REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS
AND HIGHWAYS

REPUBLIC OF THE PHILIPPINES

PREPARATORY SURVEY FOR FLOOD RISK MANAGEMENT PROJECT FOR CAGAYAN DE ORO RIVER (FRIMP-CDOR)

FINAL REPORT

VOLUME - II
MAIN REPORT

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
CTI Engineering International Co., Ltd.
PASCO Corporation

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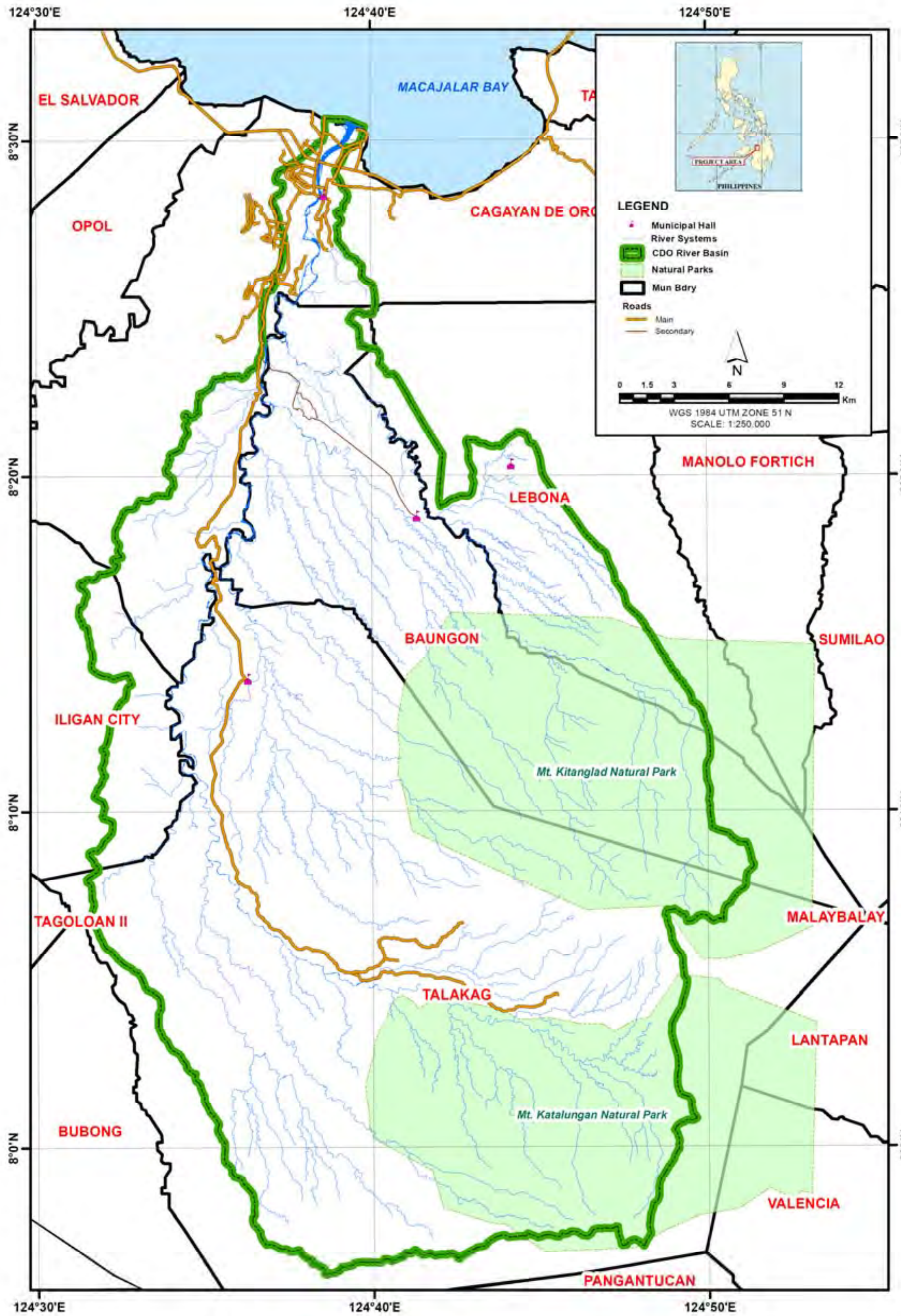
List of Reports

Exchange Rate

US Dollar (US$) 1.00 = Philippine Pesos (PHP) 42.85 = Japanese Yen (Y) 97.43

(1 Philippine Peso = 2.274 Japanese Yen)

（as of July 2013）



Location Map of Cagayan de Oro River Basin

PREPARATORY SURVEY
FOR
FLOOD RISK MANAGEMENT PROJECT
FOR
CAGAYAN DE ORO RIVER (FRIMP-CDOR)
IN
THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

VOLUME II MAIN REPORT

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Abbreviations / Acronyms

1D	One-dimensional
AASHTO	American Association of State Highway and Transportation Officials
ACEL	Association of Carriers and Equipment Lessors, Inc.
ACI	American Concrete Institute
AD	Ancestral Domain
A&D	Alienable and Disposable area
ADB	Asian Development Bank
AfD	Agence française de développement (French Development Agency)
AFP	Armed Force of Philippines
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ALOS	Advanced Land Observing Satellite
AMSL	Above Mean Sea Level
ANR	Assisted Natural Regeneration
AO	Administrative Order
ARG	Automatic Rain Gauge
ARMM	Autonomous Region in Muslim Mindanao
ASTM	American Society for Testing and Materials
AusAid	Australian Agency for International Development)
AWS	Automatic Warning System
BC Ratio	Benefit-Cost Ratio
BENRO	Bukidnon Environment and Natural Resource Office
BDRRMC	Barangay Disaster Risk Reduction and Management Council
BFAR, DA	Bureau of Fisheries and Aquatic Resources, DA
BH	Borehole
BOC, DPWH	Bureau of Construction, DPWH
BOD	Biochemical Oxygen Demand
BOD, DPWH	Bureau of Design, DPWH
BOM, DPWH	Bureau of Maintenance, DPWH
BP	Before Present
BS	British Standard
BSWM	Bureau of Soils and Water Management, DA
BWPDC	Bukidnon Watershed Protection and Development Council
BWRBF	Bukidnon Watershed and River Basin Forum
CAP	Comprehensive Action Plan
CARI	Contractor's All Risk Insurance
CATDDO	Catastrophe Deferred Drawdown Option
CBEWS	Community-Based Early Warning System
CBFEWS	Community Based Flood Early Warning System
CBFMA	Community-Based Forest Management Agreement
CCA	Climate Change Adaptation
CDIA	Cities Development Initiative for Asia, ADB
CDO	Cagayan de Oro
CDOR	Cagayan de Oro River
CDORBMC	Cagayan de Oro River Basin Management Council
CDP	Comprehensive Development Plan
CDRRMC	City Disaster Risk Reduction and Management Council
CENRO, DENR	Community Environment and Natural Resources Office, DENR
CEPALCO	Cagayan Electric Power and Light Company, Inc.
CGIAR-CSI	Consortium for Spatial Information of the Consultative Group on International Agricultural Research
CHED	Commission on Higher Education
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLENRO,	City Local Environment and Natural Resource Office, LGU

CLUP	Comprehensive Land Use Plan
CO	Central Office
COA	Commission on Audit
COCICM-TWGPMET	Cagayan de Oro City Integrated Coastal Management – Technical Working Group and Project Monitoring and Evaluation Team
COWD	Cagayan de Oro Water District
CPDO	City Planning and Development Office
CPI	Consumer Price Index
CPR	Cardiopulmonary Resuscitation
CRM	Coastal Resources Management
CRMP	Coastal Resources Management Plan
CSCAND	Collective Strengthening of Community Awareness for Natural Disaster
CSO	Civil Society Organization
CU	Consolidated Undrained
C/V	Calibrated / Validated
CY	Calendar Year
DA	Department of Agriculture
DANA	Damage Assessment & Needs Analysis
DAO	Department Administrative Order
DBM	Department of Budget and Management
DCC	Disaster Coordinating Council
DD	Detailed Design
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
Dep ED	Department of Education
DFA	Department of Foreign Affair
DF/R	Draft Final Report
DHWL	Design High Water Level
DILG	Department of Interior and Local Government
DND	Department National Defense
DO / D.O.	Department Order
DO	Dissolved Oxygen
DOE	Department of Energy
DOF	Department of Finance
DOH	Department of Health
DOJ	Department of Justice
DOLE	Department of Labor and Employment
DOST	Department of Science and Technology
DOT	Department of Tourism
DOTC	Department of Transportation and Communication
DP/R	Draft Progress Report
DPWH	Department of Public Works and Highways
DRM	Disaster Risk Management
DRRM	Disaster Risk Reduction Management
DRRMC	Disaster Risk Reduction and Management Committee
DSWD	Department of Social Welfare and Development
DTI	Department of Trade and Industry
DTM	Digital Terrain Model
DUPA	Detailed Unit Price Analysis
ECA	Environmentally Critical Areas
ECC	Environmental Compliance Certificate
ECP	Environmentally Critical Project
EIA	Environmental Impact Assessment
EIAPO	Environmental Impact Assessment Project Office
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
EISS	Environmental Impact Statement System
EL	Elevation

EMB, DENR	Environmental Management Bureau, DENR
EMD	Estate Management Division, LGU
EMoP	Environmental Monitoring Plans
ENCA	The Project for Enhancement of Capabilities in Flood Control and Sabo Engineering of the Department of Public Works and Highways
ENPV	Economic Net Present Value
ENRO	Environment and Natural Resource Office, LGU
EO	Engineering Office
EO	Executive Order
EP	Exploration Permit
EPRMP	Environmental Performance Report and Management Plan
ERDS, DENR	Ecosystems Research and Development Service, DENR
ESSO, DPWH	Environmental and Social Services Office, DPWH
EU	European Union
FCSEC, DPWH	Flood Mitigation and Sabo Engineering Center, DPWH
FEWC	Flood Early Warning Center
FEWS	Flood Early Warning System
FFWS	Flood Forecasting and Warning System
FIRR	Financial Internal Rate of Return
FMB, DENR	Forest Management Bureau, DENR
FMC	Flood Mitigation Committee
FMS, DENR	Forest Management Service, DENR
F/R	Final Report
FRIMP-CDOR	The Preparatory Survey for Flood Risk Management Project for Cagayan de Oro River
F/S	Feasibility Study
FWL	Flood Water Level
GDP	Gross Domestic Products
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GOJ	Government of Japan
GOP	Government of the Philippines
GPS	Global Positioning System
GRDP	Gross Regional Domestic Products
GSIS	Government Service Insurance System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
HEC-RAS	Hydrologic Engineering Center River Analysis System
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome
HLURB	Housing and Land Use Regulatory Board
HUDCC	Housing and Urban Development Coordinating Council
HVCC	High Value Commercial Crop
ICC	Indigenous Cultural Community
ICC	Investment Coordination Committee
IC/R	Inception Report
ICS	Incident Command System
IDP	Internally Displaced Person
IEC	Information, Education and Communication
IEE	Initial Environmental Examination
IEEC	Initial Environmental Examination Checklist
IEER	Initial Environmental Examination Report
IFMA	Industrial Forest Management Agreement
INREM	Integrated Natural Resources and Environmental Management
IP	Indigenous People
I/P	Implementation Program
IRBMDMP	Integrated River Basin Management and Development Master Plan
IRR	Implementing Rules and Regulations

IT/R	Interim Report
IUCN	International Union for Conservation of Nature and Natural Resources
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
LCP	League of Cities of the Philippines
LDRRMC	Local Disaster Risk Reduction and Management Council
LDRRMF	Local Disaster Risk Reduction and Management Fund
LGU	Local Government Unit
LIAC	Local-Inter Agency Committee
LIDAR	Light Detection and Ranging、Laser Imaging Detection and Ranging
LMP	League of Municipalities of the Philippines
LNB	*Liga Ng mga* Barangay (League of Barangays of the Philippines)
LP	Laser Profile
LPP	League of Provinces of the Philippines
LSB	Local Special Body
MBDA	Macahalar Bay Development Alliance
MCL	Maximum Contamination Level
MDRRMC	Municipal Disaster Risk Reduction Management Council
MENRO	Municipal Environment and Natural Resource Office, LGU
MFC&DP	Major Flood Control & Drainage Project
MFCDP-II	Major Flood Control and Drainage Project – Cluster II
MFL	Maximum Flood Level
MGB, DENR	Mines and Geosciences Bureau, DENR
MinDA	Mindanao Development Authority
MKRNP	Mt. Kitanglad Range Natural Park
MLLW	Mean Lower Low Water
MLLWL	Mean Lowest Low Water Level
MMC	McKeough Marine Center
MOA	Memorandum of Agreement
M/P	Master Plan
MPDO	Municipal Planning and Development Office
MSL	Mean Sea Level
MTSAT	Multi-functional Transport Satellite
MWSS	Metropolitan Waterworks and Sewerage System
NAMRIA	National Mapping and Resources Information Authority
NAPC-VDC	National Anti-Poverty Commission- Victims of Disasters and Calamities
NBCP	National Building Code of the Philippines
NCIP	National Commission on Indigenous Peoples
NCRFW	National Commission on the Role of *Filipino* Women
NDCC	National Disaster Coordinating Council
NDRRMC	National Disaster Risk Reduction and Management Council
NDRRMF	National Disaster Risk Reduction and Management Fund
NEDA	National Economic Development Agency
NFMO	National Flood Mitigation Office
NGA	National Government Agency
NGO	Non-Government Organization
NGP	National Greening Program
NHA	National Housing Authority
NIA	National Irrigation Administration
NIPAS	National Integrated Protected Areas System
NOAA	National Oceanic and Atmospheric Administration - Satellites
NOAH	Nationwide Operational Assessment of Hazards
NON-ECA	Non-Environmentally Critical Area
NON-ECP / NECP	Non-Environmentally Critical Project
NORMECA	Northern Mindanao Electric Cooperatives Association
NPAA	Network of Protected Areas for Agriculture
NPC	National Power Corporation

NSCB	National Statistical Coordinating Board
NSO	National Statistics Office
NWRB	National Water Resources Board
NWRMO	National Water Resources Management Office
OCD	Office of Civil Defense
O&M	Operation and Maintenance
OPACC	Office of the Presidential Adviser on Climate Change
OPAPP	Office of the Presidential Adviser on Peace Process
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PAWCZMS, DENR	Protected Areas, Wildlife and Coastal Zone Management Services, DENR
PAWB, DENR	Protected Areas and Wildlife Bureau, DENR
PC	Precast
PCBARMA	Protected Area Community-based Forest Management Agreement
PCDG	Prestressed Concrete Deck Girder
PCG	Philippine Coast Guard
PD	Presidential Decree
PDO	Planning and Development Office
PDR	Project Description Report
PDRRMC	Provincial Disaster Rick Reduction Management Council
PEISS	Philippine Environmental Impact Statement System
PENRO, DENR	Provincial Environment and Natural Resources Office, DENR
PEPRMP	Programmatic Environmental Performance Report and Management Plan
PES	Payment of Environmental Services
PFS	Prefeasibility Study
PhilHealth	Philippine Health Insurance Corporation
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PIA	Philippine Information Agency
PM	Particular Matter
PMO	Project Management Office
PMO	Presidential Memorandum Order
PNP	Philippine National Police
PNRC	Philippine National Red Cross
PO	People's Organization
PP	Presidential Proclamation
PPA	Philippine Ports Authority
PPP	Public-Private Partnership
P/R	Progress Report
PRC	Philippine Red Cross
PSGC	Philippine Standard Geographic Code
PTM	Philippine Traverse Mercator
QRF	Quick Response Fund
RA	Republic Act
RAP	Resettlement Action Plan
RBCO	River Basin Control Office, DENR
RBO	River Basin Organization
RC	Reinforced Concrete
RDC	Regional Development Council
RDRRMC	Regional Disaster Reduction Management Council
RED	Regional Executive Director
REDAS	Rapid Earthquake Damage Assessment System
RIDF	Rainfall Intensity Duration Frequency
ROW	Right of Way
ROWA	Right of Way Acquisition
RR	Rainfall-Runoff
SALT	Sloping Agricultural Land Technology
SAPA	Special Agreement in Protected Areas
SCF	Standard Conversion Factor

SDR	Social Discount Rate
SEA	Strategic Environmental Assessment
SIFMA	Socialized Industrial Forest Management Agreement
SPT	Standard Penetration Test
SRLSF	Safer River,. Life Saver Foundation, Inc
SRTM	Shuttle Radar Topography Mission
SSS	Social Security System
Sta.	Station
TA	Technical Assistance
TAC	Technical Advisory Committee
TDS	Total Dissolved Solid
TIN	Triangulated Irregular Network
TOR	Terms of Reference
TS	Tropical Storm
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
TTS	Telegraphic Transfer Selling
TUREDECO	Turbines Resource and Development Corporation
TWG	Technical Working Group
TY	Typhoon
ULAP	Union of Local Authorities of the Philippines
UNDP	United Nations Development Programme
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USLE	Universal Soil Loss Equation
UU	Unconsolidated Undrained
VAT	Value Added Tax
WB	World Bank
WL	Water Level

Measurement Unit

Extent

km^2	square-kilometer (1.0 km x 1.0 km)
ha	10,000 square-meter (100 m x 100 m)
acre	

Length

mm	millimeter
cm	centimeter (10 mm)
m	meter (100 cm)
km	kilometer (1,000 m)
l.m	linier meter

Currency

US$	United State Dollars
PHP	Philippine Pesos

Number

million	10^6
billion	10^9

Temperature

°C	Degree Celsius

Volume

m^3	cubic-meter
l	litter
Ncm / NCM	Normal Cubic Meter
MCM	Million Cubic Meters

Weight

g	gram
kg	kilogram (1,000 g)
ton	metric ton (1,000 kg)
mg	milligram (10^{-3} g)
µg	microgram (10^{-6} g)

Time

sec	second
min	minute (60 sec.)
hr	hour (60 min.)
yr	year
Ma	Mega annum (10^6 years)

Others

dB (A)	decibel
kN/m^2	kilonewtion per square-meter
d/s	down stream

CHAPTER 1 INTRODUCTION

1.1 Background of the Survey

The Government of the Philippines (GOP) has set measures for flood mitigation such as watershed management, and efficient and appropriate infrastructure development, as one of the important policies in the Philippine Development Plan (2011-2016), with the following strategies:

- To give priority to construction of flood mitigation structures for high flood risk area,
- To consider climate change adaptation in planning and design for flood mitigation structures, and
- To execute flood mitigation and management by structural and non-structural measures.

The Cagayan de Oro River Basin in this Survey was selected from the fifty six (56) priority river basins in “Nationwide Flood Risk Evaluation and Flood Damage Mitigation Plan in Selected River Basin, 2006-2008” by Department of Public Works and Highway (DPWH) under technical assistance of Japan International Cooperation Agency (JICA). Then, due to urgent need, DPWH has conducted a Master Plan (M/P) and Feasibility Study (F/S) in the Cagayan de Oro River Basin in June 2011, by their national budget. In the M/P, target year was set at Year 2035 with a flood protection level in 25 year probability.

Tropical Storm Sendong in December 2011, after the conduct of the said M/P and F/S, had brought about serious damages in the north Mindanao area. About 1,170 thousand people were affected and about 1,250 persons were lost. One of the serious damaged cities was Cagayan de Oro City, which is located at the downstream of the Cagayan de Oro River Basin, where about 600,000 people live. Due to tremendous changes in natural and social conditions by the Sendong, review and update of M/P and F/S are urgently necessary.

Under aforementioned circumstance, a project regarding urgent flood risk management measures for the Basin is requested in order to strengthen the disaster resilience of communities around the Basin. In March 2012, DPWH and JICA have agreed to conduct the technical assistance of JICA on the Preparatory Survey for Flood Risk Management Project for Cagayan de Oro River(the Survey) intending to formulate a Yen loan project for the Cagayan de Oro River Basin.

1.2 Objectives of the Survey

The objectives of the Survey are as follows:

- To review and update previous M/P and F/S based on the inspection and investigation of the latest topographic conditions, development situation, damage surveys and current changes of GOP for flood mitigation policy in the Cagayan de Oro River Basin, and
- To assist the GOP in formulating of Yen loan project for flood mitigation, which includes structural and non-structural measures in the Cagayan de Oro River Basin based on the above review study results.

1.3 Survey Area

The area of the Survey is the Cagayan de Oro River Basin in Mindanao Island as shown in Location Map. The situation of the major river basins in the Philippines is explained as well as the Cagayan de Oro River Basin hereinafter.

(1) Major River Basins in the Philippines

The National Water Resources Board(NWRB) has specified 12 Water Resources Regions in the whole country and designated 421 principal river basins with catchment area of over 40 km^2 so as to formulate a comprehensive water resources development plan in 1976. Among those principal river basins, the 18 river basins with catchment area of over 1,400 km^2 have been classified as Major River Basins.

Main feature and location of the Major River Basins are shown in Table 1.3.1 and Figure 1.3.1, respectively as well as the basic information as presented in Table 1.3.2 including accomplishment of the concerned studies and construction works carried out.

(2) Situation of Major River Basins and the Cagayan de Oro River

Out of the Major River Basins(18 basins), some prioritized river basins having large catchment area and highly developed city(s) with high property value, have conducted the studies on the master plan and the feasibility study as well as the detailed design for development and improvement works. Of those, the river basins, where river improvement works have been conducted or been underway, are the Agusan River、the Pampanga River、the Agno River、the Pasig River and the Bicol River, while, the improvement works are scheduled to be conducted in the Cagayan River and Tagoloan River

The Cagayan de Oro River, as one of the 18 Major River Basins, is the particular one to suffer the most serious flood damages in recent years, due to the tropical low-pressure in 2009, the tropical storm Sendong(TS. Sendong) in 2011 and the typhoon Pablo in 2012. Among such disasters, the death toll from the TS. Sendong reached more than 1,200 in around the Cagayan de Oro River Basin.

It has been believed that the northern Mindanao region is “Typhoon Free Zone” and few passing of typhoon has been ever experienced. However, due to influence of climate change and facts of frequent disasters by typhoons, the region is now to be assumed as typhoon disaster-stricken area.

Furthermore, the Cagayan de Oro River has so steep average river slope in particular in the major rivers that flood runoff time is short and that it is prone to cause a flush flood which is apt to hit the Cagayan de Oro City, which has 600,000 population of the central city of the Region X.

Consequently, the Cagayan de Oro River is regarded as one of the river basins which have the highest flood risk in the Philippines.

(3) Social Situation of the Cagayan de Oro River Basin

At the Cagayan de Oro City located in the downstream reach of the Cagayan de Oro River basin, particularly the area along the river where severe flood damages including high death toll were caused by TS.Sendong, awareness of flood damage countermeasures have been raised that building and residence are to be prohibited and refrained in the very high flood risk area.

1.4 Implementation Agency of the Project

Implementation Agency of the Flood Risk Management Project for Cagayan de Oro River Basin(FRIMP-CDOR, the Project) is DPWH as the counterpart agency for the Survey.

The Steering Committee is established by the Department Order (No.61 Series of 2012) dated August 30, 2012, as shown in Annex 1, with the following members:

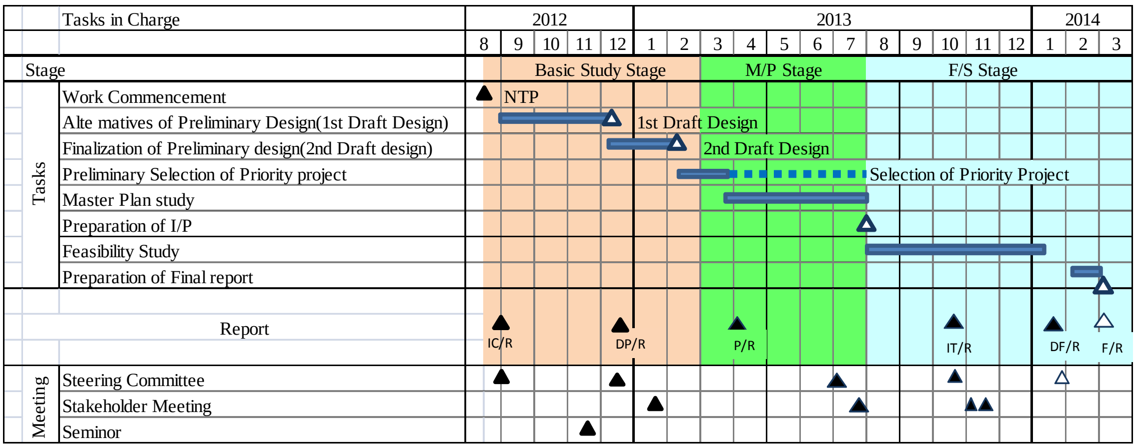
- Assistant Secretary for Planning and PPP, DPWH (Chair person)
- Project Director PMO-MFCDP, Cluster II (Vice-Chairperson)
- Director, Planning Service, DPWH
- Project Director, PMO-FCSEC, DPWH
- Director, Bureau of Design, DPWH
- Regional Director, DPWH Region X
- Department of Environment and Natural Resources (DENR)-RBCO Representative
- DENR Region X Representative
- National Economic Development Authority (NEDA) Representative
- Office of Civil Defense (OCD) Representative
- Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) Representative
- National Irrigation Administration (NIA) Representative
- National Water Resources Board (NWRB) Representative

A Technical Working Group(TWG) is also created in accordance with the same Department Order in order to assist the Steering Committee in its function. Appointed member of TWG is presented in the said Department Order compiled in Annex 1.

1.5 Survey Schedule

1.5.1 Overall Schedule

The Survey was commenced in August 2012 and to be carried out for about twenty (20) months from August 2012 to March 2014 as shown below:



The Survey works in the Philippines was commenced, after preparatory works in Japan, on August 27, 2012 upon arrival of the Survey Team. The first Steering Committee Meeting was held to have discussion on the Inception Report on August 31, 2012 in Manila with respect to objectives, schedule and approaches for successful implementation of the Survey.

After the series of discussion and exchange of views in the meeting, the Steering Committee and JICA Survey Team agreed upon the contents of the Inception Report and Main Points Discussed as per Annex 2.

The work schedule have been divided into the following three stages:

[Stage 1] Basic Survey Stage(Task 1-1 to Task 1-23) : August 2012 to February 2013

[Stage 2] Master Plan Stage(Task 2-1 to Task 2-15) : March 2013 to July 2013

[Stage 3] Feasibility Study Stage(Task 3-1 to Task 3-5) : August 2013 to March 2014

1.5.2 [Stage I] Basic Survey Stage

(1) Survey Works (Tasks 1-1 to 1-23 as enumerated in Table 1.5.1)

The survey works for the Basic Survey Stage was conducted for Tasks 1-1 to 1-23 in accordance with the scope of the works including various surveys, preparation of preliminary design(2nd Draft Design), definition of river boundary and so forth during a period from August 2012 to February 2013:

(2) Reports

The Draft Progress Report (DP/R) was prepared based on the results of studies and surveys executed by beginning of December 2012 covering the tasks 1-1 to 1-18 of the Stage 1.

The Progress Report (P/R) was prepared based on the results of studies and surveys executed by February 2013 covering all the tasks for the Stage 1(Tasks 1-1 to 1-23).

(3) Steering Committee

The second Steering Committee Meeting was held to have discussion on the Draft Progress Report on December 13, 2012 in Manila with respect to the results of studies and surveys incorporated in the Draft Progress Report including findings, assessment and analyses interim results.

After the series of discussion and exchange of views in the meeting, the Steering Committee and JICA Survey Team agreed upon the contents of the Draft Progress Report and Main Points Discussed as per Annex 2.

The third Steering Committee Meeting was held to have discussion on the Progress Report on July 2, 2013 in Manila with respect to the results of studies and surveys incorporated in the Progress Report including findings, assessment and analyses results.

After the series of discussion and exchange of views in the meeting, the Steering Committee and JICA Survey Team agreed upon the contents of the Progress Report and Main Points Discussed as per Annex 2.

1.5.3 [Stage II] Master Plan Stage

(1) Survey Works (Tasks 2-1 to 2-15 as enumerated in Table 1.5.1)

The survey works for the Master Plan Stage was conducted for Tasks 2-1 to 2-15 in accordance with the scope of the works including preparation of Environmental Impact Assessment(EIA) Report, support for preparation of Resettlement Action Plan, formulation of the Master Plan, selection of the priority projects, scoping for the project and so forth during a period from March 2013 to July 2013:

(2) Report

The Interim Report (IT/R) was prepared based on the results of studies and surveys executed by the end of August 2013 covering all the tasks for the Stage 2(Tasks 2-1 to 2-15) as well as the tasks in the Stages 1.

(3) Steering Committee

The fourth Steering Committee Meeting was held to have discussion on the contents of Interim Report on October 17, 2013 in Manila with respect to the Master Plan formulation as well as related studies and surveys incorporated in the Interim Report including findings, assessment and analyses results.

After the series of discussion and exchange of views in the meeting, the Steering Committee and JICA Survey Team agreed upon the contents of the Interim Report and Main Points Discussed as per Annex 2.

1.5.4 [Stage III] Feasibility Study Stage

(1) Survey Works (Tasks 3-1 to 3-5 as enumerated in Table 1.5.1)

The survey works for the Feasibility Study Stage have been conducted in accordance with the Tasks 3-1 to 3-3 of the following tasks during a period from August 2013 to date:

Task 3-1 Feasibility Study (F/S) for structural & non-structural measures to evaluate project feasibility

Task 3-2 Proposal for Disaster Risk Reduction and Management

Task 3-3 Draft Final Report

Task 3-4 Explanation and Discussion of Draft Final Report

Task 3-5 Final Report

(2) Report

This Draft Final Report (DF/R) is prepared based on the results of studies and surveys executed to date covering the tasks in the Stage 3(Tasks 3-1 to 3-3) as well as all the tasks for the Stages 1 and 2.

1.6 Stakeholder Meetings

(1) First Stakeholder Meeting

The first (1st) Stakeholder Meetings were held at the Cagayan de Oro City and three Municipalities including Talakag, Baungong and Libona during a period of January 23 through January 25, 2013. Minutes of Meeting of the 1st Stakeholder Meetings are compiled in Appendix K.

(2) Second Stakeholder Meeting

The second (2nd) Stakeholder Meetings were held at the Cagayan de Oro City in the following manner:

A) Cluster Meetings

i) July 20, 2013 AM ; Barangays Bonbon, Kausuwagan
ii) July 20, 2013 PM ; Barangays Carmen, Balulang
iii) July 27, 2013 AM ; Barangays Macabalan, Puntod, Consolacion
iv) July 27, 2013 PM ; Barangays Poblacion, Nazareth, Macasandig

B) Wrap up Meetings held on September 5, 2013

Minutes of Meeting for the above Cluster Meetings and Wrap up Meeting are compiled in Appendix K.

(3) Third Stakeholder Meeting

The third (3rd) Stakeholder Meeting, on the Master Plan of FRIMP-CDOR and Strategic Environmental Assessment (SEA), was held at the Cagayan de Oro City on October 24, 2013. Minutes of Meeting of the 3rd Stakeholder Meeting are compiled in Appendix K.

(4) Fourth Stakeholder Meeting

The fourth (4th) Stakeholder Meetings (Consultation Meeting) on the Resettlement Action Plan (RAP) were held at the Cagayan de Oro City in the following manner:

<u>Cluster Meetings</u>

i) November 5, 2013 AM ; Barangays Balulang, Macasandig and Nazareth

ii) November 5, 2013 PM ; Barangays Carmen

iii) November 6, 2013 AM ; Barangays Bonbon, Kausuwagan, Barangays 1, 2, 6, 7, 10, 13, 15 and 17

iv) November 6, 2013 PM ; BarangayConsolacion

Minutes of each meeting of the above are compiled in Appendix K.

(5) Fifth Stakeholder Meeting

The fifth (5th) Stakeholder Meeting, related to Feasibility Design of structural measure, Environmental Impact Assessment (EIA) study result and RAP & report on PCMs held on Nov. 5&6, was held at the Cagayan de Oro City on November 15, 2013. Minutes of Meeting of the 5th Stakeholder Meeting are compiled in Appendix K.

Table 1.3.1 Major 18 River Basins in the Philippines

No.	Name of River Basin	Region	Drainage Area (km^2)	Annual Runoff (MCM)
1	Cagayan	Cagayan Valley	25,694	53,943
2	Mindanao	Southern Mindanao	23,169	26,899
3	Agusan	Northern Mindanao	10,921	27,880
4	Pampanga	Central Luzon	9,759	10,930
5	Agno	Central Luzon	5,952	6,654
6	Abra	Ilocos	5,125	12,551
7	Pasig-Laguna	Southern Luzon	4,678	7,485
8	Bicol	Bicol	3,771	5,102
9	Abulug	Cagayan Valley	3,372	7,121
10	Tagum-Libuganon	Souther Mindanao	3,064	6,128
11	Ilog-Hilabangan	Western Visayas	1,945	2,474
12	Panay	Western Visayas	1,843	2,344
13	Tagoloan	Northern Mindanao	1,704	4,350
14	Agus	Southern Mindanao	1,645	918
15	Davao	Southeastern Mindanao	1,623	3,246
16	**Cagayan de Oro**	**Northern Mindanao**	**1,521**	**3,883**
17	Jalaur	Western Visayas	1,503	1,912
18	Buayan-malungun	Southeastern Mindanao	1,434	2,870

Source: Principal River Basins of the Philippines-NWRC

Table 1.3.2 Main Features, Accomplishment of the Studies/Development and Current Flood Damage Records in the Major 18 River Basins

No.	Name of River Basin	Region	Drainage Area (km²)	River Length *1 (km)	Major City (Population) (-)	Population in Basin *2 (person)	M/P, F/S Study	Note
1	Cagayan	Cagayan Valley	25,694	505	Tuguegarao (138,865) Tabuk (103,912)	3,272,777	X	Implementaing
2	Mindanao	Southern Mindanao	23,169	373	Cotabato (271,786)	4,261,092	under Study	
3	Agusan	Northern Mindanao	10,921	350	Butuan (309,709) Bayugan (99,361)	1,112,143		Implementaing
4	Pampanga	Central Luzon	9,759	260	Tarlac (318,332) Cabanatuan (272,676) Gapan (101,488) San Jose (129,424) Muñoz (75,462) San Fernando (285,912) Angeles (326,336) Mabalacat (215,610)	5,776,701	X	Implementaing
5	Agno	Central Luzon	5,952	206	Tarlac (318,332)	4,085,384	X	Implementaing
6	Abra	Ilocos	5,125	181	Vigan (49,747)	209,491	No Study	
7	Pasig-Laguna	Southern Luzon	4,678	78	**NCR:** Quezon (2,761,720) Taguig (644,473) Mandaluyong (328,699) Las Piñas (552,573) Malabon (353,337) Marikina (424,150) Makati (529,039) Muntinlupa (459,941) Parañaque (588,126) Pasig (669,773) Valenzuela (575,356) Caloocan (1,489,040) Navotas (249,131) Pasay (392,869) San Juan (121,430) **Rizal Province:** Antipolo (677,741) **Laguna Province:** Sta. Rosa (284,670) Calamba (389,377) Cabuyao (248,436) Biñan (283,396)	13,605,650	X	Implementaing
8	Bicol	Bicol	3,771	136	Naga (174,931) Iriga (105,919)	3,101,296	X	Implementaing
9	Abulug	Cagayan Valley	3,372	175	No major City	97,129	No Study	
10	Tagum-Libuganon	Southern Mindanao	3,064	89	Tagum (242,801)	1,324,055	No Study	
11	Ilog-Hilabangan	Western Visayas	1,945	178	Bayawan (114,074)	2,136,647	X	
12	Panay	Western Visayas	1,843	152	Roxas (156,197)	654,156	X	
13	Tagoloan	Northern Mindanao	1,704	106	Malaybalay (153,085)	1,724,603	X	Implementaing
14	Agus	Southern Mindanao	1,645	36	Marawi (187,106) Iligan (322,821)	1,558,285	No Study	
15	Davao	Southeastern Mindanao	1,623	150	Davao (1,449,296)	1,905,917	No Study	
16	Cagayan de Oro	Northern Mindanao	1,521	90	CDO (602,088)	1,522,142	X	
17	Jalaur	Western Visayas	1,503	123	Passi (79,663)	1,559,182	No Study	
18	Buayan-Malungun	Southeastern Mindanao	1,434	64	General Santos (538,086)	1,513,172	No Study	

Source: Principal River Basins of the Philippines-NWRC, and Result of interview to FCSEC

*1 This is referred to JICA brochure "Water & Floods, Alook Philippines' and Flood Mitigation Efforts, March 2004".

*2 This is referred to the data book owned by DPWH-FCSEC.

Source: Principal River Basins of the Philippines.

Table 1.5.1 Work Tasks in the Survey

Task No.	Tasks
Stage I : Basic Survey Stage	
Task 1-1	Collection and Review of Necessary Information/Data and Reports
Task 1-2	Assessment on Existing Flood Mitigation Measures
Task 1-3	Topographic Survey
Task 1-4	River Survey
Task 1-5	Design Scale of the Project
Task 1-6	Rainfall and Runoff Analysis
Task 1-7	Inventory Survey for River Structures
Task 1-8	Establishment of Design Standards
Task 1-9	Survey on Slope Failure
Task 1-10	Estimation of Sediment Yield
Task 1-11	Assessment of Sediment Balance
Task 1-12	Evaluation Criteria
Task 1-13	Initial Study for Alternatives of Preliminary Design (1st Draft Design)
Task 1-14	Study on Environmental and Social Considerations
Task 1-15	Assistance to Steering Committee
Task 1-16	Coordination among Stakeholders
Task 1-17	Survey on Organization for Project Implementation and O&M
Task 1-18	Draft Progress Report
Task 1-19	Layout Plan of Sabo Facilities
Task 1-20	Preparation of Preliminary Design(2nd Draft Design)
Task 1-21	Initial Evaluation of Flood Risk Management Plan
Task 1-22	Definition of River Boundary
Task 1-23	Progress Report
Stage II : Master Plan Stage	
Task 2-1	Collection of Additional Data, Documents and Information
Task 2-2	Strategic Environmental Assessment (SEA) on Alternative Plans
Task 2-3	Preparation of Environmental Impact Assessment(EIA) Report including EMoP Environmental Monitoring Plan (EMoP)
Task 2-4	Support for Preparation of Resettlement Action Plan
Task 2-5	Supplemental Survey of River Structures
Task 2-6	Geotechnical Investigation
Task 2-7	Runoff Analysis
Task 2-8	Inundation Analysis and Riverbed Fluctuation Analysis
Task 2-9	Basic Design of Structural Measures
Task 2-10	Assessment of Existing Non-Structural Measures
Task 2-11	Formulation of Non-Structural Measures
Task 2-12	Formulation of Master Plan
Task 2-13	Selection of Priority Projects
Task 2-14	Interim Report(IT/R)
Task 2-15	Scoping for the Project
Stage III : Feasibility Study Stage	
Task 3-1	Feasibility Study (F/S) for structural & non-structural measures to evaluate project feasibility
Task 3-2	Proposal for Disaster Risk Reduction and Management
Task 3-3	Draft Final Report
Task 3-4	Explanation and Discussion of Draft Final Report
Task 3-5	Final Report

Source: JICA Survey Team

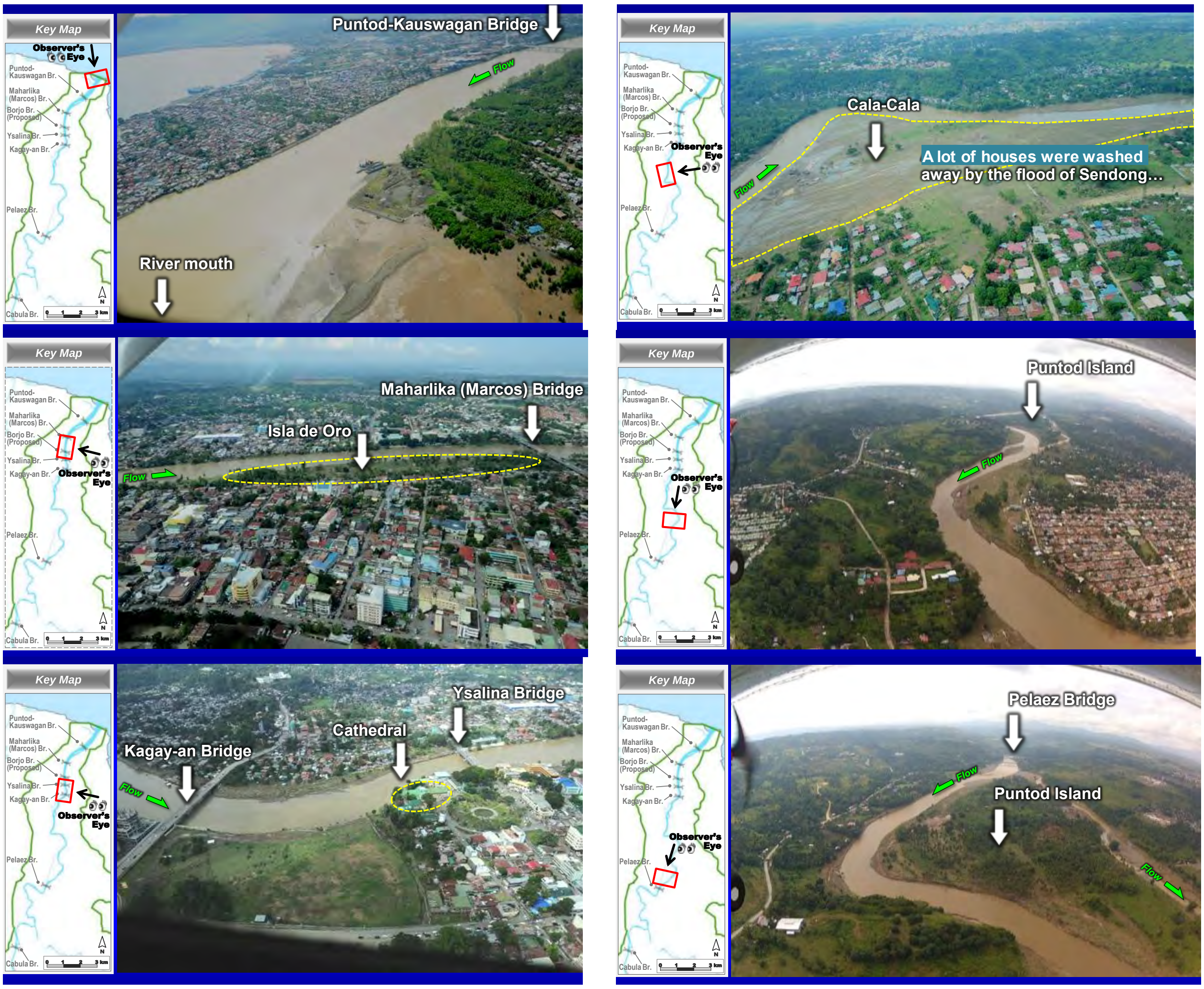
Figure 1.3.1 Major 18 River Basins in the Philippines

CHAPTER 2 THE SURVEY AREA

2.1 Project Location

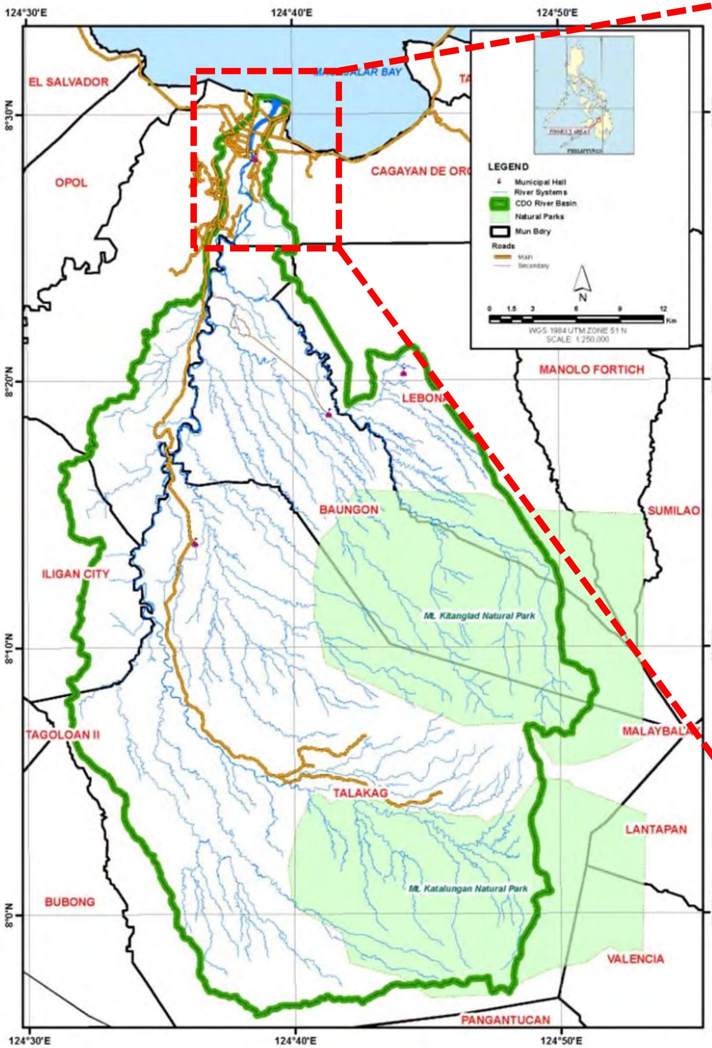
The Cagayan de Oro River Basin is situated in the Northern Mindanao Region, which is administratively called Region X and specifically located under five local government units namely, Cagayan de Oro City (highly urbanized city) and three municipalities of Talakag, Baungon and Libona in Bukidnon and Illigan City in Misamis Oriental.

Figure 2.1.1 shows the photographs of present site conditions along the Cagayan de Oro River. Location map of the Cagayan de Oro River Basin is presented in Figure 2.1.2. The Project Area is located in the most downstream area of the Cagayan de Oro River which suffered from serious damages due to recent floods. The object area is the Cagayan de Oro River stretch from the Macajalar Bay to the Pelaez Bridge which is 12 km long as shown in Figure 2.1.3.



Source: JICA Survey Team

Figure 2.1.1 Photographs of Present Condition of the Project Area



Source: JICA Survey Team

Figure 2.1.2 Cagayan de Oro River Basin

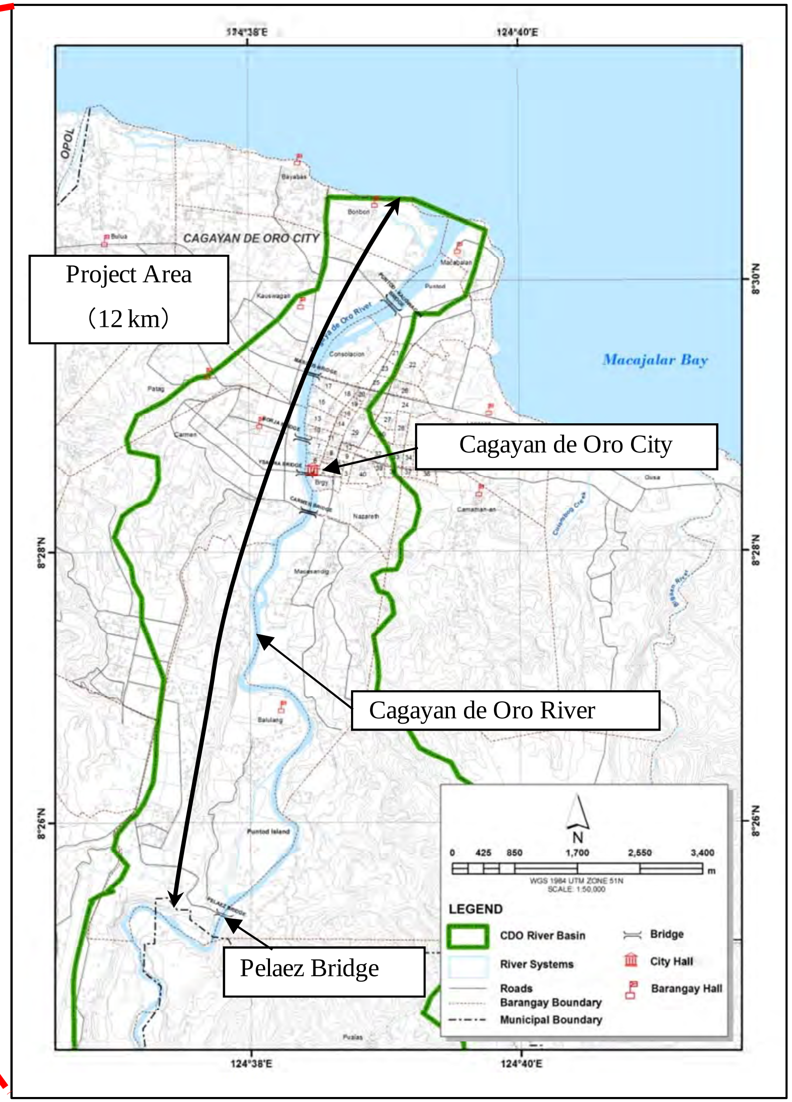
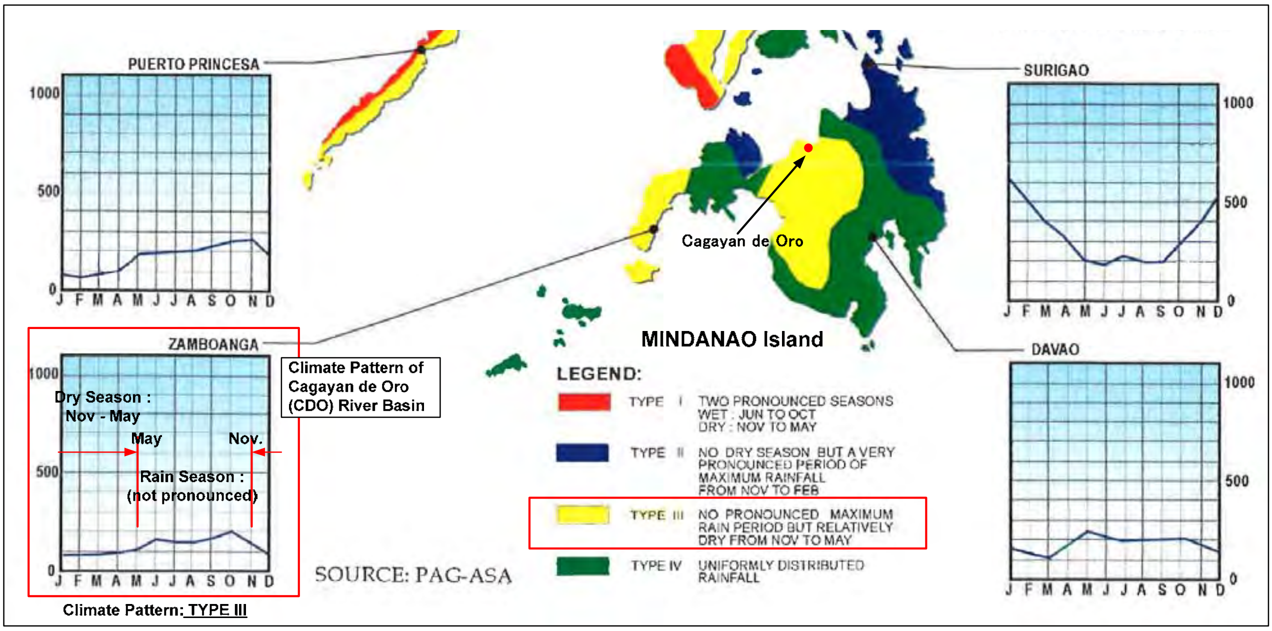


Figure 2.1.3 The Project Area

2.2 Climate Condition

Cagayan De Oro River Basin has a tropical climate with two (2) distinct types of climate: types III and IV based on the PAGASA climate map. Type III climate is characterized by a not so distinct wet and dry season with a "relatively dry period from November to April and wet from May to October. Type IV climate indicates that rainfall throughout the year is generally "evenly distributed". This is felt in the upper portions of the catchment particularly in the two mountain peaks at the southern and southeastern edge of the catchment.

