社会開発調査部報告書

NO. 52

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
REPUBLIC OF THE PHILIPPINES

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

FINAL REPORT

VOLUME 2

MAIN REPORT

FEBRUARY 1995

CTI ENGINEERING CO., LTD.
IN ASSOCIATION WITH
PACIFIC CONSULTANTS INTERNATIONAL

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
REPUBLIC OF THE PHILIPPINES

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

FINAL REPORT

VOLUME 2

MAIN REPORT

FEBRUARY 1995

CTI ENGINEERING CO., LTD.
IN ASSOCIATION WITH
PACIFIC CONSULTANTS INTERNATIONAL

LIST OF REPORTS

VOL. 1 SUMMARY

VOL. 2 MAIN REPORT

VOL. 3 SUPPORTING REPORT

VOL. 4 DATA BOOK

THE COST ESTIMATE IS BASED

ON THE PRICE LEVEL OF JUNE 1994

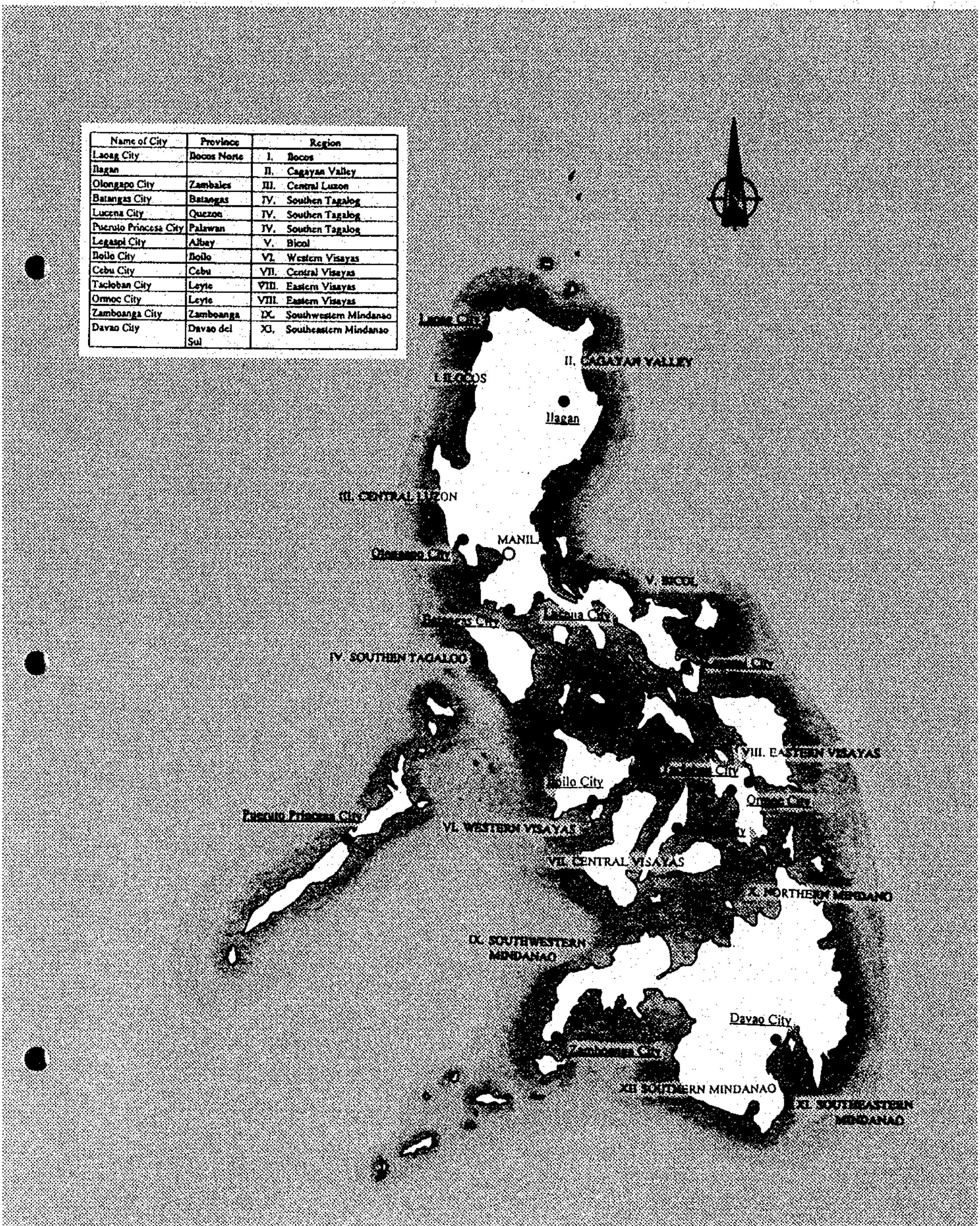
AND EXPRESSED IN PHILIPPINE PESO (₱)

ACCORDING TO THE FOLLOWING EXCHANGE RATES:

US$1.00 = ¥98.80

AND ₱1.00 = ¥3.67

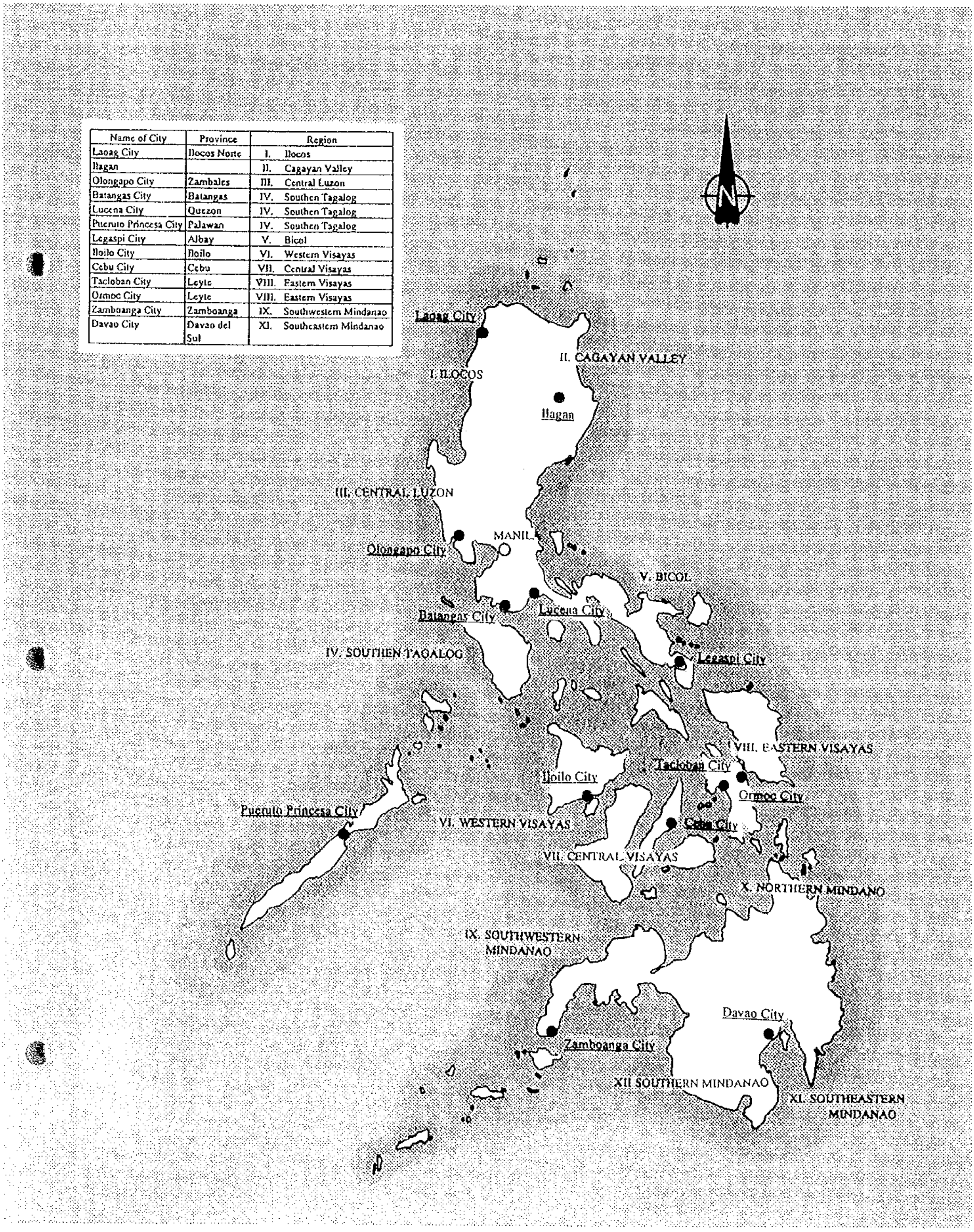
(AS OF JUNE 30, 1994)



