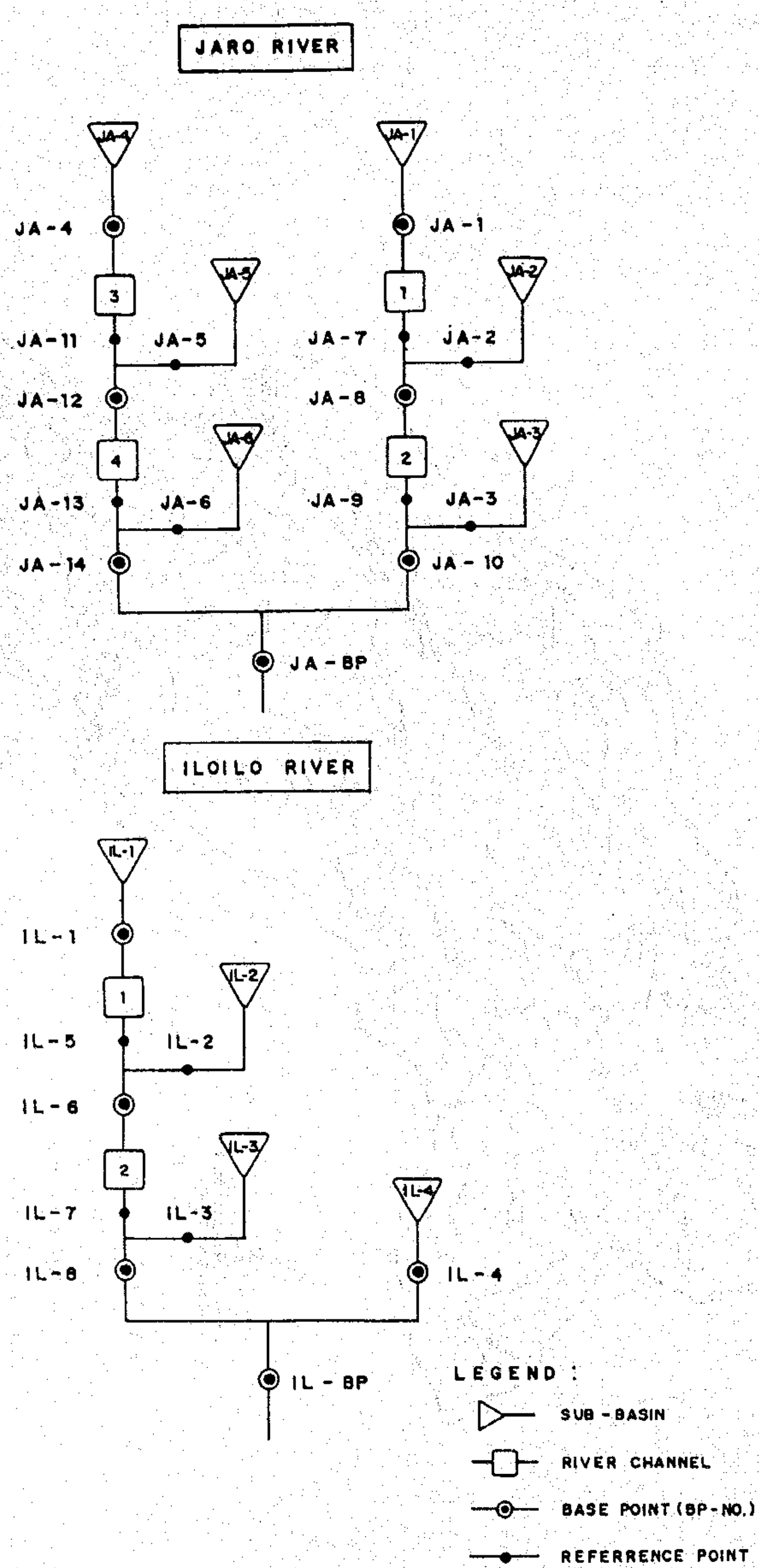
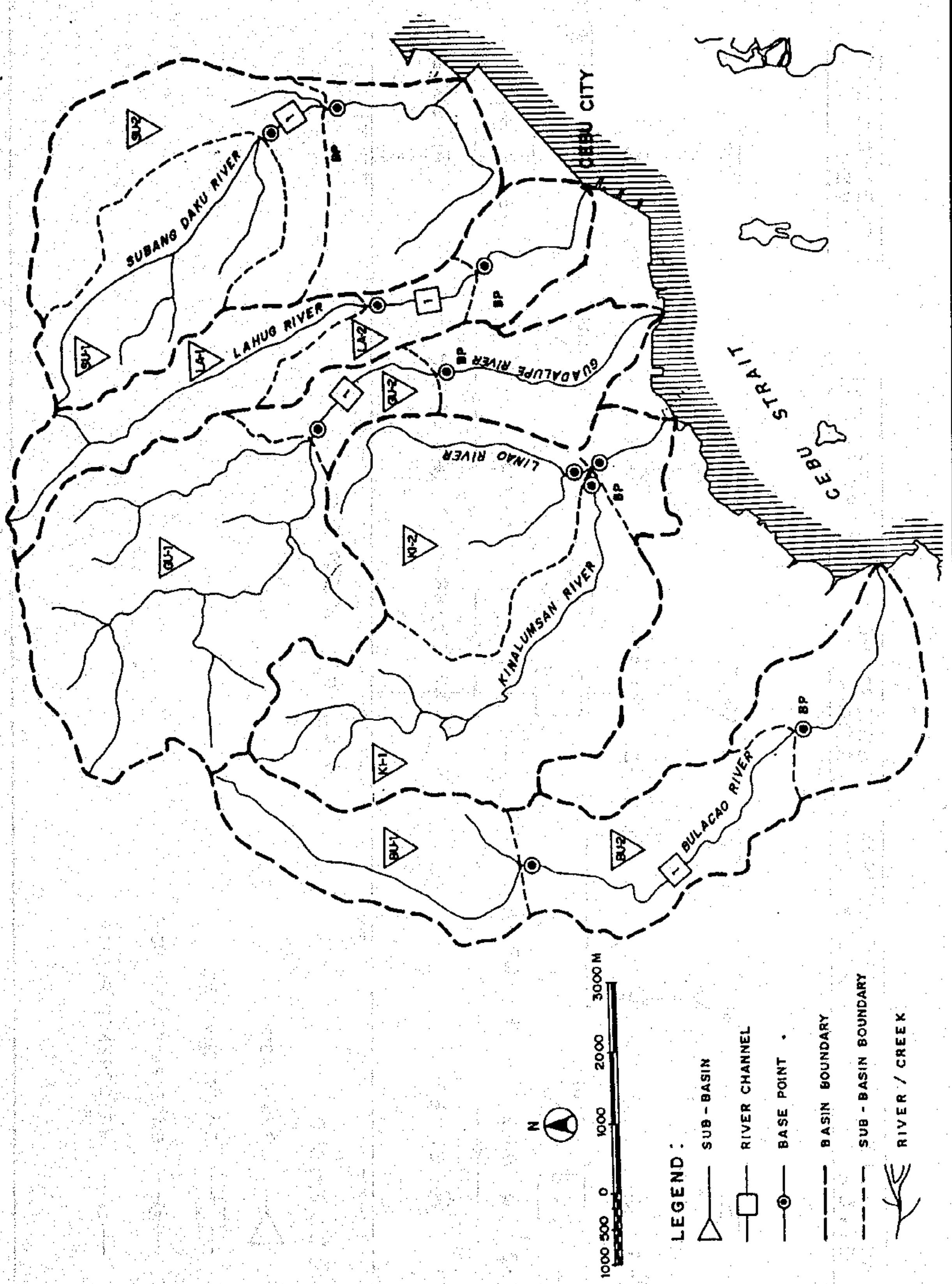
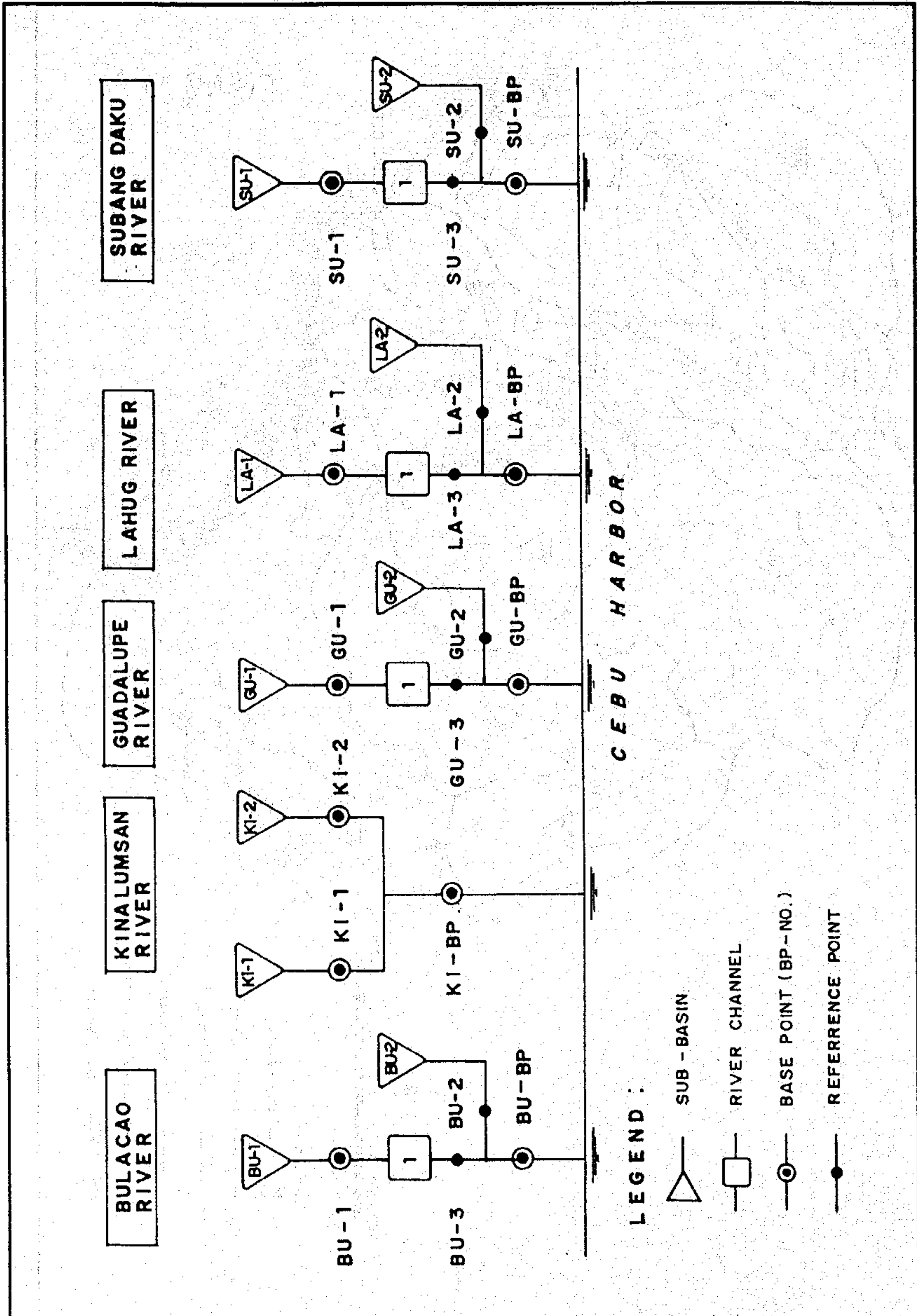


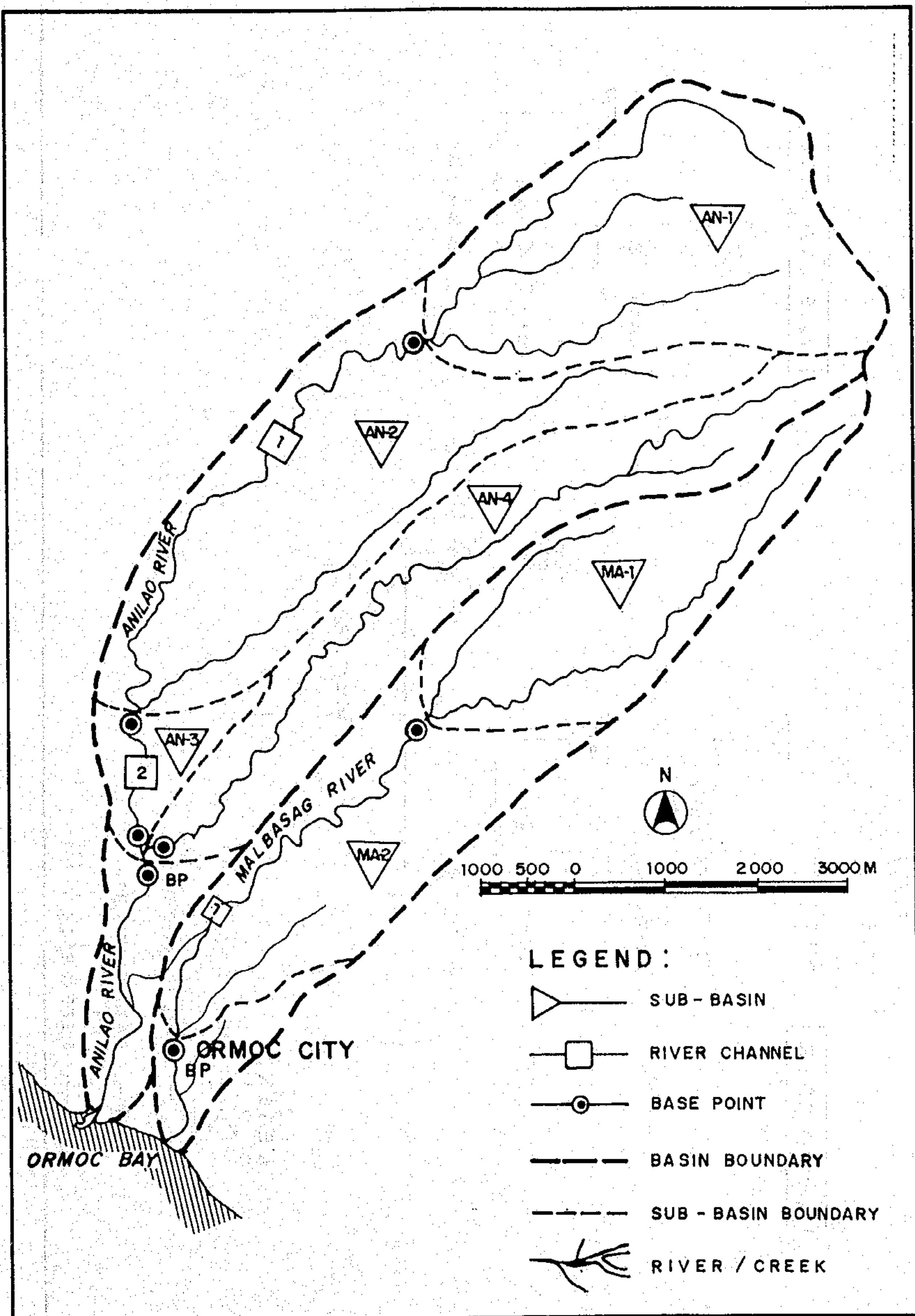
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.2
JAPAN INTERNATIONAL COOPERATION AGENCY	Jaro and Iloilo River Systems Model



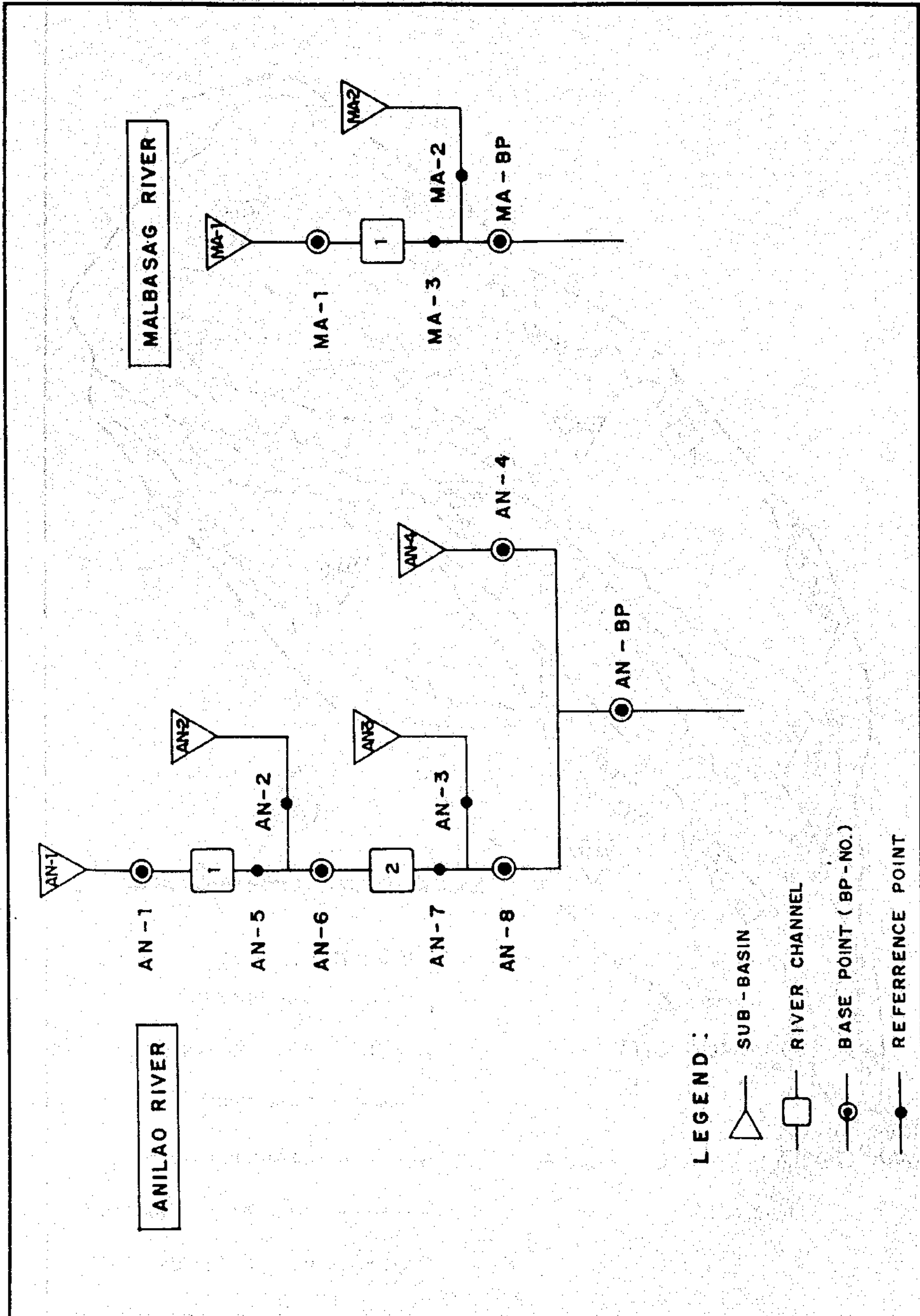
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.3
JAPAN INTERNATIONAL COOPERATION AGENCY	Basin Division, Cebu



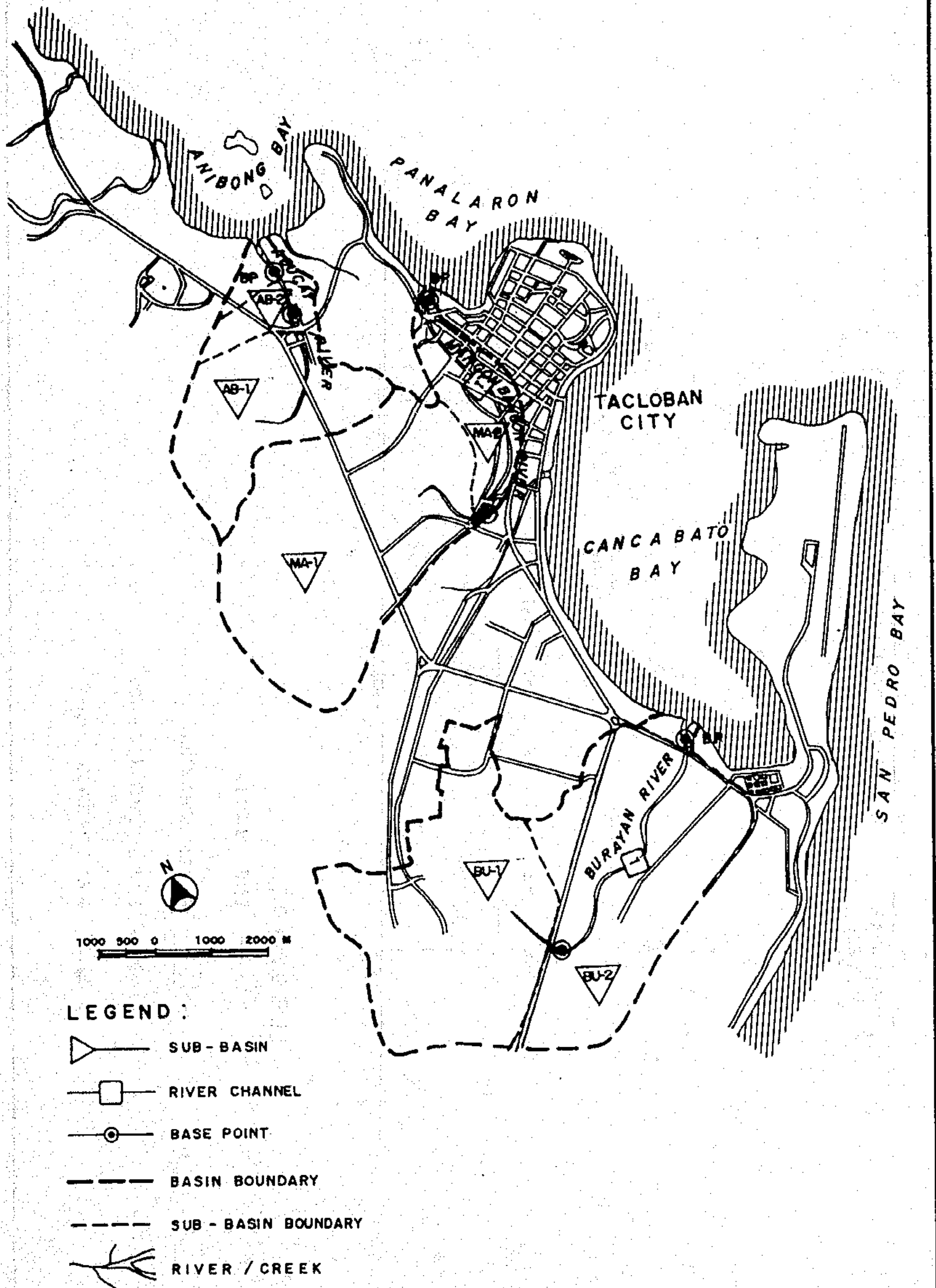
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.4 River System Model, Cebu
JAPAN INTERNATIONAL COOPERATION AGENCY	