As per climatologic normal data from the PAGASA Lumbia Synoptic Station at Cagayan De Oro for the period 1997 to 2011, the annual mean temperature is 27°C and the highest recorded temperature in the city was 38.2°C on May 1998. The driest month is April while the wettest is July. The wet season in the city starts in May and ends in October. The relatively drier period starts in November and ends in April.



Source: PAGASA, DPWH_FCSEC

Figure 2.2.1 Rainfall Pattern of Mindanao Island

2.3 River Condition

The lowland area is relatively flat with development in the City of Cagayan de Oro. Most of the developed area in the lowland is bounded by the contour lines with an elevation of 20 m. Mount Kitanglad is the highest spot in the area with an elevation of 2,927 m. From the top of the mountains in the south, rivers run through from southern parts of the river basin towards Macajalar Bay.

The Cagayan de Oro River is 97 km long from its origin to the river mouth with total catchment area of 1,364 km^2. The stretch has steep riverbed slope of 1/1-1/40 in the upstream of 76 km from the river mouth, mild slope of 1/40-1/190 between 19 and 76 km from the river mouth and gentle slope of 1/190-1/4000 in the downstream of 19 km from the river mouth.

Result of study on river flow capacity in the stretch indicates that the flow capacity of the existing river channel in the downstream stretch is small at 700-1,500m^3/s with 2 to 5-year flood recurrence.

2.4 Inundation and Flood Damage

(1) Record of Flood Damages

Large flood events in the Cagayan de Oro River Basin have been recorded in 1916, 1957, 1982, 1998 and 2009. In 2011 and 2012, the December Tropical Storm (TS) Sendong and Typhoon (TY) Pablo produced widespread inundation bringing about extensive loss of life, damage to infrastructure and disruption in socio-economic activities. Table 2.4.1 below lists the most destructive typhoons in the Cagayan de Oro River Basin.

Table 2.4.1 Destructive Flood Damages in Cagayan de Oro River Basin

Year/Month	Daily Maximum Rainfall (mm/day) （Lumbia Station）	Deaths	Affected Families /Persons in CDO	Estimated Damage Million PhP	Source
1916	n/a	n/a	n/a	n/a	
January 1957	n/a （Storm 01W）	n/a	n/a	n/a	
March 1982	84.2 （Tropical Depression Akang）	30	38,020 families, 212,564 persons	14.9	OCD
August 1998	129.3 （Heavy Rain and cold front）	5	2,762 families, 12,467 persons	653	OCD
November 2009	237.1 （Tropical Depression Urduja）	3	34,959 families, 174,839 persons	n/a	NDCC,SITREP No.6 26 Nov. 2009
December 2011	180.9 （TS Sendong）	1,268(1	38,236 families, 342,400 persons	1,689(2	NDRRMC, SITREP No.47 26 Jan. 2012
December 2012	78.1 （TY Pablo）	7	14,246 families, 55,188 persons	2,150(2	NDRRMC/, SITREP No.38 25 Dec. 2012

Source: JICA Survey Team

Note: (1.excluding the number of missing persons
(2. Data in Region 10

(2) Flood Damages by TS Sendong Flood (December 16th -17th, 2011)

Scale of the Sendong flood is estimated at around 50-year flood return period which was identified as the recorded maximum historic flood experienced in Cagayan de Oro (CDO) City. Flood damages most seriously occurred at Bgy. Balulang (Left Bank), Bgy. Macasandig (Cala-Cala Area) (Right Bank), Bgy. Carmen (Left Bank), Isla de Oro and Isla Delta Areas (Right Bank). The floodwaters rapidly increased and flowed directly towards the populated area within floodplains of the Cagayan de Oro River which killed a large number of people and caused destruction of properties mainly for the people living in the flood plain along the river bank. The duration of flood inundation in the urban area in the downstream stretch was less than one day. It was different from a characteristic of floods seen in other major river basins of Philippines such as Pampanga and Agusan Rivers.

Photo (1/2) at Left Bank: Sta.5+570

Photo (2/2) Left Bank: Sta.5+570

Source: JICA Survey Team

Figure 2.4.1 Photographs of Flood-Mark on House (Left Bank: Sta.5+570)

The existing river bank revetments damaged by the Sendong Flood are as follows:

Table 2.4.2 Damaged Existing River Bank Revetment

No.	Type of Structure	Location	Station
1	Seawall (at river mouth)	- Downstream of the Kauswagan - Puntod Bridge (right bank)	L=450m Sta.0+179.62 to Sta.0+630
2	Concrete Face Rock-fill Dike with Steel Sheet Pile	- Upstream of left abutment of Ysalina Bridge	L=130m Sta.4+170 to Sta.4+300
3	Steel Sheet Piles Revetment (inclined)	Upstream of the Ysalina Bridge / CDO Archbishop (right bank)	L=13m Sta.4+168.64 to Sta.4+181.79
4	Concrete floodwall (Golden Mile Plan)	Right bank at downstream of the Ysalina Bridge (right bank)	L=90m Sta.4+078.58 to Sta.4+168.64

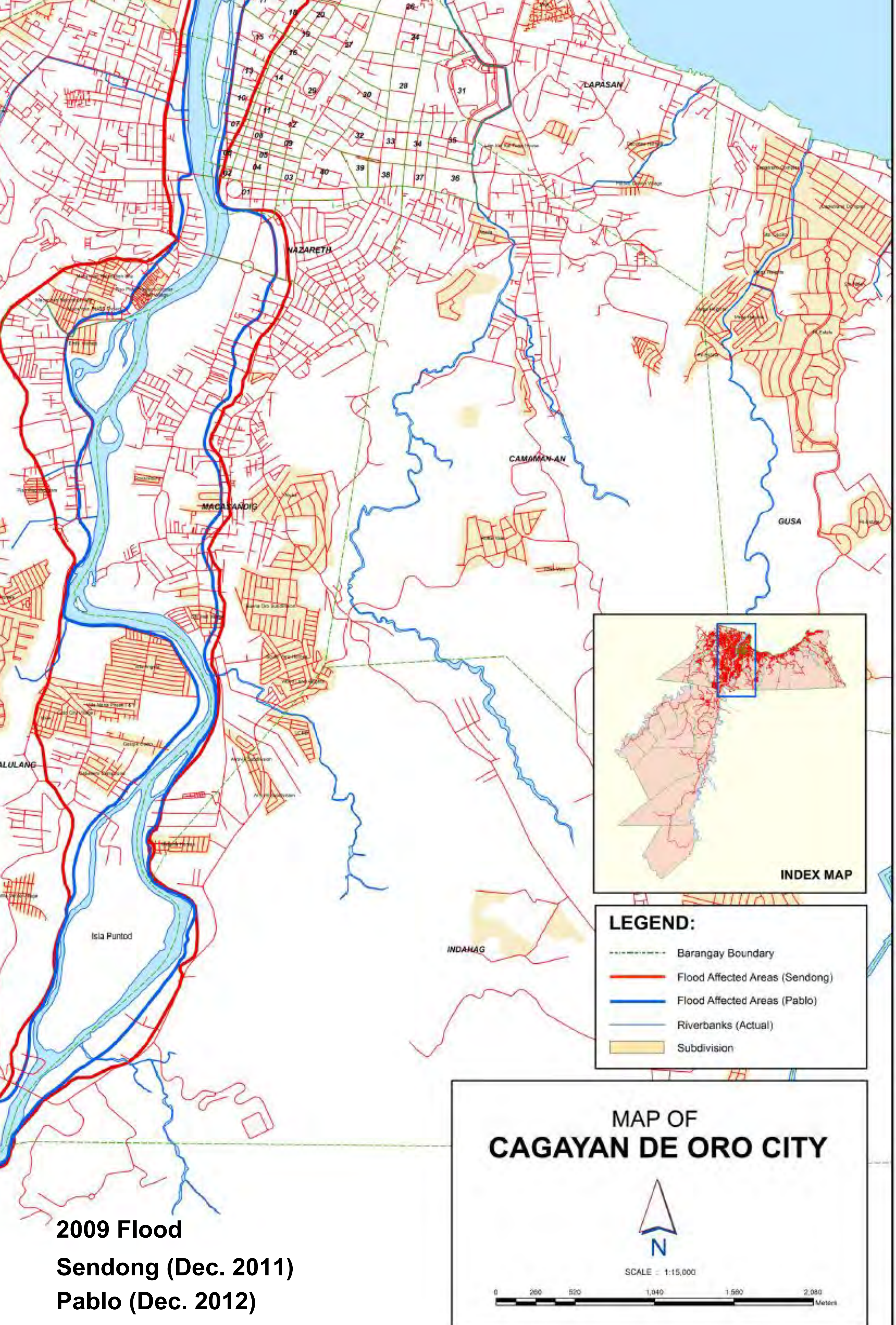
Source: JICA Survey Team

(3) Flood Damages by TY Pablo Flood (December 4th, 2012)

Typhoon Pablo hit Cagayan de Oro City on December 4th, 2012 after passing over Mindanao Island causing flood damages after TS Sendong in 2011.

As the result of ocular inspection and flood mark survey by the JICA Survey Team, the flood inundation maps showing inundation lines caused by TY Pablo and TS Sendong was prepared for the purpose of comparing the extent between the two flood inundation areas as presented below.

It was confirmed during the site investigation that flood inundation area caused by the TY Pablo did not extend to that of TS Sendong. In addition, because of the communities' preparedness activation against disaster such as early warning and pre-evacuation, no serious loss of human lives was observed during TY Pablo.



Flood Prone Area (Affected Area by 2009, Sendong and Pablo Floods)

2.5 Existing Flood Mitigation Measures and Other Facilities

(1) Existing Flood Mitigation Measures and Other Facilities

The following existing structures are identified along the Cagayan de Oro River, up to 12 km upstream from the river mouth as of February 2013.

1) Dike and Bank Protection Works
- Dike: 1,638 m
- Revetment: 569 m
- Floodwall 370 m
- River wall 400 m

2) Drain Outlet: 17 units

3) Bridge 5 units

(2) Flood Mitigation Measures after TS Sendong and TY Pablo

Table 2.5.1 shows urgent rehabilitation works which have been conducted by DPWH since the Sendong Flood (as of February 2013). In addition, as shown in Table 2.5.2 additional designs of rehabilitation works are prepared under budgets for rehabilitation works on national disaster (Task Force Sendong) which is financed from the Office of Civil Defense (OCD).

DPWH is making efforts to accelerate progress of the construction / rehabilitation works mentioned above and to complete the same before the coming rainy season.

Table 2.5.1 Urgent Rehabilitation of River Dike Works

No.	Structure	Location	Station
1	Construction of Seawall	Right bank at the river mouth	500m Sta.0+000.00 to Sta.0+500.00
2	Construction of Concrete Face Rock-fill Dike	Left bank between Ysalina Bridge and Kagay-an Bridge	200m Sta.4+059.57 to Sta.4+251.69
3	Construction of Concrete Face Rock-fill Dike	Right bank between Ysalina Bridge and Kagay-an Bridge (suspended)	150m Sta.4+168.64 to Sta.4+318.78

Source: JICA Survey Team

Table 2.5.2 Additional Urgent Rehabilitation of River Dike Works (Planned)

No.	Structure	Location	Station
1	Dredging of River Channel	Between River Mouth and Kauswagan - Puntod Bridge	1,357.8m Sta.0+500.00 to Sta.1+357.80
2	Construction of Seawall	Right bank at the river mouth	740m Sta.0+500.00 to Sta.1+240.00
3	Construction of Concrete Face Rock-fill Dike	Left bank Between Maharika Bridge and Ysalina Bridge	740m Sta.2+733.00 to Sta.3+433.00
4	Construction of Concrete Face Rock-fill Dike	Left bank between Ysalina Bridge and Kagay An Bridge	1,178m Sta.3+433.00 to Sta.4+611.00
5	Construction of Concrete Face Rock-fill Dike	Right bank between Ysalina Bridge and Kagay An Bridge	421m Sta. 4+318.78 to Sta.4+740.00

Source: JICA Survey Team

2.6 Environmental Conditions

Environmental baseline condition of the Cagayan de Oro (CDO) River consisting of physical-chemical condition and biological condition were summarized based on primary and secondary data as follows (refer to Appendix J for the details):

(1) Physical-Chemical Environment

Air Quality: NO_2 and SO_2 monitored along the CDO River in both 2011 and 2013 are well below the environmental standards stipulated in DENR Administrative Order (DAO) No. 2000-81 while the Dust (TSP) showed concentration higher than the environmental standards. Thus, the CDO City is evaluated as suffering from TSP.

Noise: Noise level data monitored along the CDO River monitored in 2011 and 2013 exceeded the environmental standard in most of the time regime stipulated in Presidential Decree (PD) No. 984. Thus, the CDO City is evaluated to often have noise pollution.

River Water Quality: Water quality of CDO River monitored in 2013 is consistent with the environmental standards (DAO No. 1990-34) except for TSS and coliform number (total and fecal). The high concentration of coliform number is consistent with the secondary data of DENR monitoring and those obtained in 2011. Thus, the CDO River is evaluated as suffering from high coliform and TSS.

Riverbed Sediment Quality: Toxicity Characteristics Leaching Procedure (TCLP) Test indicate that all the parameters of heavy metals in the riverbed sediments in CDO River are ND (not detected) or well below the standards of maximum contaminant level of hazardous waste (DAO No. 2004-36). Low concentration and ND of heavy metals in the riverbed sediment is consistent with the secondary data obtained in 2011.

Traffic: Survey results of road traffic conducted in 2013 indicate that Level of Services (LOS) of roads in the densely populated area of the CDO City are moderately or higher crowded situation. River traffic indicates that only the traffic at river mouth recorded many vessels but other two locations are few.

Groundwater: Groundwater is one of the main water sources of Cagayan de Oro City. Groundwater for water supply is taken from the water wells of Cagayan de Oro Water District (COWD). There are 27 water wells at present targeted for deep aquifer with the depth of more or less 150 to 250 m. Water wells located along the CDO River are located within the low land area of the Cagayan de Oro River.

(2) Biological Environment

Terrestrial Flora: There are three types of vegetation distinguished during the survey: 1) Mangrove ecosystem located in the mouth of Cagayan de Oro River in Barangay Bonbon, 2) Mixed Secondary vegetation-Agricultural orchards, and 3) Mixed agricultural plantation - secondary vegetation or fruit tree vegetation. An inventory survey conducted in 2013 identified 82 species belonging to 38 different families were recorded from the Kagayan Bridge up to Pelaez Bridge. The dominant tree species came from the Ficus family while palms were primarily dominated by the coconut genus. The most species came from the Family Poaceae, Moracea, and Palmae. The following two tree species; Narra (*Pterocarpus indicus)*, and Molave (*Vitex parviflora*) are considered as threatened species. But they are not growing under natural condition but estimated to be planted ones along the river bank.

Mangrove Forests:

There are 3 types of mangrove forests: 1) forested mangrove area at the west of river mouth along the sea shore consisting mainly of Bakauan Babae (*Rhizopora mucronata*), Bakauan Lalaki (*Rhizopora apiculata*) and Pagatpat (*Sonneratia alba*), 2) natural mangrove forests in marshy area at the west of river mouth consisting mainly of Nipa *(Nypa fruiticans)* with patches of Pagatpat *(Sonneratia alba)*, and 3) natural mangrove forests along both river banks consisting mainly of Pagatpat (*Sonneratia alba*) and patches of Nipa (*Nypa fruticans*).

Terrestrial Fauna: Census survey conducted in 2013 identified that a total of 27 species of wildlife vertebrates were recorded present in the study area. This total comprises 15 species of birds (55.5%), six species of reptiles (22.2%), five species of mammals (18.5%), and one species of amphibian (3.7%). There were no species listed in a National List of Threatened Species (DAO 2007-01) or IUCN Red List of Threatened Species.

Aquatic Biota:

Phytoplankton: A total of 21 phytoplankton species were identified across the three sampling stations, dominated by the diatoms which comprised 90% of the phytoplankton community. Among the diatoms, the Genus *Flagilaria* dominated, accounting for 26 % of diatoms, flowed by *Navicula* at 13% and *Surirella* at 11%. Present phytoplankton community in the project area signifies normal levels of these organisms in the sea. The likelihood of algal blooms is ruled out by the findings in the study, due to the extremely low number of HAB-causing planktons.

Zooplankton: A total of only seven (7) zooplankton species were identified across the three sampling stations. Zooplankton observed consisted of adult stage (51%) and larval stage (49%).   A large portion of the adult zooplanktons were Rotifers, comprising 34% of all cells counted (30%) and flatworm larvae (12.3%).

Macrobenthos: The species encountered consisted of the gastropods Pacific sugar limpet (*Patelloida saccharina)*, pyramid periwinkle (*Nodilittoria pyramidalis)*, shell (*Macta luzonica)*, burrowing box crab (*Callapa spp)*, and the shore crab (*Varuna litterata)*. Among the shellfish encountered, only *Macta sp.* is known to be popularly edible.

Fish: Fishing in two stations yielded only 11 individuals belonging to six (6) species and weighing less than 1 kilogram altogether due to the small sizes of the catch. This include the Goatfish (*Parupeneus barberinoides*): Bicolor, *Slipmouth Leiognathus spp*., Mullet (*Mugil cephalus*), Mackerel (*Selar boops*), Tilapia (*Oreochromis sp.*) and the lucrative species of freshwater fish known as Pigok (*Mesopriostes cancellatus*).

Protected Area: There are no protected areas designated as protected areas such as national park, nature reserve and natural park designated by laws or regulations of the Philippines in the Project area.

2.7 Socio-economic Conditions

(1) Jurisdiction of Concerned Local Government Units

The location of the project area is situated within the jurisdiction of Cagayan de Oro City and along the Cagayan de Oro River from the river mouth up to the Pelaez Bridge located at around 12 kilometer upstream

In the project area, the following 19 barangays of the city are located within the inundation area of TS Sendong, such as Bonbon, Kauswagan, Carmen and Balulang on the left bank of the river, and Macabalan, Puntod, Consolacion, 18, 17, 15, 13, 10, 7, 6, 2, 1, Nazareth, Macasandig and Indahag on the right bank of the river.

(2) Population of Concerned Local Government Units

1) Population Growth

In Cagayan de Oro City, population rapidly increased in 10 years from 2000 to 2010 with an average annual growth rate of 2.69%, which is higher than to the national growth rate (2.04%) and the regional growth rate (1.67%) of the same period. This rapid growth is observed, due mainly to inflowing migration to the city from neighboring provinces, cities and municipalities for job and income opportunities. As shown in Table 2.7.1, the suburban part of the city such as in Barangays Carmen and Balulang, where residential subdivisions were developed, observed a rapid population growth, while the drastic decline of population was observed in the central part of the city or the Poblacion area.

2) Population Density

As indicated in Table 2.7.1, population density is quite high in the central part of the city and also in the low-income group area in Barangay Macabalan located near the river mouth, with more than 100 up to 400 persons per hectare as of 2010, while a rapidly growing suburban area was still low in population density.

Table 2.7.1 Population and Population Growth Rates of Local Government Units

	Land Area(ha) under Jurisdiction*[1]	Population under Jurisdiction		Average Annual Growth Rate (%)	Population Density(2010) (Person / Hectare)
		Yr.2000*[1]	Yr.2010*[2]		
Cagayan de Oro City	56,966.62	461,877	602,088	2.69	10.6
- Barangay Bonbon	116.28	7,983	9,195	1.42	79.1
- Barangay Kauswagan	512.53	28,761	34,541	1.85	67.4
- Barangay Carmen	956.65	47,188	67,583	3.66	70.6
- Barangay Balulang	880.25	20,894	32,531	4.53	37.0
- Barangay Macabalan	45.15	18,875	20,303	0.73	449.7
- Barangay Puntod	164.90	15,615	18,399	1.65	111.6
- Barangay Consolacion	49.45	8,786	9,919	1.22	200.6
- Barangay 18 (Poblacion)	4.72	1,762	1,496	-1.62	316.9
- Barangay 17 (Poblacion)	7.70	2,327	2,342	0.06	304.2
- Barangay 15 (Poblacion)	9.79	2,029	2,966	3.87	303.0
- Barangay 13 (Poblacion)	8.73	2,375	2,330	-0.19	266.9
- Barangay 10 (Poblacion)	4.79	928	616	-4.02	128.6
- Barangay 7 (Poblacion)	5.98	603	542	-1.06	90.6
- Barangay 6 (Poblacion)	4.32	782	212	-12.24	49.1
- Barangay 2 (Poblacion)	3.67	188	84	-7.74	22.9
- Barangay 1 (Poblacion)	10.60	534	453	-1.63	42.7
- Barangay Nazareth	68.30	10,731	10,658	-0.07	156.0
- Barangay Macasandig	397.58	17,691	23,310	2.80	58.6
- Barangay Indahag	1,405.39	2,723	6,235	8.64	4.4

Sources:
* [1] Census of Population and Housing 2000 (NSO)
* [2] Census of Population and Housing 2010 (NSO)

(3) Regional Socioeconomic Conditions

The regional socioeconomic conditions of the Northern Mindanao Region, where

Cagayan de Oro city is functioned as the trade and commercial center of the Region as well as the transport hub of the Region, are shown in the following sections.

1) Key Regional Socioeconomic Indicators

The key socioeconomic indicators of the Northern Mindanao Region such as on land area, population, local administration and GRDP are presented in the table below.

Table 2.7.2 Overview of Key Regional Socioeconomic Indicators

	Description of Status
Land Area (ha) *2	2,018,618
Regional Population (2007 *1/ 2010 *2)	4,297,323 (2010)
	3,952,437 (2007)
	The total population of the Region as of 2010 reached 4.297 million. It increased by 344 thousand over the figure in the 2007 Census, at an average annual population growth rate of 2.83%.
No. of Households (2007) *2	805,530 (2007)
Average Household Size (2007) *2	4.90
Population Density	1.96 / ha
Annual Population Growth Rate (2007-2010)	2.83
No. of Provinces (2007) *3	5
No. of Cities (2007) *3	9
No. of Municipalities (2007) *3	84
No. of Barangays (2007) *3	2,022
Gross Regional Domestic Products or GRDP (2004-2009) *4	73.2 Billion Peso (2009)
	56.0 Billion Peso (2004)
	GRDP of the Region as of 2009 is 73 billion peso, which increased by 17 billion peso over the 2004 figure, at an average annual growth rate of 5.40%.
	Comparing the annual growth rate with other regions, the GRDP of the Region in 2009 (5.5%) is higher than the GDP of the country (4.45%) and the highest in Mindanao. The GRDP in the other regions are: Region IX, 5.02%; Region XI, 4.84%; Region XII, 4.31%; Caraga, 4.82%; and in ARMM, 3.44%. Furthermore, the GRDP of the Region is higher than rest of the country as well (4.35%).

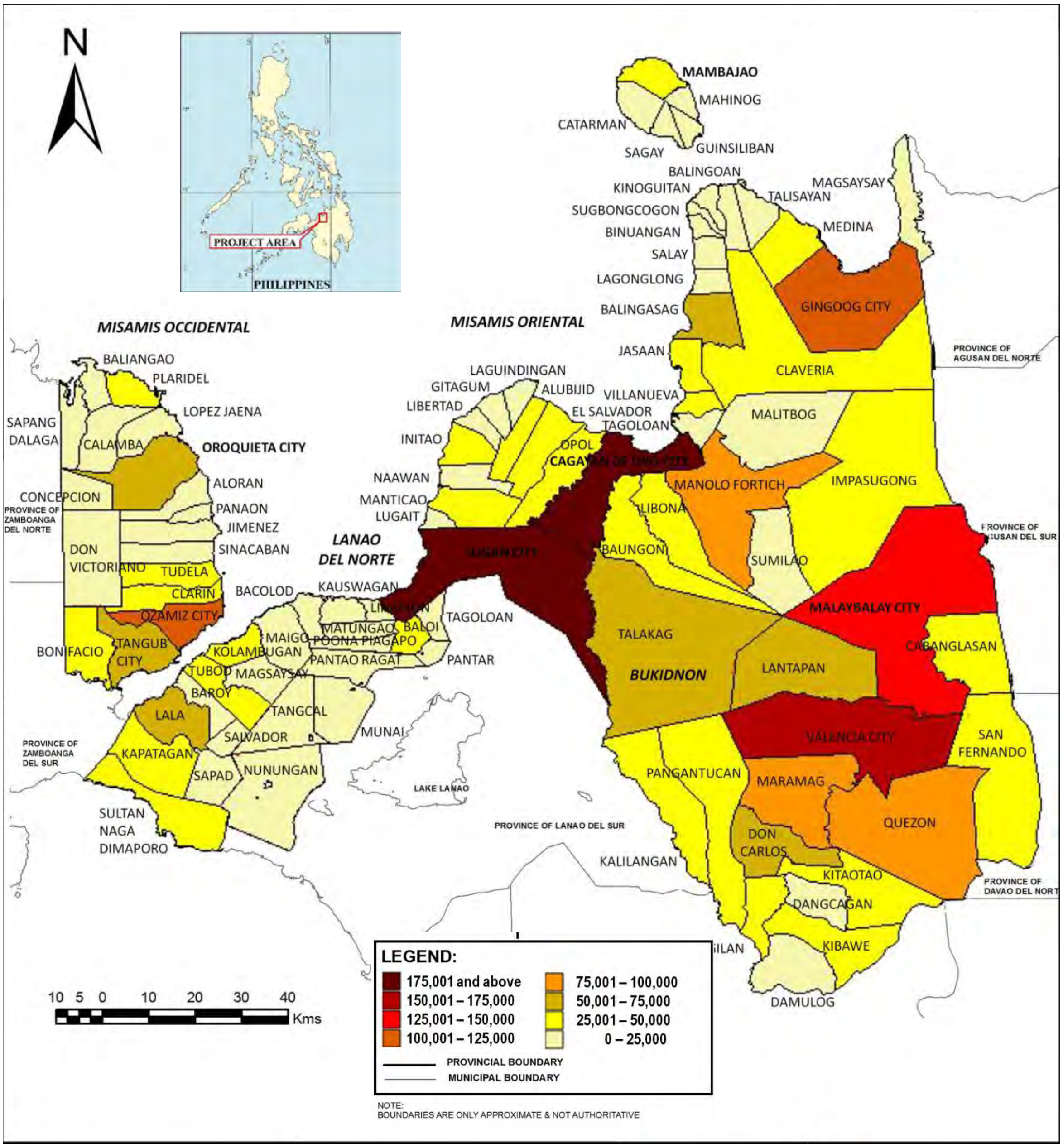
Sources:
* 1 Census of Population and Housing 2010 (NSO)
* 2 Northern Mindanao Regional Social and Economic Trend 2011 (NSCB)
* 3 Philippine Standard Geographic Code (NSCB)
* 4 Northern Mindanao Regional Development Plan 2011-2016 (NEDA)

2) Sectoral Regional Socioeconomic Conditions

The socioeconomic conditions by major sectors in the Northern Mindanao Region based on Northern Mindanao Regional Development Plan 2011-2016 (NEDA) are summarized as follows.

- Agricultural Sector (including Forestry and Fishery):
  Agriculture has been the leading sector, contributing to the regional economy growth in the Region with a GDRP growth rate of 4.2% (2008-2009) and 4.4% (2004-2005) compared to the industry sector (3.1% / 2.0%) and service sector (1.7% / 6.3%).

- Industry and Service Sector:
  The Region is in the process of a gradual economic transformation from a traditionally agriculture-led economy to being more of a service and industry-oriented economy with improvements in productivity competitiveness in all sectors. It is noted that both industry and services sectors attained accelerated growths of GDRP by sector from 2.0 % in 2004 to 8.6 % in 2007 for the industry sector and from 6.3 % to 8.1 % for the services sector during the same period, while from 4.4 % in 2004 to 6.3% in 2007 for the agricultural sector.
- Major Infrastructure Sector:
  Transportation - The total road network is 22 thousand kilometers as of 2009, composed of national roads (8%), 31% of which is unpaved and local roads (92%), 88% of which is unpaved. Majority of the unpaved roads are in provinces of Misamis Oriental and Bukidnon. Laguindingan International Airport was newly opened in June 2013, which functions as the regional air transport hub to accommodate needs of provinces in the Region.
  Power and Electrification - The power generation efficiency of the Region has decreased by 16.3% from 92% in 2004 to 75.7% in 2009, due to deteriorated plants. With the increasing economic activities in the Region, improvement of efficiency with more investments is a concern.
  Communication - While cellular phone lines have been made more available and expanded its coverage area with an annual increase of 15% from 2005-2009, the connectivity in rural areas is still low and needs to be improved.
- Social Sector:
  Health - Health situation of the Region in the past five years (2004-2009) shows that most of health indicators have a downward trend based on the 2010 plan target. Actual figures in 2009 and the target of 2010 for key indicators are: (a) crude birth rate per 1,000 population (22.03 in 2009 / 21.17 in 2010), (b) maternal mortality rate per 100,000 live births (94.00 / 57.00) and (c) infant mortality rate per 1,000 live births (7.20 / 7.17).
  Education - Basic literacy rate of the Region has been low and at 93.9% in 2009, it is lower than the national rate (95.9%). The efficiency indicators (repetition rate, dropout rate, completion rate and cohort survival rate) of the Region, all came short of the targets.
  Poverty - The poverty incidence among families in the Region in 2009 (32.8%) is higher than that of the country (20.9%). Among the provinces in the Region, except for Misamis Oriental (26.3%), incidences are higher than that of the Region, Bukidnon (33.0%), Camiguin (36.4%), Lanao del Norte (39.0%) and Misamis Occidental (36.9%).



Source: NEDA Region X (April 2011)

Figure 2.7.1 Administrative Boundary and Population Distribution (2007) of Region X

CHAPTER 3 BASIC SURVEY

3.1 Collection of Necessary Information/Data and Report

Necessary information/data and reports have been collected for the following categories, for which specific collected data are as listed in DATA BOOK.

[1.1] Laws / regulations and organizations related to flood management or watershed / river basin management

[1.2] Policies or development / conservation plans related to flood management or watershed / river basin management

[2.1] General Information /Report/ Data (Technical)

[2.2] General information on meteorological/hydrological conditions

[2.3] Socio-economic data and information

[2.4] Hazard data and information

[3.1] Existing infrastructure

[3.2] Existing flood mitigation measures

[4.1] Flood damage and flood marks

[4.2] Damage situations of infrastructures; i.e. river structures, roads, etc.

[5.1] Related laws / regulations on the environment in the Philippines

[5.2] Environmental status (physical, chemical and biological) in and around the project area

[5.3] Resettlement

[6.1] Government document for construction plan and cost estimation

[6.2] Standard of other related department and/or organization

[6.3] Price Information

[7.1] Maps and survey data

[8.1] Other donors assistances

3.2 Topographic and River Surveys

3.2.1 General of the Survey Works

(1) Survey Objectives and Scope of Works

Topographical and river surveys were conducted respectively to produce grid data showing terrain surface and to draw up river profile and cross section for the river stretch from river mouth to 14 km upstream along the Cagayan de Oro River.

The surveys are composed of the following three(3) works of which 1) and 2) were taken by single LiDAR survey system simultaneously.

1) Airborne LiDAR survey
2) Digital aerial photography and ortho imagery production
3) River profile and cross section survey

(2) Survey area

1) Topographical survey (scale of 1/1,000) : $40km^2$ in the most downstream area
2) Topographical survey (scale of 1/10,000) : 1,500 km^2 of the whole river basin.
3) River survey : River stretch from river mouth to upstream for 14 km.

(3) Work Component of the Surveys

Each survey was conducted with following work components respectively. The additional survey was executed to make up for a malfunction of LiDAR survey system.

1) Airborne LiDAR survey
   - (i) Flight and surveying plan
   - (ii) GPS base station placement
   - (iii) Ground control points placement
   - (iv) Surveying
   - (v) 3D surveyed data, Original data production
   - (vi) Ground data production
   - (vii) Grid data production
   - (viii) Contour data production

   The following works were supplementally conducted
   - (ix) Aerial triangulation
   - (x) Digital mapping

2) Digital aerial photography and ortho imagery production
   - (i) Aerial photography
   - (ii) Ortho imagery production

3) River profile and cross section survey

(i) Bench mark placement
(ii) Vertical reference point Exploration
(iii) River center and profile survey
(iv) River cross section survey
(v) Inspection

(4) Technical Specification of the Work

1) Product specification

(i) Pulse density of Airborne LiDAR survey: more than 1 points into 2m×2m
(ii) Side length of Grid : 2m
(iii) Resolution for Ortho Imagery : 50cm
(iv) Interval of river cross section : every 500m and sections at 5 bridges
(v) Aerial triangulation (supplementary works)
Standard deviation for GCP on : less than 0.5m

2) Technical reference

Standard for Public Survey Works, Notification No.413 of Japan, Ministry of Land, Infrastructure, Transport and Tourism on 31st March, 2008.

3.2.2 Investigation of Mean Sea Level (MSL)

The mean sea level for vertical reference in Cagayan de Oro was investigated in order to settle the vertical origin for the Survey because the height system of projective method in the Philippines adopts MSL (mean sea level) method.

(1) Mean Sea Level at Macabalan Wharf

The Survey Team collected and examined the tidal data as reference sea level of Cagayan de Oro.

1) Collection of tidal data

The tidal data for 51 months between 2007 and 2012 was provided by NAMRIA as shown in Table 3.2.1.

2) Methodology to convert the tidal data into the mean sea level.

It was confirmed that NAMRIA used 'Tidal Analysis and Prediction Software of Flinders University Australia' to derive MSL, which is the same method as employed in Tokyo Bay.

i) Mean level of monthly high tide in every year : $F=\Sigma f / n$
ii) Mean level of monthly low tide in every year : $E=\Sigma e / n$
iii) Mean sea level in every year : $M=F+E / 2$
iv) Mean sea level in whole examination period : $M'=\Sigma M / n$
(f = level of high tide、e = level of low tide、n = frequency)

Table 3.2.1 Tidal Data at Macabalan Wharf

MEAN SEA LEVEL CAGAYAN DE ORO																	
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	FOR YEAR		TOTAL		MONTHS
	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	m.	SUM	MEAN	SUM	MEAN	
2007											2.49	2.43	4.914	2.457	4.914	2.457	2
2008	2.41	2.45	2.51	2.52	2.57	2.54	2.57	2.57	2.58	2.51	2.49	2.48	30.200	2.517	35.114	2.508	14
2009						2.54	2.53	2.53	2.54	2.49	2.41	2.33	17.370	2.481	52.484	2.499	21
2010	2.29	2.28	2.30	2.35	2.43	2.50	2.55	2.57					19.270	2.409	71.754	2.474	29
2011			2.47	2.46	2.50	2.51	2.50	2.51	2.53	2.52	2.50	2.50	24.999	2.500	96.753	2.481	39
2012	2.44	2.49	2.53	2.51	2.55	2.56	2.56	2.54	2.60	2.55	2.46	2.46	30.232	2.519	126.985	2.490	51

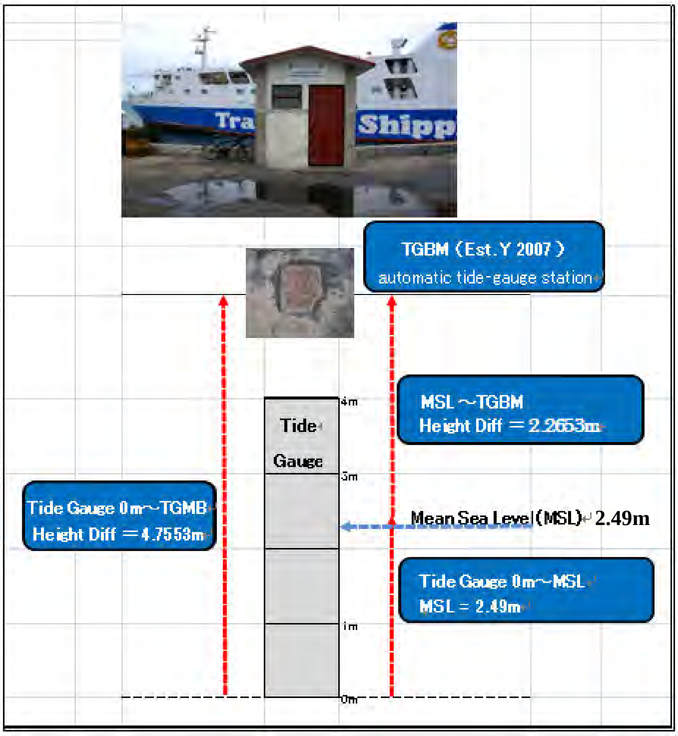
Source: NAMRIA

3) Mean sea level(MSL) at Macabalan Wharf（ref. to Figure 3.2.2）

a) Mean sea level at Macabalan wharf = +2.49m
(height from bottom of tidal gauge to MSL）

b) The height of TGBM = +4.7553m
(height from bottom of tidal gauge to the top of tidal post）

c) The difference of height between MSL and the top of tidal gauge= 2.2653m



Source: JICA Survey Team

Figure 3.2.2 Mean Sea Level at Macabalan Wharf

(2) Inspection for Bench Marks in Cagayan de Oro

1) Survey of bench marks

The inspection survey was conducted on TGBM (reference bench mark) and BM-5 which were used for the topographical survey. Other bench marks named such as MSE-100 and MSE-110 in Cagayan de Oro City also surveyed for reference. The result is presented in Table 3.2.2.

Table 3.2.2 Result of the Inspection Survey on Bench Marks in Cagayan de Oro City

Station Name	Surveyed by NAMRIA Elevation (m) (i)	Surveyed by Survey Team Elevation (m) (ii)	Difference between (i) and (ii) (m) (iii) = (ii) – (i)	Remarks
TGBM(NAMRIA)	2.265	2.265	0.000	(1)
BM 5(NAMRIA)	2.068	2.106	0.038	(1)
MSE 100	4.871	4.728	-0.143	(2)
MSE 110	5.762	5.623	-0.139	(2)

Remarks: (1) Elevation from MSL of Macabalan Wharf of Cagayan de Oro City Tide Gauge Station; Surveyed by the Hydrography Department, NAMRIA
(2) Elevation from MSL of Surigao City Tide Gauge Station; Surveyed by the Mapping and Geodesy Department, NAMRIA

Source: JICA Survey Team

2) Confirmation of reference sea level

The level heights of MSE 100 and MSE 110 as shown in Table 3.2.2 (i) are based on the MSL of Surigao City Tide Gauge Station. On the other hand, TGBM and BM-5 are based on the MSL of Macabalan Wharf of Cagayan de Oro City Tide Gauge Station. The difference of both heights is about 0.14m.

3) Vertical origin for study

According to the inspection conducted by the Survey Team, it is concluded that TGBM is to be used as the vertical origin for the Survey which was revised in 2011. However it is noted that TGBM has existed thereat since before 2011 and the previous height of TGBM (named as TGBM-2007) is different from the current TGBM.

3.2.3 Topographical Survey

Topographical survey consists of the Airborne LiDAR survey and the digital aerial photography. Producing grid data in the project area and taking aerial imagery of real terrain surface are the objectives of the topographical survey.

(1) Scope of Survey

1) Objective area

The Airborne LiDAR survey was conducted to obtain topographic data for the hydraulic analyses. It was implemented to produce: topographic data at a scale of 1/10,000 covering 1,500 km^2 in the Cagayan De Oro River basin; and orthophotomaps at a scale of 1/1,000 covering 40 km^2 from the river mouth of the Cagayan De Oro River extending 14 km upstream along the river.

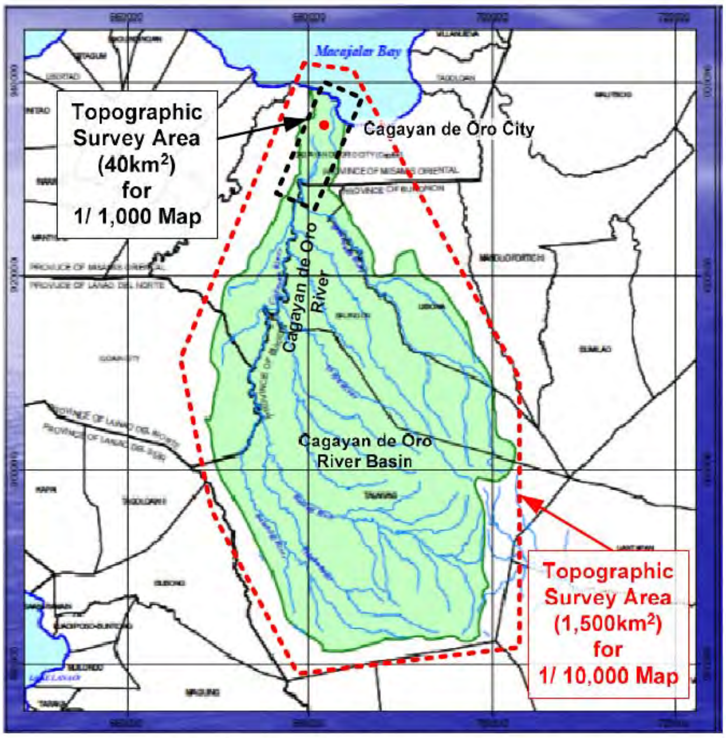
The Airborne LiDAR survey consists of the following works:

(i) Preparation of digital topographic maps at a scale of 1/10,000 with a contour line interval of 2 m. The coverage of the survey is along the Cagayan De Oro River basin and surrounding areas with a total area of about 1,500 km^2.

(ii) Preparation of orthophotomaps at a scale of 1/10,000 with a contour line interval of two (2) m. The areas to be covered are the same as mentioned in (i).

(iii) Preparation of orthophotomaps at a scale of 1/1,000 with a contour line interval of one (1) meter. The area to be cover has a 40 km^2 area from the river mouth of the Cagayan De Oro River extending 14 km upstream along the river.

Figure 3.2.3 shows work area of the survey and the plan for both survey are shown below:



Source: NAMRIA, F/S2011

Figure 3.2.3 Topographic Survey Area（Maps of 1/1,000 and 1/10,000）

2) Topographic map production

(i) Topographic map for scale 1/1,000

The topographic map for scale of 1/1,000 is prepared in ortho-photomap image, which preparation requires contour data and ortho imagery.

(ii) Topographic map for scale 1/10,000

It is necessary for preparation of the topographic map of scale 1/10,000 that topographic objects are digitized from ortho imagery and combined with contour lines from the LiDAR data in area of 1,500 km^2. A field ground survey has been conducted during the additional GCP survey to obtain necessary information to be included in the topographical map.

(iii) Contour lines for 1/10,000

Contour lines for topographic map of 1/10,000 were produced from ground data through TIN data (triangulated irregular network).

(2) Final Products

1) Original data and ground data

The ground data were attained in conformity with the standard through filtering procedure of the original data as shown below:

(i) Area for scale 1/1,000

		Plan	Actual
Survey Area	:	40.0km^2	40.0km^2
Points Density	:	1.7 points / m^2	2.6 points / m^2

(ii) Area for scale 1/10,000

		Plan	Actual
Survey Area	:	1,500 km^2	1,500 km^2
Points Density	:	0.4 points / m^2	0.6 points / m^2

2) Grid data

Grid data formed of 2m x 2m mesh were produced from the ground data. Production was made by applying interpolation incorporating terrain variation.

3) Ortho imagery

Complete ortho imageries for whole 1,500km^2 area have been secured in the survey period.

4) Topographic map

Topographic map is produced with map digitizing method following Standard for survey works.

- Planimetric features are digitized provided that the said feature is more than 1mm on orthophoto images which is equivalent to 1m on 1/1,000 map and 10m on 1/10,000 map respectively.
- Field survey was not carried out aiming at correction of planimetric features.
- Polygon shape is formed so as to pick up planimetric features in flood analysis.

The rule of data acquisition is as follows:

Table 3.2.5 Data Acquisition Rule for Planimetric Features

	Digitized	Not Digitized
Acquisition	・Objects seen on the ortho images ・Famous public facilities	・Objects to be found by field survey ・Administrative boundary such as Barangay boundary
1/1,000	Road, Stairs, Road divider, House, Building, Park, Sports Ground, Pool, River, Pond, Dam, Reservoir, Pier, Breakwater, Contour, Vegetation,	Road type, Road facilities (Traffic sign, Pole), Gate, Statue, Electric Line, River type, Wave dissipating, Covering, Land usage, Side slope
1/10,000	Road, House, Park, Sports Ground, Pool, River, Pond, Dam, Reservoir, Breakwater, Contour, Vegetation, Pier,	Stairs, Road divider, House type,
Note	Polygon shape for town block, park	House boundary, Margin design

Source: JICA Survey Team

5) Orthophoto map

Images of orthophoto maps containing the data to be acquired shown in Table 3.2.5 are presented in Figure 3.2.9.

1/10,000Map

1/1,000Map

Source : JICA Survey Team

Figure 3.2.4 Image of Orthophoto Map

3.2.4 River Survey

The objective of the River Survey is to obtain the river profile and cross section data to be used in the hydraulic analysis and structure design.

(1) Work Plan and Output

The projection for river survey is as follows:

Plane coordinates : PTM (Philippines Transverse Mercator)
Elevation coordinates : MSL (Mean Sea Level)

The output of the river survey was made with the said projection which is different from that for the topographical survey. Data adjustment in terms of data conversion is necessary when using both outputs together.

River survey was conducted with the following condition:

(i) River profile survey : 12 km

(ii) River cross section survey : 38 lines (Average length of lines; 400 m)

(iii) Bench marks for cross section : 500 m interval, 76 points on both banks

(2) Final Output of River Survey

1) River cross section survey

The location of river cross section is shown in Figure 3.2.10 in.

Digital data of river cross section including location map

River cross section maps

Scale of cross section：horizontal＝1/500、vertical＝1/500

2) River profile survey

The river profile map is attached in Appendix A.

Digital data of profile

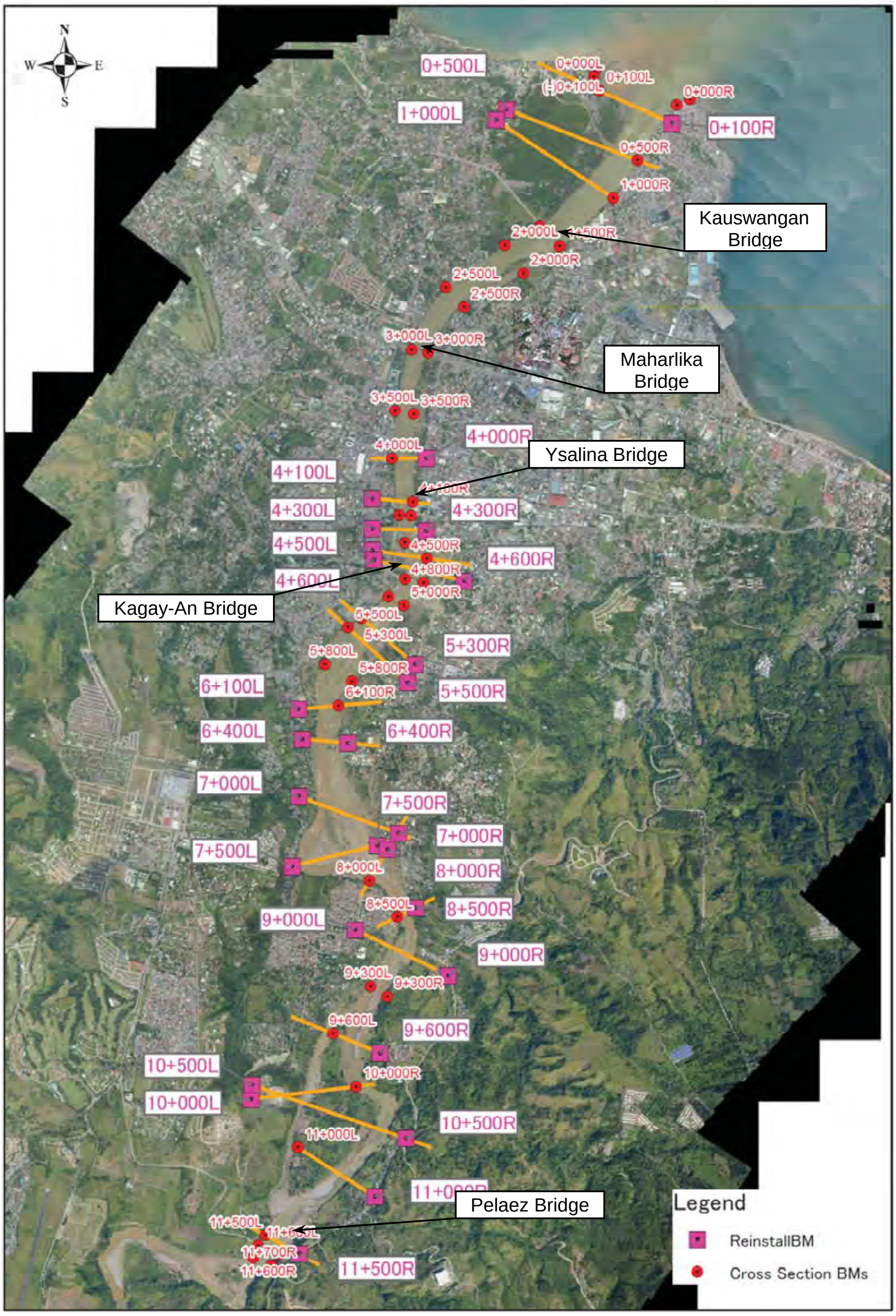
River profile maps

Scale of profile：Horizontal＝1/10,000、Vertical＝1/500

3) Bench mark (see Appendix A)

Digital data for 500 posts and its number

List of 500m posts and its number



Source : JICA Survey Team

Figure 3.2.5 Location of River Cross Section（Dec. 2012）

3.2.5 Additional River Survey and Topographic Survey in the Feasibility Study Stage

(1) General

Additional river survey and topographic survey works were conducted in July and August 2013 to provide data and information required for the Feasibility design. Additional survey was composed of the followings works:

a) Establishment of horizontal and vertical controls

b) River profile/Cross-section survey, and

c) Topographic survey and mapping

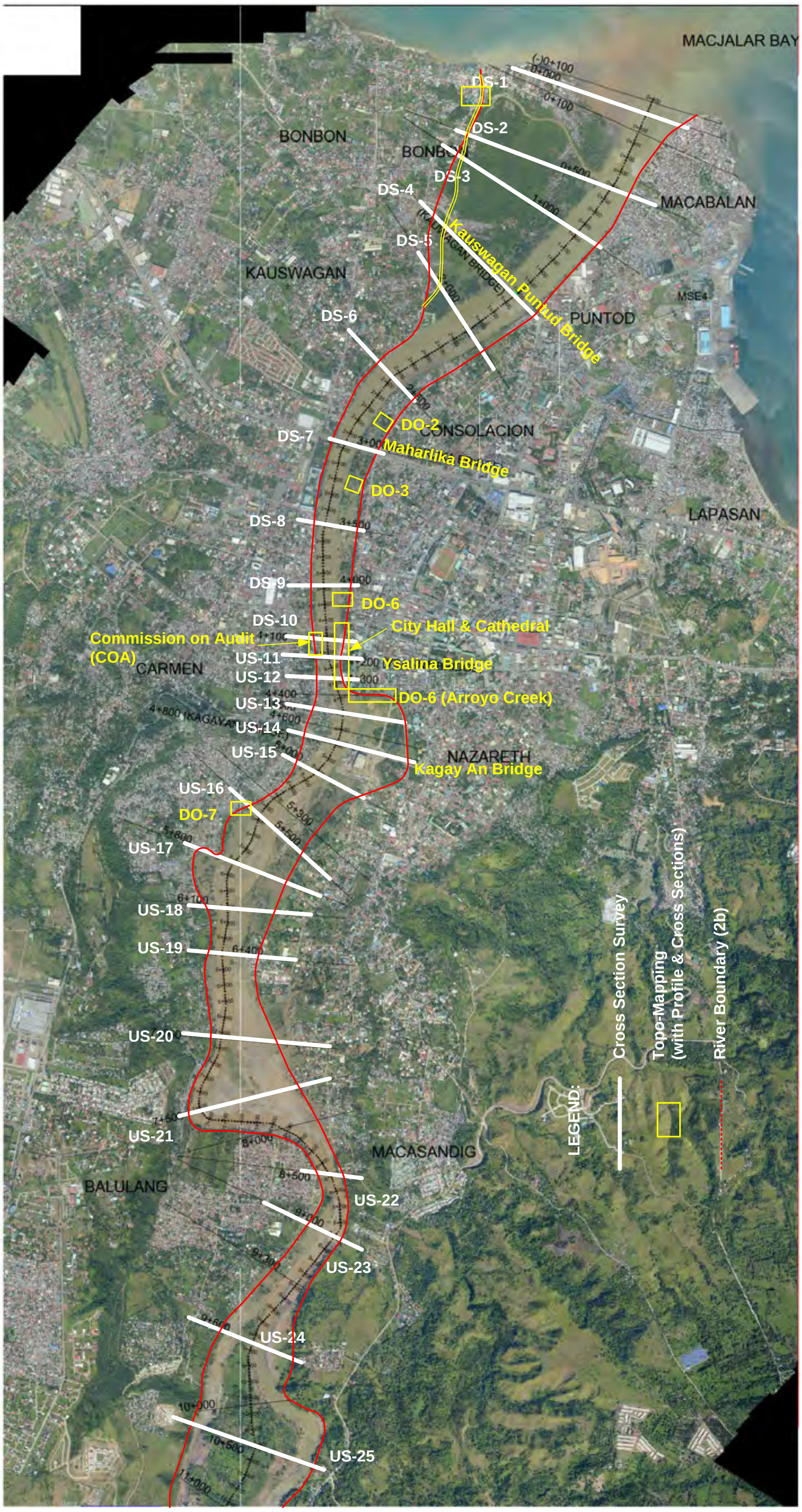
(2) Scope of Works

Locations of the topographic survey, structural profile and river cross section surveys were determined based on the locations of the proposed river structures for the Feasibility Study as shown in Table 3.2.6. Location for the river survey works is shown in Figure 3.2.6.

