

**The Study on  
Sabo and Flood Control for  
Western River Basins of Mount Pinatubo**

**in  
the Republic of the Philippines**

**Final Report**

**Volume II  
Main Report**

**September 2003**

Nippon Koei Co., Ltd.  
CTI Engineering International Co., Ltd.

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**Japan International Cooperation Agency**

## List of Volumes

**Volume I : Executive Summary**

**Volume II : Main Report**

**Volume III-1 : Supporting Report**

- Appendix I : Socio-economy
- Appendix II : Topography and Geology
- Appendix III : Meteorology and Hydrology
- Appendix IV : Sediment Balance
- Appendix V : Inundation and Damage
- Appendix VI : Sabo/Flood Control Structural Measures
- Appendix VII : Road Network
- Appendix VIII : Sabo/Flood Control Non-Structural Measures

**Volume III-2 : Supporting Report**

- Appendix IX : Community Disaster Prevention System
- Appendix X : Construction Plan and Cost Estimate
- Appendix XI : Environmental Assessment
- Appendix XII : Economic Evaluation
- Appendix XIII : Institution
- Appendix XIV : GIS
- Appendix XV : Transfer of Technology

**Volume IV : Data Book**

### Exchange Rates

US\$ 1.0 = Philippine Peso 50.5  
US\$ 1.0 = Japanese Yen 120.1

Average of July 2002

## PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct the Study on Sabo and Flood Control for Western River Basins of Mount Pinatubo and entrusted the study to the Japan International Cooperation Agency (JICA).

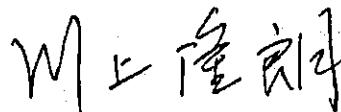
JICA selected and dispatched a study team headed by Mr. Shinsuke HINO of Nippon Koei Co., Ltd. (consisting of Nippon Koei Co., Ltd. and CTI Engineering International Co., Ltd.) to the Philippines four times between April 2002 and August 2003. In addition, JICA set up an advisory committee headed by the late Mr. Masaaki NAKANO, Director, Independent Administrative Institution Public Works Research Institute, between April 2002 and August 2003, which examined the study from specialist and technical point of view.

The team held discussions with the officials concerned of the Government of the Philippines and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Philippines for their close cooperation extended to the team.

September 2003



Takao KAWAKAMI

President

Japan International Cooperation Agency

September 2003

Mr. Takao Kawakami  
President  
Japan International Cooperation Agency  
Tokyo, Japan

Letter of Transmittal

It is a great pleasure that we submit herewith the Final Report of the "Study on Sabo and Flood Control for Western River Basins of Mount Pinatubo in the Republic of the Philippines".

The study has prepared a master plan for sabo and flood control for the western river basins of Mount Pinatubo including the Bucao, Maloma and Sto. Tomas River basins and proposed the priority projects, for which the feasibility study was conducted. The master plan has been formulated combining the structural measures, non-structural measures and community disaster prevention systems with the target year of 2022. The proposed priority projects are heightening and strengthening of the existing dikes in the Bucao and Sto. Tomas River as the structural measures, flood/ mudflow warning and evacuation system as the non-structural measures, and community disaster prevention systems consisting of community-based forest management, agricultural development on lahar area, community road rehabilitation and support programs for the Aeta people.

The report consists of 4 volumes; Volume I for Executive Summary, Volume II for Main Report, Volume III for Supporting Report and Volume IV for Data Book. The report covers all the outcomes of the master planning and feasibility study.

We hope that the report will be helpful for realization of the projects and programs proposed in the study to mitigate the flood/mudflow damages in the downstream and to secure livelihood of the people in the midstream and upstream, and will contribute to the poverty alleviation and socio-economic development of the western river basins.

We wish to express our grateful acknowledgement to the personnel from your Agency in Tokyo and the Philippines, Advisory Committee, Ministry of Foreign Affairs, Ministry of Land, Infrastructure and Transport, Embassy of Japan in the Philippines, and also to officials and individuals of the Government of the Philippines including DPWH for their kind assistance and advice extended to the study team.

Very truly yours,



Shinsuke Hino  
Team Leader  
The Study on Sabo and Flood Control for  
Western River Basins of Mount Pinatubo  
in the Republic of the Philippines



THE GOVERNMENT OF THE PHILIPPINES  
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

**The Study on Sabo and Flood Control for  
Western River Basins of Mount Pinatubo  
in the Republic of the Philippines**

JAPAN INTERNATIONAL COOPERATION AGENCY

**Location Map of Study Area**

**Structural**  
**Bucao River**

- 1) Heightening of existing right dike ( $l=6.7$  km) and construction of new dike downstream from the bridge ( $l=1.9$  km on left bank,  $l=2.4$  km on right bank)
- 2) Reconstruction of Bucao Bridge (355 lm)
- 3) Observation of hydrological/geological data at Marauot Notch  
 <to be included in the warning system>
- 4) Consolidation dam and sand pocket  
 <Review>

**Non-structural**  
**Evacuation System**

- 1) Increase of 60 evacuation centers
- 2) Renovation of 32 evacuation centers
- 3) Dissemination of hazard map

**Structural** <Review>  
**Maloma River**

- 1) Channel improvement with straightening, widening and dike heightening/construction ( $l=7$  km)
- 2) Reconstruction of Maloma Bridge (240 lm)

**CDPP** <Further discussion with people in the centers and study are recommended prior to implementation>

**Improvement of Tektek Resettlement Center**  
 Integration of three NGOs resettlement centers in Tektek Resettlement Center and improvement of community infrastructure for improvement of living conditions for the people in the centers

**Structural**  
**Sto. Tomas River**

- 1) Heightening of existing dike ( $l=13.6$  km), strengthening of existing dike ( $l=13.6$  km) and construction of new dike ( $l=2$  km) with Gabor River drainage improvement
- 2) Reconstruction of Maculcol Bridge (430 lm)
- 3) Consolidation dam/sand pocket/channel works  
 <Review>



**CDPP**  
**Agricultural Development on Lahar Area**  
 To develop lahar covered river area as agriculture land for livelihood development for the severely affected people

**CDPP**  
**Community Road Rehabilitation**  
 Community road rehabilitation for the Bucao River basin (48 km) and the Sto. Tomas River basin (60 km) to trigger the various community development in the mountain remote area

**Non-structural**  
**Watershed Management**  
 Forest management, foothill management and sediment control

**CDPP**  
**Community-based Forest Management (CBFM)**  
 To develop 25,000 ha of forest including agro-forestry under CBFM program as livelihood development for the remote community in the mountain area

**CDPP**  
**Establishment of Aeta Assistance Station (AETAS)**  
 To recover the Aeta community and to preserve their culture, history and the traditional life

**CDPP** <Further monitoring of water quality and study are recommended prior to implementation>

**Community Development in Mapanuepe Lake Basin**  
 To utilize water resources in Mapanuepe Lake for irrigation, inland fishery and tourism as income generation measures in the communities submerged by the dammed-up lake

#### Monitoring Station

▲ Rain

■ Rain&WaterLevel

✖ WaterLevel

● Bucao Bridge

■ River Structural Measure

■ Community Road

■ Non Structural Measure

■ CBFM Project

■ Lahar Agriculture

■ AETAs

■ Resettlement Plan

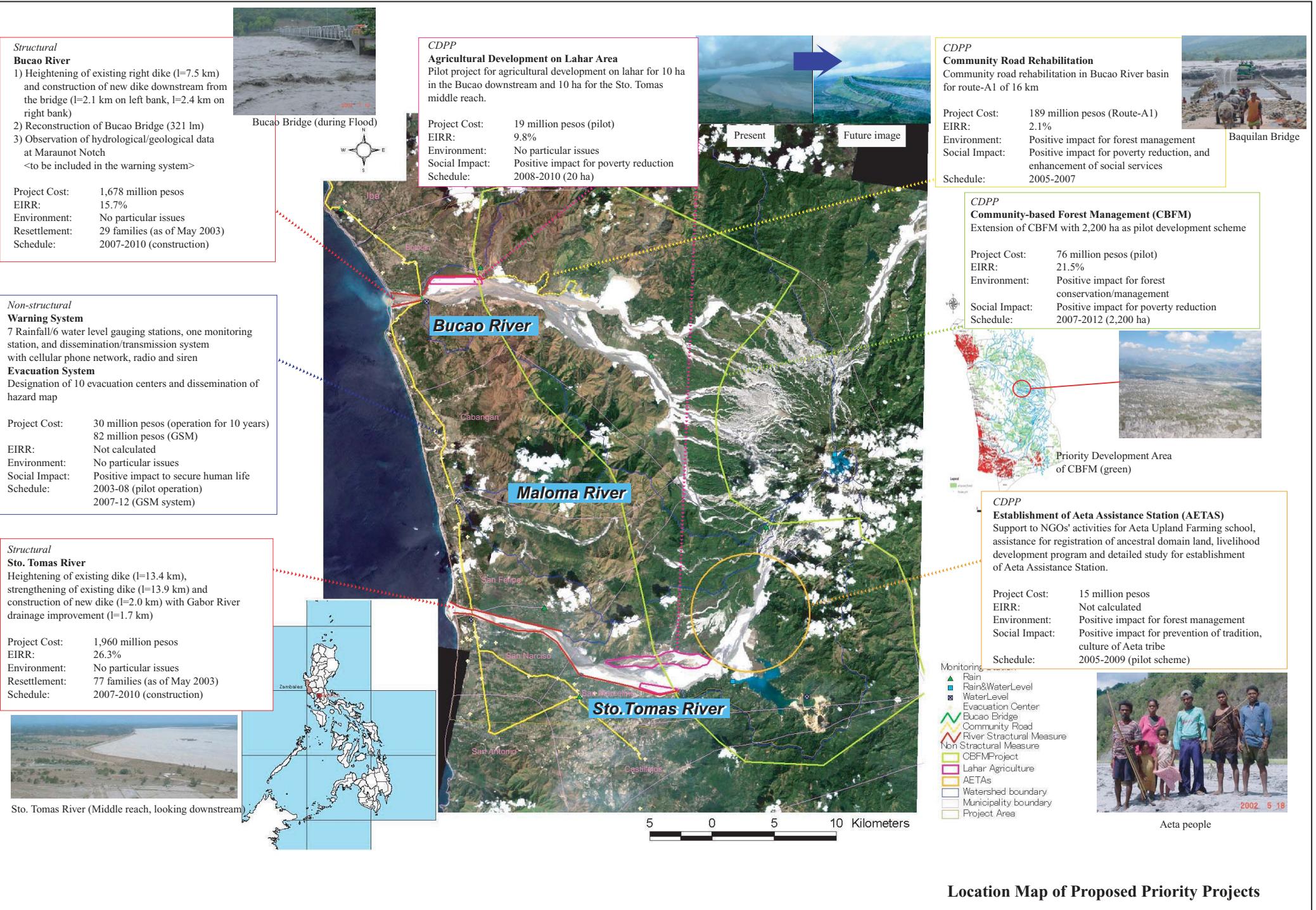
■ Community development

■ Watershed boundary

■ Municipality boundary

■ Project Area

**Location Map of Master Plan**



**THE STUDY  
 ON SABO AND FLOOD CONTROL  
 FOR WESTERN RIVER BASINS OF MOUNT PINATUBO  
 IN THE REPUBLIC OF THE PHILIPPINES**