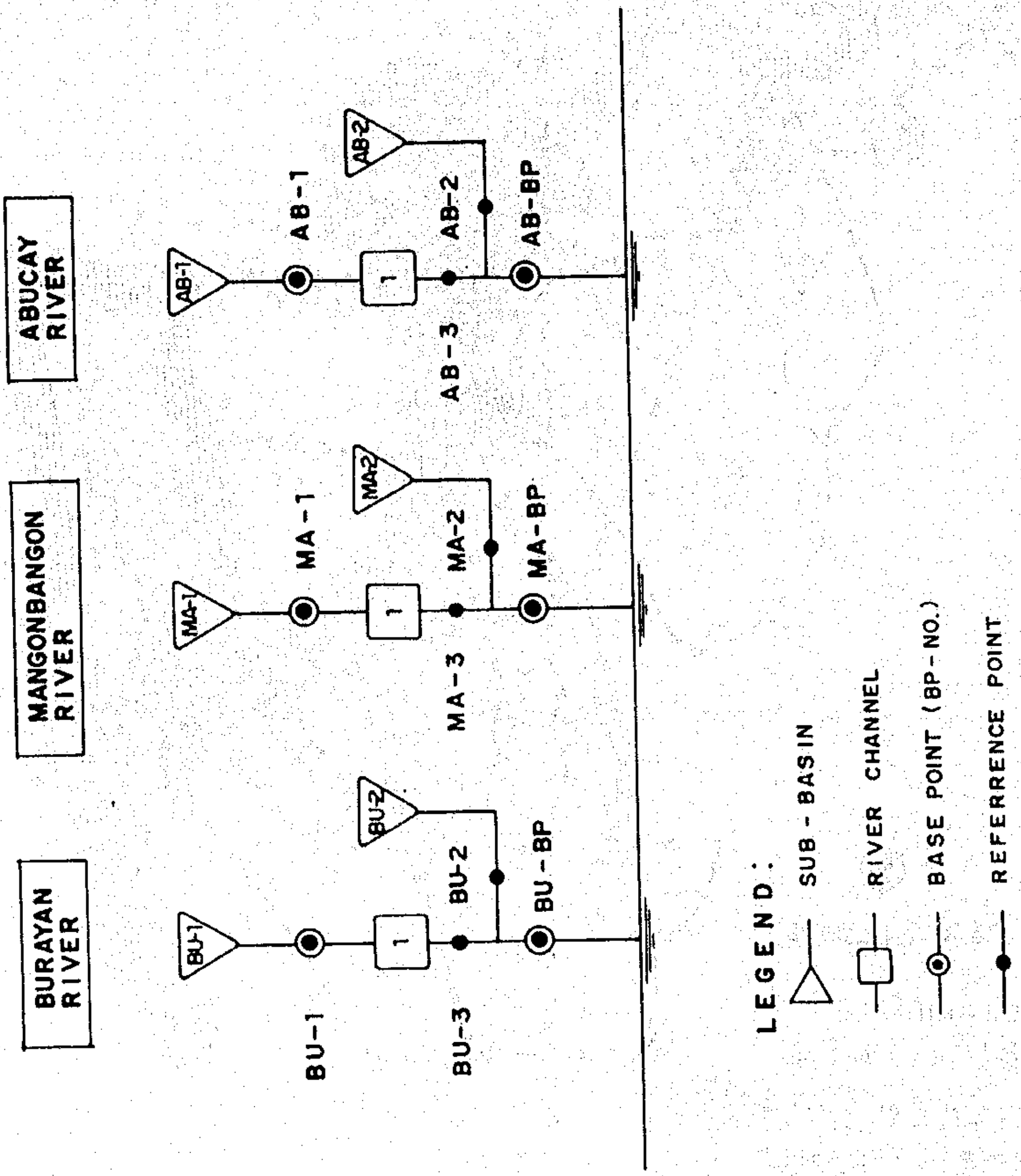
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.5 Basin Division, Ormoc
JAPAN INTERNATIONAL COOPERATION AGENCY	



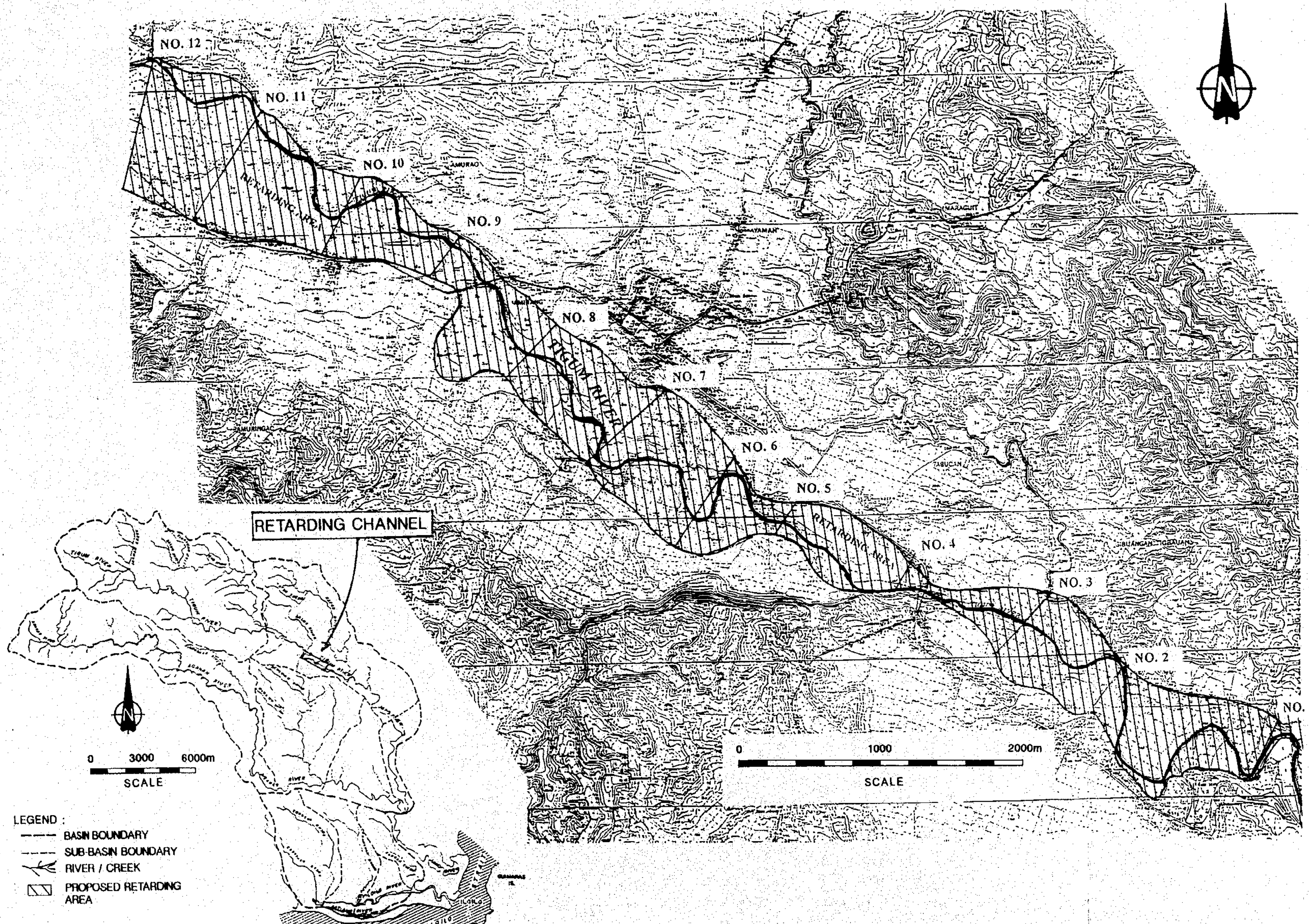
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.6 River System Model, Ormoc
JAPAN INTERNATIONAL COOPERATION AGENCY	



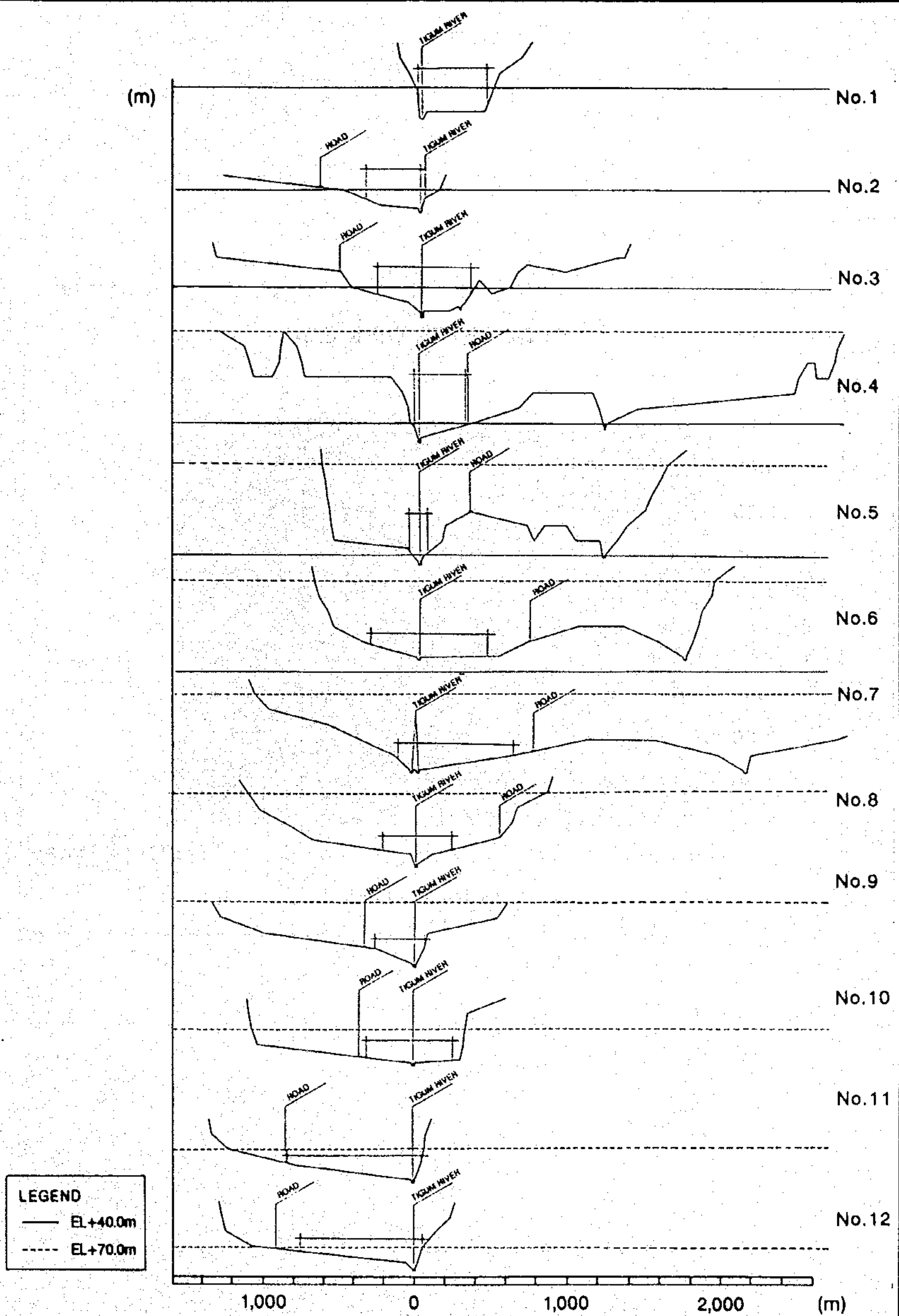
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.7 Basin Division, Tacloban
JAPAN INTERNATIONAL COOPERATION AGENCY	



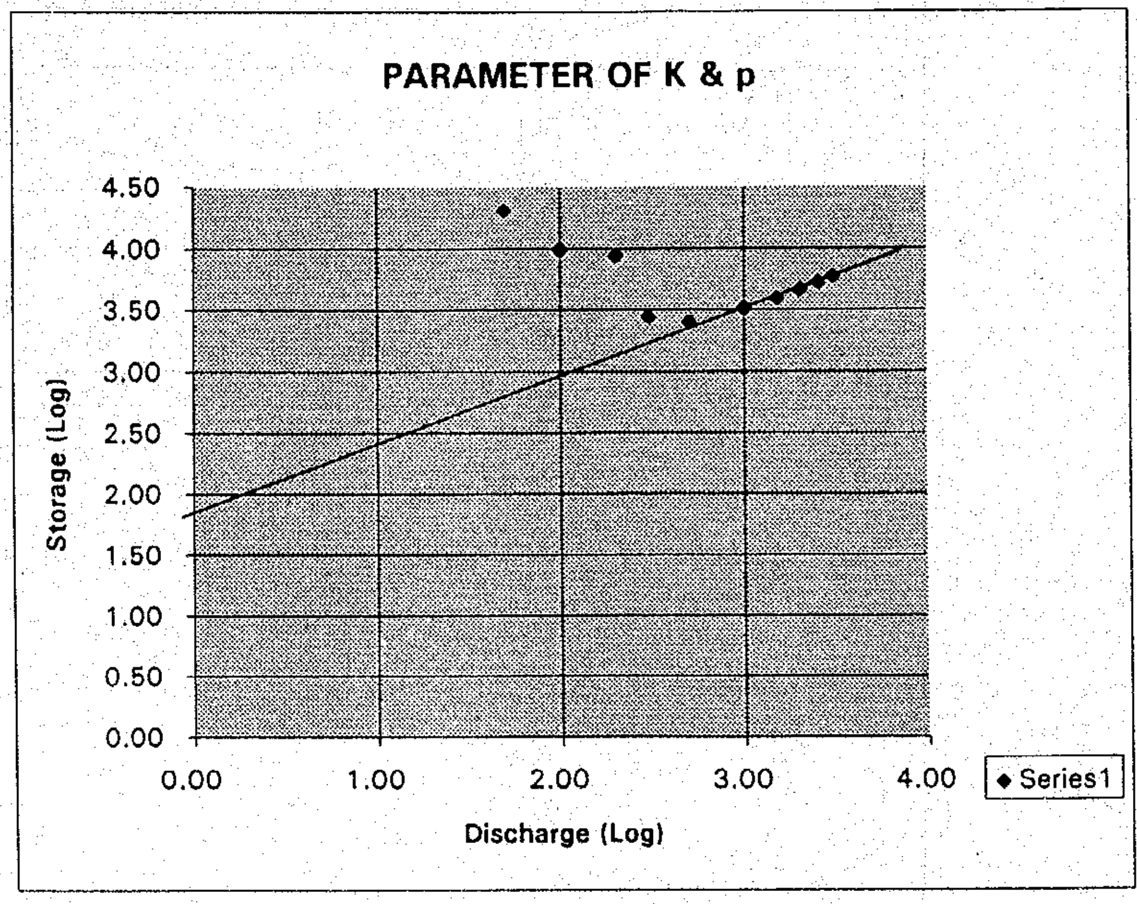
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.8
JAPAN INTERNATIONAL COOPERATION AGENCY	River System Model, Tacloban



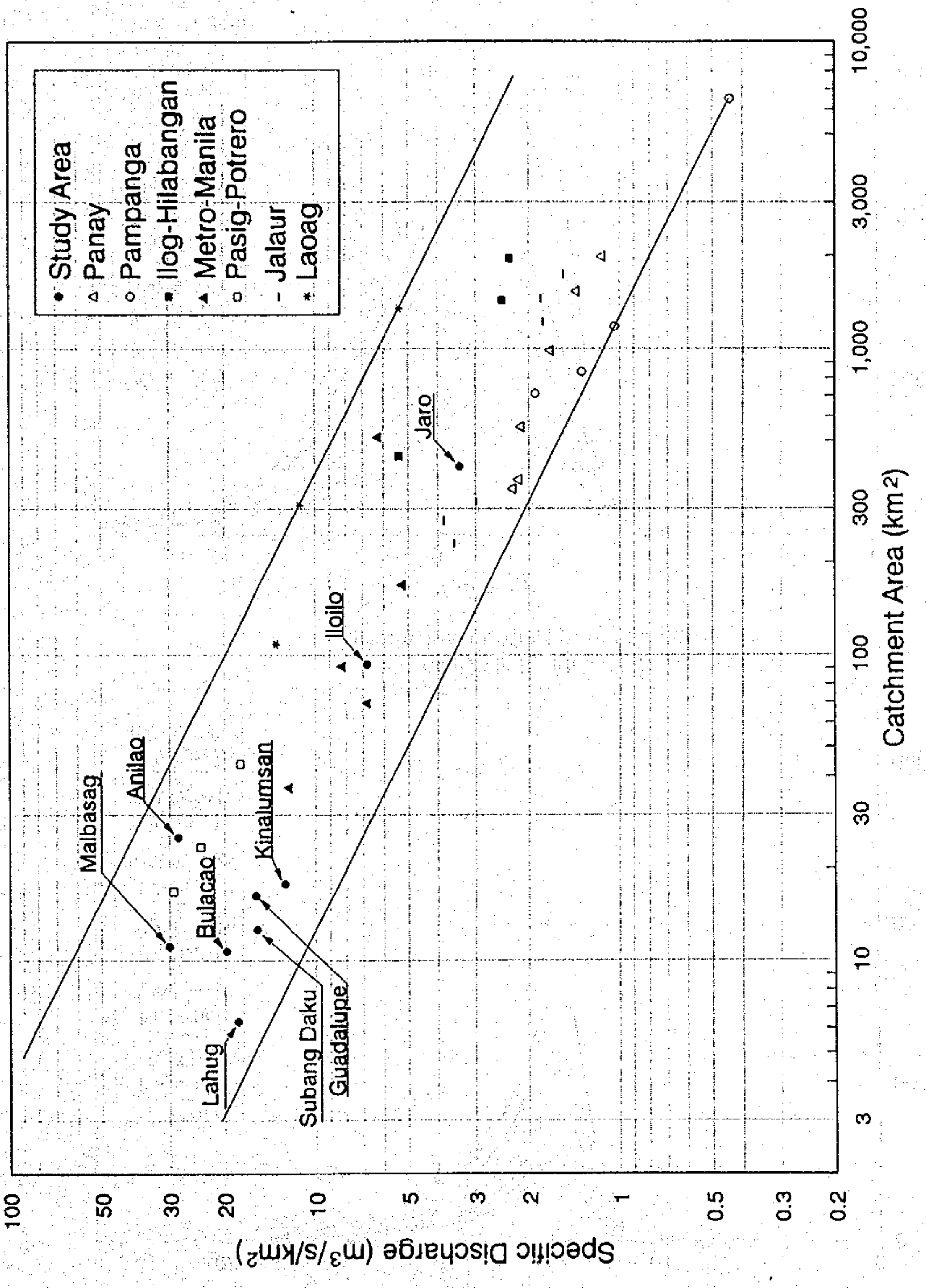
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.9
JAPAN INTERNATIONAL COOPERATION AGENCY	Location and Area of Retarding Channel



THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.10 Cross-section of Retarding Channel
JAPAN INTERNATIONAL COOPERATION AGENCY	