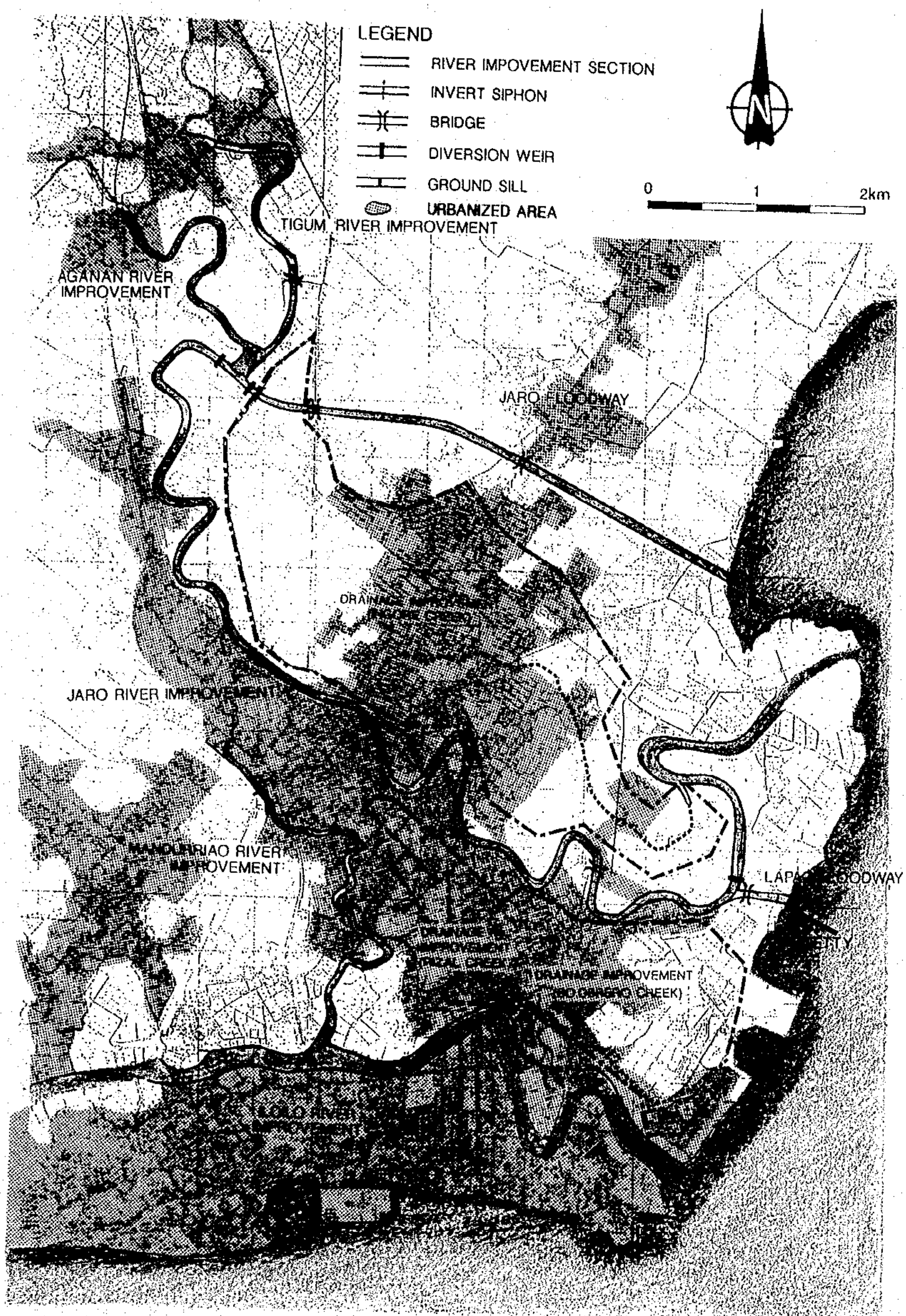
Name of City	Province	Region
Laoag City	Ilocos Norte	I. Ilocos
Ilagan		II. Cagayan Valley
Olongapo City	Zambales	III. Central Luzon
Batangas City	Batangas	IV. Southen Tagalog
Lucena City	Quezon	IV. Southen Tagalog
Puerulo Princesa City	Palawan	IV. Southen Tagalog
Legaspi City	Albay	V. Bicol
Iloilo City	Iloilo	VI. Western Visayas
Cebu City	Cebu	VII. Central Visayas
Tacloban City	Leyte	VIII. Eastern Visayas
Ormoc City	Leyte	VIII. Eastern Visayas
Zamboanga City	Zamboanga	IX. Southwestern Mindanao
Davao City	Davao del Sul	XI. Southeastern Mindanao

LOCATION MAP

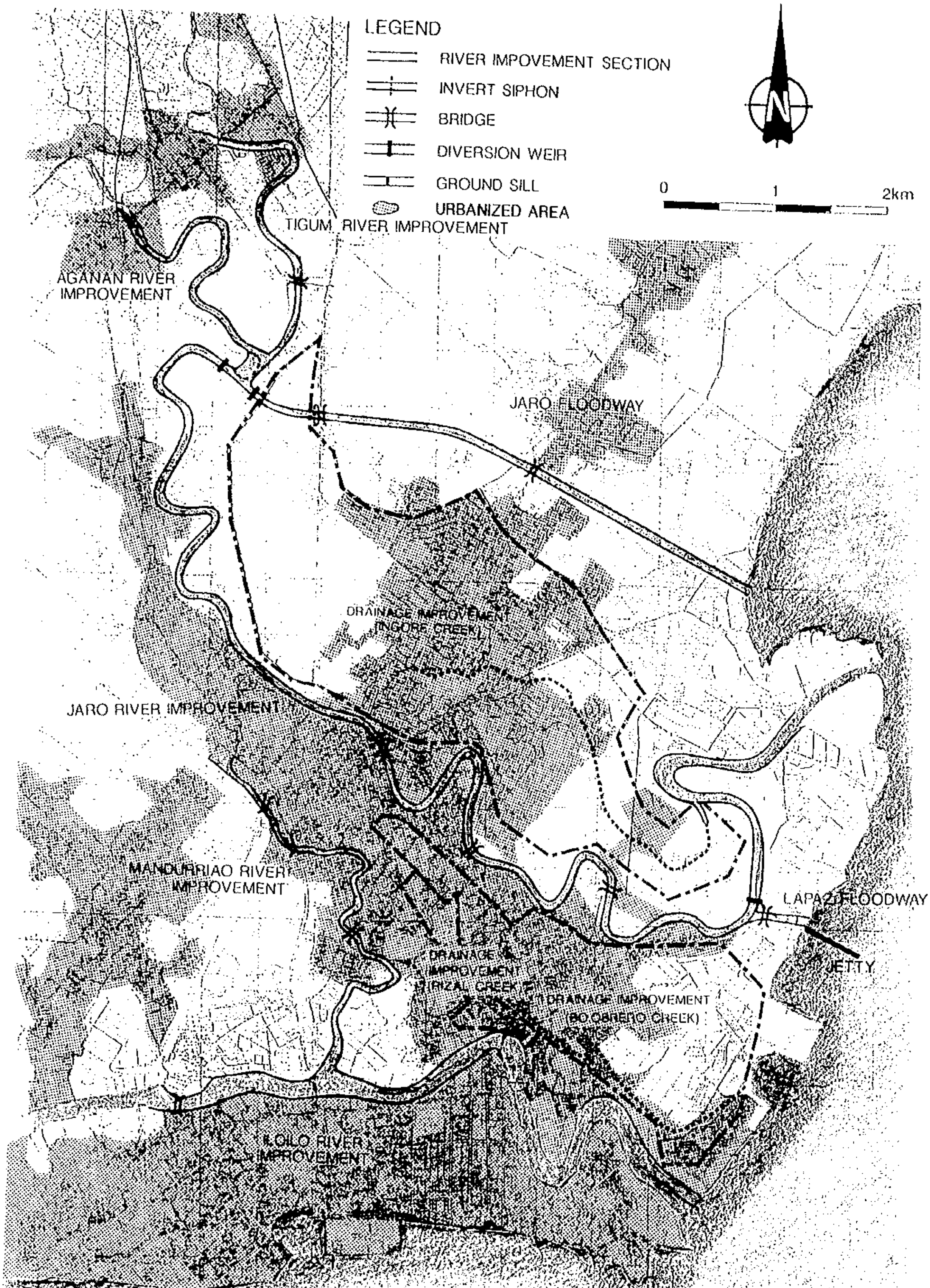
Name of City	Province	Region
Laoag City	Ilocos Norte	I. Ilocos
Ilagan		II. Cagayan Valley
Olongapo City	Zambales	III. Central Luzon
Batangas City	Batangas	IV. Southen Tagalog
Lucena City	Quezon	IV. Southen Tagalog
Puerto Princesa City	Palawan	IV. Southen Tagalog
Legaspi City	Albay	V. Bicol
Iloilo City	Iloilo	VI. Western Visayas
Cebu City	Cebu	VII. Central Visayas
Tacloban City	Leyte	VIII. Eastern Visayas
Ormoc City	Leyte	VIII. Eastern Visayas
Zamboanga City	Zamboanga	IX. Southwestern Mindanao
Davao City	Davao del Sul	XI. Southeastern Mindanao