Table 3.2.6 Scope of Survey Works

	Work Item	Work Quantities	Note
1.	Reference Control Points		
1.1	GPS positioning	4 nos.	
1.2	Leveling with Benchmark Installation	13.5 km	
2.	Profile and Cross-section Survey		
2.1	Drainage Outlets/Creeks (5 sites)		
	Profile of Drainage Outlet/Creek	5 profiles	Total L. = 335 m
	Cross-section of Drainage Outlet/Creek	10 sections	Total L. = 20 m
2.2	Cross-Sections of Road Dike	5 Sections	Total L. = 30 m
2.3	Proposed Culverts for Road Raising (1 Location)	3 Sections	Total L. = 50 m
2.4	River Cross-section Survey, (land based)	24 Sections	Total L. = 13,500 m
2.5	River Cross-section Survey (hydrographic)	24 Sections	Total L. = 5,100 m
3.	Topographic Mapping		4.02 ha in total
	Proposed Drainage Outlets/Creeks	0.20 ha	(4 sites)
	Proposed Culvert Sites	0.35 ha	(1 site)
	Proposed Floodwall (City Hall & Cathedral)	2.40 ha	
	Proposed Floodwall (COA)	0.64 ha	
	Arroyo Creek	0.43 ha	
4.	Relocation Survey for Geotechnical Investigation Sites	15 points	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.2.6 Location of Additional River Survey Work Sites

(3) Results of Survey Works

1) Cross-Section Survey

All cross-section stations were established based on the BMs established in MP stage and nearest traverse station and leveling authorized by NAMRIA. River cross sections are compiled in Data Book.

2) Topographic Survey

The topographic survey was carried out making use of the established horizontal control (primary or secondary) in order to record the salient features such as:

a. Existing river banks, Existing spoil sites and fishponds, Tributaries, Water course, Houses/Buildings, Bridge, Approaches and roads , Existing drainage outlet structures, and

b. Location of boreholes and test pits for geological investigation.

Topographic survey results and data concerned are compiled in Data Book.

3.3 Geotechnical Investigations

3.3.1 General

The geotechnical investigations were conducted for the purposes of i) to examine type of structure and design dimension of river structures such as dike or revetment and ii) to know river degradation features for preparation of basic designs of structural measures.

Existing geological data/information were also collected from DPWH, Regional Office-10 and the Government of Cagayan de Oro City (City Engineer's Office). The geological surveys were carried out at the existing bridges and proposed revetment sites along the Cagayan de Oro River.

3.3.2 Geotechnical Investigation in Master Plan Stage

(1) Boring Survey

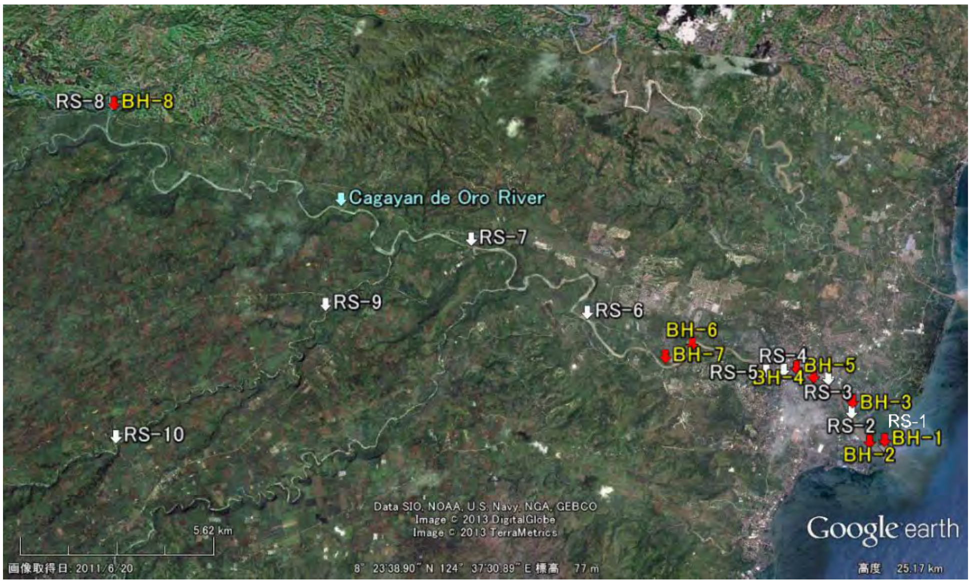
The boring survey was conducted at the 8 sites as shown in Figure 3.3.1 containing the following works:

1) Borehole Drilling,
2) Soil Sampling from Borehole,
3) In-Situ Test, and
4) Laboratory Tests.

(2) Riverbed Material Survey

The riverbed material survey was conducted at 10 sites as presented in Figure 3.3.1 to be used for obtaining parameter of riverbed fluctuation analysis as follows:

1) Riverbed material sampling
2) Grain size distribution analysis by sieve; and
3) Specific gravity test.



Source: JICA Survey Team

Figure 3.3.1 General Location Map of Geotechnical Investigations

(3) Results of Geotechnical Investigations

1) Results of Boring Survey

<u>Location of Boring Survey</u>

Boring survey was conducted to obtain geological information introduced from in-situ and laboratory tests such as standard penetration test (SPT for N-value) and grain size analysis in order to design structural measures and its foundation improvement works. Boring surveys were conducted at eight (8) locations (BH- 1 to 8). These seven (7) drilling points were set in flood inundation areas where are downstream of Cala-Cala and Macasandig of Cagayan de Oro City as shown in Figure 3.3.2. Drilling hole of BH-8 was conducted about 30 km upstream site from the estuary of the Cagayan de Oro River to examine the foundation of dam facilities.

Source: JICA Survey Team

Figure 3.3.2 Location Map of Geological Investigation and Existing Data/Information

<u>Results of Standard Penetration Test (SPT)</u>

N-value (results of SPT) and the geological formation are shown in Figure 3.3.3. According to the Figure, the geological formations in the project site are classified into two zones which consist of mainly gravels and sand and clay respectively. The zone consists of mainly gravels is observed from 0m to 10m depth, on the other hand the zone consists of sand and clay can be observed in deeper zone than 5m depth of a boring hole at left bank of the river mouth, BH-1.

Depth (m)	BH-1	BH-2	BH-3	BH-4	BH-5	BH-6	BH-7	BH-8
	30	10	10	10	10	10	2.61	10
5.0	Fine-medium sand with fine gravel Gray N : 10 (4.55-5.0)	Silty Sand Gray N : 4 (5.0-5.45)	Sand and Gravel Gray N : 5 (4.55-5.0)	Silty Sand Dark gray N : 4 (5.0-5.45)	Fine-medium Sand with silt Gray N : 7 (5.0-5.45)	Clayey Silt Gray N : 8 (4.55-5.0)	Gravel Gray N > 50 (2.5-2.61)	Boulder (basaltic andesite) Gray
10.0	Sandy Silt Dark brown N : 8 (10.0-10.45)	Clayey Silt with sand Gray N : 4 (9.55-10.0)	Gravel with sand Gray N : 7 (9.55-10.0)	Sandy Gravel Dark gray N : 13 (9.55-10.0)	Gravel with sand Gray N : 20 (9.55-10.0)			Boulder (basaltic andesite) Gray
12.5	Silty Sand Dark gray N : 9 (12.0-12.45)							
15.0	Sand and Silt Gray N : 9 (14.55-15.0)							
17.5	Sandy Silt Gray N : 11 (17.05-17.5)							
20.0	Silt with Sand Glayish brown N : 12 (20.0-20.45)							
22.5	Clayey Silt Gray N : 6 (22.05-22.5)							
25.0	Clayey Silt Gray N : 11 (25.0-25.45)							
27.5	Clayey Silt Gray N : 9 (27.05-27.5)							
30.0	Clayey Silt Gray N : 11 (29.55-30.0)							

Legend

Clayey Silt	Sandy Silt Silt with Sand	Silty Sand Sand with silt Sand and Silt	with fine gravel Sand and Gravel	Gravel Sandy Gravel Gravel with sand	Boulder

(mm)

Clay	Silt	Sand			Gravel			Cobble
		Fine	Middle	Coarse	Fine	Middle	Coarse	
< 0.005	0.005 - 0.075	0.075 - 0.25	0.25 - 0.85	0.85 - 2	2 - 4.75	4.75 - 19	19 - 75	> 75

Source: JICA Survey Team

Figure 3.3.3 Result of Geology Investigation

(Geology and Standard Penetration Test)

Grain Size Analysis and Specific gravity

The grain size analysis, the measurement of specific gravity and the compressive strength test were conducted on the soil samples from the boreholes. Grain size distribution curve of BH-1 (0-30m) is shown in Appendix-B Figure 1.4.6. Difference of grain size at this hole is clearly shown in which there are two type of materials divided at 5 m depth underneath.

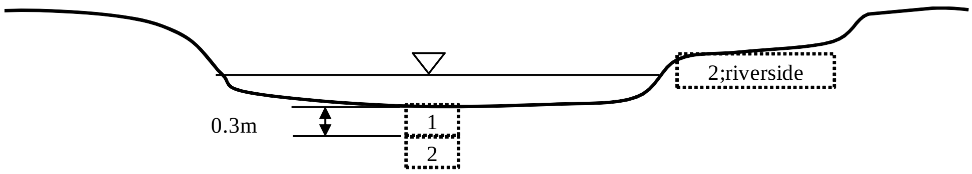
Average grain size (D_{50}) of materials which were taken from 5 m to 10 m depth underneath is shown in Appendix-B Figure 1.4.9. As shown in the figure, grain sizes are classified into sand group and gravel group. This difference is considered to be shown the difference of the tractive force at the sampling point.

The specific gravity is measured to be 2.78 from laboratory test results.

2) Results of Riverbed Material Survey

Location of Riverbed Material survey

The riverbed material investigations were conducted at ten (10) sites. Five (5) sites of these were set in the flood area between the Ysalina Bridge and the river mouth as shown in Figure 3.3.1. The riverbed material to be represented at each site was basically sampled at two points from three site within riverbed area; i) riverbed surface within 0.3m underneath at river flow area (Site-1), ii) 0.3-0.6m underneath at river flow area (Site-2) and iii) riverbank at edge of river flow (Site-2; riverside) as shown in Figure 3.3.4.



Source: JICA Survey Team

Figure 3.3.4 Sampling Point

Grain Size Analysis and Specific Gravity

Grain size distribution curve of all samples from Site-1 is shown in Appendix-B Figure 1.4.3. According to this result, the characteristic tendency is not found. But, the distribution is classified into the group (RS-1, 1', 1", 2, 3, 4, 6, 8, and 9) composed of almost sand and the group (RS-5, 7, and 10) composed of gravel. Almost samples consist of sand and gravel except RS-1 and RS-1'. RS-1, RS-1'and RS-1" are samples taken around the estuary. RS-1" located at the farthest point from the center of riverbed consists of mainly sand without clay and silt. It is supposed that this area is affected by river and tidal flows.

Grain size distribution curve of all samples from Site-2 is shown in Appendix-B Figure 1.4.4. According to this result, RS-6 and RS-7 have a little high percentage of silt and clay. RS-5 and RS-10 have a little high percentage of gravel.

The Specific gravity is calculated to be 2.77 in average.

3.3.3 Additional Geotechnical Investigations in Feasibility Study Stage

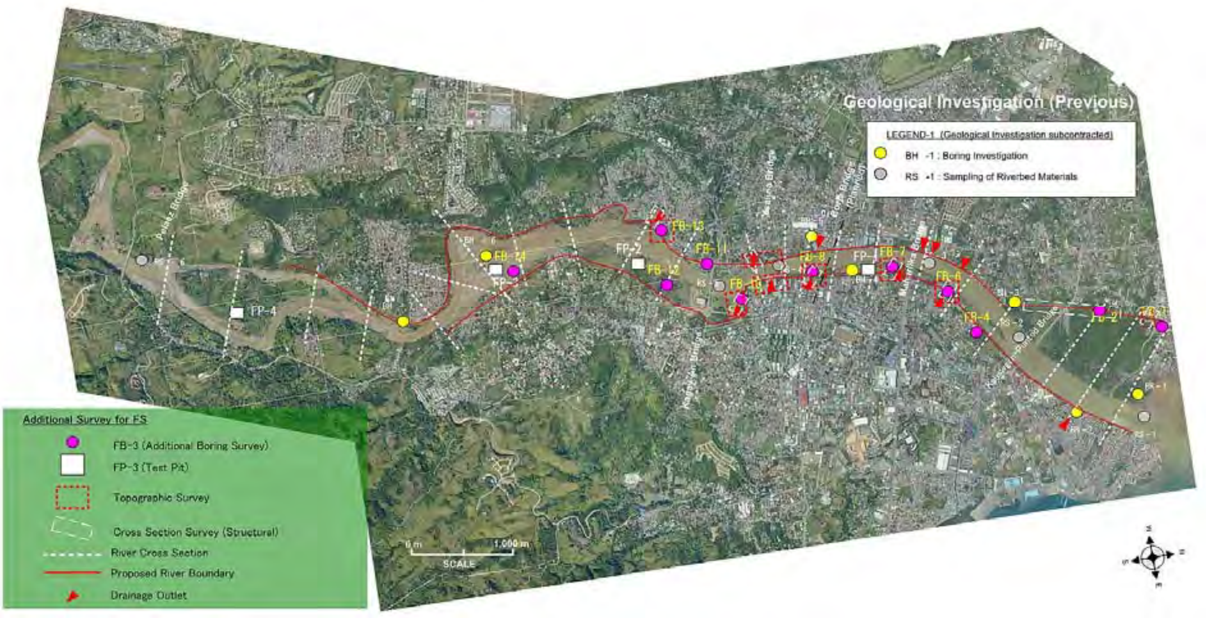
(1) Purpose of the Additional Investigation Works

Geotechnical investigation works were conducted to obtain required additional geological information for design of structural measures in the Feasibility Study Stage.

(2) Scope of Works

1) Location of Investigation Work

The borehole and test pit locations for the additional geotechnical investigation works were selected from the proposed structural measures in the JICA Master Plan. Location of the additional geotechnical investigation works is shown in Figure 3.3.5



Source: JICA Survey Team

Figure 3.3.5 Location Map of Additional Investigation Work

2) Quantity of Additional Investigations

Quantities of the additional works are summarized in Table 3.3.1.

Table 3.3.1 Quantities of Additional Investigations

Item	Quantity
Mobilization /Demobilization	11 Locations
Borehole Drilling (Rotary) and Standard Penetration Test (SPT)	11 Holes Total Depth = 250 m.
Test Pits	4 Locations
Material Sampling for Laboratory Test : Disturbed Soil Sampling - Boreholes - Test Pits - Laboratory Tests Undisturbed Soil Sampling - Boreholes - Laboratory Test	 100 Samples 4 Samples 104 Nos. 25 Samples 11 Nos. 25 Nos.
In-Situ Test	250 Nos.
Reporting	3 Sets

Source: JICA Survey Team

3) Technical Standards

American Society for Testing and Materials (ASTM) is basically applied for the following works as technical standards and criteria under the contract

a) Borehole Drilling,

b) Soil Sampling from Borehole,

c) In-Situ Test, and

d) Laboratory Tests.

(3) Results of the Additional Investigation

1) Location of Boreholes and Test Pits

The investigation works is undertaken for 11 Boreholes and 4 Test Pits sites. Locations and depths of boreholes / test pits are described in Appendix B.

2) SPT Results from Boreholes

Summary of in-situ and SPT results from boreholes are show in Figure 2.3.1 of Appendix B.

3) Findings and Recommendations

Regarding to consistent with the general geology of the CDOR, it is found that thick beds of alluvial deposit reach to 30m to 40m depth at least.

From results of the geotechnical investigation, liquefaction and settlement are probably exist in the project site as the most serious soil issues for the design of flood control structures These outstanding matters will be examined on Appendix B including of preliminary design of weak foundation improvement works.

3.4 Rainfall and Runoff Analyses

3.4.1 General

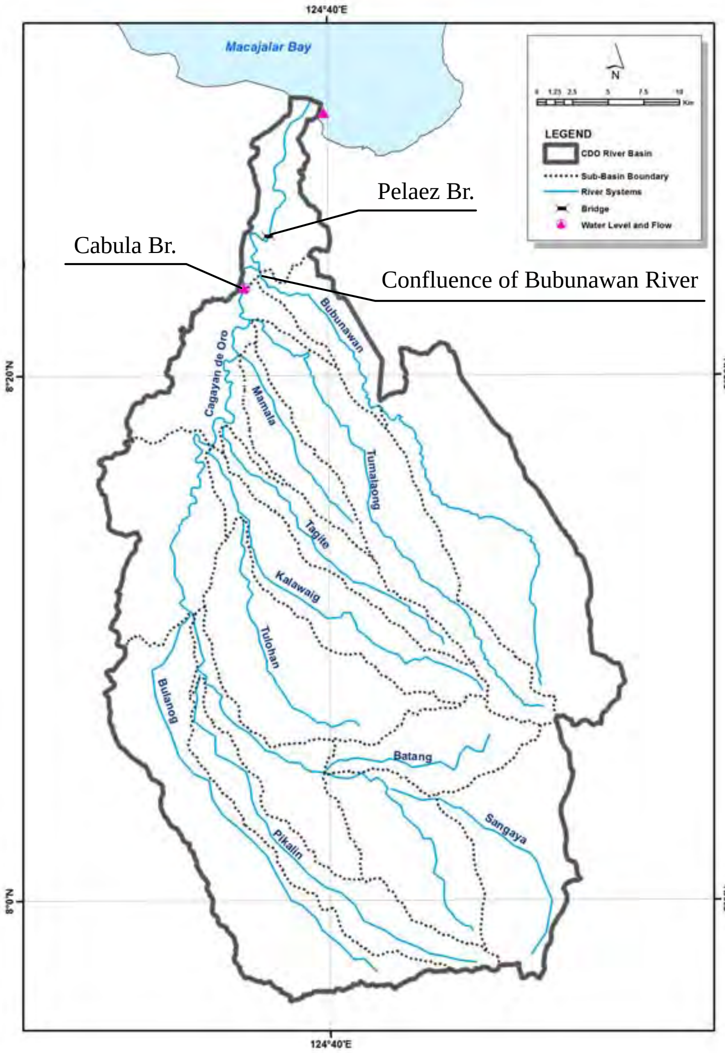
(1) Objective Area

Objective area of the rainfall and runoff analyses is the whole Cagayan de Oro (CDO) River Basin located in northern Mindanao Island including the periphery of the basin where related hydrological information is available.

The basin is bounded on the south by the Kalatungan Mountains, on the east by the Katanglad Mountains and on the west by an unidentified mountain range.

(2) River Network, Flood Plain and Catchment Area

The Cagayan de Oro River has its headwaters in the Kalatungan Mountain Range found in the central part of the province of Bukidnon. It traverses the Municipalities of Talakag, Baungon and Libona, picking up tributaries along the way in a generally northerly direction towards the city of Cagayan de Oro passing a flood plain section of the river before it finally empties into the Macajalar Bay.



Source: JICA Survey Team

Figure 3.4.1 Cagayan de Oro River Basin

Cagayan de Oro River has a catchment area of approximately 1,364 km^2 where the major part is located in the Province of Bukidnon and the rest is within the Province of Misamis Oriental. The Cagayan de Oro River, as main stream, forms the Cagayan de Oro River Basin with eight (8) major tributaries, namely; Batang, Bubunawan, Bulanog, Kalawig, Picalin, Tagait, Tumalaong Rivers, and Lapinigan Creek, Cagayan de Oro River Basin as shown in Figure 3.4.1.

(3) Analyses

The rainfall and runoff analyses are undertaken for a whole CDO River basin. In particular, the rainfall analysis is targeting at the whole basin, while the runoff analysis is made so as to obtain the discharge hydrograph at the Pelaez Bridge point which is about 12.0 km upstream from the river mouth as shown in Figure 3.4.1.

The discharge hydrograph at the Pelaez Bridge is to be given as an upstream boundary condition for the flood inundation analysis with unsteady flow as well as the riverbed fluctuation analysis which is discussed in Section 3.5.

3.4.2 Hydro-meteorological Data

(1) Rainfall

There are 73 rainfall stations in and around the CDO River basin of which data are available for the analysis in this Survey including those under Del Monte Philippine Inc, PAGASA Synoptic stations, Department of Agriculture(DA) Agromet stations, DA-Municipal Agriculture Office (MAO) in LGUs., DA-BSWM and PALASAT (private firm) as shown in Table 3.4.1. Most stations contain daily rainfall data and hourly data are available at only a few stations for the short recent period as shown in Table 2.1.2 in Chapter 2 of Appendix C.

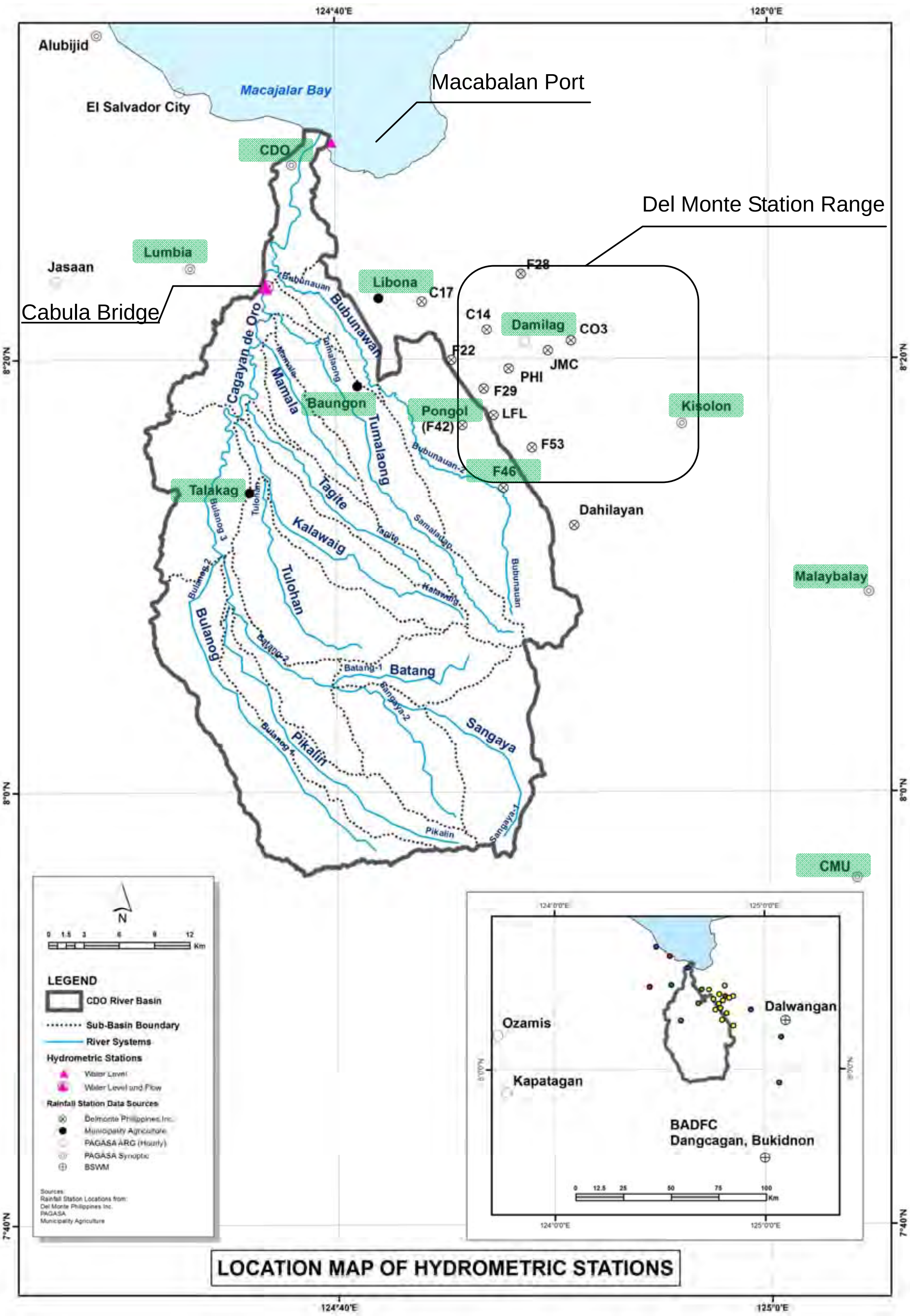
Table 3.4.1 Rainfall Data and Availability

Type of Data	Data Source	Nos. Of Station	Availability during TS Sendong
Daily Rainfall	PAGASA Synoptic Station	9(*1)	3
	Del Monte Station	45	34 (*2)
	DA Agromet station	2	1 (*2)
	DA-BSWM	1	- (*2)
	DA-MAO	3	2 (*2)
	Sub Total	60	40 (*2)
6-hour Rainfall	PAGASA Synoptic Station	(4) (*1)	3
	PAGASA Synoptic Station	2	-
	Sub Total	**(4)+2**	**3**
Hourly Rainfall	PAGASA ARG Station(*3)	9	9
	PALASAT Digital Station	2	1
	Sub Total	11	10
	Grand Total	73	53

Note: (*1) 6-hour rainfall records are available at four(4) PAGASA synoptic stations except El Salvador and Hinatuan stations out of the nine(9) where daily rainfall record are available.
(*2) Number of stations where complete daily rainfall data are available in 2012.
(*3) PAGASA Automatic Rainfall Gauge(ARG) Station

Source: JICA Survey Team

Locations of those available stations are presented in Figure 3.4.2. Data available period of the respective stations are shown in Table 2.1.2 as well as Figures 2.1.2 and 2.1.3 in Chapter 2 of Appendix C, respectively, together with the inventory of the stations.



Source: JICA Survey Team

Figure 3.4.2 Location Map of Hydrometric Stations

Note : Most of the observation stations, excluding those far from the CDO River basin, are shown in the figure above including all stations selected for further analysis. However, many observation stations operated by the Del Monte Philippines are concentrated in a limited area, only representing stations are shown above.

Stations with hatching show the selected rainfall stations as listed in Table 3.4.2.

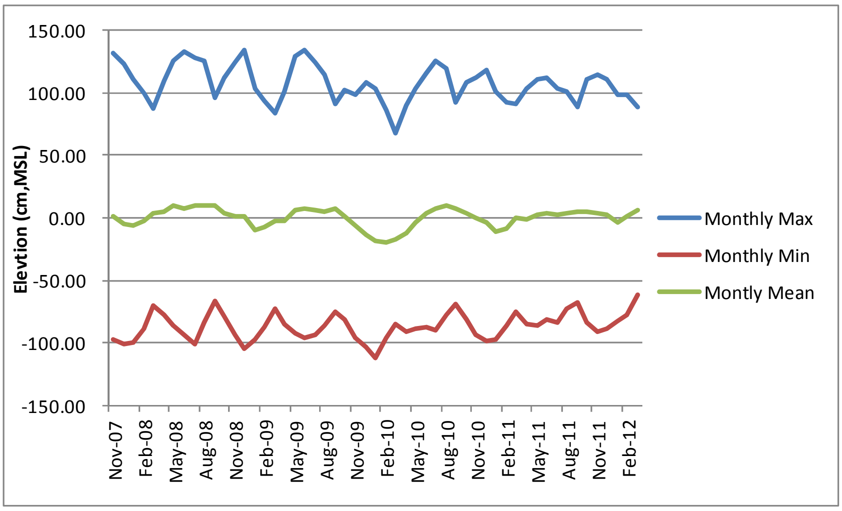
(2) Water Level and Discharge

1) Water Level Observation

There is only one regular water level and flow observation station maintained by DPWH located at the Cabula Bridge(C.A.=1,094km^2) in the CDO River. The water level and discharge data for the period from 1991 to October 2012 have been collected from the DPWH Region-10 office in the Cagayan de Oro City.

Tidal water levels of the Macajalar Bay at the CDO Port have been collected from NAMRIA. The inventory of water level and discharge gauging stations is shown in Table 2.1.2 in Chapter 2 of Appendix C.

Tidal water level for the CDO port is vertically referenced to the mean sea level as mentioned NAMRIA data sheet shown in Figure 3.4.3.

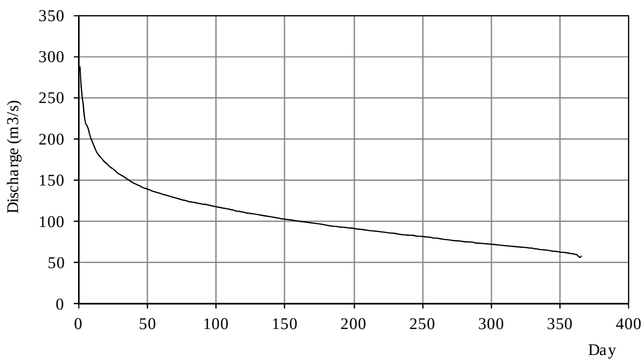


Source: NAMRIA

Figure 3.4.3 Tide Level at Macabalan Port (2007-2011)

2) Discharge-Duration Curve

Discharge-Duration Curve is shown in Figure 3.4.4. This curve was prepared based on the observed daily discharge record at the Cabula Bridge compiled in "Stream Flow Data", Cagayan River Stream Gauging Station (2011) prepared by Materials Quality Control & Hydrology Division, DPWH Region-10, recording daily water level from 1991 to 2011. This record is shown in DATA BOOK.



Source: JICA Survey Team

Figure 3.4.4 Discharge-Duration Curve (21years; 1991-2011)

(3) River Survey

The longitudinal and cross section survey of the CDO River have been conducted under this Survey for FRIMP-CDOR as described in previous section 3.2. The survey has been conducted for about 12.0 km along the river stretch between the river mouth up to the location near Pelaez Bridge as shown in Figure 3.4.5. The total number of sections is 38 including five bridge locations which are shown in Figure 3.4.5.

National Mapping and Resource Information Authority (NAMRIA) control points having Philippine Transeverse Mercator (PTM) projection coordinated were used as horizontal reference. The NAMRIA's benchmarks taken from the mean sea level (MSL) of the Philippines served as its vertical reference.

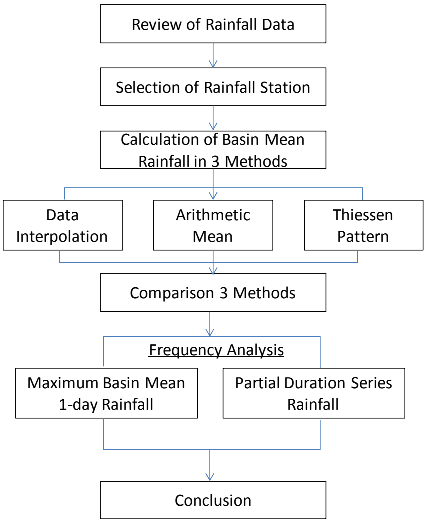
Source : JICA Survey Team

Figure 3.4.5 Locations of the Bridges

3.4.3 Rainfall Analysis

(1) Approach and Methodology of Rainfall Analysis

The study includes data collection, analyzing and checking of data, and analysis for rainfall. Figure 3.4.6 outlines the overall flow of rainfall analysis.



Source: JICA Survey Team

Figure 3.4.6 Flow of Rainfall Analysis

(2) Selection of Rainfall Station

Among 60 stations where daily rainfall record is available as shown in Table 3.4.1, there are 45 Del Monte stations in addition to the other 15 stations.

1) Selection out of Del Monte Stations

Observation at some of Del Monte stations were commenced from the middle of year 1992. Screening was made to select representative stations out of 45 Del Monte stations through the following manner:

	Selection	Stations Remained
(i)	Stations which has complete 20 year record (1993 through 2012) and location is definite	10 stations+F46(*1)
(ii)	Reliability check of record by Double Mass Curve(DMC) method(*2)	6 stations (*3) including F46(*1)
(iii)	Station(s) which location has an advantage to be a representing station in a Thiessen Polygon for estimate of basin mean rainfall among the selected stations through screening (i) and (ii)	PON(F42), F46(*1)

Notes (*1): F46 has a data available period of eight(8) yeas only(2005 – 2012), however F46 is remained due to remarkable record of 475 mm/day on December16, 2011 during TS. Sendong.

(*2): DMC sheets for combinations of all stations are compiled in DATA BOOK.

(*3): PON, LFL, PHI, F75, F86 and F46

2) Other Stations

Out of 15 stations, the following six (6) stations were discarded; three (3) stations due to distant locations from the CDO River basin(more than 50 km from the edge of the basin boundary; Butuan, Dangcagan, Kapatan) ; no exact information of location (Calaveria) and no correlation with other stations(Alubujid as seen in DATA BOOK). In addition, location of Dalwangan Station has a disadvantage not to be a representing station in any Thiessen pattern due to other adjacent stations. Thus 9 stations (No.1 to No.9 in Table 3.4.2) were evaluated as the representing stations.

3) Stations to be Used and Analysis Period

The rainfall stations selected through 1) and 2) described above are summarized in Table 3.4.2.

Table 3.4.2 Selected Stations

No.	Station	Elevation (El., m)	Available Data (Years)	Source
1	Baungon	404	’05-’11 (7)	MAO(*2)
2	Cagayan de Oro	6	’50-’09 (60)	PAGASA
3	CMU	412	’80-’12 (33)	PAGASA
4	Kisolon	675	’80-’06 (27)	PAGASA
5	Libona	309	’06-‘12(7)	MAO(*2)
6	Lumbia	182	’76-‘12(37)	PAGASA
7	Malaybalay	603	’49-‘12(64)	PAGASA
8	Talakag	404	’06-’12 (7)	MAO(*2)
9	Damilag(*1)	591	’67-’84 (18)	PAGASA
10	PON(F42),	706	’92-‘12(21)	Del Monte
11	F46	736	’’04-‘12(9)	Del Monte

Notes (*1) : Damilag station has daily record for four years only during 1972 to 1975 which period is out of the analysis period. Hourly rainfall record is available during TS. Sendong which is used for determination of storm hyetgraph during TS. Sendong.

(*2) : Manicipality Agriculture Office

(3) Basin Average Daily Rainfall

1) Basin Mean 1-day Rainfall

In order to obtain the basin mean 1-day rainfall, the following three(3) methods are adopted in consideration of the constraints comprising i) most of available stations are located in or around north and east parts of the CDO River basin and only a few stations locates inside the river basin, ii) available data period of those stations are incoherent and iii) even station where long-term period of data are available, no continuous availability can be expected due to short and/or long period of no observation.

(i) Average of daily rainfall data at the selected stations with data interpolation by applying Thiessen method (one Thiessen pattern throughout 33 years)

(ii) Arithmetic mean of observed data at the stations available

(iii) Average daily rainfall data at the stations available on the day of basin mean 1-day maximum rainfall by applying Thiessen method by the year

Out of three (3) methods to estimate a maximum basin mean daily rainfall, the method of applying Thiessen pattern by the year as described in the following sub-section 2) is assessed as the most appropriate method. Details of the evaluation procedure are to be referred to Subsection 3.3 in Appendix C.

2) Mean of Records at Stations by Applying Thiessen Pattern by the Year

The annual maximum basin mean rainfall is estimated through the way that Thiessen polygon is prepared every year by using rainfall stations available, among 11 stations listed in Table 3.4.2, on the day when annual maximum occurred.

Consequently, this method needed 12 Thiessen patterns to meet required combination in 33 years. Those Thiessen pattern are shown in Appendix C-4 and Thiessen coefficient are respectively shown in Table 3.3.6 in Chapter 3 of Appendix C.

The annual maximum basin mean rainfall is estimated according to the said 12 Thiessen patterns applicable for the respective year as shown in Table 3.4.3

Table 3.4.3 Annual Maximum Basin Mean 1-day Rainfall by Applying Thiessen Pattern by the Year

Occurrence Date of Annual Max.	Annual Max. 1-day Rainfall (mm)	Thiessen Pattern	Nos. of Stations used for Calculation
20/10/1980	51.7	t-1	5
24/01/1981	53.3	t-2	4
19/03/1982	90.9	t-3	3
25/06/1983	60.3	t-3	3
01/09/1984	52.5	t-4	4
04/01/1985	70.2	t-4	4
19/09/1986	46.1	t-5	4
24/08/1987	51.0	t-4	4
23/10/1988	65.4	t-4	4
17/07/1989	70.5	t-4	4
12/11/1990	121.4	t-4	4
24/04/1991	108.4	t-5	4
28/07/1992	60.6	t-5	4
26/12/1993	77.4	t-6	4
13/06/1994	75.5	t-6	4
27/12/1995	107.5	t-6	4

Occurrence Date of Annual Max.	Annual Max. 1-day Rainfall (mm)	Used T-sen Pattern	Nos. of Stations used for Calculation
03/06/1996	100.2	t-6	4
13/04/1997	98.5	t-6	4
09/11/1998	106.9	t-6	4
22/12/1999	104.6	t-7	3
05/06/2000	111.5	t-6	4
21/11/2001	95.2	t-6	4
19/06/2002	96.7	t-6	4
06/07/2003	95.9	t-6	4
01/06/2004	85.7	t-6	4
13/06/2005	63.4	t-8	6
01/06/2006	59.6	t-9	8
26/06/2007	68.3	t-9	8
20/08/2008	109.1	t-8	6
24/11/2009	145.8	t-11	7
06/07/2010	124.2	t-12	6
16/12/2011	187.2	t-12	6
04/12/2012	111.7	t-12	6

Source: JICA Survey Team

According to the series of annual maximum basin mean 1-day rainfall estimated by this method, it shows no contradiction to the actual rainfall record that daily amount in 2011 occurred on the TS. Sendong day is the highest in the past 33 years.

3.4.4 Probable Rainfall

Using method of Thiessen pattern by year, (i)-annual maximum basin mean 1-day rainfall analysis and (ii)-partial duration series of basin mean 1-day rainfall analysis are conducted for probability calculation.

Through the various comparisons, finally from a point of view of SLSC, the partial duration series analysis is better fitted than annual maximum series. Therefore, the partial duration series is adopted.

(1) Partial Duration Series of Basin Mean 1-day Rainfall

Through 32years from 1980 to 2012 exclusive of 2003 because of inconsistency in terms of the order of water level and annual maximum rainfall, top 100 and over 50mm 1-day rainfall are obtained and shown in Table 3.4.4.

Table3.4.4 Partial Duration Series Basin Mean 1-day Rainfall

Date/Year	1-day (mm)	Date/Year	1-day (mm)	Date/Year	1-day (mm)	Date/Year	1-day (mm)
01/29/1982	60.8	06/03/1996	100.2	04/23/2000	69.6	12/06/2008	86.7
01/30/1982	73.6	06/11/1996	70.3	06/05/2000	111.5	01/02/2009	106.0
03/19/1982	90.9	08/29/1996	89.6	06/20/2000	81.6	04/17/2009	60.9
10/03/1982	62.4	09/30/1996	78.8	07/24/2000	63.5	08/27/2009	69.1
01/04/1985	70.2	10/07/1996	60.7	11/13/2000	67.6	11/24/2009	145.8
10/23/1988	65.4	11/24/1996	61.2	11/30/2000	65.0	06/12/2010	72.3
07/17/1989	70.5	04/13/1997	98.5	12/08/2000	64.3	06/21/2010	75.9
11/07/1990	62.0	10/31/1997	92.4	03/27/2001	63.3	07/06/2010	124.2
11/12/1990	121.4	06/23/1998	61.4	05/08/2001	61.5	07/11/2010	64.4
04/24/1991	108.4	08/21/1998	74.0	08/12/2001	74.5	07/21/2010	75.6
07/28/1992	60.6	09/15/1998	70.1	09/28/2001	64.8	07/22/2010	86.2
01/15/1993	68.4	11/09/1998	106.9	11/21/2001	95.2	08/18/2010	62.4
02/01/1993	63.4	01/08/1999	93.5	06/15/2002	68.0	10/08/2010	85.5
06/30/1993	74.5	02/05/1999	106.3	06/19/2002	96.7	11/21/2010	83.9
09/13/1993	62.9	03/05/1999	69.2	05/31/2004	73.9	01/13/2011	62.9
12/25/1993	60.8	05/29/1999	69.4	04/23/2000	85.7	01/15/2011	88.9
12/26/1993	77.4	09/24/1999	77.8	06/13/2005	63.4	01/31/2011	66.2
06/13/1994	75.5	12/07/1999	88.7	12/07/2005	64.9	05/23/2011	71.4
08/21/1995	80.9	12/18/1999	65.6	06/26/2007	68.3	06/13/2011	107.5
08/30/1995	68.2	12/22/1999	104.6	04/26/2008	78.0	07/02/2011	61.8
09/11/1995	64.8	02/03/2000	99.9	04/27/2008	83.3	09/01/2011	70.9
12/26/1995	104.6	02/11/2000	66.1	04/28/2008	64.2	11/14/2011	63.9
12/27/1995	107.5	03/11/2000	74.3	06/29/2008	66.4	12/16/2011	187.2
02/05/1996	65.3	04/05/2000	70.7	08/20/2008	109.1	02/19/2012	65.8
04/10/1996	72.9	04/19/2000	66.6	11/10/2008	69.0	12/04/2012	111.7

Source: JICA Survey Team

Considering that value of SLSC and visual fitness with the distribution curve as well as Jack-knife method, the Generalized Pareto Distribution (GP) is concluded the most appropriate for the statistical analysis. The SLSC value and correlation coefficient as well as JackKnife's estimate and error are shown in Table 3.4.5.

The return period of the rainfall during TS Sendong is estimated at 57 year return period as shown in Table 3.4.5. Figure 3.4.7 presents the probable distribution plotting on some probability paper of each distribution. The return period of the rainfall during TY Pablo was estimated at 14 year return period according to TY Pablo's rainfall which was separated in 2-day (111.7mm in 4th December, 27.8mm in 5th December) and totaled 139.5mm.

Table 3.4.5 Results of Frequency Analysis for Partial Duration Series of Basin Mean 1-day Rainfall

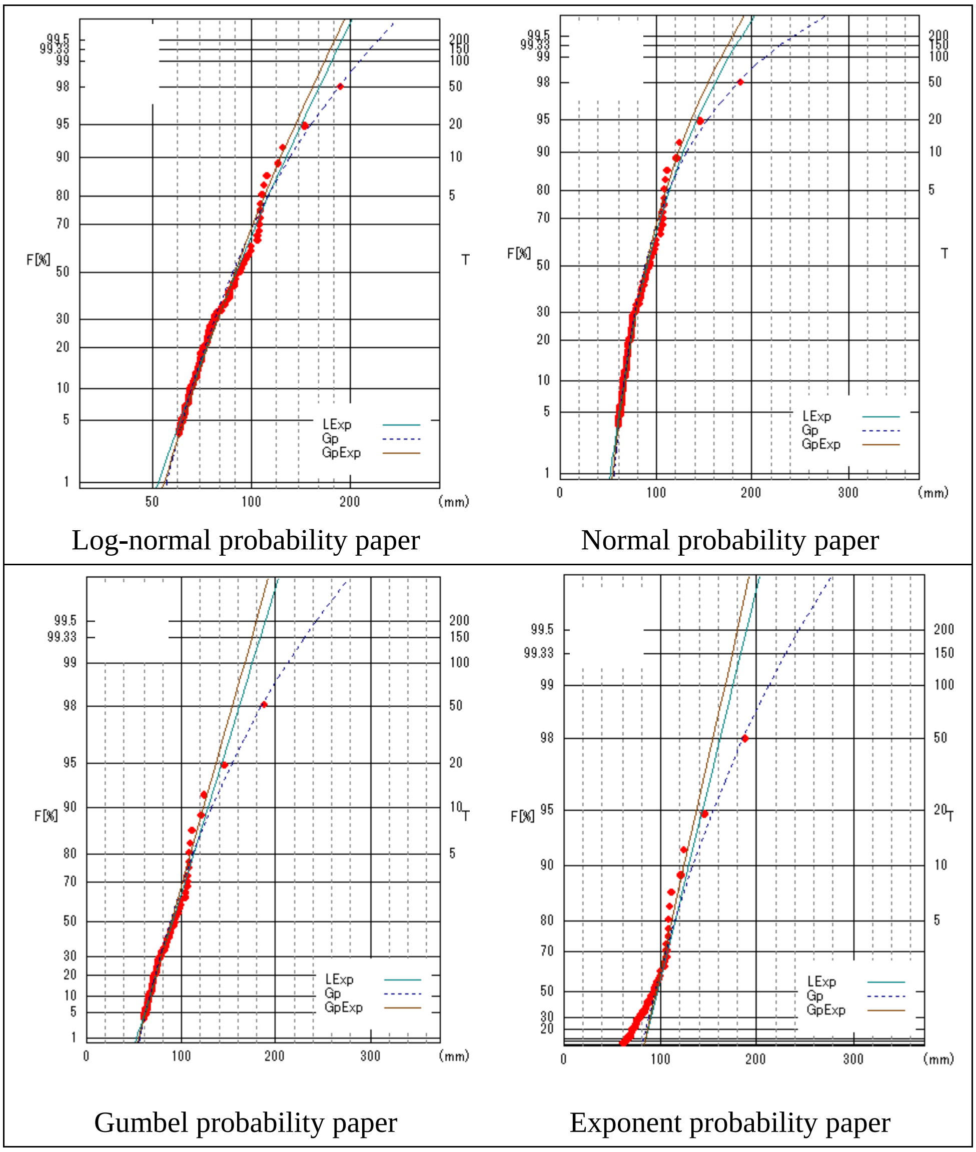
	Lexp	Gp	GpExp
X-COR(99%)	0.987	0.988	0.987
P-COR(99%)	0.995	0.998	0.996
SLSC(99%)	0.036	0.031	0.046
Log Likelihood	-401.4	-393.0	-393.4
pAIC	806.7	792.0	790.8
X-COR(50%)	0.976	0.980	0.976
P-COR(50%)	0.990	0.986	0.988
SLSC(50%)	0.059	0.042	0.074

Probability	Return P	Lexp	Gp	GpExp
	2-yr	90.4	88.2	89.5
	5-yr	113.4	113.2	110.8
	10-yr	128.7	132.2	124.9
	25-yr	148.0	159.7	142.8
	50-yr	162.3	182.8	156.0
	80-yr	172.0	199.8	164.9
	100-yr	176.6	208.3	169.1
	Sendong / Pablo 187.2 / 139.5 mm			
	Sendong	Over100yr	57yr	Over100yr
	Pablo	17yr	14yr	21yr

Jack Knife Estimate	Return P	Lexp	Gp	GpExp
	2-yr	90.4	88.4	89.6
	5-yr	113.4	113.5	111.0
	10-yr	128.7	132.3	125.1
	25-yr	148.0	158.8	143.1
	50-yr	162.3	180.4	156.3
	80-yr	172.0	195.9	165.3
	100-yr	176.6	203.5	169.5
	Sendong / Pablo 187.2 / 139.5 mm			
	Sendong	Over100yr	63yr	Over100yr
	Pablo	17yr	14yr	21yr

Jack Knife Error	Return P	Lexp	Gp	GpExp
	2-yr	3.3	3.3	3.2
	5-yr	6.0	5.9	5.5
	10-yr	7.8	9.2	7.0
	25-yr	10.2	16.2	9.0
	50-yr	11.9	24.1	10.4
	80-yr	13.0	30.8	11.4
	100-yr	13.6	34.5	11.9

Source: JICA Survey Team



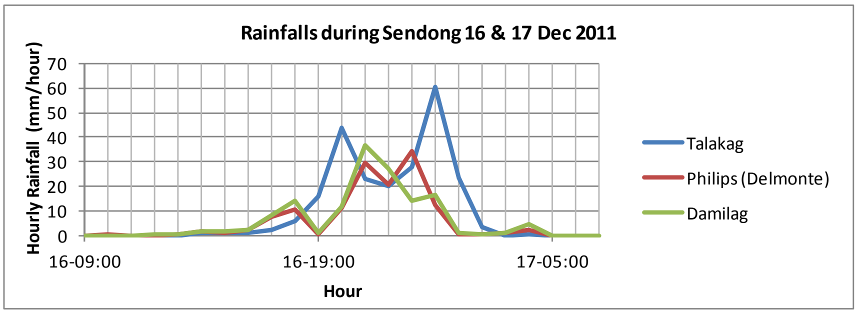
Source : JICA Survey Team

Figure 3.4.7 Result of Frequency Analysis for Partial Duration Series of Basin Mean 1-day Rainfall

(2) Design Rainfall Distribution of Sendong

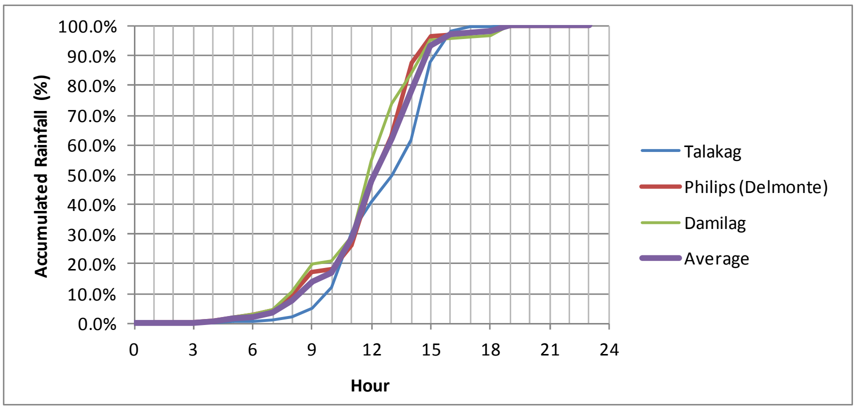
The hourly rainfall data during TS Sendong in December 2011 were recorded at three (3) stations, i.e.Talakag, Damilag and Philips in the vicinity of the CDO River basin.