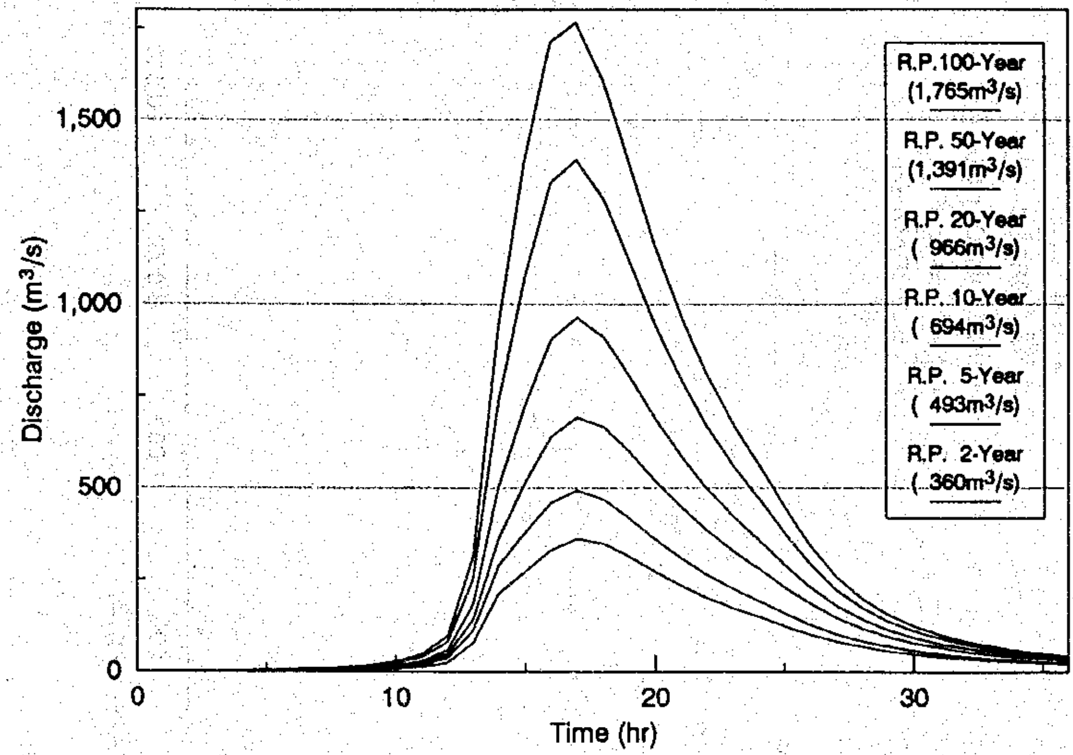


THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.11 Parameters K and p
JAPAN INTERNATIONAL COOPERATION AGENCY	

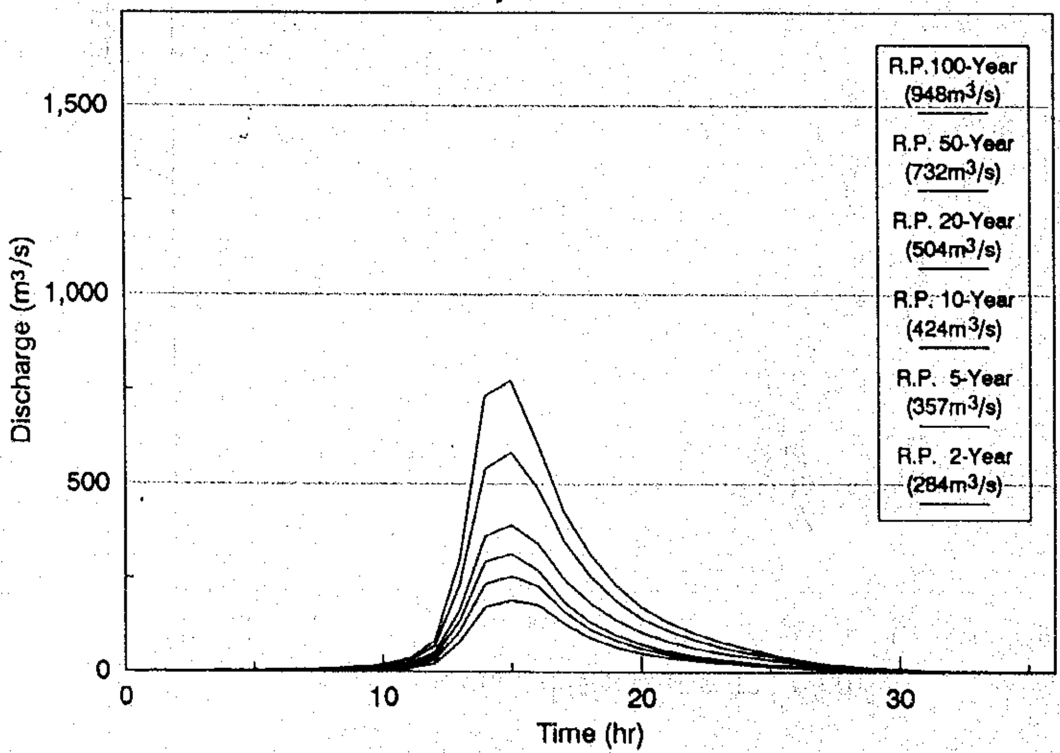


THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.12
JAPAN INTERNATIONAL COOPERATION AGENCY	Specific Discharges of 50-Year Return Period

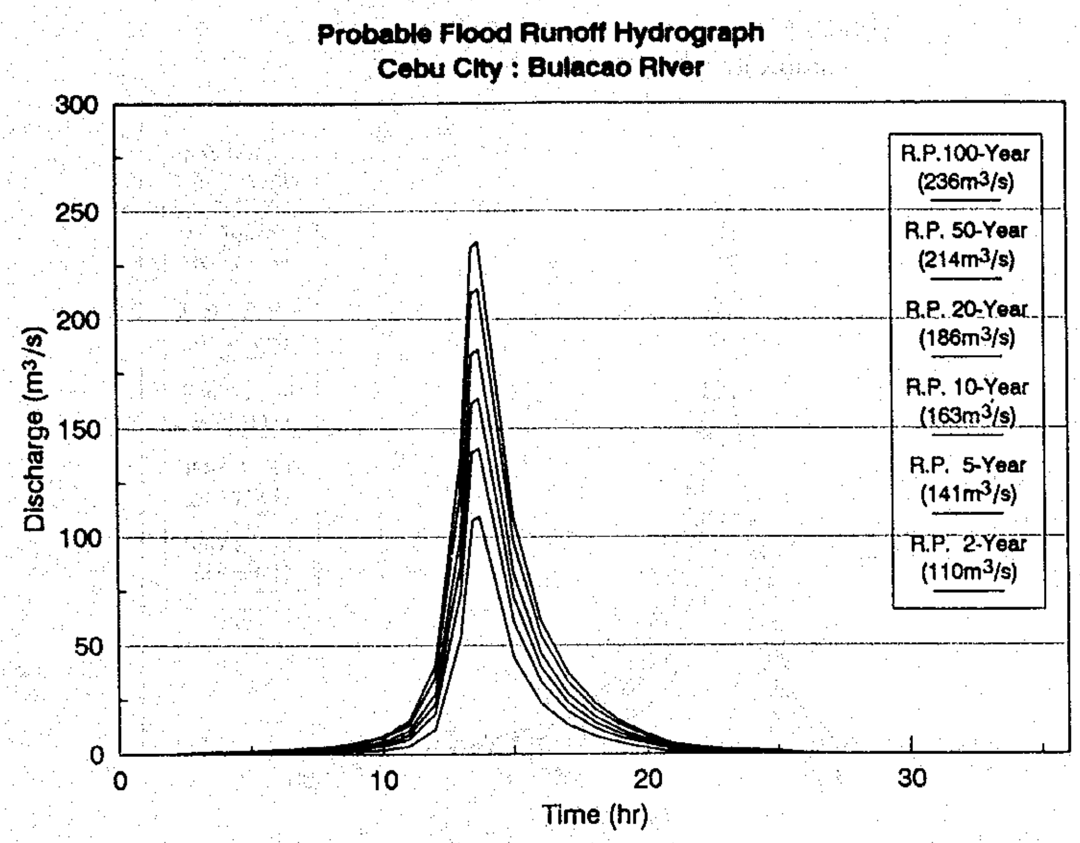
Probable Flood Runoff Hydrograph
Iloilo City : Jaro River

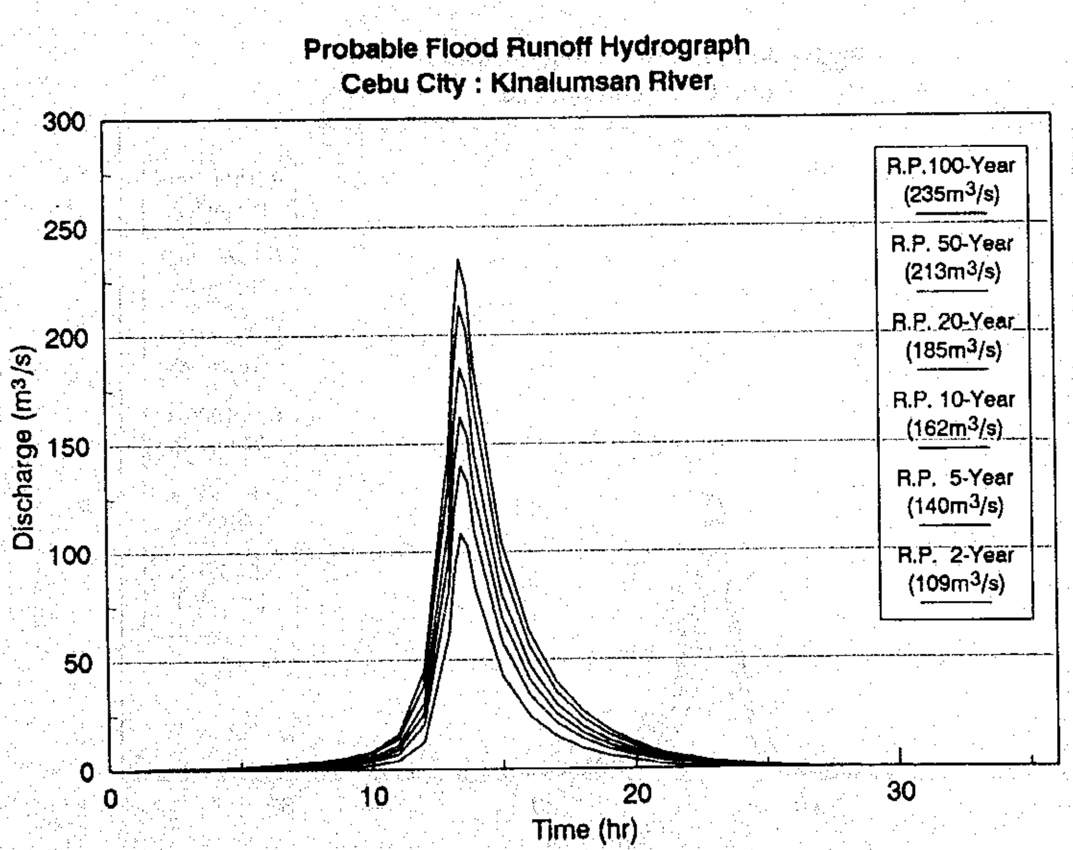


Probable Flood Runoff Hydrograph
Iloilo City : Iloilo River

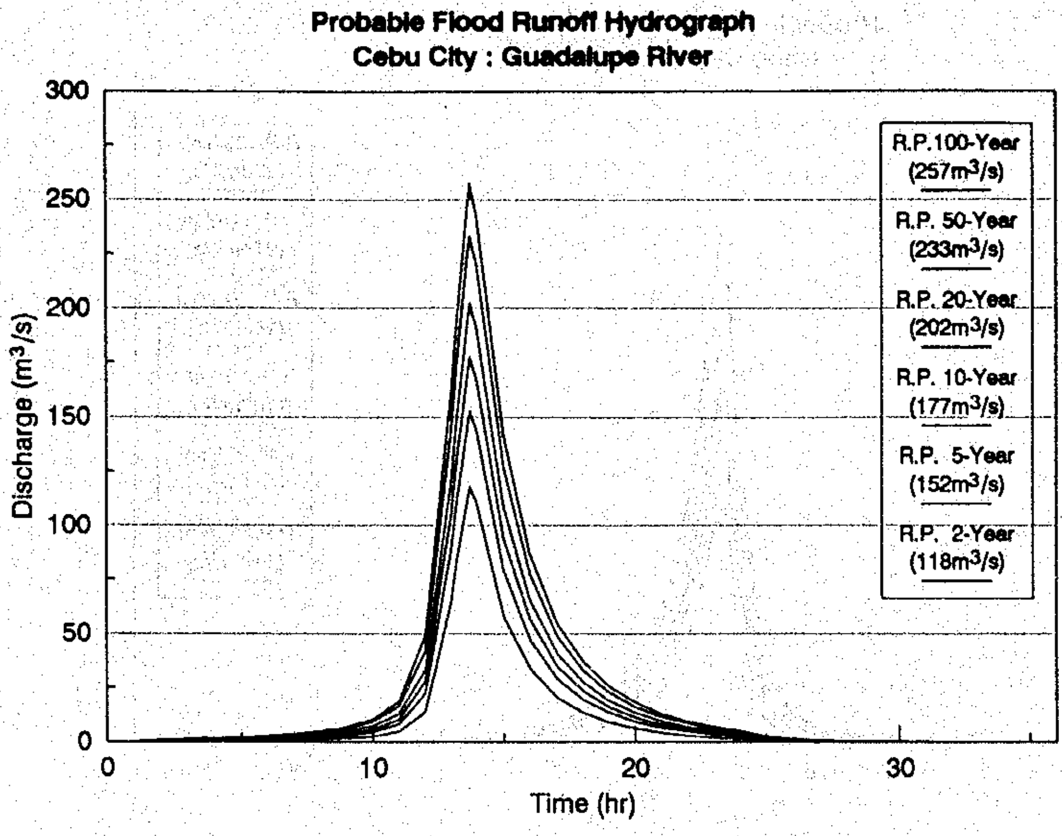


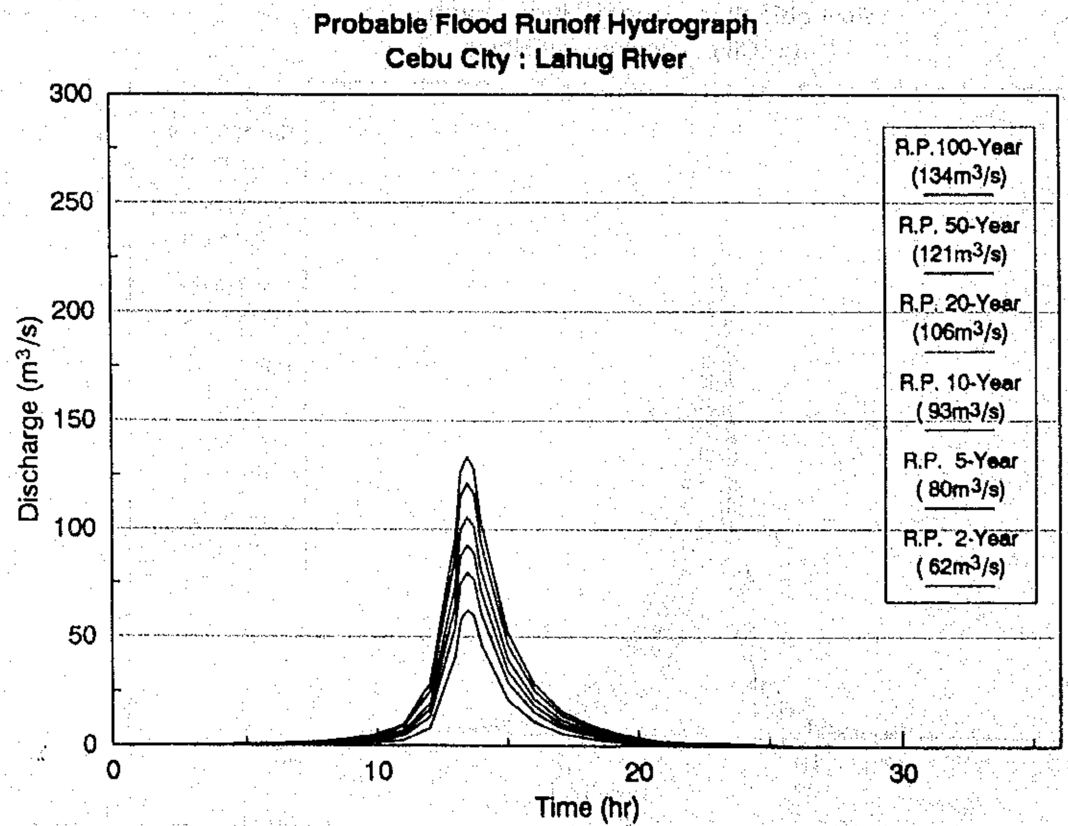
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.13
JAPAN INTERNATIONAL COOPERATION AGENCY	Design Hydrograph at Base Points, Iloilo



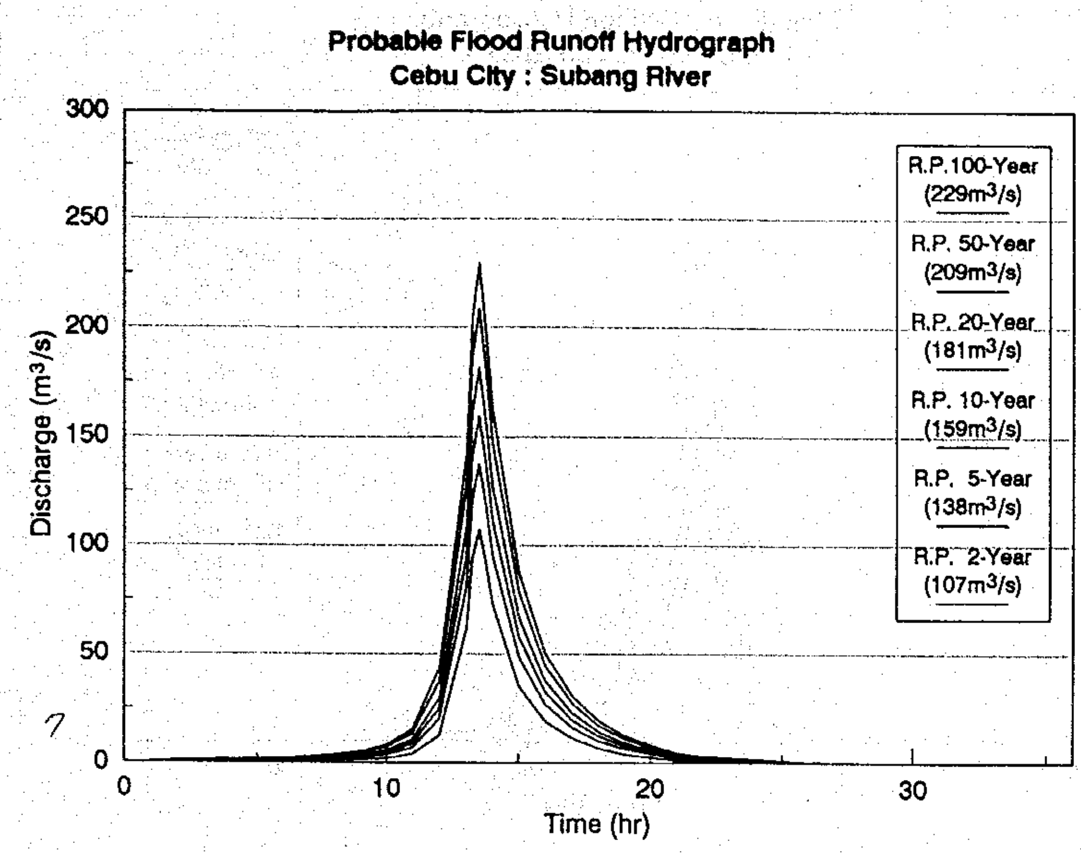


THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.14 Design Hydrogragh at Base Points, Cebu(1/3)
JAPAN INTERNATIONAL COOPERATION AGENCY	