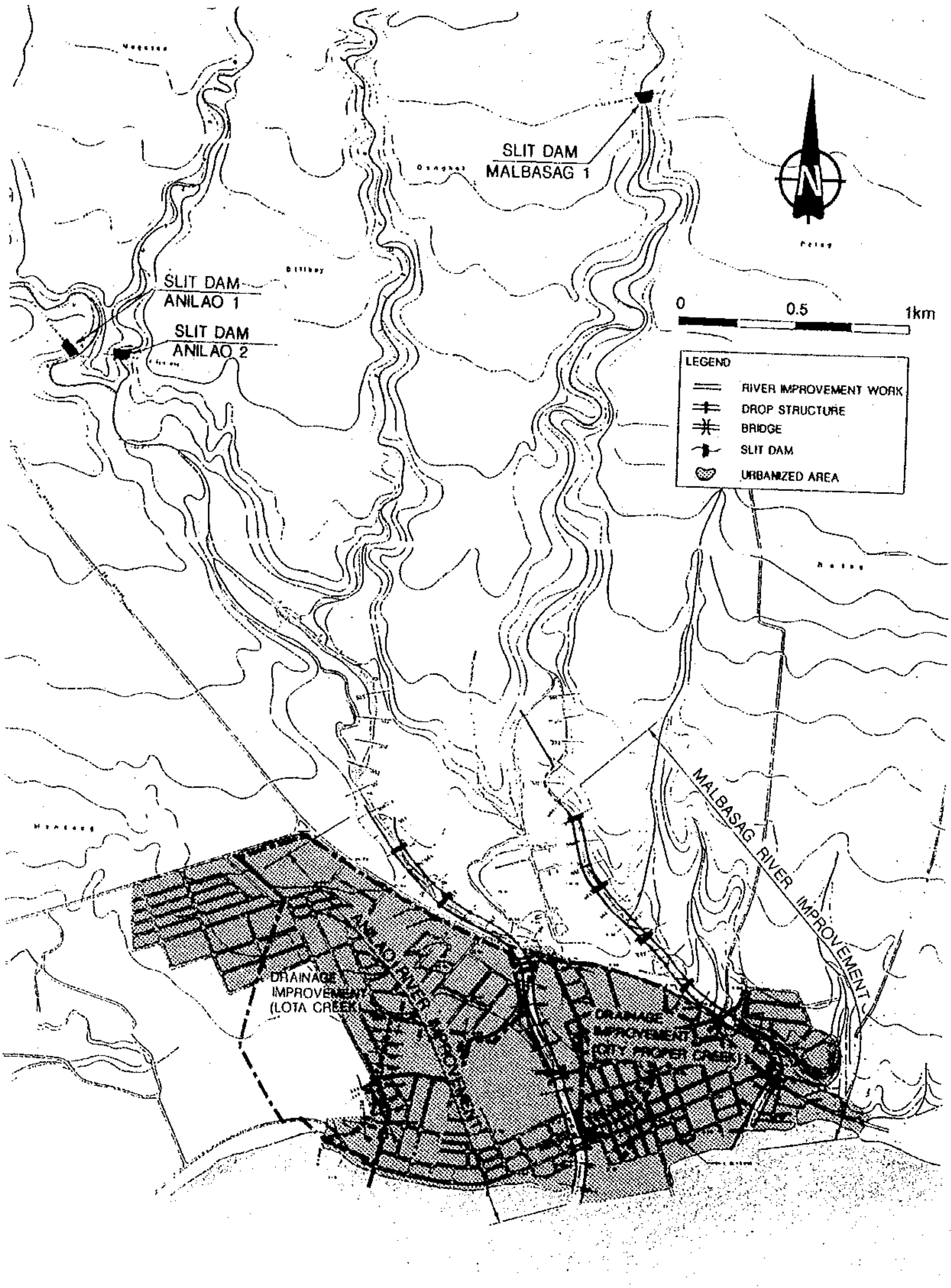
LOCATION MAP



GENERAL PLAN OF
FLOOD CONTROL PROJECT IN ILOILO CITY



GENERAL PLAN OF
FLOOD CONTROL PROJECT IN ILOILO CITY



GENERAL PLAN OF
FLOOD CONTROL PROJECT IN ORMOC CITY

PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a master plan and feasibility study on the Flood Control for Rivers in the Selected Urban Centers and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Katsuhisa Abe, CTI Engineering Co., Ltd., and composed of members from CTI Engineering Co., Ltd. and Pacific Consultants International, five times between January, 1993 and December, 1994.

The team held discussions with the officials concerned of the Government of the Philippines, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the Team.

February 1995

Kimio Fujita

KIMIO FUJITA
President
Japan International Cooperation Agency

February 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report on the Study on the Flood Control for Rivers in the Selected Urban Centers, Republic of the Philippines. The report contains the advices and suggestions of authorities concerned of the Government of Japan and the Japan International Cooperation Agency (JICA), as well as the formulation of river and drainage improvement projects. Also included are the comments made by the Department of Public Works and Highways, Government of the Republic of the Philippines during the technical discussion on the Draft Final Report in Manila.

The Final Report presents the Master Plan covering the four urban centers selected out of the thirteen objective cities proposed for the Study. It also presents the Feasibility Study on the river and drainage improvement projects for the two cities selected, Iloilo and Ormoc.

In view of the urgency and necessity of socio-economic development, we recommend that the Government of the Republic of the Philippines shall adopt all means possible to promote the river and urban drainage projects to the next stage of project implementation at the earliest possible time.

Finally, we wish to take this opportunity to express our sincere gratitude to the Government of Japan, particularly, JICA, the Ministry of Foreign Affairs, the Ministry of Construction and other offices concerned. We also wish to express our deep appreciation to the Department of Public Works and Highways and other authorities concerned of the Government of the Republic of the Philippines for the close cooperation and assistance extended to the JICA Study Team during the Study.

Very truly yours,

KATSUHISA ABE
JICA Study Team Leader

Encl.: a/s

STUDY ON FLOOD CONTROL OF RIVERS IN THE SELECTED URBAN CENTERS

FINAL REPORT

VOL. 2

MAIN REPORT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AGENCIES/ORGANIZATIONS

ADB	:	Asian Development Bank
BCGS	:	Bureau of Coast and Geodetic Survey
BOD	:	Bureau of Design, DPWH
BPW	:	Bureau of Public Works (former DPWH)
CAR	:	Cordillera Administrative Region
DENR	:	Department of Environmental and Natural Resources
DPWH	:	Department of Public Works and Highways
EDC	:	Energy Development Corporation
EMB	:	Environmental Management Bureau
GOP	:	Government of the Philippines
GOJ	:	Government of Japan
IBRD	:	International Bank for Reconstruction and Development (World Bank)
JICA	:	Japan International Cooperation Agency
LGU	:	Local Government Unit
LWUA	:	Local Water Utility Administration
MCDP	:	Metro Cebu Development Project
MCWD	:	Metro Cebu Water District
MIWD	:	Metro Iloilo Water District
MPWH	:	Ministry of Public Works and Highways (presently, DPWH)
NAMRIA	:	National Mapping and Resources Information Authority
NCR	:	National Capital Region, DPWH
NEDA	:	National Economic and Development Authority
NEPC	:	National Environmental Evaluation Commission
NIA	:	National Irrigation Administration
NGO(s)	:	Non-Governmental Organization(s)
NPC	:	National Power Corporation
NPCC	:	National Pollution Control Commission
NSCB	:	National Statistical Coordination Board
NSO	:	National Statistical Office
NWRB	:	National Water Resources Board
OCD	:	Office of Civil Defense, Department of National Defense
OECF	:	Overseas Economic Cooperation Fund, Japan
PAGASA	:	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PMO	:	Project Management Office, DPWH
PNOC	:	Philippine National Oil Company
PPA	:	Philippine Ports Authority
RDC	:	Regional Development Council
USC	:	University of San Carlos

ACRONYMS

BOD	:	Biological Oxygen Demand
DBMS	:	Database Management System
ECC	:	Environmental Compliance Certificate
ECP	:	Environmentally Critical Project
ECA	:	Environmentally Critical Area

EIA	:	Environmental Impact Assessment
EIS	:	Environmental Impact Statement
E/N	:	Exchange of Notes
GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
MSL	:	Mean Sea Level
MSHHWL	:	Mean Spring Higher High Water Level
PAR	:	Philippine Area of Responsibility
PD	:	Project Description
P.D.	:	Presidential Decree
PREMIUMED	:	Program for Essential Municipal Infrastructure, Utilities, Maintenance and Engineering Development
T-DS	:	Total Desolved Solids
T-SS	:	Total Suspended Solids
VA	:	Value Added

MEASUREMENTS/SYMBOLS

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer
g, gr.	:	gram
kg	:	kilogram
t, ton	:	metric ton
m^2	:	square meter
ha, has	:	hectare(s)
km^2	:	square kilometer
l, lt., ltr	:	liter
m^3	:	cubic meter
s, sec	:	second
min.	:	minute
hr	:	hour
yr	:	year
mm/hr	:	millimeter per hour
m/s	:	meter per second
km/hr	:	kilometer per hour
mg/l	:	milligram per liter
m^3/s	:	cubic meter per second
$m^3/s/km^2$	:	cubic meter per second per square kilometer
%	:	percent
¥	:	Japanese Yen
₱	:	Philippine Peso
$	:	US Dollar

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The geographical location and climatic conditions of the Philippines make it vulnerable to flood disasters. The annual average flood damage is estimated to be around 5.0 billion pesos, and losses due to recurrent disasters are serious obstacles to development.

