5 RIVER IMPROVEMENT PROJECTS AND THEIR IMPLEMENTATION STATUS

5.1 Present Condition of River Improvement Projects

The river improvement works planned by the Master Plan in 1981 have not yet been implemented in the Study Area. The following table shows the existing river improvement works which have been planned, designed and constructed by DPWH. The most of the dikes are not continuous but partial and tentative structures in the two rivers. The original river width for the dikes was basically maintained with a dike height of 4.00m. The design flood for the existing river structures was not disclosed, but is roughly estimated to be around 10-20 years by the Study.

Present Condition of River Improvement Works by DPWH

River System	River Name & Location	Facility Name	Height (m)	Length (m)	Date of Completion	Existing Condition
Yawa	Yawa Legazpi City	a. Boulder Dike	4.00	320	14 Feb, 1989	Good
		b. Boulder Dike	4.00	1,200	2 June, 1991	Good
		c. Boulder Dike	4.00	1,250	1 November, 1989	Good
		d. Dike No. 1,2,3,4	4.00	308	N/A	Partially Damaged
Quinali (B)	San Vicente	a. Boulder Dike No.1	4.00	115	22 December, 1990	Need to rehabilitate
		b. Boulder Dike No.2	4.00	115	22 December, 1990	Need to rehabilitate
		c. Spur Dike No.1	4.00	240	N/A	Need to rehabilitate
		d. Spur Dike No.2	4.00	240	N/A	Need to rehabilitate

The dredging of the river channel in the Yawa river has continuously been carried out every year.

5.2 Review of Previous Studies

Re-Study of Mayon Volcano Sabo and Flood Control Project is the latest study on Mayon Volcano and was submitted by JICA in March, 1983. The study report presented the re-study of Mayon Volcano Sabo and Flood Control Project to re-assess and review the Master Plan for Mayon Volcano Sabo and Flood Control

Project submitted by JICA in March, 1981, taking account of the disaster due to typhoon "Daling" in June and July 1981.

The restudy report presented the unchanged river improvement plan which was established by the Master Plan (1981). The river improvement works were planned for three rivers, the Quinali (A), Quinali (B), and Yawa rivers.

The Nasisi river which is one of the 17 rivers for the Study was included as an uppermost part of the Quinali (A) river improvement plan.

The river improvement works recommended by the Master Plan are summarized below:

River Improvement Plan by the Master Plan (1981)

Item	River Basin		
	Nasisi River	Quinali (B)	Yawa River
Improvement Length	7.6km	21.8km	2.3km
Design Discharge	920 - 1,660m^3/sec	270 - 2,420m^3/sec	2,150m^3/sec
Proposed River Slope	1/130 - 1/400	1/80 - 1/1,200	1/300 - 1/1,000
Proposed River Width	80m	42 - 270m	150 - 190m
Proposed Levee	50-yr design flood	50-yr design flood	50-yr design flood
- Slope	1 : 2	1 : 2	1 : 2
- Top Width	4 - 5m	4 - 5m	5m
- Free Board	1.0 - 1.2m	1.0 - 1.2m	1.2m
Proposed River Cross Section	Simple	Simple and Compound	Simple and Compound

Note : Items of the Nasisi river are only presented in the above list.

The plans of river improvement in the Nasisi, Quinali (B) and Yawa are shown in Figures I 5.1 to I 5.3.

The design flood of this river improvement plan was selected to be 50-year probable flood, considering importance of the region, design discharge of other rivers in the Philippines and the Japanese Standard of river planning. No economical evaluation was made by different protection levels of flood damage to determine the design flood.

6. Conceivable Structural Measures

6.1 River Improvement

The conceivable projects as structure measures for river improvement in the Study Area are presented here on the basis of the site survey and review of the existing river structures and previous studies during the First Work in the Philippines.

(1) Yawa river

The Yawa river gathers the three streams of the Anuling, Budiao and Pawa-Burabod rivers. These are regarded as the major disaster prone rivers which directly affect the main course of the Yawa river in case of flood and lahar events.

Thus, the Yawa river plays an important role as a floodway for the planned sabo structures in the Anuling, Budiao and Pawa-Burabod. The Yawa river should be improved with a suitable flood capacity, taken into consideration the economic feasibility, the land acquisition and hydrological and river hydraulic consistency with the upstream tributaries.

The design flood for the river improvement is to be determined by evaluating the efficiency of the protection level for flood damage.

Three alternatives for the river improvement of the Yawa river are considered as follows.

- Dredging the river channel
- Raising the existing dike
- Widening the river width with a compound river cross-section

(2) Nasisi and Ogsong rivers

The Nasisi river was once selected by the previous Master Plan for river improvement. Partial dikes, including the short cut channel, were constructed to protect bridges, villages and paddy fields from flood inundation along the river course after the previous Master Plan in 1981.

The Ogsong river was not selected by the previous Master Plan, but it has regularly been a flood prone river as shown in Figures I 3.1 and I 3.2.

Thus, the Nasisi and Ogsong rivers should be improved with a suitable flood capacity, taken into consideration the economic feasibility and the social impact by land acquisition.

The design flood for the river improvement is to be determined by evaluating the efficiency of the protection level for flood damage.

Two alternatives for the river improvement of the Nasisi and Ogsong rivers are considered as follows.

- Raising the existing dike
- Widening the river width with a compound river cross-section

(3) Quinali (B) and San Vicente rivers

The Quinali (B) and San Vicente rivers were also selected by the previous Master Plan for river improvement. No river improvement works were carried out except for the partial dike construction to partially protect flood prone areas.

Thus, the Quinali (B) and San Vicente rivers should be improved with a suitable flood capacity, taken into consideration the economic feasibility and the social impact by land acquisition.

The design flood for the river improvement is to be determined by evaluating the efficiency of the protection level for flood damage.

Two alternatives for the river improvement of the Quinali (B) and San Vicente rivers are considered as follows.

- Raising the existing dike
- Widening the river width with a compound river cross-section

6.2 Urban Drainage

The interior flood inundation events are chronic problems in the center of the Legazpi. The inundation in the low-lying areas is caused mainly by the inadequate urban drainage system, inadequate flood capacity of creeks or tidal effects of the sea. The cause of the inundation is not directly related with flood events of the river to be studied. Even so, the urban drainage plan shall be included in the Study to solve the interior flood inundation in Legazpi around the Mayon Volcano.

There are four alternatives to be considered for the urban drainage plan in Legazpi City.

- Widening the flood capacity of the trunk channel (as is called “estero” in the Philippines)

- Installation of flood gate to protect seawater intrusion in the case of high tide
- Pump drainage system
- Retention pond

7. River and urban drainage planning

7.1 River Improvement Plan

7.1.1 Conditions and Criteria

Planning for river improvement in the Study Area is carried out on the basis of the following conditions and criteria.

(1) Heavy rainfall

The Study Area has unique climate characteristics such as indistinct dry season and very pronounced maximum rainfall from September to January. The heavy rainfall is often caused by Southwest and Northeast Monsoons, frequent passing of Tropical Cyclones and strong convective air ascend. Mean annual rainfall is estimated to be 3,000mm at lower elevation such as Legazpi and Tabaco, and 4,000-5,000mm at higher elevation over slopes of Mt. Mayon. Daily maximum rainfall is ranged 200-300mm at lower elevation and 400-700mm at higher elevation.

(2) Year-round soil moisture

Total number of rainy days are 221 days or 60% of the year on average in Legazpi. The relative humidity is almost constant through the year and annual mean is 83% at Legazpi.

(3) Steep sloped channel

The channel slope of the rivers around the Mayon Volcano is very steep. Average river bed slopes of mudflow channel and flood flow channel (such as Yawa, Quinali (A) and Quinali (B)) are 0.06-0.26 and 0.003-0.004, respectively.

(4) Steep sloped drainage area

The river basins are draining from the mountain top of the Mayon Volcano (EL 2,400m). Therefore, river piracy caused by mudflow events had frequently occurred, specially in the rivers of the southeast slope. River courses such as the

Bulawan river are unstable in the alluvial fan. Flash floods with very short concentration time (25 - 130 min.) occurs in each river basin. Excepting for the Ogsong river, no retarding effects are expected.

(5) Sediment transport

The river bed materials survey revealed that average particle sizes (D_{50}) of the river bed materials are 13.0mm in the sediment flow portion and 0.4mm in the flood flow portion.

(6) Intensive existing land use

Paddy fields are dominant land use in the flood flow portion of the rivers. In particular, the lower reaches of the Nasisi, Ogsong, Quinali (B) and San Vicente rivers are fully utilized for rice production.

National road network is installed around the Mayon Volcano. The road system is passing the rivers to be considered with bridges.

(7) River related facilities

River improvement plan shall carefully be studied taken into consideration the above river related facilities such as irrigation and drainage system and bridges in the river basins.

(8) Alignment for planning

River bed of the flood flow portion is rather stable, and the extreme river bed aggradation or degradation is not observed in the flood flow portion.

Therefore, general alignment of the improved river sections will follow the original river courses. Partial river improvement works have been undertaken by DPWH, Region V in the Yawa, Quinali (B), Nasisi, Ogsong and San Vicente rivers in the recent past.

Meandering portion will be modified by short cut channel if needed.

River mouth of the Yawa and Quinali (B) rivers have outstandingly been influenced by coastal stream which is mainly flowing from north to south direction. The alignment of the Yawa and Quinali (B) rivers carefully planned not to be silted by the coastal stream.