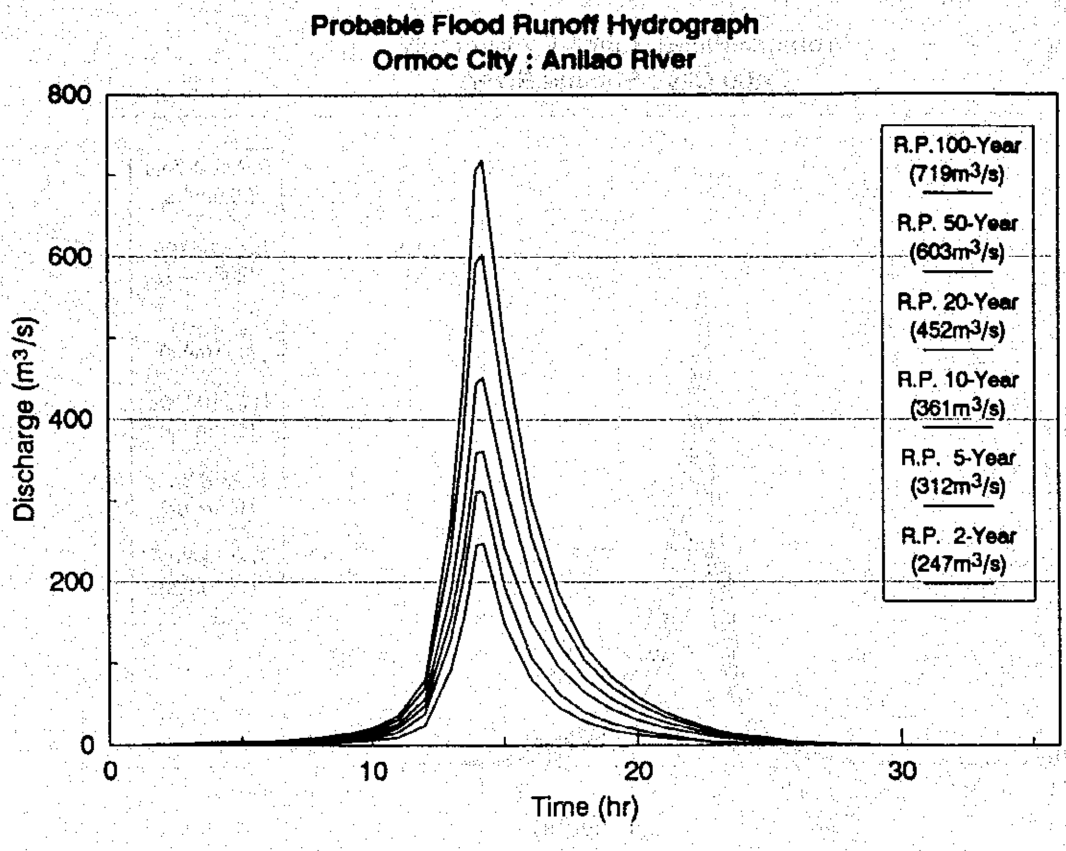


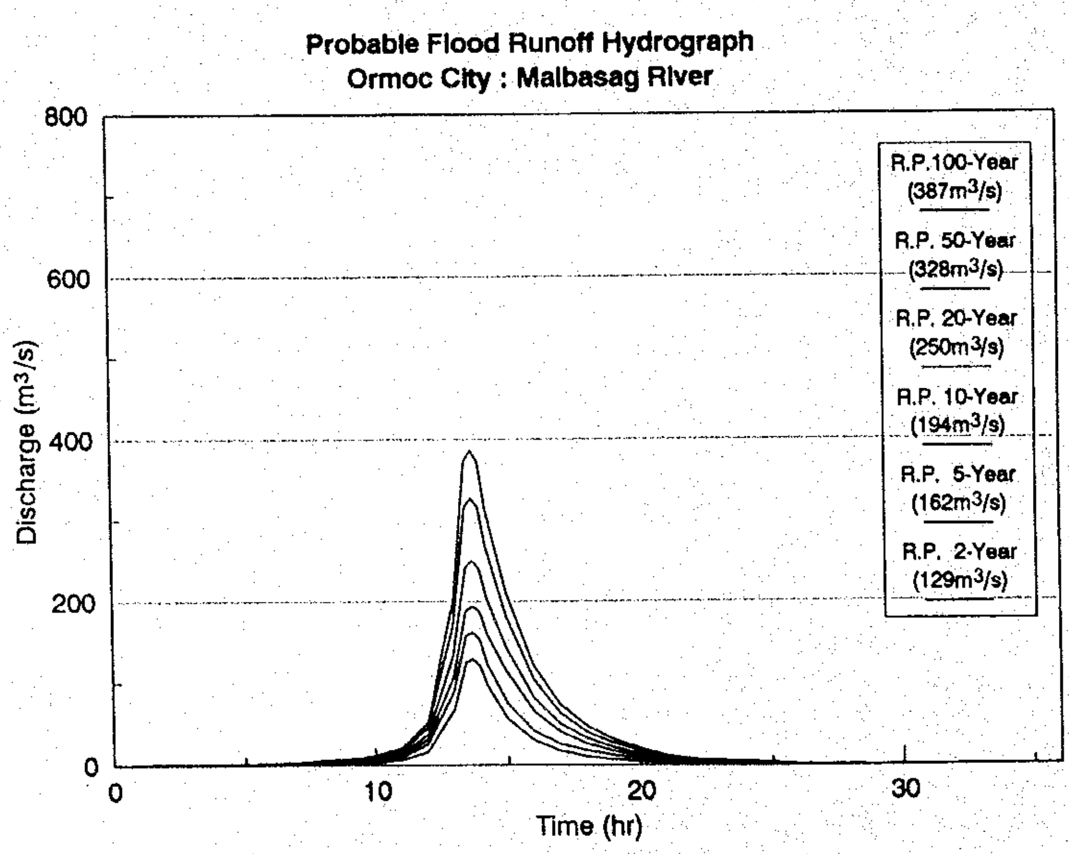


THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.14 Design Hydrogragh at Base Points, Cebu(2/3)
JAPAN INTERNATIONAL COOPERATION AGENCY	

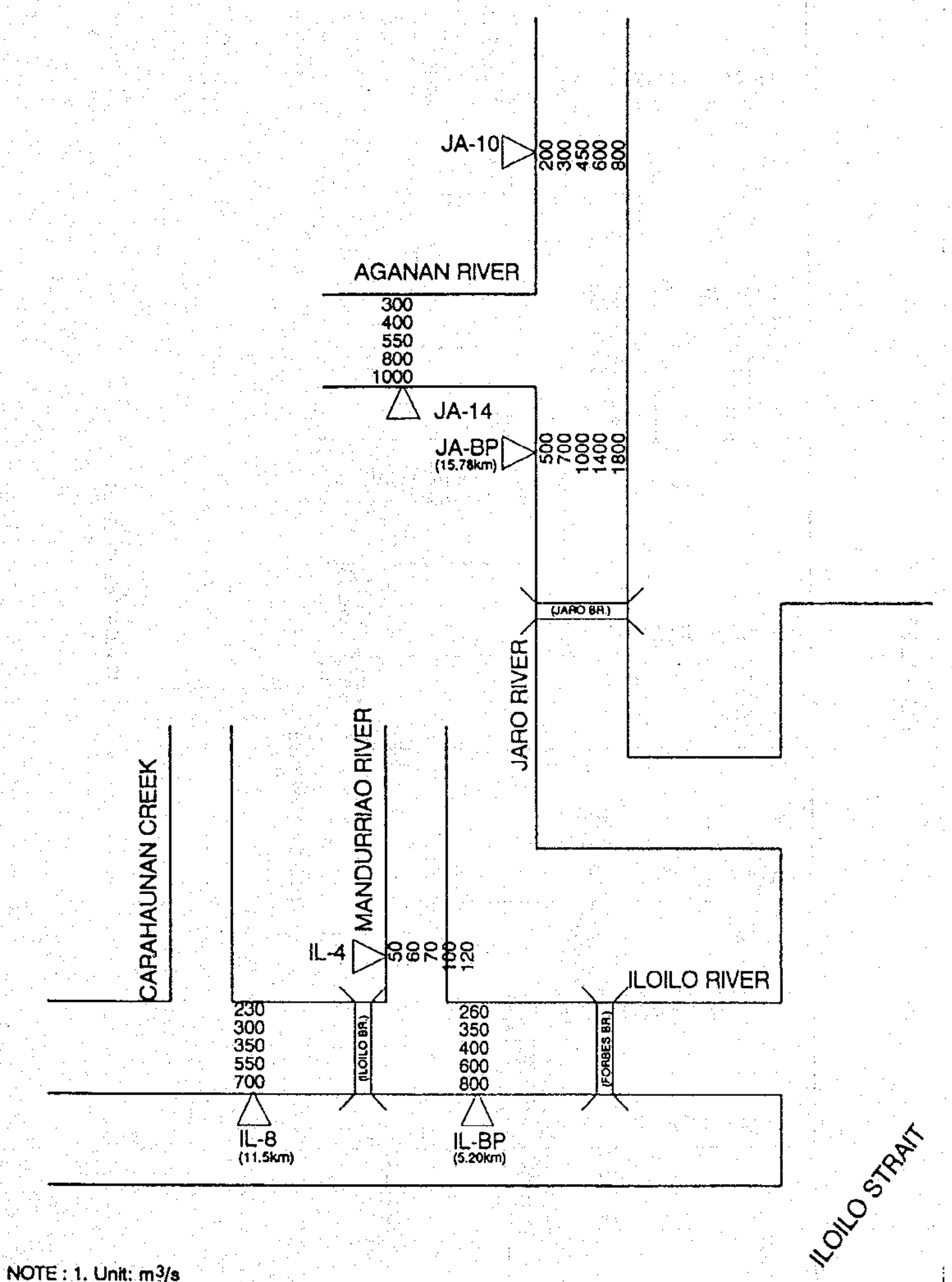


THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.14 Design Hydrogragh at Base Points, Cebu(3/3)
JAPAN INTERNATIONAL COOPERATION AGENCY	





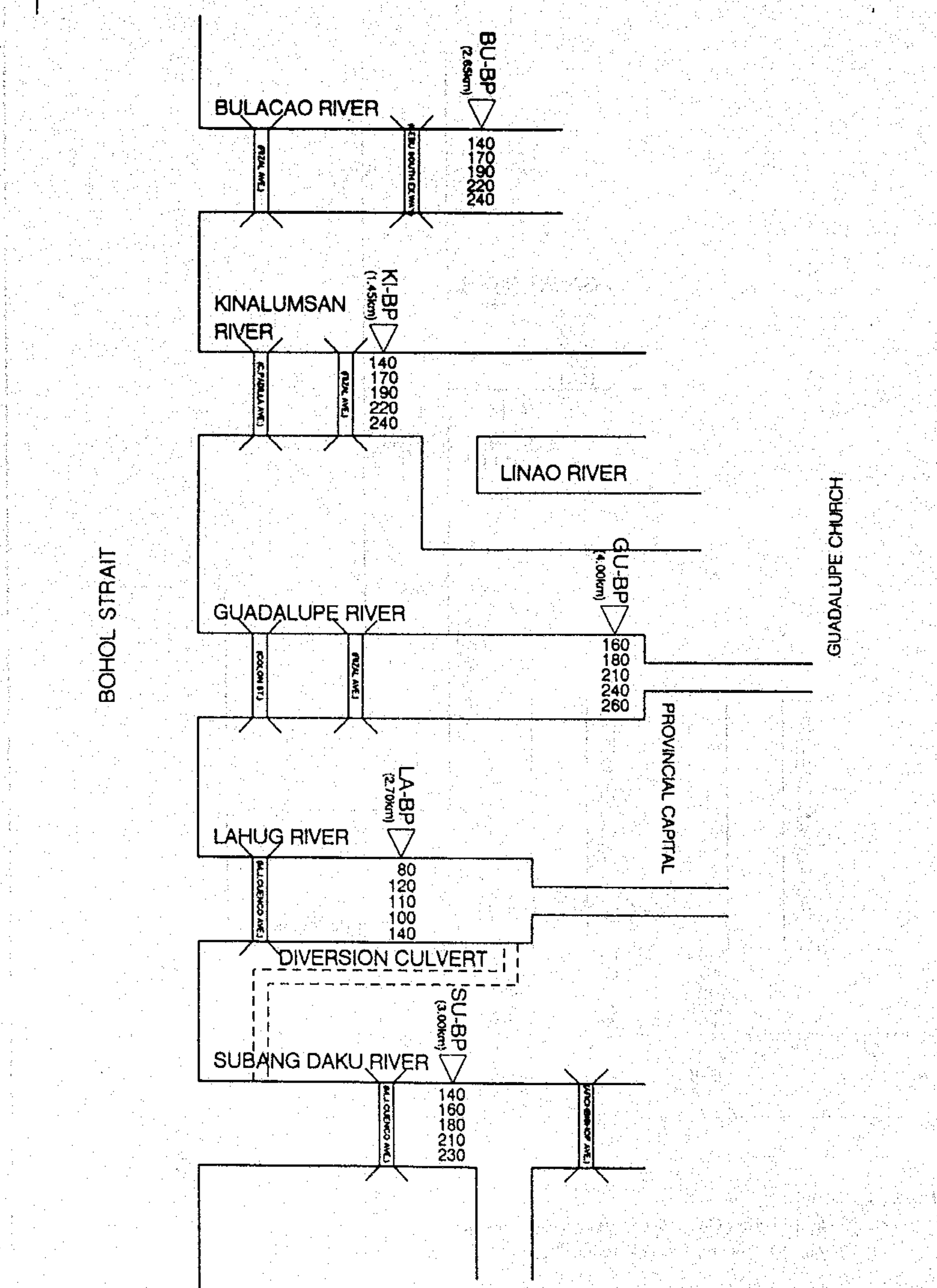
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.15 Design Hydrograph At Base Points, Ormoc
JAPAN INTERNATIONAL COOPERATION AGENCY	



NOTE : 1. Unit: m^3/s

2. The figures show Flood Discharge of 5-Year, 10-Year 20-Year, 50-Year and 100-Year Return Period.

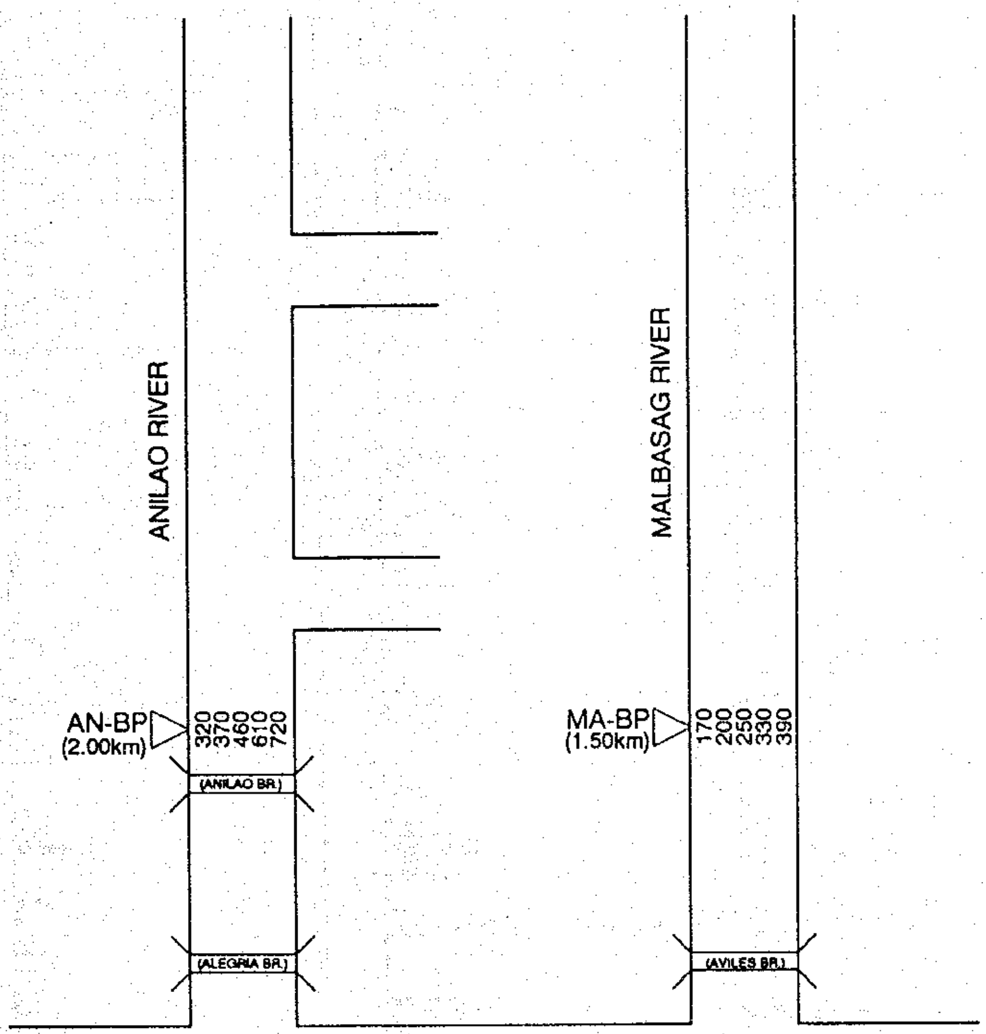
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.16
JAPAN INTERNATIONAL COOPERATION AGENCY	Distribution of Probable Flood Discharge, Iloilo



NOTE : 1. Unit: m^3/s

2. The figures show Flood Discharge of 5-Year, 10-Year 20-Year, 50-Year and 100-Year Return Period.

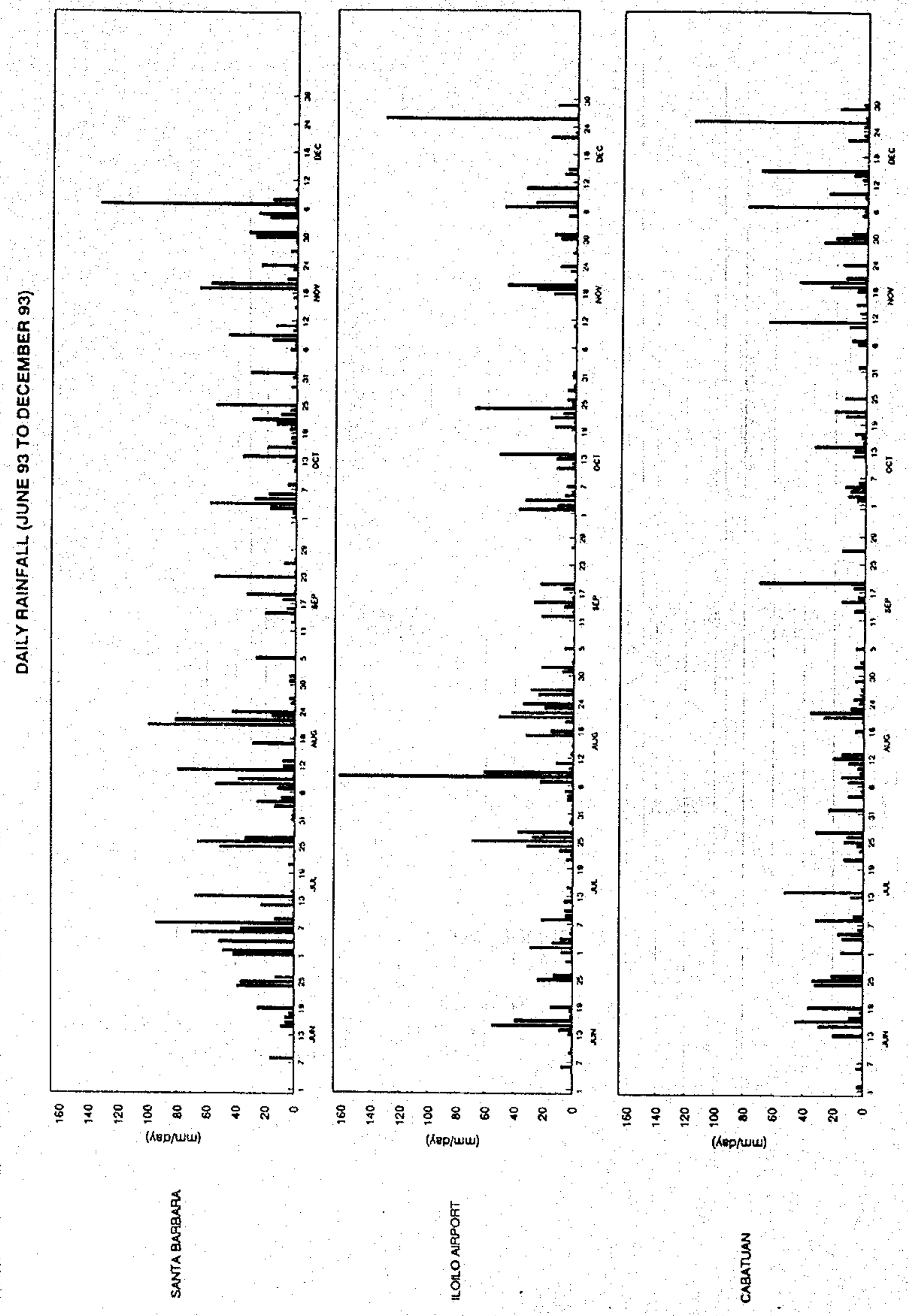
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.17
JAPAN INTERNATIONAL COOPERATION AGENCY	Distribution of Probable Flood Discharge, Cebu