**Outline of the Study**

**1. River Basin Condition**

1.1 Mount Pinatubo	Location	Central Luzon
	Peak	EL.1,449 m (EL.1,745 m before eruption)
	Crater lake	2.4 km <sup>2</sup> at EL.920 m (January 2003)
	Maraunot Notch	Andesite, fluvio-lacustrine deposit and dacite
1.2 Bucao River	Basin area	655 km <sup>2</sup> (646 km <sup>2</sup> before eruption)
	River length	36.0 km
	River gradient	1/270 at downstream (1/400 before eruption)
1.3 Maloma River	Basin area	152 km <sup>2</sup> (151 km <sup>2</sup> before eruption)
	River length	17.8 km
	River gradient	1/800 at downstream (1/1,200 before eruption)
1.4 Sto. Tomas River	Basin area	262 km <sup>2</sup> (262 km <sup>2</sup> before eruption)
	River length	32.8 km
	River gradient	1/300 at downstream (1/450 before eruption)
	Mapanuepe lake	6.8 km <sup>2</sup> in surface area, 30 million m <sup>3</sup> in capacity
1.5 Socio-economy	Population	228,148 for 8 municipalities (2000 census) (433,542 for Zambales, 8,030,945 for Region 3)
	Un-employment	37.9% for Zambales, 10.0% for Region 3 (2000)
	Family income	P123,667/year for Zambales (2000) (P144,039 for nation, P151,449 for Region 3)
1.6 Rainfall/Flood	Annual rainfall	3,600 mm in Iba (average)
	Probable flood peak	3,800 m <sup>3</sup> /s in Bucao, 810 m <sup>3</sup> /s in Maloma and 1,200 m <sup>3</sup> /s in Sto. Tomas River for 20-year probable flood
1.7 Sediment	Sediment delivery	13 MCM (2003) & 2.9 MCM (2010) in Bucao, and, 7.1 MCM (2003) & 1.4 MCM (2010) in Sto. Tomas
	Channel deposit	843 MCM in Bucao and 818 MCM in Sto. Tomas (2002)
1.8 Flood damages	Inundation area	11.1 km <sup>2</sup> for Bucao, 5.5 km <sup>2</sup> for Maloma and 58.9 km <sup>2</sup> for Sto. Tomas River for 20-year probable flood
	Death records	215 persons died after eruption in Zambales.
1.9 Land use	Current land use	69% of forest area and 31% of alienable and disposable land in Zambales

**2. Existing River and Other Structures**

2.1 Bucao River	Dike	6 km long right dike, a 300 m long spur dike, riverbank protection
	Bucao Bridge	300 m long, built in 1939

		Others	Irrigation facilities, a drainage outlet
2.2	Maloma River	Dike	3.2 km long left dike, riverbank protection
		Maloma Bridge	90 m,
2.3	Sto. Tomas River	Dike	19.1 km long left dike, 7.6 km long right dike, riverbank protection
		Maculcol Bridge	381 m long,
		Dalanawan channel	170 m long and 8m wide to drain the Mapanuepe lake water
		Bayarong dam	Tailings dam for Dizon copper mines, 126 m high, AFP/PNP watch points, disaster information and evacuee's own judgment,
2.4	Evacuation system	Warning system	36 evacuation centers
		Evacuation center	7 resettlement centers,
2.5	Resettlement center	Center by MPC	3 resettlement centers,
		Center by NGO	

### 3. Basic Concept of Recovery and Development

3.1	JICA study	Study period	March 2002 to September 2003
		Study area	Western river basins of Mount Pinatubo including Bucao, Maloma and Sto.Tomas River basins
		Scope of the study	<ol style="list-style-type: none"> <li>1) Formulation of sabo and flood control master plan and selection of priority projects</li> <li>2) Feasibility study for priority projects</li> <li>3) Transfer of technology</li> </ol>
3.2	Needs	Recovery actions	<ol style="list-style-type: none"> <li>1) Mitigation of flood/mudflow inundation and damages in lowland area</li> <li>2) Securing of national highway against flood/mudflow</li> <li>3) Recovery of life/livelihood in mountainous area affected by volcanic materials/lahar</li> </ol>
		Basin development	<ol style="list-style-type: none"> <li>1) Agriculture and tourism development</li> <li>2) Final target of sustainable economic growth with uplifting of living standard</li> </ol>
3.3	Study concept		<ol style="list-style-type: none"> <li>1) Target year of 2022 for master plan</li> <li>2) Combination of implementation of structural/non-structural measures and establishment of community-based disaster prevention systems</li> <li>3) Target of poverty alleviation</li> </ol>

### 4. Master Plan for Sabo and Flood Control

4.1	Structural measures	Bucao River	<ol style="list-style-type: none"> <li>1) Heightening of existing right dike (<math>l=6.7</math> km) and construction of new dike downstream from the bridge (<math>l=1.9</math> km on left bank, <math>l=2.4</math> km on right bank)</li> <li>2) Reconstruction of Bucao Bridge (355 m long)</li> <li>3) Observation of hydrological/geological data at Maraunot Notch</li> </ol>
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		4) Consolidation dam and sand pocket <Review>
	Maloma River <Review>	1) Channel improvement with straightening, widening and dike heightening/construction ( $l=7$ km)
	Sto.Tomas River	2) Reconstruction of Maloma Bridge (240 m long)
4.2	Non-structural measures	1) Heightening of existing dike ( $l=13.6$ km), strengthening of existing dike ( $l=13.6$ km) and construction of new dike ( $l=2$ km) with Gabor River drainage improvement
	Warning system	2) Reconstruction of Maculcol Bridge (430 m long)
	Evacuation system	3) Consolidation dam/sand pocket/channel works <Review>
4.3	Community-based disaster prevention systems	7 Rainfall/6 water level gauging stations, one monitoring station, and dissemination/transmission system with cellular phone network, radio and siren
	Watershed management	1) Increase of 60 evacuation centers
	Improvement of Tektek RC	2) Renovation of 32 evacuation centers
	CBFM	3) Dissemination of hazard map
	Agricultural development	Forest management, foothill management, and sediment control
	Basin development of Mapanuepe Lake	Integration of three NGOs' resettlement centers in Tektek RC and improvement of community infra. <Further discussion and study>
	Community road	Extension of CBFM for creation of livelihood. Agricultural development on lahar at the river side area for livelihood development.
	AETAS	Community development of Mapanuepe Lake basin for irrigation, inland fishery and tourism <Further monitoring and study>
		Community road rehabilitation in Bucao and Sto.Tomas River basins
		Establishment of Aeta Assistance Station

## 5. Priority Projects (Feasibility Projects)

### 5.1 Structural measures Bucao River

Sto.Tomas River

- 1) Heightening of existing right dike ( $l=7.5$  km) and construction of new dike downstream from the bridge ( $l=2.1$  km on left bank,  $l=2.4$  km on right bank)
- 2) Reconstruction of Bucao Bridge (321 m long)
- 3) Observation of hydrological/geological data at Maraunot Notch
- 1) Heightening of existing dike ( $l=13.4$  km), strengthening of existing dike ( $l=13.9$  km) and

			construction of new dike ( $l=2.0$ km) with Gabor River drainage improvement ( $l=1.7$ km)
5.2	Non-structural measures	Warning system	7 Rainfall/6 water level gauging stations, one monitoring station, and dissemination/transmission system with cellular phone network, radio and siren
		Evacuation system	Designation of ten evacuation centers, Dissemination of hazard map.
5.3	Community-based disaster prevention systems	CBFM	Extension of CBFM with 2,200 ha as pilot development scheme.
		Agricultural development	Pilot project for agricultural development on lahar for 10 ha at the Bucao downstream and 10 ha for the Sto.Tomas middle reach.
		Community road rehabilitation	Community road rehabilitation in Bucao River basin for route-A1 of 16 km.
		AETAS	Supporting NGOs' activities for Aeta Upland Farming school, assisting for registration of ancestral domain land, livelihood development program and the detailed study for establishment of Aeta Assistance Station,
5.4	Implementation	Organization	<ol style="list-style-type: none"> <li>1) MPE-PMO, DPWH functioning as implementation agency for the structural measures,</li> <li>2) PMO-Zambales under Zambales Province functioning as implementation agency for the non-structural and CDPP measures</li> <li>3) Establishing Project Coordination Committee (PCC) to be functioning for integration among structural, non-structural and CDPP measures.</li> </ol>
5.5	Project Evaluation	Funding source	GOP and foreign assistance
		Bucao River Structural Measures	<p>1) Project Cost: 1,678 million pesos  2) EIRR: 15.7%  3) Environment: No particular issues  4) Resettlement: Plan formulated (29 families, as of May 2003)</p>
		Sto.Tomas River Structural Measures	<p>5) Evaluation: To be implemented  6) Schedule: 2007-2010 (construction)</p> <p>1) Project Cost: 1,960 million pesos  2) EIRR: 26.3%  3) Environment: No particular issues  4) Resettlement: Plan formulated (77 families, as of May 2003)</p>
		Non-structural Measures	<p>5) Evaluation: To be implemented  6) Schedule: 2007-2010 (construction)</p> <p>1) Project Cost: 30 million pesos  (operation for 10 years)</p>

Warning and evacuation system	2) EIRR: 3) Environment: 4) Social Impact:  5) Evaluation:  6) Schedule:	82 million pesos (GSM) Not calculated No particular issues Positive impact to secure human life  To implement improving the existing system 2003-08 (pilot operation) 2007-12 (GSM system)
CDPP-CBFM	1) Project Cost: 2) EIRR: 3) Environment:  4) Social Impact:  5) Evaluation: 6) Schedule:	76 million pesos (Pilot) 21.5% Positive impact for forest conservation/management Positive impact for poverty reduction To implement (Pilot) 2007-2012 (2,200 ha)
CDPP- Agricultural development on lahar area	1) Project Cost: 2) EIRR: 3) Environment: 4) Social Impact:  5) Evaluation 6) Schedule:	19 million pesos (Pilot) 9.8% No particular issues Positive impact for poverty reduction To implement (pilot) 2008-2010 (20 ha)
CDPP- Community road rehabilitation	1) Project Cost: 2) EIRR: 3) Environment:  4) Social Impact:  5) Evaluation: 6) Schedule:	189 million pesos 2.1% Positive impact for forest management Positive impact for poverty reduction and social services To implement (Route-A1) 2005-2007
CDPP-AETAS	1) Project Cost: 2) EIRR: 3) Environment:  4) Social Impact:  5) Evaluation: 6) Schedule:	15 million pesos Not calculated Positive impact for forest management Positive impact for preservation of tradition, culture of Aeta tribe To assist NGOs' activities 2005-2009 (pilot scheme)