(9) Criteria for channel profile and section

River section should be double trapezoid river section for large rivers such as Yawa and Quinali (B) rivers since the main channel is able to confine normal flow and flash flood flow at the center of the river. Large sediment transport to those rivers cannot be expected by the construction of Sabo works upstream. Single trapezoid river section is applicable to small river.

Channel profile for the planned river improvement shall follow the original river profile since its river bed is observed to be stable.

(10) Design flood

Design flood for river improvement works should be determined by economic evaluation to several alternatives with different flood protection levels such as 10, 20 and 50-year flood.

Design flood for bridges is recommended to be 50-year flood in the Philippines and adopted to the present study.

7.1.2 Candidate Scheme

Several candidate schemes for river improvement in the Study Area are selected by the conditions and criteria for the Study as follows.

- Yawa river improvement project
- San Vicente river flood way project
- Quinali (B) river improvement project
- Nasisi river improvement project
- Ogsong river improvement project

Rivers other than the above selected rivers should be treated by Sabo works and no river improvement works are recommended by the study.

Backwater effects occasionally occur in the lowest reaches of the Quirangay, Tumpa, Maninila and Masarawag rives near the confluence to the Quinali (A) river. The river improvement for the Quinali (A) river is a premise for solving the inundation in the lowest reaches of those rivers affected by the backwater from the Quinali (B) river. The lowest parts of those rivers are situated south of National Highway passing between Legazpi and Ligao.

7.1.3 Basic Concept and Alternative Plan

(1) Basic concept

Basic concepts for river improvement plan are:

a) to mitigate flood damage in the flood prone area
b) to upgrade the function of river as a flood way for Sabo works
c) to enhance the productivity of land use

(2) Alternative plan

Based on the basic concepts, several alternative plans are considered as follows.

a) Dredging the river channel
b) Raising the existing dike
c) Widening the river channel with embankment
d) New flood way

Alternative c) is selected for all schemes to secure in advance the right of way for future river improvement works suitable for 100-year probable flood.

Alternative d) is selected for the San Vicente river to mitigate the flood inundation in Malinao by diverting the river course into the sea instead of presently draining into the Quinali (B) river.

7.1.4 Facility Design

(1) General

Master Plan level designs are prepared for the proposed structures of the alternative plan described in Section 7.1.3. The design of river structures is based on the results of hydraulic calculation, incorporating relevant design criteria as described in Section 7.1.1.

(2) Alignment

The alignment of the dike for each alternative plan for the Yawa, San Vicente, Quinali (B), Nasisi and Ogsong rivers is shown in Figures I 7.1 to I 7.3. The channel alignment is chosen to minimize the social and environmental impact by following the existing river channel wherever possible. For new flood way channel in the San Vicente river, the flood way alignment is chosen by following the past water course of the river.

The length of the dike for each alternative plan is summarized below.

Length of Dike for Alternative Plan

River Name	Length of Dike (m)	Location
Yawa	2,000	From the river mouth
San Vicente	4,000	New flood way from San Vicente Bridge to the sea following the past water course
Quinali (B)	2,650	First section (from the river mouth)
	1,400	Second section
	7,050	Third section
	150	Fourth section
	11,250	Total section
Nasisi	600	First section (from Quinali (A) to Ogsong)
	7,033	Second section
	7,633	Total section
Ogsong	5,700	From the confluence to the Nasisi river

(3) Hydraulic design

Typical cross section of the dike is shown in Figure I 7.4. The crest width is set at 4.0m for all alternatives. The riverside slope is set at 1:1.2 and the revetment is protected by grouted riprap. Gabion is installed to provide protection from scour.

The landside slope is 1:2 and protected by mountain soil and sodding to protect it from rainfall run-off.

The common hydraulic design of the dike for each alternative is summarized below.

Hydraulic Design Standard for River Improvement Plan

Free board	1.2m
Roughness coefficient	0.035

Design discharge, channel gradient, design depth and river width for each alternative are summarized below.

List of Hydraulic Design Parameters (Q20)

River Name	River Section	Design Discharge (20-year)	Channel Gradient	Design Depth (m)	Design River Width (m)
Yawa	Total section	1,350	0.0015	4.4	90
San Vicente	Total section	180	0.0063	1.6	30
Quinali (B)	First	1360	0.0008	4.0	140
	Second	1250	0.0015	4.0	120
	Third	1210	0.0021	3.5	100
	Forth	1080	0.01	2.4	80
Nasisi	First	1220	0.0025	3.8	80
	Second	680	0.0050	2.8	50
Ogsong	Total section	570	0.0035	3.5	35

List of Hydraulic Design Parameters (Q10)

River Name	River Section	Design Discharge (10-year)	Channel Gradient	Design Depth (m)	Design River Width (m)
Yawa	Total section	-	-	-	-
San Vicente	Total section	150	0.0063	1.5	30
Quinali (B)	First	1130	0.0008	3.6	140
	Second	1040	0.0015	3.6	120
	Third	1010	0.0021	3.2	100
	Forth	900	0.01	2.2	80
Nasisi	First	1070	0.0025	3.5	80
	Second	590	0.0050	2.6	50
Ogsong	Total section	500	0.0035	3.3	35

7.2 Urban Drainage Plan in Legazpi City

7.2.1 Condition and Criteria

(1) Heavy rainfall

The same conditions as 7.1.1 (1) for river improvement.

(2) Topography

Legazpi City is situated in the low-lying area and some areas in the central district is at below sea level.

(3) Insufficient drainage capacity

Main river channels functioning as an estero for urban drainage in the Legazpi City are

a) Macabalo river in the south,
b) Tibu river in the north.

Flow capacity of the main river channels are suitable up to 5-year flood peak. But, drainage capacity of secondary and tertiary channels are presently insufficient.

(4) Insufficient maintenance

Insufficient maintenance causes flood inundation in the city as described below.

a) Absence or inadequacy of drainage structures to properly train or guide the flow of rain water to natural receptacles or water bodies
b) Siltation or clogging in some drainage pipes because of inadequate maintenance
c) Dumping of solid and liquid waste in natural and man-made channels which lessen their conveyance capacity
d) Construction of subdivisions or housing developments in nearby areas without adequate drainage outflow connection

(5) High tide

The extreme high tide was measured as 1.8m in the past. The coincidence of high tide and flood events has occasionally caused inundation in the city proper. Therefore, needs for installation of flood gates and pumping facilities are raised by Legazpi City.

(6) Design flood

Design flood for urban drainage projects is recommended to be 10-year in the Philippines and also adopted to the Study.

Probable flood for Macabalo and Tibu rivers is roughly estimated by Rational Formula as shown below.

Probable Flood in Macabalo and Tibu Rivers

Main River Channel	Catchment Area (km^2)	Rainfall Intensity (mm/hr)	Probable Flood (m^3/s)
Macabalo River	10	100 (5-year) 120 (10-year)	190 (5-year) 230 (10-year)
Tibu River	4	100 (5-year) 120 (10-year)	80 (5-year) 90 (10-year)

7.2.2 Alternative Plan

(1) Enlargement of flow capacity

The main river channels such as the Macabalo and Tibu rivers are to be enlarged if design discharge is larger than flow capacity of the existing channels. But, to minimize the social impact of land acquisition along the main river channels, it is fully recommended to maintain the existing river width as same as possible. The flow capacity of two rivers is estimated to be around 5-year probable flood peak discharge. Riprapping of the channels is properly installed along the water course.

(2) Pump drainage

a) Pumping stations

Pump drainage system is fully recommended to minimize the flood damage in the city. Suitable size of pumping station is to be determined to minimize the project cost.

b) Flood gates

Suitable size of flood gate is to be installed in the Macabalo and Tibu rivers to protect the low-lying areas from the intrusion of tidal flood in the city.

c) Retention pond

Installation of retention pond is considered as an effective measure to regulate flood peak and to minimize the size of pumping station if installed with a pumping station.

7.2.3 Proposed Drainage Plan

The proposed drainage plan is selected as an integration of all alternative plans considered as follows.

(1) Riprapping along main river channels (Macabalo and Tibu rivers)
(2) Flood gates to protect tidal flood into the rivers
(3) Pumping stations to compulsorily drain interior flood inundation with flood gate operation
(4) Retention pond to regulate flood peak

7.2.4 Facility Design

(1) General

Master Plan level designs are prepared for the proposed structures of the alternative plan described in Section 7.2.2. The design of urban drainage structures is based on the results of hydraulic calculation, incorporating relevant design criteria as described in Section 7.2.1.

(2) Alignment

The alignment of the dike for each alternative plan for the Macabalo and Tibu rivers is shown in Figure I 7.5. The channel alignment is chosen to minimize the social and environmental impact by following the existing river channel wherever possible.

The length of the dike for each alternative plan is summarized below.

Length of Dike for Alternative Plan

River Name	Length of Dike (m)	Location
Macabalo	1,700	From the river mouth
Tibu	834	From the river mouth

(3) Hydraulic design

a) Main river channel

Typical cross section of the dike is shown in Figure I 7.4. The riverside slope is set at 1v:1.2h and is protected by grouted riprap. Gabion is installed to provide protection from scour.

The common hydraulic design of the dike for each alternative is summarized below.

Hydraulic Design Standard for Urban Drainage Plan

Free board	1.0m
Roughness coefficient	0.035

Design discharge, channel gradient, design depth and river width for each alternative are summarized below.