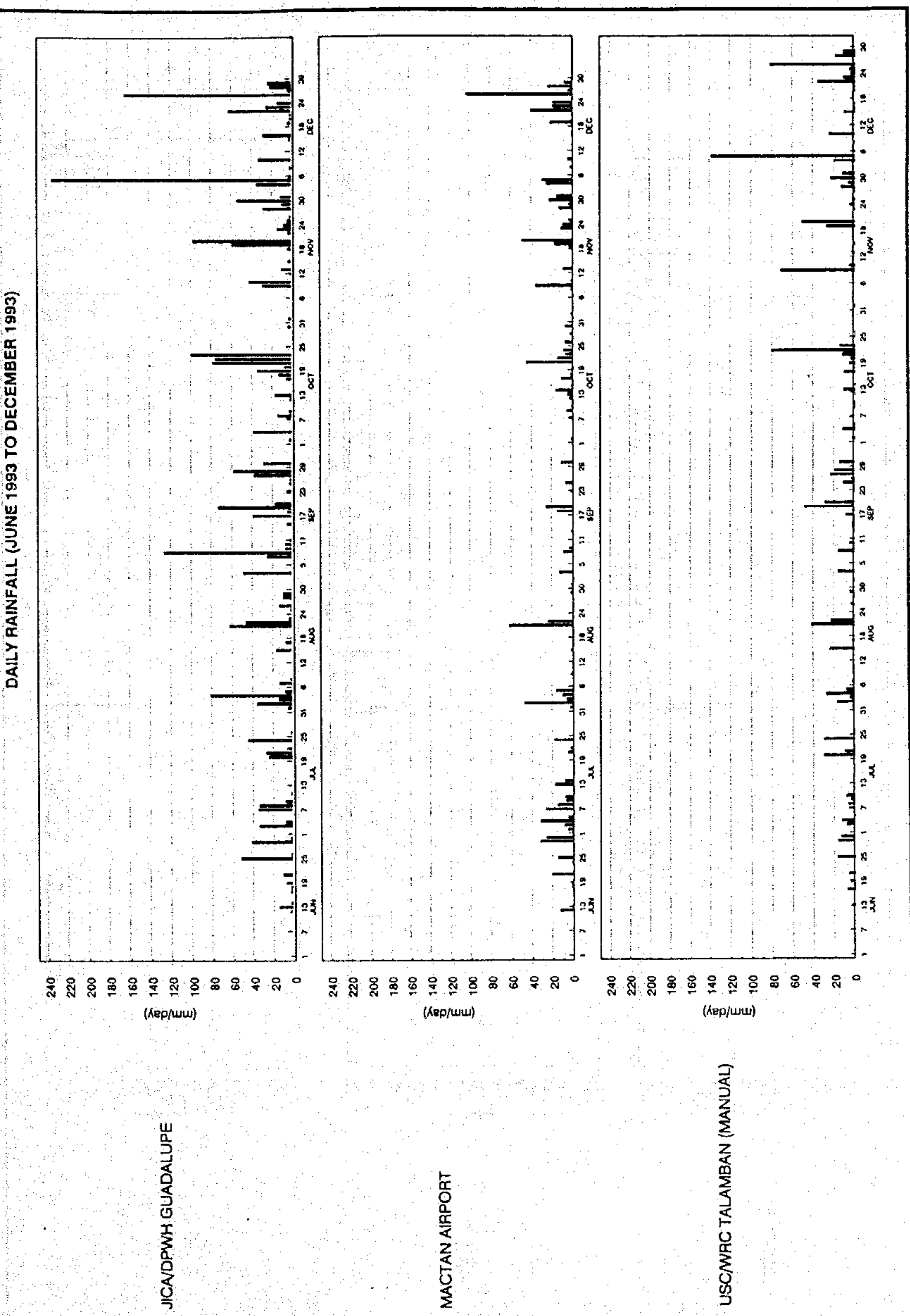
NOTE : 1. Unit: m^3/s

2. The figures show Flood Discharge of 5-Year, 10-Year 20-Year, 50-Year and 100-Year Return Period.

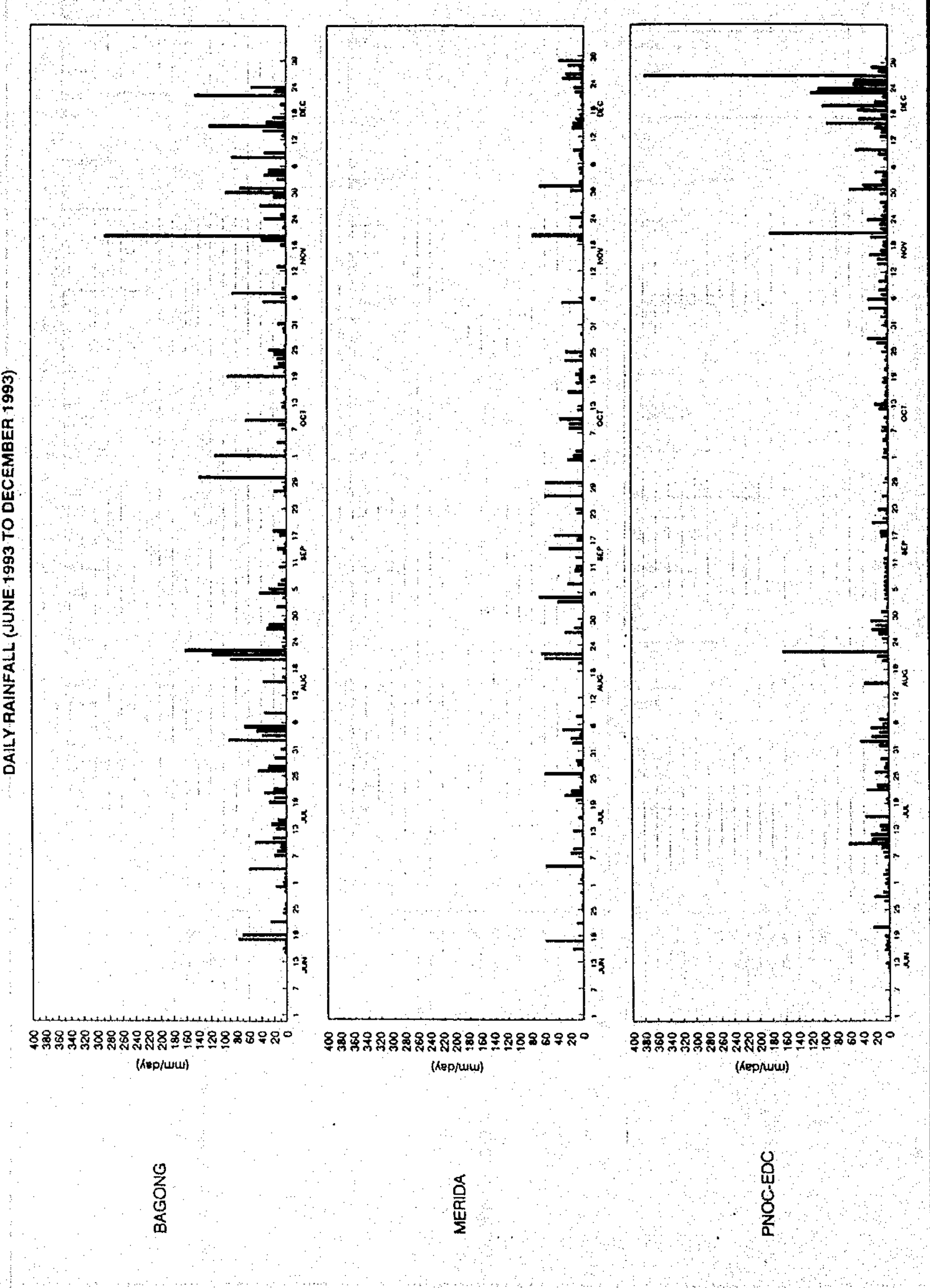
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 5.18 Distribution of Probable Flood Discharge, Ormoc
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 6.1
JAPAN INTERNATIONAL COOPERATION AGENCY	Daily Rainfall of Three Stations in Iloilo City



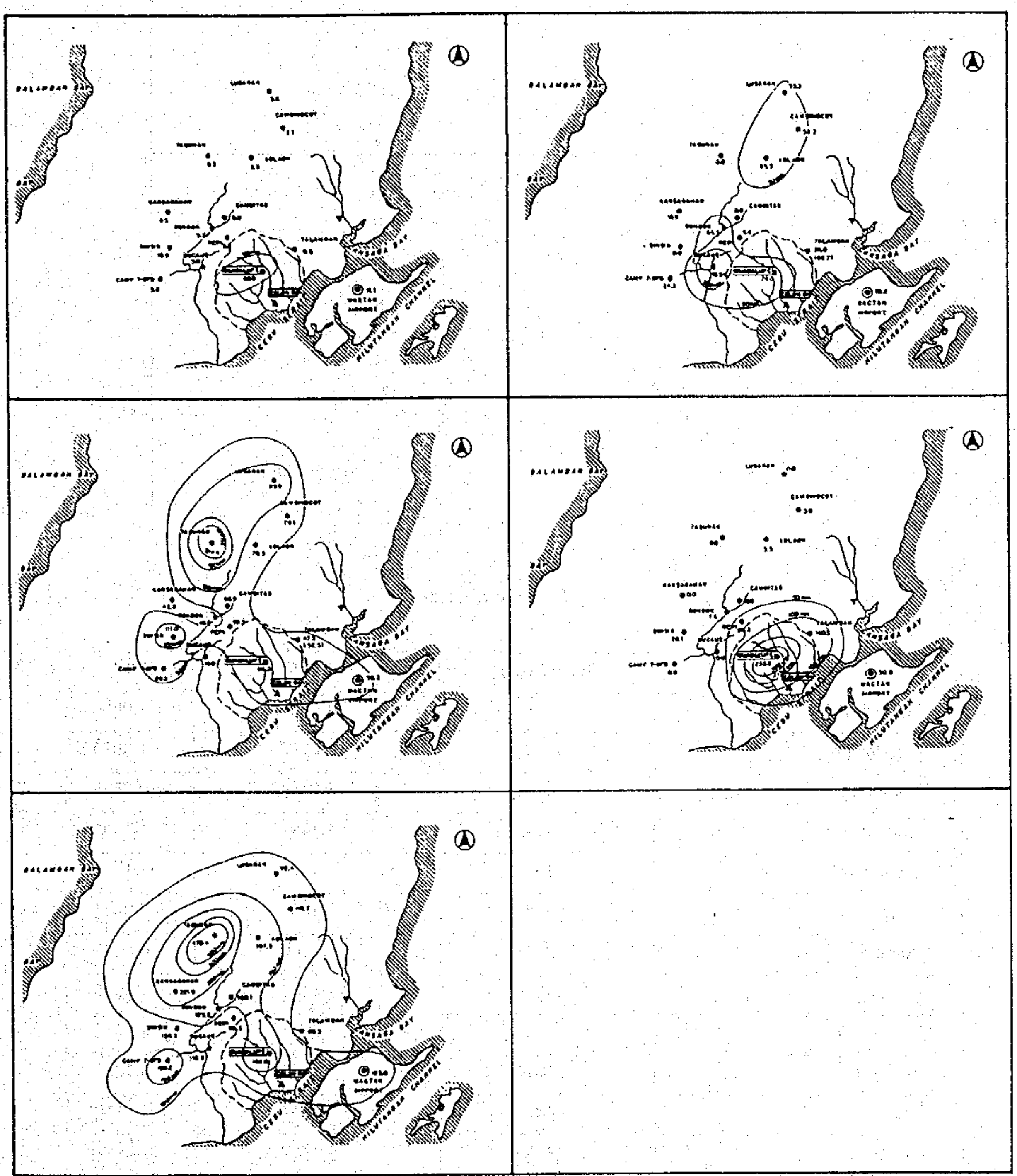
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 6.2 Daily Rainfall of Three Stations in Cebu City
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS

JAPAN INTERNATIONAL COOPERATION AGENCY

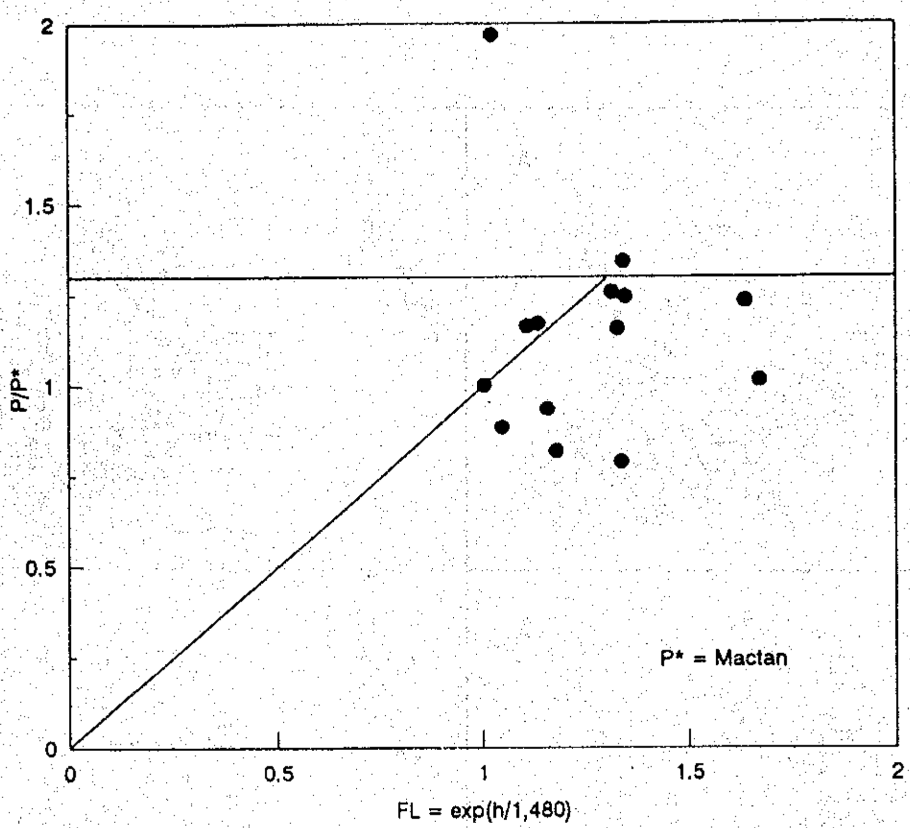
Fig. 6.3
Daily Rainfall of Three Stations in Ormoc City



THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.4
Isohyetal Map of Daily Rainfall in Cebu City



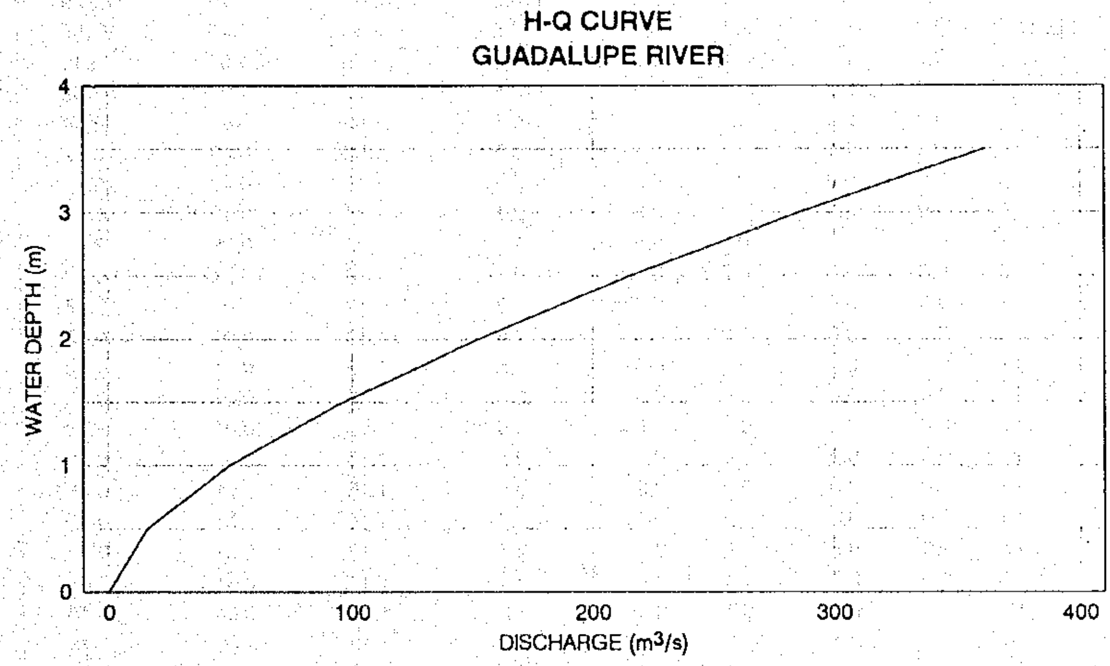
Station	Altitude (m)	(Exp(h/1480))	P/P*
Mactan Airport	8	1.0054	1.0000
Guadalupe (JICA)	38	1.0260	1.9679
Talamban	70	1.0484	0.8836
Lusaran	154	1.1097	1.1641
Cambinocot	190	1.1370	1.1717
Bonbon	218	1.1587	0.9341
Bucaue	245	1.1800	0.8179
Adlaon	404	1.3139	1.2576
Camp 7-BFD	420	1.3281	1.1562
Cambitas	430	1.3372	0.7887
Tabunan	435	1.3417	1.3419
Sinsin	440	1.3462	1.2444
RCPI	730	1.6376	1.2327
Kansagahan	760	1.6712	1.0128

THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS

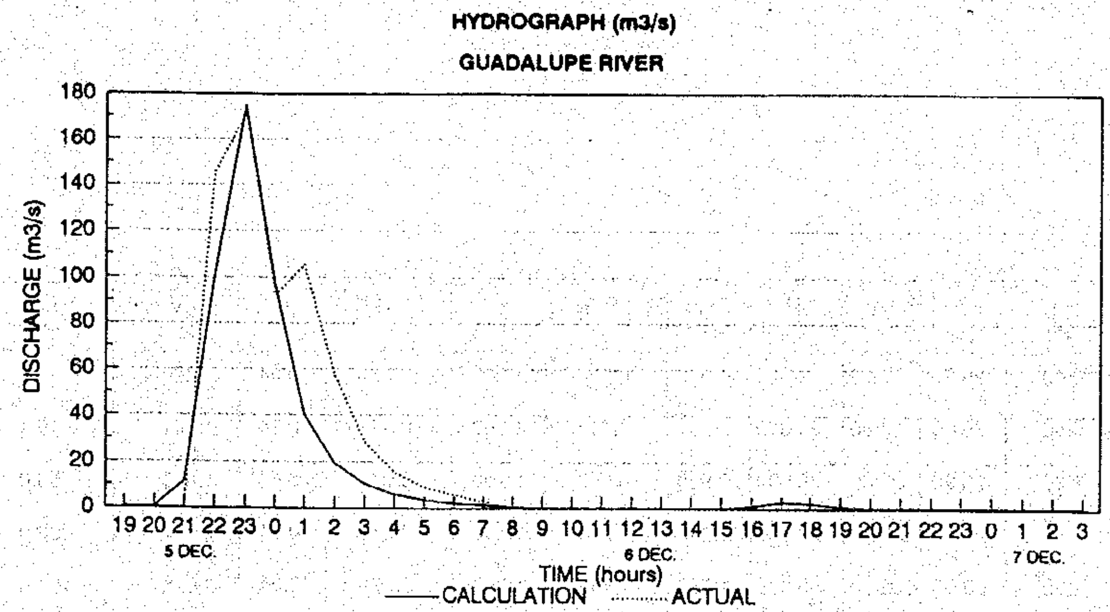
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.5
Relation between Altitude and 9-Month Rainfall in Cebu City

H (m)	B (m)	A (m2)	P (m)	R (m)	R^0.667	I	I^0.5	n	V (m/s)	Q (m3/S)
0.00	26.00	0.00	0.000	0.000	0.000	1/200	0.071	0.04	0.000	0.0
0.50	26.00	13.00	27.000	0.481	0.614	1/200	0.071	0.04	1.241	16.1
1.00	26.00	26.00	28.000	0.929	0.952	1/200	0.071	0.04	1.923	50.0
1.50	26.00	39.00	29.000	1.345	1.218	1/200	0.071	0.04	2.461	96.0
2.00	26.00	52.00	30.000	1.733	1.443	1/200	0.071	0.04	2.915	151.6
2.50	26.00	65.00	31.000	2.097	1.638	1/200	0.071	0.04	3.31	215.1
3.00	26.00	78.00	32.000	2.438	1.811	1/200	0.071	0.04	3.659	285.4
3.50	26.00	91.00	33.000	2.758	1.967	1/200	0.071	0.04	3.973	361.5



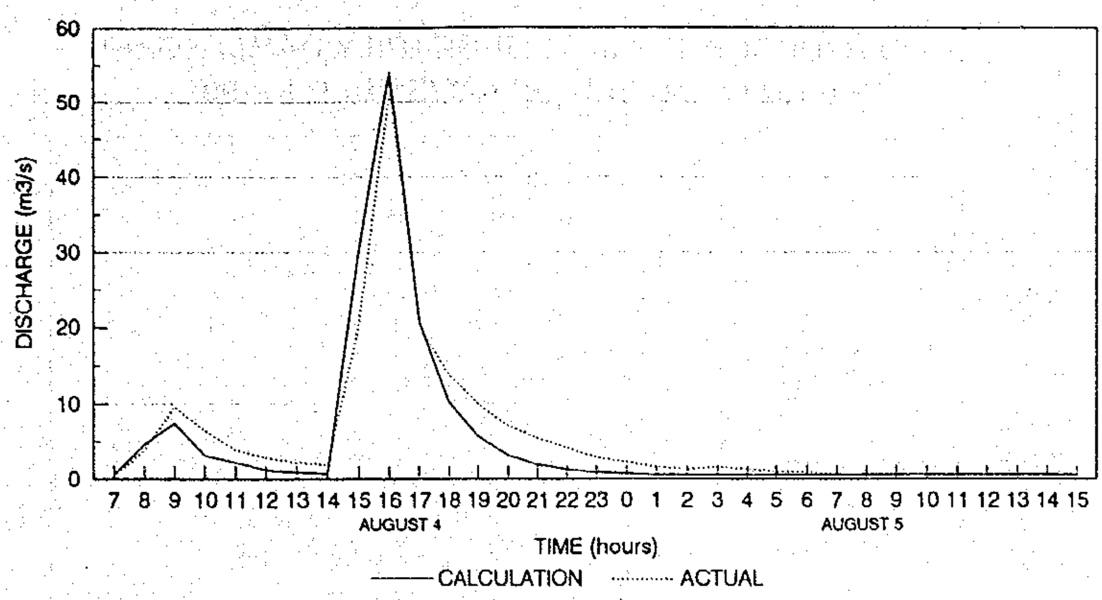
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 6.6
JAPAN INTERNATIONAL COOPERATION AGENCY	Discharge Rating Curve at Colon Brdg. Station on Guadalupe River