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**FINAL REPORT  
VOLUME II  
MAIN REPORT**

Table of Contents

List of Volumes

Location Map of Study Area

Location Map of Master Plan

Location Map of Proposed Priority Projects

Outline of the Study

Abbreviations

Measurements

Page

**PART-I GENERAL AND PRESENT CONDITION**

CHAPTER 1	INTRODUCTION .....	1-1
1.1	Background and Objectives.....	1-1
1.1.1	Study Background.....	1-1
1.1.2	Study Objectives.....	1-2
1.1.3	Study Area .....	1-2
1.1.4	Scope of the Study .....	1-2
1.2	Study Schedule and Activities.....	1-2
1.2.1	Study Schedule.....	1-2
1.2.2	Activities.....	1-2
1.3	Transfer of Technology .....	1-7
CHAPTER 2	MOUNT PINATUBO ERUPTION .....	2-1
2.1	Mount Pinatubo Eruption .....	2-1
2.1.1	Volcanic Activities .....	2-1
2.1.2	Pyroclastic Fall and Flow Deposits.....	2-2
2.1.3	Lahar.....	2-2
2.2	Extent of Damage .....	2-3
2.2.1	Damage Immediately after Eruption.....	2-3
2.2.2	Amount of Damage to Zambales up to year 2000 .....	2-3

2.3	Immediate Efforts by the Government and Others.....	2-4
2.3.1	Efforts Immediately before Eruption.....	2-4
2.3.2	Emergency Activities and Organizations .....	2-4
2.3.3	Structural Measures and Responsible Organizations .....	2-5
2.3.4	Structural Rehabilitation Plan.....	2-6
2.3.5	Support of Donors.....	2-6
2.3.6	Support by Non-Government Organizations (NGO) .....	2-7
<b>CHAPTER 3      CHANGES IN THE NATURAL AND SOCIAL BASIN CONDITIONS AFTER THE ERUPTION.....</b>		<b>3-1</b>
3.1	Geographical Location.....	3-1
3.2	Socio-economy .....	3-1
3.2.1	Administrative Structure.....	3-1
3.2.2	Population and Employment.....	3-2
3.2.3	National and Regional Economy .....	3-2
3.2.4	Sectoral Economic Profile .....	3-3
3.2.5	Infrastructure .....	3-6
3.2.6	Poverty Incidence.....	3-9
3.3	Topography, Geology and Soil Condition .....	3-10
3.3.1	Topography .....	3-10
3.3.2	Geology.....	3-11
3.3.3	Soil Condition .....	3-12
3.4	Meteorology and Hydrology.....	3-13
3.4.1	Meteorology.....	3-13
3.4.2	Hydrology .....	3-14
3.4.3	Water Quality.....	3-14
3.5	River Conditions .....	3-15
3.5.1	River System.....	3-15
3.5.2	River Channel.....	3-17
3.6	Flood and Mudflow Damage .....	3-18
3.6.1	Bucao River Basin .....	3-18
3.6.2	Maloma River Basin .....	3-18
3.6.3	Sto. Tomas River Basin.....	3-19
3.7	Existing Flood and Mudflow Control Plans/Projects and Facilities .....	3-20
3.7.1	Existing Flood and Mudflow Control Plans/Projects (Structural Measures).....	3-20

3.7.2	Existing Disaster Prevention System (Non-Structural Measures).....	3-21
3.7.3	Existing Flood and Mudflow Control Facilities .....	3-22
3.8	Land Use.....	3-26
3.8.1	Land Use Trends .....	3-26
3.8.2	Current Land Use.....	3-26
3.8.3	Existing Land Use Plan.....	3-27
3.8.4	Existing Agricultural Development Plan.....	3-28
3.9	Traffic Condition.....	3-28
3.9.1	Present Road Network.....	3-28
3.9.2	Existing Road Development Plan .....	3-29
3.9.3	Existing Bridges and Other Facilities.....	3-29
3.10	Baseline Environmental Conditions.....	3-30
3.10.1	Biological Environment .....	3-30
3.10.2	Socio-Economic and Cultural Environment .....	3-32
3.11	Institution .....	3-33
3.11.1	Law and Regulation.....	3-33
3.11.2	Organization.....	3-35
3.11.3	Issues.....	3-43

## **PART-II FORMULATION OF MASTER PLAN**

CHAPTER 4	BASIC CONCEPT OF MASTER PLAN.....	4-1
4.1	Main Issues to be Addressed in the Study Area.....	4-1
4.2	Necessity of Master Plan Formulation.....	4-2
4.3	Basic Concept of Master Plan .....	4-2
4.3.1	Approach to Basin-wide Comprehensive Sediment Control .....	4-2
4.3.2	Combination of Improvement Works in Lowlands and Highlands .....	4-3
4.3.3	Combination of Structural and Non-structural Measures .....	4-3
4.3.4	Regional Economic Development and Poverty Alleviation .....	4-3
4.3.5	Target Year and Planning Scale.....	4-4
4.4	Points to be Considered in Formulating the Master Plan .....	4-4
4.4.1	Overall Disaster Prevention Plan around Mount Pinatubo.....	4-4
4.4.2	Formulation of Realistic and Economical Plan.....	4-4

CHAPTER 5	FLOODS AND DAILY RUNOFF .....	5-1
5.1	Floods.....	5-1
5.1.1	Probable Rainfall .....	5-1
5.1.2	Probable Flood.....	5-2
5.2	Daily Flow Duration Curve.....	5-3
5.2.1	Water Balance Analysis .....	5-3
5.2.2	Flow Duration Curve .....	5-4
5.3	Floods in July 2002 .....	5-4
5.3.1	Overview.....	5-4
5.3.2	Rainfall Observation .....	5-5
5.4	Discharge Measurement .....	5-5
5.4.1	Discharge Measurement Record.....	5-5
5.4.2	Changes of Cross Sections.....	5-6
5.4.3	Discharge Rating Curve.....	5-6
5.4.4	Abnormal Runoff Coefficient of Flood in July 2002 .....	5-6
CHAPTER 6	SEDIMENT BALANCE .....	6-1
6.1	Mechanism of Sedimentation.....	6-1
6.2	Future Sediment Yield.....	6-2
6.2.1	Sediment Source .....	6-2
6.2.2	Sediment Yield in 2001 .....	6-2
6.2.3	Sediment Delivery in 2002.....	6-5
6.2.4	Future Sediment Yield.....	6-7
6.3	Sediment Transport Capacity.....	6-7
6.3.1	Riverbed Material .....	6-7
6.3.2	Annual Sediment Transport .....	6-8
6.3.3	Sediment Transport Formula.....	6-8
6.3.4	Annual Sediment Transport Capacity .....	6-8
6.4	Riverbed Movement Analysis.....	6-9
6.4.1	Short Term Riverbed Movement.....	6-10
6.4.2	Long Term Riverbed Movement.....	6-11
6.4.3	Comparison of Short Term and Long Term Riverbed Movement Analysis .....	6-14
6.5	Monitoring for Riverbed Movement.....	6-15

CHAPTER 7	MUDFLOW PRONE AREA.....	7-1
7.1	Two-Dimensional Flood/Mudflow Analysis.....	7-1
7.1.1	Approaches .....	7-1
7.1.2	Methodology .....	7-1
7.2	Flood/Mudflow Hazard Area .....	7-4
7.2.1	Bucao River Basin .....	7-4
7.2.2	Maloma River Basin .....	7-5
7.2.3	Sto. Tomas River Basin.....	7-5
CHAPTER 8	STRUCTURAL MEASURES IN MASTER PLAN.....	8-1
8.1	Assessment of Planning Scale.....	8-1
8.2	Possible Structural Measures .....	8-1
8.2.1	Sediment Source Zone: to reduce the volume of sediment at the source.....	8-1
8.2.2	Sediment Deposition/Secondary Erosion Zone: to stabilize unstable sediment.....	8-2
8.2.3	Sediment Conveyance Zone: for smooth transportation of sediment to the river mouth .....	8-3
8.3	Structural Measures Recommended by USACE.....	8-3
8.4	Hazard Scenarios by PHIVOLCS .....	8-4
8.4.1	Bucao River Basin .....	8-4
8.4.2	Sto. Tomas River Basin.....	8-4
8.5	Flood/Mudflow Control in the Bucao River Basin.....	8-5
8.5.1	Sabo Dams in Sediment Source Zone .....	8-5
8.5.2	Alternative Flood/Mudflow Control Measures in Sediment Conveyance Zone .....	8-6
8.5.3	Comparative Study through Two Dimensional Mudflow Analysis during Flood .....	8-7
8.6	Structural Measures in the Maloma River Basin .....	8-8
8.7	Structural Measures for the Sto. Tomas River Basin .....	8-9
8.7.1	Alternative Flood /Mudflow Control Measures.....	8-9
8.7.2	Comparative Study through Riverbed Movement Analysis.....	8-10
8.8	Maraunot Notch of Pinatubo Crater Lake.....	8-12
8.8.1	Topographic/Geological Conditions.....	8-12
8.8.2	Breach of Maraunot Notch.....	8-13
8.8.3	Detailed Field Investigations.....	8-13

8.8.4	Mechanism of the Breach.....	8-14
8.8.5	Proposed Activity .....	8-15
8.9	Road Network.....	8-15
8.9.1	Proposed Master Plan for the Road Network.....	8-15
8.9.2	Proposed Master Plan for Bridge Reconstruction .....	8-15
<b>CHAPTER 9 NON-STRUCTURAL MEASURES IN MASTER PLAN.....</b>		<b>9-1</b>
9.1	General.....	9-1
9.2	Forecasting and Warning System.....	9-1
9.2.1	Present Conditions.....	9-1
9.2.2	Alternative Plans for Warning System.....	9-3
9.2.3	Recommended Monitoring and Warning System.....	9-6
9.3	Evacuation System.....	9-7
9.3.1	Present Condition .....	9-7
9.3.2	Improvement of Evacuation System.....	9-8
9.4	Basin Management .....	9-11
9.4.1	Legal Basis of Watershed Management.....	9-11
9.4.2	Watershed Management in the Study Area.....	9-13
9.4.3	Forest Management .....	9-13
9.4.4	Indigenous Peoples' Rights Act and the Aeta People (Foothill Management) .....	9-14
9.4.5	Sediment Control .....	9-15
9.4.6	Particular Issues.....	9-15
9.4.7	Recommended Approach for Watershed Management .....	9-18
<b>CHAPTER 10 COMMUNITY-BASED DISASTER PREVENTION AND SOCIAL DEVELOPMENT PLANS IN MASTER PLAN .....</b>		<b>10-1</b>
10.1	Basic Concept of CDPP .....	10-1
10.2	Objectives and Framework of CDPP: Livelihood Support .....	10-2
10.3	Field Investigation and Needs Assessment.....	10-3
10.3.1	Household Interview Survey.....	10-3
10.3.2	PCM Workshop .....	10-5
10.4	Resettlement.....	10-11
10.4.1	Present Conditions.....	10-11
10.4.2	Improvement of Resettlement Centers .....	10-13