Observed hourly rainfall records at the said three(3) stations are shown in Figure 3.4.8. Hourly rainfall distribution of the three records are shown in Figure 3.4.9 together with the mean of the three.



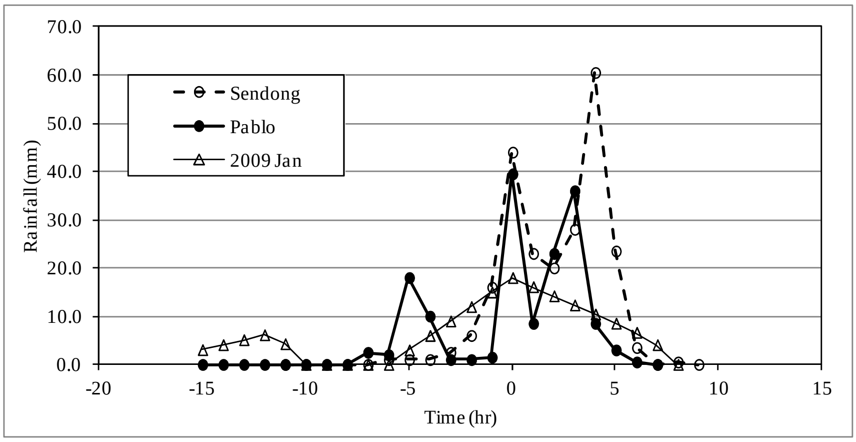
Source: JICA Survey Team

Figure 3.4.8 Observed Hourly Rainfall Record at Three Rainfall Stations during TS.Sendong



Source: JICA Survey Team

Figure 3.4.9 Hourly Rainfall Distribution during TS.Sendong

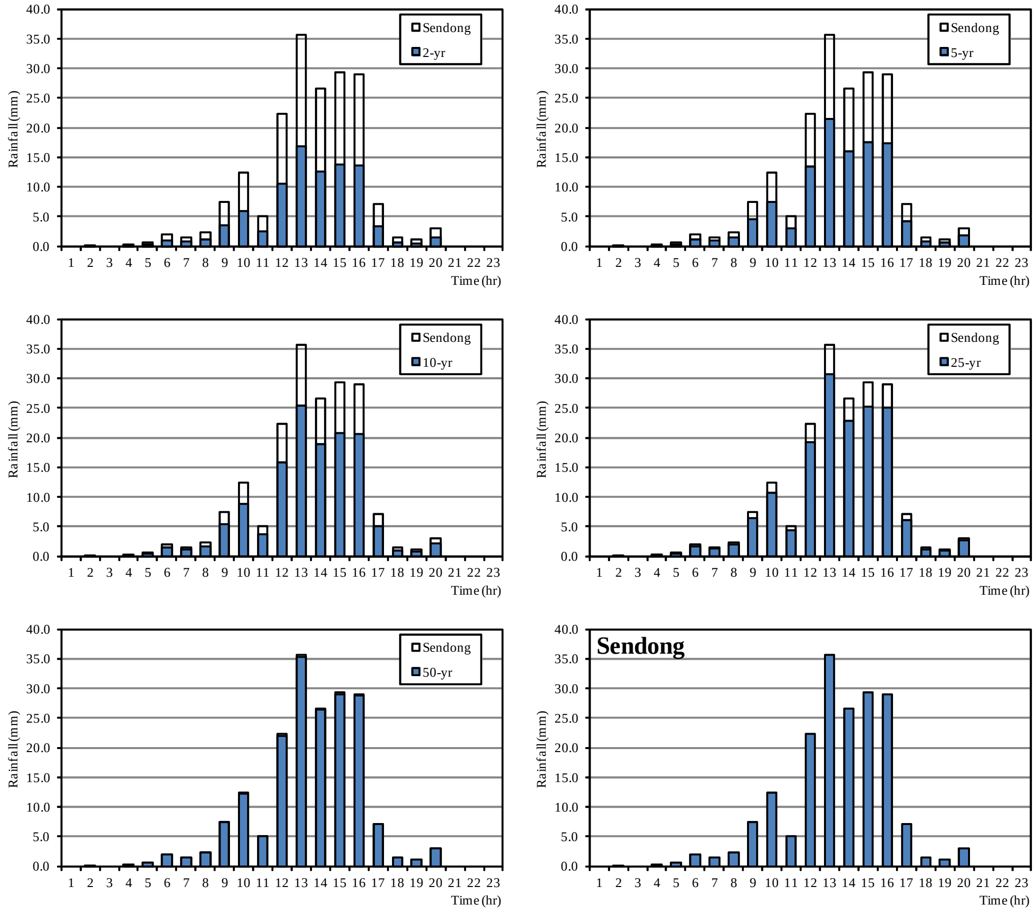


Source: JICA Survey Team

Figure 3.4.10 Rainfall Distribution of the Recent Stormy Rainfall

Figure 3.4.10 shows rainfall distribution during TS Sendong and TY Pablo at Talakag Station, respectively, together with that during TY Ondoy (Jan. 2009 at Malaybalay Station). Rainfall duration in those Typhoon and Tropical Storm are within 24 hours.

Average rainfall distribution during TS. Sendong shown in Figure 3.4.9 is applied to every station available in 2011, which stations are used for Thiessen pattern t-12 as shown in DATA BOOK (Thiessen Pattern t-12). Hourly rainfall of each return period (2-yr, 5-yr, 10-yr, 25-yr, and 50-yr) is estimated based on the hourly rainfall during TS Sendong with a depletion rate. Estimated hyetograph of each return period is shown in Figure 3.4.11.



Source: JICA Survey Team

Figure 3.4.11 Probable Hourly Rainfall Pattern

3.4.5 Run-off Analysis

(1) Runoff Model

Referring to the previous several related studies having been conducted in the Philippines, the Storage Function Model is applied in the Survey.

1) Storage Function Model

Basic equations of the Storage Function Model are composed of continuity equation and equation of motion. The runoff is computed as phenomena of a network of basins and channels in the Storage Function Model.

a) Basic storage function for basin

Equation of motion $$S_l = KQ_l^{\,p}$$

Continuity equation $$\frac{dS_l}{dt} = \frac{1}{3.6} f \cdot r_{ave} \cdot A - Q_l$$

where,

S	:	storage volume of the basin
Q	:	runoff discharge
l and p	:	constants

f : inflow coefficient,
r_{ave} : basin mean rainfall (mm/hr),
A : catchment area (km^2),
$Q_l = Q(t + T_l)$: direct runoff discharge (m^3/s) from a basin at time of delay,
S_l : apparent storage volume (m^3/s hr) in a basin
T_l : time of delay.

b) Basic storage function for river channels

The equation of motion for a river channel and the continuity equation for channels is as follows:

Equation of motion for a river channel : $S_l = KQ_l^{\,p} - T_l Q_l$

Continuity equation for channels : $\frac{dS}{dt} = \sum_{j=1}^{n} f_j I_j - Q_l$

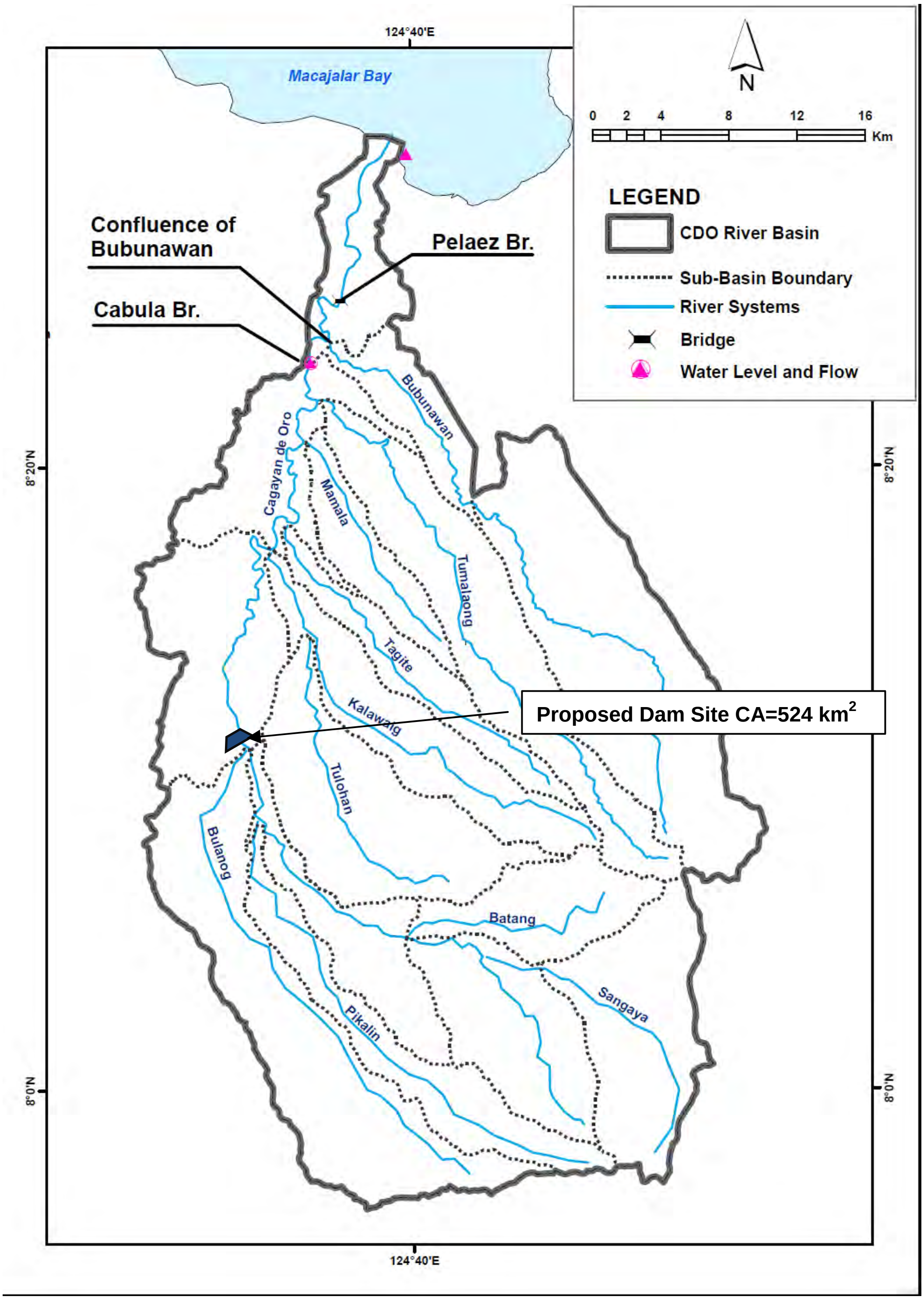
where,

l and p : constants of river course
T_l : delay of time for river course.
l_j : inflow discharge group, which flows into the channel from basins, tributaries and/or upper end of the channel,
f_j : inflow coefficient of each inflow,
$Q_l = Q(t + T_L)$: discharge (m^3/s) at the lower end of the channel where time of delay is considered,
S_1 : apparent storage volume (m^3/s hr) in the channel and
T_L : lag time

2) Basin Division and Runoff Model.

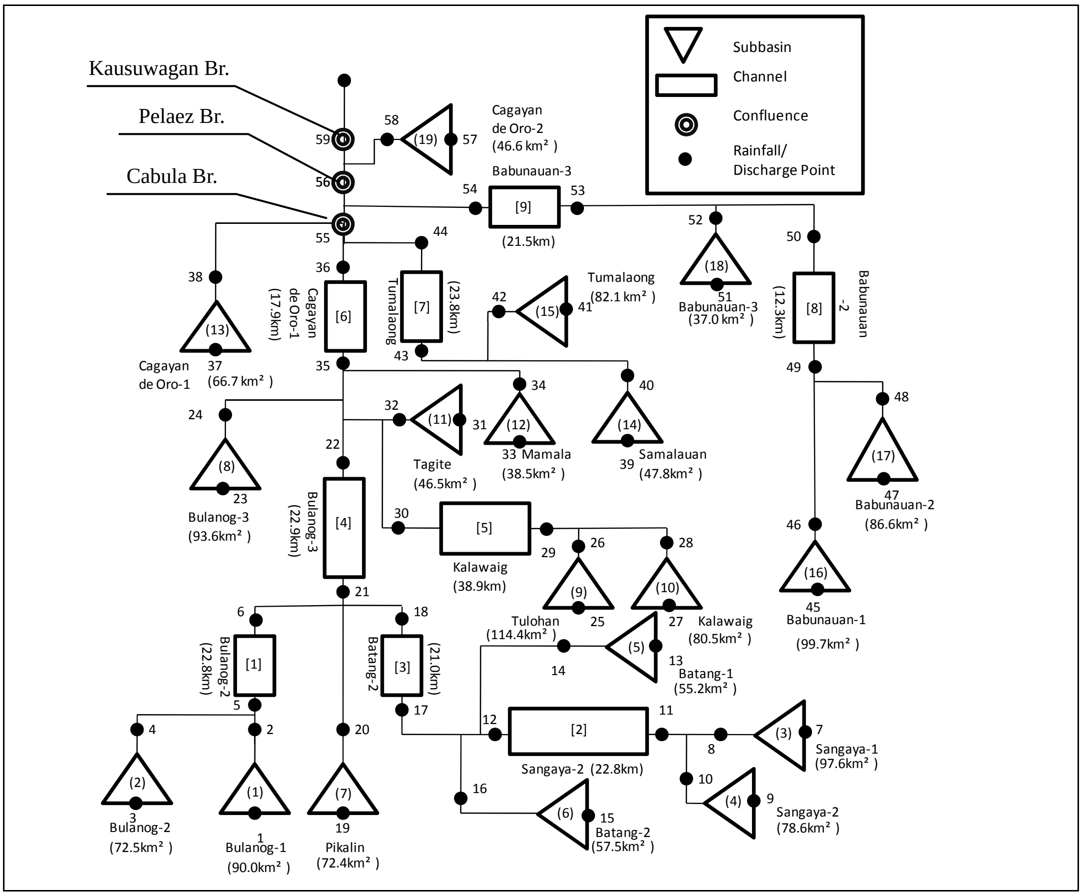
Total catchment area of the Cagayan de Oro River(CDO River) is 1,364 km^2 as shown in Figure 3.4.12. The total area are divided into 19 sub-basins and 10 channels dividing whole basin by major tributaries and additional segmentation when a sub-basin has a long shape, which is shown in Figure 3.4.13 to be served as the runoff model diagram.

Considering the available observed flow at Cabula Bridge with a catchment area of 1,094 km^2, a runoff model has been calibrated at the Cabula Bridge point as shown in Figure 3.4.12 including 15 sub-basins.



Source : JICA Survey Team

Figure 3.4.12 Basin Division of Cagayan de Oro River Basin (C.A = 1,364 km^2)



Source : JICA Survey Team

Figure 3.4.13 Runoff Model Diagram for Cagayan de Oro River Basin

(2) Setting of Parameters

1) Basin model parameter

$$K = 43.4 \cdot C \cdot I^{-1/3} \cdot L^{1/3}, \quad p = 0.33 \quad (= 1/3)$$

$$T_L = 0.047 \cdot L - 0.57 \quad (L \geq 11.9)$$

$$T_L = 0 \quad (L < 11.9)$$

where, C : lzzard coefficient by land use(0.12 at mountain watershed and 0.012 at urban area)

I : slope of river basin,

L : length of river basin (km),

T_L : time of delay (hr).

2) Channel model parameter

$$K = 0.166 \cdot L \cdot I^{-0.5}, \quad p = 0.6$$

$$T_L = 7.36 \cdot 10^{-4} \cdot L \cdot I^{-0.5}$$

where, L : channel length (km),

I : channel slope,

T_L : time of delay (hr)

3) Runoff coefficient (fl) is fixed at 0.5

4) Summary of Parameters

Table 3.4.6 Parameters for Sub-Basin

No.	Sub-Basin	Area A (km2)	Length of RC L (km)	High EL. (m)	Low EL. (m)	1/Slope	Nature (%)	Urban (%)	Rough C	K	P	TL (hr)
1	Bulanog-1	90.0	25.5	1750	830	27.7	99.9 %	0.1 %	0.12	46.3	0.3	0.6
2	Bulanog-2	72.5	23.1	1000	380	37.2	100.0 %	0.0 %	0.12	49.5	0.3	0.5
3	Sangaya-1	97.6	21.4	2763	920	11.6	100.0 %	0.0 %	0.12	32.7	0.3	0.4
4	Sangaya-2	78.6	24.6	2260	650	15.3	100.0 %	0.0 %	0.12	37.6	0.3	0.6
5	Batang-1	55.2	20.1	2480	650	11.0	100.0 %	0.0 %	0.12	31.5	0.3	0.4
6	Batang-2	57.5	30.5	1240	380	35.4	100.0 %	0.0 %	0.12	53.4	0.3	0.9
7	Pikalin	72.4	45.0	2560	460	21.4	100.0 %	0.0 %	0.12	51.4	0.3	1.6
8	Bulanog-3	93.7	26.9	1120	140	27.5	99.9 %	0.1 %	0.12	47.1	0.3	0.7
9	Tulohan	114.4	37.3	1800	250	24.0	99.9 %	0.1 %	0.12	50.1	0.3	1.2
10	Kalawaig	80.6	39.5	1860	140	23.0	99.8 %	0.2 %	0.12	50.3	0.3	1.3
11	Tagite	46.5	32.2	1560	100	22.1	100.0 %	0.0 %	0.12	46.5	0.3	1.0
12	Mamala	38.5	27.6	700	60	43.2	100.0 %	0.0 %	0.12	55.2	0.3	0.7
13	Cagayan de Oro-1	66.7	14.2	820	50	18.5	99.3 %	0.8 %	0.12	33.1	0.3	0.1
14	Samalauan	47.8	21.8	2560	460	10.4	100.0 %	0.0 %	0.12	31.7	0.3	0.5
15	Tumalaong	82.1	31.8	980	60	34.6	99.9 %	0.1 %	0.12	53.7	0.3	0.9
16	Bubunauan-1	99.7	23.4	2600	560	11.5	100.0 %	0.0 %	0.12	33.6	0.3	0.5
17	Bubunauan-2	86.6	21.4	1020	300	29.7	100.0 %	0.0 %	0.12	44.7	0.3	0.4
18	Bubunauan-3	37.1	22.9	470	40	53.3	100.0 %	0.0 %	0.12	55.6	0.3	0.5
19	Cagayan de Oro-2	46.6	15.9	240	0	66.2	56.6 %	43.4 %	0.07	32.3	0.3	0.2
	Total / Average	1363.8	505.1	1568	338	27.5	97.7 %	2.3 %				

Source: JICA Survey Team

Table 3.4.7 Parameters for Channels

No.	Channel	Length L (km)	High EL. (m)	Low EL. (m)	1/Slope	K	P	TL (hr)
1	Bulanog-2	22.8	830	380	50.7	27.0	0.6	0.1
2	Sangaya-2	22.8	1900	650	18.3	16.2	0.6	0.1
3	Batang-2	21.0	650	380	77.9	30.8	0.6	0.1
4	Bulanog-3	22.9	380	140	95.6	37.2	0.6	0.2
5	Kalawaig	38.9	1520	140	28.2	34.2	0.6	0.2
6	Cagayan de Oro-1	17.9	140	50	198.8	41.9	0.6	0.2
7	Lumalaong	23.8	460	60	59.6	30.5	0.6	0.1
8	Bubunauan-2	12.3	560	300	47.4	14.1	0.6	0.1
9	Bubunauan-3	21.5	300	40	82.6	32.4	0.6	0.1
10	Cagayan de Oro-2	19.4	140	0	138.5	37.9	0.6	0.2
	Total / Average	223.4	688	214	79.7			

Source: JICA Survey Team

5) Base flow

Base flow at the Cabula Bridge was estimated at 103 m^3/s (0.1 m^3/s/km^2 ≒103 m^3/s /1,094 km^2) according to the daily discharge record at the Cabula Bridge, which record are shown in DATA BOOK. The base flow was estimated according to the flow duration curve based on the 21years daily discharge computed from the observed water level by the rating curve at Cabula Bridge as referred to Figure 4.2.3 in Chapter 4 of Appendix C.

(3) Simulation of Discharge Hydrograph during Sendong at Cabula Bridge

1) Flood runoff hydrograph of TY. Pablo

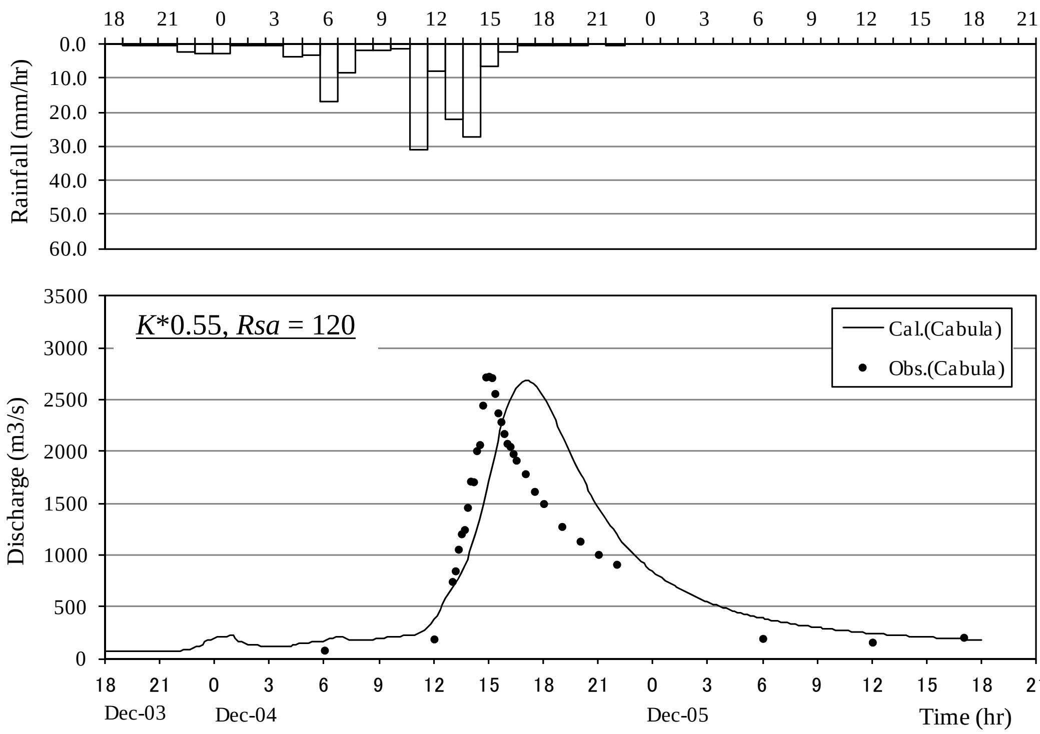
The simulated flood runoff hydrograph in TY Pablo is shown in Figure 3.4.14 by applying the optimum parameters of sub-basins of the runoff model shown in Table 3.4.8.

Table 3.4.8 Optimum Parameters of Sub-basins in CDO River Basin

№	Sub-basin	Basin Area (km2)	K	P	TL	f1
1	1Bulanog-1	90.0	25.5	0.230	0.3	0.5
2	2Bulanog-2	72.5	27.2	0.230	0.3	0.5
3	3Sangaya-1	97.6	18.0	0.230	0.2	0.5
4	4Sangaya-2	78.6	20.7	0.230	0.3	0.5
5	5Batang-1	55.2	17.3	0.230	0.2	0.5
6	6Batang-2	57.5	29.4	0.230	0.5	0.5
7	7Pikalin	72.4	28.3	0.230	0.8	0.5
8	8Bulanog-3	93.7	25.9	0.230	0.4	0.5
9	9Tulohan	114.4	27.6	0.230	0.6	0.5
10	10Kalawaig	80.6	27.7	0.230	0.7	0.5
11	11Tagite	46.5	25.6	0.230	0.5	0.5
12	12Mamala	38.5	30.4	0.230	0.4	0.5
13	13Cagayan-1	66.7	18.2	0.230	0.1	0.5
14	14Samalauan	47.8	17.5	0.230	0.2	0.5
15	15Lumalaong	82.1	29.6	0.230	0.5	0.5
16	16Bubunauan-1	99.7	18.5	0.230	0.3	0.5
17	17Bubunauan-2	86.6	24.6	0.230	0.2	0.5
18	18Bubunauan-3	37.1	30.6	0.230	0.3	0.5
19	19Cagayan-2	46.6	17.8	0.230	0.1	0.5

Source: JICA Survey Team

Comparing to the flood hydrograph based on the observed data in TY Pablo, the hydrograph by the runoff model shows good conformity with the rising limb of the hydrograph and peak discharge, however, the hydrograph still contains low recession ratio. However, the runoff coefficient of the simulated hydrograph would be lower than 0.5 in case that simulated hydrograph would be forced to be similar to the "observed" hydrograph.



Source: JICA Survey Team

Figure 3.4.14 Calibrated Flood Hydrograph at Cabula Bridge after Parameter Adjustment (Adjustment of time of delay)

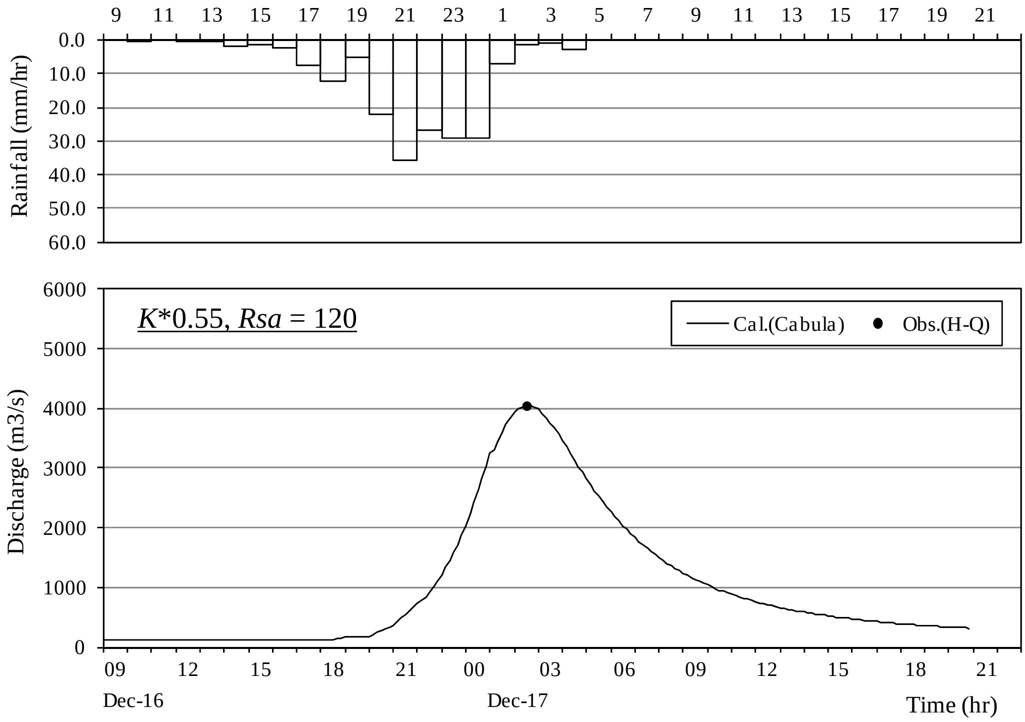
2) Verification of Peak Discharge at Cabula Bridge during TS. Sendong

i) Flood hydrograph at Cabula Bridge in TS. Sendong

The maximum gauge reading height during TS Sendong was 9.8 m at Cabula Bridge, which is equivalent to the peak discharge at about 4,050 m^3/s by applying the water level – discharge rating curve at Cabula Bridge as referred to Figure 4.2.3 in Chapter 4 of Appendix C.

The base flow is around $103m^3/s$ ($0.1m^3/s/km^2$) at day 15^{th} and 16^{th} December according to the daily discharge record in DATA BOOK.

The flood hydrograph having been calibrated by the observed data in TY Pablo with a peak discharge is shown in Figure 3.4.15.



Source: JICA Survey Team

Figure 3.4.15 Flood Runoff Hydrograph at Cabula Bridge in TS. Sendong

ii) Assessment of the peak discharge by applying Rational formula

The Rational formula as defined below is used for estimation of high flow by determining the parameters as below:

$$Qp = 1/3.6 \times f \times R \times A$$

where,

Qp : Peak runoff (m^3/s)

f : Runoff coefficient

R : Rainfall intensity during flood travelling time (mm/hr)

A : Catchment area (km^2)

a) Time of flood concentration time is estimated by applying Kraven Formula which gives flood wave propagation time:

Slope	> 1/100	1/100 ~ 1/200	< 1/200
Velocity	3.5 m/s	3.0 m/s	2.1 m/s

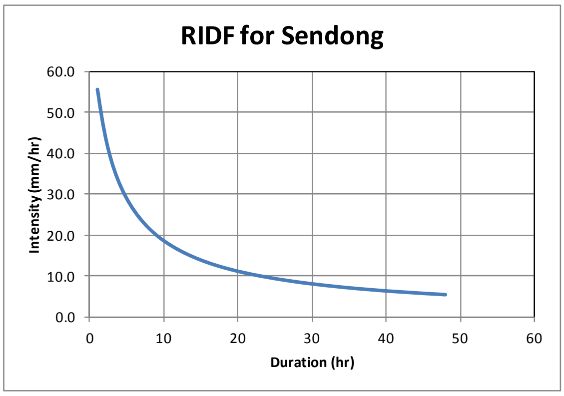
Time of flood concentration time from the most far sub-basin(s)

No.	Sub-Basin	Length L (km)	High EL. (m)	Low EL. (m)	Diff (m)	1/Slope	Velocity (m/s)	Flow time (hr)
3	Sangaya-1	19.5	2400	920	1480	13.2	3.5	1.5
4	Sangaya-2	22.8	1900	650	1250	18.3	3.5	1.8
6	Batang-2	21.0	650	380	270	77.9	3.5	1.7
13	Cagayan de Oro-1	17.9	140	50	90	198.8	3	1.7

Consequently, total flood concentration time to the Cabula Bridge is estimated at 7 hours.

b) Rainfall intensity

Referring to the hourly rainfall data available at Talakag during TS. Sendong, Rainfall Intensity Duration Frequency (RIDF) is prepared:



Source: JICA Survey Team

Figure 3.4.16 Rainfall Intensity Duration Frequency of TS Sendong

According to the figure above, 7-hr rainfall intensity is obtained at 23.5 mm/hr.

c) Runoff coefficient

Runoff coefficient in undulating highland or forest is in a range of 0.50 to 0.70 according to the "Manual for River Works in Japan". Qp is computed at about 3,570 m^3/s (coeff. 0.5) and 4,280 m^3/s (coeff. 0.60), respectively. A coefficient of 0.57 corresponds to a peak discharge of the current hydrograph (Q= 4,050m^3/s).

3.4.6 Probable Flood Hydrograph

(1) Runoff Parameter

Optimum parameters to be applied for determination of the design flood hydrograph are specified in Table 3.4.7 for K, P and T_l of each river channel and in Table 3.4.8 for the area, f_1, K, P and T_l of each sub-basin.

As for an amount of the saturated rainfall depth (Rsa), it is determined to employ Rsa of 120 mm.

(2) Flood Hydrographs during TS. Sendong at the Selected Locations in the Cagayan de Oro River

Flood hydrographs at the selected locations in the Cagayan de Oro River during TS Sendong are obtained in the following manner:

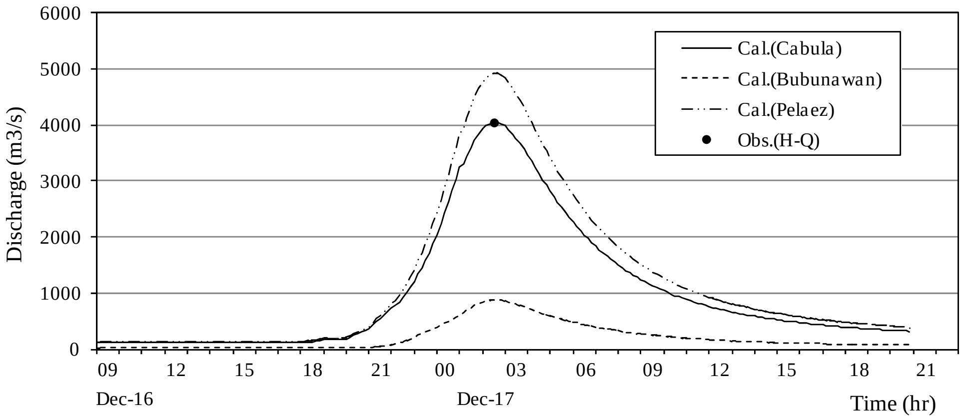
(i) Bubunawan : Discharge hydrograph obtained by runoff model in the Bubunawan River sub-basins which directly flow into the river runoff model at the confluence.

(ii) Cabula Bridge : Discharge hydrograph obtained through the Runoff Model; Inflow from Bubunawan River sub-basins and Cagayan de Oro-2 sub-basin are not included.

(iii) Pelaez Bridge : Discharge hydrograph through the Runoff Model; Inflow from Cagayan de Oro- 2 sub-basin is not included.

(iv) Kausuwagan Bridge : Discharge hydrograph through the Runoff Model; Inflow from Cagayan de Oro- 2 sub-basin is included. This would be the input flow for hydraulic analysis in next Chapter.

The each location of (i), (ii) and (iii) is shown in Figure 3.4.1 and Figure 3.4.5.



Name of Basin	Distance from River Mouth(km)	Catchment Area (km^2)	Sendong Flow (m^3/s)
Cabula	18.7	1,094	4,052
Pelaez	11.62	1,317	4,925
Bubunawan Basin	-	223	872

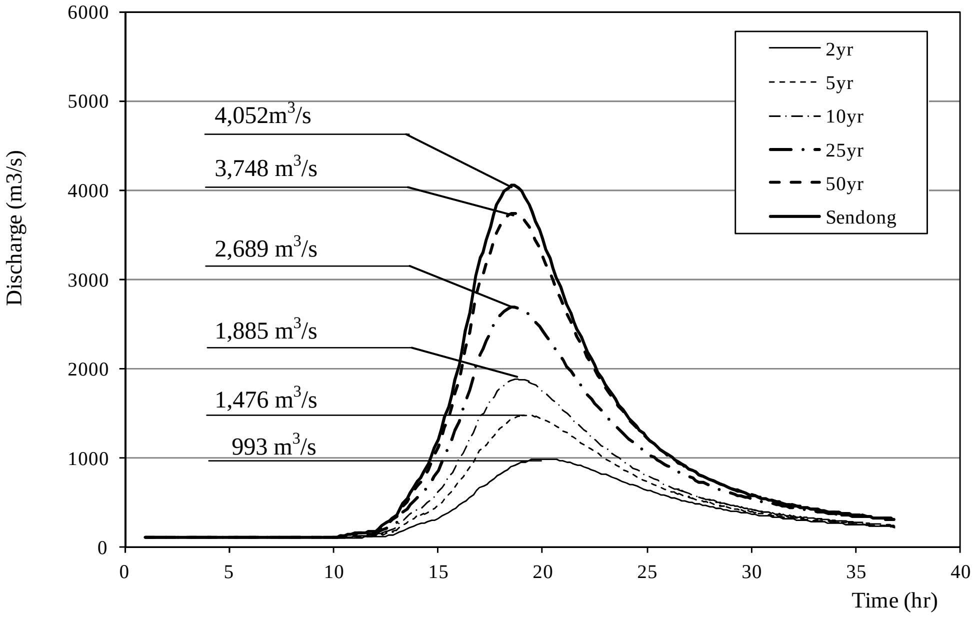
Source: JICA Survey Team

Figure 3.4.17 Flood Hydrographs during Sendong

(3) Selected Discharge Hydrographs for Design Scale Alternatives

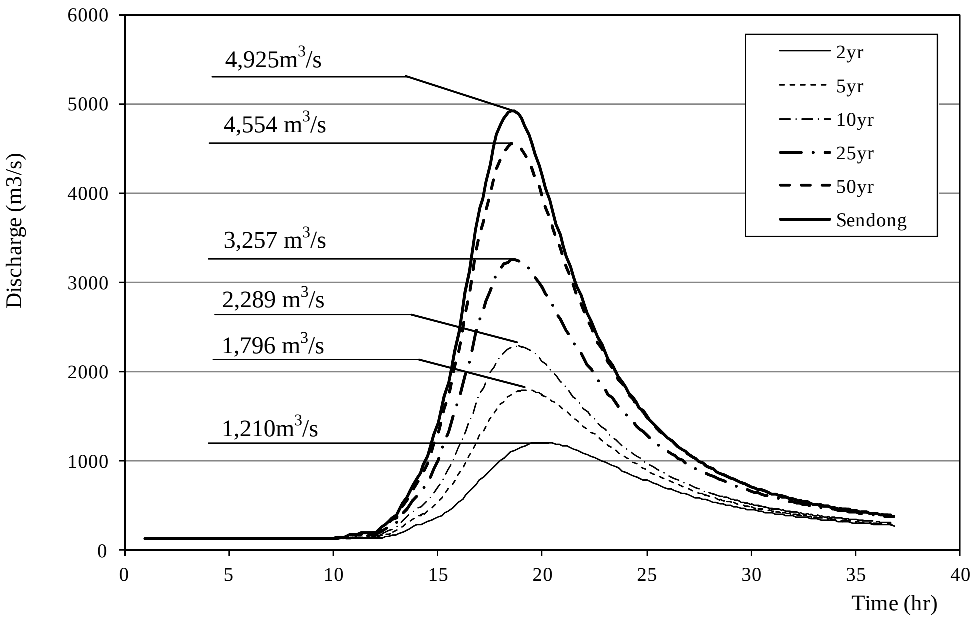
Selected flood hydrograph for the design scale alternatives at the selected locations are presented herein for the Cabula Bridge and the Pelaez Bridge in Figures 3.4.18 and 3.4.19 respectively with design scale alternatives for 2-yr, 5-yr, 10-yr, 25-yr and 50-yr as well as return period equivalent to TS Sendong scale.

Return Period	Flood Discharge (m^3/s) at Cabula Bridge	Flood Discharge (m^3/s) at Pelaez Bridge	Flood Discharge (m^3/s) at Kausuwagan Bridge
2 year	1,000	1,300	1,300
5 year	1,500	1,800	1,900
10 year	1,900	2,300	2,400
25 year	2,700	3,300	3,400
50 year	3,800	4,600	4,700
TS.Sendong Scale	4,100	5,000	5,100



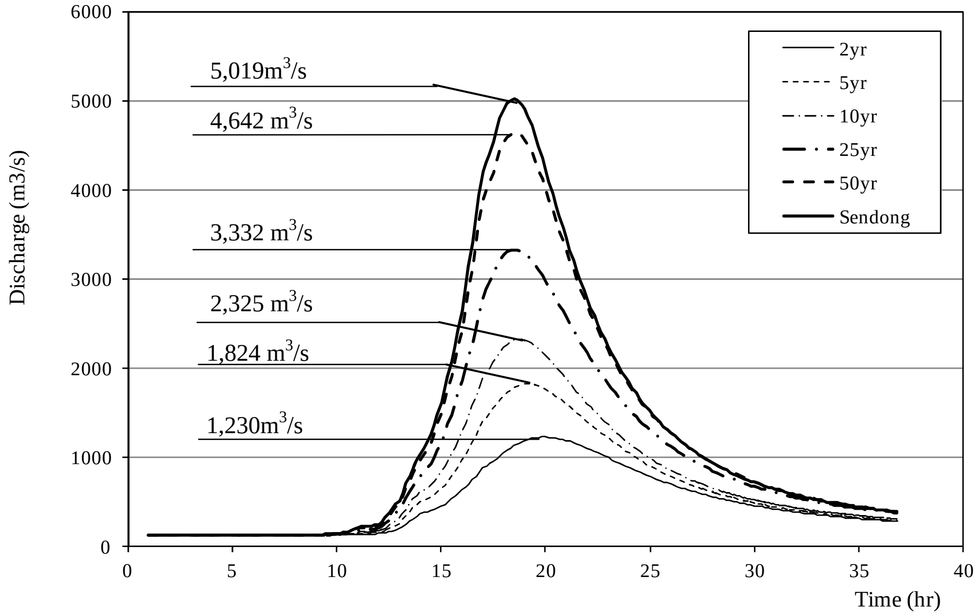
Source: JICA Survey Team

Figure 3.4.18 Probable Flood Hydrographs at Cabula Bridge



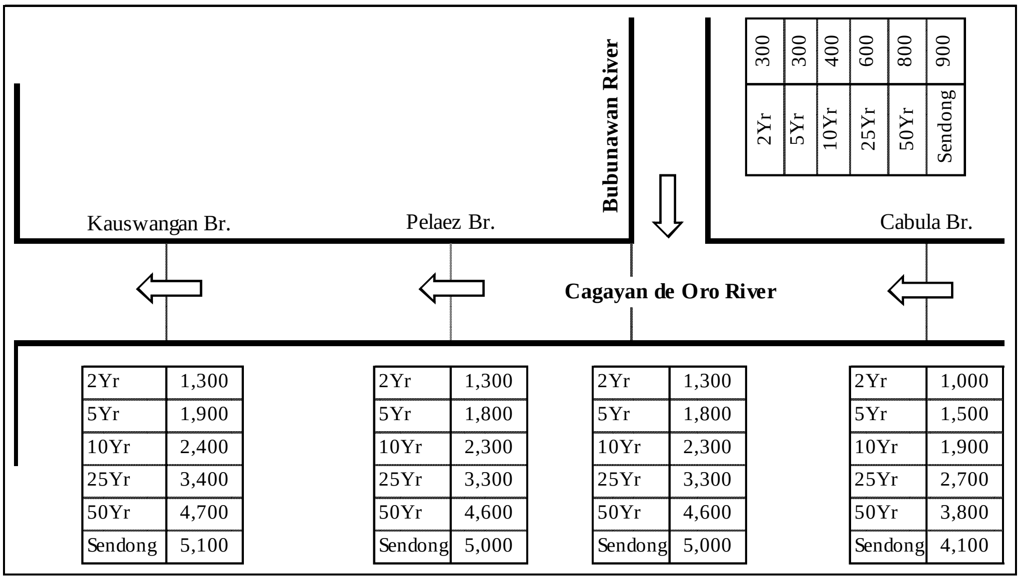
Source: JICA Survey Team

Figure 3.4.19 Probable Flood Hydrographs at Pelaez Bridge



Source: JICA Survey Team

Figure 3.4.20 Probable Flood Hydrographs at Kausuwagan Bridge

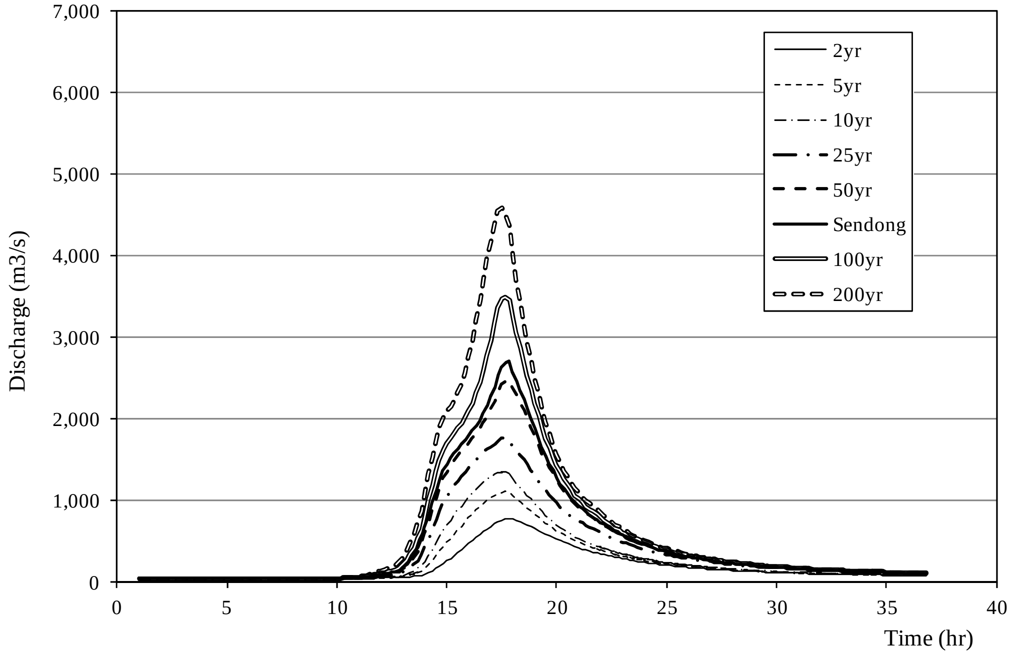


Source: JICA Survey Team

Figure 3.4.21 Flood Discharge Distribution (Probable Flood and Sendong Flood)

(4) Flood Hydrograph at the Proposed Dam Site

The flood inflow hydrograph at the proposed dam site is shown in Figure 3.4.22. Inflow discharge for 25-year return period is 1,768 m^3/s and 4,549 m^3/s for 200 years return period .



Source: JICA Survey Team

Figure 3.4.22 Probable Flood Hydrograph at the Proposed Dam Site

3.5 Hydraulic Analysis

3.5.1 General

In the course of the hydraulic study, past inundation and flood marks during TS Sendong in 2011 and PY Pablo in 2012 were examined in detail. Inundation analysis model was developed through calibration comparing with the actual results of flood inundations. The establish model was used to simulate flood water level, extent of inundation area and inundation depth to estimate the flood damages in the affected area.

In addition, study for riverbed movement in the downstream channel was conducted based on the results of cross section surveys in 2011, 2012 and 2013 to assess trend of riverbed fluctuation and necessity of dredging/channel excavation. One-dimensional riverbed fluctuation analysis model was preliminary developed adopting the cross section and riverbed material data obtained in the Survey, and dry run was conducted referring to the existing sediment sampling data in the upstream basin. The results of the hydraulic analysis are presented below.

3.5.2 Past Inundation

In Cagayan de Oro River Basin, the floods caused by Tropical Storm Sendong in 2011 and Typhoon Pablo in 2012 wreaked enormous damage. The hydrological and characteristics such as basin mean rainfall, water level and flood discharge and flood marks as well as damage conditions of TS Sendong and TY Pablo are summarized in Chapter 6 of Appendix C.

(1) Flood Mark

The survey team has conducted survey of flood marks at each bridge from river mouth up to Pelaez Bridge for TS Sendong and TY Pablo. JICA also conducted the survey for upstream from Pelaez bridge to downstream of the Cabula Bridge and DPWH conducted the survey at Kauswagan, Maharika and Ysakina Bridges at the time of TS Sendong.

Table 3.5.1 Flood Mark Elevation (TS Sendong)

Name of Survey	Investigation Point	Station	Flood Mark	Remarks
This Survey[*1]	Kauswagan Br.	1+504	4.14m	Datum: Macajalar Bay mean sea level
	Maharika Br.	2+927	4.86m	
	Ysalina Br.	4+299	7.19m	
JICA, Woodfield Consultants Inc.[*2]	Pelaez Br.	11+606	18.57 m	Datum: Temporary Bench Mark
	Section 1	11+718	19.83m	
	Section 2	12+101	20.28m	
	Section 3	12+453	21.23m	
	Section 4	12+765	24.48m	
	Section 5	13+082	26.60m	
	Section 6	13+386	26.75m	
	Section 7	13+581	26.74m	
	Section 7-A	13+716	27.06m	
	Section 8	13+801	26.75m	
	Section 9	14+048	26.77m	
	Section 10	14+388	30.54m	
	Section 11	14+573	30.54m	
	Section 12	14+838	30.60m	
	Section 12-A	15+009	33.81m	
	Section 13	15+098	30.60m	
	Section 14	15+276	34.14m	
	Section 15	15+479	34.56m	
	Section 16	15+786	34.56m	
	Section 17	15+975	34.64m	
	Section 18	16+140	34.65m	
	Section 19	16+279	35.79m	
DPWH, CENTUNION Philippines, Inc.	Kauswagan Br.	1+504	1.5-2.0m below the beam	
	Maharika Br	2+927	2.0-2.5m below the beam	
	Ysalina Br.	4+299	Reach the beam	

Source: 1) JICA Survey Team
2) Flood Condition Survey of Tropical Storm "Sendong" in Cagayan de Oro and Iligan City (JICA, March 2012)

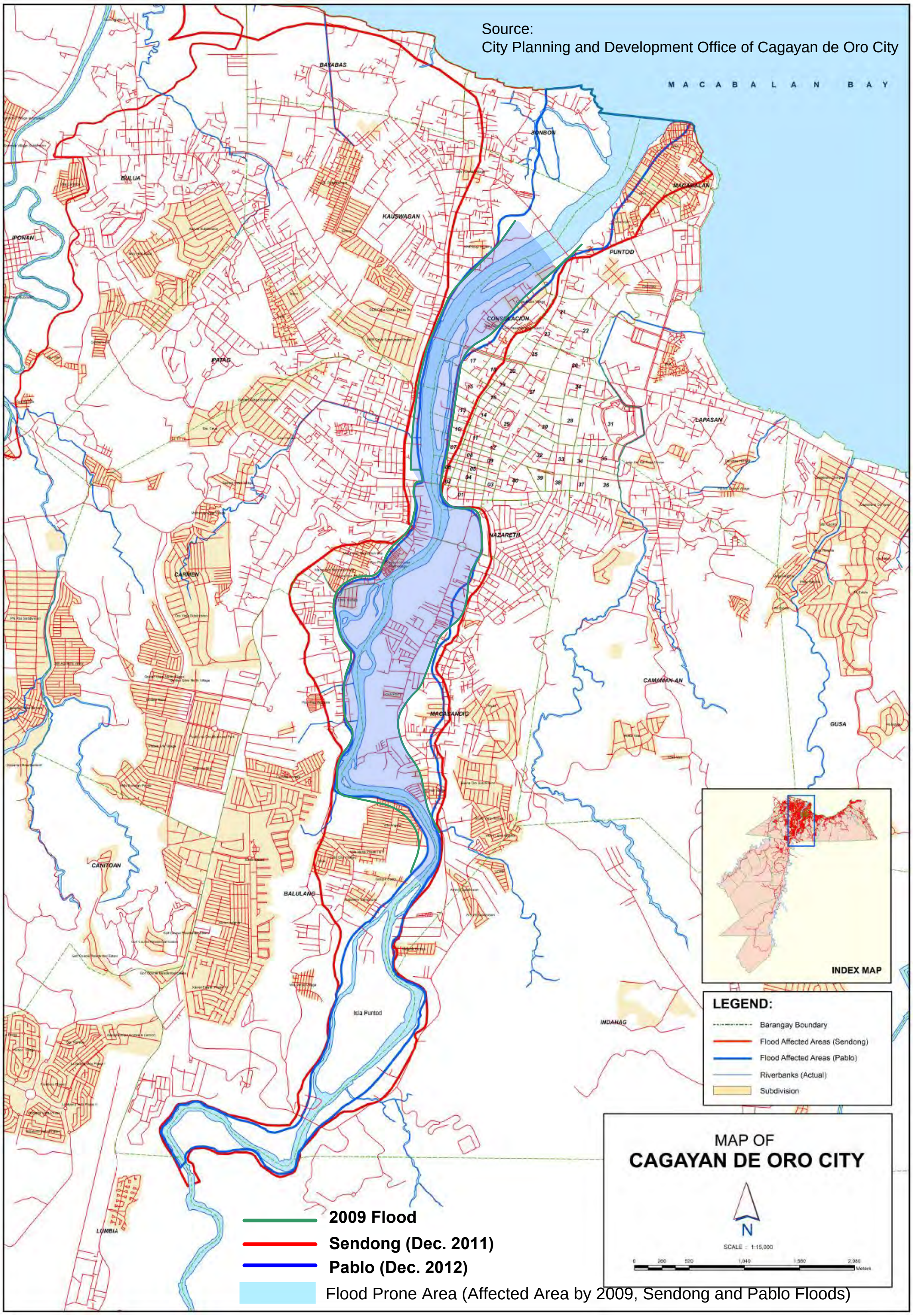
Table 3.5.2 Flood Mark Elevation (TY Pablo)

Name of Survey	Investigation Point	Flood Mark	Remarks
The Survey Team	Kauswagan Br.	2.60m	Datum: Macajalar Bay mean sea level
	Maharika Br.	2.62m	
	Ysalina Br.	3.69m	
	Kagay-an Br.	5.60m	

Source: JICA Survey Team

(2) Inundation Depth, Inundation area and Flood Damage

The survey of inundation depth of TS Sendong taking around 200 points depth was conducted in the Survey. The City Planning and Development Office in CDO City summarized the areas of inundation of TS Sendong and TY Pablo as shown in the Figure 3.5.1. The survey team modified the areas according to inundation survey and the geography of the river basin as shown in Figure 3.5.3, and put the damage situation with the actual interview at the site. The detail figures showing condition of inundation depth, area of the inundated and damage situation for TS Sendong and TY Pablo are presented in Chapter 6 of Appendix C.