Hour	Rainfall (mm)	GU-2 (m3/s)	GU-1 (m3/s)	Base flow (m3/s)	Discharge -calcu- (m3/s)	Recorded Water Level (m)	Water Depth (m)	Discharge -actual- (m3/s)
5 DEC 19	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
20	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
21	27.0	7.8	3.2	0.5	11.5	1.13	0.01	0.48
22	170.0	60.2	40.1	0.5	100.8	3.06	1.95	145.48
23	34.0	38.0	136.6	0.5	175.2	3.27	2.16	171.29
6 DEC 0	2.0	15.3	81.8	0.5	97.6	2.57	1.46	91.86
1	0.0	7.1	32.8	0.5	40.4	2.70	1.59	105.45
2	0.0	3.7	15.2	0.5	19.5	2.20	1.09	57.82
3	0.0	2.0	8.0	0.5	10.5	1.80	0.69	28.64
4	0.0	1.1	4.3	0.5	6.0	1.60	0.49	15.62
5	0.0	0.6	2.4	0.5	3.5	1.40	0.28	9.18
6	0.0	0.3	1.3	0.5	2.1	1.30	0.19	5.96
7	0.0	0.2	0.7	0.5	1.4	1.20	0.08	2.74
8	0.0	0.0	0.2	0.5	0.7	1.13	0.01	0.48
9	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
10	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
11	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
12	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
13	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
14	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
15	0.0	0.0	0.0	0.5	0.5	1.13	0.01	0.48
16	1.0	0.6	0.2	0.5	1.3	1.13	0.01	0.48
17	1.0	0.8	1.5	0.5	2.7	1.13	0.01	0.48
18	0.0	0.3	1.6	0.5	2.4	1.13	0.01	0.48
19		0.1	0.5	0.5	1.2	1.13	0.01	0.48
20		0.1	0.2	0.5	0.8	1.13	0.01	0.48
21		0.0	0.1	0.5	0.7	1.13	0.01	0.48
22		0.0	0.1	0.5	0.6	1.13	0.01	0.48
23		0.0	0.0	0.5	0.5	1.13	0.01	0.48
7 DEC 0		0.0	0.0	0.5	0.5	1.13	0.01	0.48
1		0.0	0.0	0.5	0.5	1.13	0.01	0.48
2		0.0	0.0	0.5	0.5	1.13	0.01	0.48
3		0.0	0.0	0.5	0.5	1.13	0.01	0.48

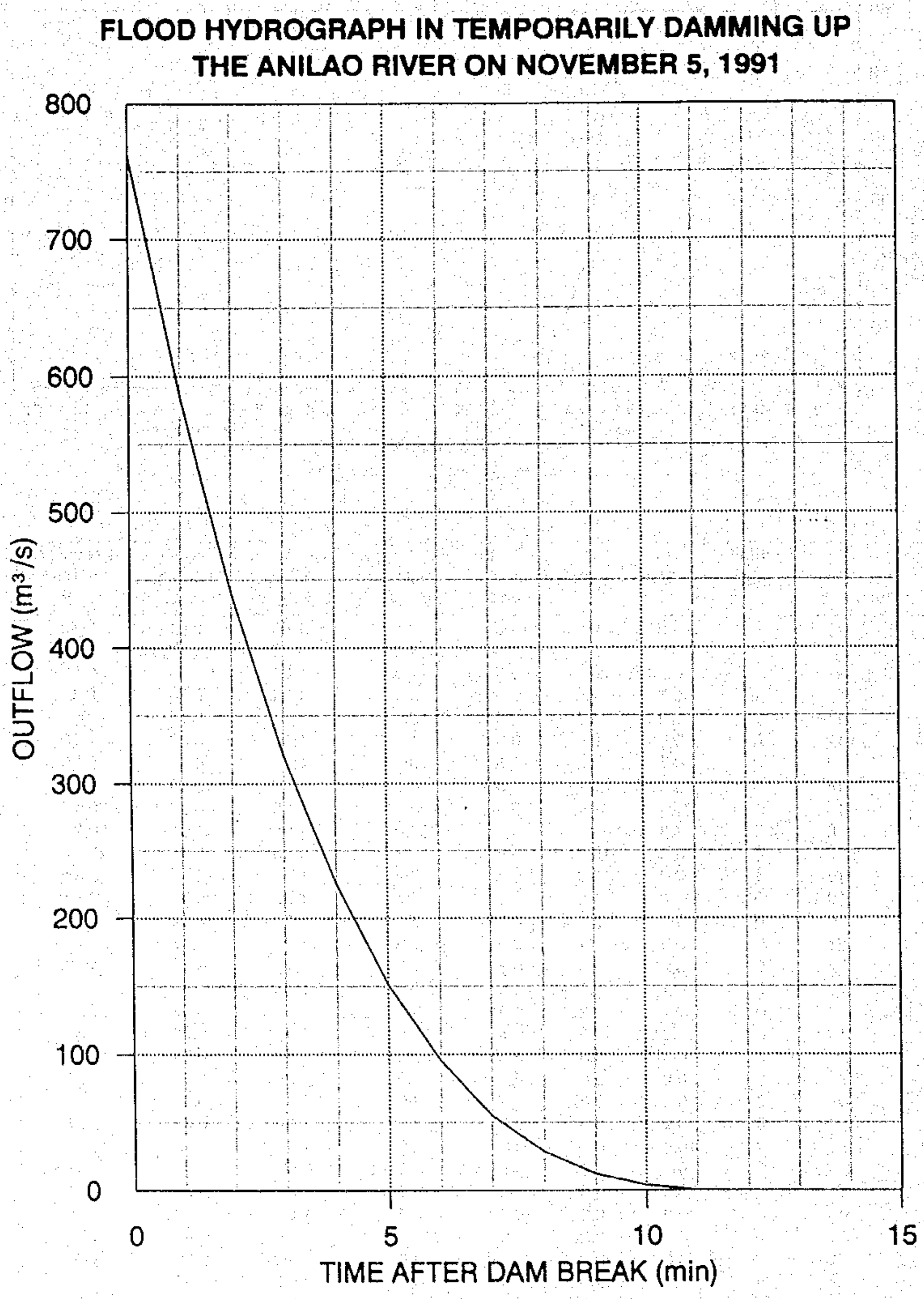
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 6.7 Flood Simulation of Guadalupe River During T. Monang
JAPAN INTERNATIONAL COOPERATION AGENCY	

HYDROGRAPH (m3/s)
GUADALUPE RIVER



Hour		Rainfall (mm)	GU-2 (m3/s)	GU-1 (m3/s)	Base flow (m3/s)	Discharge -calcu- (m3/s)	Recorded Water Level (m)	Water Depth (m)	Discharge -actual- (m3/s)
4AUG.	7	0	0.0	0.0	0.5	0.5	1.05	0.01	0.32
	8	10	2.9	1.2	0.5	4.6	1.16	0.12	3.86
	9	0	0.9	6.2	0.5	7.5	1.34	0.30	9.66
	10	1	0.7	2.0	0.5	3.1	1.24	0.20	6.44
	11	0	0.3	1.4	0.5	2.2	1.16	0.12	3.86
	12	0	0.1	0.6	0.5	1.2	1.13	0.09	2.90
	13	0	0.1	0.3	0.5	0.9	1.11	0.07	2.25
	14	0	0.0	0.2	0.5	0.7	1.10	0.06	1.93
	15	73	21.1	8.6	0.5	30.2	1.60	0.56	20.17
	16	5	7.8	45.7	0.5	54.0	2.05	1.01	50.92
	17	1	3.6	16.7	0.5	20.8	1.60	0.56	20.17
	18	1	2.0	7.7	0.5	10.2	1.47	0.43	13.85
	19	0	1.0	4.2	0.5	5.7	1.35	0.31	9.98
	20	0	0.5	2.1	0.5	3.1	1.26	0.22	7.08
	21	0	0.3	1.1	0.5	1.9	1.21	0.17	5.47
	22	0	0.2	0.6	0.5	1.3	1.17	0.13	4.19
	23	0	0.1	0.3	0.5	0.9	1.13	0.09	2.90
5AUG.	0	0	0.1	0.2	0.5	0.7	1.11	0.07	2.25
	1	0	0.0	0.0	0.5	0.5	1.09	0.05	1.61
	2	0	0.0	0.0	0.5	0.5	1.08	0.04	1.29
	3	0	0.0	0.0	0.5	0.5	1.09	0.05	1.61
	4	0	0.0	0.0	0.5	0.5	1.08	0.04	1.29
	5	0	0.0	0.0	0.5	0.5	1.07	0.03	0.97
	6	0	0.0	0.0	0.5	0.5	1.07	0.03	0.97
	7		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	8		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	9		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	10		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	11		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	12		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	13		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	14		0.0	0.0	0.5	0.5	1.06	0.02	0.64
	15		0.0	0.0	0.5	0.5	1.06	0.02	0.64

Fig. 6.8
Flood Simulation Of Guadalupe River During T. Openg



THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 7.1 Flood Hydrograph in Temporary Dam-Up of Anilao River on November 5, 1991
JAPAN INTERNATIONAL COOPERATION AGENCY	

Flood Inundation on Nov. 5, 1991

Result of Flood Surveys

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1									2.0	0.0	0.0	0.0				
2									2.0	2.0	0.0	0.0				
3									2.5	2.0	2.0	0.0	0.0	2.5	2.5	0.0
4									2.5	2.5	2.0	1.8	2.0	2.5	0.0	0.0
5									2.5	2.5	2.5	2.0	2.5	2.5	0.0	0.0
6				0.5	0.5			0.3	0.5	3.0	3.5	2.5	3.0	2.5	0.0	0.0
7	0.2	0.9	0.7	0.8	0.7	0.7	1.0	1.0	0.8	3.0	4.0	2.3	2.5	2.5	0.0	0.0
8	0.5	0.7	1.0	1.0	1.0	1.2	1.1	1.1	2.0	3.5	3.8	2.8	2.5	2.0	0.0	0.0
9	0.5	0.6	1.0	1.2	1.2	1.4	1.4	1.5	1.7	1.7	1.6	1.7	2.0	2.0	0.0	0.0
10	0.5	0.5	0.8	1.4	1.4	1.4	1.4	1.6	1.6	1.5	1.6	1.6	2.1	2.0	0.0	0.0
11			0.8	1.4	1.6	1.5	1.5	1.5	1.5	1.6	1.6	1.6	2.3	2.3	0.0	0.0
12			0.8	1.5	1.7	1.7	1.6	1.6	1.6	1.7	1.7	1.6	2.4	2.4	0.0	0.0
13					1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	2.5	2.5	0.0	0.0
14					1.7	1.7	1.7	1.7	1.6	1.7	1.5	1.5	1.7	1.7	1.3	0.0
15									1.5	2.0	2.0	0.7	0.8	1.0	1.5	0.0
16									1.0	1.0	1.0	1.0	1.0	1.0	1.5	0.0

Result of Simulation Model

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1									2.4	0.0	0.0	0.0				
2									2.0	2.0	0.0	0.0				
3									2.2	2.1	2.1	0.0	0.0	2.7	2.6	0.0
4									2.4	2.2	2.3	2.1	2.1	2.5	0.0	0.0
5									2.6	2.1	2.3	2.1	1.9	2.1	0.0	0.0
6				0.2	0.2			0.5	0.7	3.0	3.1	2.0	1.6	1.9	0.0	0.0
7	0.6	0.4	0.2	0.2	0.2	0.3	0.6	0.1	0.4	2.5	3.0	1.5	1.0	1.5	0.0	0.0
8	0.6	0.6	0.6	0.4	0.4	0.5	0.9	0.3	1.2	3.0	3.5	2.6	1.1	1.5	0.0	0.0
9	0.8	0.8	0.6	1.1	1.0	1.1	1.2	1.7	1.5	1.8	2.2	2.0	1.3	1.6	0.0	0.0
10	0.6	0.9	1.0	1.2	1.3	1.2	1.1	1.9	1.1	1.5	1.7	1.2	1.5	1.8	0.0	0.0
11			1.1	1.2	1.4	1.4	1.5	1.4	1.1	1.4	1.5	1.2	1.6	2.0	0.0	0.0
12			1.1	1.4	1.5	1.6	1.7	1.8	1.6	1.5	1.1	1.1	1.5	1.8	0.0	0.0
13					1.6	1.6	1.6	1.7	1.5	1.5	1.3	1.2	1.5	1.7	0.0	0.0
14					1.5	1.7	1.9	1.6	1.3	1.2	1.0	1.1	1.2	1.4	1.2	0.0
15									1.5	1.0	1.1	1.1	1.3	1.5	1.7	0.0
16									1.3	1.4	1.5	1.6	1.7	1.8	1.8	0.0

NOTE

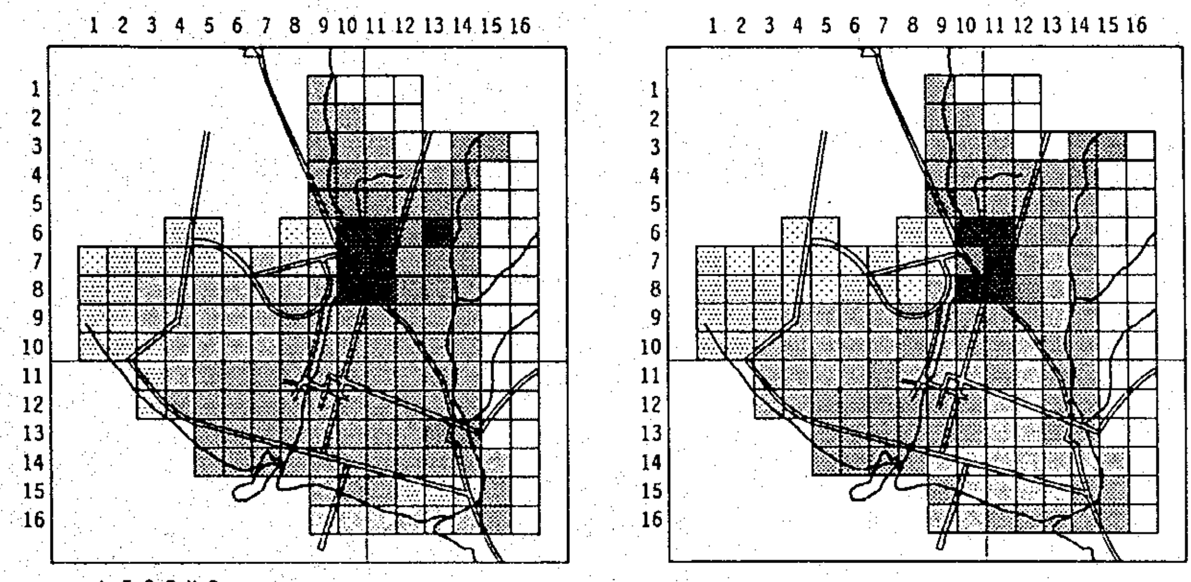
☐ : Mesh unit (125 m x 125 m).

Figures in meshes present inundation depth in meter.

Flood Inundation on Nov. 5, 1991

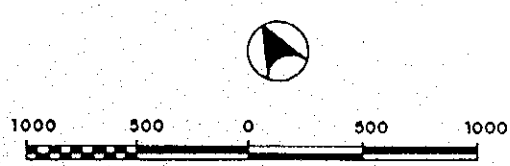
Result of Flood Surveys

Result of Simulation Model

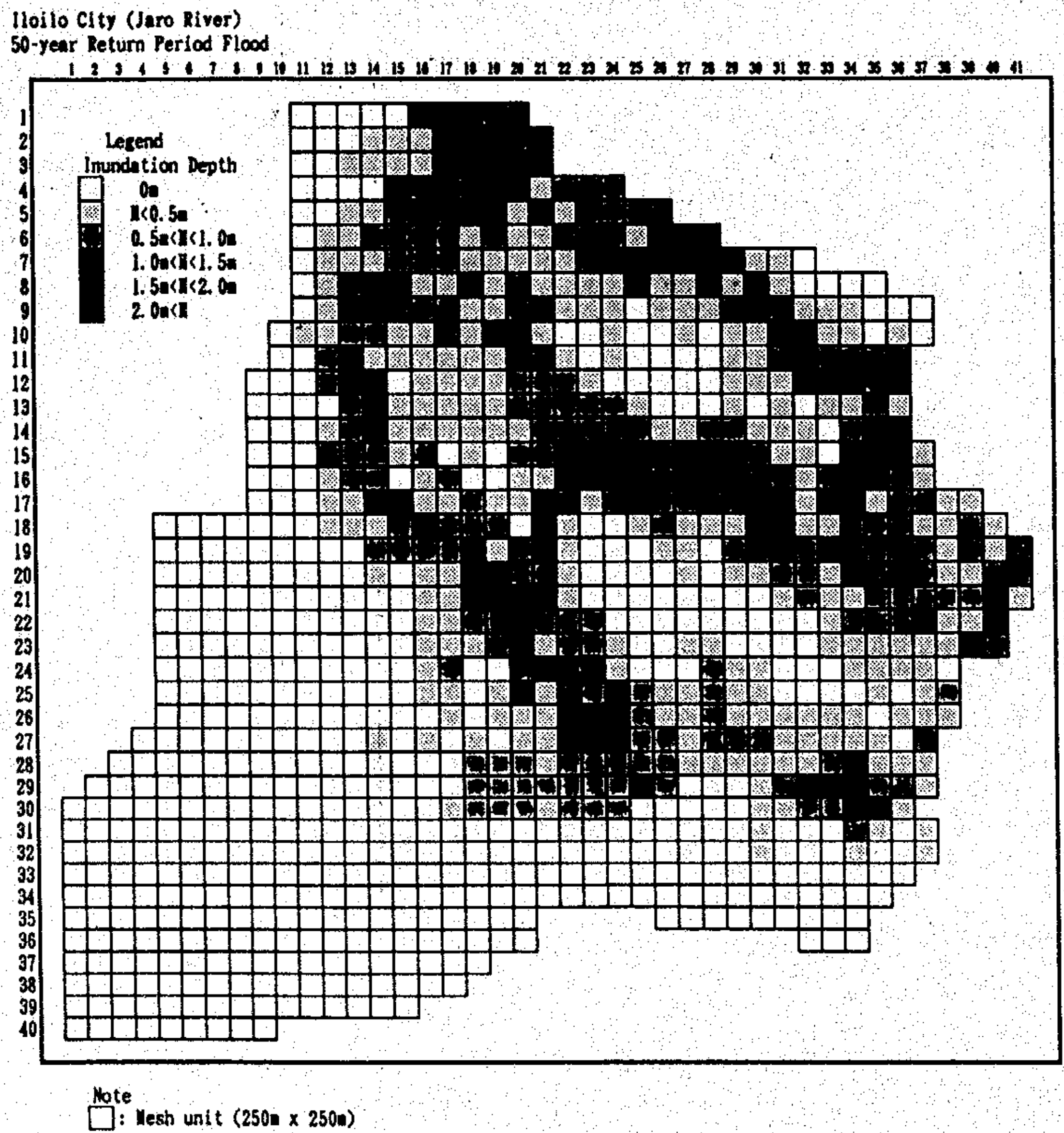


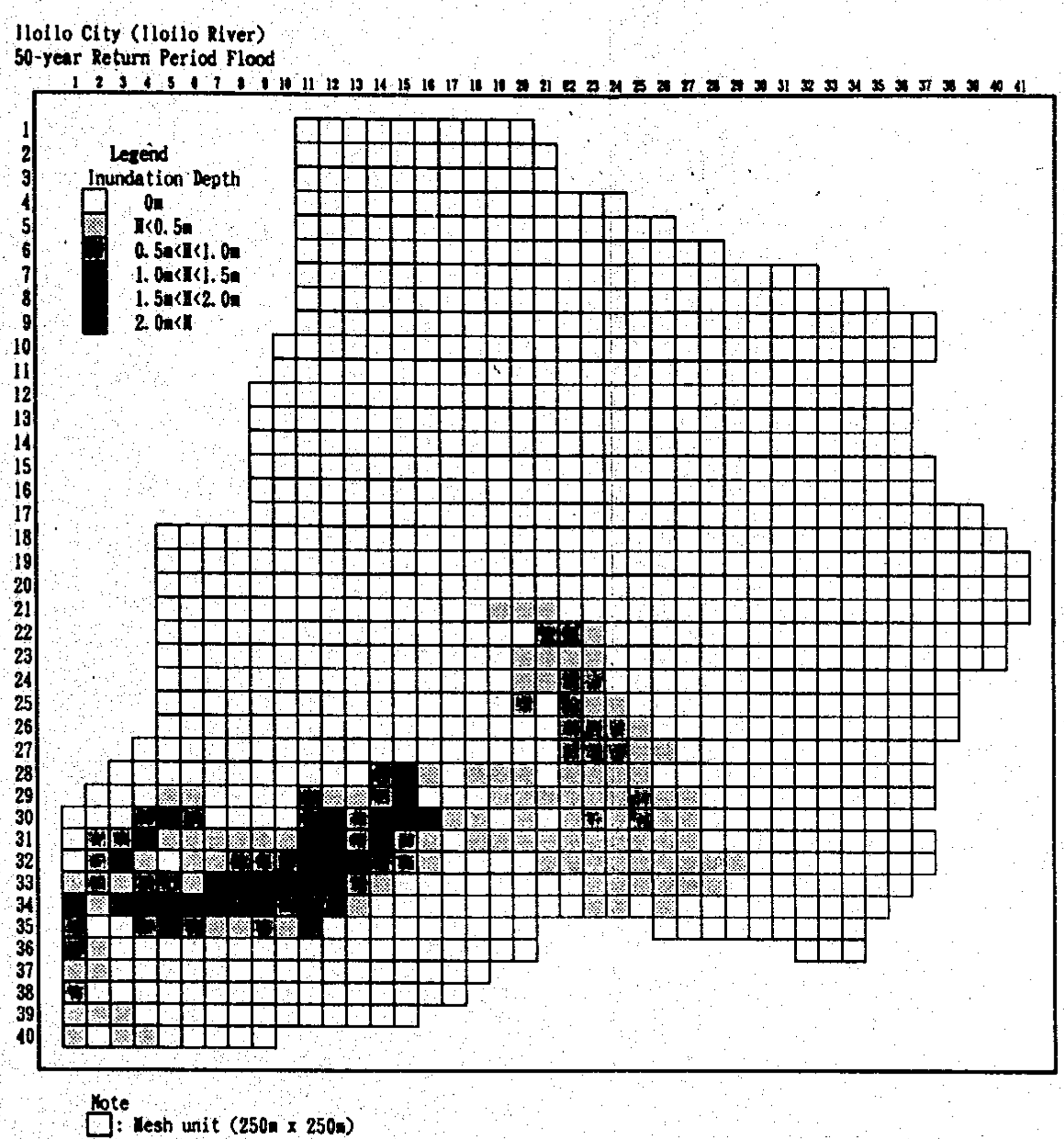
LEGEND

- : No inundation
- : 0.00 - 0.50 m
- : 0.50 - 1.00 m
- : 1.00 - 1.50 m
- : 1.50 - 2.00 m
- : 2.00 - 2.50 m
- : 2.50 - 3.00 m
- : > 3.00 m