10.5	Proposed Overall Plan for the Community Disaster Prevention.....	10-14
<b>CHAPTER 11 ENVIRONMENTAL IMPACT ASSESSMENT OF MASTER PLAN.....</b>		<b>11-1</b>
11.1	IEE Methodology.....	11-1
11.1.1	Methodology .....	11-1
11.1.2	Data Sources .....	11-1
11.2	Future Environmental Conditions without the Project .....	11-2
11.2.1	Physical Environment .....	11-2
11.2.2	Biological Environment .....	11-2
11.2.3	Socio-Economic Environmental Conditions.....	11-2
11.3	Potential Environmental Impacts and Mitigation .....	11-2
11.3.1	Impact Zone and Summary of Potential Environmental Impacts.....	11-2
11.3.2	Physical Environment.....	11-3
11.3.3	Biological Environment .....	11-4
11.3.4	Socio-Economic Environment .....	11-4
11.3.5	Resettlement .....	11-5
11.4	Environmental Management Plan.....	11-6
11.4.1	Brief Descriptions of the Potential Environmental Impacts and their Mitigation/Enhancement Measures .....	11-6
11.4.2	Summary Matrix of Proposed Mitigation and Enhancement Measures, Estimated Costs and Responsibilities .....	11-7
11.4.3	Summary Matrix of Proposed Environmental Monitoring Plan .....	11-7
<b>CHAPTER 12 ECONOMIC EVALUATION OF MASTER PLAN.....</b>		<b>12-1</b>
12.1	Criteria, Assumptions and Methodology.....	12-1
12.1.1	Definition of Project Benefits.....	12-1
12.1.2	Methodology for Estimating Flood Damage.....	12-1
12.1.3	Project Benefit.....	12-7
12.2	Structural Measures .....	12-7
12.3	Non Structural Measures and Community Disaster Prevention Plans.....	12-8

CHAPTER 13	IMPLEMENTATION SCHEDULE FOR MASTER PLAN.....	13-1
13.1	Project Implementation Schedule .....	13-1
13.2	Project Implementation Structure.....	13-1
13.2.1	River Basin Management: Legislation and Organization.....	13-1
13.2.2	Project Organization and Management.....	13-2
CHAPTER 14	SELECTION OF PRIORITY PROJECTS .....	14-1
14.1	Criteria for Selection.....	14-1
14.2	Selected Structural Measures.....	14-1
14.3	Selected Non-Structural Measures.....	14-1
14.4	Selected Community Disaster Prevention Plans.....	14-1
<b>PART-III FEASIBILITY STUDY OF PRIORITY PROJECTS</b>		
CHAPTER 15	FEASIBILITY DESIGN OF PRIORITY PROJECTS.....	15-1
15.1	Mudflow Control of the Bucao River .....	15-1
15.1.1	General.....	15-1
15.1.2	Design Condition in the Bucao River .....	15-1
15.1.3	Preliminary Design for the Bucao River.....	15-3
15.2	Reconstruction of the Bucao Bridge.....	15-6
15.3	Mudflow Control of the Sto. Tomas River.....	15-8
15.3.1	General.....	15-8
15.3.2	Design Condition in the Sto. Tomas River .....	15-8
15.3.3	Preliminary Design of the Sto. Tomas River .....	15-10
15.4	Warning and Evacuation System .....	15-16
15.4.1	Outline of Warning System.....	15-16
15.4.2	Stage-wise Development for Warning System.....	15-19
15.4.3	Development Plan of Evacuation System.....	15-19
15.4.4	Institutional Arrangement for Project Implementation.....	15-20
15.5	Community Infrastructure Development at Tektek Resettlement Center .....	15-21
15.5.1	Outline of the Project.....	15-21
15.5.2	Results of Field Investigation & Direct Interview with the People .....	15-21
15.5.3	Conclusion on the Feasibility Study.....	15-21
15.6	Extension of CBFM Program .....	15-22
15.6.1	Basic Concept of CBFM Program.....	15-22
15.6.2	Potential Development Area for CBFM in the Study Area .....	15-22

15.6.3	Priority Area for CBFM Extension.....	15-23
15.7	Agricultural Development in Lahar Area .....	15-24
15.7.1	Selection of Appropriate Crops for Lahar Agriculture .....	15-24
15.7.2	Key Issues for Development Plan Formulation .....	15-25
15.7.3	Proposed Development Plan.....	15-26
15.8	Community Development in the Mapanuepe Lake Basin.....	15-30
15.8.1	Proposed Development Plan.....	15-30
15.8.2	Major Issues for Mapanuepe Lake Basin Development.....	15-30
15.8.3	Water Quality Survey.....	15-30
15.8.4	Conclusions for the Feasibility Study .....	15-32
15.9	Community Road Development in Mountain Area .....	15-32
15.9.1	Proposed Community Road Rehabilitation Network .....	15-32
15.9.2	Feasibility Design for Community Road Development .....	15-34
15.9.3	Priority Route for Community Road Development.....	15-36
15.10	Establishment of Aeta Assistance Station (AETAS).....	15-37
15.10.1	Project Formation .....	15-37
15.10.2	Details of the Project .....	15-37

<b>CHAPTER 16</b>	<b>CONSTRUCTION PLAN AND COST ESTIMATE OF PRIORITY PROJECTS.....</b>	<b>16-1</b>
16.1	Construction Plan and Schedule of the Bucao River Dike Heightening/Strengthening.....	16-1
16.2	Construction Plan and Schedule of the Sto. Tomas River Dike Construction/Heightening/Strengthening.....	16-2
16.3	Construction Plan and Schedule for the Bucao Bridge .....	16-4
16.3.1	Construction Plan .....	16-4
16.3.2	Construction Schedule .....	16-7
16.4	Cost Estimate .....	16-8
16.4.1	Constitution of Project Cost .....	16-8
16.4.2	Conditions and Method of Cost Estimate .....	16-8
16.4.3	Project Cost for Sabo and Flood Control Structure .....	16-9
16.4.4	Project Cost for Non-Structural Measures.....	16-11
16.4.5	Project Cost for Community-Based Disaster Prevention .....	16-13
16.4.6	Overall Project Cost.....	16-15

<b>CHAPTER 17</b>	<b>IMPLEMENTATION PLAN OF PRIORITY PROJECTS.....</b>	<b>17-1</b>
17.1	General.....	17-1
17.2	Implementation Organization.....	17-1
17.2.1	Overview.....	17-1
17.2.2	Proposed Project Implementation Structure.....	17-2
17.3	Implementation Schedule.....	17-4
17.4	Capacity Building .....	17-6
17.5	Relations with the Community and NGOs.....	17-6
<b>CHAPTER 18</b>	<b>ENVIRONMENTAL IMPACT ASSESSMENT OF PRIORITY PROJECTS.....</b>	<b>18-1</b>
18.1	General.....	18-1
18.1.1	Brief Description of the Proposed Project.....	18-1
18.1.2	Brief Description of Methodology of the EIA .....	18-1
18.1.3	Scoping Meetings .....	18-1
18.1.4	Consultation Workshop and Household/Perception Surveys.....	18-2
18.2	Environmental Impact Assessment.....	18-2
18.2.1	Impact Zones and Environmental Factors .....	18-2
18.2.2	Potential Impacts on Physical Environment .....	18-2
18.2.3	Potential Impacts on Biological/Ecological Environment .....	18-4
18.2.4	Socio-Economic Impact.....	18-4
18.3	Environmental Impact Mitigation.....	18-5
18.3.1	Physical Impact.....	18-5
18.3.2	Biological Impact.....	18-6
18.3.3	Socio-Economic and Cultural Impact .....	18-6
18.3.4	Resettlement and Compensation Plan .....	18-6
18.4	Environmental Management Plan.....	18-6
18.4.1	Environmental Management Program during Construction .....	18-6
18.4.2	Environmental Monitoring Program during Construction and Operation .....	18-7
18.4.3	Risk Management Program.....	18-7
18.4.4	Emergency/Contingency Response Plan .....	18-8
18.4.5	Social Development Plan.....	18-8
18.5	Resettlement Plan for Affected People .....	18-9

CHAPTER 19 EVALUATION OF PRIORITY PROJECTS .....	19-1
19.1 Economic Evaluation for Flood/Mudflow Control Measures.....	19-1
19.1.1 Definition of Project Benefits.....	19-1
19.1.2 Direct Damage .....	19-1
19.1.3 Indirect Damage.....	19-2
19.1.4 Conversion Factors for Real Economic Values.....	19-5
19.1.5 Economic Costs .....	19-7
19.1.6 Economic Benefits.....	19-8
19.1.7 Economic Evaluation.....	19-8
19.2 Economic Evaluation for Non-Structural Measures and Community Disaster Prevention Plans .....	19-9
19.2.1 Economic Benefits.....	19-9
19.2.2 Economic Evaluation.....	19-12
19.3 Poverty Assessment through Barangay Comparative Study .....	19-13
19.3.1 Objective of the Comparative Study.....	19-13
19.3.2 Approach and Methodology .....	19-13
19.3.3 Conclusions on Poverty Assessment.....	19-14
19.3.4 Effective Projects for Poverty Reduction.....	19-15
19.4 Overall Project Evaluation.....	19-17
 CHAPTER 20 CONCLUSIONS AND RECOMMENDATIONS.....	20-1
20.1 Proposed Projects for Urgent Implementation.....	20-1
20.2 Preparatory Actions for Proposed Projects .....	20-1
20.3 Actions for Other Recommended Projects .....	20-2

## List of Tables

	<u>Page</u>
Table 1.3.1 Achievements on Transfer of Technology .....	T-1
Table 2.2.1 Estimated Cost of Damages on Public Infrastructure in Region III, 1991 .....	T-2
Table 2.3.1 List of Major NGOs' Activities in the Study Area .....	T-3
Table 3.2.1 Municipality Population of the Study Area in 1980, 1990 and 2000.....	T-4
Table 3.2.2 Labor Force, Employment Status and Employed Persons by Major Industry Group (1990, 1995, 2000).....	T-5
Table 3.2.3 Labor Force and Employment: 2000 Census Year.....	T-5
Table 3.2.4 GRDP and Per Capita GRDP by Region: 1990 ~ 2000 .....	T-6
Table 3.2.5 Gross Regional Domestic Product at Current Prices: 1990, 1995, and 2000.....	T-7
Table 3.2.6 Percentage Distribution of GRDP by Economic Sector: 1990, 1995, and 2000.....	T-8
Table 3.2.7 Percentage Distribution of GRDP per Capita: 1990, 1995, and 2000.....	T-8
Table 3.2.8 Gross Regional Domestic Product at 1985 Constant Prices: 1990, 1995, and 2000.....	T-9
Table 3.2.9 Real Annual Growth of GRDP by Economic Sector: 1990-2000 .....	T-10
Table 3.2.10 Real Growth of GRDP per Capita: 1990-2000 .....	T-10
Table 3.2.11 Production of Major Crops: 1990, 1995, and 2000.....	T-11
Table 3.2.12 Production, Harvested Area and Yield of Paddy in Zambales Province: 1990, 1995, and 2000.....	T-12
Table 3.2.13 Production, Harvested Area and Yield of Corn in Zambales Province: 1990, 1995, and 2000.....	T-12
Table 3.2.14 Farm-gate Price of Paddy and Corn for Region 3: 1996-2000 .....	T-13
Table 3.2.15 Inventory of Freshwater Fishponds by Municipality in Study Area: 2000.....	T-14
Table 3.2.16 Production and Farm-gate Price of Fish Species in Freshwater Fishpond for Zambales Province: 1996-2001 .....	T-14
Table 3.2.17 Inventory and Farm-gate Price of Livestock and Poultry: 1996-2000 .....	T-15
Table 3.2.18 Inventory of Establishments Registered to DTI by Municipality in Zambales and Study Area: From January 1, 1997 to April 23, 2002.....	T-15
Table 3.2.19 Assets of Manufacturing Industry: 1997 .....	T-16
Table 3.2.20 Family Annual Income and Expenditure at Current Prices: 2000.....	T-17

