdike/Revet.	(Site, m)	1	110	0	0	1	500
	Breaches/Gaps	(P:1,000)		20,000		0		1,200
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	0	0	1	4
		(P:1,000)		0		0		8,120
Tarlac Rievr	Earthdike/Revet.	(Site, m)	0	0	3	70	5	490
	Breaches/Gaps	(P:1,000)		0		660		5,845
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	0	0	3	46
		(P:1,000)		0		0		1,280
Tributaries of Agno River	Earthdike/Revet.	(Site, m)	0	0	3	140	7	1,080
	Breaches/Gaps	(P:1,000)		0		1,000		8,300
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	0	0	8	61
		(P:1,000)		0		0		1,744
Allied Rivers	Earthdike/Revet.	(Site, m)	4	976	1	40	9	1,820
	Breaches/Gaps	(P:1,000)		8,166		231		8,767
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	2	10	3	48
		(P:1,000)		0		576		997
Total Cost of Restoration Works		(P:1,000)		82,538		20,355		109,017

Source : Agno Flood Control System Office, Rosales

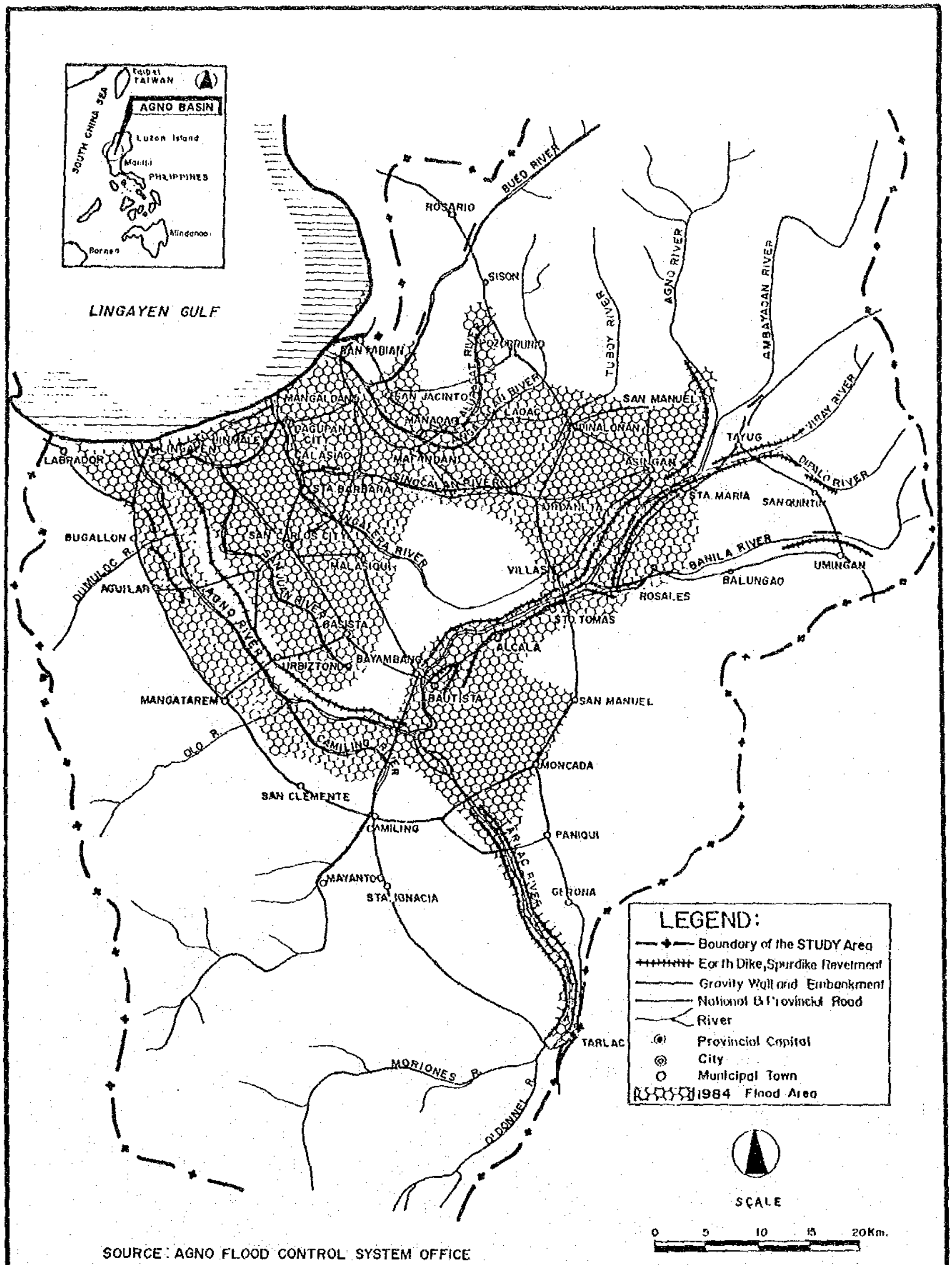