List of Hydraulic Design Parameters (Q10)

River Name	River Section	Design Discharge (10-year)	Channel Gradient	Design Depth (m)	Design River Width (m)	River Width to be Widen (m)
Macabalo	Total section	105	0.001	2.0-2.5	26-32	0.0-28
Tibu	Total section	17	0.001	1.1-4.0	4.8-39	-

b) Flood gate

Flood gate is planned to be installed in the Macabalo and Tibu rivers at the river mouth as shown in Figure 7.5.

Hydraulic design adopted to the rivers is briefed below.

Hydraulic Design for Flood Gate

River Name	Probable Flood (year)	Flood Peak (m^3/s)	Gate Height (m)	Gate Width (m)	No. of Flood Gates
Macabalo	10	105	3.5	3.0	5
Tibu	10	17	3.5	3.0	3

c) Pumping station

Pumping station is designed in the Macabalo and Tibu rivers as follows.

Hydraulic Design for Pumping Station

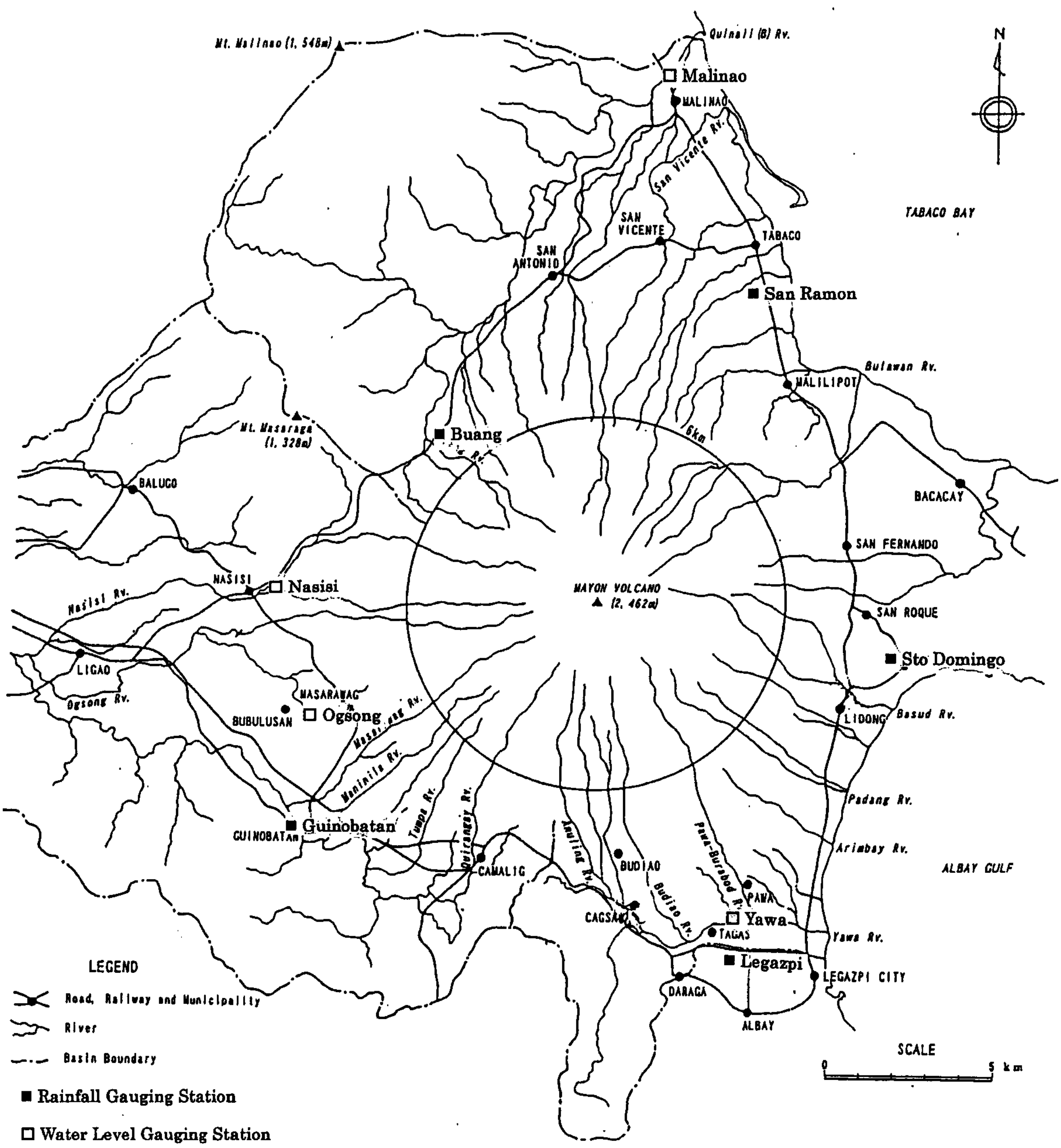
River Name	Probable Flood (year)	Flood Peak (m^3/s)	Design Pumping Capacity (m^3/s)
Macabalo	10	105	10.0
Tibu	10	17	1.0

d) Retention pond

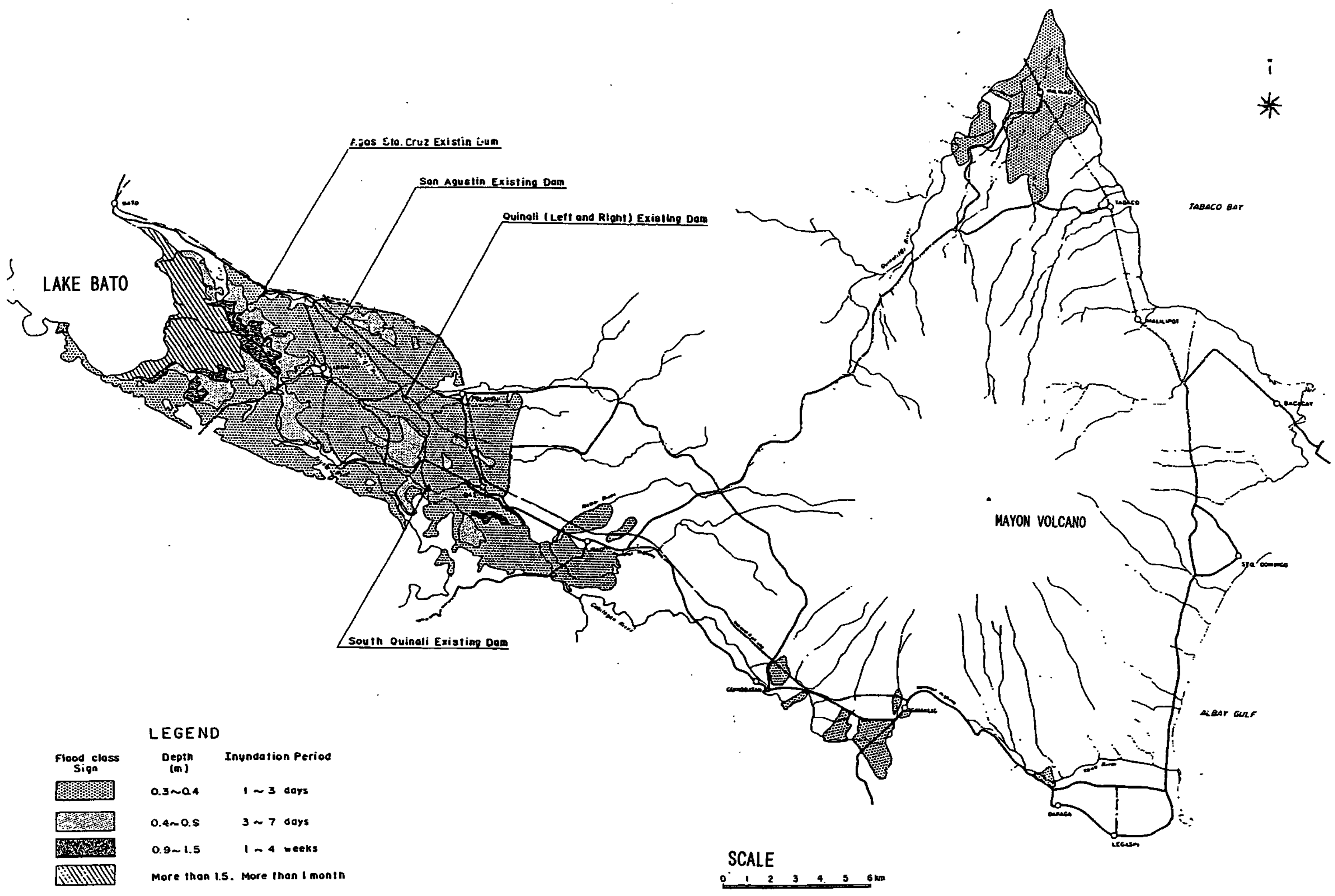
The design of retention pond is roughly carried out with limited information from the Legazpi City.