Source: City Planning and Development Office

Figure 3.5.1 Inundation Areas of TS Sendong and TY Pablo

3.5.3 Geography of Floodplain

The Survey conducted the river cross section surveying and complement order leveling and 1/1,000 topography mapping. Figure 3.5.3 shows the profiles. Also, Figure 3.5.4 shows Digital Elevation Model (DEM) made by contour line of topography map and working point of cross section and leveling.

Geographic feature is broken down in three (3) zones as follows from river mouth to Pelaez Bridge where is the range for inundation analysis.

<Area 1 from river mouth to Sta.4+300 vicinity>

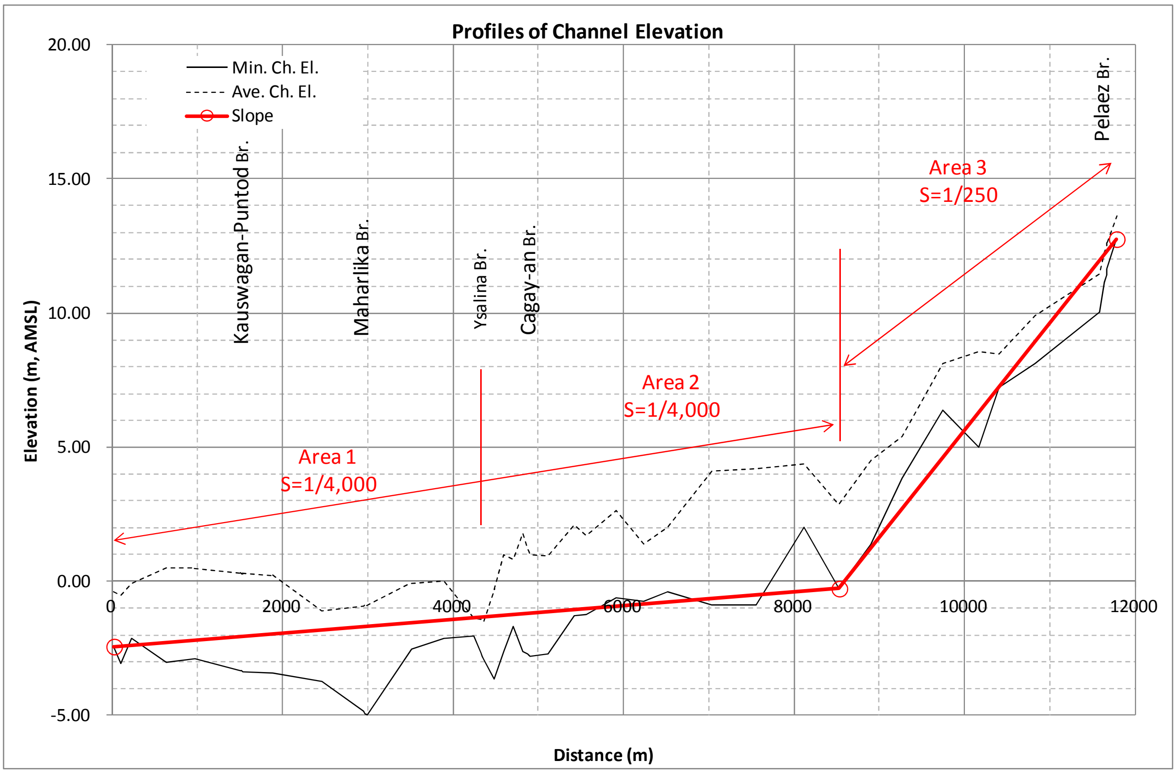
There is the constrained in the vicinity of Sta.4+300, and then downstream from that is flood plain. However, considering that longitudinal slope around 1/4,000 is steep for river mouth, it is estimated for flood flow to show the straight-line except part of the river mouth. It is also estimated that diffusional flood morphology is shown at downstream from Sta.1+500 of river mouth.

<Area 2 from Sta.4+300 to Sta.8+500 vicinity>

Because Sta.4+300 vicinity is narrow pass, flood whose width is around 1km occurred up to Sta.8+500 where is the changing point of slope. The longitudinal slope is around 1/4,000. Flood flow is presumed to be a straight-line.

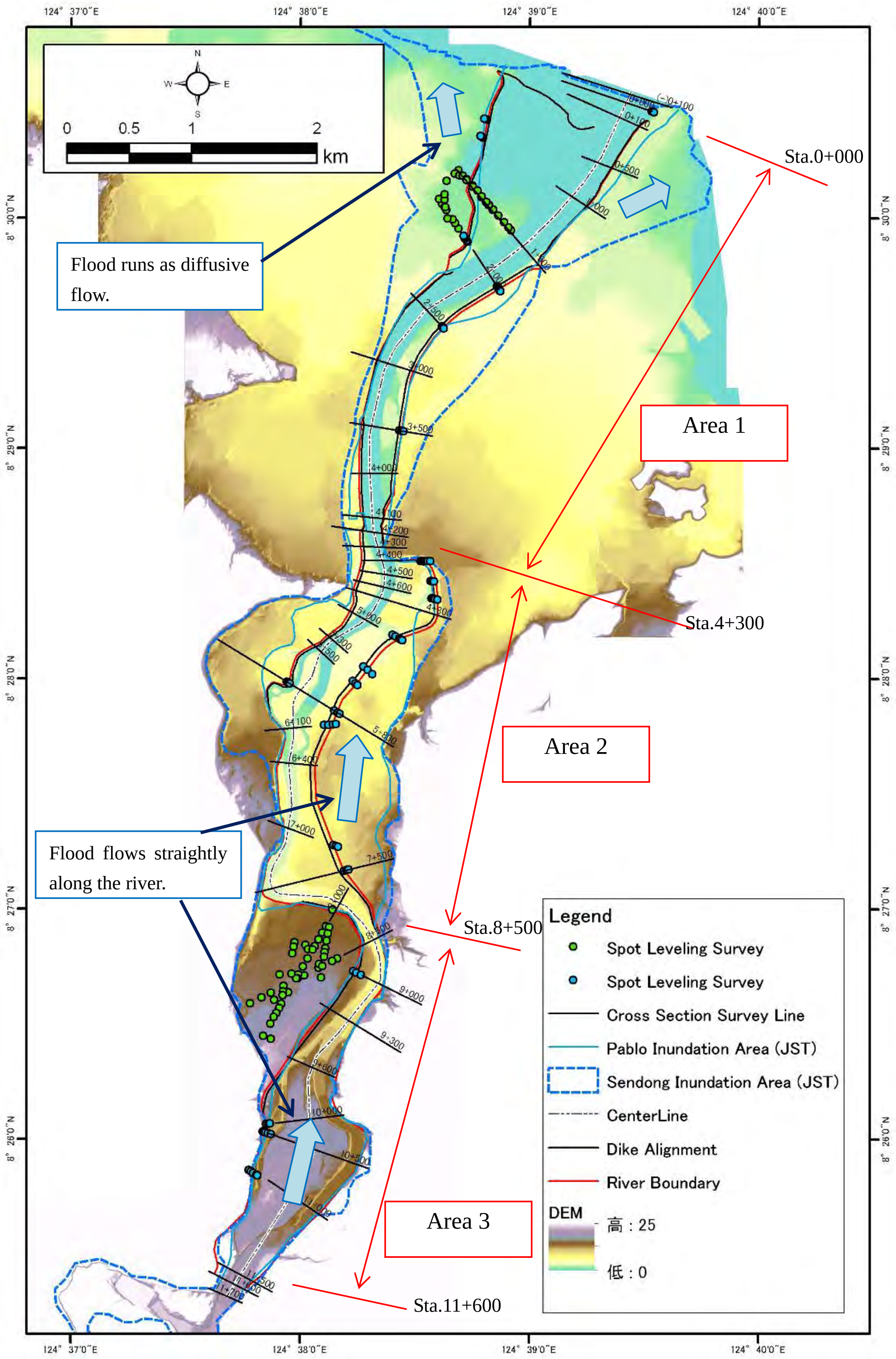
<Area 3 from Sta.8+500 to Pelaez Bridge>

The longitudinal slope is steep as around 1/250 from upstream of Sta.8+500. Therefore, the cross section and flood plain is narrow. Flood flow is presumed to be a straight-line.



Source: JICA Survey Team

Figure 3.5.2 Profile of River Mouth to Pelaez Bridge



Source: JICA Survey Team

Figure 3.5.3 Geography from River Mouth to Pelaez Bridge

3.5.4 Inundation Analysis

Inundation analysis model in the downstream area of the Cagayan de Oro River was formulated through calibration based on the actual results of flood inundation during TS Sendong and TY Pablo. The established inundation analysis model was used to simulate extent of inundation area and inundation depth to estimate the flood damages in the affected area.

(1) Objective Area

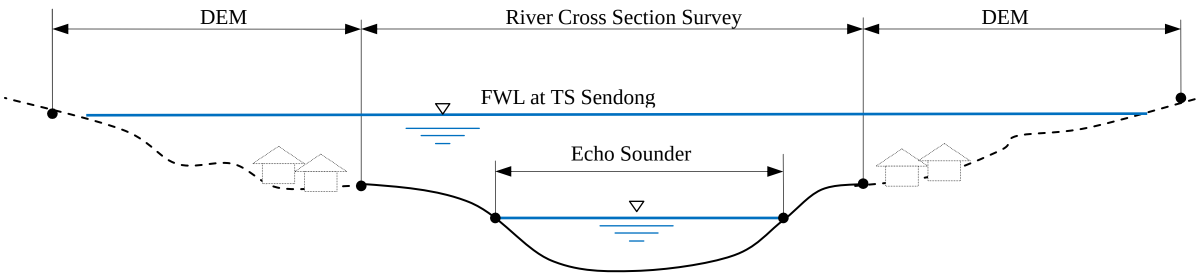
The objective area of the inundation analysis is the downstream stretch of the Cagayan de Oro River from the river mouth to the Pelaez Bridge located at Sta.11+600.

(2) Inundation Analysis Model

The flood inundation type in the objective area is basically classified into “flowing down type”. Hydraulic characteristics of the flowing down type flood inundation can be simulated adopting a one-dimensional hydraulic analysis model. In this study, the inundation analysis model is applied the one-dimensional unsteady flow analysis model of the HEC-RAS (Hydrologic Engineering Center - River Analysis System) which is currently being used by various agencies in the nation-wide of the Philippines .

(3) Cross Section Data

The 37 cross sections data surveyed in this study in November 2012 are used for the inundation analysis model. Since the river cross section survey was conducted along the river channel, topographic data in the inundation area located outer side of the extent of the river cross section is generated from the DEM which was prepared based on the contour data of the latest topographic map with 1/1000 scale prepared in the Survey. The extent of cross section is set up to the flood inundation area during the TS Sendong. The cross section model is presented in figure below:



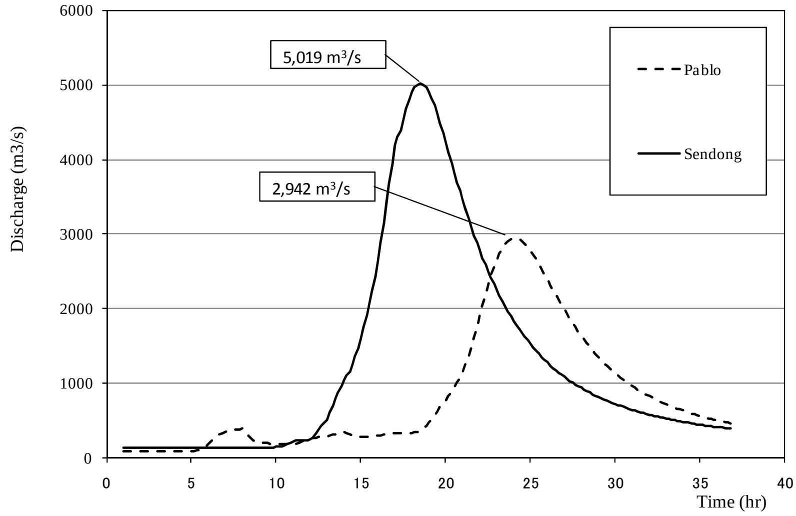
Source: JICA Survey Team

Figure 3.5.4 Method of Preparation of Cross Section Data for Inundation Analysis

(4) Conditions of Runoff

1) Storm Discharge in the Basin (Storms of Pablo and Sendong)

Actual flood hydrographs recorded at typhoon Pablo and tropical storm Sendong are used for study on the design hydrograph in the Cagayan de Oro River basin. Design flood hydrograph is assumed based on basin rainfall - runoff analysis at Kauswagan Bridge in Cagayan de Oro City, which need to be derived from the rainfall – runoff model because flood water level has not been measured in the study area.

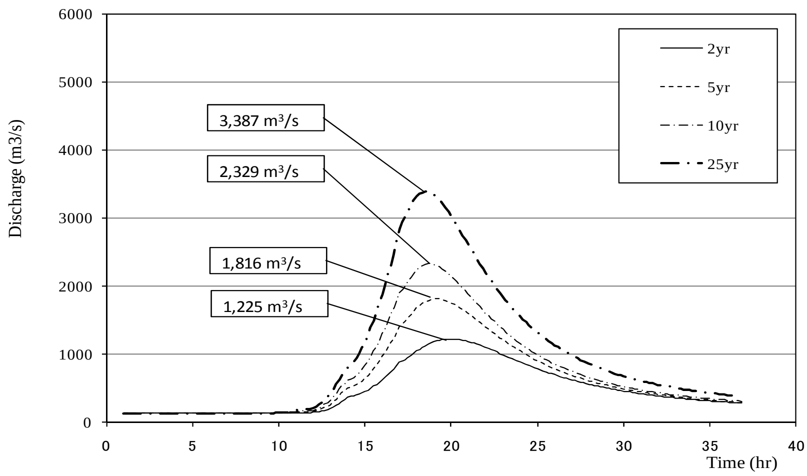


Source: JICA Survey Team

Figure 3.5.5 Flood Hydrographs of TS Sendong and TY Pablo at Kauswagan Bridge

2) Design Storm Discharge in the Basin (Discharges by Flood Return Period)

River channel improvement plan is formulated under the design flood discharge of 25-year return period. Accordingly one dimensional non-steady flow analysis should be conducted based on design hydrograph derived through rainfall-runoff analysis at the Kauswagan Bridge, in which four (4) cases of flood discharges of 2-year, 5-year, 10-year and 25-year return period are used for the study.



Source: JICA Survey Team

Figure 3.5.6 Probable Flood Hydrographs at Kauswagan Bridge

(5) Other Conditions

1) Roughness Coefficient

The following roughness coefficients (n) are applied for the runoff analysis referring to design standards of DPWH and HEC-RAS.

Table 3.5.3 Roughness Coefficient (n)

General Classification		n
1	River Channel（Sta.0+000 - Sta.4+800）	0.030
	River Channel（Sta.5+000 - Sta.11+700）	0.035
2	Sand bar with vegetation	0.055
3	Flood plain with grass/brush	0.045
4	Flood plain with medium to dense houses and buildings	0.090

Source: JICA Survey Team

2) Tide Level

Measured tide level is applied for runoff / hydraulic analysis on storm discharges of Sendong and Pablo. On the other hand, average high tide level (mean sea level of MSL=1.01m) should be applied for runoff analysis in each flood return period.

3) Ineffective Flow Area

Ineffective flow area is set by five (5) degree and twenty six (26) degree for rapid-enlarge and rapid-contraction to ordinary-river flow respectively.

The ineffective flow areas and roughness coefficient at each river cross section for the runoff analysis are shown in Chapter 6 of Appendix C.

(6) Results of Inundation Analysis for TS Sendong and TY Pablo

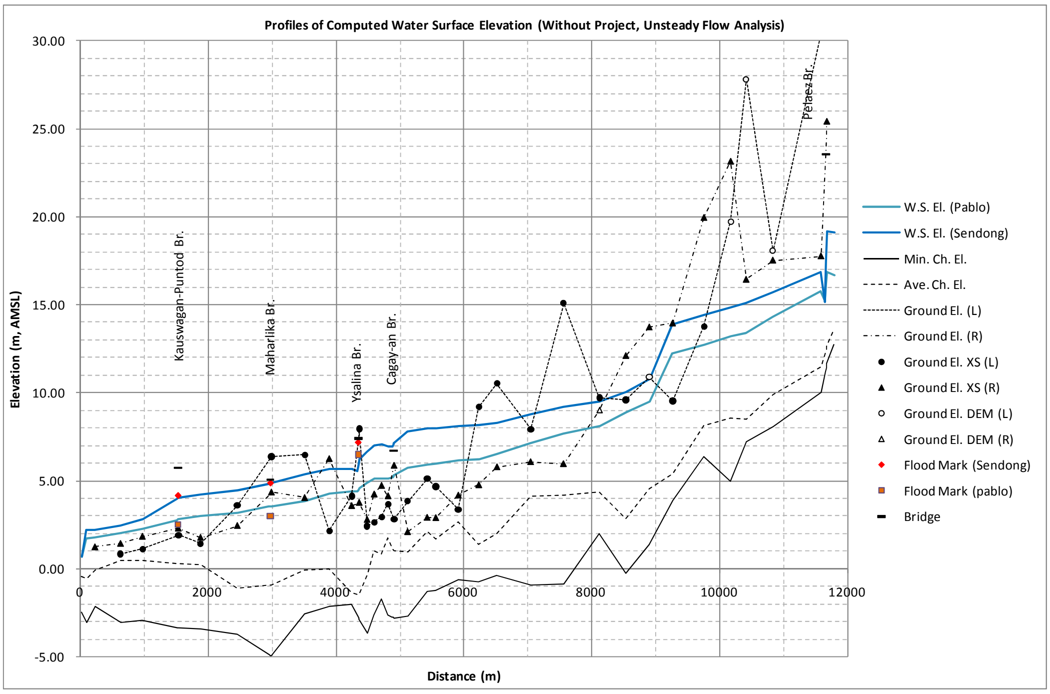
Figure 3.5.7 shows the estimated water level distribution during typhoon Sendong and Pablo, in addition Figure 3.5.8 shows the estimated inundation depths during typhoon Sendong, and Figure 3.5.9 shows that of Pablo.

The analysis was done with one dimensional hydraulic calculation. Therefore, inundation depth rank map was made by the following method.

1) Water levels at any point on the survey lines are estimated with linear interpolation based on the calculated values on the survey lines. The format of the dataset is a meter mesh.
2) Inundation depths are obtained from calculating the difference between the water level derived in 1) and the ground elevation (DEM).
3) Inundation depth distribution of each occurrence frequencies for estimating damages is a meter mesh. It is obtained by averaging inundation depths above.

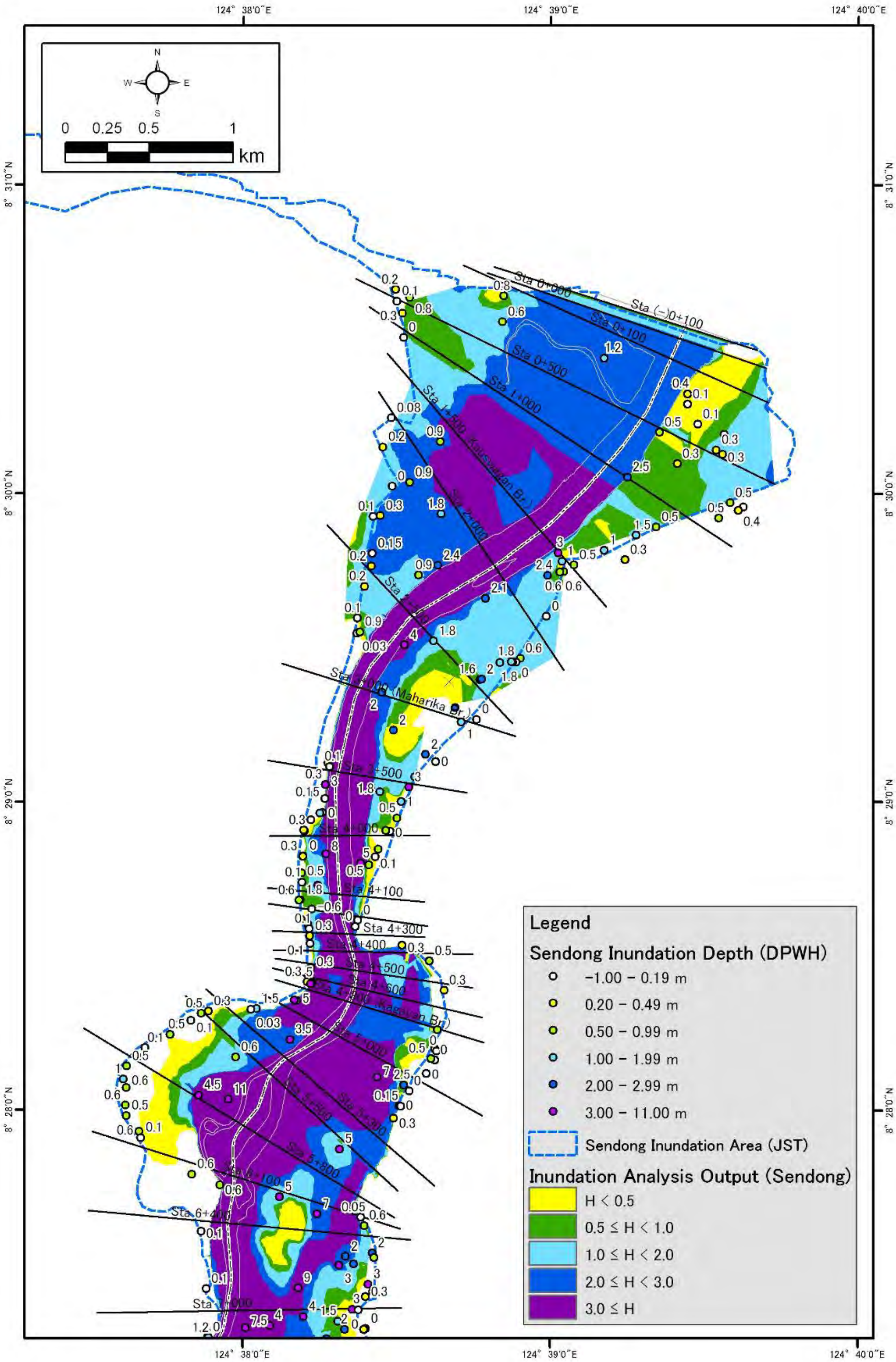
In the case of Sendong Analysis, the estimated water levels are consistent with flood marks between Kauswagan Bridge and Maharika Bridge, while they are about a meter lower than them at Ysalina Bridge. The estimated inundation depths are consistent with the results of the survey about the actual past inundation areas and depths. However, they tend to be higher than actual above the Ysalina Bridge, while they do lower than actual below it.

In regard to Pablo Analysis, the trend is as same as Sendong Analysis. The estimated water levels are consistent with flood marks between Kauswagan Bridge and Maharika Bridge, while they are about a meter lower than them at Ysalina Bridge. The estimated inundation depths are consistent with the results of the survey about the actual past inundation areas and depths. However, they tend to be higher than actual above the Ysalina Bridge, while they do lower than actual below it.



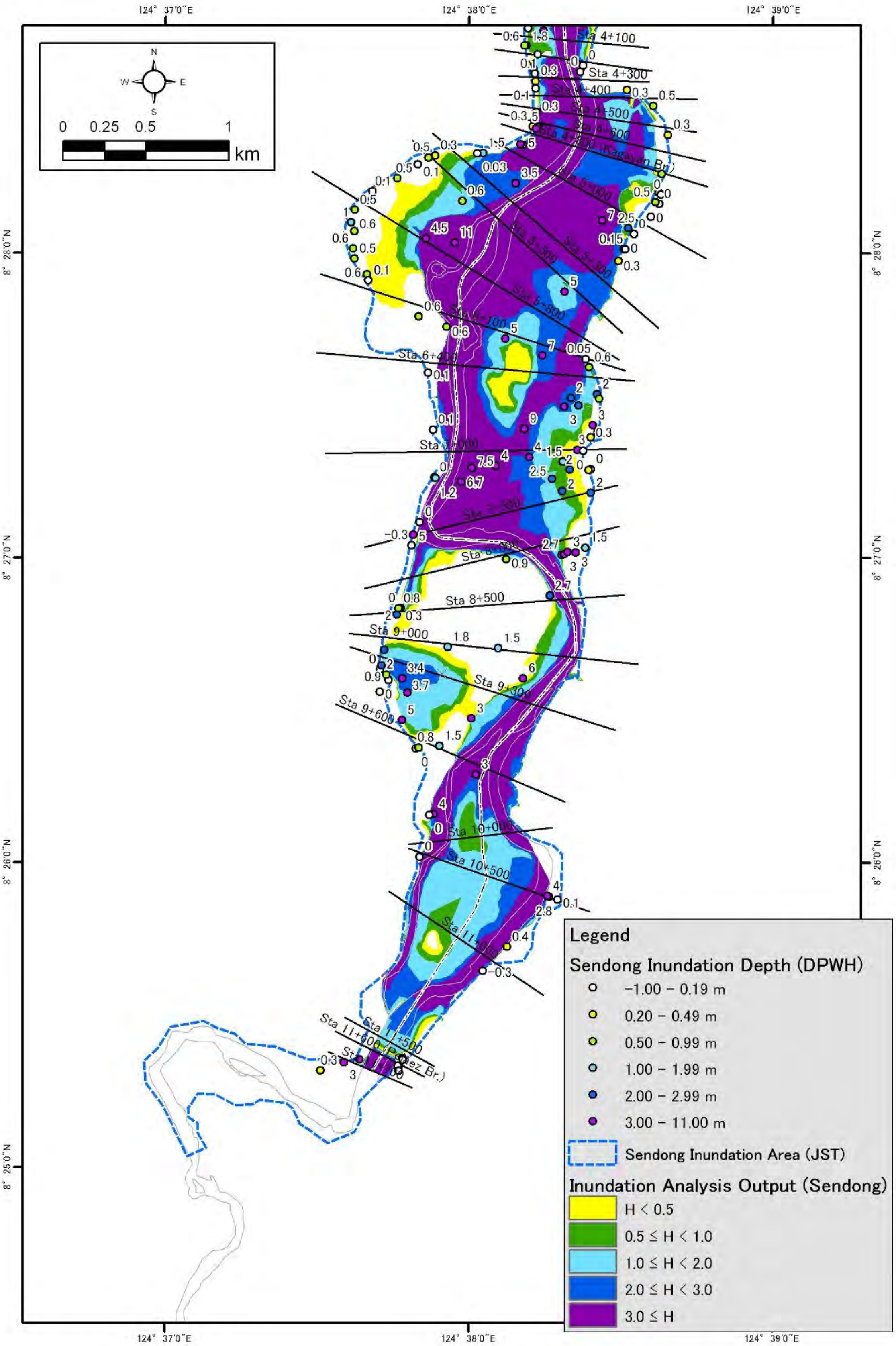
Source: JICA Survey Team

Figure 3.5.7 Estimated Water Level Distributions of TS Sendong and TY Pablo



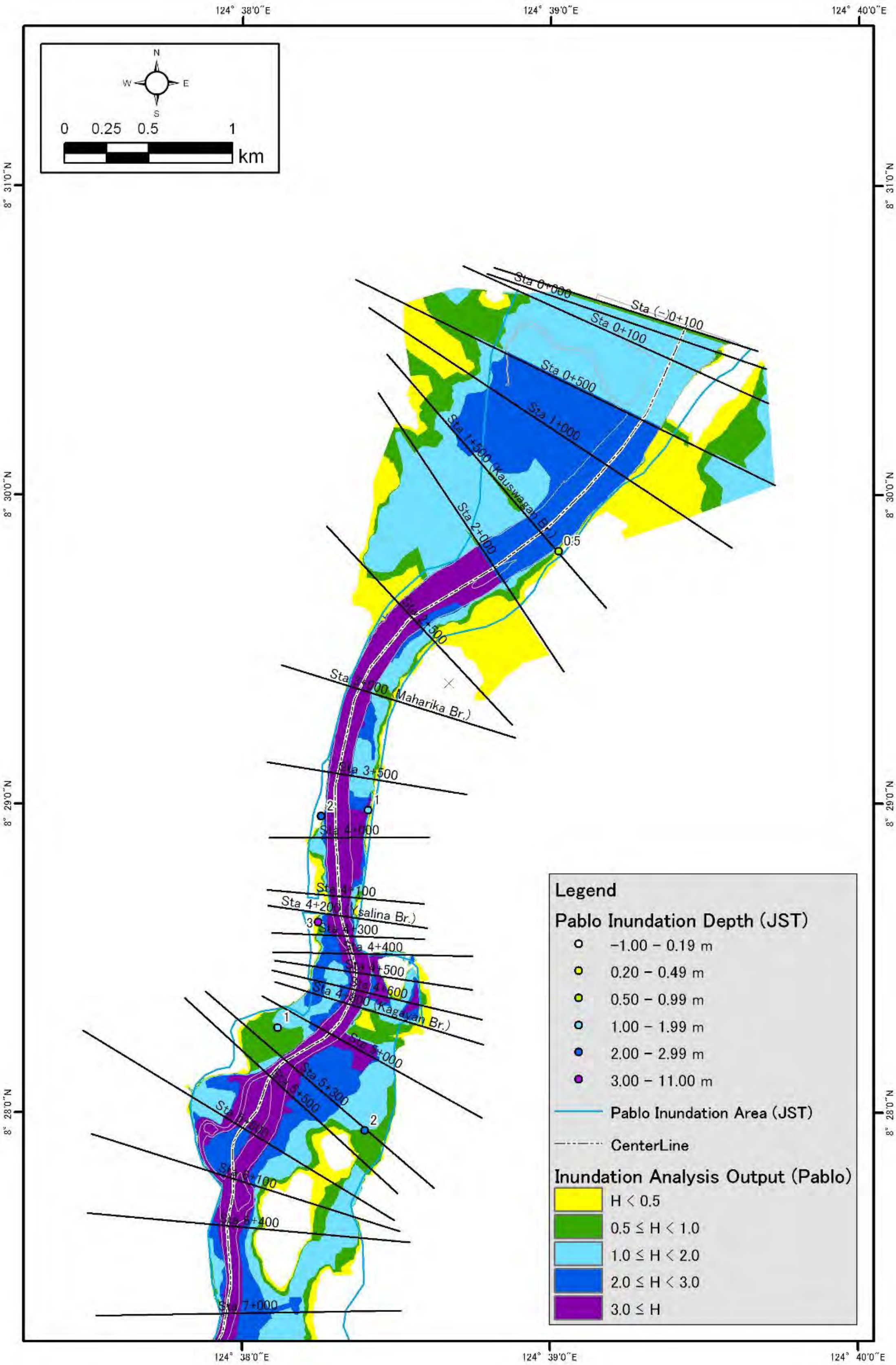
Source: JICA Survey Team

Figure 3.5.8 Estimated Inundation Depth of TS Sendong (1/2)



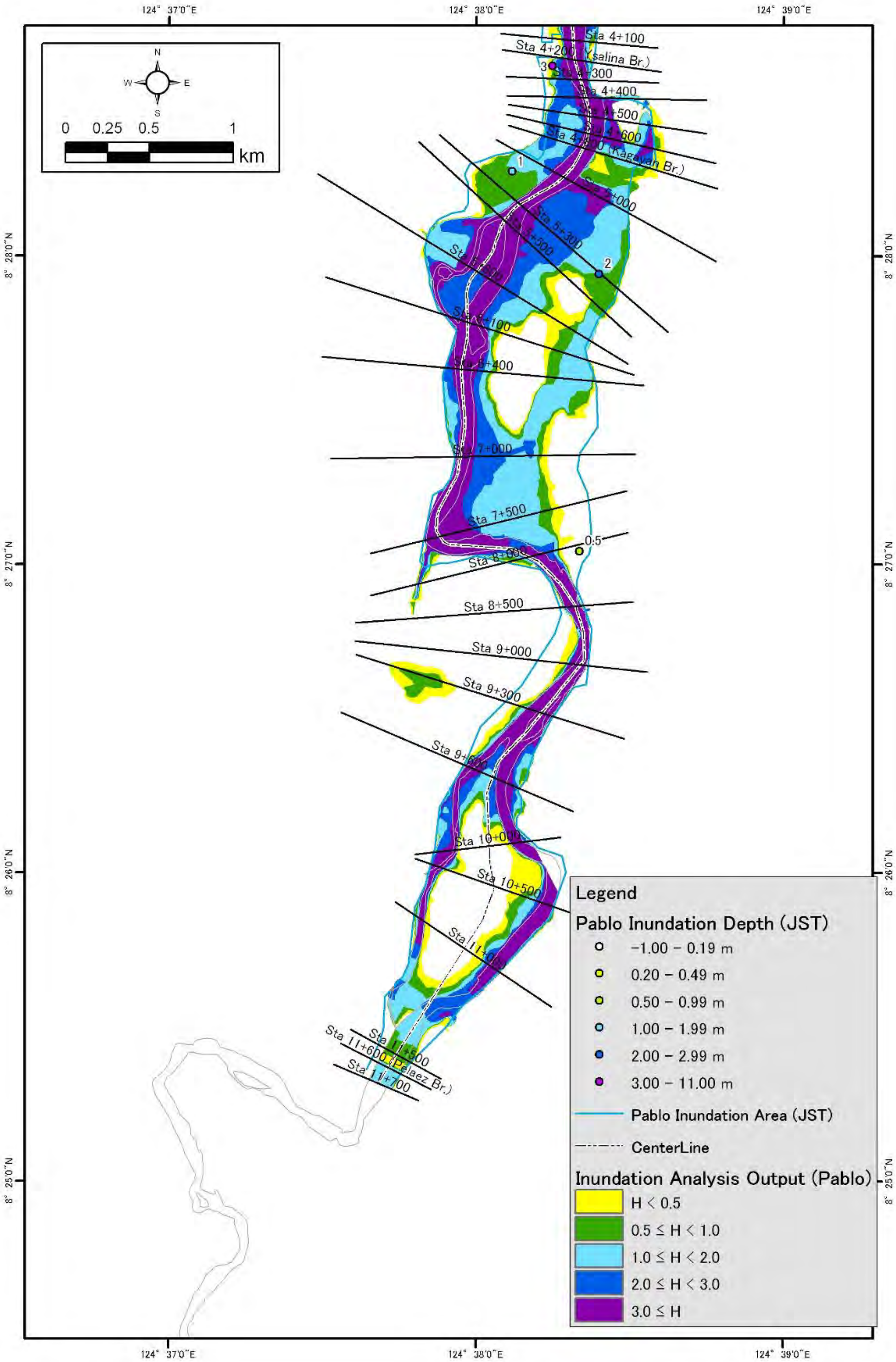
Source: JICA Survey Team

Figure 3.5.8 Estimated Inundation Depth of TS Sendong (2/2)



Source: JICA Survey Team

Figure 3.5.9 Estimated Inundation Depth of TY Pablo (1/2)



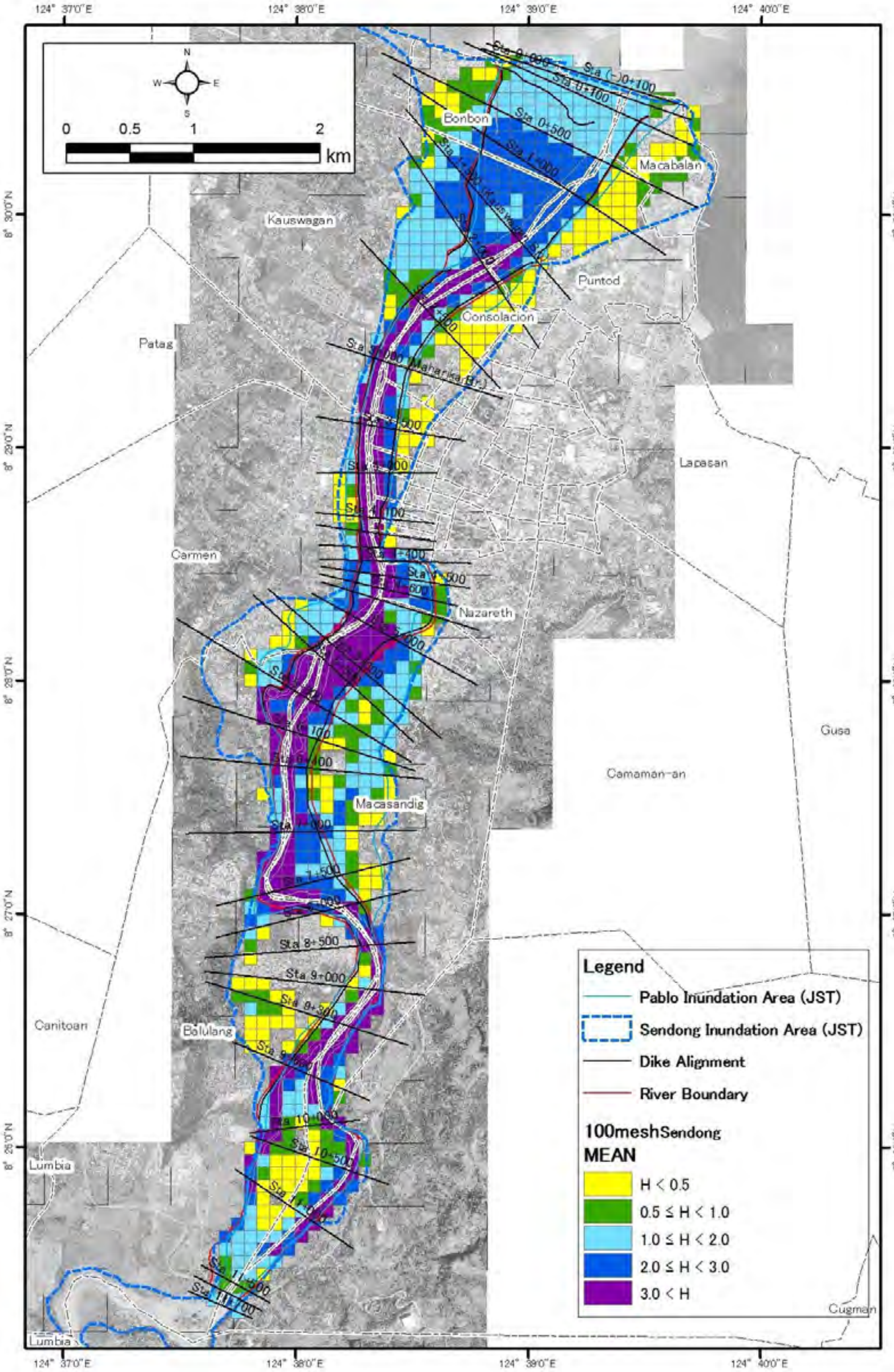
Source: JICA Survey Team

Figure 3.5.9 Estimated Inundation Depth of TY Pablo (2/2)

(7) Result of Flood Inundation Analysis

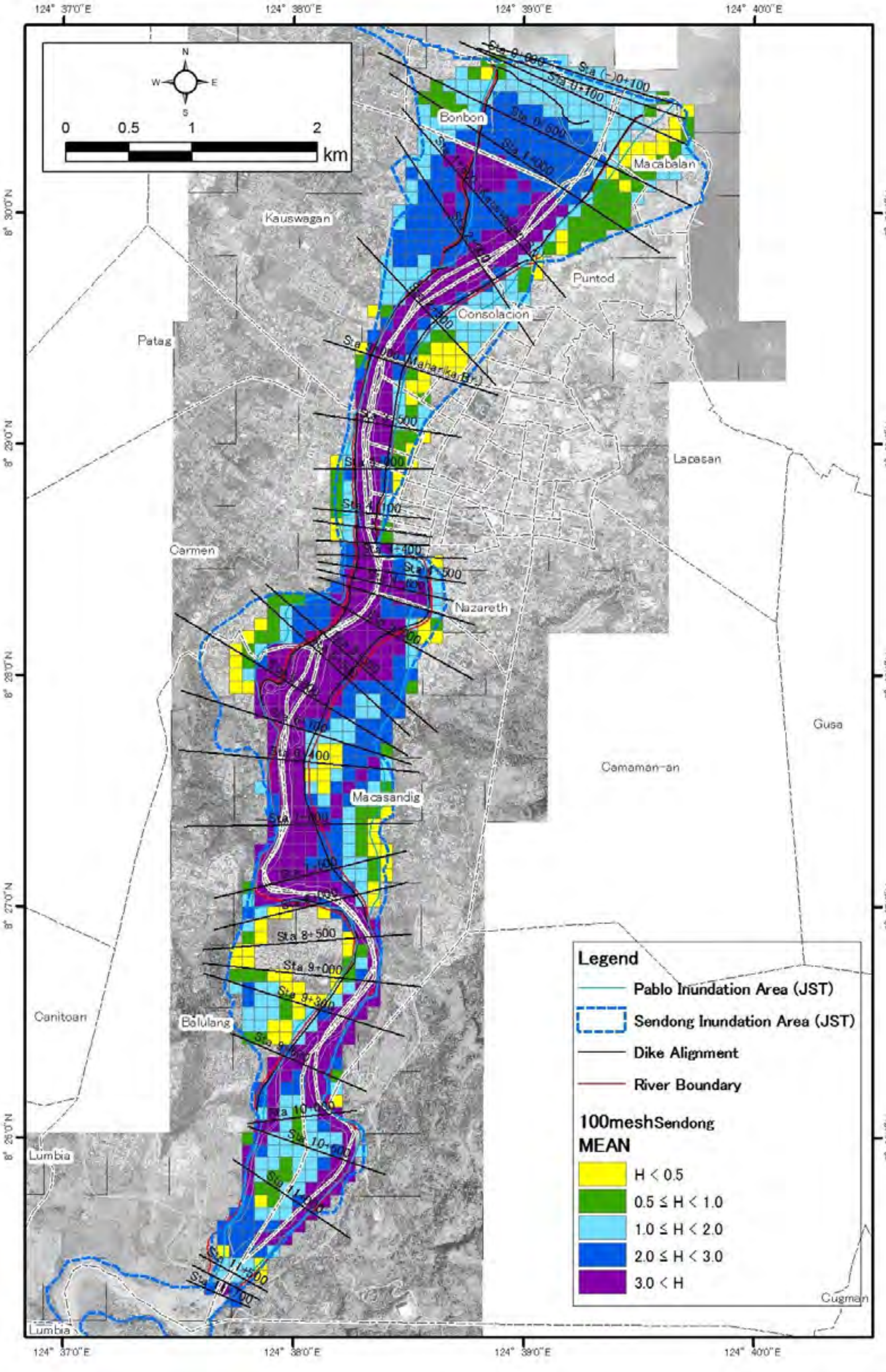
In Economic Analysis mentioned later, the inundation depth (H) is evaluated per 100 m squares and classified into five (5) ranks of i) H<0.5m, ii) 0.5m≦H<1.0m, iii) 1.0m≦H<2.0m, iv) 2.0 m≦H<3.0m and v)3.0 m ≦H. The inundation maps of 1/25 and 1/50 probable flood used for the economic analysis are shown in Figure 3.5.10, respectively. The inundation maps of probable floods of 1/2, 1/5 and 1/10 are presented in Chapter 6 of Appendix C.

Comparing the results of inundation analysis with the actual inundation areas of TY Pablo and TS Sendong, the inundation areas of 1/50 probable flood is simulated well that of TS Sendong, and the inundation area of 1/25 probable flood is a little bigger than that of TY Pablo corresponding to the difference of the discharge.



Source: JICA Survey Team

Figure 3.5.10 Result of Inundation Analysis for Each Design Scale Alternatives (25 years)



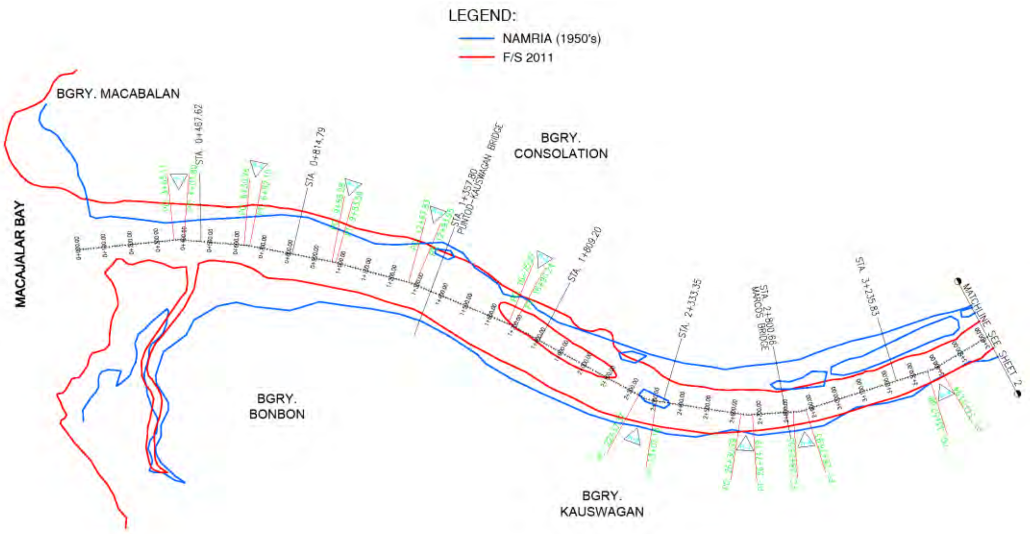
Source: JICA Survey Team

Figure 3.5.10 Result of Inundation Analysis for Each Design Scale Alternatives (50 years)

3.5.5 Study for Riverbed Movements

(1) Present situation of sedimentation in river mouth

The figure below shows the historical change of the river mouth of the Cagayan de Oro River comparing with the topographic maps prepared by NAMRIA in 1950's and in 2011. The coastal line adjacent of the river mouth is moving toward the Macajalar Bay with development of the delta.



Source: JICA Survey Team

Figure 3.5.13 Historical Change of River Mouth in Cagayan de Oro River

The aerial photo of the river mouth indicates the turbidity water from the river penetrating into the river mouth. According to the local sand mining operators and local residents during the site reconnaissance, it was informed that the riverbed in the downstream of the river is getting shallower than the previous situation. The staff of the Port Authority and a chief of pilot who have worked in this area since long before mentioned that the ship could voyage along the coastal side but it is impossible at present due to development of shallow areas along the coastal line. They also stated that the periodic maintenance dredging is being conducted at the harbor in the port located at around 1 km east of the river mouth.

Source: PARASAT

Figure 3.5.14 Aerial Photo of River Mouth of Cagayan de Oro River (taken after TY Pablo in January 2013)

(2) Existing Data of Cross Section Survey

1) Existing Data

River cross section surveys along the Cagayan de Oro River were conducted three times since 2011, including the second and third ones carried out in the Survey.

The location map of these cross section surveys is presented in Figure 3.5.15.

Table 3.5.4 Cross Data of Cross Section Survey

Cross Section Survey	Date of Survey	Survey Area, Bench Mark	Status
Previous F/S in 2011 By DPWH	April –June, 2010	BM: NAMRIA BM5 (+2.677 m above MLLW*) Cross Section： 28sections	Before TS Sendong
This Survey By JICA	October – November , 2012	BM: NAMRIA Tidal Gauge at CDO port (above MSL) Longitudinal Profile：12 km Cross Section：38 sections	After TS Sendong, before TY Pablo
This Survey By JICA	July –August, 2013	BM: NAMRIA Tidal Gauge at CDO port (above MSL) Longitudinal Profile：12 km Cross Section：38 sections	After TY Pablo

Source: JICA Survey Team

2) Comparable Sections

Since there is a discrepancy on the survey datum and alignment of survey section in 2011 comparing with the ones in 2012 and 2013, it is judged that some cross sections in 2011 cannot be used for comparison. The comparison of cross section is presented in Appendix A.

(3) Assessment of riverbed variation based on cross section data

The riverbed variation from the river mouth to the Pelaez Bridge was assessed comparing with the results of cross section surveys between 2012 and 2013. In this period TY Pablo hit the area. The trend of riverbed variation in this stretch in this period is presented in the table below:

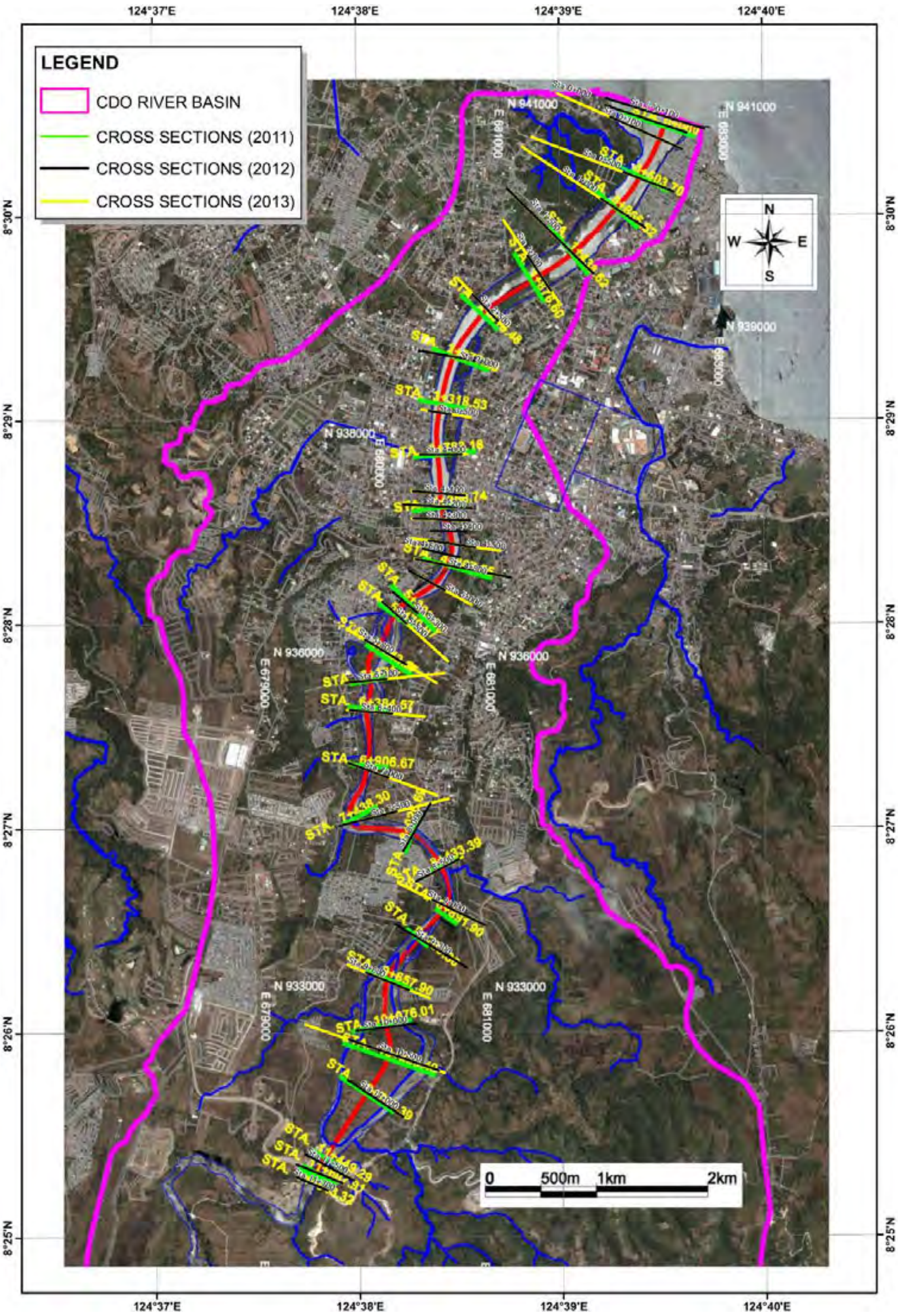
Table 3.5.4 Trend of Riverbed Variation from 2012 to 2013 in the Downstream of the Cagayan de Oro River

Sta. No.	Date	Remarks
Sta.0+500～3+000	2012→2013	Aggradation of riverbed
Sta.3+500	2012→2013	Change of river cross section due to construction of Borja Bridge
Sta.4+000～4+800	2012→2013	Degradation of riverbed Possibility of local scouring at Ysalina and Kagay-An Bridges
Sta.5+500～7+500	2012→2013	Degradation of riverbed
Sta.8+000～10+000	2012→2013	Minor change (almost stable)

Source: JICA Survey Team

- In the downstream of the river from Sta.0+500 to Sta.3+500, the riverbed aggradation is observed. This is corresponded to the result of interview to the local residents and sand mining operators.
- At Ysalina and Kagay-An Bridges, local scouring might be happened surrounding area of the piers at the time of TY Pablo.