Fig. 5.1.1 ESTIMATED INUNDATION AREA BY 1984 FLOOD

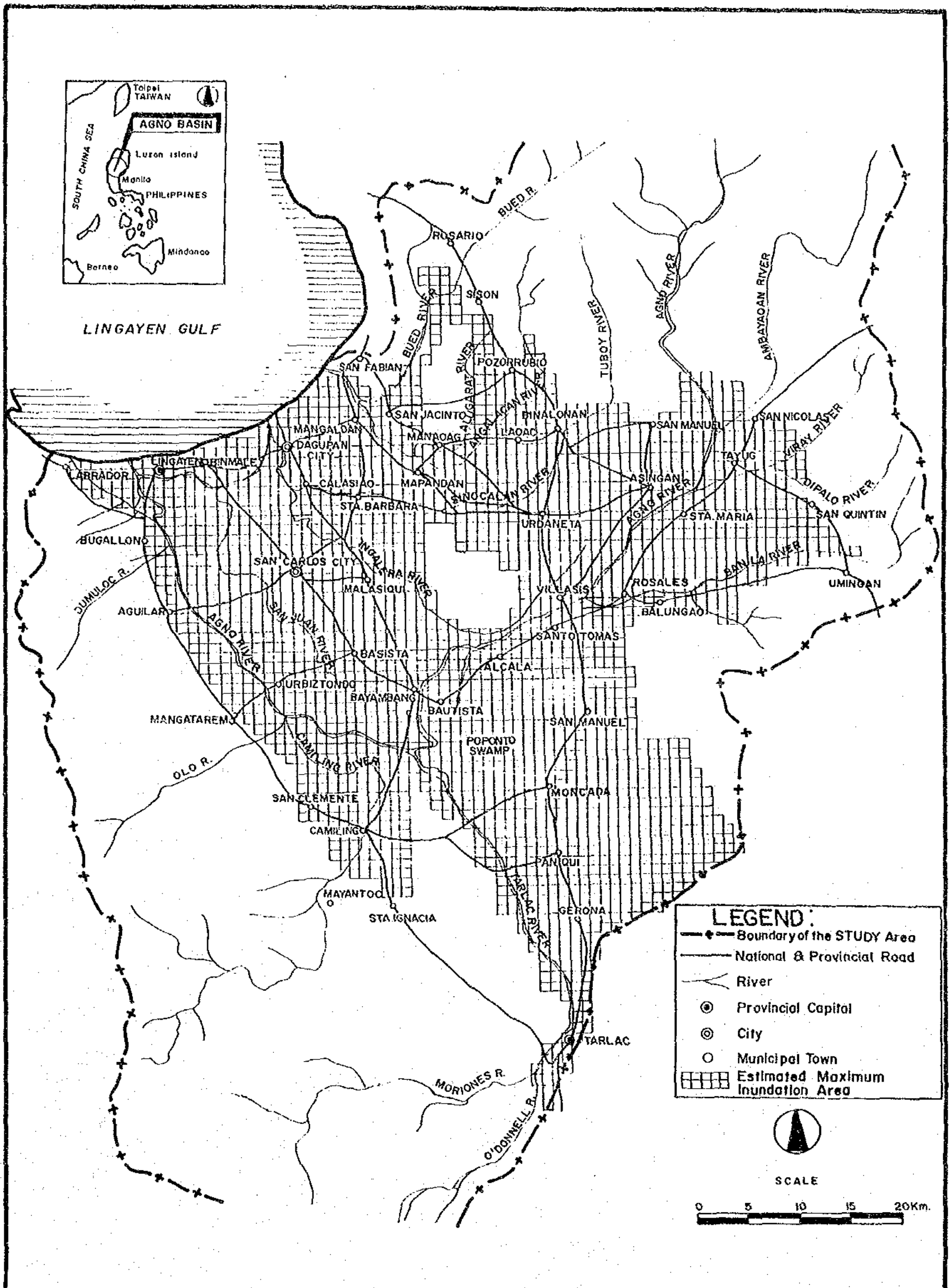


Fig. 5.2.1 MAXIMUM ENVELOP OF FLOOD INUNDATION AREA

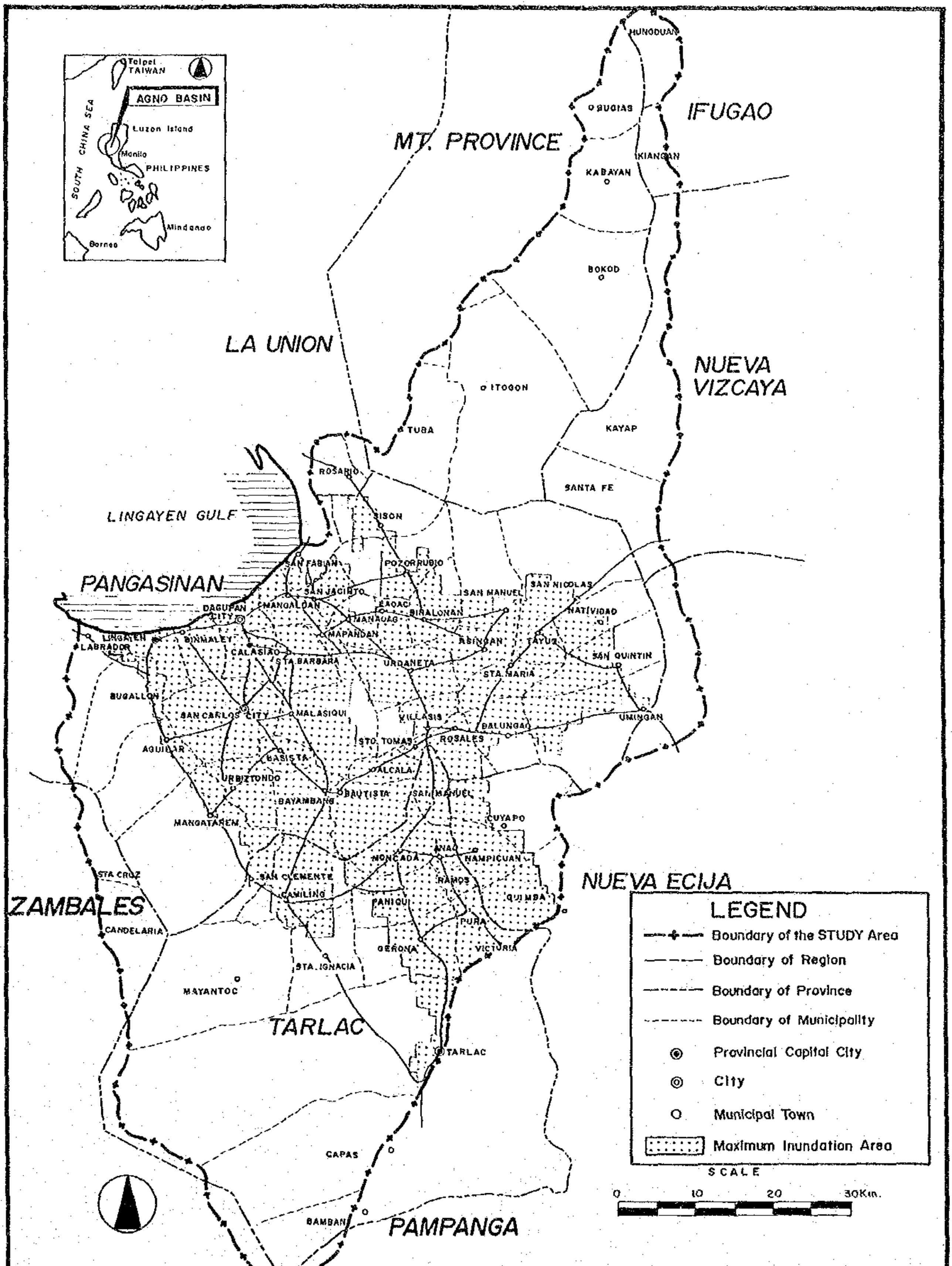


Fig. 5.2.2 ADMINISTRATIVE DIVISION AND MAXIMUM INUNDATION AREA

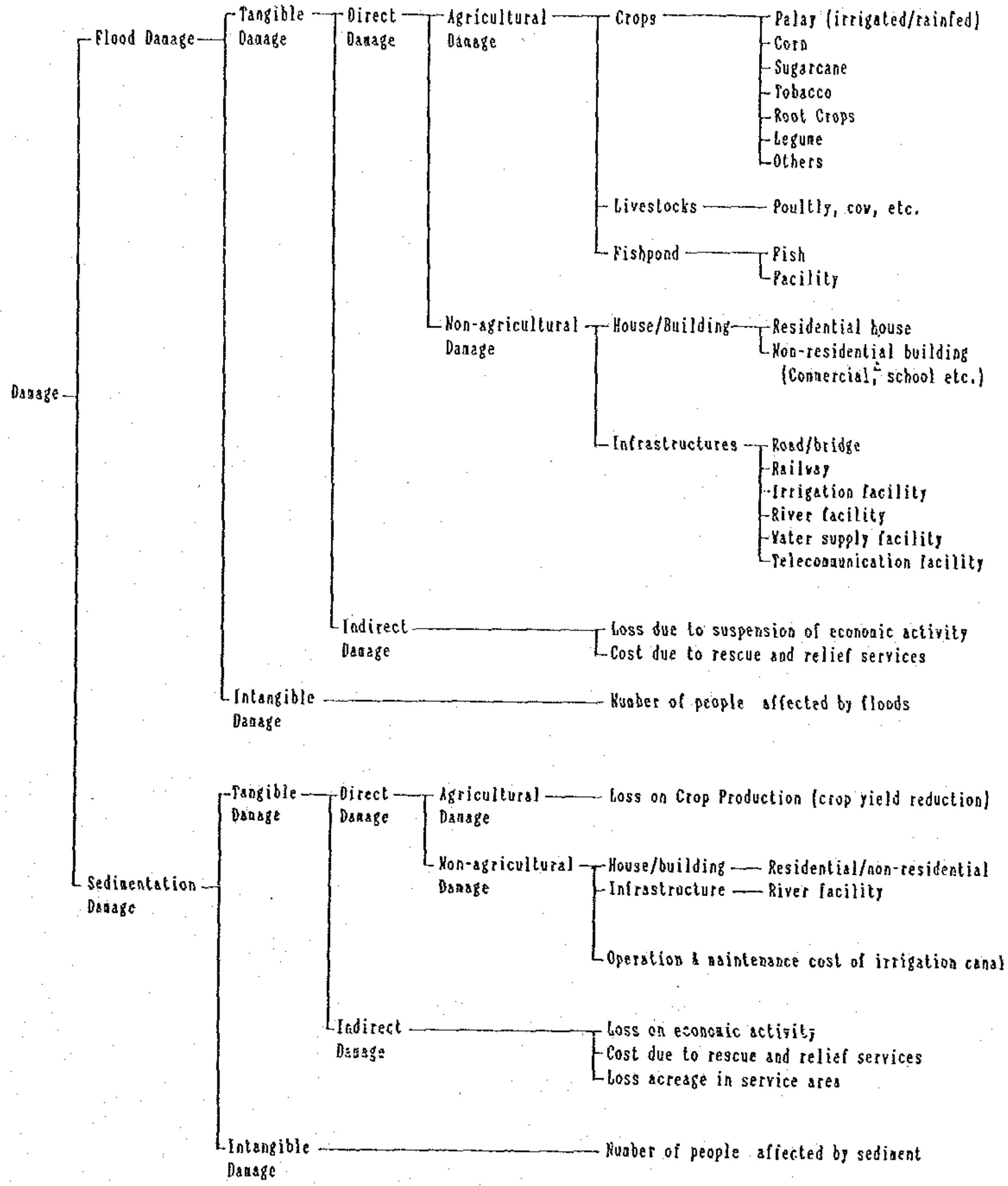


Fig. 5.3.1 CONSTITUTION OF DAMAGES DUE TO FLOOD AND SEDIMENT

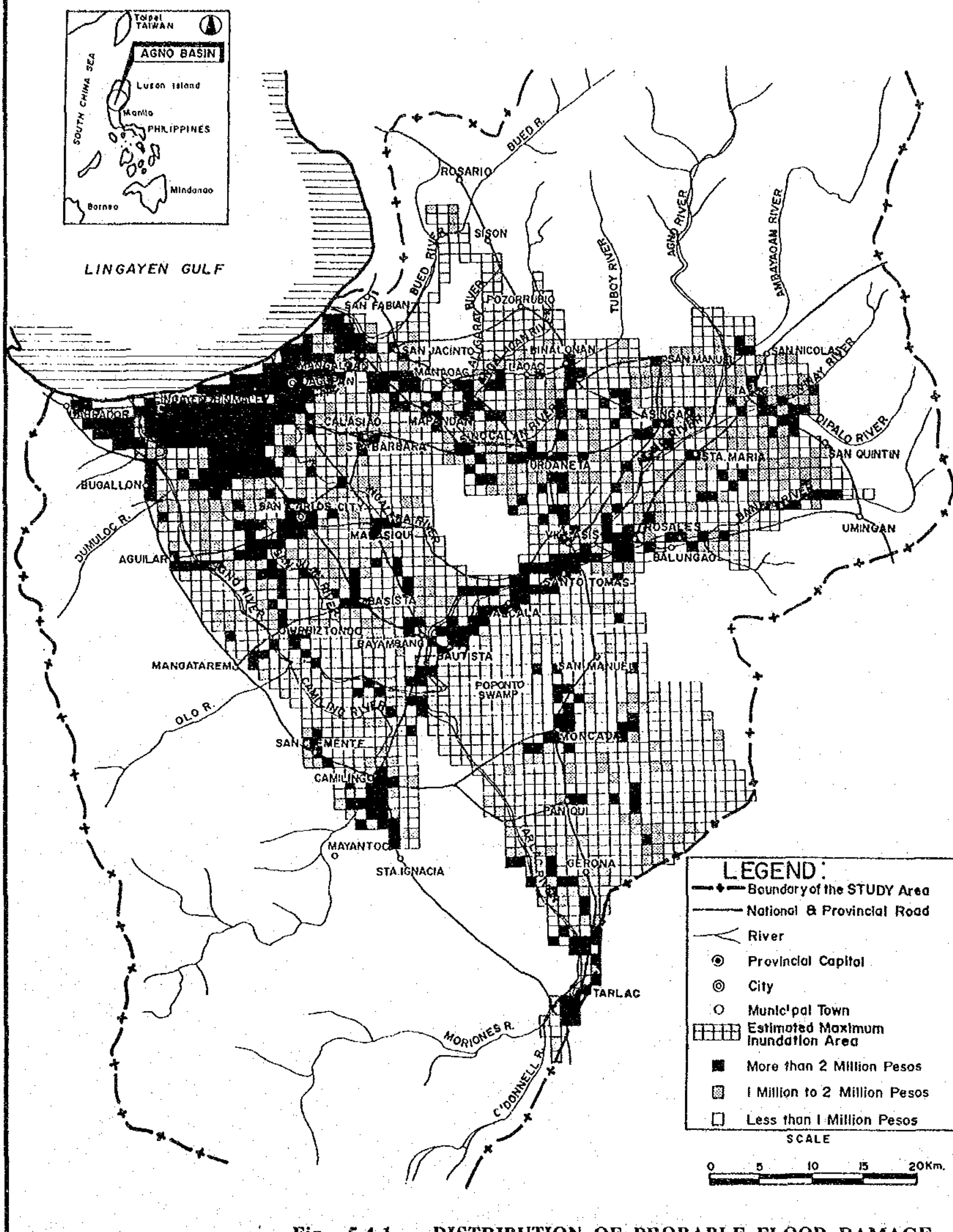


Fig. 5.4.1 DISTRIBUTION OF PROBABLE FLOOD DAMAGE BY 100-YEAR FLOOD (DIRECT DAMAGE)