The Government of the Philippines has been making continuous efforts to mitigate flood damage with the aim of providing a safer and a more pleasant living condition for the Filipino people. A flood control program has been provided, with 13.8% (1.91 billion pesos) of the 1994 DPWH Infrastructure Investment and is proposed with 24 billion pesos in the Medium Term Development Plan for 1993-1998.

However, most of the expenditures for flood control have been directed to Metro Manila and to large river basins having a catchment area of more than 1,400 km^2. Flood control works for medium and small rivers, especially in regional urban centers, have been neglected. Since the medium and small-scale river basins cover two-thirds of the whole land area of the Philippines, flood damage affecting a considerable lot of the population is always a hindrance to national socio-economic growth.

Serious flood damage takes place, especially in and around the regional urban centers such as provincial capitals and chartered cities located along the medium and small-scale rivers. These urban centers are expanding outwards due to the influx of population from rural areas, converting paddy fields into residential areas to absorb the increased number of inhabitants. The rapid urbanization had increased flood damage potential, but flood control works had been kept in abeyance due to financial constraints, or are limited to only emergency measures, good for particular circumstances.

It is essential to stimulate the regional economy through the even distribution of development works in future national development plans. A comprehensive flood control plan with a phased implementation program is imperative for medium and small-scale rivers nationwide, especially those flowing in regional urban centers.

In response to the request of the Government of the Republic of the Philippines (GOP), the Government of Japan (GOJ) decided to conduct the Study on Flood Control for Rivers in the Selected Urban Centers in the Republic of the Philippines (the Study). The Exchange of Notes (E/N) concerning the implementation of the Study was executed in Manila, Philippines on July 31, 1992.

The Study has been carried out in stages. The Japan International Cooperation Agency (JICA), the agency responsible for the implementation of technical cooperation programs of GOJ, dispatched the JICA Study Team (the Study Team) to the Philippines on January 6, 1993, to carry out the First Stage Study (Inventory Study). Through the Inventory Study, which was completed in February 1993, four (4) priority urban centers, namely; Iloilo City, Cebu City, Ormoc City and Tacloban City were selected for the Second Stage Study (Master Plan Study).

The Master Plan was carried out from March to November 1993. Compiled in the Interim Report are the results of the Inventory and the Master Plan Study, and two (2) cities, Iloilo and Ormoc, were selected for the Third Stage Study (Feasibility Study) which commenced on May 15, 1994.

This Final Report is prepared to present all the results of the three-staged Study.

1.2 Outline of the Study

1.2.1 Objective

The objectives of the Study are:

(1) To collect and compile the existing data on representative medium and small-scale rivers in thirteen (13) urban centers and prepare a river inventory based on the aforementioned data;

(2) To formulate a master plan on flood control for rivers located in the four (4) cities considered as priority areas for the Master Plan Study;

(3) To conduct a feasibility study on the most urgent flood control project identified in the Master Plan; and

(4) To carry out transfer of technical knowledge to Philippine counterpart personnel concerned through the foregoing series of studies and project formulation in the Philippines and in Japan.

1.2.2 Scope of Work

The Study is divided into three stages with work items enumerated as follows:

First Stage Study (Inventory Study)

(1) Related Data Compilation

(2) Preparation of Inventory Items and Form

(3) Preparation of Database Model

(4) Field Reconnaissance and Data Collection

(5) Inventory Survey

(6) Establishment of Database Model

(7) Selection of Urban Centers for Master Plan Study

Second Stage Study (Master Plan Study)

(1) Data Collection and Compilation

(2) Field Survey and Investigation

(3) Flood Damage Survey

(4) Socio-economy, Land Use and Environmental Study

(5) Hydraulic and Hydrological Analysis

(6) Study of the Framework of Flood Control and Urban Drainage Plan

(7) River and Topographic Survey

- River Survey
- Channel Survey
- Leveling

(8) Riverbed Material Survey

(9) Installation of Hydrological Equipment

(10) Preliminary Environmental Survey

(11) Flood Inundation and Damage Analysis

(12) Basic Design of Flood Control Plan

(13) Preliminary Design

(14) Construction Plan and Cost Estimate

(15) Project Evaluation

(17) Formulation of Master Plan

(18) Selection of Priority Project

Third Stage Study (Feasibility Study)

(1) Supplemental Data Collection

(2) Additional Hydrological Analysis

(3) Study on Project Features

(4) Preparation of Program for Seminar on Flood Control

(5) Additional River and Topographic Survey
   - River Survey
   - Channel Survey
   - Topographic Survey

(6) Geological and Soil Mechanics Investigation

(7) Environmental Study

(8) Structural Design

(9) Construction Plan

(10) Cost Estimation

(11) Project Evaluation

(12) Conclusion of Feasibility Study

(13) Seminar on Flood Control Plan of Medium and Small-Scaled Rivers

Transfer of Knowledge

(1) On-the-Job training throughout the field survey

(2) Periodical lectures and discussions with the counterpart personnel in the Philippines

(3) Training of three (3) counterpart personnel in Japan

1.2.3 Organization for the Study

JICA had established an organization consisting of the Advisory Committee and the Study Team. The Advisory Committee was responsible to JICA for the advisory to the Study Team so as to ensure the successful execution and completion of the Study. The Study Team was responsible to JICA for solving technical problems, when encountered, after consultation with the Advisory Committee.

The members of the Advisory Committee and the Study Team are listed, together with their designations and assignments, in Tables 1.1 and 1.2. The members of the Steering Committee and the Technical Working Group organized by the Government of the Philippines are given in Tables 1.3 and 1.4, respectively.

(1) Study Schedule

The Study was conducted in the Philippines and in Japan in accordance with the time schedule shown in Fig. 1.1.

(2) Counterpart Personnel

For the smooth execution and successful completion of the Study, counterpart personnel were assigned by the DPWH as listed in Table 1.5.

CHAPTER 2 INVENTORY STUDY

2.1 Present Condition

2.1.1 Geography

The Philippines, one of the largest archipelagoes in the world, has 7,107 islands and covers an area of approximately 300,000 km^2. It consists of three major island groups: Luzon with an area of 141,395 km^2; Visayas with 56,606 km^2; and Mindanao with 101,909 km^2.

The study area for the river inventory shall cover the representative medium and small-scale rivers in the thirteen (13) selected urban centers (hereinafter referred to as SUC or SUCs); namely, the cities of Laoag, Ilagan, Olongapo, Batangas, Lucena, Puerto Princesa, Legaspi, Iloilo, Cebu, Tacloban, Ormoc, Zamboanga and Davao. The area and population of the urban centers and their related river basins are given as follows:

Item No.	Name of SUC	Area (km^2)	Population (1990)	Related Rivers	Catchment Area (km^2)
1.	Laoag	108	83,756	Laoag	1,319.0
2.	Ilagan	1,394	99,120	Ilagan	1,840.0
3.	Olongapo	103	193,327	Sta. Rita	95.0
4.	Batangas	283	184,970	Kalumpang	406.0
5.	Lucena	69	150,624	Tayabas	269.0
6.	Puerto Princesa*	2,107	92,147		
7.	Legaspi	154	121,116	Yawa	70.0
				Macabalo	25.0
8.	Iloilo	56	309,505	Jaro	412.0
				Iloilo	106.0
9.	Cebu	281	610,417	Bulacao	10.7
				Kinalumsan	17.8
				Guadalupe	16.3
				Lahug	6.3
				Subang Daku	12.6
10.	Tacloban	464	136,891	Mangonbangon	4.9
				Abucay	2.4
				Burayan	6.5
11.	Ormoc	101	129,456	Anilao	25.2
				Malbasag	11.1
12.	Zamboanga	1,415	442,345	Tumaga	228.0
13.	Davao	2,211	849,947	Davao	1,623.0
Total		8,746	3,403,621		6,506.8

* Puerto Princesa is not related to or affected by any river.

