

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

**Final Report**

**Volume I  
Executive Summary**

**September 2003**

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

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**Japan International Cooperation Agency**

## List of Volumes

<b>Volume I : Executive Summary</b>
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**Volume II : Main Report**

**Volume III-1 : Supporting Report**

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- Appendix II : Topography and Geology
- Appendix III : Meteorology and Hydrology
- Appendix IV : Sediment Balance
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- Appendix VII : Road Network
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<p><u>Exchange Rates</u></p> <p>US\$ 1.0 = Philippine Peso 50.5 US\$ 1.0 = Japanese Yen 120.1</p> <p>Average of July 2002</p>
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## 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).

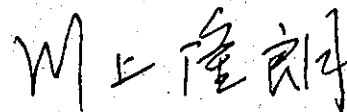
JICA selected and dispatched a study team headed by Mr. Shinsuke HINO of Nippon Koei Co., Ltd. (consisting of Nippon Koei Co., Ltd. and CTI Engineering International Co., Ltd.) to the Philippines four times between April 2002 and August 2003. In addition, JICA set up an advisory committee headed by the 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,



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Shinsuke Hino  
Team Leader

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

#### 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 Maraunot 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 Tektok Resettlement Center

Integration of three NGOs resettlement centers in Tektok 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>

#### Non-structural

##### Warning System

7 Rainfall/6 water level gauging stations, one monitoring station, and dissemination/transmission system with cellular phone network, radio and siren

#### 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

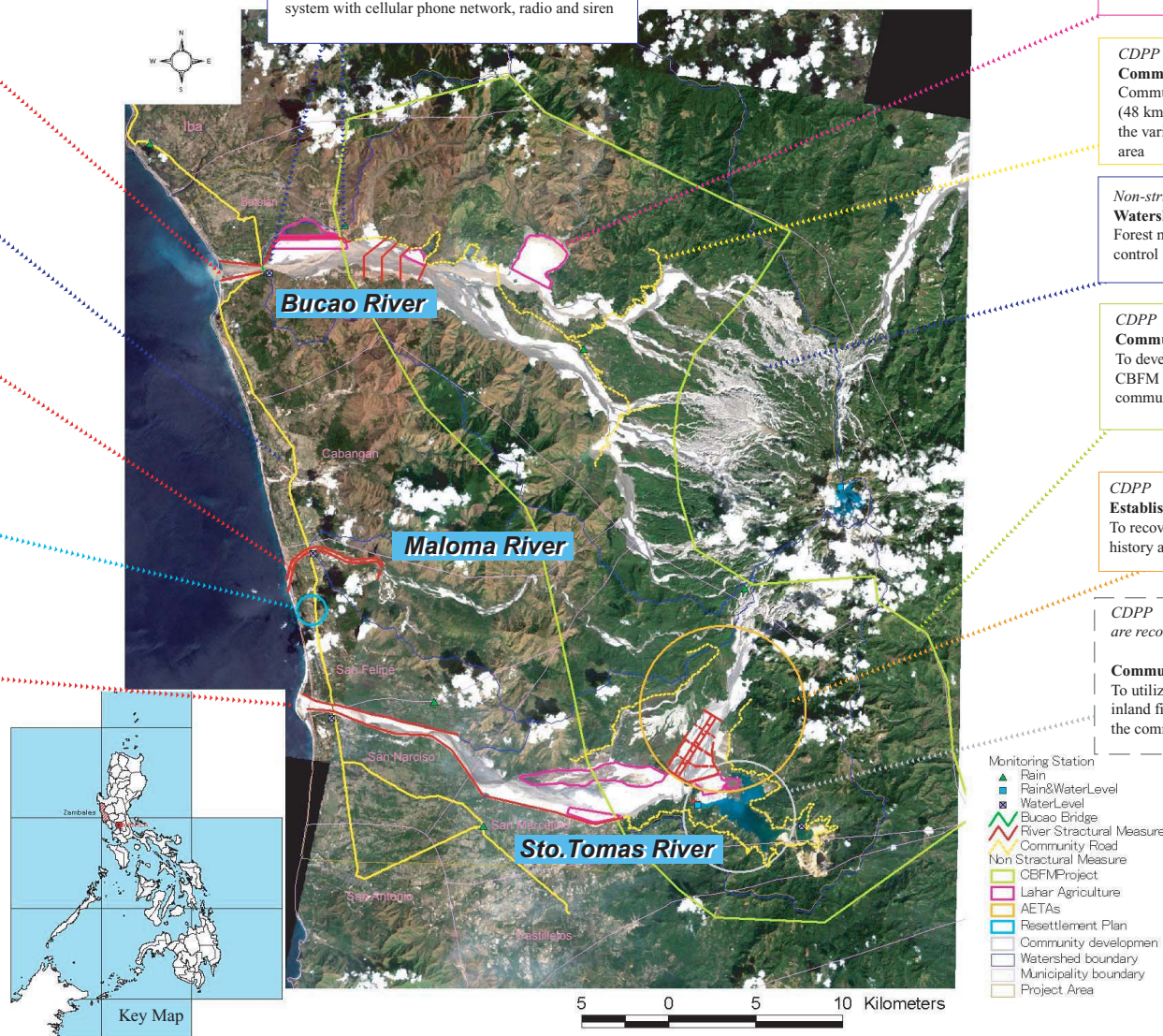
##### Establishment of Aeta Assistance Station (AETAS)