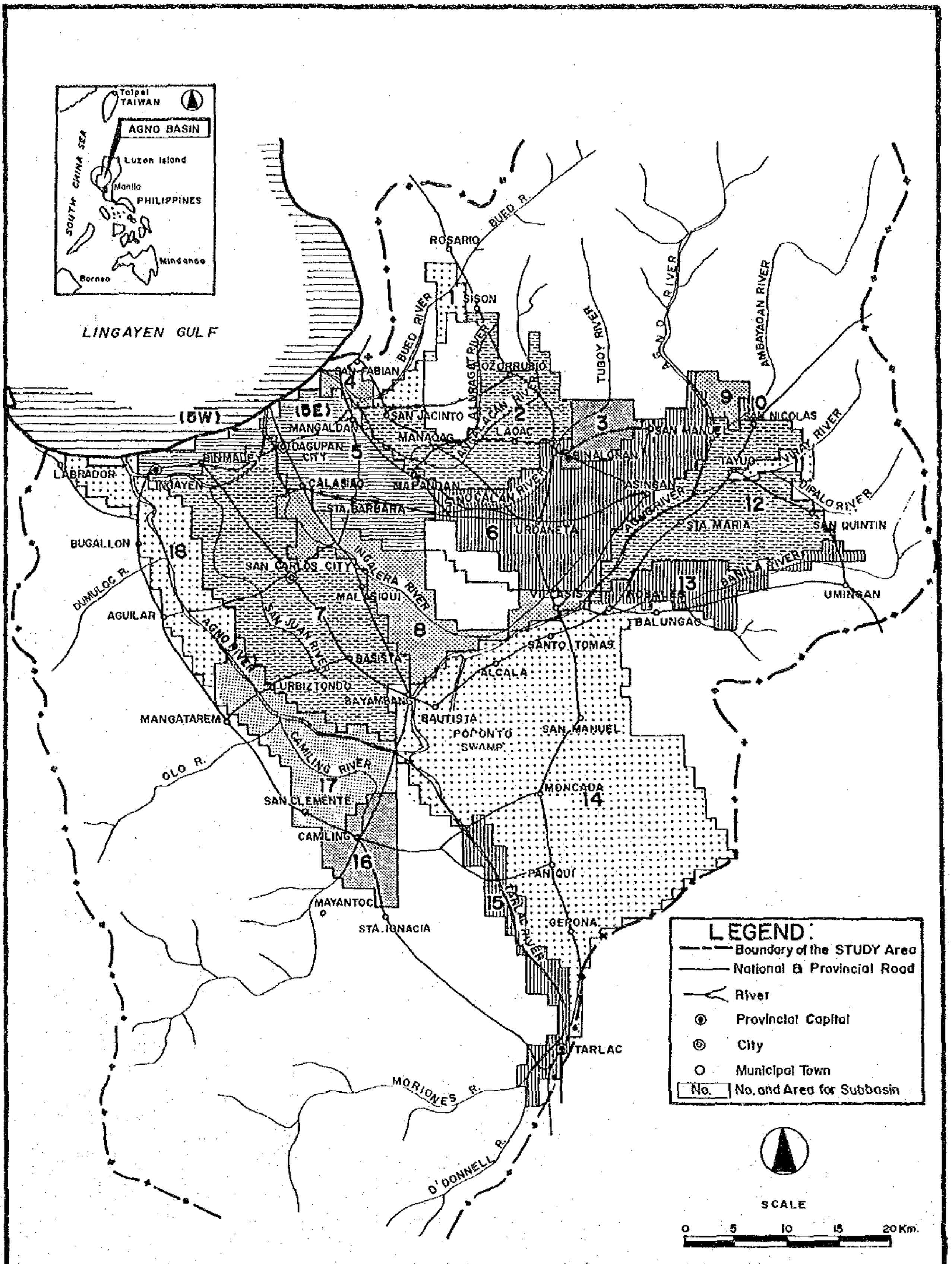


Fig. 5.4.2 DIVISION OF SUB-BASIN FOR ESTIMATION OF PROBABLE FLOOD DAMAGE

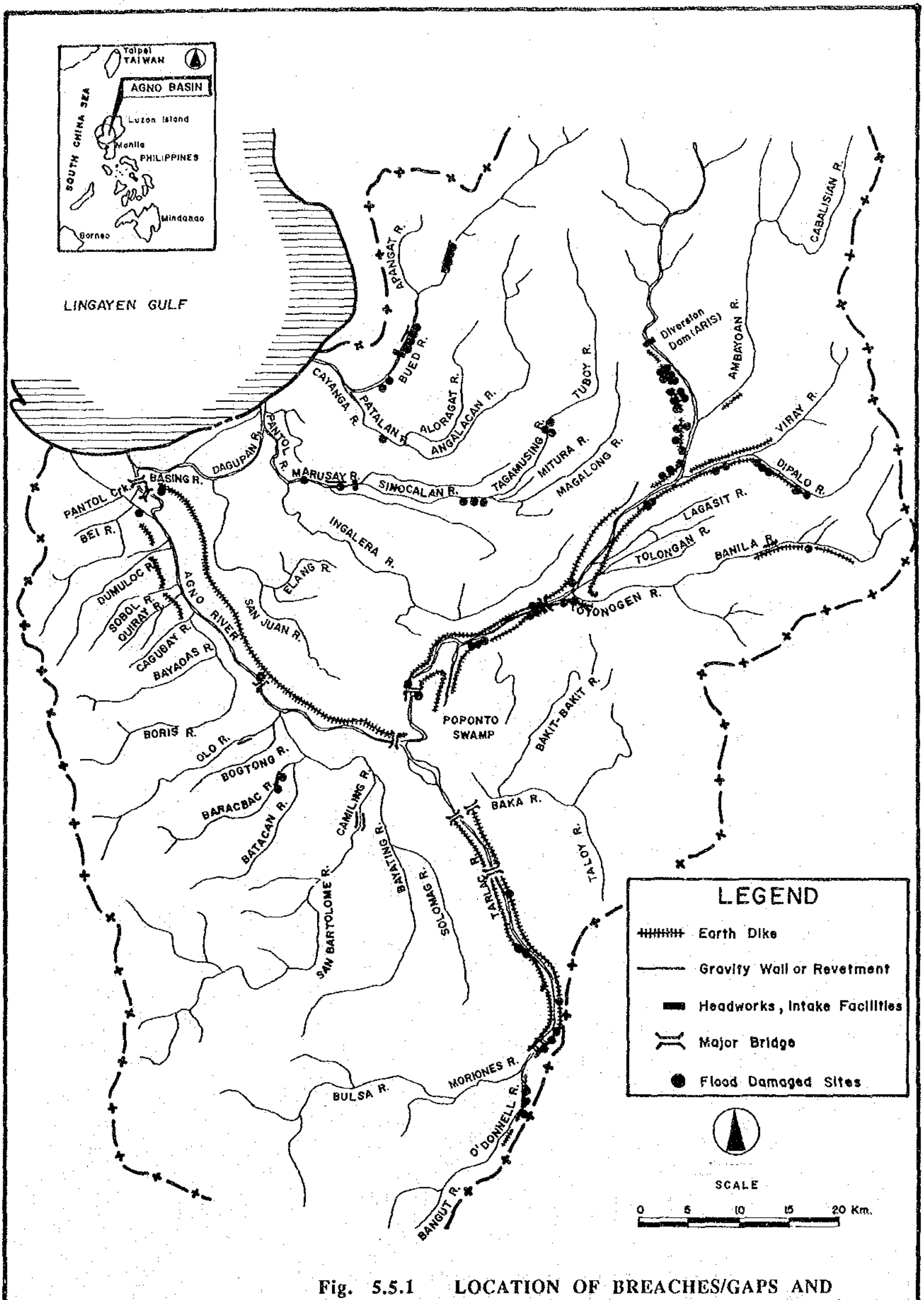