- The riverbed variation in the downstream is affected by the sand mining activities in this area. DPWH Region 10 is conducting minor dredging works in this area, and the dredged materials are disposed onto the spoil bank yard located at left bank of the river mouth. The disposed volume is roughly estimated at around 60,000 -90,000m^3 (2-3 ha x 3 m in height). According to DPWH Regional X office, total volume of the dredging works was about 75,000 m^3 for three months from September to November, 2012 and they intermittently continue dredging due to budget constraint.



Source: JICA Survey Team

Figure 3.5.15 Location Map of Cross Section Surveys in 2011, 2012 and 2013

(4) Assessment of riverbed variation based on longitudinal section

Longitudinal profiles of the river channel are generated based on the river cross survey data in 2011, 2012 and 2013 mentioned in the above. They are superimposed each other to asses historical variation of riverbed profile in the Cagayan de Oro River. The longitudinal profile is presented in figure in the next page.

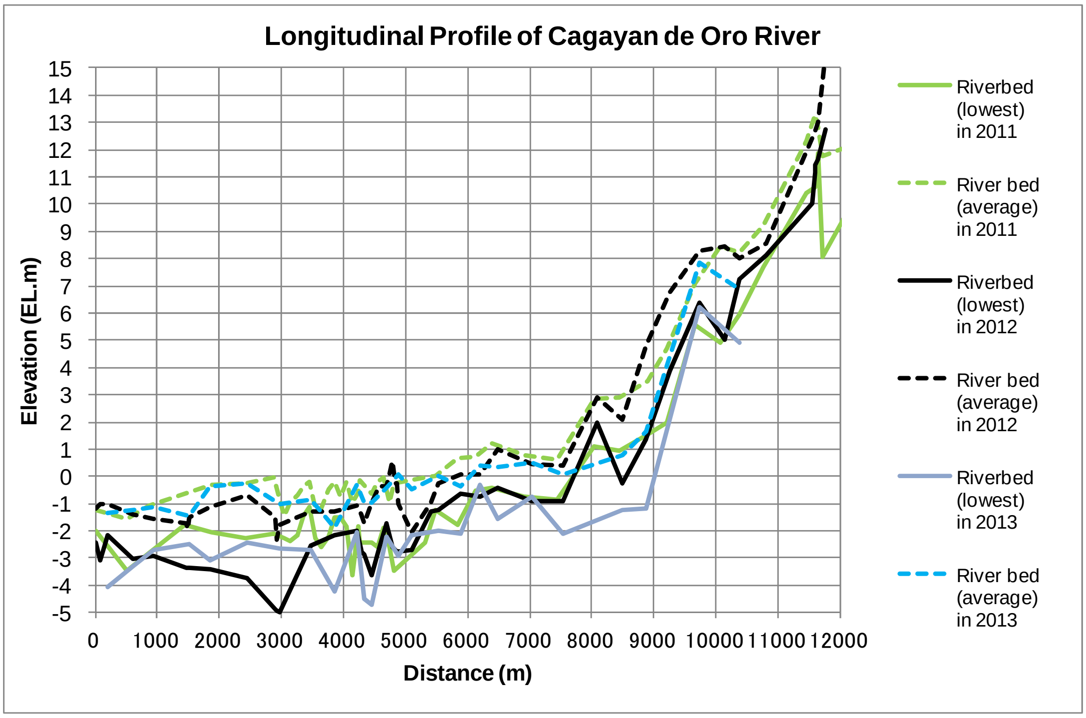
Table 3.5.5 Trend of Riverbed Variation from 2011 to 2013 in the Downstream of the Cagayan de Oro River

Sta. No.	Historical change	Remarks
Sta.0+000～1+500	2011-2013	● Average riverbed level is almost stable ● Lowest riverbed profile shows degradation in the downstream stretch. This is considered due to DPWH dredging works.
Sta.1+500～3+000	2011-2013	● 2011→2012 riverbed degradation by 0.5-1.0 m ● 2012→2013 riverbed aggradation by about 0.5 m ● At Maharika Bridge (Sta.2+800) from 2011to 2012, the lowest riverbed was lowered by about 2m. It is considered due to local scouring.
Sta.3+000～5+000	2011-2013	● 2011→2012 riverbed degradation by about 0.5 m ● 2012→2013 Almost stable ● Lowest riverbed level at Sta4+000 from 2012 to 2013 was lowered by about 2 m. This is caused by excavation of riverbed materials undertaken by the on-going construction of the Borja Bridge
Sta.5+000～9+000	2011-2013	● Average riverbed profile from 2011 to 2012 shows local degradations. These are caused by sand mining activities, and considered by local scouring over sandbars and flood plains during Sendong. ● Lowest riverbed profile in the stretch from Sta.7+500-9+000 shows large riverbed degradation from 2012 to 2013. This is caused by active sand mining works in Calacala area.
Sta.9+000～11+600	2012→2013	● Average riverbed level is almost stable ● Riverbed profile in the stretch from Sta.9+000-10+000 shows large riverbed degradation from 2012 to 2013. This is caused by active sand mining works in Calacala area.

Source: JICA Survey Team

As the result of comparison of cross sections and longitudinal profiles, there is a tendency of riverbed degradation in the downstream stretch from Sta.0+000 – Sta.5+000 from 2011 to 2012. It is considered that it have been caused by a large scale of flushing of riverbed materials during TS Sendong flood with about 50 year return period.

On the other hand, from 2012 to 2013 the riverbed was aggregated in this stretch. Between these periods, though a flood of TY Pablo occurred resulting minor flushing of the riverbed materials, continuous sediment deposition might have been surplus than the flushing by Pablo. The trend of riverbed aggradation is corresponding with the result of hearing about sedimentation in the downstream stretch. Sediment deposition volume in the stretch from Sta.0+000 to Sta.5+000 from 2012 to 2013 is preliminary estimated at around 162,000 m^3 as per comparison of the cross section data.



Source: JICA Survey Team

Figure 3.5.16 Comparison of Longitudinal Riverbed Profile in 2011, 2012 and 2013

(5) Study for deepening of river channel in the downstream of the river

Channel excavation/dredging in the downstream of the river is one of the measure to increase flow capacity of the channel but not effective in the downstream stretch due to tide level and sedimentation. It will be difficult to maintain the deeply dredged sections due to sediment transportations from the upstream basin and coastal areas. Therefore, it is no recommended to implement channel dredging and excavation in the Master Plan.

(6) Study for removal of sandbars in the downstream of the river

The case study to evaluate the impact of removal of a large sandbar at Sta.2+000 in the downstream of the river was conducted. As the result, it was tuned out that the removal of the sandbar can decrease flood water level in the upstream by around 10 cm. However, the flood water level of 25-year return period without removal of the sand bar is able to be kept lower than the established DHWL. In addition, the removal of sandbar would affect natural environmental conditions in and surrounding area of the sandbar. Taking into consideration of above, the removal of the sandbar is not recommend in the Master Plan and will remain as it is.

(7) Necessity of periodical maintenance dredging in the downstream river and river mouth

As mentioned above, deepening of channel in the downstream river is not recommendable option. However, siltation in the downstream of the river is a trend of the Cagayan de Oro River. Visible sediment depositions occur over the river mouth and in downstream of the river. Instead of deepening of the river channel, periodic monitoring of channel cross section is proposed and regular maintenance dredging/channel excavation is recommended to remove sediment deposition.

(8) Riverbed Fluctuation Analysis

1) General

Riverbed fluctuation analysis model is preliminary set up aiming at simulating riverbed movement in the downstream stretch from the river mouth to the Pelaez Bridge. Theoretical basis is presented in Appendix C, Chapter 6. The HEC-RAS 1-D hydraulic model is employed for riverbed fluctuation analysis as the same as the inundation analysis as mentioned in the above.

2) Sediment Grain Size Analysis

The input data for the sediment discharge computation are the water properties (e.g. temperature, unit weight, kinematic viscosity etc) and sediment properties such as D_n, (n = 10%, 35%, 50%, 65% or 90%) and specific gravity which usually is in the range of 2.5 to 2.7. The particle diameter values are obtained from the particle grain size analysis that was undertaken for the CDO River at specific locations of the reach in this Survey as mentioned in previous section 3.3.

3) Sediment Load from Upstream Basin

Periodical sampling of suspended sediment is conducted at the Cabula Bridge within the Cagayan de Oro basin for 12 years from 2001 to 2012. In addition that, there are four (4) sampling sites (Cabulig, Alubijid, Iponan and Damilag) in surrounding area of the Cagayan de Oro River basin. Location map of these sampling sites of suspended sediment is presented in figure below.

Figure 3.5.17 Location Map of Suspended Sediment Sampling in Region X

Sediment rating curve (relation between discharge and suspended sediment load) were created to preliminary estimate the sediment load from the upstream basin referring to the data of three stations, Cabula, Albujid and Damilag those have more available data in the past record. The rating curve is presented in Figure 3.5.18.

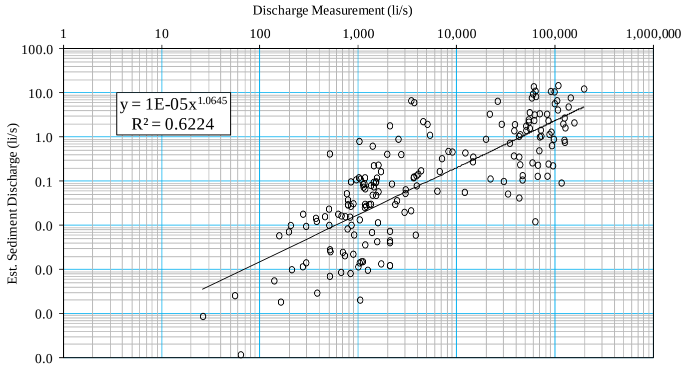


Figure 3.5.18 Relation between Discharge and Suspended Sediment Load (3 sites)

4) Boundary Condition of Discharge

The boundary condition of discharge is given at the Pelaez Bridge. Long term discharge data at the Cabula Bridge is properly recorded from 1991 to 2012 which is calculated from the water level observation data adopting discharge rating curve. The discharge at the Pelaez Bridge can be estimated based on the specific discharge of the Pelaez Bridge.

5) Other Conditions

Other conditions for the riverbed fluctuation analysis are same as the inundation analysis as mentioned in the previous section.

6) Calibration

Existing river cross section survey data of 2012 and 2013 are referred to a calibration of the riverbed fluctuation analysis model. A dry run for the calibration was conducted adopting daily discharge data from 2012 and 2013 for the boundary condition. The result of dry run is presented in the figure below.

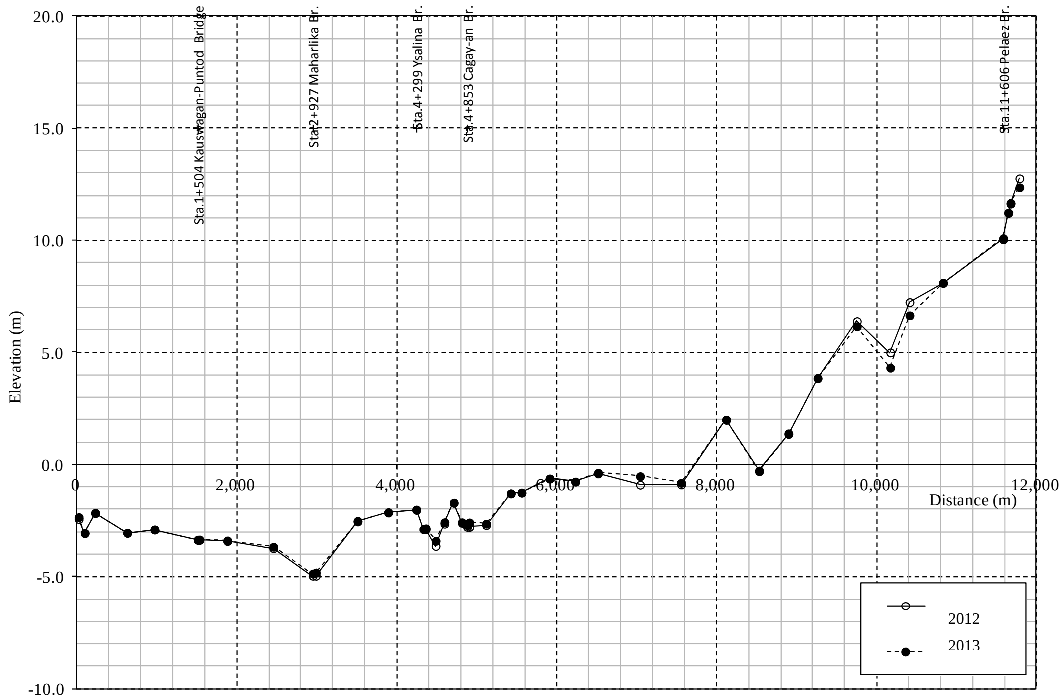


Figure 3.5.34 Simulated Riverbed Profile (2012 – 2013)

The simulated riverbed profile is almost stable in this period and minor scouring is observed at the Maharika and Ysalina Bridge sections and Sta.10+500 while riverbed aggradation is occurred in Sta.7+000. The result of the dry run could not simulate the actual sediment deposition in the downstream stretch as shown in the comparison of existing river cross section data mentioned in the previous sub-section and is not consistence with the actual trend of riverbed fluctuation. One of the reasons of inconsistency is quality and quantity of sampling data of the suspended sediment. The riverbed fluctuation analysis is very sensitive on input condition of the sediment discharge given at the upstream boundary. Due to lack of data for suspended sediment during floods, all discharge data at the time of sampling is less than 200 m^3/s. Hence, it is considered that sediment discharge and grain size distribution of the suspended sediment are not estimated exactly.

Annual sediment discharge from the upstream basin is preliminary estimated by using the said sediment rating curve and available discharge data from 1991 to 2012. It is estimated at about 260,000 m^3/year. On the other hand, annual sediment yield in the Cagayan de Oro River basin can be roughly estimated at 1,300,000 – 2,700,000 m^3/year. It is considered that the sediment discharge derived from the sediment rating curve is underestimated due to constrain of accuracy of the sediment rating curve. In order to improve the riverbed fluctuation analysis model in the Cagayan de Oro River, it is recommended to continue suspended sediment sampling particularly during floods and to conduct periodical river cross section survey to monitor actual riverbed fluctuation.

3.6 Study on Sediment Movement Characteristics and Sabo Facilities

3.6.1 Activity of the Sediment Production in the Present Stage from the perspective of topography

(1) Outline of Topography and Geology

The topography of Cagayan de Oro River watershed has a characteristic of volcanic topography. The headwater of watershed is located in the mountains consisting of volcanoes which are not active at present. And one of the topographic characteristics is the broad and gentle slope which consists of the volcanic deposits and the terraces.

Metamorphic rock of Pre-Cretaceous, and ultrabasic rock of Cretaceous, and pelitic schist and granodiorite after Cretaceous are distributed as bedrock. Tertiary period sedimentary rocks, which consist of conglomerate and mudstone, mainly of limestone, form hilly area over bed rock.

(2) Historical Development of Landform

This watershed is presumed that a large amount of pyroclastic material, welded tuff and basaltic lava flowed out around the foot of the mountain in the Late Holocene of Quaternary (approx. 1~2, million years ago).

Pyroclastic flow, volcanic mud flow and volcanic ash were deposited in Quaternary Pleistocene – Holocene (approx. 1~0.006, million years ago). After that, a large amount of sediment flows out toward the lowland or shallow sea.

After the last ice age, in Holocene era begun from about 12,000 years ago, the temperature rose a little by little, especially in the Holocene climatic optimum called Hypsithermal which is a warm period existed during 5,000 to 7,000 years ago, a lot of sediments are considered to have flowed out toward the downstream by erosive action involving sediments which had been produced in the ice age. As a result, a large amount of sediments were deposited around the coast. After that, as the sea level dropped gradually, the terraces were formed along the sea and the river.

The present erosion stage is considered to be the condition in which the erosion front had progressed already to the upstream. In other words the activity of sediment production is presumed to be the lowest condition in the Holocene period.

3.6.2 Condition of the Sediment Production in the Cagayan de Oro River Watershed

(1) The Reality of Sediment Production before and after Sendong

1) Before Sendong

The mountain is covered by vegetation, therefore the obvious slope failures and debris flow deposits are not observed by satellite photos (Alos).

2) After Sendong

Phenomena confirming by aerial photos (orthophoto) and satellite photos (World view 2) are debris flow, slope failure, flood inundation by bed load transport and landslide. Outline of each phenomenon is summarized as follows.

a) Debris flow

Debris flow is confirmed at the left tributary (Bitanog river) which is located at the upstream from Uguiaban Bridge. The possibility which have flowed out to the downstream is low.

Slope failure

Small slope failures are scattered around the cultivated land (Bubunawan-DelMonte). There are almost no sediments which have flowed into the river.

Riverbed inundation

Riverbed inundations which are due to the bed load transport are confirmed in Bubunawan River and Tumalaong River locally. Effect on the downstream is small.

Landslide

Landslide is confirmed along the terrace cliff of the main river and the tributaries on the topographic map. Active landslides are not confirmed by photographic interpretation.

(2) Condition of Flood Deposit after Sendong

The investigation was conducted at the typical sites accessible on the Cagayan de Oro River and tributaries including Bubunawan River and Tumaraong River which were severely damaged due to Sendong.

1) Cagayan de Oro River

In upstream, the riverbed sediments which consisted of sand, cobble and boulder are observed, but the debris flow deposit is not observed. For this reason, the sediment movement form is presumed to be mainly bed load. A few amount of sediment movement was considered to be moved as shown after typhoon Pablo.

The area from the middle reach to downstream, the sediment movement form is considered to be changed from “bed load” to “suspended load”, “wash load”. In the Calacala area, the severe erosion action on the terrace surface was observed after typhoon Pablo as shown. As the flood energy is greater, the fine material is presumed to tend to flow out toward the sea as “wash load”.

2) Bubunawan River

In upstream, the riverbed sediments which consisted of sand, cobble and boulder are observed, but the debris flow deposit is not observed. For this reason, the sediment movement form is presumed to be mainly bed load. The sediment movement after Pablo is relatively obvious.

The sediment movement of the fine materials is one of the characteristics of the outflow in this river. The fine materials which are judged to be constantly flowed out every year from the cultivated fields on the plateau are considered to have a influence on the aggradation of riverbed of downstream. Especially, as the flood energy is greater, the fine material is presumed to tend to be flowed out toward the estuary and the sea as “wash load”.

3) Tumalaong River

In the middle reach of the river, the riverbed sediments which consisted of sand, cobble and boulder were observed, but the debris flow deposit is not observed. For this reason, the sediment movement form is presumed to be mainly bed load.

The sediment movement after Pablo is relatively obvious.

4) Bitanog River

Debris flow was stopped at the confluence of Cagayan de Oro River, but the main stream was not dammed up at that time. The sediments were presumed to have been safety flowed out gradually to downstream.

3.6.3 Sabo Facilities

(1) Fundamental Requirements

The fundamental requirements of structural measures are as follows.

i) The preservation of public and private properties such as schools, hospitals, roads, bridges, houses and cultivated lands.

ii) The disaster form is the sediment disaster due to landslide, slope failure and debris flow.

iii) The sediment production in the upstream is active, and the sediment disaster is concerned in the future.

iv) In the cases the repair is easy and the economic loss is small is not included. And the limited damages are also not included.

(2) Sediment Production and Discharge and Disaster Condition

The characteristics of the sediment production and discharge of the Cagayan de Oro River watershed are summarized as follows (Table 3.6.1) and criteria for assessment is presented in Appendix E.

Table 3.6.1 Condition of Slope Failure and Sediment Discharge

River	Condition of slope failure	Condition of sediment discharge	Condition of disaster	Effect to the downstream
Cagayan de Oro	A little	Sediments transported by bed load Gentle slope more than the zone of debris flow No trace of debris flow	Nothing	Low
Bubunawan	A little	Sediments transported by bed load Gentle slope more than the zone of debris flow No trace of debris flow	Nothing	Low
		Constantly outflow of fine materials	Nothing (Almost carried out every year from the Cepalco dam)	Largish (Aggradation of river bed around the estuary: require study)
Tumalaong	A little	Sediments transported by bed load Gentle slope more than the zone of debris flow No trace of debris flow	Nothing	Low
Bitanog	A little	Debris flow occurred	Embankment of the abutments are flowed out (locally)	Low

Source: JICA Survey Team

(3) Necessity of Check Dam

1) About Sediment Production and Discharge

The characteristics of the sediment production and discharge of the Cagayan de Oro River watershed are summarized as follows:

a) Slope failures are few in amount, and the sediment productivity is not active.

b) There are no objects that obviously need preservation in the upstream and middle reach of the river.

c) The flood disaster was seen, but the sediment disasters were not observed.

d) Including the significant aggradations of riverbed, the risk of sediment disaster is considered to be low in the future.

2) Necessity of Check Dam

The fundamental requirements are not satisfactory against Cagayan de Oro River, Bubunawan River, Tumalaong River and Bitanog River. Consequently the check dams are judged to be no need.

3.6.4 Issues of Outflow of Fine Material on the Sediment Management

The cultivated lands on the plateau are distributed vastly in the northern part of the Mt. Kitanglad, especially the cultivated lands were planted by pineapple, banana fields etc. The cultivated lands on the plateau are assumed to be the source area of the fine materials

The fine materials (wash load) will be mostly deposited around the estuary, which can cause not only riverbed aggradation but also impact to the sea's ecosystem.

3.7 Non-structural Measures

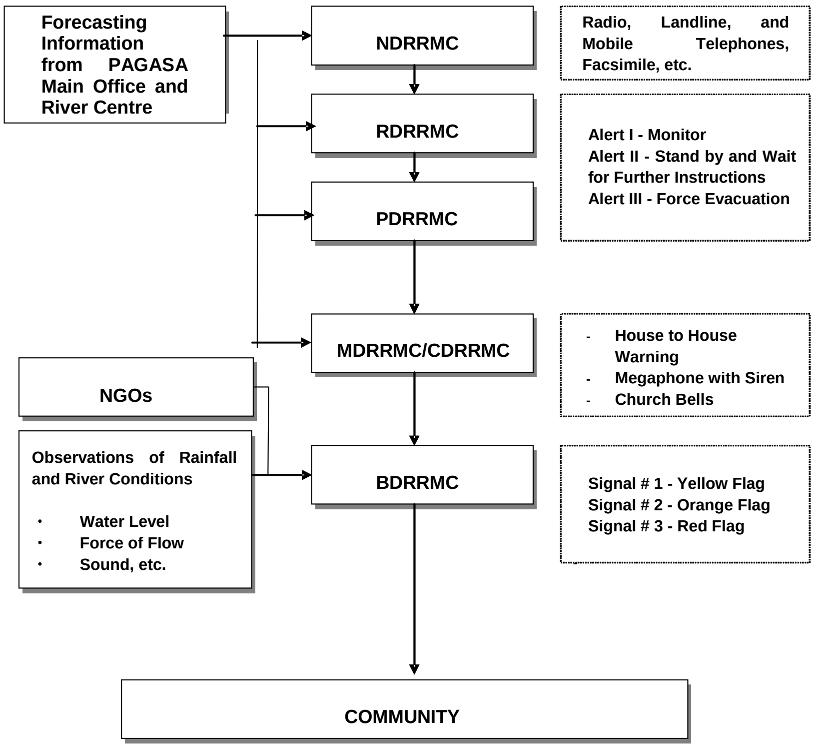
3.7.1 Flood Management

(1) Assessment of Existing Non-Structural Measures

1) Philippine Government's Non-Structural Measures for Flood Risk Mitigation

Regarding policies in disaster preparedness and flood mitigation, it was assessed that the change of flood disaster management from top-down approach to more responsive and accountable local government approach by decentralization by RA 7160, increase of local government funds to program disaster preparedness activities from 2% to 5% by RA 8185, and 70% of the 5% Calamity fund for Disaster Risk Reduction Management (DRRM) allowed for LGUs to program without the need for actual declaration of a "State of Calamity" by RA 10121 are judged reasonable. Further change in policy by RA on disaster preparedness and flood mitigation was expected according to change in situation in the future.

Regarding organization structure for flood management, Disaster Risk Reduction and Management Councils (DRRMCs) at the national, regional, provincial, municipal/city and barangay together with concerned agencies have played important roles for mitigation of disaster, including flood in the Survey area. The organizational structure of the DRRMCs from the national to the barangay, and concerned agencies is illustrated in the following chart. OCD acts as coordination agency for DRRMCs.



Source: JICA Survey Team (2013)

Figure 3.7.1 Organizational Structure of DRRMCs and Concerned Agencies

RA10121 was enacted in May 2010, and formulation of DRRMCs/Disaster Risk Reduction and Management Offices (DRRMOs) at the local level has been continuously promoted particularly with the recent linkages with the formulation of

Local Disaster Risk Reduction and Management Plan (LDRRMP) and Local Disaster Risk Reduction and Management Fund (LDRRMF) in Mar 2013. Three (3) years has been passed since the enactment, and promotion of actual formulation of LDRRMP including establishment of DRRMOs in local level. Therefore, it can be assessed that there are absolutely needs of capacity development and technical support for institutional development, coordination, information dissemination of DRRMCs and other related agencies.

2) Assessment of Existing Non-Structural Measures on Flood Management in the Cagayan de Oro River Basin

Community Based Flood Early Warning System (CBFEWS), contingency planning and watershed management, recommended in the previous Master Plan and Feasibility Study, prepared by DPWH in 2010, were judged reasonable and considered to be implemented as quickly as possible. However, more detailed plans will be prepared and its implementation. Consistency for establishment of CBFEWS with proposed FFWS is necessary, since FFWS was already programmed to implement by PAGASA, in which system configuration will be determined soon.

In November 2010, the Cagayan de Oro River Basin Management Council (CDORBMC) was organized. It was recommended that the CDORBMC will formulate the Comprehensive Watershed Management Plan for promotion of soil and water conservation of watershed to be attained through activities including monitoring of the conditions of watershed and river course. The plan will be formulated after 18 months from April 2013. The recommendations made by the CDORBMC was judged reasonable, however, it will be further studied in detailed after formulation of the said plan.

In relation to the annual investment plan for DRRM in 2013 for the CDO city, and three (3) municipalities in Bukidnon, details of the contingency plans for the CDO City, and municipalities of Talakag, Baungon & Libona in the province of Bukidnon were not well prepared yet due to insufficient information for scenarios for disaster, policies, strategy, future actions, etc. On the other hand, 5-year DRRM plan for the CDO city for the period from 2013 to 2017 was prepared. As of September 2013, all 3 Municipalities have submitted DRRMP. For Baungon, all 16 barangays have submitted DRRMP. For Libona, 6 barangays out of total 14 barangays have submitted DRRMP. For Talakag, 13 barangays out of total 29 barangays have submitted DRRMP. It is expected that non-structural measures proposed in this Survey will be incorporated in their contingency plan.

Regarding assessment of flood hazard map, flood runoff and inundation models for TS Sendong, TY Pablo and those for each probable flood were prepared by the hydrologist in this Survey, which are useful as flood hazard maps, important as one of the non-structural measures.

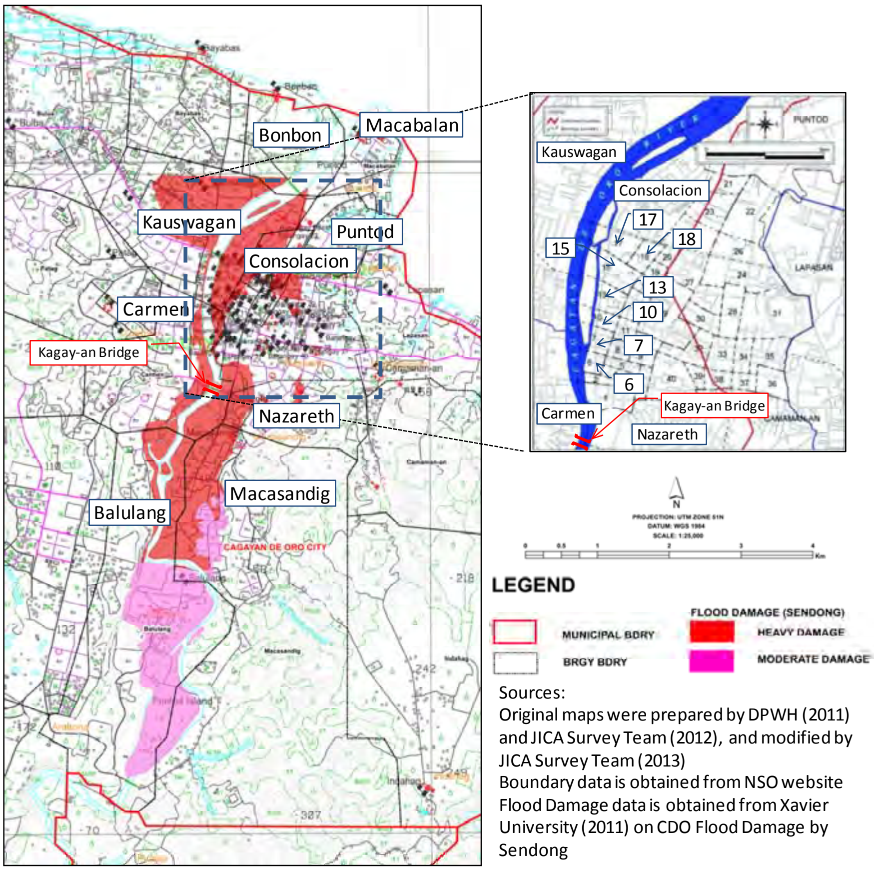
As an assessment of existing non-structural measures on land use management, draft Comprehensive Land Use Plan (CLUP), for the CDO City was referred to as future urban land use. The majority of the areas in the left and right banks along the CDO River, were planned as residential area. Therefore, the plan for these areas should be changed based on the "River Boundary" set in this Survey. In this connection, the CDO City has been working to finalize the CLUP incorporating the disaster related plan into the CLUP.

(2) Study on Non-Structural Measures

Basically, prevention and mitigation, preparedness, response and recovery compose the four (4) pillars of the flood management cycle. Of these, prevention/mitigation and preparedness are mainly measures to be made before flooding, which will be important for non-structural measures in this Survey. Questionnaire surveys were undertaken mainly to grasp current situation/problems and measures mainly for prevention/mitigation and preparedness.

1) Questionnaire Survey for Barangays in the CDO City Flooded by TS Sendong

It was reported that there were 16 flooded barangays in the CDO city, seriously affected by TS Sendong. Questionnaire surveys for the said 16 barangays were undertaken in September 2012 under this Survey.



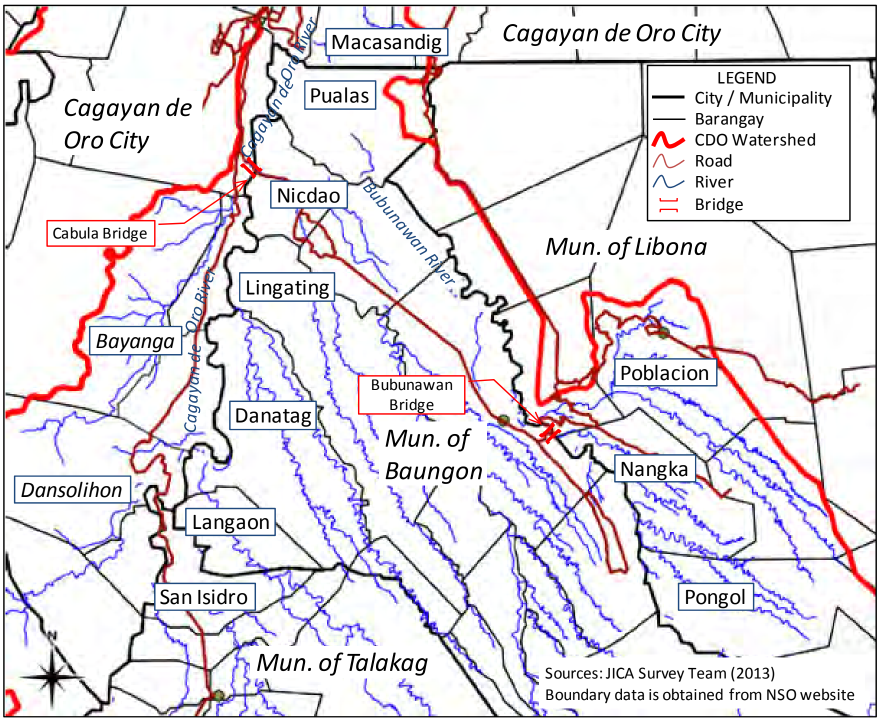
Source: JICA Survey Team

Figure 3.7.2 Locations of the Barangays for Questionnaire Survey for Barangays Flooded by TS Sendong, conducted in September, 2012

Based on the results of answers to questionnaires, barangays in the downstream areas near the river mouth such as Barangay Macalaban, Bonbon, and those in the upstream areas such as Barangay Bayanga, Dansolihon, were not so seriously affected compared to others. However, barangays in the middle stream areas such as Barangay 13 in Isla de Oro area, Cala Cala area in Barangay Macasandig, Balulang, were badly affected. It is also noted that the combined total of affected households in Barangays 7, 10, 13, 15 and 17 (where Isla de Oro is located) is 5,090 comprising 20% of all affected households in CDO.

It is noted that many barangays had established DRRMCs, contingency plans, disaster response team even before TS Sendong, however, these were not functioned well during TS Sendong, due to flash flood in the night time, insufficient warning dissemination, etc. It is further noted that Barangay Macasandig, one of the severely damaged barangays, has already established a new BDRRMC in April 2012 after TS Sendong, and already prepared Barangay hazard and evacuation maps and disaster response team.

Even in the upper watershed of CDO River Basin, some barangays were seriously damaged by TS Sendong. Barangay seriously damaged in the Municipality of Talakag is Barangay San Isidro due to topographic conditions according to MDRRMC officials. Barangays damaged in the Municipality of Baungon are Pualas, Nicdao, Lingating, Danatag, and Langaon, etc. mostly located along the CDO River. There are several barangays damaged in the Municipality of Libona, such as Barangay Poblacion, Nangka, Pongol, etc. along the Bobonawan River, tributary of CDO River, and Barangay Crossing, etc. along the Agusan River.



Source: JICA Survey Team

Figure 3.7.3 Locations of Barangays seriously damaged by TS Sendong in the Upper Watershed of Cagayan de Oro River Basin

2) Interview and Questionnaire Surveys for DRRMCs in the CDO River Basin

Interview and questionnaire surveys for DRRMC in the CDO River Basin were conducted for the period from March to April in 2013. Target DRRMCs are DRRMC of CDO city, municipalities of Talakag, Libona & Baungon, and barangays seriously affected by TS Sendong in 2011 and TY Pablo in 2012.

Originally, 23 DRRMCs which include CDO city, 16 barangays in the CDO city, 3 municipalities and 1 barangay each in 3 municipalities were selected as target DRRMCs, however, the number has increased to 3 barangays each in 3 municipalities based on the discussions with DPWH during the course of the survey.

However, due to bad peace and order situation at that time, interview and questionnaire survey for selected Barangay Ligron could not be undertaken. As a result, the survey was conducted for 28 DRRMCs.

Contents of the surveys were: 1) Readiness of DRRMC for organization and preparation of hazard map and situation of DRRM Fund, 2) Awareness for CBFEWS & skill of training, 3) Activities for TS Sendong and TY Pablo, and 4) Existing evacuation centers.

First, weather information, incidents, etc. for TS Sendong are shown as follows:

- TS Sendong has appeared in the ocean, about 700km east from the Mindanao Island at 8am on 15th (Thu) Dec., 2011. AT 4pm, warning signal No.1（30-60 Kph winds）was announced by PAGASA (Lowest out of 4 Public Storm Warning Signals). Rainfall intensity ranging from 10 to 25mm/hr was forecasted within the range of 400km radius.
- In the next day at 8am on 16th (Fri) Dec., TS Sendong moved to 200km east from the Mindanao Island. At 11am in the same day, warning signal was changed to No.2 （61-100 Kph winds）. Rainfall from 5pm to 12pm at Lumbia PAGASA station at airport in the CDO city was recorded at 180mm. In Macasandig, rainfall started in the morning and its intensity became stronger from 7pm, which resulted in flash flood in the midnight. The flood receded gradually from 4am in the next day, however, it brought about serious damages.
- AT 5am on 17th (Sat) Dec., warning signal was changed to No.1 and moved to ocean north-west from the Mindanao Island at 8am.
- Preparatory works, monitoring works, warning to local people, evacuation, relief activities, etc. were not sufficiently undertaken, probably due that 1) PAGASA warning signal was only No.1 (lowest among 4 signals) on 15th Dec, 2) Rainfall intensity was strong with short duration, 3) Peak discharge by flash flood occurred in the midnight, after work of the government officials on Friday, etc.

Next, weather information, incidents, etc. for TY Pablo are shown as follows:

- TY Pablo has appeared in the ocean, about 1,000km east from the Mindanao Island at 8am on 2nd (Mon) Dec., 2012. AT 10am, rainfall intensity ranging from 20 to 30mm/hr was forecasted by PAGASA, but no warning signal was announced since it was still outside the Philippines territory.
- In the next day at 5pm on 3rd (Tue) Dec., warning signal was changed to No. 3 (101-185 Kph winds).
- TY Pablo moved to east in the Mindanao Island at 8am on 4th (Wed) Dec. At 5pm in the same day, warning signal was same as No.3. Rainfall peak at Talakag station in the upstream of the CDO River Basin occurred at 12:15 pm with 19mm in the same day. Flood peak was observed at 1pm at Bubunawan Bridge, 3pm at Cabula Bridge, and 5pm at Kagay-an bridge. At 2pm, TY Pablo moved to north-west from the Mindanao Island.
- Warning signal was changed to No.1 on 5th Dec.

There were no serious damages, probably due to 1) lessons learnt from TS Sendong, 2) instructions on preparatory works, evacuation, necessary measures, etc. in the Association of Barangay Councils (ABC) meetings held on 2-3 Dec., 3) careful monitoring on flood on 4th Dec., 4) relief activities, food provision, etc.

Source: PAGASA

Figure 3.7.4 Track of TS Sendong

Source: PAGASA

Figure 3.7.5 Track of TY Pablo

3) Current Situation/Problems and Measures for Flood Management

Based on the results of interview and questionnaire surveys, current situation/problems and measures considered as necessary for the four (4) aspects are summarized as follows:

Table 3.7.1 Current Situation/Problems and Measures considered as Necessary for the Four (4) Aspects (Flood Management)

No.	Current Situation/Problems	Measures considered as Necessary
Aspect I: Assessment on DRRMC Readiness and Fund Sources		
I.1	DRRMC : Most of them were established before TS Sendong in December 2011 and some of them were re-organized after TS Sendong. During TS Sendong, many of them could not function well due to various reasons mentioned previously 【1) PAGASA warning signal was only No.1 (lowest among 4 signals) on 15th Dec, 2) Rainfall intensity was strong with short duration, 3) Peak discharge by flash flood occurred in the midnight, after work of the government officials on Friday, etc. 】. As a result, serious damages were brought about to the CDO River Basin. On the other hand, during TY Pablo, significant improvement in operational measures by utilization of flood hazard map, ABC meetings, advanced guidance on evacuation, flood monitoring, etc. As a result, no significant damages were reported.	There are about 100 barangays in the CDO River Basin. Of these, more than one half of the barangays were affected by TS Sendong. As explained in the left column, operation of DRRMCs was not well functioned due to (1) initial warning signal was 1 (light), (2) flash flood occurred in the midnight by high intensity rainfall with short duration, (3) response of DRRMCs were delayed due to after work on Friday. Operation of DRRMCs was improved by lessons learnt from TS Sendong. However, Institutional reinforcement of DRRMCs by capacity development measures before, during and after flood disasters is necessary for improvement in operational measures by utilization of flood hazard map, advanced guidance on evacuation, flood monitoring, etc. more effectively based on the DRRMP and contingency plan to be prepared.

No.	Current Situation/Problems	Measures considered as Necessary
I.2	Hazard Map : The maps were prepared for CDO city and some barangays in the city under technical assistance of Xavier university. For some barangays in the 3 municipalities (Talakag, Libona and Baungon) in the Bukidnon province, the maps were prepared by Mines and Geosciences Bureau (MGB) under DENR (Geohazards: Landslide and Flood, Assessment and Mapping (1:10,000), details are not known) and/or LGUs/NGOs. However, these were based on the previous floods by TS Sendong, TY Pablo,etc. The maps could not be utilized during TS Sendong, however, used by some DRRMCs during TY Pablo for evacuation. Further, thematic maps in the CLUPs are drawn by hand or graphic design software. It is difficult for them to update/revise the maps and calculate the land use changes due to the lack of capacity in terms of personnel and equipment.	The hazard map is core of the contingency plan. Present maps were prepared based on the inundation areas referring from TS Sendong and TY Pablo. The maps based on the computed inundation areas with return period of 1/2, 1/5, 1/10, 1/25, 1/50 prepared in this Survey, are also good references. However, these maps need to be improved with more accurate elevation and big scale. Accordingly, improvement of hazard map and education to local residents is necessary. Further, preparation and/or improvement of evacuation plan is also necessary. Based on the hazard maps to be developed, land use regulation for flood plain is necessary. In this case, technical assistance for data base introducing such as GIS may be considered.
I.3	DRRMP : 5-year DRRM Plan (2013-2017) was prepared by the CDO DRRMC in March 2013 under financial assistance by UNDP. Required budget for the 5-year DRRMP was estimated at P 1.3 Billion, which is 2.6 times of that of DRRMC. CDRRMC anticipates financial assistance from the GOP, NGO, foreign countries, etc. Barangays in the city did not prepare DRRMPs. PDRRMC of Bukidonon province prepared old DRRMP in 2008, however, it was not updated. Barangays in the 3 municipalities in Bukidnon province did not prepared the DRRMPs.	Based on the RA 10121, all DRRMCs should prepare the DRRMPs. Under this situation, Minutes of Agreement (MOA) was signed by Bukidnon province, 3 municipalities of Bukidnon, (Talakag, Libona and Baungon), CDO city and Iligan city in October 2012, to prepare all BDRRMPs. In this connection, all DRRMCs in the CDO River Basin should prepare the DRRMPs.
I.4	DRRMF 2013 : The fund requirement and proposed works for the following aspects: (1) Prevention & Mitigation, (2) Preparedness, (3) Response, (4) Recovery, were shown.	Ever year, similar proposal and budget request were made. The fund should be secured based on the DRRMP. Accordingly, DRRMP should be formulated.
II.	Assessment on DRRMC Awareness & Skill	
II.1	CBFEWS : In some barangays, warning by siren, megaphone, etc. based on monitoring river water level, etc. were made, however, most of barangays did not do any warning. So, there are no CBFEWS basically in the CDO River Basin.	CBFEWS shall be established for selected barangays in the CDO River Basin.

No.	Current Situation/Problems	Measures considered as Necessary
II.2	Trainings: Various kinds of trainings were undertaken by GOP, NGOs, donor countries, etc. For CDO city, it was observed there were many trainings related to contingency plan and DRRM under financial assistance by UNDP, especially after TY Pablo in December 2012. For local residents in some barangays in the city, trainings mainly for DRRM were made by GOP, CDO city, Xavier university, etc., however, trainings for structural measures for flood mitigation were not made, which are important for them to understand the necessity, importance, effectiveness, etc. of the project proposed. For 3 municipalities (Talakag, Libona and Baungon), 2-4 trainings for rescue, DRRM, etc. were made by GOP, LGUs, etc. since 2012.	Trainings on CBFEWS considered to be developed, and formulation and implementation of Contingency Plan is necessary. Further, Information, Education and Communication (IEC) to the local residents is necessary in order for them to understand the necessity, importance, effectiveness, etc. of the project proposed in this Survey and to be implemented.
III.	Assessment on DRRMC Activities, Before, During and After Sendong and Pablo	
III.1	Advisory & Warning / Updated Information : Information was not timely during TS Sendong. However, it was improved during TY Pablo. More adequate advisory and warning shall be provided, which will be better for self assistance, community assistance and public assistance.	Establishment of FFWS by PAGASA is necessary in order to obtain more adequate advisory and warning in the CDO River Basin. CBFEWS is also necessary, which will be quick and effective system for small area such as barangay area. These systems will be expected to contribute self assistance, community assistance and public assistance in the basin.
III.2	Actions taken : Actions were not properly taken due to less understanding on flood and insufficient information during TS Sending. However, actions were well taken during TY Pablo, by preparedness 4 days before the typhoon attack and evacuation 2 days before the attack.	Lessons lernt for TY Pablo were obtained, however, Capacity development on organizational and operational aspects, etc. for DRRMC is necessary in order to take actions more effectively during floods.
IV.	Assessment on Existing Evacuation Centers	
IV.1	Evacuation Center : Based on the RA 10121, class room cannot be used for evacuation. However, some were seemed to be used due to insufficient number and area of evacuation center.	Additional evacuation centers are necessary.
IV.2	Location of Evacuation Center : Some centers were flooded.	Other sites where safe from habitual inundation are necessary. Based on the information from the CDO City, Improvement (Heightening) of Roads in the left side near the river mouth and those in the right side in barangay Macasandig is necessary as approach to the evacuation centers.
IV.3	Facilities of Evacuation Center : Data on facilities for 64 centers listed by the CDO City were not available. Therefore, site investigation was made. Based on the results of the investigation, facilities of the centers were insufficient in view of area, number of toilet, kitchen, etc during TY Pablo.	Improvement of some facilities is necessary. Required number of toilet, kitchen, etc of the facilities shall be investigated.

No.	Current Situation/Problems	Measures considered as Necessary
IV.4	Electricity : It was cut for about 6 weeks in the CDO City, 2 weeks in Talakag, 3 weeks in Baungon and 1 day in Libona during and after TS Sendong, while 3days to 1 week during and after TY Pablo. Water Supply: It was cut for about 7 weeks in the CDO City, 4 weeks in Talakag, 3 days in Baungon and 0 day in Libona during and after TS Sendong, while 2days to 2 weeks during and after TY Pablo.	Hazard maps for electricity and water supply are necessary to anticipate potential damages. Study on arrangement of staff for restoration, priority ranking for restoration, assistance request of staff from other areas, re-organization of staff for restoration, is also necessary. For these above, preparatory works for restoration of infrastructure and improvement on actions are necessary to be taken immediately after the incident.

Source: JICA Survey Team (2013)

Based on the results of review of the existing non-structural measures in this Survey, questionnaire/ interview surveys for the DRRMCs, 5-Year DRRM Plan (2013-2017) of the CDO City, MOA signed by Bukidnon province, 3 Municipalities of Bukidnon, (Talakag, Libona and Baungon), CDO City and Iligan City, FFWS in the CDO River Basin, current activities of other foreign countries and NGOs, non-structural measures required for each area and agencies concerned were considered as follows:

Table 3.7.2 Non-Structural Measures required for Each Area and Agencies Concerned (Flood Management)

No.	CDO City	Talakag	Baungon	Libona	PAGASA
(1) Reinforcement of DRRMCs	✓	✓	✓	✓	
(2) Preparation of Contingency Plan and DRRMP, which includes Preparation/Update of Flood Hazard Map, Evacuation Planning, etc.	✓	✓	✓	✓	
(3) FFWS					✓
(4) Community Based Flood Early Warning System (CBFEWS)	✓	✓	✓	✓	✓
(5) Information, Education and Communication (IEC)	✓	✓	✓	✓	
(6) Land Use Regulation for Flood Plain	✓				

Source: JICA Survey Team

3.7.2 Watershed Management

Review of activities of DENR and related agencies for watershed management were undertaken in this Survey. Further, discussions with DENR, LUGs (CDO City and municipalities of Bukidnon, etc.), DPWH, etc. were conducted, studies on improvement for plans and activities were undertaken, and recommendations on watershed management were made as shown below.

(1) Assessment of Land Classification and Forest Distribution in the CDO River Basin

1) Land Classification on Forestlands and Alienable & Disposal (A&D) Lands

All the lands in the Philippines are categorized into the Forestlands and Alienable & Disposal (A&D) Lands, and forestlands occupy 57% in the CDO River Basin, and A&D Lands 43%. The forestlands are utilized for the agricultural lands, residential areas, and other purposes. DENR has responsibility to manage the forestlands, whilst DA and LGUs for A&D Lands.

2) Land uses in the CDO River Basin

Based on the land use classification, the forest rates in the CDO River Basin are 39%.

3) Vegetative Cover in the CDO River Basin

Based on the vegetative cover, the forest cover ratio in the CDO River Basin is 27% in 2003.

4) Transition of the Forest Cover in the CDO River Basin

The forest cover ratio of the Mindanao Island in 1900s was approximately 87%, and was decreasing to 58% in 1960s, 40% in 1987 and 27% in 1999, due to the forest development for the timber production and agricultural land development. The forest cover ratio in the CDO River Basin was almost 100% in 1900s, and decreased to 42% in 1970s, and 24% in 1999, and increased to 27% in 2003. The forest areas decrease significantly in the south and central part of Mindanao, compared to those in the CDO River Basin.

5) Transition of the Forest Cover and Floods in the Lower Portion of CDO River Basin

It was quite rare for the Mindanao Islands to be hit by the destructive typhoons in the past, however, the Mindanao areas become easily suffered by the destructive typhoons since 2000s. The increased frequency of the attacks by the typhoons would be one of the causes of the heavy damages by the floods in the downstream of the CDO River Basin, in addition to the decrement of the forest areas.