2.1.2 Hydrology

Climatic Classification

Using the average monthly distribution of rainfall at different stations, Corona defined four types of such rainfall distribution are defined in the Philippines as follows (refer to Fig. 2.1):

Type I : The first type which has two pronounced seasons, dry from November to April and wet during the rest of the year, is predominant in the cities of Laoag, Olongapo, Batangas and Iloilo.

Type II : The second type which is characterized with no dry season with a very pronounced maximum rainfall from November to January is predominant in the cities of Legaspi and Tacloban.

Type III : The third type which is characterized with no pronounced season and relatively dry from November to April and wet during the rest of the year is predominant in the cities of Lucena, Puerto Princesa and Zamboanga.

Type IV : The fourth type which is characterized with evenly distributed rainfall throughout a year is predominant in the cities of Ilagan, Cebu, Ormoc and Davao.

Rainfall

Rainfall in the Philippines is brought about by different rainfall causing weather patterns such as air streams, tropical cyclones, the Intertropical Convergence Zone (ITCZ) and to a lesser extent, by fronts, easterly wave, local convection, etc. Rainfall intensity is influenced by latitude or geographical setting, topography and exposure, and the season. In a recent study, it has been shown that 47% of the average annual rainfall in the country is attributed to the occurrence of tropical cyclones in the vicinity. The northeast and southwest monsoons each contribute 7%. The remaining 39% is due to the combined effects of the ITCZ, shearline, easterly waves and other rainfall-causing weather patterns.

To evaluate the safety of SUCs and their related rivers against flood, extreme rainfall conditions were analyzed on the basis of daily rainfall, as mentioned below:

(1) Maximum Daily Rainfall

The maximum daily rainfall which measures the scale of floods is recorded to be higher in Luzon Region and less in the Visayas and Mindanao regions. The recorded first, second and third maximum daily rainfalls for each SUC are given in the following table:

(Unit: mm/day)

Item No.	City	1st Max. Rainfall	2nd Max. Rainfall	3rd Max. Rainfall	Recording Period
1.	Laoag	510.3	498.4	437.2	31 yrs. (1961-1991)
2.	Ilagan	746.0	349.7	345.4	31 yrs. (1961-1991)
3.	Olongapo	471.8	449.4	422.3	18 yrs. (1975-1992)
4.	Batangas	765.8	499.2	283.6	31 yrs. (1961-1991)
5.	Lucena	557.7	359.7	306.0	20 yrs. (1970-1989)
6.	P. Princesa	269.3	265.9	252.0	31 yrs. (1961-1991)
7.	Legaspi	484.6	458.6	432.3	31 yrs. (1961-1991)
8.	Iloilo	303.0	255.6	203.8	31 yrs. (1961-1991)
9.	Cebu	374.0	129.0	112.8	19 yrs. (1972-1991)*
10.	Tacloban	204.0	167.9	163.6	31 yrs. (1961-1991)
11.	Ormoc	259.1	257.8	217.1	22 yrs. (1971-1992
12.	Zamboanga	193.2	138.7	117.5	30 yrs. (1971-1990)
13.	Davao	174.3	150.3	149.6	31 yrs. (1961-1991)

* Recording period except 1990.

(2) Probable Daily Rainfall

Probable daily rainfalls are estimated for the representative rainfall stations by means of the Gumbel Method, as follows:

(Unit: mm/day)

Item No.	City	2-Yr	5-Yr	10-Yr	20-Yr	50-Yr	100-Yr
1.	Laoag	200	300	370	430	510	570
2.	Ilagan	170	260	320	370	450	500
3.	Olongapo	190	280	350	410	490	540
4.	Batangas	160	240	290	330	400	440
5.	Lucena	170	260	330	390	470	530
6.	P. Princesa	110	180	220	260	320	360
7.	Legaspi	190	280	340	400	470	520
8.	Iloilo	110	180	220	260	320	360
9.	Cebu	80	120	150	180	210	240
10.	Tacloban	120	150	170	200	220	240
11.	Ormoc	130	200	240	280	330	370
12.	Zamboanga	80	120	140	160	190	210
13.	Davao	100	130	150	170	190	210

Tropical Cyclones

Tropical cyclones contribute largely to the rainfall in the Philippines from June to December. About 47% of rainfall is associated with these cyclones. They affect prevailing winds, humidity and cloudiness, and are usually responsible for maximum values of rainfall and wind minimal pressure observed in many places.

Fig. 2.2 shows the mean percentage frequency of tropical cyclone passage in the different parts of the Philippines.

River Runoff

There are a few streamflow gauging stations in and around the study area. The maximum discharge and mean monthly discharge of the related rivers are given in Table 2.1. The range of specific discharge in the related river basins is from 1.2 $m^3/s/km^2$ to 15.3 $m^3/s/km^2$.

The range of runoff coefficient of the related rivers is estimated to be from 57% to 99%, and the average runoff coefficient is about 75%. The study by NWRC/BRS gives the relation of runoff to size of drainage area for Philippine rivers, as shown in Fig. 2.3.

2.1.3 Socio-Economy

Administration

The 13 SUCs selected for the medium and small-scale river basin study are distributed in Regions and Provinces, as follows:

Item No.	Name of SUC	Region No.	Province Related to River Basin and SUC
1.	Laoag	I	Ilocos Norte
2.	Ilagan	II	Isabela, Quirino, Aurora
3.	Olongapo	III	Zambales, Bataan
4.	Batangas	IV	Batangas
5.	Lucena	IV	Quezon
6.	Puerto. Princesa	IV	Palawan
7.	Legaspi	V	Albay
8.	Iloilo	VI	Iloilo
9.	Cebu	VII	Cebu
10.	Tacloban	VIII	Leyte
11.	Ormoc	VIII	Leyte
12.	Zamboanga	IX	Zamboanga del Sur
13.	Davao	XI	Davao del Sur, Davao

Population

Among the 13 SUCs, the largest SUCs in terms of population are the cities of Davao, Cebu, Zamboanga and Iloilo in order of the number of population, which have more than 300 thousand in the 1990 census. Regarding population growth rate between 1980 and 1990, Puerto Princesa City had attained the highest annual rate of 4.2% on average. Succeedingly, Lucena, Davao, Tacloban, Batangas and Zamboanga have grown at a higher rate than the national average rate of 2.4% per annum. Laoag City showed the lowest rate of 1.9% per annum. (as shown in Table 2.2)

The city population in the 1990 census was classified into urban and rural populations. Table 2.3 shows the urban and rural populations and their density in the 13 SUCs. The following five (5) SUCs have been identified as the most densely inhabited Poblacions among 13 SUCs: Ormoc, Batangas, Davao, Laoag and Iloilo in order of population density. In the case of Ormoc City, the density of 221 persons/ha seems to be too big for urban people to live with comfort. On the other hand, the Poblacions of Zamboanga, Tacloban and Olongapo recorded the lower population density; less than 20 persons/ha. In particular, that of Zamboanga City was only 9.7 persons/ha.

Gross Regional Domestic Product

Gross Regional Domestic Product (GRDP) of the respective Regions are shown in Tables 2.4(1) and 2.4(2). Among all Regions in the country, the National Capital Region (NCR, Metro Manila) attained the largest share in GDP, accounting for ₱346 billion in 1990 or almost one-third of the GDP. GRDP per capita of NCR was ₱43,524, which was approximately 2.5 times that of the country.

Among Regions related to the 13 SUCs, GRDP of Region IV (Southern Tagalog) was the largest, ₱148 billion in 1990. It shares approximately 14% of the GDP. Its GRDP per capita was ₱17,863, almost the same as the national one. Per capita GRDPs of other Regions were lower than the national average. Only Region XI (Southern Mindanao) attained close to the national average. The lowest value of GRDP per capita was shown in Region V (Bicol), accounting for ₱7,896 or less than half of the national one.

The Region which showed the highest growth of GRDP in 1990 is Region III (Central Luzon). It grew at 7.1%. The second highest growth was attained by Region VII at 3.9% as shown in Table 2.4(2). Regarding the growth of GRDP per capita, the following three Regions could slightly exceed the national growth rate of 2.3% per annum during 1985 to 1990: Region VII, Region III and Region V. Hence, the disparity between the regional per capita GRDPs and the national one has gradually been increasing as understood in Table 2.4(1).

Present Land Use

Table 2.5(2) shows the existing land use by region concerned in the 13 SUCs on the basis of the above broad categories. In the country, the settlement area accounted for 7,197 km^2 or 2.4% of the total area. In the same manner, the agricultural area occupied 88,443 km^2 or 29.5% and inland fishery, 6,758 km^2 or 2.2%. In particular, the NCR area is classified into these three categories only, i.e., 93% of settlements, 6% of agriculture, and 1% of inland fishery. The region, having the largest share of settlements, is Region VII. Of the total regional land area, 921 km^2 or 6.2% is used for settlement. On the other hand, Region II recorded the smallest share for settlements, which accounted for 29.4 km^2 or 0.8%. It also had the smallest share for agricultural land accounting for 5,134 km^2 or 14.1%. On the contrary, Region V had the largest share for agricultural purposes, which accounted for 8,273 km^2 or 46.9%.