Table 3.2.21	Consumer Price Index and Inflation Rate: 1985-2001.....	T-18
Table 3.2.22	Wholesale Price Index of all Items and Construction Materials in Metro Manila: 1985-2000 .....	T-19
Table 3.2.23	Foreign Exchange Rate of the Peso versus the US Dollar: 1987-2001 .....	T-20
Table 3.2.24	Inventory of Educational Facilities: 2000-2001 School Year .....	T-21
Table 3.2.25	Inventory of Hospitals, Barangay Health Stations and Rural Health Units: 2000 .....	T-21
Table 3.2.26	Inventory of Roads and Bridges: December 2001 .....	T-22
Table 3.2.27	Number of Households by Type of Water Supply System: 1990 and 1997.....	T-23
Table 3.2.28	Electrification Program: Coverage, Number and Percentage Served:December 2000 .....	T-24
Table 3.2.29	Telephone Service Penetration by Operation by Operator Category: 2000 .....	T-24
Table 3.3.1	Results of Soil Analysis .....	T-25
Table 3.3.2	Results of Sediment Analysis, January 2003 .....	T-26
Table 3.4.1	Water Quality of Surface Waters within Mt. Pinatubo Western Watershed Area, May 2002.....	T-27
Table 3.4.2	Water Quality of Surface Waters within Mt. Pinatubo Western Watershed Area, August 2002.....	T-28
Table 3.4.3	Laboratory Results of the Groundwater Survey of Water Wells .....	T-29
Table 3.5.1	Changes in River Channel before and after Eruption of Mount Pinatubo.....	T-30
Table 3.8.1	Land Use Trends in the Study Area.....	T-31
Table 3.8.2	Existing Agricultural Land Use Condition in the Study Area.....	T-32
Table 3.9.1	Measurement of Road and Bridge in the Study Area.....	T-32
Table 3.10.1	Common Wildlife Species in Terrestrial Landscapes of Sto. Tomas, Bucao and Maloma Rivers .....	T-33
Table 3.10.2	Rare and Threatened Philippine Wildlife .....	T-33
Table 3.10.3	Estimated Population of IPs and their Locations (as of March 2001) (1/2).....	T-34
Table 3.10.3	Estimated Population of IPs and their Locations (as of March 2001) (2/2).....	T-35
Table 5.1.1	Annual Maximum Daily Rainfall in the Study Area.....	T-36
Table 5.1.2	Basin Mean Rainfall.....	T-36
Table 5.2.1	Water Balance Analysis in the Bucao River Basin .....	T-37
Table 5.2.2	Water Balance Analysis in the Sto. Tomas River Basin .....	T-37
Table 5.2.3	Daily Flow Duration Data for the Bucao River .....	T-38

Table 5.4.1	Summary of Discharge Measurements during Flood in July 2002 .....	T-39
Table 6.2.1	Ratio of New Collapse on Each Geology (Watershed Under 100 km <sup>2</sup> ) .....	T-40
Table 6.2.2	Depth of Collapse on Each Geology .....	T-40
Table 6.2.3	Average Depth of Erosion of Each Geology .....	T-41
Table 6.2.4	Estimation of Annual Sediment Yield in 2001 .....	T-42
Table 6.3.1	Grain Size and Specific Gravity of Riverbed Material .....	T-43
Table 6.3.2	Grain Size Distribution of Riverbed Material.....	T-44
Table 6.4.1	Conditions for Two-Dimensional Mudflow Analysis .....	T-45
Table 6.4.2	Conditions for One-Dimensional Riverbed Movement Analysis .....	T-46
Table 6.4.3	Lowest Riverbed Profile for 20 Years in the Bucao River under Present Condition (Alternative-1).....	T-47
Table 6.4.4	Lowest Riverbed Profile for 20 Years in the Sto. Tomas River under Present Condition (Alternative-1).....	T-48
Table 8.2.1	Possible Structural Measures in Western River Basins of Mount Pinatubo.....	T-49
Table 8.7.1	Lowest Riverbed Profile after 20 Years in the Sto. Tomas River.....	T-50
Table 8.9.1	Measurement of Proposed Bridge against Existing Bridge .....	T-51
Table 9.3.1	List of Evacuation Center during Calamities (1/3) .....	T-52
Table 9.3.1	List of Evacuation Center during Calamities (2/3) .....	T-53
Table 9.3.1	List of Evacuation Center during Calamities (3/3) .....	T-54
Table 9.3.2	Capacity and Condition of Evacuation Center.....	T-55
Table 9.3.3	Estimation Process of Number of Evacuees and Inundation Area.....	T-56
Table 10.3.1	Results of Household Interview .....	T-57
Table 10.4.1	Priority Development / Improvement Needs for Resettlement Centers.....	T-58
Table 10.5.1	List of CBFM Projects in the Study Area .....	T-59
Table 10.5.2	Monitoring and Evaluation of CBFM Projects in the Study Area (Based from the PENRO Reports).....	T-60
Table 11.1.1	Matrix of Primary and Secondary Data .....	T-61
Table 11.3.1	Summary of Environmental Impacts .....	T-62
Table 11.4.1	Summary Matrix of the Environmental Management Plan (1/3).....	T-63
Table 11.4.1	Summary Matrix of the Environmental Management Plan (2/3).....	T-64
Table 11.4.1	Summary Matrix of the Environmental Management Plan (3/3).....	T-65
Table 11.4.2	Summary Matrix of the Environmental Monitoring Plan .....	T-66
Table 12.1.1	Assessed Values of New Constructed Buildings and Taxable Improvements.....	T-66
Table 12.1.2	Schedule of Unit Values for Buildings: 1999 .....	T-67

Table 12.1.3	Results of Household Survey: Housing Condition (Responses & Weighted Values).....	T-68
Table 12.1.4	Results of Household Survey: Floor Areas (Responses and Weighted Averages).....	T-68
Table 12.1.5	Results of Household Survey: Ownership of Household Effects (Responses & Weighted Cost).....	T-69
Table 12.1.6	Damage Value for Economic Evaluation on Structural Measures .....	T-70
Table 12.1.7	Probable Damage Quantities.....	T-71
Table 12.1.8	Probable Damage Amount .....	T-72
Table 12.1.9	Annual Damage Calculation .....	T-73
Table 12.2.1	Summary of Economic Evaluation for Structural Measures.....	T-74
Table 15.1.1	Numerical Proposed Design Water Level in the Bucao River.....	T-75
Table 15.2.1	Comparison of the Bucao Bridge Location for Reconstruction.....	T-76
Table 15.2.2	Comparison Table of Alignment of Approach Road in Manila Side.....	T-77
Table 15.2.3	Applicable Span Length and Superstructure Type .....	T-78
Table 15.2.4	Comparison Table of Bucao Bridge Type for Reconstruction .....	T-79
Table 15.3.1	Numerical Proposed Design Water Level in the Sto. Tomas River .....	T-80
Table 15.3.2	Numerical Proposed Design Water Level in the Diversion Channel of the Gabor River .....	T-81
Table 15.7.1	Cost Estimate for River Training Works for Lahar Agriculture Development .....	T-82
Table 15.7.2	Market Price, Expenses and Net Income for Selected Crop Products.....	T-82
Table 15.7.3	Construction Cost for Farm Land on Lahar Covered Riverside Area.....	T-83
Table 15.8.1	Results of Water Quality Survey at Mapanuepe Lake and the Reservoir of Dizon Mine Tailing Dam.....	T-84
Table 15.8.2	Results of Bed Material Quality Survey for Mapanuepe Lake and Reservoir of Dizon Mine Tailing Dam.....	T-85
Table 16.4.1	Unit Price of Construction Works .....	T-86
Table 16.4.2	Salient Features of Contract Price Obtained from Three Projects .....	T-87
Table 16.4.3	Unit Price for Land Acquisition .....	T-88
Table 16.4.4	Construction Cost of Bucao River Basin .....	T-89
Table 16.4.5	Construction Cost of Sto. Tomas River Basin.....	T-90
Table 16.4.6	Summary of Cost for Land Acquisition and Compensation .....	T-91
Table 16.4.7	Project Cost of Bucao River Basin.....	T-92
Table 16.4.8	Project Cost of Sto. Tomas River Basin .....	T-92
Table 16.4.9	Disbursement Schedule of Bucao River Basin .....	T-93

Table 16.4.10	Disbursement Schedule of Sto. Tomas River Basin .....	T-94
Table 16.4.11	Summary of Supply and Installation Cost for Flood/Mudflow Monitoring & Warning System .....	T-95
Table 16.4.12	Project Cost for Flood/Mudflow Monitoring & Warning System .....	T-95
Table 16.4.13	Unit Price for Evacuation Center Construction .....	T-96
Table 16.4.14	Summary of Construction Cost of Schools for Evacuation .....	T-97
Table 16.4.15	Unit Price for Forest Management.....	T-98
Table 16.4.16	Plantation Cost for Forest Management.....	T-99
Table 16.4.17	Summary of Unit Prices of Land Development for Agriculture in Lahar Areas .....	T-99
Table 16.4.18	Production Cost of Seasonal and Perennial Crops per Hectare .....	T-100
Table 16.4.19	Production Cost of Mango Orchard per Hectare.....	T-101
Table 16.4.20	Construction Cost of Agriculture Development in Lahar Area.....	T-102
Table 16.4.21	Construction Cost of Community Road.....	T-103
Table 18.1.1	List of Proposed Priority Structure Measures .....	T-104
Table 18.1.2	Socio-Economic Surveys and Other Consultative Activities.....	T-104
Table 18.2.1	Summary Matrix of Potential Geo-hazards to Structures (Dams/Dikes) .....	T-105
Table 18.2.2	Biological Environmental Impacts and Mitigation/Enhancement Measures for Sto.Tomas River Dike Heightening and Construction(1/2) .....	T-106
Table 18.2.2	Biological Environmental Impacts and Mitigation/Enhancement Measures for Sto. Tomas River Dike Heightening and Construction(2/2) .....	T-107
Table 18.2.3	Biological Environmental Impacts and Mitigation/Enhancement Measures for Bucao River Dike Heightening and Reconstruction/Relocation of Bucao Bridge (1/2) .....	T-108
Table 18.2.3	Biological Environmental Impacts and Mitigation/Enhancement Measures for Bucao River Dike Heightening and Reconstruction/Relocation of Bucao Bridge (2/2) .....	T-109
Table 18.4.1	Summary Matrix of the Environmental Monitoring Plan (1/2) .....	T-110
Table 18.4.1	Summary Matrix of the Environmental Monitoring Plan (2/2) .....	T-111
Table 19.1.1	Probable Damage Amount .....	T-112
Table 19.1.2	Annual Damage Calculation .....	T-113
Table 19.1.3	Calculation of Average Annual Detour Days for Bridge Damage .....	T-114
Table 19.1.4	Estimation of Additional Transportation Cost for Bucao Bridge Damage .....	T-115
Table 19.1.5	Estimation of Additional Transportation Cost for Maloma Bridge Damage .....	T-116