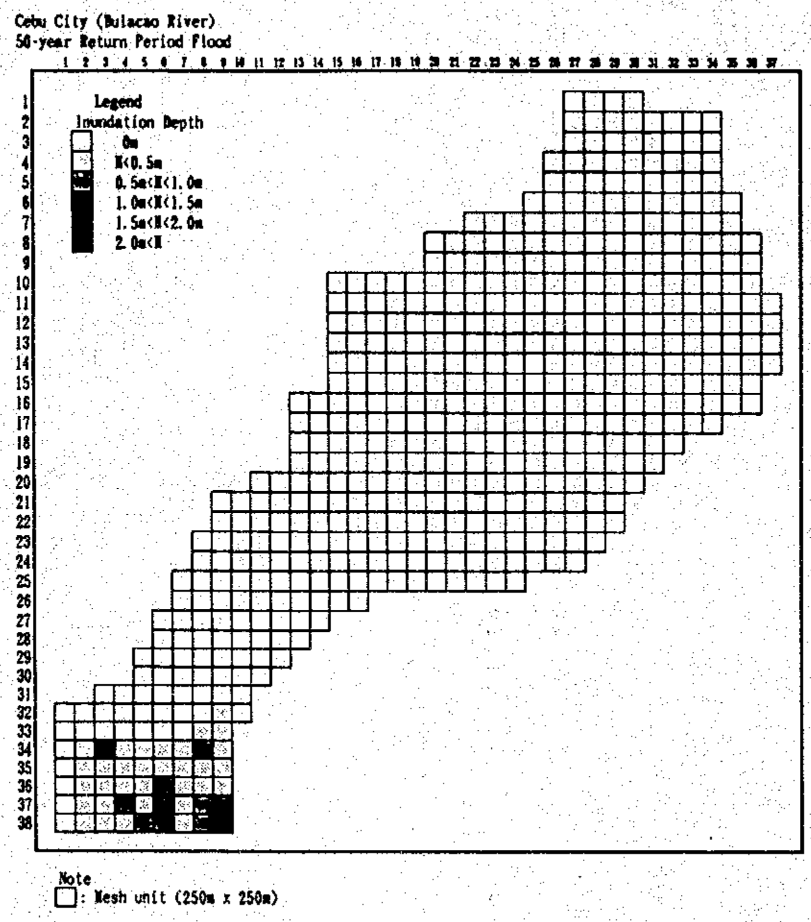


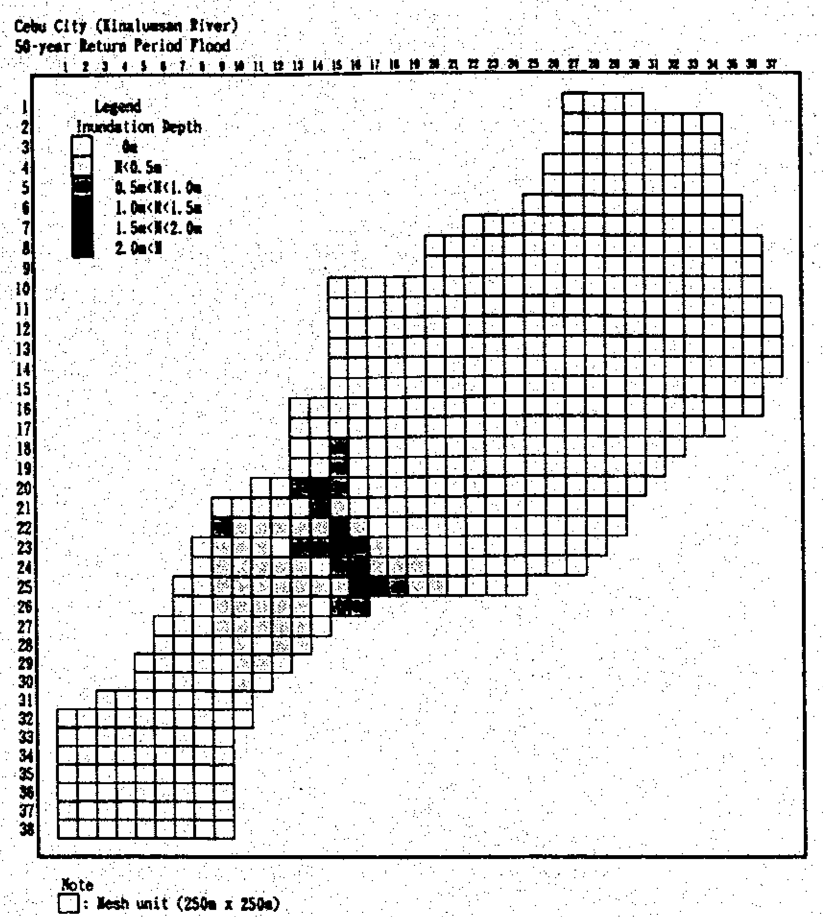
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 7.2 Comparison of Inundation Areas and Depth by Flood Surveys and Computation, Ormoc
JAPAN INTERNATIONAL COOPERATION AGENCY	

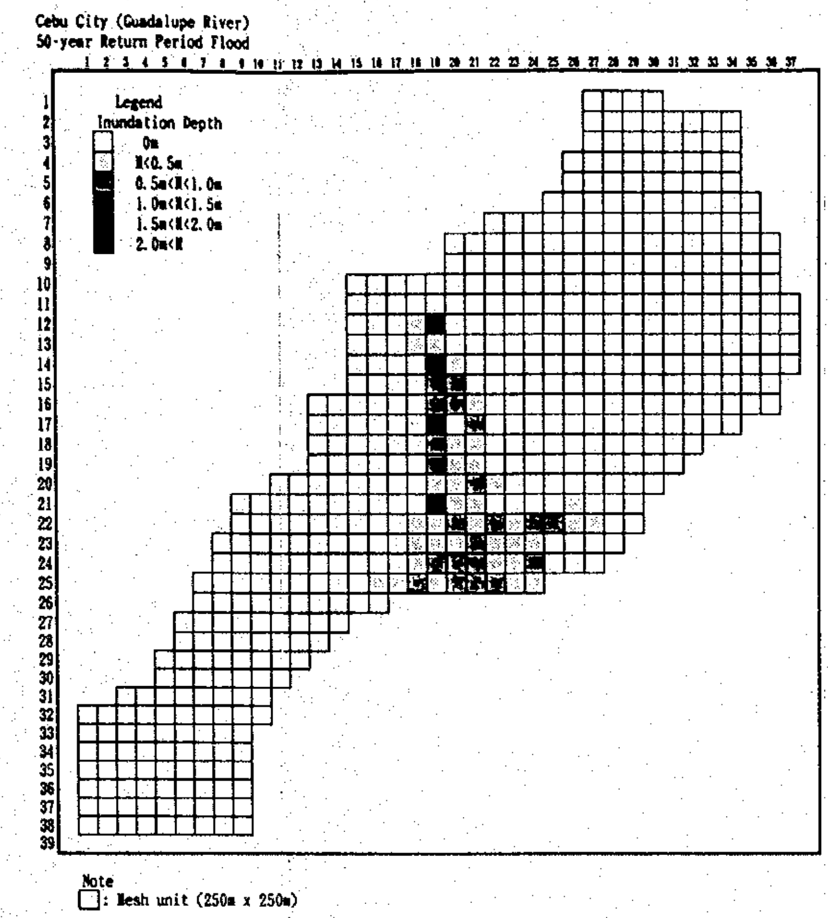


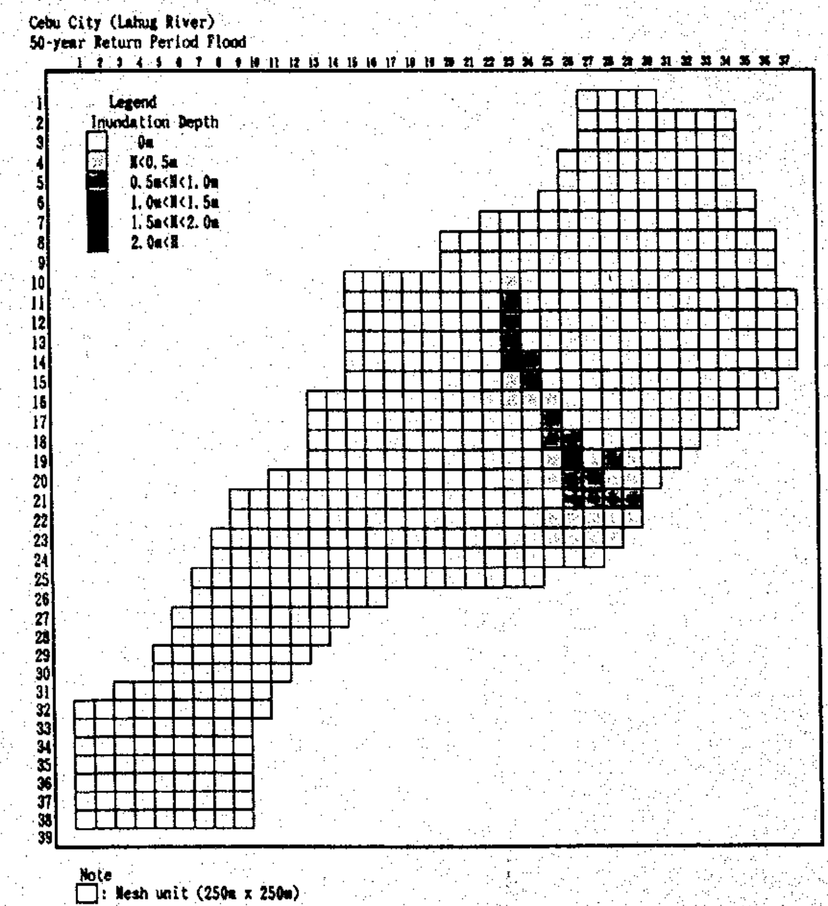


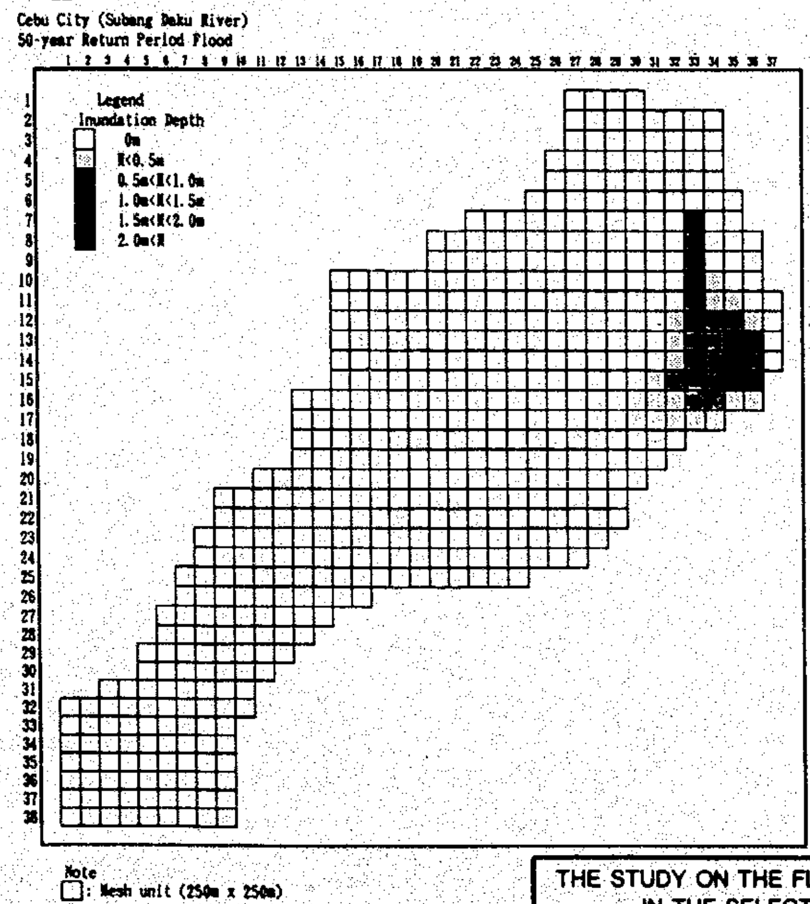
THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 7.3
JAPAN INTERNATIONAL COOPERATION AGENCY	Result of Inundation Analysis of a 50-Year Return Period Flood, Iloilo City





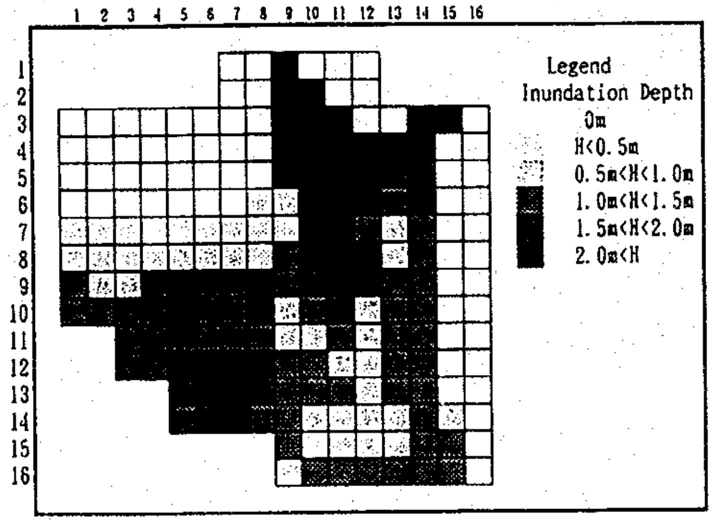






THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 7.4 Result of Inundation Analysis of a 50-Year Return Period Flood, Cebu City
JAPAN INTERNATIONAL COOPERATION AGENCY	

Ormoc City (Anilao and Malbasag Rivers)
50-year Return Period Flood



Note
: Mesh unit (125m x 125m)

THE STUDY ON THE FLOOD CONTROL FOR RIVERS IN THE SELECTED URBAN CENTERS	Fig. 7.5 Result of Inundation Analysis of a 50-Year Return Period Flood, Ormoc City
JAPAN INTERNATIONAL COOPERATION AGENCY	

SUPPORTING REPORT

ON

GEOLOGY AND SOIL MECHANICS

SUPPORTING REPORT
ON
GEOLOGY AND SOIL MECHANICS

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1. INTRODUCTION

1.1 Outline of the Survey

To fully understand the geological and subsurface structure of the study area, geological and soil mechanics survey has been carried out during the two (2) stages, the Master Plan and the Feasibility Study. The outline of the survey conducted for each stage is summarized as follows.

(1) Master Plan Stage

- Survey Area : Iloilo, Cebu, Tacloban and Ormoc
- Survey Period : April to July, 1993
- Survey Contents : Collection of geological and soil mechanics data;
  : Geological field reconnaissance;
  : Provision of regional geological map;
  : Analysis of general soil conditions.

(2) Feasibility Study Stage

- Survey Area : Iloilo and Ormoc
- Survey Period : May to August, 1994
- Survey Contents : Boring test with SPT for river improvement;
  : Boring test with coring for sabo dam sites;
  : Soil mechanics test for embankment materials;
  : Soil mechanics test for soft ground of Iloilo.

1.2 Survey Location

Geological field reconnaissance in the Master Plan Stage has been conducted for four (4) cities to obtain the regional geological and soil conditions. Locations of boring test and soil mechanics investigation in the Feasibility Study Stage have been specified based on the proposed project site.

Borehole locations were set along proposed river improvement sites, sabo dam sites and expected soft ground areas. The sampling sites for soil mechanics test were placed at proposed borrow pits for embankment materials and the area estimated as soft ground.

For the details of each survey location for the Feasibility Study Stage, refer to Fig. 1.1 for Iloilo City and Fig. 1.2 for Ormoc City.

1.3 Survey Quantity

A total of 35 boring tests were carried out at related rivers for improvement and sabo dam sites. The test includes standard penetration test at every one (1) meter depth of drilling for all boreholes. At the sabo dam sites, five (5) core samples of basement rock were collected. Uniaxial compression tests were conducted for the collected samples.

Embankment materials were examined by the laboratory test for physical properties, including grain size analysis, specific gravity, moisture content and consistency. A total of 45 samples were collected for each test.

Four (4) locations were selected for the soil test of soft ground. A total of four (4) boring tests and laboratory tests on twelve (12) samples were carried out. Consolidation test was supplemented to physical test items mentioned above.

The survey quantities conducted in this study period are summarized in Table 1.1.

2. GEOLOGY OF STUDY AREA

2.1 Iloilo

Geomorphology

Jaro and Iloilo rivers are bounded by a mountainous range running from west to north. The hilly area in Iloilo City has a gentle slope where an alluvial plain widely extends. The main regional geomorphology in the study area is summarized as follows:

(1) Mountainous Area

The area is characterized as Panpnan Basalt Formation basin located in the upper stream of Aganan and Tigum rivers, the major tributaries of Jaro River. The elevation of the area is approximately 500 m to 1,000 m and Mt. Inaman (1,380 m) is the highest peak in the Jaro river basin. The physiography of the area shows a rugged and irregular structure of the outcropped formation consisting of metamorphic and igneous rocks. The drainage texture pattern in the area is dendritic and very dense.

(2) Hilly Area

The area extends in the middle stream of Aganan and Tigum rivers at an elevation of 50 m to 400 m with a smooth relief. An irregular drainage texture pattern reflecting the structure of the Sedimentary Rocks of Panlupan, Lagdo and Sewaragan Formation. Along Tigum River, especially from Maasin to Santa Barbara, remnants of river terraces composed of Cabatuan Formation of the Quaternary and Apdo Formation of the Tertiary are still visible.

(3) Alluvial Plain

The alluvial plain is evidenced by a very flat morphology with a regular seaward slope. The alluvial plain is widely observed in Iloilo City, and it is a broad structure trending southwest to northeast.

Geology

Panpnan Formation, located at the mountainous area and composed mainly of basalt and breccia, is part of the "Basement Complex" designating the assemblage of igneous and metamorphic rocks bordering Iloilo basin. Unconformably overlying or in fault contact is a sequence of Miocene to Pliocene of sedimentary rocks consisting of Sewarangan Formation, Lagdo Formation, Mayos Formation, Panlupan Conglomerate and Apdo Formation. The formation is mainly located in the hilly area midstream of Tigum and Aganan rivers and its structural trending is southwest to northeast direction, respectively. Sedimentary rocks of the Quaternary named Cabatuan Formation is overlying those Tertiary sedimentary rocks and it is exposed in the middle to the downstream of Tigum River. Alluvium deposits are widely observed in the whole reaches of Iloilo River and downstream of Jaro River.

Based on the geological field reconnaissance and data analysis in the master plan stage, a geological map is provided as shown in Fig. 2.1. Geological profiles along Jaro River and Iloilo River are provided based on the lithostratigraphic data of existing water wells obtained from the Metro Iloilo Water District. The stratigraphy of Iloilo City is summarized in Table 2.1.

The details of various geological formations are described as follows:

(1) Alluvium (Qal)

Alluvial plains mainly originated from the recent river and coastal deposits. Main compositions are sediments of the numerous water courses that flow in the plain (Jaro and Iloilo rivers). The sediments generally consist of clay, silt and fine sand. Small scale terrace remnants are visible along the Tigum and Aganan rivers. These commonly consist of silt, sand or gravel and range in thickness from 0.5 m to 10 m.

(2) Cabatuan Formation (Q2)

The formation consists mainly of reddish brown, false bedded sandstone including dark gray, fossiliferous, homogeneous, soft mudstone and fine sandstone. The completed section of the formation is exposed along the Tigum River between Cabatuan and Santa Barbara. This formation is widely distributed in the middle to southern part of Central Panay Plain.