Fig. 5.5.1 LOCATION OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

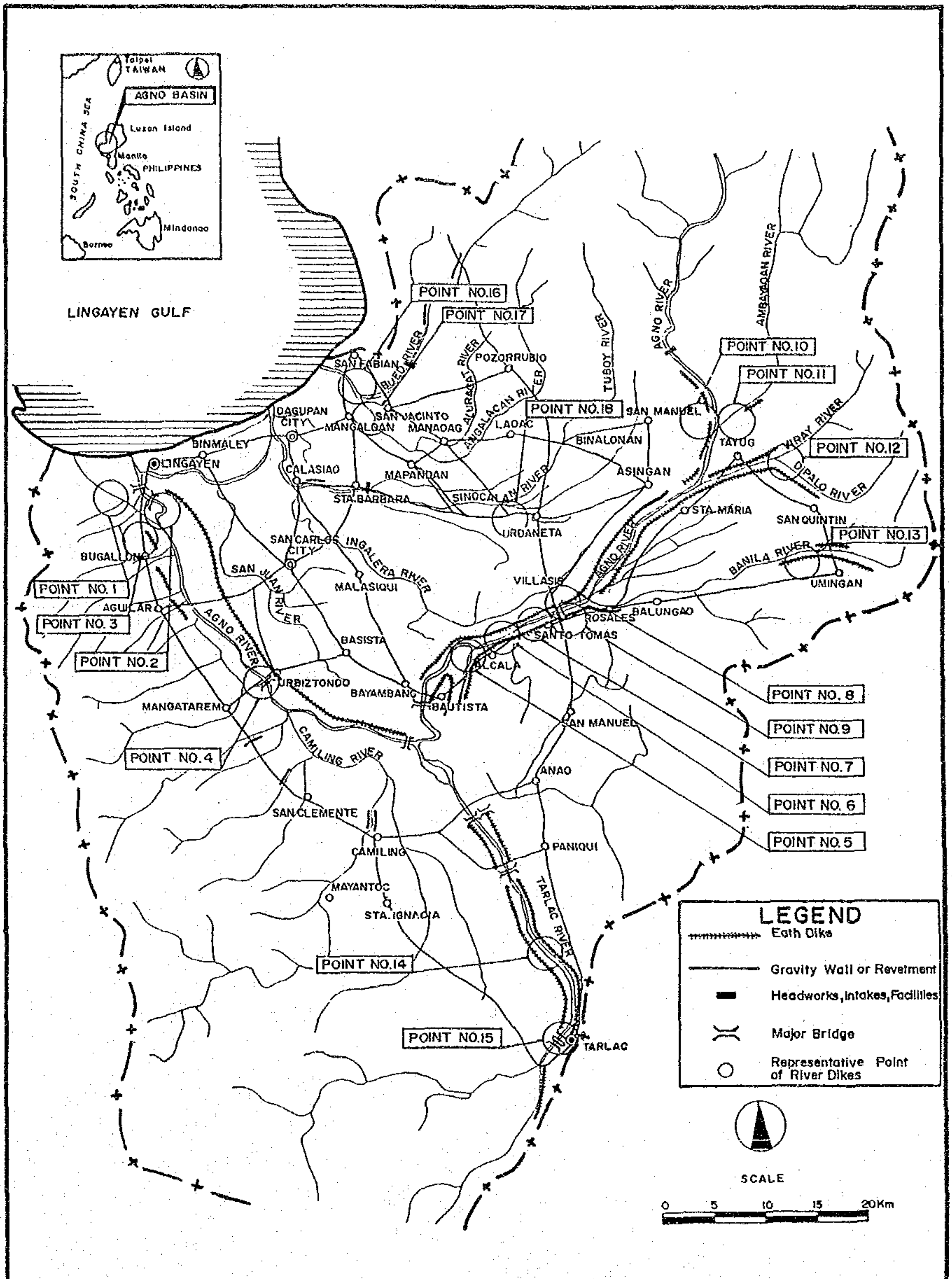