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



Location Map of Master Plan



#### Structural

##### Bucao 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 lm)
- 3) Observation of hydrological/geological data at Maraunot Notch  
<to be included in the warning system>

Project Cost: 1,678 million pesos  
EIRR: 15.7%  
Environment: No particular issues  
Resettlement: 29 families (as of May 2003)  
Schedule: 2007-2010 (construction)



Bucao Bridge (during Flood)



#### CDPP

##### Agricultural Development on Lahar Area

Pilot project for agricultural development on lahar for 10 ha in the Bucao downstream and 10 ha for the Sto. Tomas middle reach.

Project Cost: 19 million pesos (pilot)  
EIRR: 9.8%  
Environment: No particular issues  
Social Impact: Positive impact for poverty reduction  
Schedule: 2008-2010 (20 ha)



Present

Future image

#### CDPP

##### Community Road Rehabilitation

Community road rehabilitation in Bucao River basin for route-A1 of 16 km

Project Cost: 189 million pesos (Route-A1)  
EIRR: 2.1%  
Environment: Positive impact for forest management  
Social Impact: Positive impact for poverty reduction, and enhancement of social services  
Schedule: 2005-2007



Baquilan Bridge

#### Non-structural

##### 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 10 evacuation centers and dissemination of hazard map

Project Cost: 30 million pesos (operation for 10 years)  
82 million pesos (GSM)  
EIRR: Not calculated  
Environment: No particular issues  
Social Impact: Positive impact to secure human life  
Schedule: 2003-08 (pilot operation)  
2007-12 (GSM system)