Table 19.1.6	Estimation of Additional Transportation Cost for Maculcol Bridge Damage.....	T-117
Table 19.1.7	Calculation of Average Annual Detour Days due to Road Inundation by Flood/mudflow.....	T-118
Table 19.1.8	Estimation of Additional Transportation Cost for Bucao River Flood/mudflow on Road .....	T-119
Table 19.1.9	Estimation of Additional Transportation Cost for Maloma River Flood/mudflow on Road .....	T-120
Table 19.1.10	Estimation of Additional Transportation Cost for Sto. Tomas River Flood/mudflow on Road.....	T-121
Table 19.1.11	Loss of Non-agricultural Production from Flood and Lahar .....	T-122
Table 19.1.12	Base Data for Estimate of GRDP Loss caused by Flood and Lahar .....	T-123
Table 19.1.13	Evacuation Cost from Flood and Lahar .....	T-124
Table 19.1.14	Cleanup Cost from Flood and Lahar(1/2).....	T-125
Table 19.1.14	Cleanup Cost from Flood and Lahar(2/2).....	T-126
Table 19.1.15	Economic Evaluation for Bucao River Flood/Mudflow Control Project (including re-construction of Bucao Bridge) .....	T-127
Table 19.1.16	Economic Evaluation for the Sto. Tomas Flood/Mudflow Control Works (cost for Maculcol Bridge is added) .....	T-128
Table 19.2.1	Economic Evaluation on CBFM Program for Community Based Disaster Prevention Activities (For Pilot Scheme Development of 2,200ha).....	T-129
Table 19.2.2	Economic Evaluation for Agriculture Development on Lahar Area (For Pilot Development Area: Full Development Scheme) .....	T-130
Table 19.2.3	Economic Evaluation for Community Road Rehabilitation (For Priority Scheme: Route-A1:16km) .....	T-131
Table 19.3.1	Results of Barangay Accessibility Ranking Study .....	T-132
Table 19.4.1	Overall Economic Evaluation for Basinwide Integrated Disaster Prevention Activities .....	T-133

## List of Figures

	Page
Figure 1.2.1 Overall Study Schedule .....	F-1
Figure 1.2.2 Progress of the Study .....	F-2
Figure 1.3.1 General Schedule and Outline of Workshop and Seminar for Transfer of Technology.....	F-3
Figure 2.1.1 View of Mount Pinatubo before and after Eruption.....	F-4
Figure 2.1.2 Pinatubo Volcano Disaster Map .....	F-5
Figure 2.1.3 Pyroclastic Flow Deposits in the Marella River .....	F-6
Figure 3.2.1 Areas of Municipalities within the Study Area .....	F-7
Figure 3.3.1 Topographic Map in the Study Area .....	F-8
Figure 3.3.2 Geological Map of Mount Pinatubo and Environs .....	F-9
Figure 3.3.3 Water, Soil and Sediment Sampling Locations, also the Land Cover Image (August 2002).....	F-10
Figure 3.4.1 Monthly Meteorological Values in the Regions.....	F-11
Figure 3.4.2 Isohyetal Map of Annual Rainfall (Year 1995).....	F-12
Figure 3.4.3 Water Quality Sampling Location.....	F-13
Figure 3.5.1 Basin Boundary Map.....	F-14
Figure 3.5.2 Change in Catchment Area in the Bucao River System.....	F-15
Figure 3.5.3 Location of Dammed-up Lakes.....	F-16
Figure 3.5.4 Volume of Lahar Deposition along River Channels .....	F-17
Figure 3.6.1 Lahar Deposit Area in the Bucao River System.....	F-18
Figure 3.6.2 Habitual Inundation Area along Bucao River .....	F-19
Figure 3.6.3 Inundation Area along the Maloma River in August 2001 .....	F-20
Figure 3.6.4 Inundation Area along the Maloma River in July 2002 .....	F-21
Figure 3.6.5 Lahar Deposit Area in the Sto. Tomas River System.....	F-22
Figure 3.6.6 Inundation Area along the Sto. Tomas River in 2000 and 2002.....	F-23
Figure 3.7.1 Proposed Recovery Action Plans by USACE in 1994 (1/3) .....	F-24
Figure 3.7.1 Proposed Recovery Action Plans by USACE in 1994 (2/3) .....	F-25
Figure 3.7.1 Proposed Recovery Action Plans by USACE in 1994 (3/3) .....	F-26
Figure 3.7.2 Construction Records of Existing Flood/Mudflow Control Works .....	F-27
Figure 3.7.3 Existing Dike Arrangement along the Bucao River.....	F-28
Figure 3.7.4 Typical Cross Section of the Existing Dike along the Bucao River (Right Bank).....	F-29
Figure 3.7.5 General Layout of Irrigation Channel along the Bucao River .....	F-30
Figure 3.7.6 Existing Revetment Arrangement along the Maloma River .....	F-31
Figure 3.7.7 Typical Cross Section of the Existing River Bank Protection along the Maloma River.....	F-32
Figure 3.7.8 Existing Dike Arrangement along the Sto. Tomas River .....	F-33
Figure 3.7.9 Typical Cross Section of the Existing Dike along the Sto. Tomas River (Right Bank).....	F-34

Figure 3.7.10	Typical Cross section of the Existing Dike along the Sto. Tomas River (Left Bank).....	F-35
Figure 3.7.11	Location of Diversion Channel at Mapanuepe Lake.....	F-36
Figure 3.8.1	Change Land Condition after the Eruption of Mount Pinatubo.....	F-37
Figure 3.8.2	Existing Land Use for the Province of Zambales .....	F-38
Figure 3.8.3	Future Land Use Plan (Target Year is 2002) .....	F-39
Figure 3.9.1	Location of Proposed Master Plan for Road and Bridge Construction... F-40	
Figure 3.11.1	Organization Chart of the Philippine Government .....	F-41
Figure 3.11.2	Functional Relationship for Water Related Activities.....	F-42
Figure 3.11.3	Organizational Relationship for Water Related Activities .....	F-43
Figure 3.11.4	Department of Public Works and Highways Central Office .....	F-44
Figure 3.11.5	Department of Public Works and Highways, Region III .....	F-45
Figure 3.11.6	Organization of Zambales Provincial Government.....	F-46
Figure 4.3.1	Basic Concept of the Master Plan .....	F-47
Figure 4.3.2	“W” Shaped Spatial Development Strategy of Central Luzon .....	F-48
Figure 5.1.1	Location of Present and Former Rainfall Gauges .....	F-49
Figure 5.1.2	Thiessen Polygon for Study Area.....	F-50
Figure 5.1.3	Probable Rainfall Distributions (Log-Pearson III).....	F-51
Figure 5.1.4	Model Hyetograph .....	F-52
Figure 5.1.5	Model Diagram for the Bucao, Maloma and Sto. Tomas Rivers .....	F-53
Figure 5.1.6	Flood Hydrographs for the Bucao, Maloma and Sto. Tomas Rivers .....	F-54
Figure 5.1.7	Flow Distribution Diagram for the Bucao River.....	F-55
Figure 5.1.8	Flow Distribution Diagram for the Maloma River .....	F-56
Figure 5.1.9	Flow Distribution Diagram for the Sto. Tomas River .....	F-57
Figure 5.1.10	Simulated Maximum Water Level of Mapanuepe Lake .....	F-58
Figure 5.1.11	Regional Specific Discharge .....	F-59
Figure 5.2.1	Monthly Rainfall and Discharge in the Bucao River in 1963 and 1984 . F-60	
Figure 5.2.2	Comparison of Normalized Flow Duration Curves .....	F-61
Figure 5.3.1	Pictures during Flood in July 2002 .....	F-62
Figure 5.3.2	Rainfall in Eastern and Western Pinatubo Area in July 2002 .....	F-63
Figure 5.4.1	Cross Section Change at the Bucao, Maloma and Maculcol Bridges....	F-64
Figure 5.4.2	Rating Curve at the Bucao and Maloma Bridges.....	F-65
Figure 5.4.3	Observed and Simulated Discharge during Flood in July 2002 .....	F-66
Figure 5.4.4	Assumed Storage Effect of Lahar Deposits .....	F-67
Figure 6.1.1	Classification of Sediment Balance in the Bucao River .....	F-68
Figure 6.1.2	Classification of Sediment Balance in the Sto. Tomas River.....	F-69
Figure 6.2.1	Classification of Slope Stability on Western Slope of Mount Pinatubo.. F-70	
Figure 6.2.2	Past and Future Sediment Delivery in the Bucao and Sto. Tomas Rivers.....	F-71
Figure 6.2.3	Investigation Results of Sediment Delivery in 2002 in the Marella River.....	F-72