Fig. 5.5.2 LOCATION MAP OF REPRESENTATIVE POINTS FOR RIVER DIKES

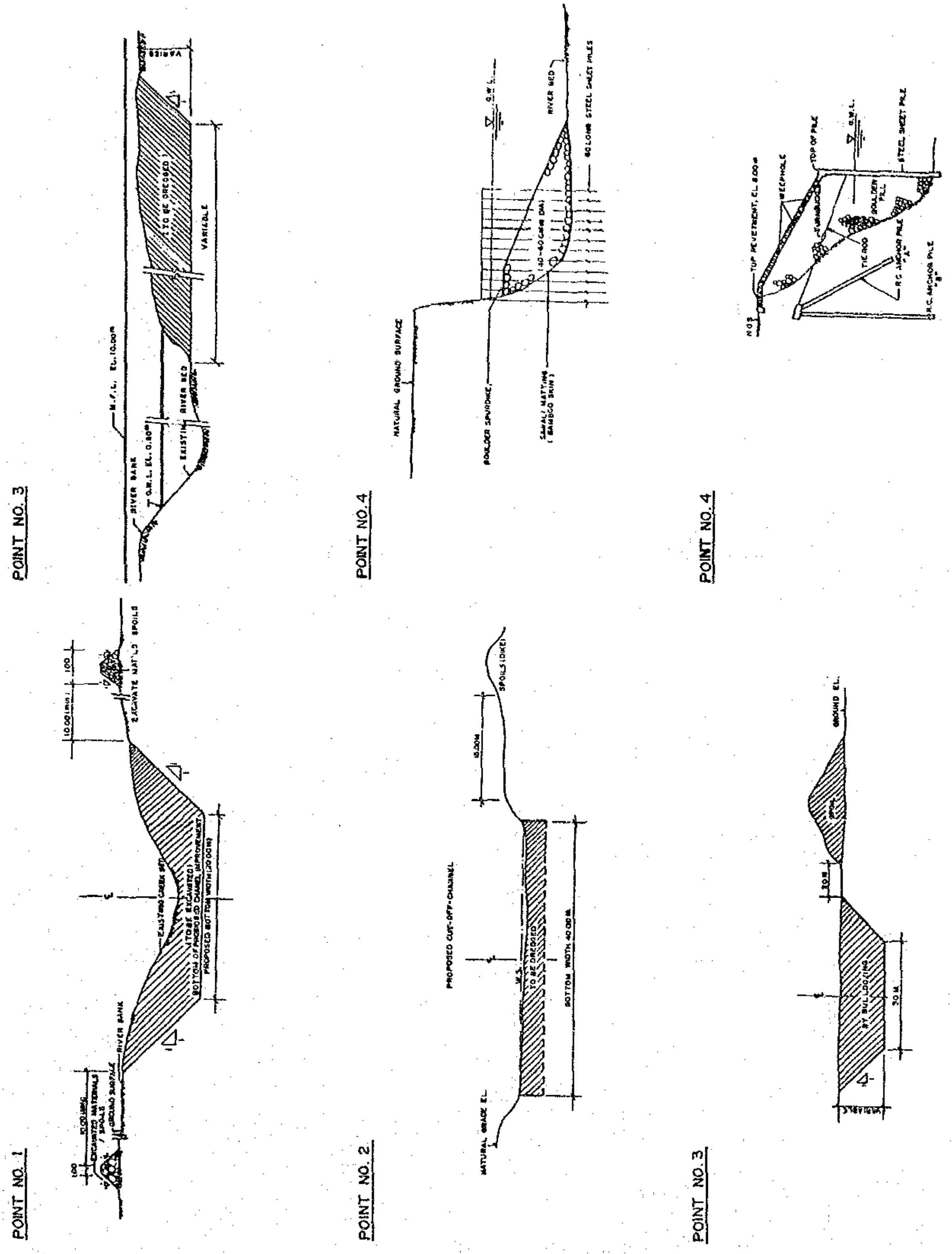


Fig. 5.5.3 TYPICAL CROSS SECTIONS OF EXISTING DIKE (1/4)