2.2 Floods and Flood Control Works

2.2.1 Flood Problems

Floods in the SUCs, in general, occur as a result of overbank flow of rivers and stagnant water due to inadequate drainage systems during periods of intense storm runoff. As shown in Table 2.6, the total flood area in the city proper of the 13 SUCs is 2,385 ha or 2.2% of the whole urbanized area.

Among the 13 SUCs, the five (5) largest cities in terms of flood area are Iloilo, Legaspi, Laoag, Ormoc and Cebu, which have more than 190 ha of the flood area in each city proper. Regarding the ratio of flood area to the total urbanized area of the city proper, Ormoc City has the largest flood area ratio, followed by Batangas, Laoag and Iloilo, which have more than 9% of flood area's ratio.

As to flood depth and duration, Laoag, Ilagan, Legaspi, Iloilo and Ormoc have more severe conditions than other SUCs because the major cause of floods in those five SUCs is the overbank flow of rivers.

2.2.2 Flood and Damage

The Office of Civil Defense (OCD), Department of National Defense has compiled damage records of major typhoons that occurred at the 13 SUCs, as enumerated in Table 2.7. Although the OCD damage records cannot be directly substituted as flood damages, they indicate the tendency of flood damage conditions, because most of the major floods occurred during the typhoons.

Among the SUCs, Ormoc City has the largest casualty of 4,561 dead with total direct damages amounting to 560 million pesos. The damage in Ormoc City was mostly caused by Typhoon Uring on November 5, 1991.

In terms of population affected by the typhoon, the largest are Cebu, Legaspi, Ormoc, Tacloban and Iloilo in order of population scale, which have more than 100 thousand in the records. The largest affected population of 638 thousand in Cebu City for the last 11 years was brought by the inadequate capacity of rivers and drainage systems with intense rainfall in the busy city areas. Therefore, the direct damage amount of 278 million pesos in Cebu City for the last 11 years, which ranked only 4th highest among the 13 SUCs, would definitely increase taking the indirect damage in the busy city areas into account.

The Municipality of Ilagan, compared with other cities, had only minor damages, therefore, OCD had not compiled any flood damage records in the past 11 years.

2.2.3 Existing Flood Control Works

Existing flood control works are given as follows:

(1) River

The conditions of existing flood control works for medium and small-scale rivers in the Philippines are summarized as follows. The inventory is given in Table 2.8.

(a) Main river flood control works are bank protection works with boulder concrete revetments, or concrete walls without embankment.

(b) These structures were designed based on the records of past floods.

(c) There is no comprehensive master plan of flood control for the medium and small-scale rivers except Laoag and Yawa rivers which have rather old plans.

(d) Maintenance works of flood control structures are usually inadequate due to budgetary constraints.

(e) Riparian areas behind river walls have suffered from floods due to lack or insufficiency of drainage facilities.

(f) Expansion of SUC urban areas to low-lying areas has increased the flood damage potential.

(g) Most small-scale rivers in urban areas are clogged with heavy siltation and dumping of solid waste/garbage.

As mentioned above, the existing flood control works have been partially provided only to prevent bank failure, not overflow. Therefore, every river requires river improvement works under a comprehensive master plan of the river basin.

(2) Drainage

The results of inventory of the existing drainage systems are given in Table 2.9, and summarized as follows:

(a) The planning and designing of drainage systems in the SUCs are conducted by the Planning Division of each City Government, and construction is executed by the City Engineer's Office.

(b) For the SUCs, drainage networks are constructed for densely populated areas; the surrounding areas have no drainage works.

(c) Only drainage pipes were installed at many places without overall plans have not been formulated. Therefore, inundation has been chronic due to the insufficient capacity of pipes.

(d) Maintenance of drainage systems are rarely executed by local government organizations concerned.

(e) Siltation in the pipes and deterioration of pipe capacity are remarkable.

2.3 Selection of Master Plan Study Area

In this section, the four (4) master plan study SUCs are selected on the basis of the findings described in the previous section.

2.3.1 Prioritization of SUCs

To select the master plan study areas, the priority of each SUC has been determined on the aspects of necessity, urgency, benefit, and regional equality. These four aspects are evaluated by the following factors with data and information collected in the Inventory Study.

Item No.	Aspect	Evaluation Factor
1.	Necessity	Extent of floods
2.	Urgency	Flood control capacity
3.	Benefit	Extent of flood damage
4.	Regional Equality	Improvement program

Values of the evaluation factors are still broad. Therefore, quantification of the factors should have some limitation in accuracy which are considered allowable in such prioritization procedure. An outline of the criteria for prioritization of each SUC in respect of the above four aspects adopted is given below.

(1) Necessity

To evaluate the priority of necessity of flood control and drainage projects in each SUC, the flooding condition factors expressed by affected areas, depth, duration and people are employed. Higher priority is given to the SUC with more severe flooding conditions.

(2) Urgency

The priority of urgency for project implementation is evaluated using the factors of present flood control capacity of rivers and drainage systems as well as risk of loss of human life by floods. As for the capacity of rivers, occurrence of river flood in each SUC is employed as the substituted factor for flood control capacity, because there is no sufficient data and information available to evaluate river flow capacity. Higher point is given to the SUC with occurrence of overflow.

For the capacity of drainage systems, higher point is given to smaller covering ratio of drainage service area.

Casualties of the SUCs brought by the floods in the last 11 years from 1982 to 1992 are substituted for the risk of human life. Higher point is given to the SUC with a bigger number of casualties.

(3) Benefit

As for the aspect of project benefit, the priority is evaluated using the flood damage amount for the last 11 years from 1982 to 1992.

Since the flood damage is not available, typhoon damage compiled by OCD is substituted for the flood damage in each SUC for this priority study. Higher point is assigned to the larger flood damage.

(4) Regional Equality

Taking the information of ongoing programs into consideration, the priority of regional equality in investment is evaluated for both river and drainage improvement programs. Higher point is given to the SUC which has no comprehensive improvement program.

2.3.2 Selection of Study Area

The cumulative point of priority ranking for each SUC is summarized in Table 2.10. It indicates that the SUC ranked at the highest is Ormoc, followed by Tacloban. Iloilo, Cebu, Legaspi and Laoag, which have more than 10 points in the evaluation.

Evaluation Point	Urban Center
10 to 12 points	Ormoc, Tacloban, Iloilo, Cebu, Legaspi and Laoag
8 to 9 points	Olongapo, Batangas, Lucena, Zamboanga Davao and Ilagan
6 to 7 points	P. Princesa

As discussed and agreed between DPWH and the JICA Preparatory Survey Team, the four (4) SUCs of Tacloban, Ormoc, Cebu and Iloilo are evaluated to have higher priority among the 13 SUCs, and Legaspi and Laoag are also ranked at the same priority. Therefore, the first four (4) SUCs are selected as the master plan study areas.

2.4. Formulation of Database Model

The structure of the model is described below.

(1) Relational Database Management System (RDBMS)

A database management system (DBMS) is a collection of related programs for loading, accessing and controlling a database. The database is independent of the programs that process the information, and a system may have several databases within one database management system. The most fundamental property of a relational database management system is that data are presented to the user as tables. Thus, the data consist of rows and columns, with the rows corresponding to traditional database records or segments and the columns representing fields within the records.

"Join" is a RDBMS operation capable of combining relational tables. Another relational operation is "Selection," creating a subset of all the records in a table. A relational operation always produces new tables. This makes it possible to provide very powerful and concise languages for the manipulation of relational data structures.

(2) Hardware and Software

One set of personal computer and some application programs were provided for this system during the First Field Study, as follows:

(a) Personal computer: AcerMate 386SX133

(b) Printer: HP LASERJET III Plus

(c) Lotus 123 (Multipurpose tabulation software)

(d) dBASE IV (Database software)

(3) Model Structure

An outline of the database management system is shown in Fig. 2.4 and the structure of the database model is shown in Fig. 2.5. This system can be composed of the following functions:

(a) Data Input Function

To enter the following information and records:

- Area data (population, household, area, etc.)
- Industrial data (GRDP, production, land use, etc.)
- Meteo-hydrological data (rainfall, discharge, etc.)
- River information (dimensions, embankment, etc.)
- Flood control structures (sluice, river gate, pump station, etc.)
- Water use (municipal water, irrigation, etc.)
- Urban drainage channel/creek
- Flood damage (inundation area, damage, etc.)

(b) Search Function

To search information and records by specified range.

(c) Display and Print Function

To display the searched information and records on screen and print out.

(d) Assist Function

To arrange records graphically on screen and print out.