Hydraulic Design for Retention Pond

River to be Drained	Pond Capacity (m^3)	Pond Area (ha)	Design Water Depth (m)
Macabalo	444,600	12	3.7
Tibu	13,536	0.5	2.7



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure I 1.1**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Location Map of Meteoro-Hydological Gauging Station sin the Study Area**

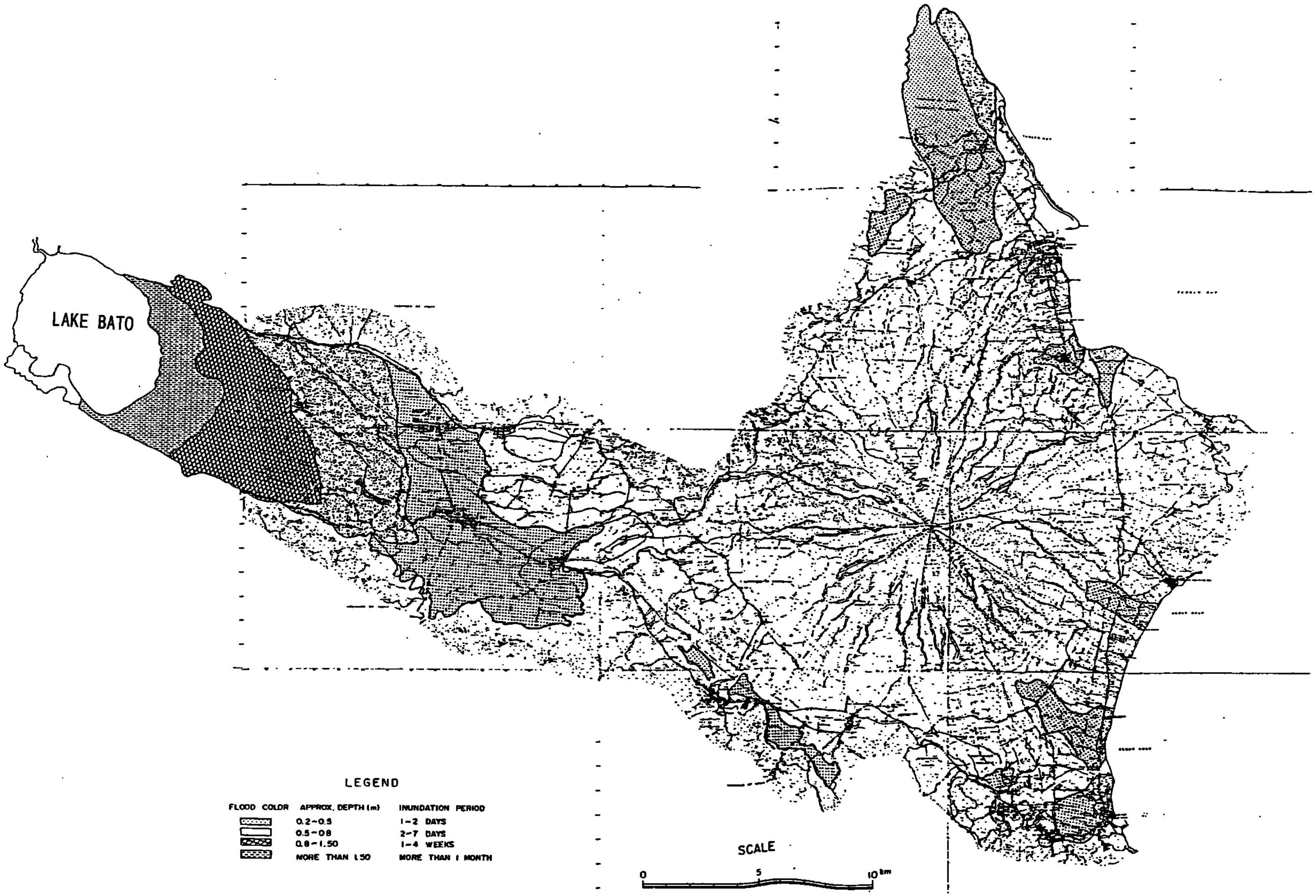


COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

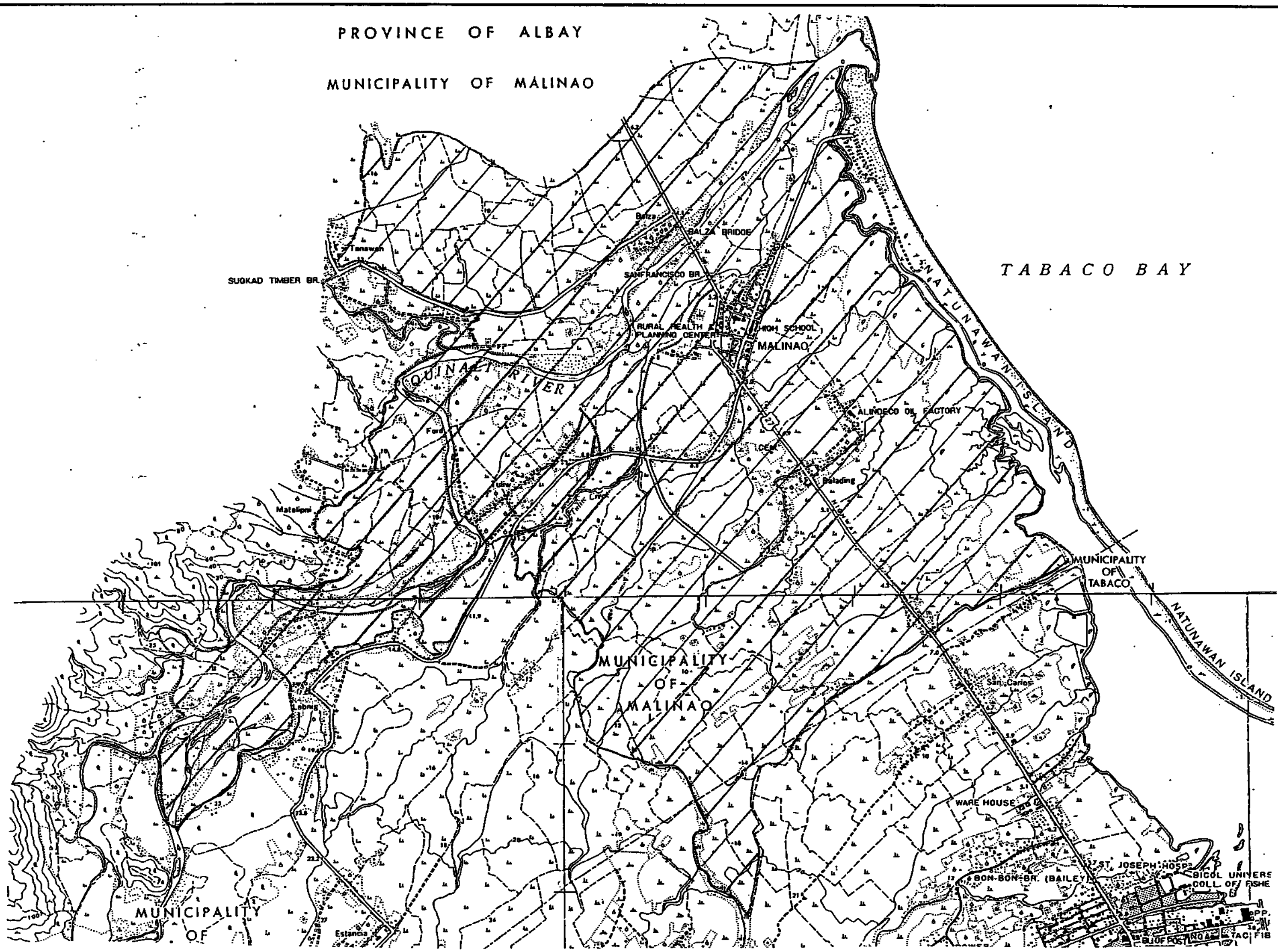
Figure I 3.1

Flood Inundation Area by Flood f Typhoon "Pepang" in 1979

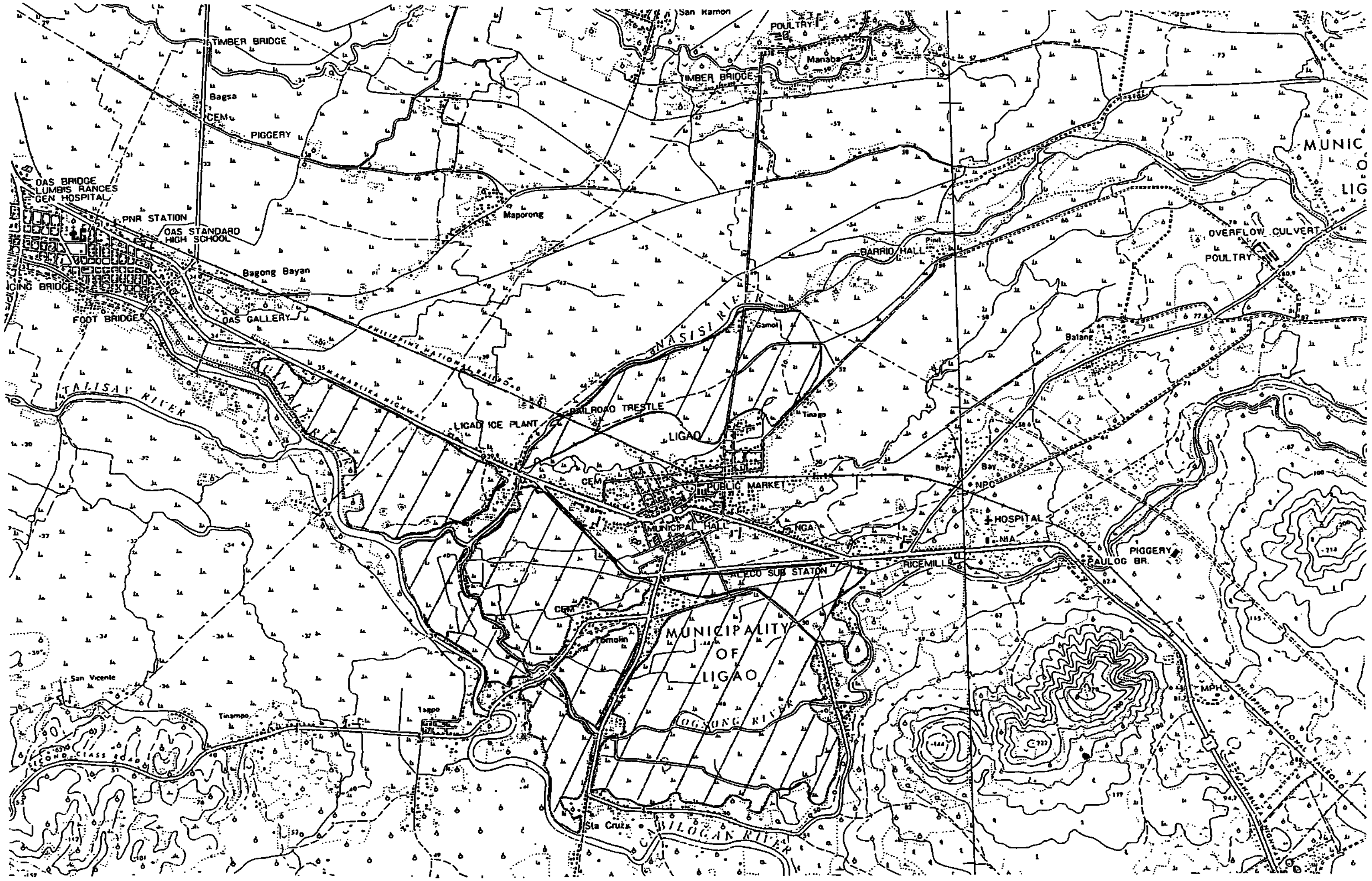


COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure I 3.2 Flood Inundation Area by Flood of Typhoon "Daling" in 1981