Figure 6.2.4	Comparison of River Cross Sections before and after the Flood in July 2002 in the Sto. Tomas River .....	F-73
Figure 6.2.5	Investigation Results of Sediment Delivery in 2002 in the Bucao River .....	F-74
Figure 6.3.1	Location Map for Riverbed Material Sampling.....	F-75
Figure 6.3.2	Grain Size of Riverbed Materials in the Study Area.....	F-76
Figure 6.3.3	Comparison of Grain Size Distribution of Riverbed Materials .....	F-77
Figure 6.3.4	Flow Chart of Calculation of Annual Sediment Transport.....	F-78
Figure 6.3.5	Stepwise Approximation of Duration Curve .....	F-79
Figure 6.3.6	Annual Sediment Transport Capacity in the Bucao River .....	F-80
Figure 6.3.7	Annual Sediment Transport Capacity in the Maloma River .....	F-81
Figure 6.3.8	Annual Sediment Transport Capacity in the Sto. Tomas River.....	F-82
Figure 6.4.1	Calculation Procedure of Two-Dimensional Mudflow Analysis .....	F-83
Figure 6.4.2	Hydrograph and Sediment Input for Two-Dimensional Mudflow Analysis.....	F-84
Figure 6.4.3	Calibration Results for Two-Dimensional Mudflow Model .....	F-85
Figure 6.4.4	Longitudinal Profile of Simulated and Actual Sediment Deposit by the Lahar in July 2002.....	F-86
Figure 6.4.5	Simulated Maximum Deposit by a 20-Year Probable Flood under Present Condition in the Bucao and Sto.Tomas Rivers.....	F-87
Figure 6.4.6	Longitudinal Profile and River Width of the Bucao River .....	F-88
Figure 6.4.7	Longitudinal Profile and River Width of Sto. Tomas River.....	F-89
Figure 6.4.8	Flow Duration Curve and Annual Hydrograph Pattern for Simulation ..	F-90
Figure 6.4.9	Simulated Riverbed Movement for 20 Years in the Bucao and Balin Baquero Rivers (under Present Condition) .....	F-91
Figure 6.4.10	Simulated Riverbed Movement for 20 Years in the Upper Bucao River (under Present Condition) .....	F-92
Figure 6.4.11	Simulated Riverbed Movement for 20 Years in the Sto. Tomas River (under Present Condition) .....	F-93
Figure 7.1.1	Definition of Safety Discharge and Bank-full Capacity .....	F-94
Figure 7.1.2	Inundation Blocks and Breach Points of Dike for the Bucao & Maloma Rivers .....	F-95
Figure 7.1.3	Inundation Blocks and Breach Points of Dike for the Sto. Tomas River F-96	
Figure 7.2.1	Mudflow Hazard Area in the Bucao River Basin under 100-year Probable Flood .....	F-97
Figure 7.2.2	Mudflow Hazard Area in the Maloma River Basin under 100-year Probable Flood .....	F-98
Figure 7.2.3	Mudflow Hazard Area in the Sto. Tomas River Basin under 100-year Probable Flood .....	F-99
Figure 8.5.1	Probable Sabo Dam Sites in the Three River Basins .....	F-100
Figure 8.5.2	General Layout of Probable Sabo Dam .....	F-101
Figure 8.5.3	Schematic Plans of Alternatives in the Bucao River.....	F-102
Figure 8.5.4	General Layout of Structural Measures (Alternative-1) in the Bucao River.....	F-103

Figure 8.5.5	General Layout of Structural Measures (Alternative-2) in the Bucao River.....	F-104
Figure 8.5.6	Longitudinal Profile of Structural Measures (Alternative-2) in the Bucao River.....	F-105
Figure 8.5.7	General Layout of Structural Measures (Alternative-3) in the Bucao River.....	F-106
Figure 8.5.8	Longitudinal Profile of Structural Measures (Alternative-3) and Typical Cross Sections of Lateral Dike.....	F-107
Figure 8.5.9	Simulated Maximum Deposit by a 20-Year Probable Flood in the Bucao River.....	F-108
Figure 8.5.10	Longitudinal Profile of Simulated Sediment Deposits under the Probable Design Flood in the Bucao River.....	F-109
Figure 8.6.1	General Layout of River Improvement Plan in the Maloma River.....	F-110
Figure 8.6.2	Longitudinal Profile of River Improvement in the Maloma River .....	F-111
Figure 8.7.1	Schematic Plans of Three Alternatives in the Sto. Tomas River .....	F-112
Figure 8.7.2	General Plan of River Improvement (Alternative-1) in the Sto. Tomas River.....	F-113
Figure 8.7.3	Typical Cross Sections of River Improvement (Alternative-1) in the Sto. Tomas River .....	F-114
Figure 8.7.4	General Layout of Structural Measures (Alternative-2) in the Sto. Tomas River .....	F-115
Figure 8.7.5	Typical Cross Sections of Structural Measures (Alternative-2) in the Sto. Tomas River .....	F-116
Figure 8.7.6	General Layout of Structural Measures (Alternative-3) in the Sto. Tomas River .....	F-117
Figure 8.7.7	Typical Cross Sections of Structural Measures (Alternative-3) in the Sto. Tomas River .....	F-118
Figure 8.7.8	Simulated Maximum Deposit by a 20-Year Probable Flood in the Sto. Tomas River .....	F-119
Figure 8.7.9	Presumed Riverbed Change with Two-Dimensional Mudflow Analysis in the Sto. Tomas River .....	F-120
Figure 8.7.10	Simulated Riverbed Movement for 20 Years in the Sto. Tomas River (Alternative-2).....	F-121
Figure 8.7.11	Simulated Riverbed Movement for 20 Years in the Sto. Tomas River (Alternative-3).....	F-122
Figure 8.7.12	Simulated Riverbed Movement for 20 Years in the Sto. Tomas River (Alternative-2*).....	F-123
Figure 8.7.13	Simulated Riverbed Movement for 20 Years in the Sto. Tomas River (Alternative-3*).....	F-124
Figure 8.7.14	Presumed Riverbed Change after 20 Years with One-Dimensional Riverbed Movement Analysis in the Sto. Tomas River .....	F-125
Figure 8.8.1	Geologic Map and Typical Photograph of Each Geology.....	F-126
Figure 8.8.2	Comparison of Topography of Maraunot Notch before and after Eruption.....	F-127
Figure 8.8.3	Aerial Photograph of Maraunot Notch.....	F-128

Figure 8.8.4	The Condition of Maraunot Notch and Close Up of Notch (30 July 2002) .....	F-129
Figure 8.8.5	Condition of Existing Cliff and Cave at Downstream of the Notch after Breach .....	F-130
Figure 8.9.1	Traffic Volume.....	F-131
Figure 9.2.1	Location of Installed Observatories .....	F-132
Figure 9.2.2	General Idea of Data Dissemination System by Cellular Phone.....	F-133
Figure 9.3.1	Location of Existing Evacuation Centers.....	F-134
Figure 9.3.2	Out of Coverage Area of Existing Evacuation Centers.....	F-135
Figure 9.3.3	Minimum Requirement of Distribution of Evacuation Center .....	F-136
Figure 9.3.4	Location of Evacuation Centers for All Evacuees .....	F-137
Figure 9.3.5	Hazard Map (Bucao River Basin).....	F-138
Figure 9.3.6	Hazard Map (Maloma River Basin).....	F-139
Figure 9.3.7	Hazard Map (Sto. Tomas River Basin : Right Side) .....	F-140
Figure 9.3.8	Hazard Map (Sto. Tomas River Basin : Left Side I, II).....	F-141
Figure 9.3.9	Hazard Map (Sto. Tomas River Basin : Left Side III).....	F-142
Figure 9.4.1	CBFM Implementation Framework .....	F-143
Figure 9.4.2	Territorial Jurisdiction of Proposed Ancestral Domain Claim.....	F-144
Figure 9.4.3	Progress of Collapse at Spillway Portion of Dizon Mines Tailing Dam .....	F-145
Figure 9.4.4	Formation of Mapanuepe Lake before and after the Eruption.....	F-146
Figure 10.1.1	Improvement of Basin Natural Condition between 1992 and 2002.....	F-147
Figure 10.1.2	Family Income Comparison between 1990 and 2002 in the Study Area .....	F-148
Figure 10.2.1	Objectives and Framework of the CDPP .....	F-149
Figure 10.2.2	Procedures to Upgrading Disaster Management Capabilities on Poor Communities .....	F-150
Figure 10.3.1	Target Area of PCM Workshop .....	F-151
Figure 10.3.2	Problem Analysis of Workshop No.1 (Resettlement Centers in Botolan).....	F-152
Figure 10.3.3	Problem Analysis of Workshop No.2 (Affected Areas on the Bucao Upstream).....	F-153
Figure 10.3.4	Problem Analysis of Workshop No.3 (NGO Resettlement Centers in San Felipe) .....	F-154
Figure 10.3.5	Problem Analysis of Workshop No.4 (Pure Aeta Community in Mountain Area) .....	F-155
Figure 10.3.6	Problem Analysis of Workshop No.5 (Along Sto. Tomas River).....	F-156
Figure 10.4.1	Location Map of Existing Resettlement Centers .....	F-157
Figure 10.5.1	Image of Lahar Agriculture Development (Bucao River).....	F-158
Figure 10.5.2	Image of Lahar Agriculture Development (Sto. Tomas River) .....	F-159
Figure 10.5.3	Community Development Plan for Mapanuepe Lake Basin.....	F-160
Figure 12.1.1	Damage Curves for Properties .....	F-161
Figure 12.1.2	Actual Flood Damage Condition due to Dike Breach in July 2002 in the Sto.Tomas River .....	F-162

Figure 13.1.1	Proposed Implementation Schedule for Master Plan.....	F-163
Figure 13.2.1	Proposed Organization for Implementing Master Plan (For Future Vision) .....	F-164
Figure 15.1.1	General Plan of Proposed River Improvement in the Bucao River .....	F-165
Figure 15.1.2	Presumptive Riverbed Change after 20 years in the Bucao River.....	F-166
Figure 15.1.3	Longitudinal Profile of Proposed River Improvement in the Bucao River.....	F-167
Figure 15.1.4	Typical Cross Section of Proposed New Dike in the Bucao River .....	F-168
Figure 15.1.5	Results of Computed Landside Slope Failure .....	F-169
Figure 15.1.6	Typical Cross Sections of Proposed Dike Heightening in the Bucao River.....	F-170
Figure 15.1.7	Typical Cross Section of Proposed Spur Dike Strengthening in the Bucao River.....	F-171
Figure 15.2.1	Abutment Location of Manila Side of the Bucao Bridge for Reconstruction.....	F-172
Figure 15.2.2	Abutment Location of Iba Side at Downstream for Reconstruction.....	F-173
Figure 15.2.3	Abutment Location of Iba Side at the Upper Stream Side for Reconstruction.....	F-174
Figure 15.2.4	Location of the Bucao Bridge .....	F-175
Figure 15.2.5	Plan of the Bucao Bridge for Reconstruction .....	F-176
Figure 15.2.6	Vertical Curvature, Alternative 1, Downstream Side for Reconstruction .....	F-177
Figure 15.2.7	Vertical Curvature, Alternative 2, Upper Stream Side for Reconstruction.....	F-178
Figure 15.2.8	General View of the Bucao Bridge for Reconstruction.....	F-179
Figure 15.2.9	Desirable Bridge Span for Flood Discharge .....	F-180
Figure 15.3.1	General Plan of Proposed River Improvement in the Sto. Tomas River .....	F-181
Figure 15.3.2	Presumptive Riverbed Change after 20 Years in the Sto. Tomas River .....	F-182
Figure 15.3.3	Longitudinal Profile of River Improvement in the Sto. Tomas River (1/4) .....	F-183
Figure 15.3.3	Longitudinal Profile of River Improvement in the Sto. Tomas River (2/4).....	F-184
Figure 15.3.3	Longitudinal Profile of River Improvement in the Sto. Tomas River (3/4).....	F-185
Figure 15.3.3	Longitudinal Profile of River Improvement in the Sto. Tomas River (4/4).....	F-186
Figure 15.3.4	Typical Cross Section of Proposed New Dike in the Sto. Tomas River F-187	
Figure 15.3.5	Typical Cross Section of Proposed Dike Heightening in the Sto. Tomas River.....	F-188
Figure 15.3.6	Site Inspection Results of Eroded Existing Landside Slope in the Sto. Tomas River .....	F-189