#### Structural

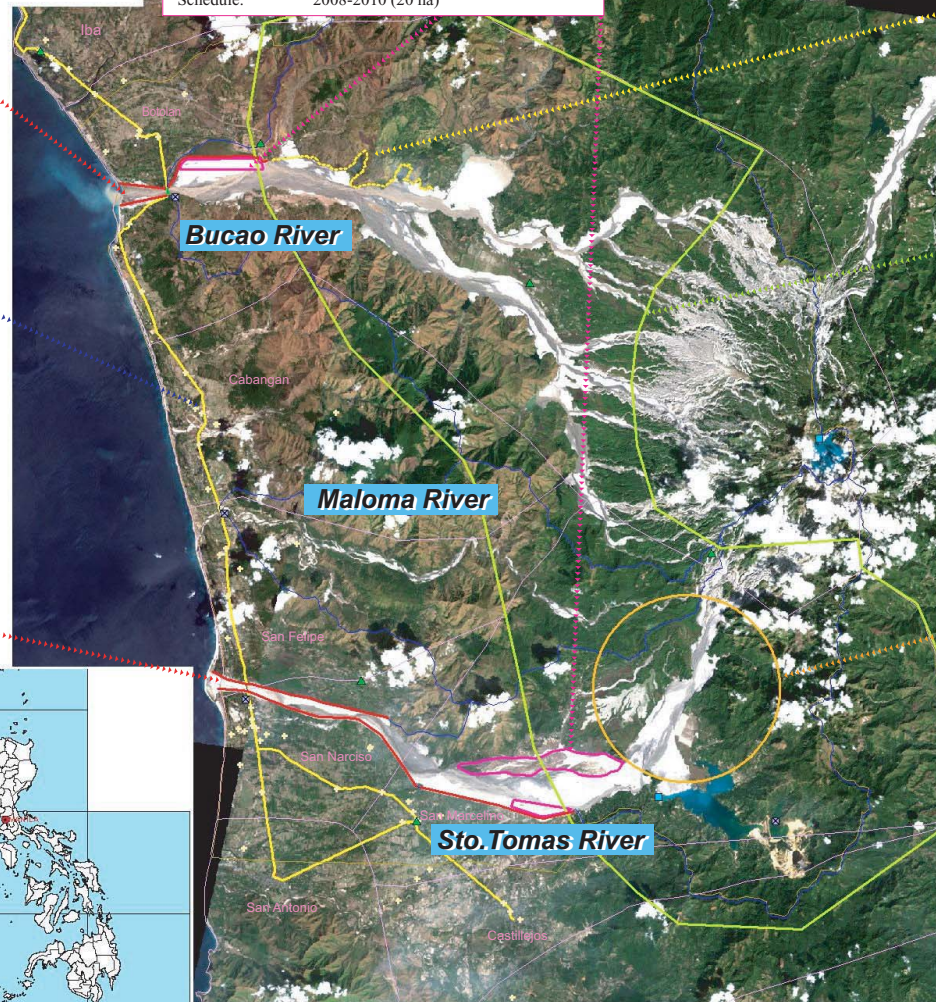
##### Sto. Tomas River

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)

Project Cost: 1,960 million pesos  
EIRR: 26.3%  
Environment: No particular issues  
Resettlement: 77 families (as of May 2003)  
Schedule: 2007-2010 (construction)



Sto. Tomas River (Middle reach, looking downstream)



#### CDPP

##### Community-based Forest Management (CBFM)

Extension of CBFM with 2,200 ha as pilot development scheme

Project Cost: 76 million pesos (pilot)  
EIRR: 21.5%  
Environment: Positive impact for forest conservation/management  
Social Impact: Positive impact for poverty reduction  
Schedule: 2007-2012 (2,200 ha)



Priority Development Area of CBFM (green)



#### CDPP

##### Establishment of Aeta Assistance Station (AETAS)

Support to NGOs' activities for Aeta Upland Farming school, assistance for registration of ancestral domain land, livelihood development program and detailed study for establishment of Aeta Assistance Station.

Project Cost: 15 million pesos  
EIRR: Not calculated  
Environment: Positive impact for forest management  
Social Impact: Positive impact for prevention of tradition, culture of Aeta tribe  
Schedule: 2005-2009 (pilot scheme)

- Monitoring:
- ▲ Rain
  - ▲ Rain&WaterLevel
  - WaterLevel
  - Evacuation Center
  - ▲ Bucao Bridge
  - ▲ Community Road
  - ▲ River Structural Measure
  - ▲ Non Structural Measure
  - ▲ CBFMProject
  - ▲ Lahar Agriculture
  - ▲ AETAs
  - ▲ Watershed boundary
  - ▲ Municipality boundary
  - ▲ Project Area



Aeta people

## Location Map of Proposed Priority Projects

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)
1.5	Socio-economy	Mapanuepe lake	6.8 km <sup>2</sup> in surface area, 30 million m <sup>3</sup> in capacity
		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
2.4	Evacuation system	Bayarong dam	Tailings dam for Dizon copper mines, 126 m high,
		Warning system	AFP/PNP watch points, disaster information and evacuee's own judgment,
		Evacuation center	36 evacuation centers
2.5	Resettlement center	Center by MPC	7 resettlement centers,
		Center by NGO	3 resettlement centers,

### 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	1) Formulation of sabo and flood control master plan and selection of priority projects 2) Feasibility study for priority projects 3) Transfer of technology
3.2	Needs	Recovery actions	1) Mitigation of flood/mudflow inundation and damages in lowland area 2) Securing of national highway against flood/mudflow 3) Recovery of life/livelihood in mountainous area affected by volcanic materials/lahar
		Basin development	1) Agriculture and tourism development 2) Final target of sustainable economic growth with uplifting of living standard
3.3	Study concept	1) Target year of 2022 for master plan 2) Combination of implementation of structural/non-structural measures and establishment of community-based disaster prevention systems 3) Target of poverty alleviation	

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

4.1	Structural measures	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 m long) 3) Observation of hydrological/geological data at Maraunot Notch
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		Maloma River <Review>	4) Consolidation dam and sand pocket <Review> 1) Channel improvement with straightening, widening and dike heightening/construction (l=7 km) 2) Reconstruction of Maloma Bridge (240 m long)
		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 m long) 3) Consolidation dam/sand pocket/channel works <Review>
4.2	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	1) Increase of 60 evacuation centers 2) Renovation of 32 evacuation centers 3) Dissemination of hazard map
		Watershed management	Forest management, foothill management, and sediment control
4.3	Community-based disaster prevention systems	Improvement of Tektok RC	Integration of three NGOs' resettlement centers in Tektok RC and improvement of community infra. <Further discussion and study>
		CBFM	Extension of CBFM for creation of livelihood.
		Agricultural development	Agricultural development on lahar at the river side area for livelihood development.
		Basin development of Mapanuepe Lake	Community development of Mapanuepe Lake basin for irrigation, inland fishery and tourism <Further monitoring and study>
		Community road	Community road rehabilitation in Bucao and Sto.Tomas River basins
		AETAS	Establishment of Aeta Assistance Station