JAPAN INTERNATIONAL COOPERATION AGENCY	

COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure I 3.3** Probable Flood Inundation in Yawa River Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	



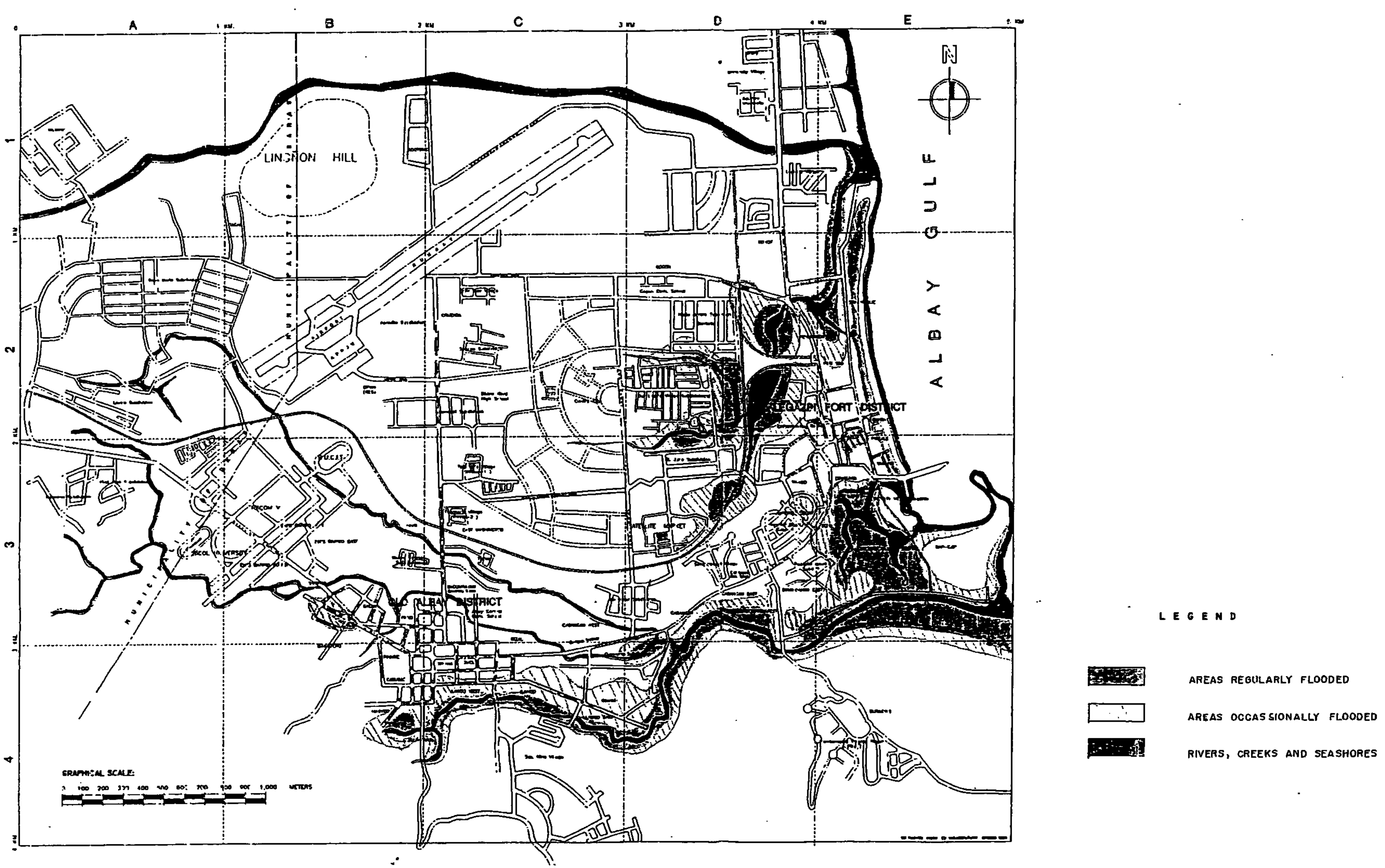
COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure I 3.4 Probable Flood Inundation in Quinali (B) and San Vincente River Basins
JAPAN INTERNATIONAL COOPERATION AGENCY	



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES

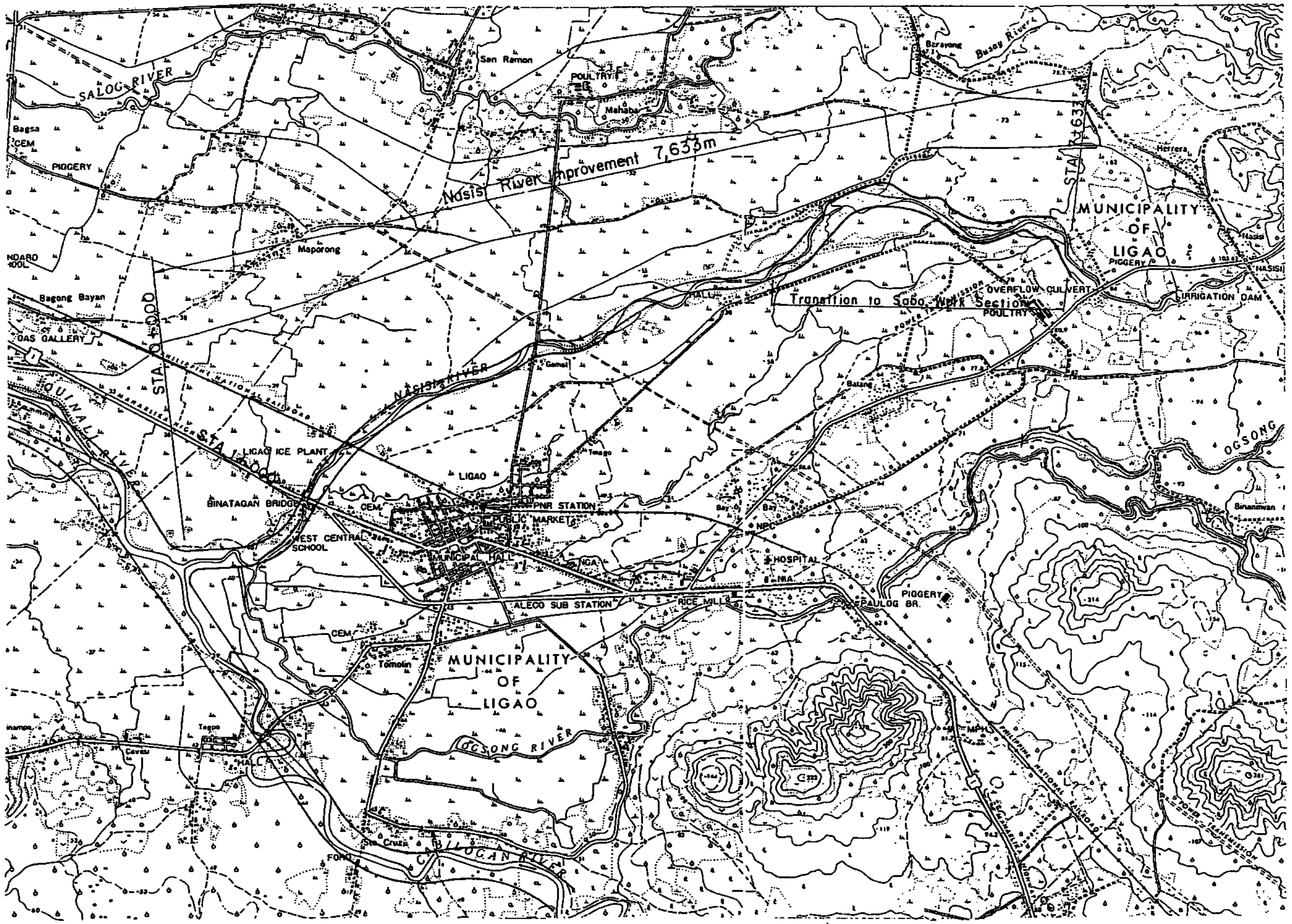
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure I 3.5
Probable Flood Inundation in Nasisi and Ogsong River Basins