(4) Input/Output Method

The input/output form for this database is attached as Annex. The output form is arranged and programmed to access project and its necessity, urgency, benefit and regional equality.

CHAPTER 3 STUDY AREA

The Master Plan covers four (4) cities; namely, Iloilo, Cebu, Ormoc and Tacloban, which include the 12 related river basins of the Jaro, Iloilo (Iloilo City), Bulacao, Kinalumsan, Guadalupe, Lahug, Subang Daku (Cebu City), Anilao, Malbasag (Ormoc City), Abucay, Mangonbangon, and Burayan (Tacloban).

Some drainage areas not covered by the present flood control plan for the 12 rivers and identified to be presently urbanized with frequent floods due to the inadequate flow capacity of the major drainage channels are also included.

Totally, therefore, 21 drainage areas having an aggregate area of approx. 52 km^2 were selected to formulate the Master Plan; namely, three (3) in Iloilo, nine (9) in Cebu, two (2) in Ormoc and seven (7) in Tacloban.

3.1 Hydrology

3.1.1 Rainfall Analysis

Probable Maximum Daily Rainfall

Probable maximum daily rainfalls at the respective stations have been computed by the Iwai Method, as summarized below:

(Unit: mm/day)

Return Period	Iloilo	Cebu Lahug	Ormoc Merida	Tacloban
2	121.1	91.4	130.7	119.9
5	159.6	123.5	184.7	146.1
10	191.7	145.7	221.7	161.2
20	227.3	167.5	259.1	174.5
50	280.7	196.7	309.5	190.2
100	326.7	219.4	349.0	201.3

Rainfall Intensity and Duration

Intensity-duration curves can be put into the Talbot Formula, as follows:

$$I = b / (t+a)$$

where;

I	:	rainfall intensity (mm/hr)
t	:	storm duration (min.)
a, b	:	regression coefficients to be derived by analytical method employing the least square method.

As for Ormoc City, neither hourly rainfall data nor intensity-duration analysis is available. Therefore, the intensity-duration curve of Tacloban is adopted. The probable daily rainfall in Ormoc is analyzed by correlation between Merida and PNOC-EDC stations. The probable daily rainfall of Merida Station is adopted by means of the Iwai Method.

$$Ror = 2.008\ Rmr + 50.0$$

where;

Ror	:	daily rainfall in Ormoc (mm/day)
Rmr	:	daily rainfall in Merida (mm/day)

Design Hyetograph

The storm rainfall duration is fixed at 24 hours. The hourly rainfall distribution is assumed to have a center-concentrated pattern which is commonly applied to the estimation of design flood runoff. Design hyetograph is constructed by using the intensity-duration-frequency equation of PAGASA for its hourly distribution and the Iwai Method for its probable daily (24-hour) rainfall, as presented in Fig. 3.1.

Basin Mean Probable Rainfall *(R_m)*

The basin mean rainfall is estimated by the area conversion factor, together with the adjustment coefficient of altitude.

$$R_m = f \cdot R_0$$

where;

R_m	:	basin mean probable rainfall
R_0	:	point rainfall

f : conversion factor

$f = f_a \cdot f_e$

where; f_a: area conversion factor

f_e: altitude adjustment factor

City	River	Catchment Area at Base Point (km²)	Altitude of Representative Rainfall Station (m)	Mean Altitude of River Basin (m)	f_a	f_e	Conversion Factor (f)
Iloilo	Jaro	412.1	10	190	0.62	1.0	0.62
	Iloilo	93.1	10	20	0.74	1.0	0.74
Cebu	Bulacao	10.7	40	400	0.86	1.3	1.12
	Kinalumsan	17.8	40	180	0.83	1.1	0.91
	Guadalupe	16.3	40	320	0.84	1.2	1.01
	Lahug	6.3	40	220	0.88	1.2	1.06
	Subang Daku	12.6	40	60	0.85	1.0	0.85
Ormoc	Anilao	25.2	400	250	0.82	0.83	0.72
	Malbasag	11.1	400	200	0.85	0.87	0.74

3.1.2 Flood Runoff Analysis

River System Model

The river system model has been constructed for the flood runoff analysis of shapes, stream networks and topographies of the different river basins. The model comprises all the elements of a river system such as subbasins and channels. These elements are linked together by computation points. A base point is the principal point among computation points to evaluate the design flood discharge for the formulation of a flood control plan.

Subbasin areas of the nine (9) rivers are shown in Table 3.1. The basin divisions including all basin components and river system model of the related rivers are shown in Fig. 3.2 to 3.7.

Methodology

The river runoff computation has been carried out by the unit hydrograph derived from Nakayasu's Synthetic Unit Hydrograph Method, while flood routing along the Jaro and Iloilo rivers has been calculated by the storage function method.

Effective Rainfall

The effective rainfall has been evaluated by both saturation rainfall and primary runoff rate. The saturation rainfall is the infiltration depth depending on the antecedent rainfall and geological conditions, while the primary runoff rate is dominated by land use. Considering the geological conditions of the study area, saturation rainfall is taken as 100 mm for Iloilo, Cebu and Tacloban, and 300 mm for Ormoc. Furthermore, saturation rainfall of the Iloilo river basin is estimated to be higher by 50 mm than the Jaro river basin, because the Iloilo river basin mostly consists of paddy fields where there is more storage of rainfall.

The primary runoff rate employed is generally 0.5, while it is 0.8 in Cebu on account of the highly urbanized land use.

Probable Flood Discharge

Probable flood discharges of the rivers are computed for 2, 5, 10, 20, 50 and 100-year return periods. The probable discharges at respective base points are as given below:

(Unit: m^3/s)

City	River	2-yr.	5-yr.	10-yr.	20-yr.	50-yr.	100-yr.
Iloilo	Jaro	360	493	696	966	1,391	1,765
	Tigum*	146	204	293	415	616	797
	Aganan*	214	289	403	551	775	968
	Iloilo	190	255	314	390	584	774
	Mandurriao*	36	45	54	63	91	119
Cebu	Bulacao	110	140	164	187	214	236
	Kinalumsan	109	140	162	185	213	235
	Guadalupe	118	153	177	202	233	257
	Lahug	63	80	93	106	121	134
	Subang Daku	107	138	160	181	209	229
Ormoc	Anilao	247	313	362	453	603	719
	Malbasag	129	162	195	250	328	387

* Major tributary

The specific discharges of 50-year return period were also estimated as tabulated below for comparison with those of other river basins, while the flood discharges were estimated by rounding off the computed probable discharges.

City Name	River Name	Basin Area (km^2)	Peak Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
Iloilo	Jaro	412.1	1,400	3.4
	Tigum*	213.3	600	2.8
	Aganan*	198.8	800	4.0
	Iloilo	93.1	600	6.4
	Mandurriao*	9.9	100	10.1
Cebu	Bulacao	10.7	220	20.6
	Kinalumsan	17.8	240	13.5
	Guadalupe	16.3	260	16.0
	Lahug	6.3	140	22.2
	Subang Daku	12.6	230	18.3
Ormoc	Anilao	25.2	610	24.2
	Malbasag	11.1	330	29.7

* Major tributary

The specific discharges were compared with those estimated for other river basins, as shown in Fig. 3.8. The computed flood discharge is within the range of flood discharge for rivers in the Philippines. This justifies the method and parameters employed in the computation for rivers in the study area.

Probable Discharge for Drainage Area

Probable flood discharge for the urban drainage area was computed using the Rational Formula. Due to the scarcity of flood discharge data and corresponding rainfall records during floods, the runoff coefficient was determined according to the table below depending on the land use conditions. Peak discharges of drainage areas in the four cities are shown in Table 3.2.

Land Use in River Basin	Runoff Coefficient
Urban Area-1 (Low Density, Residential)	0.50
Urban Area-2 (Middle Density, Residential)	0.65
Urban Area-3 (High Density, Residential)	0.80
Mountain and Hill of Tertiary	0.70 - 0.80
Rolling Land and Forest	0.50 - 0.75
Basin with Around Half of Flat Land	0.50 - 0.75

Source: Nationwide Flood Control Plan and River Dredging Program (DPWH, 1982)

Design Hydrograph

Design hydrographs at the base points in the related rivers are shown in Fig. 3.9 to 3.11. The probable flood discharge was estimated for the base point of each river, as shown in Fig. 3.12 to 3.14.

3.1.3 Flood Inundation Analysis

Flood Inundation Model

According to the inundation conditions on record, flood discharge beyond the river channel flow capacity widely spread over the low land. To express the hydraulic condition, the Two-Dimensional Unsteady Flow Model was employed under the following conditions:

(1) The whole flood-prone area is divided into mesh blocks of 250 m by 250 m, but mesh blocks of 125 m by 125 m are applied for Ormoc City because of its comparatively small flooding area.

(2) The average ground height of each mesh is obtained using the topographic map with the scale of 1/5,000 or 1/10,000 prepared in this Study.