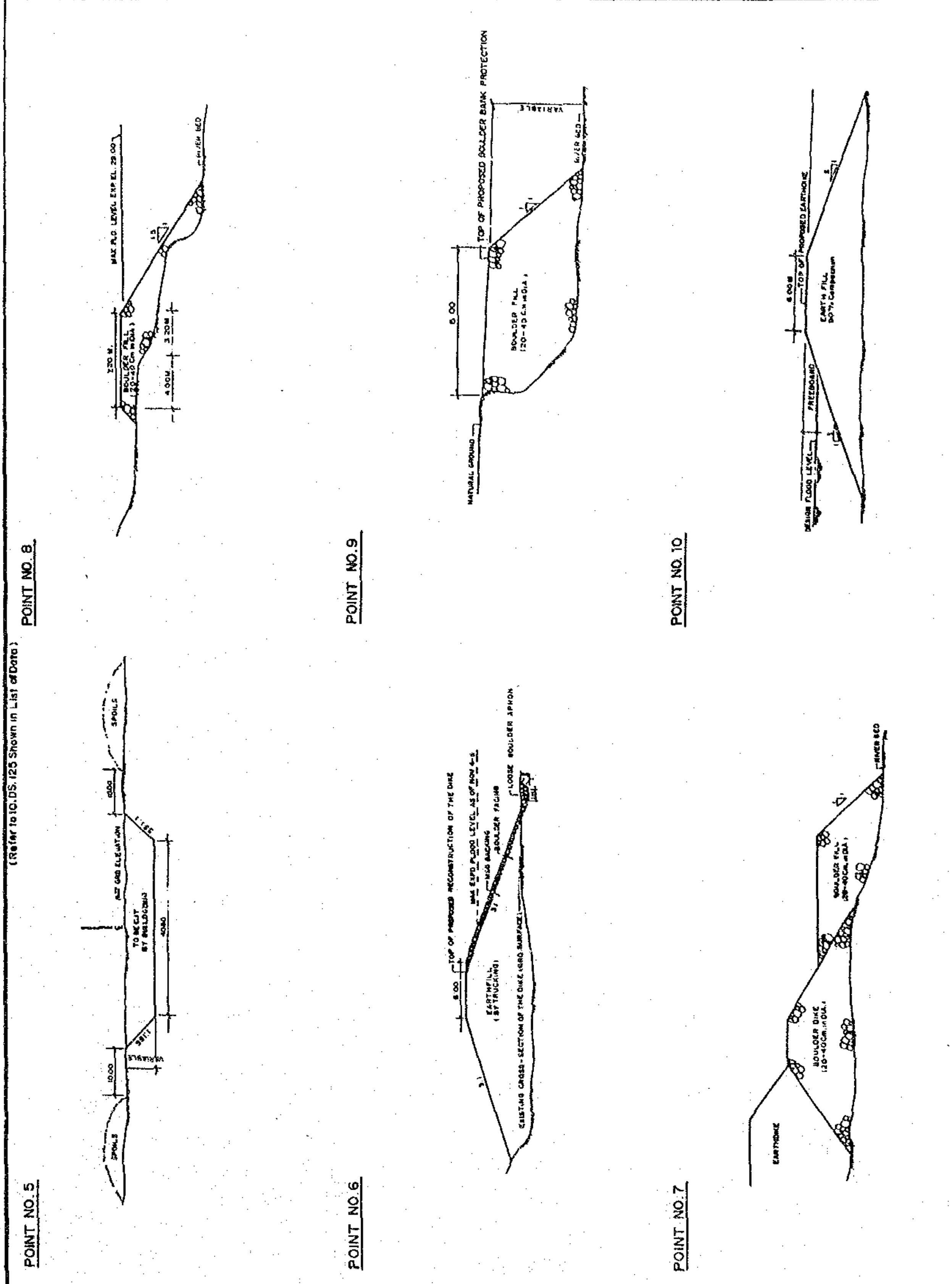


Fig. 5.5.3 TYPICAL CROSS SECTIONS OF EXISTING DIKE (2/4)

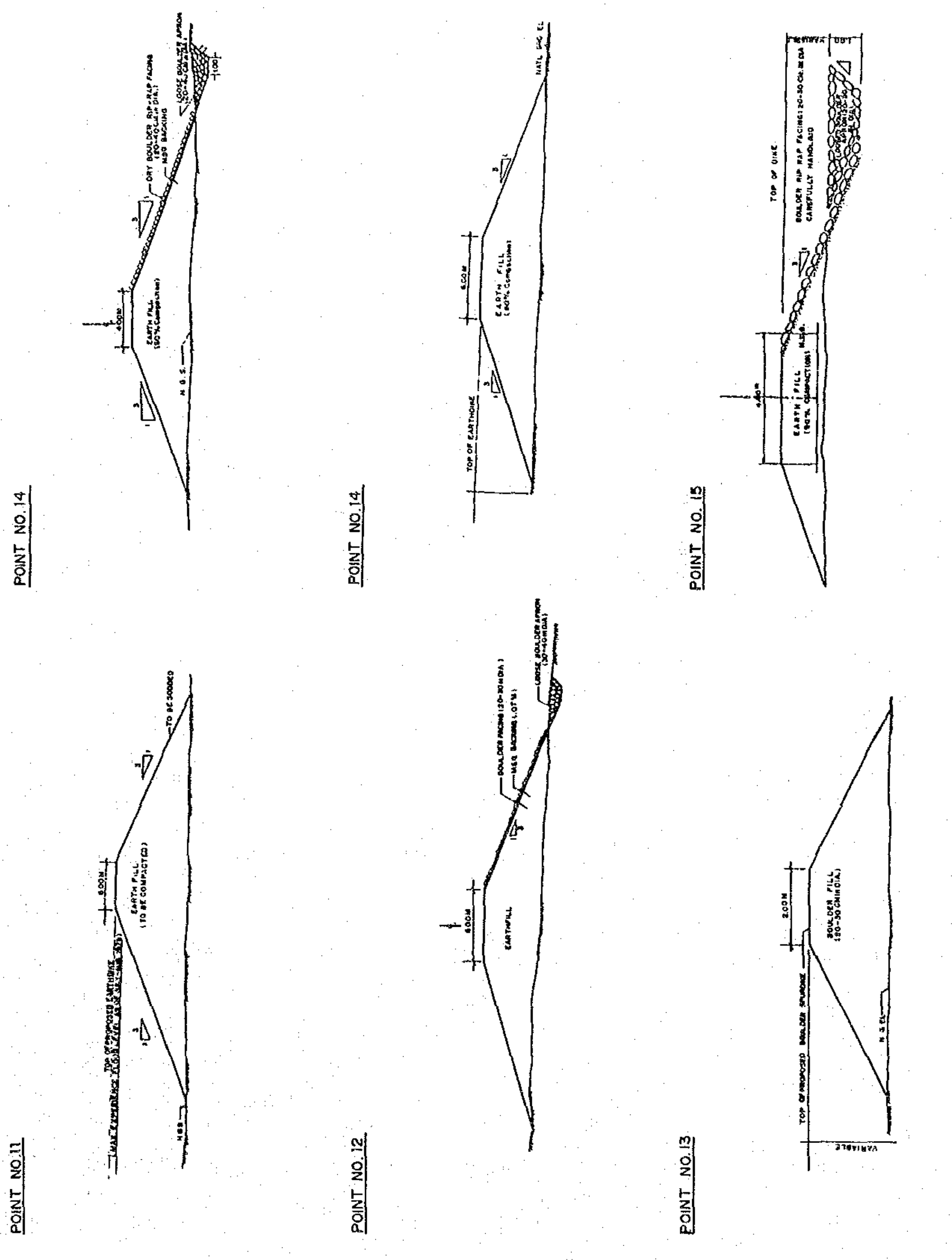


Fig. 5.5.3 TYPICAL CROSS SECTIONS OF EXISTING DIKE (3/4)