## 5. Priority Projects (Feasibility Projects)

5.1	Structural measures	Bucao 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
		Sto.Tomas River	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	1) MPE-PMO, DPWH functioning as implementation agency for the structural measures, 2) PMO-Zambales under Zambales Province functioning as implementation agency for the non-structural and CDPP measures 3) Establishing Project Coordination Committee (PCC) to be functioning for integration among structural, non-structural and CDPP measures.
		Funding source	GOP and foreign assistance
5.5	Project Evaluation	Bucao River Structural Measures	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) 5) Evaluation: To be implemented 6) Schedule: 2007-2010 (construction)
		Sto.Tomas River Structural Measures	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) 5) Evaluation: To be implemented 6) Schedule: 2007-2010 (construction)
		Non-structural Measures	1) Project Cost: 30 million pesos (operation for 10 years)

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

**THE STUDY ON SABO AND FLOOD CONTROL  
FOR WESTERN RIVER BASINS OF MOUNT PINATUBO  
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**FINAL REPORT**

Executive Summary

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## **Abbreviations**

A	AETAS	-	Aeta Assistance Station
	AFP	-	Armed Forces of the Philippines
B	BOD	-	Biochemical Oxygen Demand
C	CBFM	-	Community-Based Forest Management
	CDPP	-	Community-Based Disaster Prevention Plan
	COD	-	Chemical Oxygen Demand
D	DA	-	Department of Agriculture
	DENR	-	Department of Environment and Natural Resources
	DILG	-	Department of Interior and Local Government
	DPWH	-	Department of Public Works and Highways
	DSWD	-	Department of Social Welfare and Development
E	ECC	-	Environmental Compliance Certificate
	EIA	-	Environmental Impact Assessment
	EIRR	-	Economic Internal Rate of Return
	EIS	-	Environmental Impact Statement
F	FMB	-	Forest Management Bureau, DENR
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
H	HH	-	Household
I	ICC	-	Investment Coordination Committee, NEDA
	IEE	-	Initial Environmental Examination
J	JBIC	-	Japan Bank for International Cooperation
	JICA	-	Japan International Cooperation Agency
K	K	-	Potassium
L	LGU	-	Local Government Unit
M	MPC	-	Mount Pinatubo Commission
	MPE	-	Mount Pinatubo Emergency, DPWH
	MPR	-	Mount Pinatubo Rehabilitation, DPWH
N	N	-	Nitrogen
	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
	NSCB	-	National Statistical Coordination Board
	NSO	-	National Statistics Office
	NWRB	-	National Water Resources Board
O	OCD	-	Office of Civil Defense
P	P	-	Phosphorus
	PAGASA	-	Philippine Atmospheric, Geophysical and Astronomical Services Administration
	PCC	-	Project Coordination Committee
	PCM	-	Project Cycle Management
	PDCC	-	Provincial Disaster Coordinating Council
	PHIVOLCS	-	Philippine Institute of Volcanology and Seismology
	PMO	-	Project Management Office
	PNP	-	Philippine National Police
R	RC	-	Resettlement Center
	RDC	-	Regional Development Council
	RDCC	-	Regional Disaster Coordinating Council
S	SALT	-	Slope Agriculture Land Technology
U	USACE	-	United States Army Corps of Engineers



## Measurements

### Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer
LM	=	linear meter

### Area

m <sup>2</sup>	=	square meter
ha	=	hectare
km <sup>2</sup>	=	square kilometer

### Volume

cm <sup>3</sup>	=	cubic centimeter
l	=	liter
kl	=	kiloliter
m <sup>3</sup>	=	cubic meter
MCM	=	million cubic meter

### Derived Measures

m/s	=	meter per second
m <sup>3</sup> /s	=	cubic meter per second
kWh	=	kilowatt hour
MWh	=	megawatt hour
GWh	=	gigawatt hour
ppm	=	parts per million
kmph	=	kilometer per hour
lps/m	=	liter per second per meter

### Weight

g	=	gram
kg	=	kilogram
ton	=	metric ton
meq	=	milligram equivalent

### Currency

PHP	=	Philippine Peso
¥	=	Japanese Yen
US\$	=	US Dollar

### Time

sec	=	second
min	=	minute
hr	=	hour
d	=	day
y	=	year

### Other Measure

%	=	percent
°	=	degree
°C	=	degree(s) Celsius
10 <sup>3</sup>	=	thousand
10 <sup>6</sup>	=	million
10 <sup>9</sup>	=	billion
pH	=	potential of hydrogen
mbgs	=	meter below ground surface
M	=	magnitude of earthquake