(3) Structures such as roads and railways which may hamper the smooth flow of inundation water are taken into consideration assuming them as weirs between the mesh blocks.

(4) Flood discharge overtop at points with low flow capacity and spread over the inundation area.

On the other hand, stormwater inundation along the primary drainage channel was analyzed by means of uniform flow computation for each cross-section of the channel. The inundation area for each channel was delineated by enveloping the inundation width at each cross-section.

Results of Inundation Analysis

The maximum inundation areas and depths of a 50-year return period flood in each river are expressed in both patterns and figures and shown in Fig. 3.15.

3.2 Rivers

3.2.1 River System

Iloilo City

(1) Jaro River

Jaro River, located at the northern part of Iloilo City, has a catchment area of 412 km^2 and stretches about 20 km from the river mouth to the confluence of two major rivers; namely, Jaro-Tigum River, the main stream with a length of about

55 km and a catchment area of 200.2 km^2; and, Aganan River, the largest tributary with a length of 40 km and a catchment area of 198.8 km^2.

Tigum River originates in Mt. Llorente (EL. 1,344 m) and flows southeast toward Sta. Barbara through Maasin where the mountain area turns into plain area. At Sta. Barbara, the river now named Jaro River heads southward to the confluence with Aganan River gathering small tributaries. The river course of Tigum at the stretch between Maasin and Sta. Barbara shapes the wide flood plain with small water channels called braided rivers.

Aganan River flows southeast to south in the mountain area. After passing the plain area, the river turns east and meets Jaro River at Pavia.

Jaro River, after joining the Aganan River, flows south with meandering. Although quite steep upstream with a riverbed gradient of 1/1,500, Jaro River slopes gently downstream at 1/4,500 and flows out into the Iloilo Strait.

(2) Iloilo River

Iloilo River is sandwiched between the sandbar and alluvial plain formed by its tributaries. It flows 10 km along the coastal line from west to east, with a catchment area of 93.1 km^2 and a gentle gradient of 1/4,000.

Three tributaries flowing into Iloilo River run almost in parallel from north to south; namely, Mandurriao River (Pandan Creek), Carahauan Brook and Corosan Brook with catchment areas of 9.9 km^2, 27.5 km^2 and 39.7 km^2, respectively. The channel length of the tributaries is from 5 to 6 km.

Cebu City

Cebu City has five (5) related rivers; namely, Bulacao River, Kinalumsan River, Guadalupe River, Lahug River and Subang Daku River. The five rivers have similar topographic features. All the rivers are usually steep with a longitudinal gradient of 1/200 to 1/50 in the mountain area and flow from north to south almost in parallel gathering several drainage channels.

Lahug River is diverted at 3.32 km from the river mouth to the drainage channel connected to Subang Daku River. At this point, all base flow of Lahug River is released to the Subang Daku river basin.

Cebu City has expanded to the south by reclamation of the seashore. The river mouth of Subang Daku River has been reclaimed and used for the Cebu International Port.

Ormoc City

Ormoc City is situated between two rivers: Anilao River on the west side and Malbasag River on the east side. With the length of 17 km to 12 km, respectively, these two rivers flow on the western slope of Mt. Banao closely in parallel to each other from northwest to southeast and eventually join tributaries running along the mainstream. The river channels in the mountain area form up a deep valley where the river gradient ranges from 1/10 to 1/45. Where the rivers pass the plain area, both turn south and merge into the Ormoc Bay keeping a steep river gradient of 1/150.

Tacloban City

There are three (3) rivers in Tacloban City; namely, Abucay River, Mangonbangon River and Burayan River. Since all of them do not have large self-catchment areas, the characteristics of these rivers classify them as urban drainage channels.

Abucay River, a small brook, is located on the northern part of Tacloban City and flows for approx. 2 km into a swampy area.

Mangonbangon River runs 5 km north of Tacloban city proper and merges with the Panalaron Bay. The upper stretch from the highway is covered by a swampy area and the river channel is not clearly formed.

Burayan River with a total length of 4 km flows from southwest to northeast on the southern part of Tacloban City. At the upper end of the river, the river channel receives drainage channels of subdivisions under construction.

3.2.2 Flow Capacity

To evaluate the present condition of the river channels, the flow capacities were estimated. Non-uniform calculation method was employed for sub-critical flow at the bankfull water level, and uniform calculation was employed for super-critical flow. Generally, the flow capacity of the respective rivers is small at less than the probable flood discharge of a 2-year return period. The estimated flow capacity of rivers is shown in Fig. 3.16 to 3.19.

3.2.3 River Structures

There are many existing river structures categorized into four items, i.e., flood control structures, bridges, municipal water intake and irrigation system. River structures in the study area for the four cities/rivers are summarized as follows:

City/River	Flood Control	Bridge	Water Supply	Irrigation	Others
Iloilo City					
Jaro	Dike (2.965 m)	10 (1)	3 intakes	1 intake	---
Iloilo	---	5	---	---	---
Mandurriao	Dike (200 m)	6	---	---	---
Cebu City					
Bulacao	Dike (1,500 m) Revetment	2	---	---	Seawall
Kinalumsan	---	7	---	---	---
Guadalupe	Revetment (300 m)	7	---	---	Groundsill
Lahug	Diversion Weir (6 m)	9	---	---	Culvert
Subang Daku	Revetment	6	---	---	Port wharf
Ormoc City					
Anilao	Revetment (1,140 m)	3	---	----	----
Malbasag	Revetment (2,060 m)	2	1 intake	1 intake	---
Tacloban City					
Abucay	---	1	---	---	Culvert
Mangonbangon	Revetment	7	---	---	Culvert
Burayan	---	2	---	---	---

3.2.4 River Floods

Most of the past floods in the study area were brought about by typhoons. In the last decade from 1982 to 1991, ten (10) typhoons passing the Visayas brought heavy rainfall of more than 100 mm/day in either one of the four cities in the study area.

The data on flooding conditions such as area, depth and duration were obtained for rather recent floods during typhoons Ruping (November 1990) and Uring (November 1991). Typhoon Ruping mainly hit Iloilo and Cebu, and Typhoon Uring hit only Ormoc. In addition to these floods, data on the latest floods in Iloilo were also compiled.

<u>**Iloilo**</u>

(1) Past Floods

With heavy rains brought by Typhoon Ruping, flood overflow occurred at several sections of the river bank in the middle reaches of Jaro River. The flood peak discharge was estimated to be approx. 800 m^3/s which is almost equivalent to a 10-year return period flood discharge.

The flooded area was, as shown in Fig. 3.20, estimated to be approximately 1,400 ha. The flood depth reported was 0.5 to 1.0 m, and flood duration was estimated to be several hours.

As for Iloilo River, no report on floods caused by river bank overflow has been made in the last several decades. Some lowland areas around the confluence with tributaries were recognized by the Region VI Office of DPWH.

(2) Flood on July 29, 1994

Iloilo City suffered from widespread flooding on July 29 to August 1, 1994, caused by the unusual heavy monsoon rains. Massive rainfall (319 mm/day) was recorded at the PAGASA Station near the Iloilo Airport on July 29, 1994. The heavy rain started in July 28 and lasted for three days with a 3-day total rainfall of 628.6 mm. Under this unpredictable circumstance, 80% of Iloilo City, especially low-lying areas, was submerged for two days/nights, and infrastructures were destroyed and human activities disrupted. The flooding areas are plotted in Fig. 3.21.

At Jaro District in Iloilo City and Oton in Iloilo Province, a total of 25,000 families were affected. More than two-thirds of the casualties reported occurred at these places and total/partial destruction of houses have been reported.

<u>Cebu</u>

During the typhoon in Cebu City, no overflow was reported in the middle reaches of the five (5) rivers. However, a narrow belt along the seashore was flooded due to flood overflow in the five (5) rivers. Although no flood discharge was observed, the flood by Typhoon Ruping in November 1990 was estimated to correspond to a 10-year return period based on the daily rainfall of 139.7 m at Lahug Station. The flooded area was estimated to be approx. 800 ha as presented in Fig. 3.22, and the flood depth was about 0.5 m to 1.5 m at the deepest site. Flood duration was rather short at 1 to 5 hours.

<u>Ormoc</u>

As reported many times through newspapers and communication networks because of its big death toll of about 5,000 people, a big flush flood caused by the downpour brought by Typhoon Uring on November 5, 1991 swept Ormoc City. A simple computation of flood runoff shows the peak flood discharges of the Anilao and Malbasag rivers to be 600-700 m^3/s and 250-300 m^3/s, respectively. They correspond to floods of about a 20-year return period.

The flood area is rather small at approx. 200 ha as shown in Fig. 3.23, although flood depths were reported to be 1.5 m to 4.0 m at the deepest site. The flood discharge was once dammed up by driftwood and debris stagnating at 500 m upstream of the Anilao Bridge, and the "dam" was breached by flood overflow resulting in the formation of a hydraulic bore.