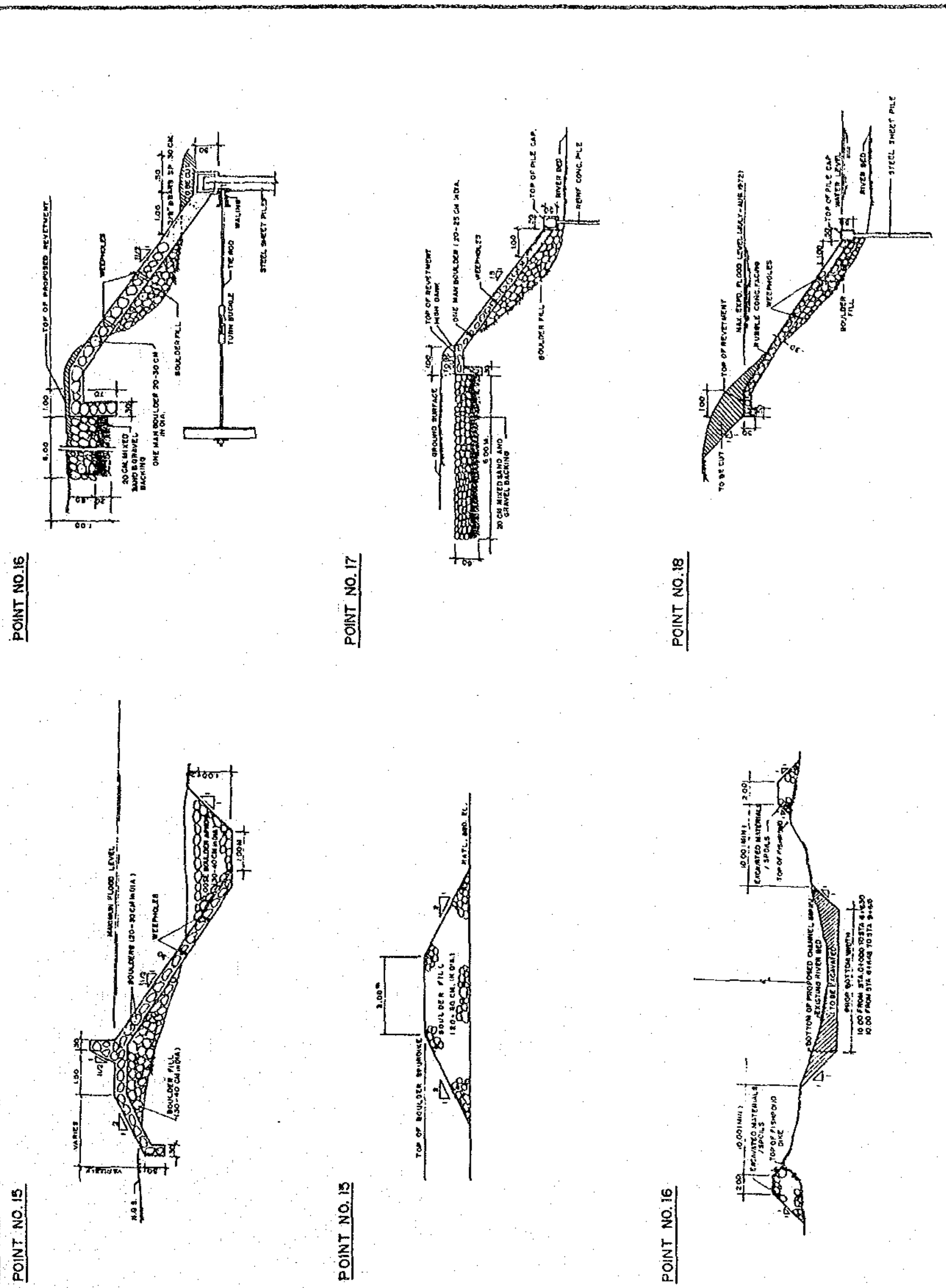


Fig. 5.5.3 TYPICAL CROSS SECTIONS OF EXISTING DIKE (4/4)

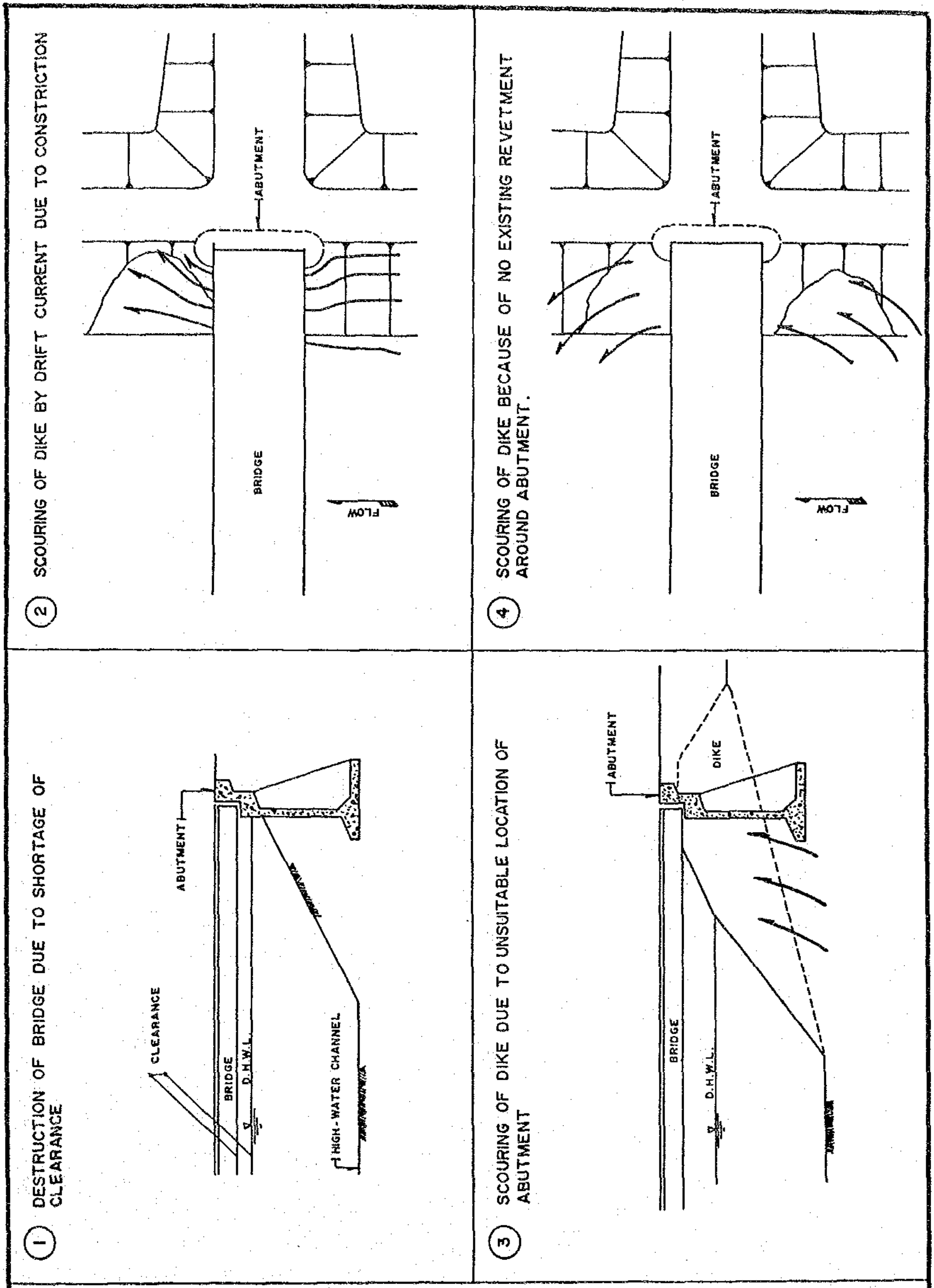


Fig. 5.5.4 CAUSES OF BRIDGE DESTRUCTION