(2) Assessment of Existing Watershed Management

1) Organization Structures for the Watershed Management for the CDO River Basin

The members of the Board of Stakeholders of the Cagayan de Oro River Basin Management Council (CDORBMC) were composed in the organizations and LGUs only from the downstream of the CDO River Basin at the start. Three (3) municipalities were chosen as one of the members of the Board of Stakeholders in 2012, and such organizations as DPWH and MBDA in April 2013.

Bukidnon Watershed Protection and Development Council (BWPDC) was established by the Presidential Decree in 1995 to manage and protect forest areas in the Bukidnon Province. Bukidnon Watershed and River Basin Forum (BWRBF) was established as the Civil Society Organization in and became formalized by the Executive Order of the Governor in 2012. BWRBF was chosen as one of the members of the Technical Advisory Committee of the BWPDC in April 2013.

Macajalar Bay Development Alliance (MBDA) is composed in 14 LGUs along the Macajalar Bay for the proper management and development of the natural environment and coastal resources of the Macajalar Bay. The MBDA has become one of the members of CDORBMC, based on the “Ridge to Reef Approach”.

2) Watershed Management Plans for the CDO River Basin

The Cagayan (de Oro) River Watershed Management Plan in 1999 was prepared for CDO River Basin, and the Characterization Study (2007) and Vulnerability Assessment (2009) were conducted only for Bubunawan River, which is one of the tributaries of CDO River, by DENR Region X.

RBCO-DENR is formulating the Integrated River Basin Management and Development Master Plans (IRBMDMPs) for 18 major rivers in the Philippines, including the CDO River Basin. The tender was bidden in August 2012 for the CDO River Basin, and the study has been commenced in April 2013. Total period of the study is 18 months. Ahead of this study, the mapping activities to show the geohazard; i.e. landslide, flood, drought, were conducted for the CDO River Basin.

Based on the Watershed Management Framework Plan in 1995, the Bukidnon Environment and Natural Resource Office (BENRO) is assisting each municipality and Barangay to formulate their own watershed management plans. The watershed management plans of most of the municipalities are not updated since the formulation in and around 2002. There are no watershed management plan and forest management plan for the whole areas of CDO City.

ADB conducted the pre-feasibility study for the wastewater, watershed management and solid waste management for CDO City in 2012. The CDO River Basin was out of the focus as of the watershed management component.

There are two (2) Protected Areas (Natural Parks) located on the upmost part of the CDO River Basin, managed by PAWCZMS-DENR Region X, and the management plans for those two Protected Areas have been already formulated.

Based on the Executive Order 53, CDO City is formulating the coastal resource management plan (CRMP), but not yet finalized it because the contents of CRMP are being integrated into the CLUP. There are six (6) candidate Marine Protected Areas along the coast in the CDO City, and the management plans of those areas are already prepared.

Some activities on the watershed management are planned in the DRRMP of CDO as one of the mitigation measures.

3) Watershed Management-related Activities in CDO River Basin

The several national-level authorities; i.e. DENR, local-level authorities: i.e. LGUs, and international donors: i.e. ADB, have been implementing many kinds of activities related to the watershed management inside the CDO River Basin. Among the activities by those organizations, the locations of activities implemented by DENR Region X are indicated in the following figure.

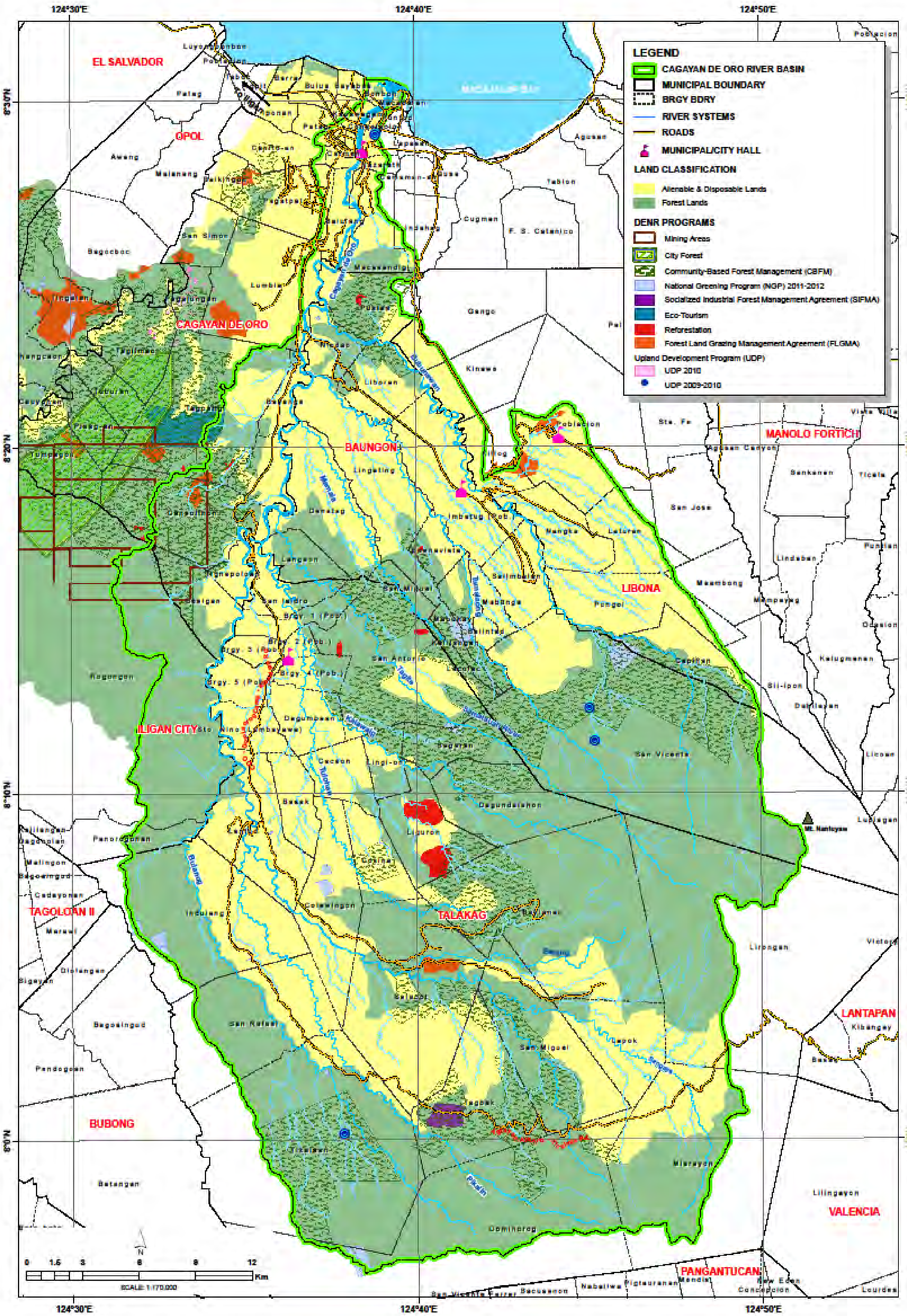


Figure 3.7.6 Location Map on the Watershed Management-related Activities by DENR Region X in the CDO River Basin

DENR is implementing the Community-Based Forest Management (CBFM) activities with People's Organizations (POs) inside the forestlands after allocating the land tenures to the POs. Based on the recommendations by CDORBMC, DENR is promoting to plant bamboos along the river side areas, however, there are issues that bamboo and palm trees along the river were easily uprooted during the flood at the time of the TS Sendong. Therefore, it is recommended to promote dee-rooted and indigenous tree species for the riparian areas

The Protected Area Management Boards (PAMBs) are established for each of two (2) Protected Areas inside the CDO River Basin to conduct the participatory management activities for the Protected Areas.

CDO City LGU Environment and Natural Resource Office (CLENRO) is promoting bamboo plantations together with other tree species to the riverine areas of the rivers inside CDO City. BENRO/ Municipal Environment and Natural Resource Offices (MENROs) are promoting the tree seedling delivery to the barangays in Bukidnon. In the Libona municipality, the MENRO is trying to establish the riparian forests along the small rivers inside the agricultural lands in cooperation with Del Monte Philippines, and others. There are no such activities in the municipalities of Talakag and Baungon in Bukidnon.

Agricultural Productivity Office (APO) of CDO City is promoting to plant mangrove propagules along the coastal areas in cooperation with DENR.

ADB is conducting the technical assistances in updating the current municipal watershed management plans, and the conduct of capability building activities. And this is considered as the start-up program for the up-coming ADB-loan project (INREM). The French Development Agency (AfD) has a plan to conduct the technical assistances on the forest management, watershed management and conservation agriculture in Bukidnon.

3.8 Current Main Laws/Regulations/Orders related to Flood Risk Management

3.8.1 Main Laws/Regulations/Orders

(1) Republic Act 10121 (RA10121)

RA10121, otherwise known as "Philippines Disaster Risk Reduction and Management Act of 2010" enacted on May 2010. The Act has the following four main objectives:

- Strengthening the Philippines disaster risk and reduction and management system
- Providing for the National Disaster Risk Reduction Framework
- Institutionalizing the Disaster Risks and Management Plan
- Appropriating funds for disaster risk and reduction and management

Table 3.8.1 shows the important features of the RA10121.

Table 3.8.1 Important Features of RA10121

Main Items	Important Features
Declaration of Policy (Section 2)	Adopting a DRRM approach that is holistic, comprehensive, integrated, and proactive in lessening the socio-economic and environmental impacts of disasters including climate change, and promote the involvement and participation of all sectors and all stakeholders concerned, at all levels, especially the local community
Scope (Section 4)	Providing for the development of policies and plans and the implementation of actions and measures pertaining to all aspects of disaster risk reduction and management, including good governance, risk assessment and early warning, knowledge building and awareness raising, reducing underlying risk factors, and preparedness for effective response and early recover
Institutional Mechanisms (Section 5, 6, 7, 8, 9, 10, 11, 12, 13)	Providing the following four institutional mechanisms for DRRM: - DRMMC networks from the national, regional, provincial, city/municipal levels, and Barangay DRRM Committee - Local DRRM Offices in every PDRRMC, every CDRRMC/MDRRMC, and in Barangay DRRM Committee - Powers and functions of Office of Civil Defense (OCD) - Disaster Volunteers
Funding (Section 21, 22)	- Regulating "Local Disaster Risk Reduction and Management Fund (LDRRMF)"; *Not less than five percent of the estimated revenue from the regular sources shall be set aside as the LDRRMF to support disaster risk management activities.* - Regulating "National Disaster Risk Reduction and Management Fund (NDRRMF)"

Source: Republic Act 10121, May 2010

The Implementing Rules and Regulations of the Act were issued on September 2010 for providing more concrete compositions, functions and activities of the related Councils. Based on the Act, the National Disaster Risk Reduction and Management Framework (NDRRMF) was also prepared and issued on June 2011. In accordance with the NDRRMF, the National Disaster Risk Reduction and Management Plan (NDRRMP), which has exactly same four aspects and expected outcomes of the NDRRMF, was also prepared as well.

Table 3.8.2 shows four aspects and the expected outcomes of the NDRRMF and NDRRMP.

Table 3.8.2 Four Aspects and Expected Outcomes of NDRRMF/NDRRMP

DRRM Aspect	Expected Outcomes
Prevention and Mitigation	Avoided hazards and mitigated their potential impacts by reducing vulnerabilities and exposure and enhancing capacities of communities
Preparedness	Established and strengthened capacities of communities to anticipate , cope and recover from the negative impacts of emergency occurrences & disaster
Response	Provided life preservation and met the basic subsistence needs of affected population based on acceptable standard during or immediately after a disaster
Rehabilitation and Recovery	Restored and improved facilities, livelihood and living conditions and organizational capacities of affected communities, and reduced disaster risks in accordance with the "building back better" principle.

Source: National Disaster Risk Reduction and Management Framework, 2011

(2) Water Code (PD1067)

The Philippines has a water related law, Presidential Decree (PD) No. 1067 December 31, 1976, otherwise known as "the Water Code of the Philippines". This Law stipulates several water uses and the rights in the water bodies of the Philippines. In relation to flood risk management, the Water Code regulates the following articles and amended the latest implementing rules and regulations, shown in Table 3.8.3.

Table 3.8.3 Main Statements of Articles/ Amended Implementing Rules and Regulations of the Water Code related to flood risk management

Article 5: Rivers and their natural beds belong to the State.
Article 51: The bank of rivers and streams and the shores of the seas and lakes throughout their entire length and within a zone of three (3) meters in urban areas, twenty (20) meters in agricultural areas and forty (40) meters in forest areas, along their margins are subject to the easement of public use in the interest of recreation, navigation, floatage, fishing and salvage. No person shall be allowed to stay in this zone longer than what is necessary for recreation, navigation, floatage, fishing or salvage or to build structures of any kind. **Section 31 of Amended Implementing Rules and Regulations** ***Determination of Easements -*** For purposes of Article 51 of the Code, all easements of public use prescribed for the banks or rivers and the shores of seas and lakes shall be reckoned from the line reached by the highest flood which does not cause inundation or the highest equinoctial tide whichever is higher. Any construction or structure that encroaches into such easement shall be ordered removed or cause to be removed by the Board in coordination with DPWH, LGU or appropriate government agency or local government unit.
Article 53: To promote the best interest and the coordinated protection of flood plain lands, the Secretary of Public Works, Transportation and Communication may declare flood control areas and promulgate guidelines for governing flood plain management plans in these areas.
Article 54: In declared flood control areas, rules and regulations may be promulgated to prohibit or control activities that may damage or cause deterioration of lakes and dikes, obstruct the flow of water, change the natural flow of river, increase flood losses or aggregate flood problems.
Article 55:The government may construct necessary flood control structures in declared flood control areas, and for this purpose it shall have a legal easement as wide as may be needed along and adjacent to the river bank and outside the bed or channel of the river.
Article 56: River beds, sand bars and tidal flats may not be cultivated except upon prior permission from the Secretary of the Department of Public Works, Transportation and Communication and such permission shall not be granted where such cultivation obstructs the flow of water or increase flood levels so as to cause damage to other areas.

Source: "Water Code of the Philippines and the Amended Implementing Rules and Regulations", House of Representative, 2012, National Water Resources Boards, March 2005

(3) National Water Security Act of 2012

Although the Water Code (PD1067) is still effective at present, amendment of the Water Code had been discussed recently. Then, the Act renaming the Water Code into "National Water Security Act of 2012" was proposed on November, 2012

The proposed National Water Security Act of 2012 mainly envisaged and added the following items:

- To promote and integrate water resources management using appropriate physiographic units such as watershed or river basins
- To require all the LGUs to include in their Land Use Plan water management and development plan
- To cover the supervision and the regulation of the sewerage systems

Concerning the revisions related to flood risk management, the following bold portion of the statements are added corresponding to each Article of the Water Code:

"Section 52 (Corresponding to Article 51 of the Water Code): The bank of rivers and streams and the shores of the seas and lakes throughout their entire length and within a zone of three (3) meters in urban areas, twenty (20) meters in agricultural areas and forty (40) meters in forest areas, along their margins are subject to the easement of public use in the interest of recreation, navigation, floatage, fishing and salvage. No person shall be allowed to stay in this zone longer than what is necessary for recreation, navigation, floatage, fishing or salvage or to build structures of any kind ***without proper clearance from appropriate governmental agency."***

"Section 54 (Corresponding to Article 53 of the Water Code): To promote the best interest and the coordinated protection of flood plain lands, the Secretary of Public Works, Transportation and Communication ***in coordination with other concerned national and local government agencies*** *may declare flood control areas and promulgate guidelines for governing flood plain management* ***to be included in the Integrated Water Resources Management plan in every river basin."***

The abovementioned National Water Security Act of 2012 promotes a more comprehensive approach for flood risk management; on the other hand, the Act may cause unclear lead governmental agency for declaration and management of the Flood Control Areas.

(4) Local Government Code of 1991, Local Disaster Risk Reduction and Management Fund (LDRRMF), and Municipal Executive Orders related to flood risk management

Local Government Codes (RA7160)

Republic Act 7160, otherwise known as "Local Government Code of 1991" stipulates various powers and roles of all the LGUs in the Philippines. In relation to flood risk management, the Code regulates the following basic services and facilities, including flood control or related facilities of LGUs:

"Section 17: Basic Services and Facilities. Local government units shall endeavor to be self-reliant and shall continue exercising the powers and discharging the duties and functions currently vested upon them. They shall also discharge the functions and responsibilities of national agencies and offices devolved to them pursuant to this Code Local government units shall likewise exercise such other powers and discharge such other functions and responsibilities as are necessary, appropriate, or incidental to efficient and effective provision of the basic services and facilities"

"Notwithstanding, public works and infrastructure projects and other facilities funded by the national government under the annual General Appropriations Act, other special laws, pertinent executive orders, and those wholly or partially funded from foreign sources, are not covered under this Section, except in those cases where the local government unit concerned is duly designated as the implementing agency for such projects, facilities, programs, and services."

The said regulation means that LGUs have the responsibility to deliver basic services, including flood control or related facilities, intended primarily to service the needs of residents of the municipality or province and funded out of municipality or provincial funds. However, the Code does not specify, which will render such services, the National Government or the LGUs, in the case of national funds given to LGUs for infrastructure projects. Any other laws or regulations also do not specify this case.

The DPWH has the role as an interim measure for such projects to be handed over to LGUs with acceptance agreement in the manner of a Memorandum of Agreement (MOA) when the project is completed. Some of the LGUs, however, may decline to accept mainly due to lack of capacities, experiences, and the budget for O&M of large-scale-structural measures.

Local Disaster Risk Reduction and Management Fund (LDRRMF)

Recently, a Joint Memorandum Circular (JMC) by NDRRMC and DILG was issued. The purposes of the JMC are to serve as a guide to LGUs in the allocation and use of the LDRRMF and to enhance transparency and accountability in the use of the LDRRMF. The LDRRMF is known as "former Local Calamity Fund".

According to the RA10121, not less than five percent (5%) of the estimated revenue from regular sources of a LGU shall be set aside as the LDRRMF to support disaster risk management activities such as, but not limited to, pre-disaster risk management activities.

In consideration of this,, the budget for O&M for flood control or related facilities could be financed through LDRRMF depending on the arrangement of LDRRMP.

Municipal Executive Orders related to flood risk management

Recently, all the concerned LGUs enacted each Executive Order (EO), which stipulates organization of Local Disaster Risk Reduction Management Council in each municipal level (Municipal Disaster Risk Reduction Management Council (MDRRMC) based on the RA10121. Table 3.8.4 shows the latest Executive Orders by each concerned LGU.

Table 3.8.4 Executive Order by Concerned LGUs related to Flood Risk Management

Municipality	Name of the Executive Order	Main contents of the latest Executive Order
Libona	EO No. 01 S. 2012	- Declaration of Policy for flood risk management - Composition, functions, task/responsibility, operation center, budget of MDRRMC - Organization Chart of MDRRMC
Baungon	EO No. 09 S. 2011	- Declaration of Policy for flood risk management - Composition, functions, task/responsibility, operation center, budget of MDRRMC - Organization Chart of MDRRMC
Talakag	EO No. 014 S. 2010, and EO No. 014 S. 2012 (Amendment of 2010)	- Declaration of Policy for flood risk management - Composition, functions, task/responsibility, operation center, budget of MDRRMC

Source: Municipalities of Libona, Baungon, Talakag

Also, each MDRRMC prepared a Disaster Risk Reduction Management (DRRM) Plan of 2011 or 2012, and then, each MDRRMC is conducting some activities with concerned organizations based on their DRRMC plan.

(5) Other laws, regulation, decrees closely related to flood risk management

The other Philippines laws, regulations, and decrees closely related to flood risk management are shown in Table 3.8.5.

Table 3.8.5 Other laws, regulations, and decrees closely related to Flood Risk Management

Name	Title/Main contents related to flood risk management
Presidential Decree 1152, 1977	<u>Philippines Environmental Code</u> Chapter 14: Flood control and natural calamity of the Code stipulates the following items: - Measures in flood control program (Section 34) - Measures to mitigate destructive effects of calamities (Section 35)
DENR Administrative Order No. 13, 1992	<u>Establishment of Buffer Zone within Forest Lands</u> Section 4: Areas Identified as Buffer Zone of the Order establishes each buffer zone, including for river side areas.
Executive Order No.510, 2006	<u>Creation of River Basin Control Office (RBCO) under DENR</u> Section 2 of the Order stipulates the following roles of the RBCO - Develop a national master plan for flood control by integrating the various existing river basin projects and developing additional plan components as needed with DPWH and National Disaster Coordination Council - Rationalize and prioritize reforestation in watershed - Develop a master plan on integrated river basin management and development including flood mitigation framework

Source: JICA Survey Team

3.8.2 Legal Aspects related to River Boundary and a Preliminary Conceptual Proposal of the River Area

(1) Related laws and orders

As mentioned in the previous section, the Philippines have the Water Code, the proposed National Water Security Act of 2012, as well as administrative orders by DENR which are related to the river boundary. However, these laws and orders do not define the river area clearly, and may cause unclear lead governmental agency issues related to river boundary.

(2) Present main issues and recent enactment situations in the Cagayan de Oro City

<u>Present main issues</u>

Based the present findings, present main issues related to river boundary in the Philippines is summarized as follows:

- DPWH had never invoked the Article 53 of the Water Code to declare Flood Control Area for protection of flood plain land
- In spite of the provision of Article 56 of the Water Code, river beds, sand bars, and tidal flats are being disorderly developed
- Many local people living along the rivers, including informal settlers still settled or may come back to previous settlement areas, unsuitable for settlement because these are highly flood-prone

A clear or reasonable definition of the River Area and delineation of boundaries of the river area would be essentially required to deal with flood risk management as well.

<u>Recent enactment situations in the Cagayan de Oro (CDO) City</u>

Main enactment process and the latest situations related to river boundary of the Cagayan de Oro River in the CDO City shown in Figure 3.8.1.

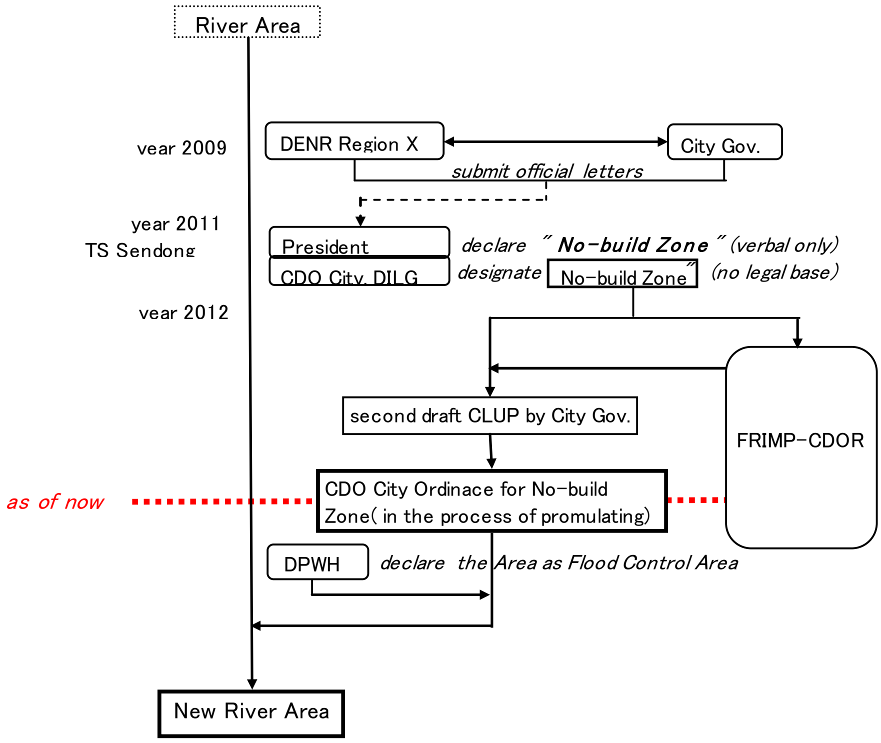
In 2009, the "DENR Region X Committee" recommended to the City Government of CDO that entry of new inhabitants and construction of new units in some highly flood prone areas, including small islands in the Cagayan de Oro River basin should strongly be prohibited and that the existing residents in those areas should be programmed for relocation to a safer site, based on the Letters between DENR Region X and CDO City.

Just after occurrence of the Sendong in December 2011, the President of the Philippines declared five "No-build Zones", which are mainly the small islands inside Cagayan de Oro River. However, this declaration is verbal, and there is no written document.

Furthermore, City Planning and Development Office of CDO City and DILG designated a total of nine areas, including the said five areas as "No-build Zones". This additional "No-build Zone" is derived from a geo-hazard assessment by the Geosciences Division of the Mines and Geosciences Bureau, Region X, DENR. However, all of the "No-build Zones" have no formal legal bases yet.

On the other hand, the No-build Zones also have to correspond to the Comprehensive Land Use Plan (CLUP) by each LGU. The second draft plan of the CLUP of the CDO City is being reviewed. At present, CDO is in the process of promulgating the City Ordinance for the "No-build Zone", which can be one of the River Areas.

Finally, it is necessary that the DPWH Secretary will declare these areas as Flood Control Area, in order to protect the flood plain land and to enforce the relocation of settlers in the area another area based on the Water Code.



Source: JICA Survey Team

Figure 3.8.1 Main Enactment Process and Present Situations related to River Boundary in the Cagayan de Oro City

Reference case of the Iligan City

A reference case is that of Iligan City where some barangays were also heavily damaged by Tropical Storm Sendong. On February 27, 2012, Iligan City enacted City Ordinance No. 12-5815 declaring some of those barangays as danger zones after having found these unfit and unsuitable for residential settlement with City Resolution No. 12-117 dated February 13, 2012. This enactment process of the City Ordinance may be used as reference by Cagayan de Oro City.

(3) Preliminary conceptual proposal of the River Area

In the baseline study of this FRIMP-CDOR, it was confirmed that the cadastral boundary of the governmental owned river area property of the Cagayan de Oro River is almost same as the waterway of the River on the maps, which were prepared by DENR/LGUs in 1950's. The boundary could be considered as existing river boundary of the Cagayan de Oro River.

Also, the aforementioned "No-build Zones" are reasonable as the river area. These areas are actually prohibited areas for any construction and settlement to avoid the flood damages, although these areas need supporting legal bases.

Furthermore, the FRIMP-CDOR will propose necessary structural measures such as construction of new dikes for flood risk mitigation in some river sections. The Right of Way for necessary structural measures is also in the river area.

Based on the said present understanding, a concept of an actual new River Area in the Cagayan de Oro River is preliminarily proposed by the FRIMP-CDOR:

- "Proposed River Area" is "Existing River Area" plus "No-build Zone" plus "Right Of Way for proposing necessary structure measures"

3.9 Current Organizations for Flood Risk Management and FRIMP-CDOR

3.9.1 Main Organizations

The following are the main organizations for flood risk management in the Philippines as well as references for the proposed measures by the FRIMP-CDOR.

(1) NDRRMC

The National Disaster Risk Reduction and Management Council (NDRRMC) is the highest policy, coordinating, and supervising body at the national level for disaster risk reduction management and the highest allocator of resources in the country to support the efforts of the lower Disaster Risk Reduction and Management Councils (DRRMCs).

At present, the Council's consists of forty four (44) members, including civil societies and private sector. The details of the governmental organizations and the other members are shown in Table 3.9.1.

Table 3.9.1 The NDRRMC Members

Organization status	Name and the numbers of the Organizations
Governmental Agency	1 Secretary and 4 Vice-Chairperson Governmental Line Agencies - DND (Secretary of NDRRMC) - DILG (Vice-Chairperson for Disaster Preparedness) - DSWD(Vice-Chairperson for Disaster Response) - DOST(Vice-Chairperson for Disaster Prevention and Mitigation) - NEDA (Vice-Chairperson for Disaster Rehabilitation and Recovery)
	14 Governmental Line Agencies - DOH, DENR, DA, DepEd, DOE, DOF, DTI, DOTC, DBM, DPWH, DFA, DOJ, DOLE, DOT 15 Other governmental agencies -The Executive Secretary, OPAPP, CHED, AFP, PNP, The Press Secretary, PRC, NAPC-VDC, NCRFW, HUDCC, Climate Change Commission, GSIS, SSS, PhilHealth 5 LGU leagues - ULAP, LPP, LCP, LMP, LMB
Civil Society	4 representatives from the Civil Society Organizations
Private Sector	1 representative from the private sector

Source: Implementing Rules and Regulations of Republic Act No. 10121

Under the NDRRMC, the Disaster Risk Reduction Management Council (DRRMC) in the Regional level; is called RDRRMC, in the Provincial level; it is called PDRRMC, in the City or Municipal level; it is called CDRRMC/MDRRMC, and Barangay level; it is called BDRRMC were set up based on the RA10121.

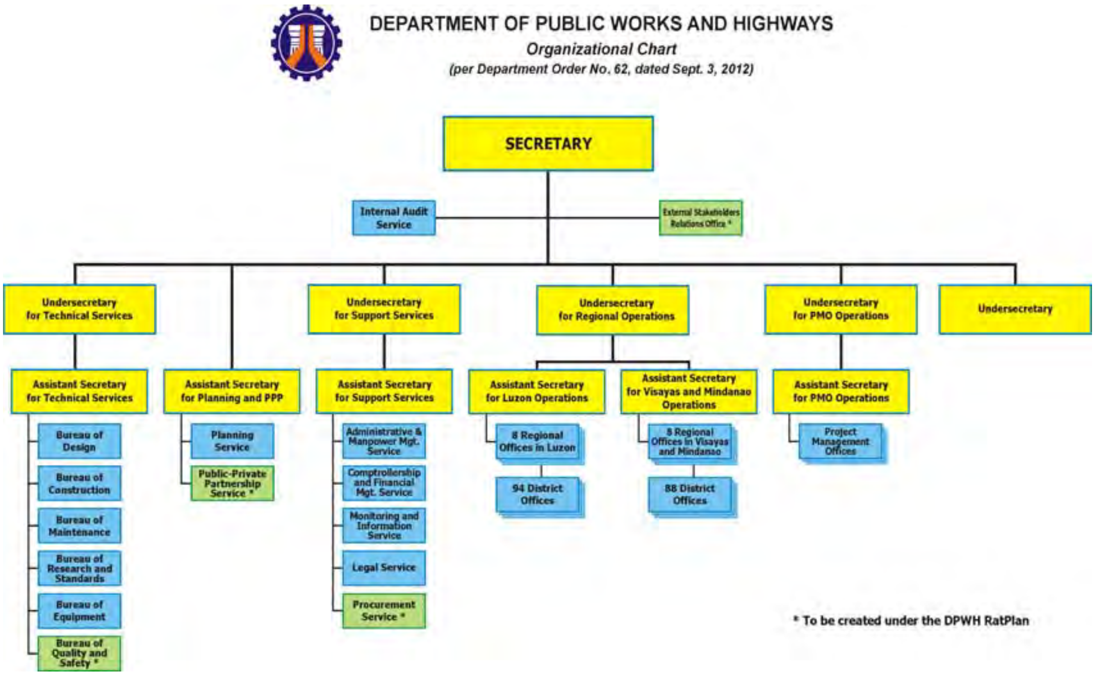
In the FRIMP-CDOR area, it was confirmed that the following level of the Local DRRMC were established recently:

- RDRRMC: Regional X
- PDRRMC: Misamis Oriental Province, Bukidnon Province
- CDRRMC: Cagayan de Oro City
- MDRRMC: Libona Municipality, Baungon Municipality, Talakag Municipality

Each level of Local DRRMC is conducting several local disaster risk reduction management activities mainly with concerned LGUs' planning or engineering officials, who are also the main members of each CDRRMC/MDRRMC. Also, some barangays are conducting one of the disaster risk reduction management activities, raising the awareness of settlers mainly for flood preparedness in the FRIMP-CDOR areas.

(2) Department of Public Works and Highway (DPWH)

As mentioned in the previous section, flood risk management in the Philippines requires holistic and integrated approach, which needs to be involved in multiple governmental agencies. On the other hand, DPWH has been implementing many infrastructure development projects for flood risk management. DPWH acts as the leading governmental agency for structural measures for flood risk management in the Philippines.



Source: DPWH

Figure 3.9.1 Present Organizational Structure of DPWH

At present, DPWH has five sections, led by undersecretaries, according to the Department Order No.62, dated September 3, 2012. The present organizational structure of DPWH is shown in Figure 3.9.1

The following are the main related offices/bureaus under the DPWH for attending to the proposed measures by FRIMP-CDOR.

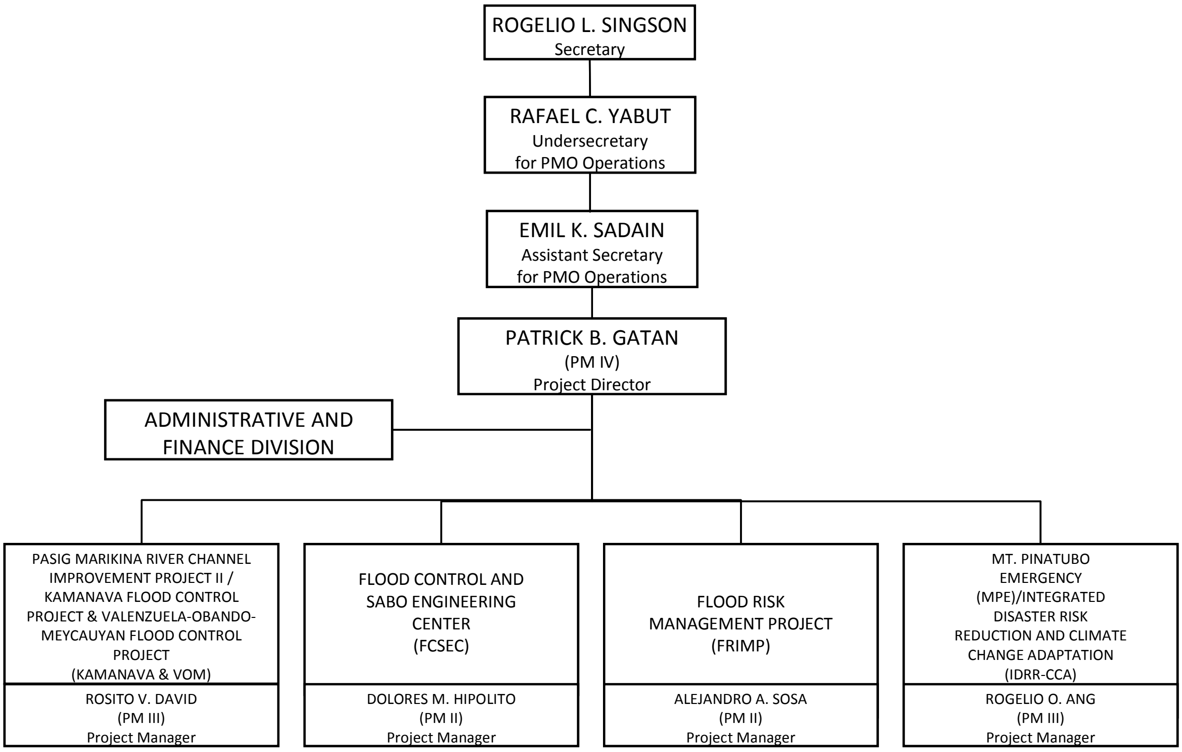
<u>Project Management Office (PMO)-Flood Control</u> [1]

The PMO-Major Flood Control & Drainage Project (MFC&DP) was established by DPWH Department Order No.232, Series of 2000. The PMO-MFC&DP had been undertaking foreign assisted flood control and sabo projects in the Philippines.

However, on January 11, 2013, it was proposed that a new organization Project Management Office, it is called "PMO-Flood Control", which has four Project Management Offices: i) PMO-Flood Risk Management Project (FRIMP) ii) PMO-Flood Control and Sabo Engineering Center (FCSEC); iii) PMO-Pasig Marikina River Channel Improvement Project/KAMANAVA and Valenzuela-Obando-Meycauayan Flood Control Project (KAMANAVA &VOM), iv) PMO-Mt. Pinatubo Emergency (MPE) Integrated Disaster and Climate Change Adaptation (IDRR-CCA).

[1] As of January 2014, it has been renamed to "United Project Management Office-Flood Control (UPMO-FC)"

The PMO-FRIMP and the PMO-FCSEC are directly related to the FRIMP-CDOR. The Project Director of the PMO-Flood Control was assigned by DPWH Special Order No.17. The Project Managers of the PMO-FRIMP, and the PMO-FCSEC were assigned by DPWH Special Order No.24, No.22 respectively. Key and Main official staff of the PMO-FRIMP and the PMO-FCSEC are re-assigned from the PMO-MFC&DP and the former FCSEC respectively. Figure 3.9.2 shows the proposed, but actually authorized organizational structure of the PMO-Flood Control as of July 2013.



Source: DPWH PMO-Flood Control

Figure 3.9.2 Proposed Organizational Structure of the PMO-Flood Control

PMO-Flood Risk Management Project (FRIMP) [2]

At present, the PMO-FRIMP is actually undertaking foreign assisted flood control and sabo projects in the Philippines, which was the tasks of the PMO MFC&DP.

As for the task of the food control, the PMO-FRIMP may have the following specific roles:

- To provide technical comments/advice to the M/P and F/S of the flood control project in cooperation with the PMO-FCSEC
- To coordinate the planning, design, construction, organization, and maintenance of the proposed measures of the flood control project in coordination with concerned agencies
- To manage the proposed measures of the flood control project

Concerning the said final role, it is also expected that the PMO-FRIMP is the overall implementing office for all the proposed measures by the FRIMP-CDOR including issues and concern related to project preparation, procurement, contracting, disbursement, and

[2] As of January 2014, it has been renamed to "United Project Management Office-Flood Control Management Cluster (UPMO-FCMC)"

so on.

PMO-Flood Control and Sabo Engineering Center (FCSEC) [3]

The FCSEC was originally created in December 1999 through the Department Order No.237 as the PMO of DPWH for the implementation of Project for Enhancement of Capability of DPWH Engineers in the Field of Flood Control and Sabo Engineering (ENCA) with assistance from JICA. The main objectives of establishment of the FCSEC are as follows:

- To improve the effectiveness of flood control and Sabo structures and other measures implemented by DPWH in accordance with technical standards
- To strengthen the flood management function of DPWH through research and development, training, information management, implementation of pilot projects and creation of internal support mechanism

FCSEC has actually conducted formulation of technical standards and guidelines for flood control and sabo works, training of engineers from selected DPWH offices, establishment of database and information system for flood control, and initiation of hydraulic experiments. The present actual functions and authorities of the FCSEC are basically same as the ones of the FCSEC.

The roles of the FCSEC for the FRIMP-CDOR are as follows:

- To conduct technical trainings for the local engineers in DPWH, and LGUs,
- To conduct hydraulic experiments, if necessary
- To develop/revise operation and maintenance manual for structural measures.

Bureau of Design (BOD)

The authorities and areas of responsibilities of the BOD are based on the Section 19, Executive Order No.124 dated January 30, 1987. The Hydraulics Division is mainly in charge of the flood control projects of the DPWH. The BOD has the following main roles related to flood risk management.

- To supervise and review the preparation of schemes, designs, specifications, estimates, tender contract documents covering the technical design aspects of flood control projects
- To evaluate the design, specifications, estimates, tender, and contract documents covering the technical design aspects of flood control projects
- To provide technical assistance in the selection of firms or entities that shall undertake actual construction of flood control projects

For the proposed measures by the FRIMP-CDOR, the BOD is expected to be involved mainly at pre-construction stage. Also, the BOD will be involved at the construction stage for proposed measures, if the design of the structures was drastically changed.

Bureau of Construction (BOC)

Related to flood risk management, the responsibilities of the BOC are as follows:

- To review Project costing, construction schedule as well as the finalization of contract (documentation) to implement flood control projects (e.g. construction of revetment, spur dike, earth dike, and drainage facilities)
- To conduct the document review, inspection and monitoring during the construction

[3] As of January 2014, it has been renamed to ”United Project Management Office-Flood Control Management Office (UPMO-FCMO) ”

stage

For the proposed measures by the FRIMP-CDOR, the BOC is expected to be involved at Pre-Construction and Construction stage. The BOC will be involved at the pre-construction stage for reviewing Project costing, construction schedule as well as the finalization of contract for proposed structure measures. Also, the BOC will be involved at the construction stage for conducting document review, inspection and monitoring during the construction stage for proposed structure measures.

Bureau of Maintenance (BOM)

Related to flood risk management, the responsibilities of the BOM are as follows:

- To maintain the flood control structures (e.g. revetment, spur dike, earth dike, drainage facilities)
- To conduct the regular inventory/assessment/inspection of the flood control structure

The BOM has five divisions; namely: i) Planning and Programming, ii) Monitoring and Methods, iii) Inspectorate, iv) Building Services, and v) Inventory and Statistics. These technical personnel in the divisions, except Building Services, have experiences/capabilities to undertake activities related to maintenance of flood control structures.

Planning Services

Planning Services is under Department of the Planning and Public-Private Partnership (PPP). The Planning Services in general, provide technical services relating to public works infrastructure, planning, programming and project development.

Related to the flood risk management, Planning Services has the following main roles:

- To manage the conduct of Master Plan (M/P) and Feasibility Study (F/S) in infrastructure projects using preliminary engineering and economic evaluation procedures and practices
- To prepare prioritized list of infrastructure development projects for local financing, and prepare list of candidate infrastructure development projects for foreign financing

Environmental and Social Services Offices (ESSO) [4]

The ESSO is one of the division offices under the Planning Services of Planning and PPP, DPWH. The ESSO was created and renamed from the Environmental Impact Assessment Project Office (EIAPO) by Department Order, No.58 Series of 2004. As for the task related to flood risk management, ESSO has the following main roles:

- To manage assessments of environmental and social impacts, which may be caused by development projects, including flood facility development by DPWH
- To conduct environmental monitoring and post-implementation evaluation, and monitor Resettlement Action Plan (RAP) implementation by development projects by DPWH

For the proposed measures by the FRIMP-CDOR, the ESSO is expected to assist the PMO-FRIMP in the activities regarding environmental and social considerations, in particular, facilitation of consultation and information dissemination to the project affected persons and other stakeholders.

Table 3.9.2 shows current human resources of each office/bureau of the DPWH.

[4] As of January 2014, it has been renamed to ”Environmental and Social Service Division (ESSD) ”

Table 3.9.2 Present Human Resources of the related Offices/ Bureaus of DPWH

Offices/ Bureaus	Number of Staff		Total
PMO-FRIMP	Technical	Administrative	
	6	20	26
PMO-FCSEC	Technical	Administrative	
	9	2	11
BOD	Hydraulics Division	Other Division	
	11	94	105
BOC	Technical	Administrative	
	94	22	116
BOM	Technical	Administrative	
	114	45	159
Planning Services	Technical (Economist)	Administrative	
	20	10	30
ESSO	Technical	Administrative	
	10	5	15

Source: Each Office/Bureau of DPWH

DPWH Region X

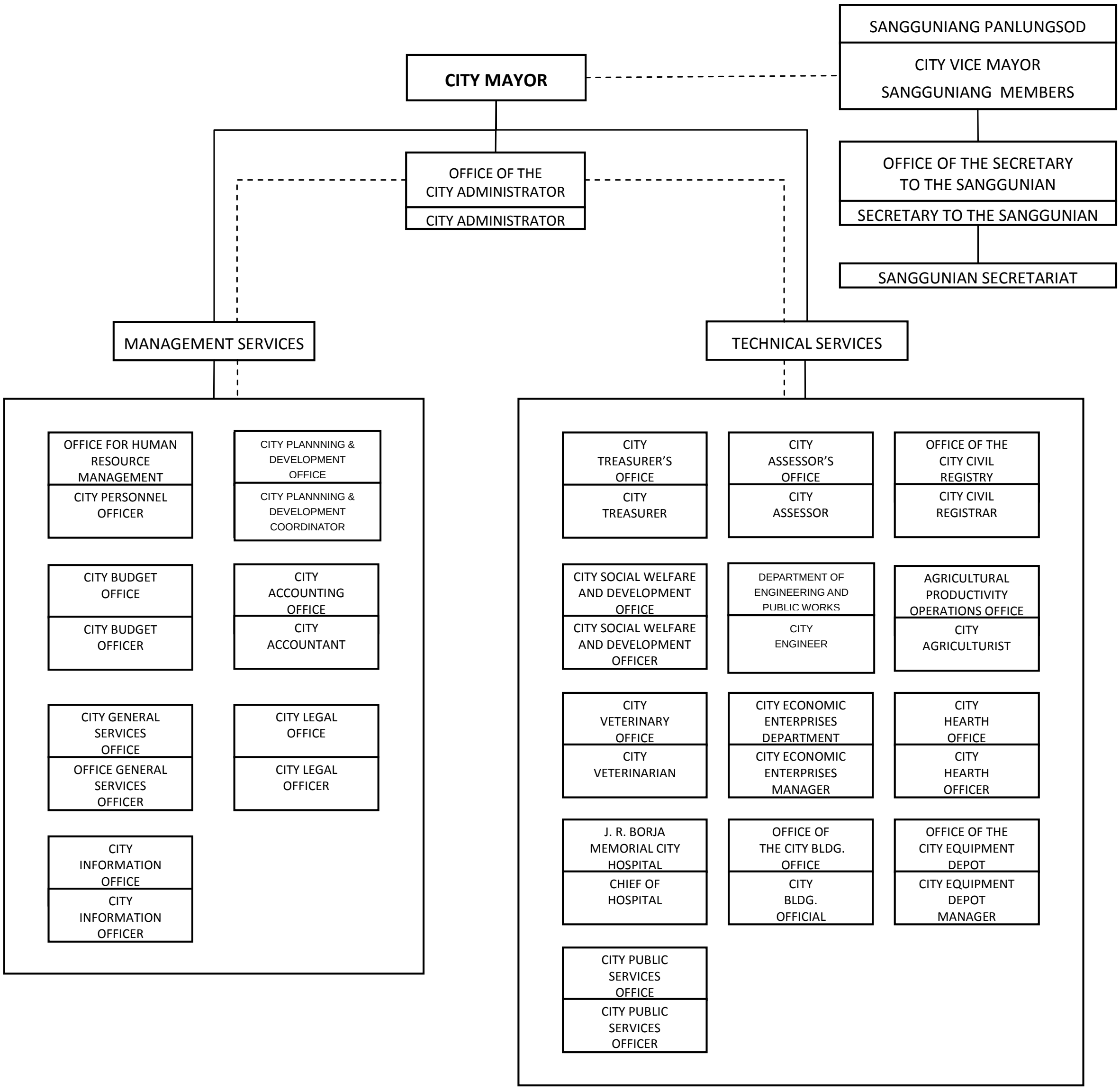
Concerning the flood risk management, the DPWH Region X undertakes basically locally funded flood control and sabo projects in the region. It manages the planning, implementation and operation and maintenance, including flood monitoring of the Project within the Region X.

For the proposed measures by the FRIMP-CDOR, the DPWH Region X is expected as an actual management agency for proposing structural measures in coordination with the PMO-FRIMP and the concerned LGUs based on the regional management experiences of the flood control facilities.

(3) Concerned LGUs

All the concerned municipalities and city (Cagayan de Oro City, Municipalities of Libona, Baungon, and Talakag) in the Cagayan de Oro River Basin have almost same organizational structures based on the Local Governmental Code of 1992.

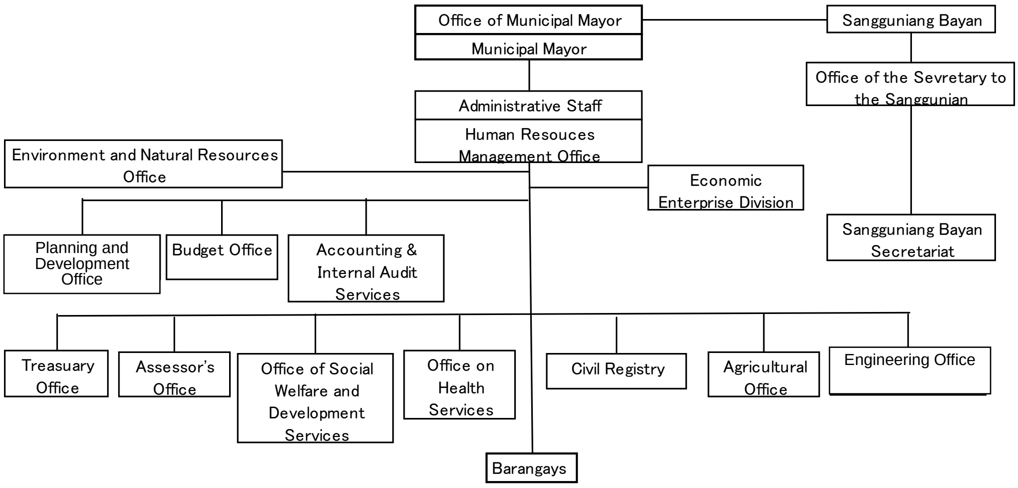
Figure 3.9.3 shows the present organizational structure of the Cagayan de Oro City. Figure 3.9.3 was excluded the Special Services, which does not related to flood control project.



Source: Office of Human Resources Management, Cagayan de Oro City

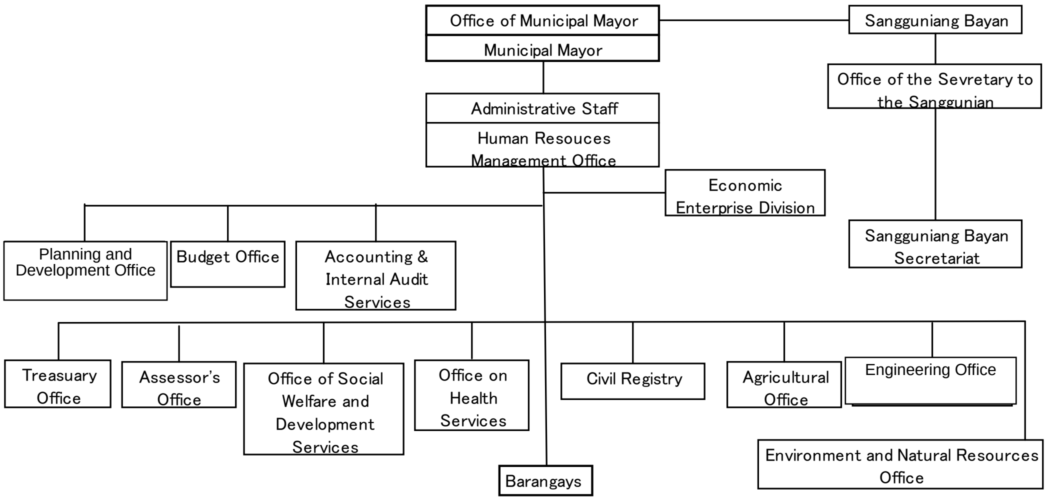
Figure 3.9.3 Present Organizational Structure of the Cagayan de Oro City

Figures 3.9.4 to 3.9.6 show the current organizational structure of the Municipalities of Libona, Baungon and Talakag, respectively.