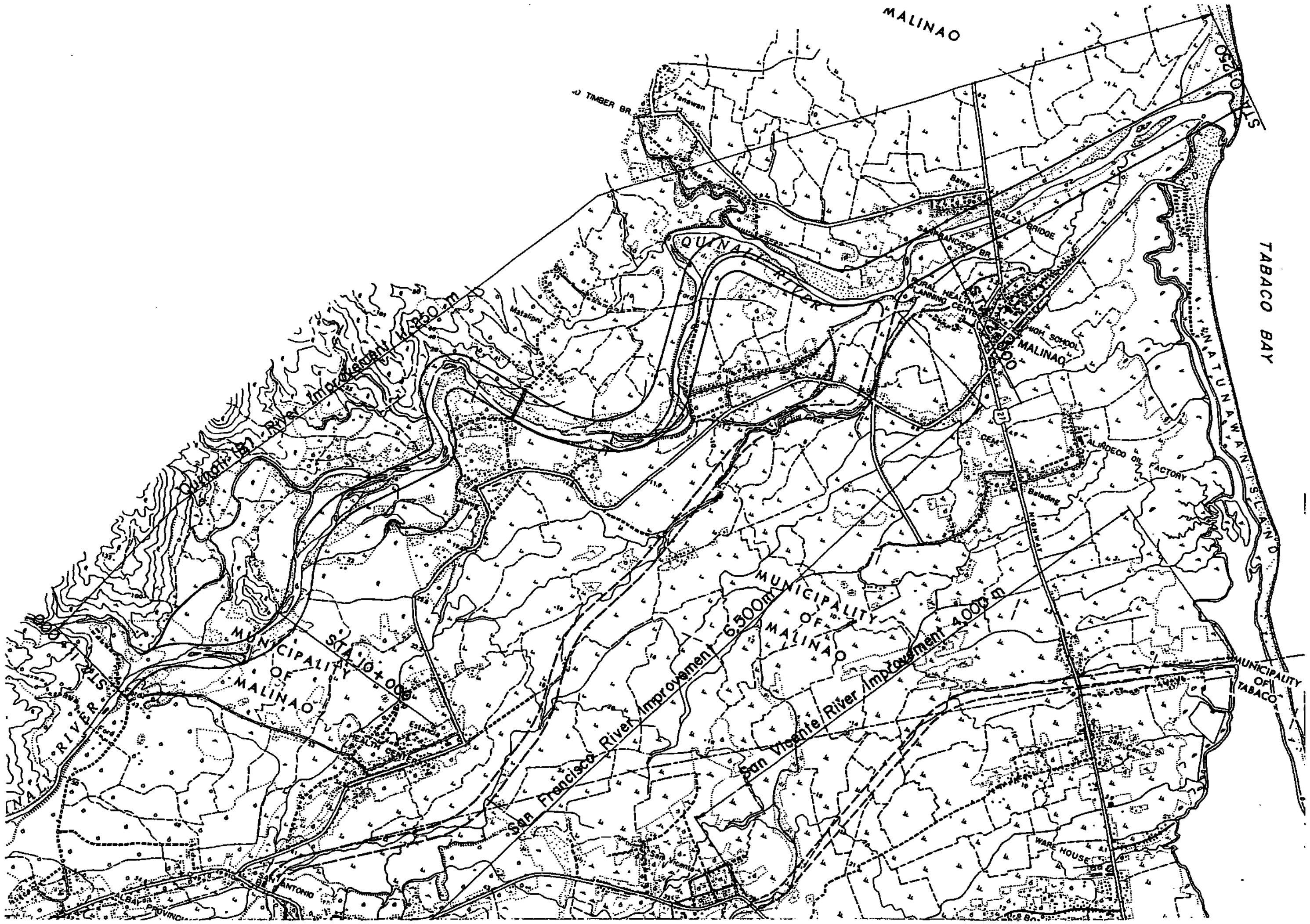


COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure I 3.6** **Flood Prone Area in Legazpi City**
JAPAN INTERNATIONAL COOPERATION AGENCY	

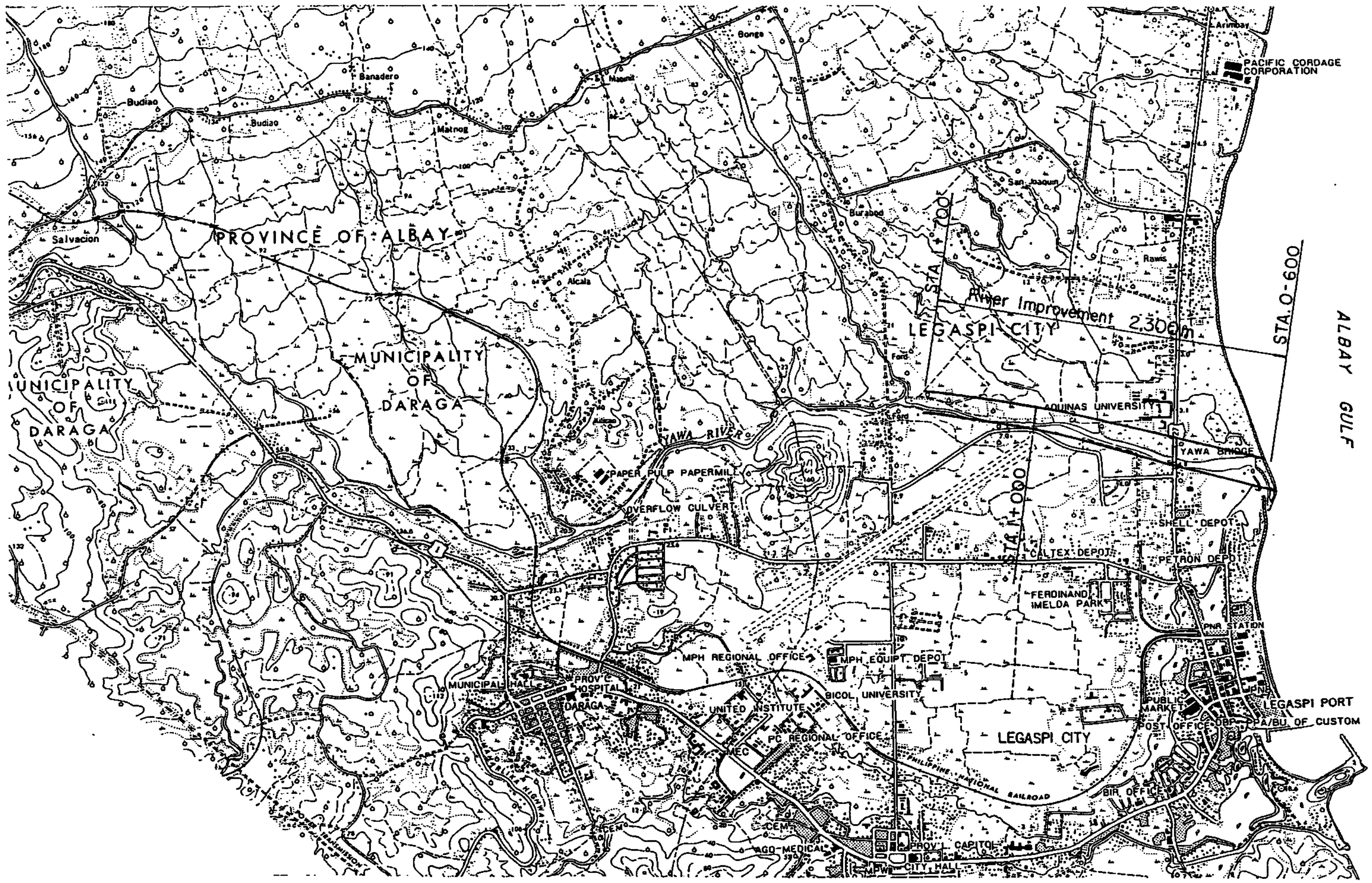
COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure I 4.1**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Location of Water Sources for LCWD and DWAD**