(3) Apdo Formation (N2a)

The Formation is exposed in the area of low rolling hills along the western side of Iloilo river basin and southwestern of Cabatuan, especially along Tigum River. It consists mainly of brown to gray colored mudstone, marl and siltstone.

(4) Panlupan Conglomerate (N2pc)

The formation consists of irregular alternations of calcareous conglomerate, fine grained sandstone and slate. Outcrops of the formation in the study area are in a narrow belt following a trend of north to south axis starting south of Alimodian to the north of Maasin.

(5) Mayos Formation (Nim)

The formation consists of calcareous sandstone, siltstone, mudstone, conglomerate and basaltic clastics, distributed from southwest of the area having southwest to northeast trending band to the west of the alignment Guimbal-Leon-Massin, narrowing northward.

(6) Lagdo Formation (Nil)

The formation is composed of clastic sediments and consists of siltstone, mudstone, tuff, wacke, and minor conglomerates. The outcrops of the formation show in a continuous belt trending northeast to southwest along the southwestern margin of Iloilo river basin.

(7) Sewaragon Formation (Nis)

The formation consists of layered to massive wacke, slate, interbedded fossiliferous sandstone shale and minor basalt, and andesite flow. It is distributed northwest of the hilly area in the middle to upper stream of Tigum and Aganan rivers. The Maasin Dam constructed by the Metro Iloilo Water District is founded on this formation.

(8) Panonan Basalt (Ppb)

The formation is confirmed as volcanic rocks in the upper stream of Tigmu and Aganan rivers located at the mountainous area northeast of the study area. It consists of predominant basaltic lava and breccia, and green tuff.

2.2 Cebu

Geomorphology

Cebu City is formed by five (5) rivers, Bulacao, Kinalumsan, Guadalupe, Lahug and Subang Daku, which flow in parallel from the mountainous area toward the coastal area. These rivers shows trends of flow from northwest to southeast with steep slope. Alluvial plains extend along the coastline of Cebu City. The main regional geomorphology in the study area is summarized as follows.

(1) Mountainous Area

Five (5) major formations of Cretaceous to Oligo-Miocene of Tertiary (Mananga, Cebu, Maludog, Bulacao and Maingit) are mainly exposed at elevations of about 300 m to 700 m. The headwaters of the Guadalupe River is the highest in the five (5) river basins. The area of the headwaters is covered by the formation of Mananga group and Bulacao andesite. The physiography of the area shows a rugged and irregular structure of the formation consisting of sedimentary and volcanic rocks. Many dendritic drainage texture patterns are observed in this area.

(2) Hilly Area

The midstream of the five (5) related rivers are located at the hilly area with elevation of about 100 m to 300 m. Relatively moderate structures are observed in the area. The area is formed by the Carcar Formation of limestone. Maingit Formation and Bulacao Andesite are observed at both sides of the valley and the riverbed downstream of Buhisan Dam. Smooth and simple drainage texture patterns are observed in each river basin due to the massive formation of the area.

(3) Alluvial Plain

The alluvial plain is distributed along the coastline of Cebu City as a narrow belt following a southwest-northeast trend. Along Guadalupe and Linao rivers, the alluvium plain is well extended up to the north of Guadalupe Church. River deposits have accumulated more than in other rivers, which is an evidence of higher elevation than other alluvial plain areas. In general, the plain is characterized by a flat morphology with a regular sea-warded slope.

Geology

In general, the area is characterized as complex and highly diverse forms of sedimentary and volcanic rocks which have a structure trend of narrow parallel belts on southwest to northeast direction. The oldest formation of the area is the Mananga Group of the Cretaceous composed of andesitic to basaltic pyroclastics with a thick accumulation. The sequence of Oligo-Miocene consists of marine sedimentary rocks of the Cebu Formation, Maludog Formation and Maingit Formation, and volcanic rocks of Bulacao Andesite are unconformably overlying on the Mananga Group. Most of the sedimentary rocks are characterized by poor sorting and extreme variations in thickness and lithology within the short distance. Sedimentary rock of Carcar Formation of limestone is distributed at the hilly area. Barili formation which also consists of limestone is locally observed west of Mananga River. The formation is classified as Pliocene by paleontology. Alluvium deposits are distributed along the coastline of Cebu City and downstream of the five (5) related rivers.

Based on the geological field reconnaissance and data analysis in the master plan stage, a geological map is provided as shown in the Fig. 2.2. Geological cross sections are provided based on the lithostratigraphic data of existing water wells obtained from the Water Resources Center, University of San Carlos (WRC-USC). The stratigraphy of Cebu City is shown in Table 2.2.

The details of various geological formations are described as follows:

(1) Alluvium (Qal)

Alluvial plains originating from recent river and coastal deposits and coral reefs consist mostly of sand, gravel, silt and clay. The plain is of the Carcar Formation and extends from southeast to northwest along the coastline. In general, the thickness of the formation in the north part of the plain bounded by the Kinalumsan River is much thicker than the southern part.

(2) Carcar Formation (Caf)

The formation which forms the hilly area consists of coral limestone including abundant marine fossils. The formation is confirmed as the youngest rock formation, so that most of the limestone is porous and powdery. Massive layers are poorly bedded and distributed locally. Dolomitic parts occur and sometimes mined in local places. The Carcar Formation is hard to distinguish from the Barili Formation. However this formation is characterized by a gentler dip than the Barili Formation and mostly consists of powdery limestone with much marine fossils. The formation is well known as main aquifer of most water wells in Cebu City.

(3) Barili Formation (BlF)

The formation consists of a lower coral limestone unit and an upper marl unit. The lower coral limestone exhibits a pale brown to yellowish brown color. A major part is massive though porous and powdery and is loosely compacted compared with the older limestone. The upper marl unit is composed of calcareous and soft silty sandstone. In the study area, the formation locally and intermittently outcrops in the west part of Mananga River.

(4) Maingit Formation (Mif)

The formation is composed of conglomerates which contain medium to coarse-sized, rounded to sub-rounded clastics sandstone and shale. The base part of the formation is characterized by bigger clastics. The formation is distributed as a narrow belt along the middle to upper stream of Bulacao and Kinalumsan rivers, where the old valley consists of Maludog Formation and Bulacao Andesite. Thus, it is estimated that the formation originated from old river deposits. North of Guadalupe Church, the formation exposes at the riverbed of the midstream of Guadalupe River. In this location, sandstone is observed more predominantly than conglomerates and it is not consolidated well.

(5) Bulacao Andesite (BA)

The formation consists of porphyritic andesite and partly intrusive breccia. The formation exposes in the central part of the study area within the mountainous area. The Buhisan Dam is founded on this andesite.

(6) Maludog Formation (Mbf)

The formation, consisting of mudstone, shale, interbedded conglomerate, limestone and coal, conformably overlies the Cebu Formation. Gray to black colored mudstone and shale are the dominant lithology of this formation. In general, mudstone and shale are at the basal part of the formation, grading gradually to sandstone and conglomerate at the upper part. The formation generally developed into intensive, smooth slope and low rolling hills, currently dominated by native grasses.

(7) Cebu Formation (CF)

The formation is composed of conglomerate, sediments with interbedded coal deposits at the lower and limestone at the upper part. Limestone is the dominant lithology of the formation. The formation is distributed at the west side of the Maldog Formation at the central highland, and unconformably overlies the Mananga Group. The limestone shows white to pink color, sometimes exhibiting massive to boulder-like appearance.

(8) Mananga Group (MG)

This series consists of a lower and upper formations. The lower formation is composed of sedimentary origin materials such as chart, sandstone and conglomerate, while the upper formation is composed of basaltic to andesitic volcanic pyroclastics and breccia. Thick, folded formation is exposed at the central highland area.

2.3 Ormoc

Geomorphology

Anilao and Malbasag rivers flow in parallel at Ormoc City from the southwest toward the river mouth. The two rivers mostly flow on the moderate dipping pyroclastic deposits of the hilly area, from the mountainous area which is composed mainly of young volcanic rocks to the alluvial plain at Ormoc City. The main regional geomorphology in the study area is summarized as follows:

(1) Mountainous Area

The area is characterized by late Pleistocene volcanic lahar. The area has its elevation from 400 m to 800 m, and Mt. Bonao is the highest peak at elevation of 812 m. The formation is mainly composed of late Pliocene volcanic rock. Therefore, rugged and irregular structures of the drainage texture pattern are observed.

(2) Hilly Area

The upper and middle reaches of Anilao and Malbasag rivers lie on this hilly area. The formation is characterized with Plio-Pleistocene pyroclastics deposits composed of thick accumulations of lahar having moderate dipping. The elevation of the area is 30 m to 400 m, and simple relief drainage texture patterns are observed. However, the valley which has been formed with erosion by river flow is generally deep and steep. It shows that the area has a young history of area topographic evolution.

(3) Alluvial Plain

The plain is limited only to the city proper area. A narrow belt of plain lies along the coastal area. The plain is formed with recent alluvial sediment by river deposit s.

Geology

The oldest rock of the area is the Central Highland Volcanic of Miocene which is composed of volcanic flows including intrusive hornblende and pyroxene andesite. Plio-Pleistocene Dolores formation is widely distributed mainly at the hilly area. The formation underlay the Quaternary volcanic rock of the mountainous area.

Based on the geological field reconnaissance and data analysis in the master plan stage, a geological map of the area is provided as shown in the Fig. 2.3. The stratigraphy of Ormoc City is shown in Table 2.3.

The details of various geological formations are described as follows:

(1) Alluvium (Qal)

The formation consists of recent river deposits of sand, gravel, silt and clay. The formation covers the Dolores formation and distributed in a narrow area of Ormoc city proper.

(2) Young Volcanic Cone (Qv)

The formation constitutes height mountain peaks with Lake Danao at the center. The formation consists of hornblende proxene andesite and overlays the Dolores Formation. All the headwaters of the two related rivers are located at this formation.

(3) Dolores Formation (Qtd)

The formation is widely outcropped in the hilly area. The formation consists of andesitic, volcanic clastics and low angle, well bedded breccia, sandstone, and shale. It is sometimes accompanied with a thin layer of calcareous tuffaceous shale, sandy mud and white colored limestone lens. Volcanic breccia consists mainly of sub-angular fragments of andesite and sandy, tuffaceous cementing materials. It seems to be the basement of volcanic clastics of a recent volcano.

(4) Pangasugan Formation (Tp)

The formation is composed mainly of poor sorting and bedded massive conglomerate accompanied with coarse sandstone and tuffaceous shale lens in places. Conglomerate consists of angular and sub-angular fragments of andesite and fine, sandy and partial tuffaceous materials. The formation outcrops a narrow area of the southeastern area.

(5) Central Highland Volcanic (Chv)

This volcanic soil constitutes the basement of the central mountain range of Leyte Island. The formation is composed of porphyritic hornblende pyroxene andesite, agglomerate and flow breccia.

2.4 Tacloban

Geomorphology

The study area consists of the four (4) related rivers basin of Abucay, Mangonbangon, Tanghas Lirang and Buayan. The flow of each river is almost parallel, with south to north axis in the narrow alluvial plains of Tacloban City. A mountainous area is located west of the city and small scale hilly area is exposed at the center and east of Tacloban City. The main regional geomorphology in the study area is summarized as follows.

(1) Mountainous Area

The area is characterized as Tacloban Volcanic Formation located at the western side of the city, with an elevation of 50 m to 300 m. Mt. Naganaga is the highest peak with the elevation of 380 m. The physiography of the area is massive structure of volcanic rocks. Among the four related rivers, only the Mangonbangon River has its headwaters in the area.

(2) Hilly Area

There are two hilly areas in the city, composed of Tertiary sedimentary rocks. One is located west of Mangonbangon River, forming a narrow belt along the river and exposing Sanricardo Formation. The other one is located at a protuberance in San Pablo Bay at the eastern side of the city proper and exposes Bagahupi Formation.

(3) Alluvial Plain

The alluvial plain shows relatively flat morphology with very gentle sea-warded slope where all related rivers extend. The plain is narrow between the mountainous area and the hilly area, and it corresponds to a broad structure trending south to west.

Geology

Northern Leyte is divided into two geological provinces by the rift valley of the Philippine Fault. In the east part of the province where Tacloban City is located lacks the lower and upper Miocene formation and Plio-Pleistocene formation. The oldest formation of the area is Tacloban Volcanic of Cretaceous which expose at the mountainous area and bounded by the Babatugon Fault. The formation consists of two units, one is basalt and andesite, the other one is gabbro diabase. Tertiary sedimentary rocks form the hilly area. It consists of the Bagahuip Formation and Sanricardo Formation of sandstone and conglomerate.

Based on the geological field reconnaissance and data analysis in the master plan stage, a geological map is provided as shown in Fig. 2.4. The stratigraphy of Tacloban City is shown in Table 2.4.

The details of various geological formations are described as follows:

(1) Alluvium (Qal)

The formation is reported as a recent river and coastal deposit in the area. It consists of unconsolidated mud, silt, sand and gravel derived mainly from older formations along the hilly area. Most reaches of the four related rivers are observed in the plain with gentle slope.

(2) Bagahupi Formation (Tbi)

The formation is composed of low inclined conglomerate, sandstone and marlish tuffaceous shale. Conglomerate consist of sub-angular gravel of andesite, basalt, serpentine, schist gabbro, cemented by sandy and clayey materials. Sandstone is mainly coarse grained, and arcoarsic and well bedded. Shale is marly and tuffaceous, and interbedded with a thin layer of fine tuff. The formation forms the hilly area located at the central part of the city.

(3) Sanricardo Formation (Tsr)

The formation consist of sandstone, conglomerate, shale and lava flow with steep dip. In the study area, the outcrops of the formation form a low ridge west of the city and extend along Mangonbangon River.

(4) Tacloban Volcanic (Tv) (Gd)

Basaltic and andesitic volcanic are dominant in the formation with subordinate amount of chert, wacke and shale. The intrusion period of the formation is considered Upper Cretaceous - (Tv)

Gabbro diabase is generally middle to coarse grained gabbro which have allotrio to hipidiomorphic texture and ophitic texture. The intrusion period of the formation is considered Middle Cretaceous - (Gd). This formation forms a massive mountain west of the study area.

3. SOIL CONDITION OF STUDY AREA

Based on the existing boring data collected during the Master Plan Stage, regional soil conditions have been analyzed for the four (4) cities of Iloilo, Cebu, Ormoc and Tacloban. On the other hand, detailed boring and soil mechanics tests have been conducted during the Feasibility Study Stage for the two (2) cities selected, Iloilo and Ormoc. The regional soil conditions of the cities of Cebu and Tacloban analyzed from the existing boring data is described in this section, while the detailed soil conditions analyzed by the boring tests and soil mechanics tests conducted in the Feasibility Study are presented in Sections 4 and 5.

3.1 Iloilo

Soil conditions in Iloilo are as described below.

(1) General Soil Condition

The study area in Iloilo has the largest alluvial plain among the four (4) cities. Recent alluvial deposits cover this wide plain in Iloilo City. The basement rock of this alluvial plain is Cabatuan Formation composed of sandstone, siltstone and mudstone. Alluvial deposits, classified as upper layer of Cabatuan Formation are composed of river and coastal sediments, mainly consisting of clay, silt and sand.

(2) Surface Soil Condition

A soil map of Iloilo City is provided from the results of the boring tests in the feasibility study, as shown in Fig 3.1. Two (2) sedimentary basins, Jaro and Iloilo, are confirmed by the analysis. As shown as Fig. 3.1, surface soil of Iloilo City is mainly cohesive soil of clay or silt. Marine deposits are distributed only at the Iloilo sedimentary basin.

For the detailed analysis of soil profile and properties, refer to Sections 4 and 5 of this supporting report.

3.2 Cebu

Soil conditions in Cebu are as described below.

(1) General Soil Condition

Most of the soils in the alluvial plain originated from sedimentary materials of shale, sandstone, conglomerate, limestone and volcanic rock, and coastal detritus deposits. Distribution of sedimentary materials are strongly related to elevation and the steep-sloped landform of the area.

The basement rock of the alluvial plain is Carcar Formation of Pleistocene limestone. The expected thickness is approximately 10 m to 20 m at the northern part, and 5 m to 10 m at the southern part. Alluvial deposits, classified as upper layer of Carcar Formation, mostly consist of sand, gravel, silt, and clay.

(2) Surface Soil Condition

A regional soil map has been provided by the Bureau of Soils, Department of Agriculture, as shown in Fig. 3.2. According to the map, the study area is classified under three (3) major soil formations. In the high mountainous area, Baguio Clay Loam is distributed, may be as a surface soil of Mananga group. Detailed soil strata and thickness of the three formations are described below.

(a) Mandaue Clay Loam (Alluvial Plain to Hilly Area)

Layer	Facies	Thickness
1st	Coarse granular clay loam	0.20m
2nd	Slightly compact coarse granular clay loam	0.30m
3rd	Slightly compact coarse columnar clay loam	0.70m
4th	Coarse columnar clay loam	0.30m

(b) Medrellin Clay (River Mouth of Bulacao to Kinalumsan River)

Layer	Facies	Thickness
1st	Coarse granular plastic sticky clay	0.25m
2nd	Coarse granular plastic clay	0.30m
3rd	Medium coarse plastic friable clay	0.95m

(c) Faraon Clay (Mountainous Area)

Layer	Facies	Thickness
1st	Coarse granular plastic friable clay	0.15m
2nd	Coarse granular clay	0.10m
3rd	Non-structural soft weathered limestone clay	0.25m
4th	Non-structural hard limestone	1.00m

(3) Soil Profile

Four (4) soil profiles are provided based on the existing boring data. The profiles, together with borehole locations, are shown in Fig. 3.3. As can be observed from the profiles, depth to the basement rock is generally more than 20 m. Several cohesive soil layers with a relatively low N-value are widely observed as the uppermost 10-m depth from the ground surface except the reclamation area.

Based on the soil profiles provided, the soil strata of Cebu City is classified as shown in Table 3.1. The table compiles the N-value and range of thickness for each layer.

(4) Soil Property

Based on the available laboratory test results of the existing boreholes, soil properties for each layer are analyzed as shown in Table 3.2. The table shows the range and average of specific gravity, water content and grain size distribution, together with the number of samples used for this analysis.

3.3 Ormoc

Soil conditions in Ormoc are as described below.

(1) General Soil Condition

Alluvial deposits in the study area are located only at a limited area of Ormoc City Proper and along the downstream river bank of Anilao-Malbasag River. The depth to the basement rock of Dolores formation is 10 m to 20 m, in general.

Alluvial deposits originating from river deposits consist of sand, gravel, silt and clay. Soil in the upstream, particularly along the valley having a very steep slope, are of a different soil material of young volcanic origin developed mainly from andesitic rocks. In general, these are loose, unstable and highly susceptible to erosion.

(2) Surface Soil Condition

A soil map of Ormoc City is provided from the results of the boring tests in the feasibility study, as shown in Fig. 3.4. There are only fluvial deposits in Ormoc City. The fluvial deposit is sand and gravel at the river mouth and clayey silt at the river bank in the hilly area.

For the detailed analysis of soil profiles and properties, refer to Sections 4 and 5 of this supporting report.

3.4 Tacloban

Soil conditions in Tacloban are as described below.

(1) General Soil Condition

The alluvial deposit in this area is narrowly distributed between the mountainous area and the hilly area where the whole reaches of the four rivers extend. The basement rock of the alluvial deposit is Tertiary sedimentary rocks of Bagahupi Formation and Sanricard Formation. The deposit is composed mainly of unconsolidated clay, silt, sand and gravel derived from older rocks deposited along river channels, flood plains and river mouths.

(2) Surface Soil Condition

A regional soil map has been provided by the Bureau of Soils, Department of Agriculture, as shown in Fig. 3.5. The study area consists of the following six (6) major soil formations. Detailed soil strata and thickness are described as follows:

(a) Obando Fine Sand (San Jose Cape, East of Alluvial Plain)

No strata data

(b) Pawing Fine Sandy Loam (Along Burayan River Basin)

Layer	Facies	Thickness
1st	Loose friable sandy loam	0.2m
2nd	Non-structural very loose coarse sand	1.3m

(c) San Manuel Silt loam (Alluvial Plain between Mountain and Hill)

No strata data

(d) San Manuel Fine Sandy Loam

No strata data

(e) Tacloban Clay (Along East Bank of Abucay River)

Layer	Facies	Thickness
1st	Coarse granular clay	0.25m
2nd	Slightly compact clay loam	0.25m
3rd	Coarse crumbly friable weathered shale	0.50m
4th	Massive shale	0.50m

(f) Palo Clay Loam

Layer	Facies	Thickness
1st	Slightly friable clay loam	0.25m
2nd	Slightly compact silty loam	0.20m
3rd	Friable slightly compact sandy loam	0.55m
4th	Very loose friable sand	0.50m

(3) Soil Profile

There is only one (1) profile provided based on the existing boring data. On the other hand, four (4) existing soil profiles covering the whole stretches of related rivers provided by Overall Drainage Master Plan Study have been obtained. The profiles, together with the location of existing boreholes, are shown in Fig. 3.6.

Based on the soil profiles provided, the soil strata of Tacloban City is classified as shown in Table 3.3. The table compiles N-value and range of thickness for each layer.

(4) Soil Property

Based on the available laboratory test results of the existing boreholes, soil properties for each layer are analyzed as shown in Table 3.4. The table shows the range and average of specific gravity, and water content. Raw data of the laboratory tests for the boreholes are not available in this profile, so that a summary of the results is quoted from the soil report of the Tacloban Fishing Port Project.