Figure 15.3.7 Typical Cross Sections of Proposed Dike Strengthening in the Sto. Tomas River .....	F-190
Figure 15.3.8 General Plan of Proposed Diversion Channel in the Gabor River.....	F-191
Figure 15.3.9 Longitudinal Profile of Proposed Diversion Channel in the Gabor River .....	F-192
Figure 15.3.10 Typical Cross Sections of Diversion Channel in the Gabor River.....	F-193
Figure 15.4.1 Probable Propagation Area of Radio Wave for Cellular Phone .....	F-194
Figure 15.4.2 Data Transmission System .....	F-195
Figure 15.4.3 Step-wise Development on Flood Warning System.....	F-196
Figure 15.4.4 Proportion of Capacity of Evacuation Centers to Number of Evacuees .....	F-197
Figure 15.6.1 Potential Area of CBFM Program.....	F-198
Figure 15.6.2 Selected Priority Area of CBFM Program .....	F-199
Figure 15.7.1 Potential Development Area for Agriculture Development on Lahar Area .....	F-200
Figure 15.7.2 Priority Development Area for Agriculture Development in Lahar Area .....	F-201
Figure 15.8.1 Location of Water / Bed Material Samples for Mapanuepe Lake / Dizon Dam .....	F-202
Figure 15.9.1 Proposed Community Road Network .....	F-203
Figure 16.1.1 Construction Schedule of the Bucao River Dikes.....	F-204
Figure 16.2.1 Construction Schedule of the Sto. Tomas River Dikes .....	F-205
Figure 16.3.1 Construction Schedule of the Bucao Bridge .....	F-206
Figure 17.2.1 Proposed Organization for Implementing Priority Projects with Present MPE-PMO Responsibilities .....	F-207
Figure 17.3.1 Implementation Schedule for Priority Projects.....	F-208
Figure 19.3.1 Results of Barangay Accessibility Ranking.....	F-209

## **Abbreviations**

A	AADT	-	Annual Average Daily Traffic
	AD	-	Administrative Order
	ADA	-	Aeta Development Association
	ADB	-	Asian Development Bank
	AETAS	-	Aeta Assistance Station
	AFM	-	Acoustic Flow Monitors
	AFP	-	Armed Forces of the Philippines
	ARMM	-	Autonomous Region of Muslim Mindanao
	ASTM	-	American Society for Testing and Materials
	ATI	-	Agricultural Training Institute
B	BAS	-	Bureau of Agricultural Statistics
	BDCC	-	Barangay Disaster Coordinating Council
	BOD	-	Biochemical Oxygen Demand
	BOD	-	Bureau of Design, DPWH
	BOT	-	Build-Operate-Transfer
	BRS	-	Bureau of Research and Standards, DPWH
	BSWM	-	Bureau of Soils and Water Management, DA
C	Ca	-	Calcium
	CAD	-	Computer Aided Design
	CAR	-	Cordillera Administrative Region
	CARP-IC	-	Comprehensive Agrarian Reform Program – Irrigation Component
	CBFM	-	Community-Based Forest Management
	CDC	-	Clark Development Corporation
	CDCC	-	City Disaster Coordinating Council
	CDPP	-	Community-Based Disaster Prevention Plan
	CENRO	-	Community Environment and Natural Resources Office
	CIP	-	Communal Irrigation Project
	CIS	-	Communal Irrigation System
	COD	-	Chemical Oxygen Demand
	COMVOL	-	Commission on Volcanology
	CPDO	-	City Planning and Development Office
	CPI	-	Consumer Price Index
D	DA	-	Department of Agriculture
	DAR	-	Department of Agrarian Reform
	DBM	-	Department of Budget and Management
	DCSMI	-	Dizon Copper & Silver Mines, Inc.
	DENR	-	Department of Environment and Natural Resources
	DEO	-	District Engineering Office
	DepEd	-	Department of Education
	DILG	-	Department of Interior and Local Government
	DIV	-	Dutch Intervention Value
	DND	-	Department of National Defense
	DO	-	Department Order

	DOE	-	Department of Energy
	DOH	-	Department of Health
	DOST	-	Department of Science and Technology
	DOTC	-	Department of Transportation and Communications
	DPWH	-	Department of Public Works and Highways
	DSWD	-	Department of Social Welfare and Development
	DTI	-	Department of Trade and Industry
	DTM	-	Digital Topographic Map
E	EC	-	Electric Conductivity
	ECC	-	Environmental Compliance Certificate
	EHS	-	Environmental Health Service
	EIA	-	Environmental Impact Assessment
	EIS	-	Environmental Impact Statement
	EIRR	-	Economic Internal Rate of Return
	EMB	-	Environmental Management Bureau, DENR
	EO	-	Executive Order
	EPZA	-	Export Processing Zone Authority
F	FMB	-	Forest Management Bureau, DENR
	FY	-	Fiscal Year
G	GIS	-	Geographic Information System
	GDP	-	Gross Domestic Product
	GOJ	-	Government of Japan
	GOP	-	Government of the Philippines
	GRDP	-	Gross Regional Domestic Product
	GSM	-	Global System for Mobile Communications
	GVA	-	Gross Value Added
H	HH	-	Household
	HUDCC	-	Housing and Urban Development Coordinating Council
I	ICC	-	Investment Coordination Committee, NEDA
	IEE	-	Initial Environmental Examination
	IR	-	Inflation Rate
	IRA	-	Internal Revenue Allotment
	IRR	-	Implementing Rules and Regulations
	IRRI	-	International Rice Research Institute
	IPs	-	Indigenous Peoples
	ISF	-	Irrigation Service Fee
J	JBIC	-	Japan Bank for International Cooperation
	JICA	-	Japan International Cooperation Agency
K	K	-	Potassium
	KPA	-	Key Production Area
L	LGU	-	Local Government Unit

	LLDA	-	Laguna Lake Development Authority
	LWUA	-	Local Water Utilities Administration
M	MDCC	-	Municipal Disaster Coordinating Council
	MFDP	-	Major Flood Control and Drainage Project
	MGB	-	Mines and Geosciences Bureau, DENR
	MOA	-	Memorandum of Agreement
	MOOE	-	Maintenance Organization and Operation
	MPC	-	Mount Pinatubo Commission
	MPE	-	Mount Pinatubo Emergency, DPWH
	MPR	-	Mount Pinatubo Rehabilitation, DPWH
	MTPDP	-	Medium-Term Philippine Development Plan
	MTPIP	-	Medium-Term Public Investment Plan
	MWSS	-	Metropolitan Waterworks and Sewerage System
N	N	-	Nitrogen
	Na	-	Sodium
	NAMRIA	-	National Mapping and Resource Information Authority
	NAPOCOR	-	National Power Corporation
	NCIP	-	National Commission on Indigenous People
	NCR	-	National Capital Region
	NDCC	-	National Disaster Coordinating Council
	NEDA	-	National Economic and Development Authority
	NGO	-	Non-Government Organization
	NHA	-	National Housing Authority
	NIA	-	National Irrigation Administration
	NIP	-	National Irrigation Project
	NIPAS	-	National Integrated Protected Areas System
	NIS	-	National Irrigation System
	NSCB	-	National Statistical Coordination Board
	NSO	-	National Statistics Office
	NWRB	-	National Water Resources Board
	NWRC	-	National Water Resources Council
O	OCD	-	Office of Civil Defense
	ODA	-	Official Development Assistance
	OJT	-	On the Job Training
	O&M	-	Operation and Maintenance
P	P	-	Phosphorus
	PAGASA	-	Philippine Atmospheric, Geophysical and Astronomical Services Administration
	PAMB	-	Protected Areas Management Board
	PCC	-	Project Coordination Committee
	PCM	-	Project Cycle Management
	PCSD	-	Philippine Council for Sustainable Development
	PDCC	-	Provincial Disaster Coordinating Council
	PDDP-IC	-	Pampanga Delta Development Project – Irrigation Component

	PHIVOLCS	-	Philippine Institute of Volcanology and Seismology
	PIDIC	-	Pampanga Irrigation Development-Irrigation Component
	PIO	-	Provincial Irrigation Office
	PMO	-	Project Management Office
	PNP	-	Philippine National Police
	PO	-	People's Organization
R	RA	-	Republic Act
	RAAMPE	-	Rehabilitation of Areas Affected by Mt. Pinatubo Eruption
	RAP	-	Recovery Action Plan
	RC	-	Resettlement Center
	RDC	-	Regional Development Council
	RDCC	-	Regional Disaster Coordinating Council
	RES	-	Regional Equipment Service
	ROW	-	Right of Way
	RWS	-	Rural Waterworks System
S	SALT	-	Slope Agriculture Land Technology
	SAPI	-	Special Assistance for Project Implementation
	SBMA	-	Subic Bay Metropolitan Authority
	SCF	-	Standard Conversion Factor
	SDR	-	Swiss Disaster Relief
	SO <sub>4</sub>	-	Sulfate
	SWIM	-	Small Water Impounding Management
T	TAV	-	Total Assessed Value
	TLRC	-	Technology & Livelihood Research Center
	TWG	-	Technical Working Group
	TSP	-	Total Suspended Particulates
U	USACE	-	United States Army Corps of Engineers
	USAID	-	United States Agency for International Development
	USGS	-	United States Geological Survey
V	VAT	-	Value Added Tax
W	WCLDP	-	West Central Luzon Development Program
	WHO	-	World Health Organization
Z	ZAMECO	-	Zambales Electric Cooperative

## Measurements

<u>Length</u>		<u>Area</u>	
mm	=	millimeter	$m^2$ = square meter
cm	=	centimeter	ha = hectare
m	=	meter	$km^2$ = square kilometer
km	=	kilometer	
LM	=	linear meter	
<u>Volume</u>		<u>Derived Measures</u>	
$cm^3$	=	cubic centimeter	$m/s$ = meter per second
l	=	liter	$m^3/s$ = cubic meter per second
kl	=	kiloliter	kWh = kilowatt hour
$m^3$	=	cubic meter	MWh = megawatt hour
MCM	=	million cubic meter	GWh = gigawatt hour
			ppm = parts per million
			kmph = kilometer per hour
			lps/m = liter per second per meter
<u>Weight</u>		<u>Currency</u>	
g	=	gram	PHP = Philippine Peso
kg	=	kilogram	¥ = Japanese Yen
ton	=	metric ton	US\$ = US Dollar
meq	=	milligram equivalent	
<u>Time</u>		<u>Other Measure</u>	
sec	=	second	% = percent
min	=	minute	$^\circ$ = degree
hr	=	hour	$^\circ C$ = degree(s) Celsius
d	=	day	$10^3$ = thousand
y	=	year	$10^6$ = million
			$10^9$ = billion
			pH = potential of hydrogen
			mbgs = meter below ground surface
			M = magnitude of earthquake