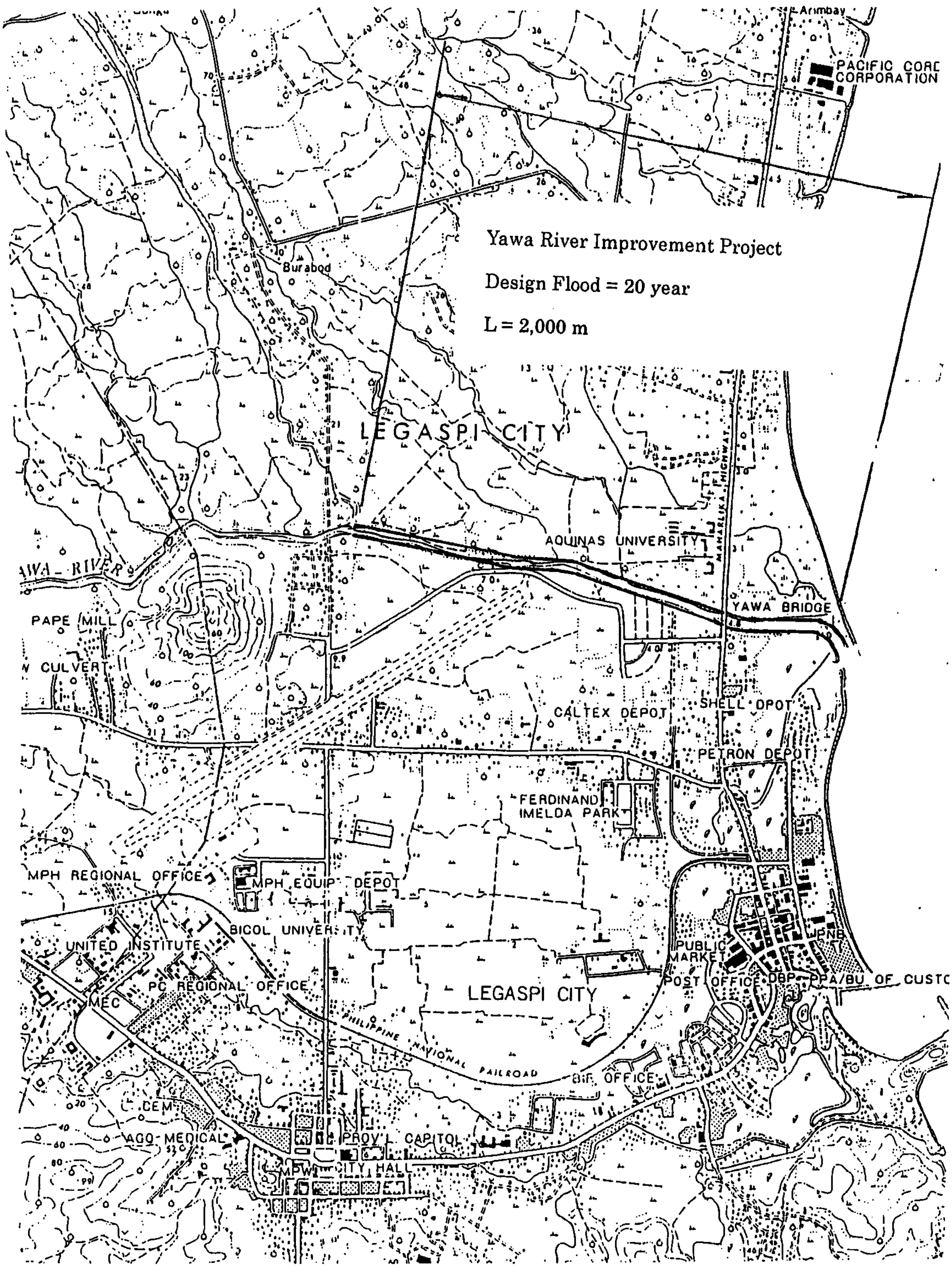
COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure I 5.1 River Improvement Plan for the Nasisi River Recommended by the Master Plan (1981)
JAPAN INTERNATIONAL COOPERATION AGENCY	



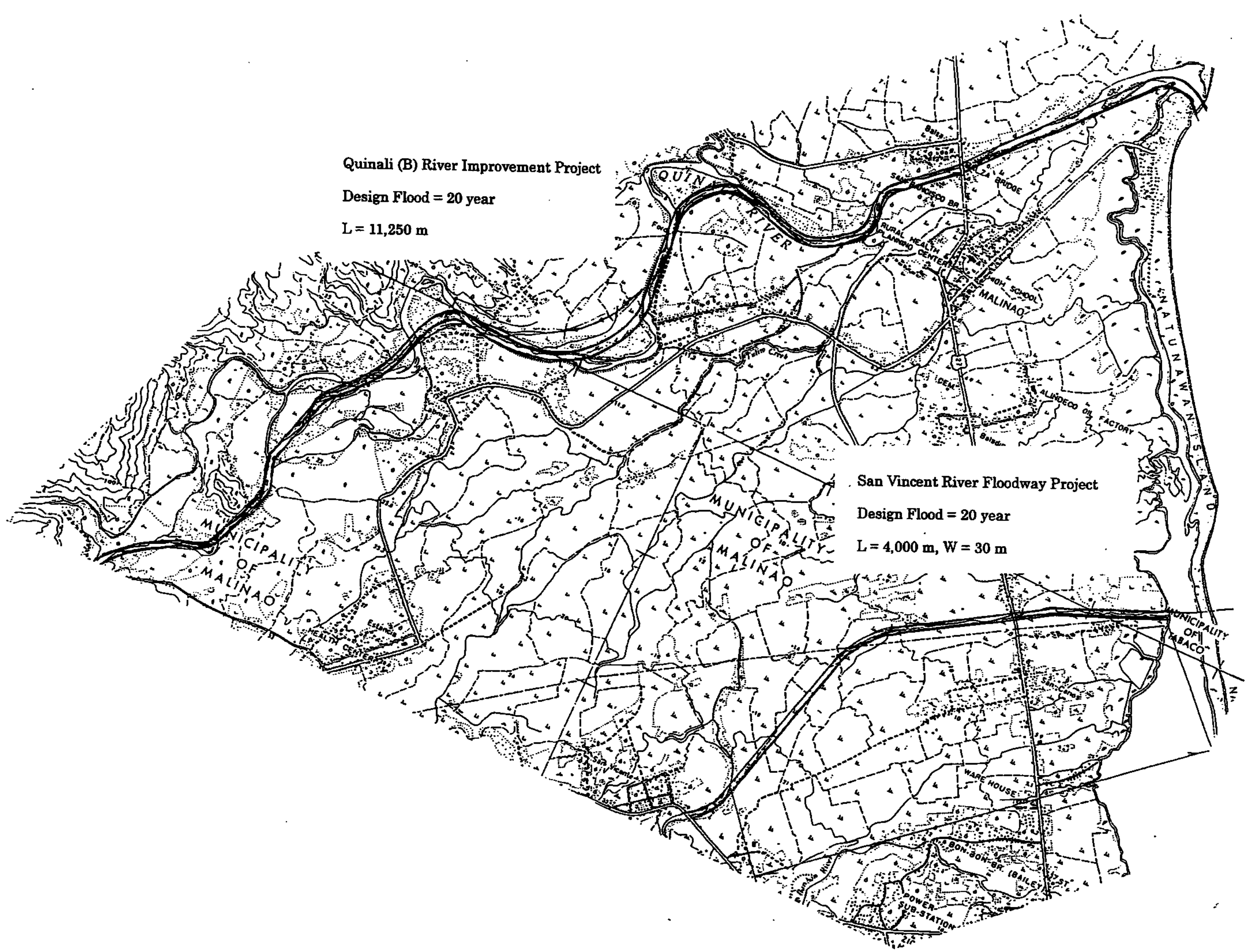
COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure I 15.2 River Improvement Plan for the Quinali (B) River Recommended by the Master Plan (1981)
JAPAN INTERNATIONAL COOPERATION AGENCY	



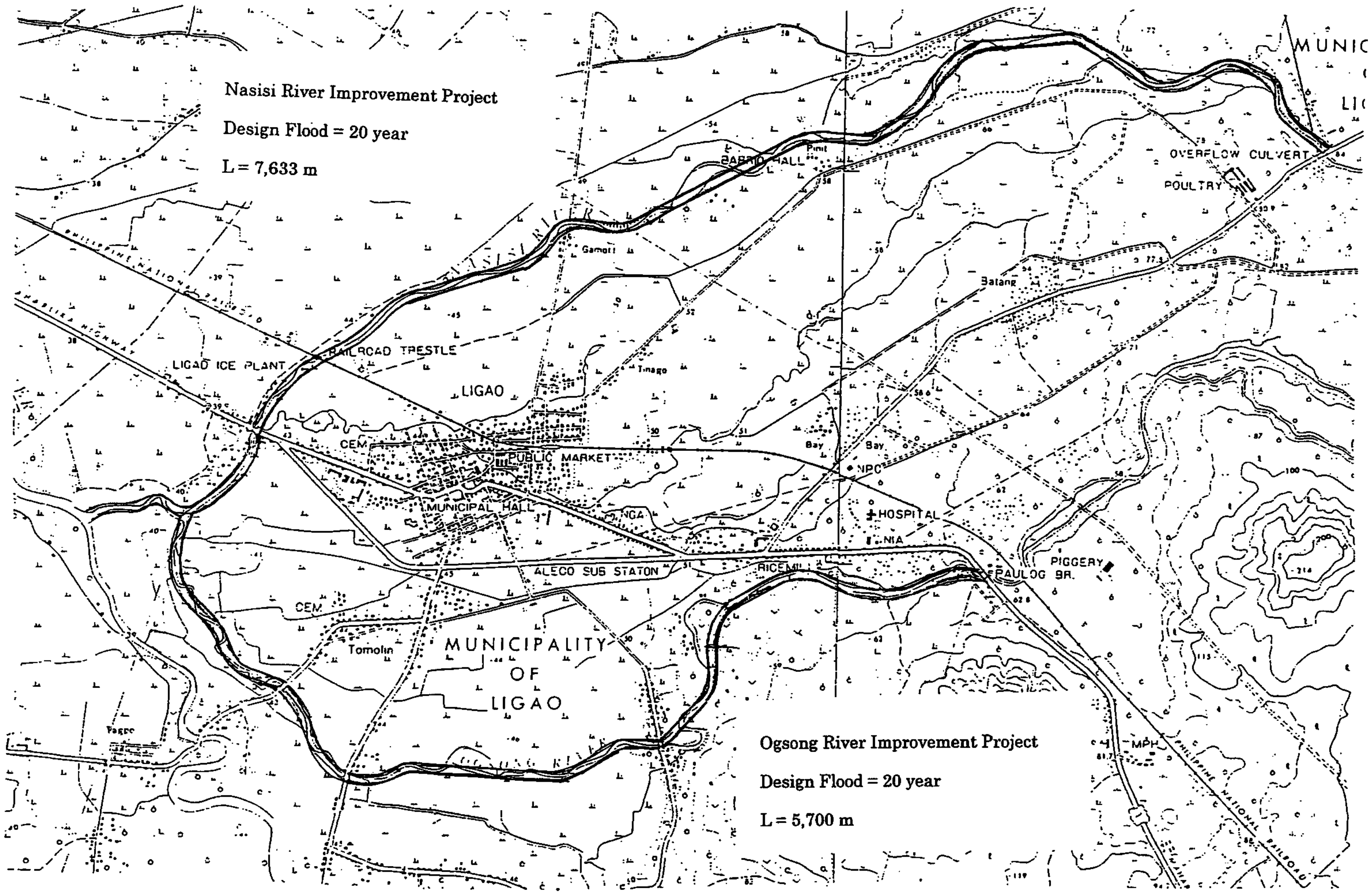
COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure I 5.3**
JAPAN INTERNATIONAL COOPERATION AGENCY	**River Improvement Plan for the Yawa River Recommended by the Master Plan (1981)**



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure I 7.1** **Proposed Alignment of the Quinali (B) and San Vicente River Improvement Plans**
JAPAN INTERNATIONAL COOPERATION AGENCY	

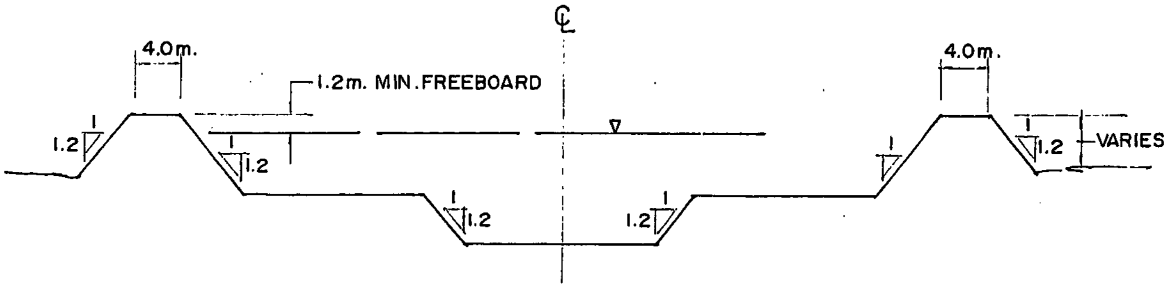


COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure I 7.2 Proposed Alignment of the Quinali (B) and San Vincente River Improvement Plans
JAPAN INTERNATIONAL COOPERATION AGENCY	

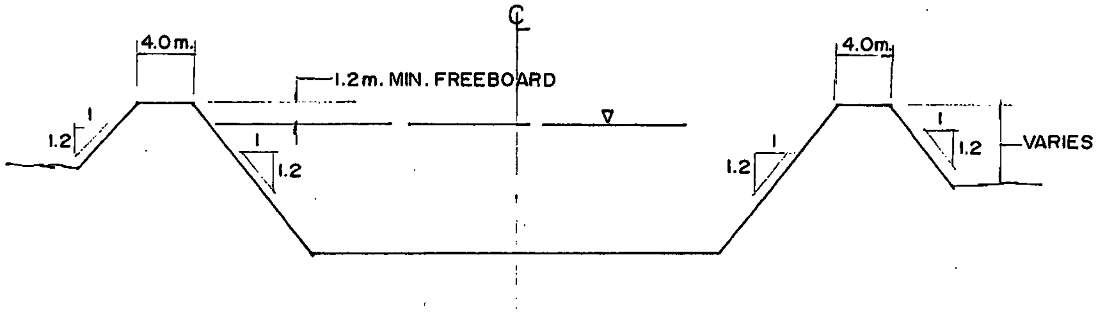


COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure I 7.3 Proposed Alignment of the Nasisi and Ogsong River Improvement Plans
JAPAN INTERNATIONAL COOPERATION AGENCY	

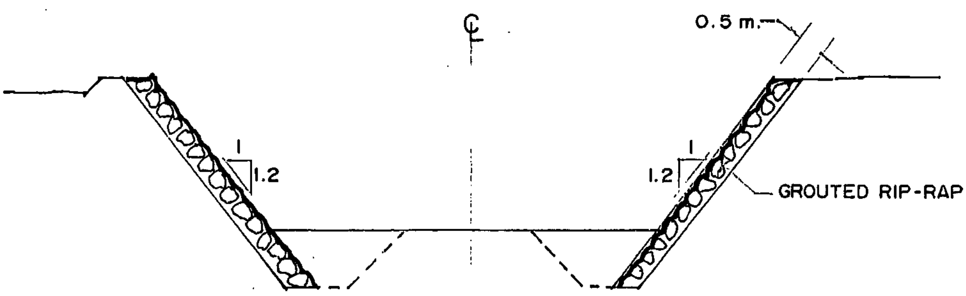
1) YAWA , QUINALI (B) (DOUBLE TRAPEZOID)



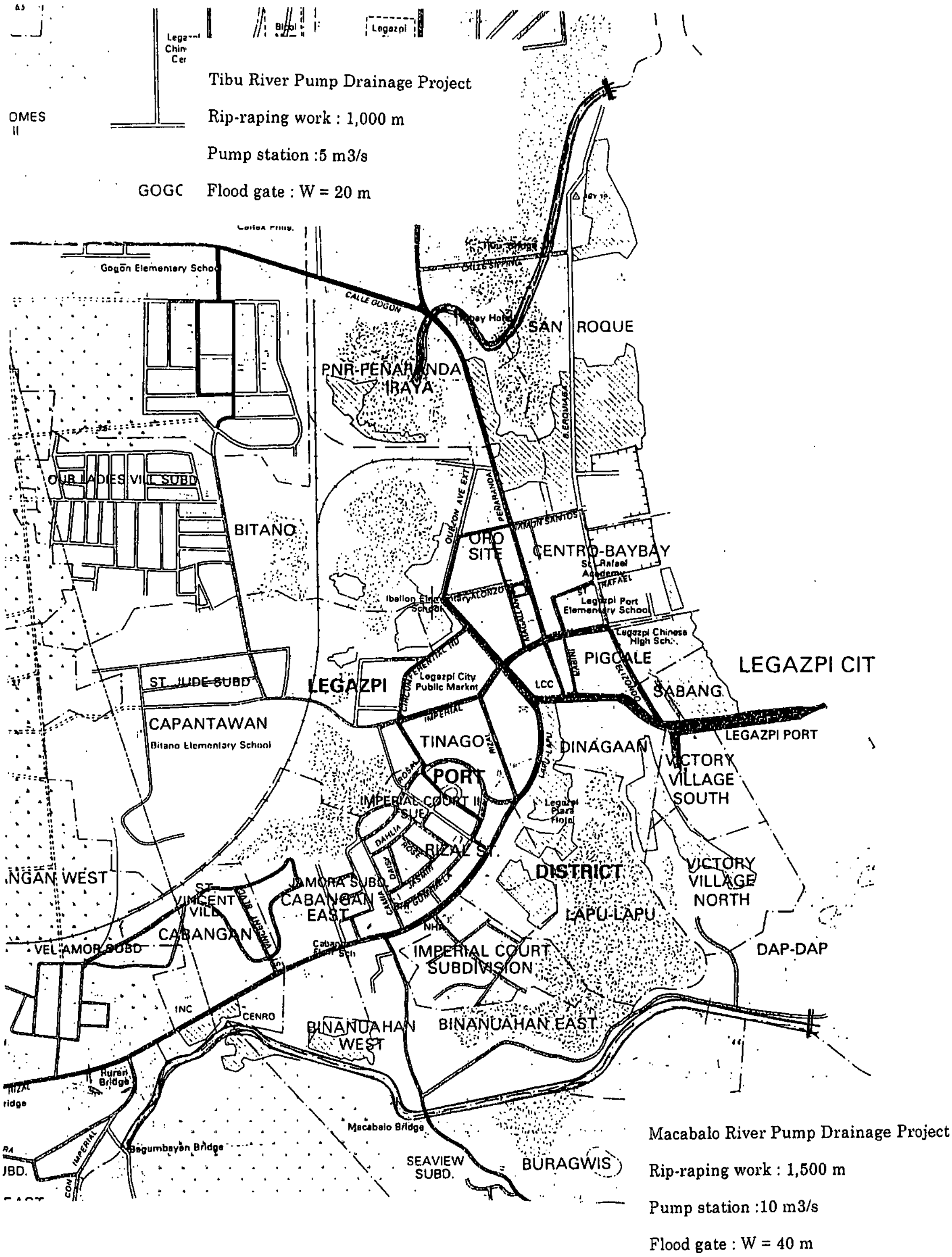
2) OTHERS (SINGLE TRAPEZOID)



3) ESTEROS IN LEGAZPI CITY (RIP-RAPING WORKS)



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure I 7.4** Typical Cross Sections for Proposed River Improvement and Drainage Plans
JAPAN INTERNATIONAL COOPERATION AGENCY	



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure I 7.5

Proposed Alighment of the Masisi and Ogsong River Improvement Plans