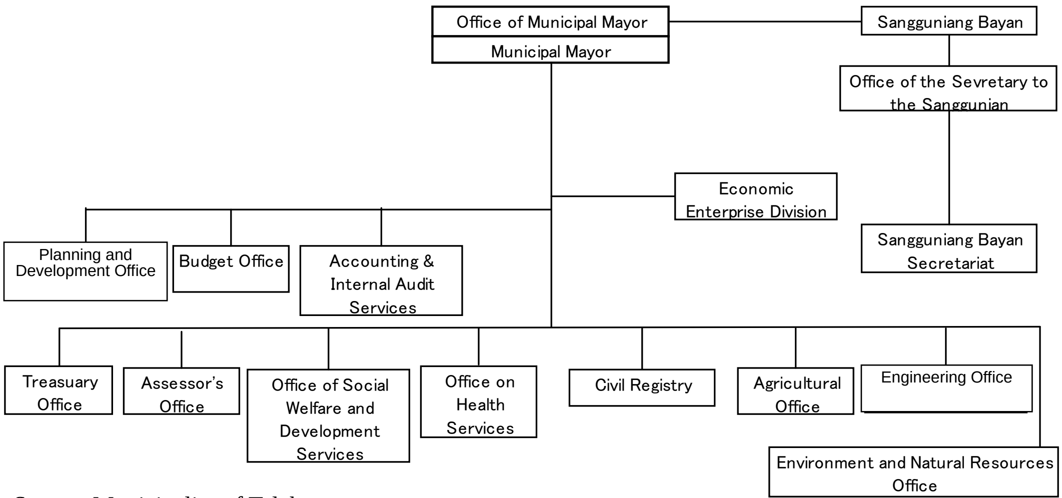
Source: Municipality of Libona

Figure 3.9.4 Organizational Structure of the Municipality of Libona



Source: Municipality of Baungon

Figure 3.9.5 Organizational Structure of the Municipality of Baungon



Source: Municipality of Talakag

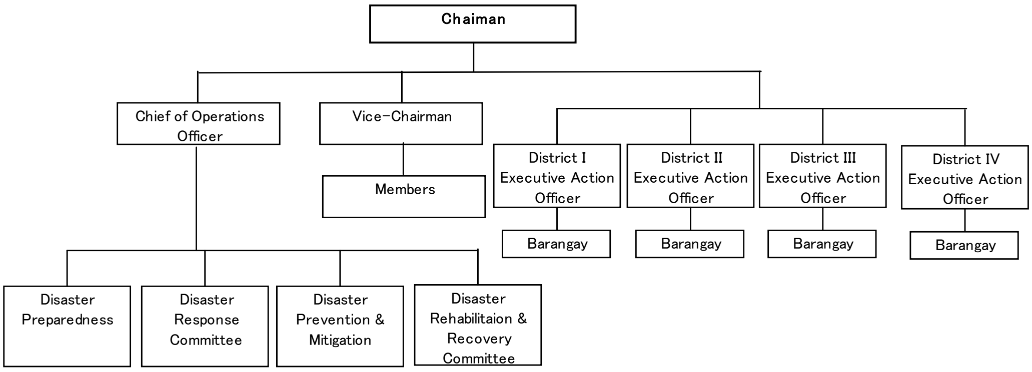
Figure 3.9.6 Organizational Structure of the Municipality of Talakag

Disaster Risk Reduction and Management Council (DRRMC) of each municipality or Cagayan de Oro (CDO) City is usually categorized and established as a special body.

Figure 3.9.7 shows the current organizational structure of the DRRMC of the CDO City.

All of the officials/organizations in Figure 3.9.7 are concerned officials/organizations for FRIMP-CODR.

Of special note is the organizational structure of the DRRMC of the CDO City that the eighty (80) urban and rural barangays are divided into four (4) districts with each District Executive Action Officer, to facilitate immediate response during disasters and/or calamities.



Source: Cagayan de Oro City

Figure 3.9.7 Current Organizational Structure of the CDRRMC of the CDO City

Each Planning and Development Office (PDO) and Engineering Office (EO) of the City or Municipalities are in charge of the formulation of Comprehensive Land Use Plan (CLUP) /local development plans, and management of local infrastructure projects respectively.

Table 3.9.3 shows current human resources of related offices of the concerned LGUs.

Table 3.9.3 Present Human Resources of the related Offices of the concerned LGUs

LGUs	Number of Staff		Total
Cagayan de Oro City	PDO	EO	
	110	272	382
Libona Municipality	PDO	EO	
	5	7	12
Baungon Municipality	PDO	EO	
	3	3	6
Talakag Municipality	PDO	EO	
	7	5	12

Source: Municipalities of Libona, Baungon, Talakag
Note: These abovementioned staff includes non-permanent staff

3.9.2 Main Related Organizations

The following are the main related organizations for flood risk management in the Philippines as well as for the proposed measures by the FRIMP-CDOR

(1) National Economic and Development Authority (NEDA)

The NEDA is the country's independent economic development and planning agency, as mandated by the Constitution of the Philippines. The NEDA has the following main roles related to flood risk management by foreign funds:

- To assist in mobilizing resources through technical assistance in the formulation of projects for ODA funding or programming
- To consider that flood (disasters) concerns are in both the national and local development plans and to analyze the effects of flood (disasters) and calamities in the socio-economic plans and programs of the country

For the proposed measures by the FRIMP-CDOR, the NEDA is expected to be involved in the planning stage (pre-construction Stage) of the measures, in particular, economic and financing matters.

(2) Office of the Civil Defense (OCD), Department of National Defense (DND)

The basic task of the OCD is to coordinate the activities and functions of various governmental agencies, private institutions, and civil organizations for protection and preservation of life and properties during emergencies.

Regarding the flood risk management, the OCD serves as the Executive Arm and Secretariat of the National Disaster Risk Reduction and Management Council (NDRRMC). The NDRRMC is headed by the Secretary of DND as chairperson.

The OCD has the following main actual powers and functions for flood risk management:

- To review and evaluate the Local Disaster Rick Reduction and Management Plans (LDRRMCPs), in coordination with concerned agencies and or institutes, to facilitate the integration of disaster risk reduction measures into the local Comprehensive Development Plan (CDP) and Comprehensive Land Use Plan (CLUP);
- To ensure that the LGUs, through the Local Disaster Rick Reduction and Management Offices (LDRRMOs) are properly informed and adhere to the national standards and programs;
- To ensure governmental agencies and LGUs give top priority and take adequate and appropriate measures in disaster risk reduction and management; and
- To provide advice and technical assistance and assist in mobilizing necessary resources to increase the overall capacity of LGUs, specifically the low income and high-risk areas.

(3) River Basin Control Office (RBCO), DENR

RBCO under the DENR is the leading governmental agency for the integrated planning, planning, management, rehabilitation and development of the country's major river basins. The Cagayan de Oro River is one of the 18 major river basins in the Philippines. The RBCO has the PMO/Focal Office in the Cagayan de Oro River Basin.

For the proposed measures by the FRIMP-CDOR, the RBCO is expected to be involved in the planning and implementation stage of the nonstructural measures based on the integrated river basin approach.

According to the former Executive Director of the RBCO, DENR, a small Consultation Meeting, which discussion items included river boundary issues between the former Executive Director of the RBCO and the Project Manager of PMO-FCSEC was conducted on October 2012. The discussion items relating to river boundary issues were; i) land use control issues, ii) identification of river easement zones, iii) presence of informal settlers issues. However, any minutes of meeting or the related written references/documents actually did not left.

(4) The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), DOST

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) were established under Department of Science and Technology (DOST) in 1972. The mandate of the PAGASA is to provide information and advisories for protection against natural calamities utilizing scientific knowledge as an effective instrument, in order to insure the safety of all the people in the Philippines.

Concerning flood mitigation management, National Flood Mitigation Office (NFMO) under the PAGASA, is now known as Hydrometeorology Division., It undertakes operational activities in flood forecasting and warning covering important major river basins in the Philippines, which does not include the Cagayan de Oro River Basin.

In relation to the FRIMP-CDOR, the PAGASA is currently undertaking establishment of River Centers as well as monitoring facilities in other major river basins, including the Cagayan de Oro River Basin. The River Centers are responsible for conducting local meteorological and hydrological monitoring operations for flood forecasting and warning, and preparation, issuance, and dissemination of flood bulletins in the respective area.

For the proposed measures by the FRIMP-CDOR, the PAGASA will be expected to be involved at the planning and implementation stage for proposing nonstructural measures such as Flood Forecasting and Warning System (FFWS).

(5) The National Water Resources Board (NWRB) and National Water Resources Management Office (NWRMO)

The National Water Resources Board (NWRB) was established to formulate and coordinate the policies, programs, and standards relating to all water sectors in the Philippines based on the laws such as a series of presidential decrees. On the other hand, in 2012, it was proposed that reconstitution and strengthening the current NWRB into a National Water Resources Management Office (NWRMO) under the President through the issuance of an Executive Order, which was submitted to the President on April 4, 2012.

However, the President Aquino has not yet signed the Executive Order creating NWRMO at present. The Office of the Cabinet Secretary called for an Inter-agency Meeting on March, 2013 that was attended by the concerned agencies in the water sector. During the meeting, the concerned agencies were asked to submit their final comments and suggestions of the NWRMO, according to a Planning Officer of Policy and Program Division, NWRB.

(6) Office of Civil Defense (OCD), Region X

Concerning the flood risk management, OCD Region X acts as the Regional Disaster Reduction Management Council (RDRRMC) Region X. The RDRRMC Region X office has the following four components and their vice chairpersons; i) disaster prevention & mitigation (vice chaired by Regional Director of DOST 10); ii) disaster preparedness (vice chaired by Regional Director of DILG 10), iii) disaster response (vice chaired by Regional Director of DSWD 10), iv) disaster rehabilitation & recover (vice chaired by Regional Director of NEDA 10). The RDRRMC is composed of 50 organizations, including one private sector representative.

The RDRRM is actually supporting some barangay flood mitigation activities, for example, preparation of local generating map, making it easier to understand the flood water level.

For the proposed measures by the FRIMP-CDOR, OCD Region X is expected to be involved in the planning and implementation stage such as the leading coordinating-agency for proposing non- structural measures in the concerned LGUs and Barangays.

(7) Department of Interior and Local Government (DILG), Region X

In general, DILG Region X is responsible for promoting peace and order, ensuring public safety, and strengthening the capabilities of LGUs in Region X.

In relation to flood risk management, the main role of the DILG Region X is presently to strengthen, particularly in flood preparedness, the capabilities of related provincial, city/municipality government, as well as at the barangay level. The DILG Region X also prepared the Memorandum Of Agreement (MOA) of the involved areas for the collaborative DRRM activities in 2012, in consultation with the concerned LGUs (Bukidnon Province, Cagayan de Oro City, Iligan City, Municipalities of Talakag, Libona, and Baungon).

For the proposed measures by the FRIMP-CDOR, the DILG Region X is expected to be involved at the planning stage for proposing non- structural measures such as consultation with the concerned LGUs and Barangays regarding the measures.

(8) Cagayan de Oro River Basin Management Council (CDORBMC)

When the CDORBMC was established before the occurrence of TS Sendong on November 2010, the members were limited the CDO City and the organizations within the CDO City. However, the Board of the Stakeholders of the present CDORBMC are most of the concerned governmental organizations from the upstream to downstream of the CDO River, including the DENR-Region X, all the concerned LGUs, OCD, Region X,-DILG, and Academic Organization such as Xavier University, as well as NGOs,/Private Sectors. Furthermore, the DPWH became one of the Board of Stakeholder of the CDORBMC on April, 2013.

For the proposed measures by the FRIMP-CDOR, the CDORBMC is expected to be involved at implementation stage for proposing non- structural measures as the integrated advocating council.

3.9.3 Recent Situations of Flood Mitigation Committee (FMC) in Other Areas

According to JICA project key team members of each project, recent situations of each FMC in each area are as follows:

(1) FMC in the Ormoc City

When the construction of the structural measures for the flood control development project was completed in 2001, the Ormoc City Government accepted the responsibility of operation and maintenance of the structures when it was turned over from the DPWH. Concrete maintenance activities performed by the City Government were as follows:

- Removal of deposits, vegetation control, repainting of steel components, regular check of the structures, and repairing of damaged structures, as well as raising of awareness of the people along the river as non- structural e measures.

The general idea adopted by the LGU was the creation of a central coordinating body that oversees the monitoring and maintenance activities of the flood control facilities. Thus, the FMC was created with the following main responsibilities:

- Secure the budget for operation and maintenances
- Evaluate the magnitude of any damage during disaster or other flood, and recommend to the concerned agencies such as DPWH for the appropriate repair and rehabilitation activities to be undertaken
- Supervise the progress of operation and maintenance, repair and rehabilitation activities
- Act as the main coordinating body/council for all technical, physical and socially related activities of the Anilao and the Malbasag rivers
- Conduct regular monitoring activities for the river improvement structures at the Anilao and Malbasag rivers
- Monitor illegal structures (facilities) and encroachment by the local peoples
- Promote disaster mitigation activities
- Inform and recommend appropriate regular operation and maintenance activities to all concerned agencies
- Collect and maintain data of the activities undertaken

The abovementioned main tasks are undertaken at present by the FMC. The operation fund (two million pesos yearly) of the FMC is continuously provided for twelve years.

It may say that the FMC in the Ormoc City is a successful case mainly due to stable funding sources for operation of the FMC, as well as a simple organizational structure, resulting to quick responses to the issues of the FMC due to only one concerned LGU (Ormoc City).

The sustainable activities for the O&M of the above two rivers were highly appreciated. Then, for example, on April 2013, a large-scale sedimentation soil loading project, which is funded by the Philippine's local fund (about Php. 98 mil.), and is managed by the Region Office, was commenced in the Ormoc City, in order to maintain the river courses.

(2) FMC in the Iloilo River Basin

In the Iloilo River and Jaro River Basins, the flood control project had been conducted by DPWH with JICA's financial assistance through from the Master Plan Study, and the Construction Project, which was commenced from year 1993. The present outline of the Project is as follows:

- The major contents of the Project include river channel improvement, construction of diversion channel, and main drainage channel inside the Iloilo City.
- The Detail Design (DD) of the structural measures of the Project was commenced on March 1999, then the DD was completed on June 2000.
- The construction of the structural measures, including the DD review and the tendering of the Project was commenced on October 2002 and was completed on April 2012.

The DPWH had done the construction of structural measures of the Project. For the operation and maintenance after completion of the construction, the DPWH, the Iloilo City, and the Municipality of Pavia each had a responsibility. To clarify the responsibilities among them, a Memorandum of Agreement (MOA) was to be prepared. However, the MOA has not been concluded among the concerned governmental organizations at present. Furthermore, the DPWH proposed to set-up a Flood Mitigation

Committee (FMC) in 2011, in order to assure the realization of the MOA and operation and maintenance. However, establishment of the FMC is still under considerations with the Iloilo City, and the Municipality of Pavia.

On the other hand, it is reported that some discussions and progresses are made for appropriate operation and maintenance of the structural measures for the dikes, which was constructed by the DPWH through JICA's financial assistance in "The Iloio River Rehabilitation Council (The Iloilo River Basin Council)".

Also, in relation to flood risk management in the Iloilo City, it has been conducted that a capacity development project for the relevant organizations by the Yokohama City under JICA Partnership Programme.

(3) FMC in the Pasig-Marikina River Basin

In the Pasig-Marikina River Basin, the flood control project has been conducted by the DPWH with JICA's financial assistance. The present outline of the Project is as follows:

- The Project had been conducted in three phases based on the updated Master Plan and Feasibility Study on flood control in Pasig-Marikina River, which were completed in the end of 1990's.
- At present, the Detailed Design of the Phase III was finalized.
- The major contents of Project III include river channel improvement and non-structural measures, which was proposed by the JICA Preparatory Study.
- The Detail Design (DD) of the structural measures of the Project Phase III was commenced on April 2012, and then the DD was completed on February 2013.

FMC in the Pasig-Marikina River Basin has been discussed through the preparatory survey, appraisal and DD stages. It was important to discuss about FMC from the preparation stage. The followings are the present situations related to FMC in the Pasig-Marikina River Basin.

It is recently that the comments for the draft MOA for establishment of the FMC by all the concerned agencies (three agencies, and seven LGUs) were submitted.

Furthermore, the 1st FMC Meeting among the concerned agencies, with the following agenda, was held on December 6, 2012

- Explanation of the Project Summary
- Explanation of overview of the proposed FMC Summary
- Report of Accomplishment of Information Campaign and Publicity under the JICA Study Team for the Detailed Design of Phase III Project
- Special Discussion on "Declaration of Flood Control Area"

However, the 1st FMC Meeting was a promotion meeting for soliciting approval of the concerned agencies for the MOA. Then it was revised the MOA by several comments and adjustments. After that the revised MOA was approved among the concerned agencies on January 24, 2013.

The MOA of the Pasig-Marikina River Basin was one of the great results of the official agreements in the Philippines. The MOA was approved among many concerned organizations, actually, thee concerned agencies; i) DPWH, ii) MMDA, and iii) Pasig River Rehabilitation Commission (PRRC), and seven concerned LGUs; i) Manila City, ii) Makati City, iii) Mandaluyong City, iv) Pasig City, v) Quezon City, vi) Marikina City, and vii) San Juan City.

CHAPTER 4 MASTER PLAN

4.1 Approach to Master Plan

(1) General

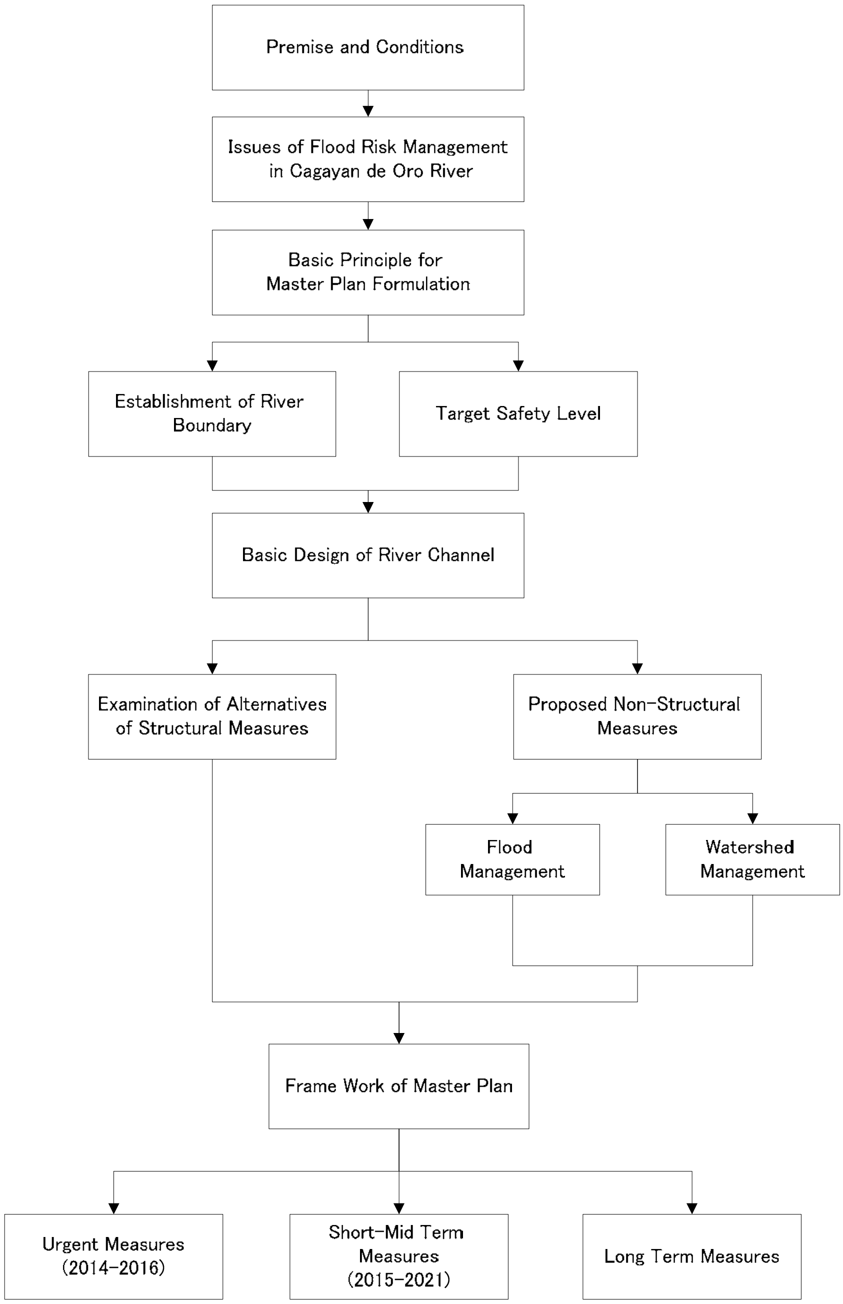
Cagayan de Oro River is one of the rivers draining the northern central part of the island of Mindanao. The river basin is bounded on the south by the Kalatungan Mountains, on the east by the Kitanglad Mountains, and on the west by an unidentified mountain range. The river has its headwaters in the Kalatungan Mountain Range found in the central part of the province of Bukidnon. It traverses the Municipalities of Talakag, Baungon and Libona, then finally empties into the Macajalar Bay at Cagayan de Oro City in the Province of Misamis Oriental.

Cagayan de Oro River runs the center of the Cagayan de Oro City, which is the regional center and most-higlly urbanized city in northern Mindanao. However, despite its important role in the region and Mindanao, flood control measures have not been implemented except for the partial construction of dikes.

Due to urgent need under such situation and serious flood damages caused by January 03 flood in 2009, DPWH conducted the master plan and the feasibility study in the Cagayan de Oro River Basin in June 2011, by their national budget. The master plan was formulated, which target year was set at Year 2035, with design scale of 25-year return period to attain the maximum flood control effects of the Cagayan de Oro River basin.

Tropical Storm Sendong in December 2011, after the conduct of the said master plan and feasibility study, had brought about serious damages in the north Mindanao area. About 1,170 thousand people were affected and about 1,250 persons were lost. One of the serious damaged cities was Cagayan de Oro City, where about 600,000 people live. Due to tremendous changes in natural and social conditions by the Sendong which flood magnitude is estimated at over 50-year return period, review and update of M/P and F/S are urgently required so that the Flood Control Risk Management Project for Cagayan de Oro River (FRIMP-CDOR) is formulated to cope with the current situation.

The Master Plan of Flood Risk Management for the Cagayan de Oro River is formulated through following flow chart as presented in next page. The Master Plan comprises urgent measures, middle-short term measures and long term measures including both structural and non-structural measures.



Source: JICA Survey Team

Figure 4.1.1 Work Flow for Formulation of the Master Plan of Flood Risk Management for the Cagayan de Oro River

(2) Premises and Conditions for Master Plan

1) Objective Area

The objective area is whole Cagayan de Oro River basin with catchment area of 1,364 km^2. The Cagayan de Oro River, river length of the main river course is 97 km from its origin to the river mouth, has two major tributaries i.e.; the Tumalaong River and the Bubunawan River, both run-offs come from the east slope of the mountainous area in the basin.

2) Target Year

The target year was set at the year 2035, which is the same target year having applied in the previous master plan that a year after the final year of the four (4) Medium-Term Philippine Development Plans that has started from 2011.

3) Land Use

There is existing land use plan prepared by Cagayan de Oro City. At present, taking into consideration of the flood damages of TS Sendong, the local government is undertaking resettlement activities in the area and updating comprehensive land use plans including establishment of Non-Build Zone along the Cagayan de Oro River, which was identified at seven(7) areas in or adjacent the river. While, the DENR is preparing a map showing hazard area and river area in which policy of the River Boundary established by DPWH is to be incorporated.

(3) Characteristics and Issues of Flood Damage in Cagayan de Oro River

In the Cagayan de Oro River Basin, past flood damage record shows that there were several large floods hit the basin in 1916, 1957, 1982, 1998 and 2009. In 2011 and 2012, TS Sendong in December 2011 and Typhoon Pablo in December 2012 passed over the Cagayan de Oro River Basin resulting in large inundation damages in the area.

TS Sendong especially, had brought about serious damages in the objective area. About 1,170 thousand people were affected and about 1,250 persons were lost in total.

Under aforementioned circumstance, a project regarding urgent flood risk management measures for the Basin is required to be implemented in order to strengthen the disaster resilience of communities around the Basin.

Table 4.1.1 below shows the characteristics and issues of the flooding in the Cagayan de Oro River obtained in the course of the Survey.

Table 4.1.1 Characteristics and Issues of Flooding in the Cagayan de Oro River

Characteristic	Issue
Flashflood	● Short lead time for warning, evacuation before flooding ● Difficulty in evacuation during flood due to rapid increase of flood level ● Risk on sudden action/response for flood occurrence during night time
Occurrence of extraordinary floods in recent years	● Inadequate existing structural flood mitigation measures (flow capacity of existing river channel is only for 2-5 year flood) ● Partial dike system ● Very high flood risk in case of higher flood level and deeper inundation ● Risk of bridge collapsing (almost no freeboard at some of existing bridges during TS Sendong)
Flooding water passing over the narrow inundation area	● Relatively high speed flood flow passing through narrow inundation area ● Strong force of fast flow velocity posing disadvantage for evacuation and serious damages on structures such as shanties and wooden houses
Inundation in inland area	● No installation of sluice gate at existing outlet of drainage channel causing backwater intrusion during flood ● Inadequate local drainage system
Flood damages on residents and residential houses living in the area on the river bank	● Increase of loss of human lives ● Decrease of flow area

Source: JICA Survey Team

(4) Basic Principle to Formulation of Master Plan

Following six (6) basic principles are established for formulation of Master Plan for Flood Risk Management:

(i) Consistency with Philippines National Development Plan（2011-2016）
(ii) Formulation of Master Plan and Feasibility Study referring to Comprehensive Flood Mitigation Measures
(iii) Consideration for Climate Change Adaptation in Planning and Design for Flood Mitigation Structures
(iv) Execution of Flood Mitigation and Management by Structural and Non-structural Measures
(v) Considerations on Natural and Social Environmental Impacts by the Flood Mitigation Measures
(vi) Establishment of River Boundary (Land Use Control, Restriction of Construction and Living in High Risk Area)

4.2 River Boundary

4.2.1 General

TS Sendong in December 2011 had brought about serious damages in the north Mindanao area and especially a lot of residents living along the river bank were lost though there was a recommendation for flood prone area along the river bank by DENR in 2009. After TS Seondong struck out the area, Isla de Oro area was defined as “Prohibited Area” and GOP is undertaking resettlement activities to prohibit living and construction of houses in the area.

The land acquisition and resettlement action plan in this area shall be prepared by the GOP after the river boundary was established taking into account of the river zone, river conservation zone, etc. since the river area and river boundary have not been clearly identified in the previous master plan.

Objective of establishment of the river boundary along the Cagayan de Oro River is:

<u>to establish river alignment for clear demarcation of flood control area and easement.</u>

The definition of the river boundary will contribute to prevent recurrence of calamity such as TS Sendong by:

i) securing required land to flow down flood water safely,
ii) protection from living and reconstruction of houses in highly flood prone areas,
iii) control land use and development in the river area not to obstruct flood flow, and
iv) securing necessary construction area for river structures such as dike embankment, flood plain, revetment, sluice gate, etc.

This policy will mitigate flood risks, loss of human lives and damages on properties, buildings and infrastructures in the flood prone area, and contribute to regional developments and economic growth of the LGUs, and peace and safe of residents living adjacent to the river.

4.2.2 Establishment of River Boundary

The river boundary along the Cagayan de Oro River was established, in consideration with existence of wider flood-prone area than the NBZ declared after TS Sending, and based on results of studies for river morphology, inundation analysis and flood risk assessment. The established river boundary is shown in Figure 4.2.1 below.

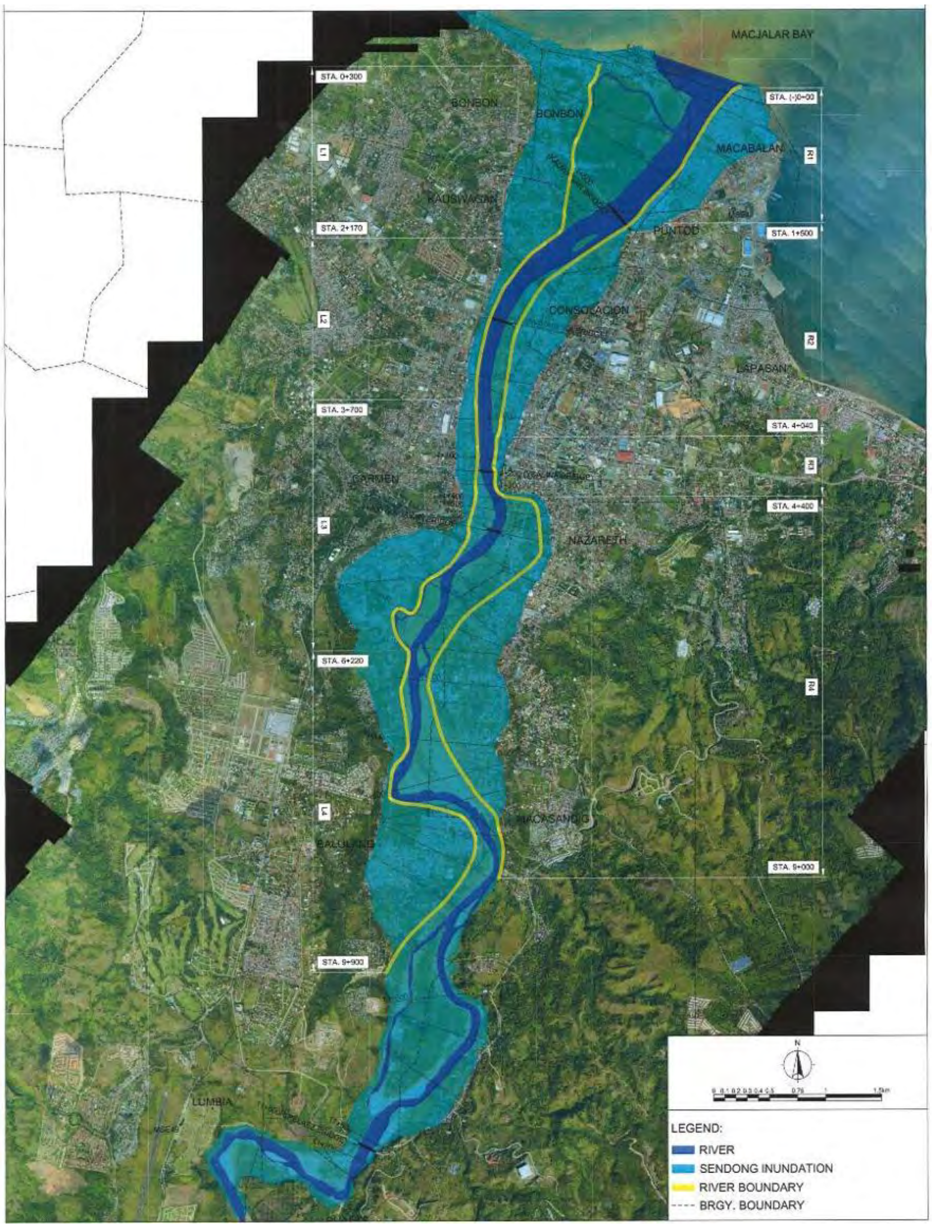


Figure 4.2.1 Base Map for Study of River Boundary in Cagayan de Oro River

4.2.3 River Boundary and Assessment of Flood Risk Level

The flood risk was assessed in reference to the evaluation criteria adapted by the World Bank Study on the Flood Management Master Plan for Metro Manila and Surrounding Areas (2010). The criteria for assessment of flood risk level is shown in Figure 4.2.2 and classified into 4 levels: Flood Risk Level 4 (Very High Risk of Casualty: 5.0 m < D), Flood Risk Level 3 (High Risk of Casualty: 2.0 m < D $\leqq$ 5.0 m), Flood Risk Level 2 (Medium Risk of Casualty: 0.5 m < D $\leqq$ 2.0 m), Flood Risk Level 1 (Low Risk of Casualty (D $\leqq$ 0.5 m).

According to the assessment of flood risk level, the river boundary was set along the outer line of the Flood Risk Level 4 where local residents are impossible to evacuate, lose the safety place in their house during flood event. The area of Flood Risk Level 4 was seriously damaged by recent floods repeatedly.

Table 4.2.1 Criteria for Assessment of Flood Risk Level

Flood Risk Level	Risk	Inundation Depth (D)	Remarks
Level 4	Very High	5.0 m <D	Very difficult to evacuate, lose the safety place in their house during flood event
Level 3	High	2.0 <D≦5.0 m	The safety place during flood is only roof area in case of a two-story house.
Level 2	Medium	0.5 <D≦2.0 m	In case of a single-story house, the safety place during flood is only roof area.
Level 1	Low	D≦0.5m	People can evacuate to evacuation places by themselves during flood event

Source: World Bank Flood Management Master Plan for Metro Manila and Surrounding Areas (2010)

As stated in the above, the area of the Flood Risk Level 4 is not the safe place where people can live and, therefore, it is strongly recommended for people not to live and put any structure in this area. The basic concept of flood risk management of the Project is, therefore, to relocate people living in the area of the Flood Risk Level 4 to safe place and to protect people in the Flood Risk Levels 1 to 3 based on the established river boundary, as shown in Figure 4.2.2.

In case of breaching of dike by extreme floods like TS Sendong, this basic concept will protect human lives in the Flood Risk Levels 1 to 3 from serious flooding, in combination with flood forecasting and early warning systems and evacuation system.

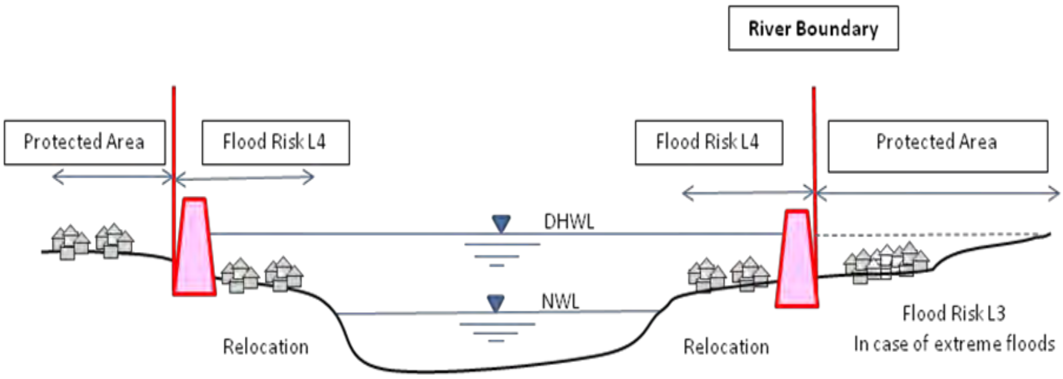


Figure 4.2.2 Conceptual Illustration of Flood Risk Management of the Project

4.3 Target Safety Level and Design Scale

4.3.1 Target Safety Level of Master Plan

The target safety level was set so as to correspond to the largest recorded flood in the Northern Mindanao Region, which is TS Sendong scale flood in accordance with the memorandum from the DPWH Secretary regarding upgrading the design standard of flood control works. The flood return period of TS Sendong is corresponding to approx.50-year return period.

4.3.2 Design Scale

Previous Master Plan and Feasibility Study prepared in June 2011 had adopted 25-year probability as an optimum design scale both for M/P and F/S. However, the return period of TS Sendong was evaluated at around 50-year probability which exceeds the design scale of the previous M/P and F/S.

The long term plan to be proposed in this Master Plan was formulated taking into account the return period of TS Sendong and the said memorandum of DPWH Secretary.

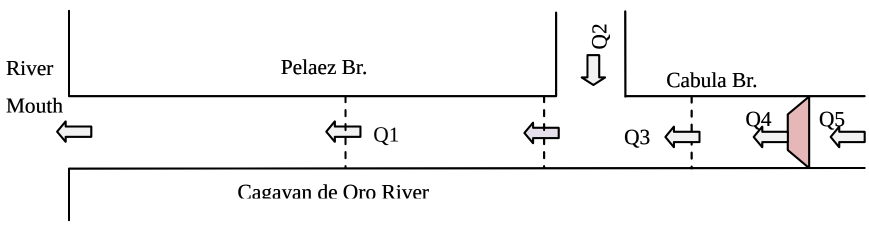
The suitable design scale of the Feasibility Study for the river improvement works in the downstream stretch was determined at 25-year flood because it is not reasonable to adopt higher design scale for actual implementation of the Project considering the existing flow capacity, design scales of other major rivers in the Philippines, existing river improvement works and site development conditions, and social impacts.

i) Design Scale of Master Plan :Sendong scale (around 50-year probability)
ii) Design Scale of Feasibility Study : 25-year flood

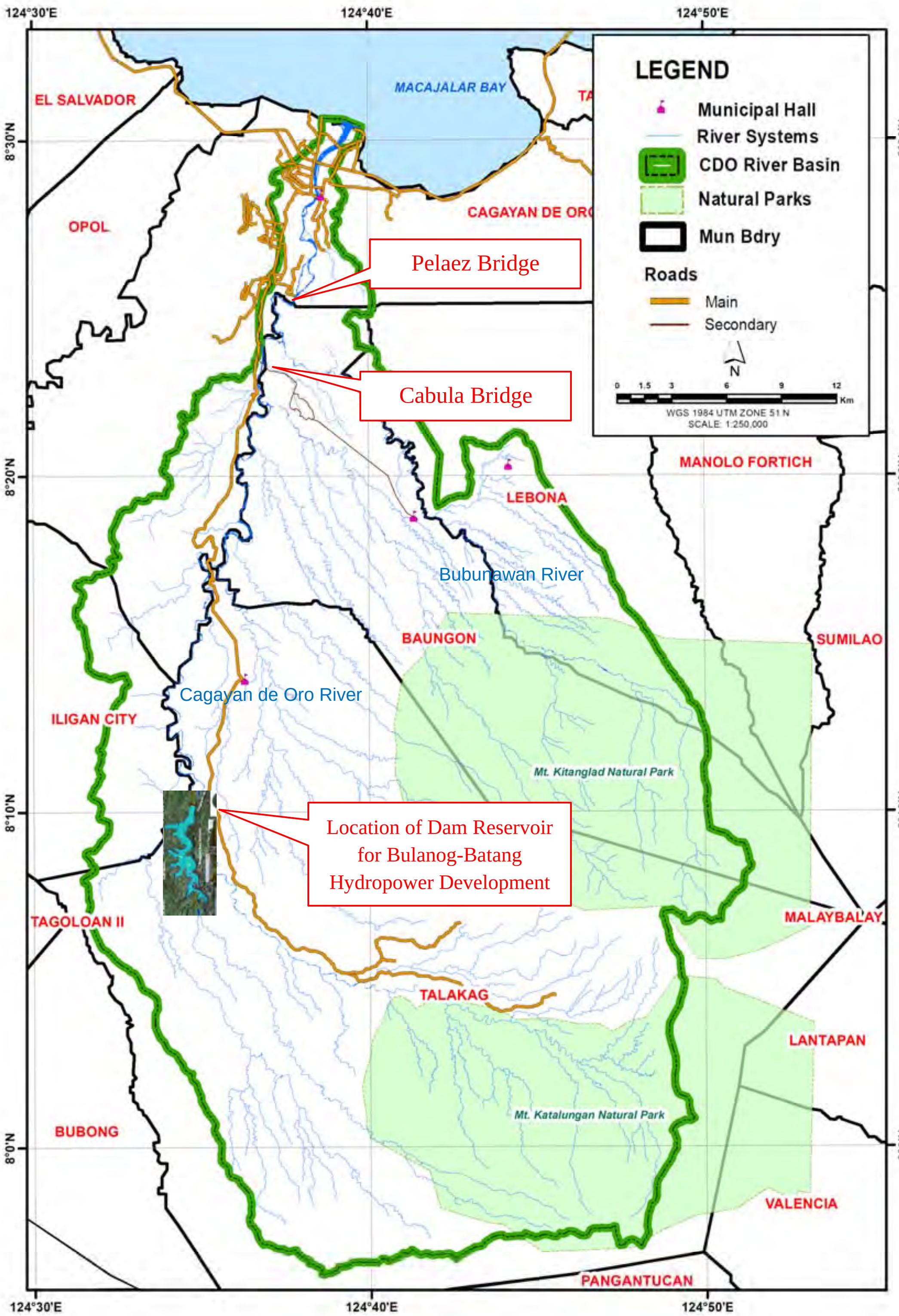
The design discharge distribution was prepared for the cases of with/without the proposed long term plan (flood control dam) as discussed later. The design scale of the proposed river improvement works in the downstream stretch is set will be upgraded from 25-year probability to Sendong scale after completion of the long term plan.

Table 4.3.1 Design Discharge Distribution (Sendong Scale)

Return Period	Case	Pelaez Bridge (Q1)	Bubunawan River (Q2)	Cabula Bridge (upstream of Bubunawan Conf.) (Q3)	Proposed Dam Site (Q4)	Proposed Dam Site (Q5)
25-year	Without Dam	3,300 m^3/s	600 m^3/s	2,700 m^3/s	-	-
Sendong Scale	Without Dam	5,000 m^3/s	900 m^3/s	4,100 m^3/s	-	-
	With Dam	3,300 m^3/s	900 m^3/s	2,400 m^3/s	1,000 m^3/s	2,700 m^3/s



Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3.1 Location of Pealez and Cabula Bridges, Bubunawan River and Existing Dam Construction Plan

4.4 Basic Design of River Channel

(1) Channel Alignment

The Cagayan de Oro River flows from south to north passing through the city proper which is highly developed as the center of the Cagayan de Oro City in the Province of Misamis Oriental in Northern Mindanao. There is no potential site found for construction of new diversion channel at both sides of the river. Therefore, the alignment of the proposed river improvement work shall basically follow the alignment of the existing channel.

(2) Typical Cross Section

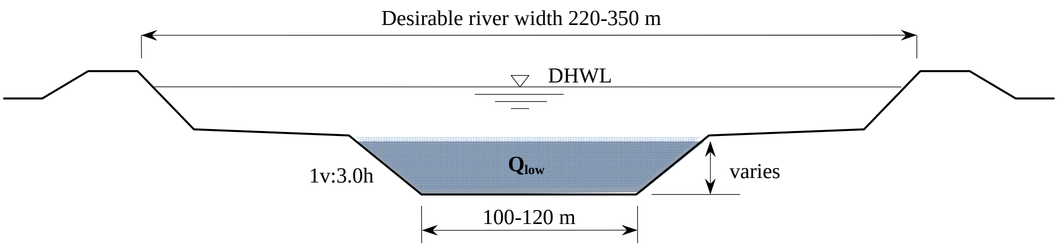
(i) Compound Section

River width in the downstream varies from approximately 100 m to 270 m, and some sections have wider flood plain with sand bars. Seasonal discharge of the river varies in wider range, less in dry season and bigger in wet season, due to topographic and hydro-meteorological characteristics in the basin. The design cross section is, therefore, proposed to have compound section composed with low water channel and high water channel.

(ii) Low Water Channel

The design riverbed width of the low water channel is set at 120 m in normal section and 100 m in narrow section considering the existing river width in the area so as not to affect the dike and structures along the bank. The side slope of the low water channel is set at 1v:3.0h.

The flow capacity of low water channel is estimated at 650-800 m^3/s which corresponds to the existing channel flow capacity of around 2-year flood.



Source: JICA Survey Team

Figure 4.4.1 Typical Cross Section

(iii) High Water Channel

Desirable river width in the downstream of the Cagayan de Oro River is estimated at 220 - 350 m for the design flood of 3,300 m^3/s based on the past experience in the river improvement works. The established boundary is basically aligned satisfying the said desirable river width in the objective stretch while there are a few narrow sections.

(3) Longitudinal Profile

A riverbed slope in the downstream of the Cagayan de Oro River is around 1/4,000 from the river mouth to Sta.8+5000, while it is steep as around 1/250 from upstream of Sta.8+500 to Sta.12+000 based on the result of the river profile survey in 2012.

(4) Design High Water Level

The design high water level is set referring to the results of non-uniform flow analysis under the following conditions:

- Cross section: results of cross section survey and topographic survey in 2012
- Water level at river mouth : H.W.L +1.01 m above MSL
- DHWL is designed not to be lower than the calculated water level in whole stretch and recorded high tide level of +1.34 m (above MSL) in the downstream
- DHWL is set to consider required clearance at bridge sections, previous highest flood levels, flood risk against extraordinary flood, and land use, environmental aspect.

Table 4.4.1 Design High Water Level

Station	Design High Water Level	Gradient of DHWL
Sta.0+000	+1.34 m (HHWL) +2.50 m	1/1200
Sta8+000	+9.17m	
Sta.10+000	+14.88m	1/350

Source: JICA Survey Team

(5) Design Crest Level and Freeboard

The design crest level of the proposed dike is set considering required freeboard above the Design High Water Level. The required freeboard of the downstream of the Cagayan de Oro River is 1.2 m corresponding to the design flood discharge of 3,300 m^3/s based on the design guideline of DPWH as below.

Table 4.4.2 Minimum Required Freeboard

Design flood discharge (m^3/s)	Freeboard (m)
Less than 200	0.6
200 and up to 500	0.8
500 and up to 2,000	1.0
2,000 and up to 5,000	1.2
5,000 and up to 10,000	1.5
10,000 and over	2.0

Source: Manual on Design of Flood Control Structures, DPWH

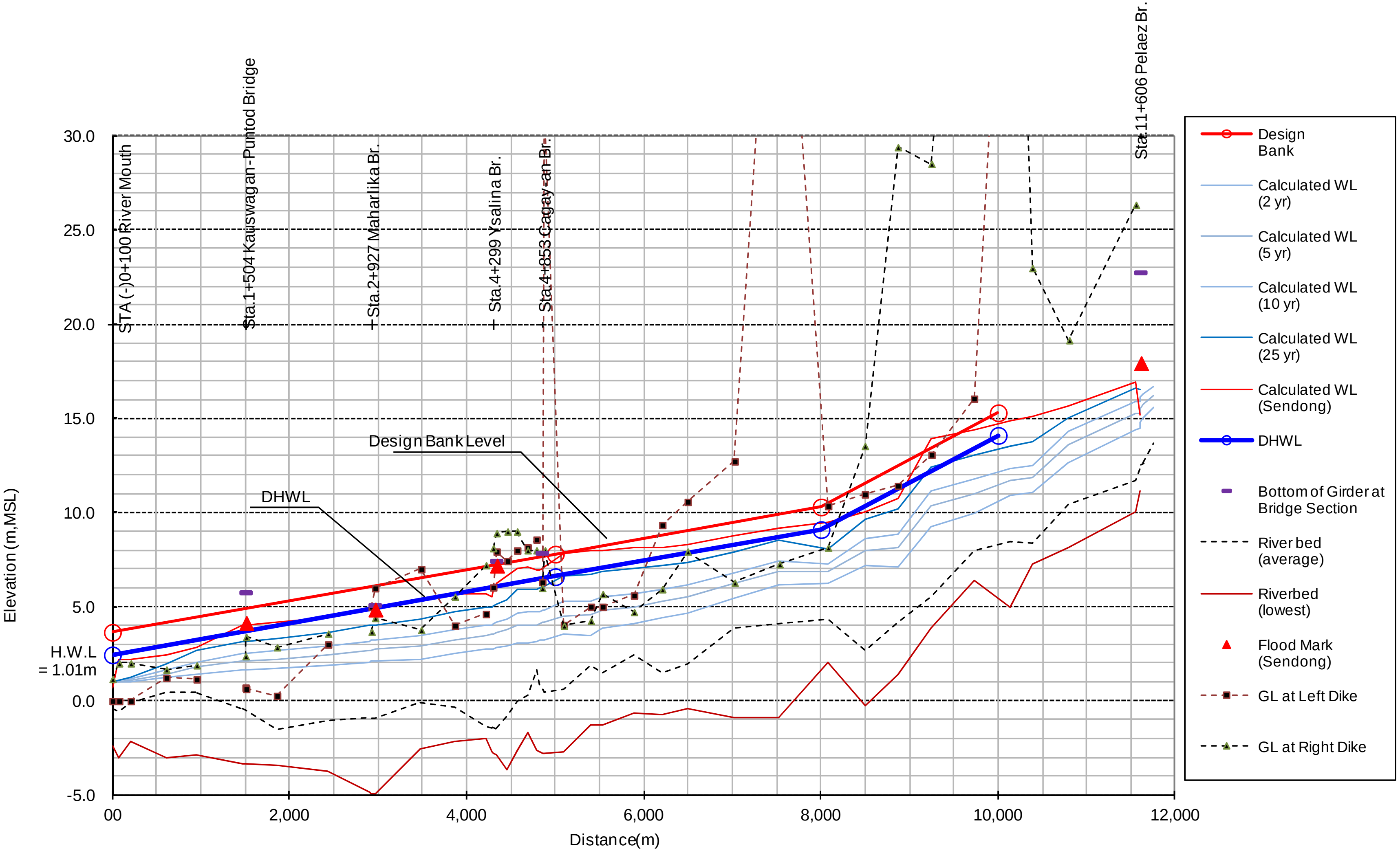


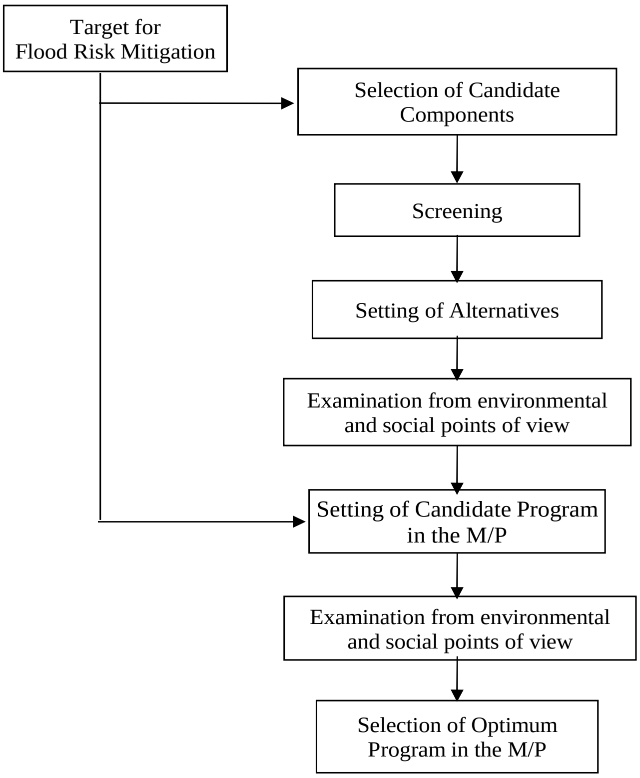
Figure 4.4.2 Design Longitudinal Profile of Cagayan de Oro River

4.5 Examination of Alternatives of Structural Measures

4.5.1 General

(1) Procedure of Examination

Examination of alternatives of structural measures aims at selection of the optimum measures in the Master Plan (M/P). The purpose of the examination is to verify the adequacy of the components in the M/P. The procedural flow of the examination is shown on Figure 4.5.1. Based on the target, structural measures for the flood risk mitigation to achieve the conditions were selected as candidate components. The components were screened out in terms of the effectiveness to contribute to the target for flood risk mitigation above. Then, the alternatives of the components and programs to be adopted in the M/P were set and examined from the environmental and social points of view including the technical aspects and necessary cost. Finally, the most advantageous alternative was selected as the optimum alternative to be adopted in the M/P.



Source: JICA Survey Team

Figure 4.5.1 Procedural Flow of Examination of Alternatives for Master Plan

(2) Viewpoints for Environmental and Social Evaluation

Examination from the environmental and social considerations for the alternatives will be given based on the following viewpoints:

- Natural environment elements: conservation area, ecology (terrestrial and aquatic), hydrological regime, topography and geology,
- Public pollution: air quality, water quality, noise and vibration, wastes, soil contamination, ground subsidence, odor, riverbed sediment and traffic, and

- Social environment elements: resettlement, poverty group, indigenous people, local economy/livelihood, land use, water usage, existing social infrastructure, social institutions, misdistribution of benefit and damage, conflict of interest, cultural heritage, landscape, gender/socially vulnerable group, rights of children, HIV/AIDS, and labor environment.

Comparison of the magnitude of environmental negative impact among each alternative will be made based on selected indicators, among listed above, which are strongly related to the project components, including the number of involuntary resettlement, major infrastructures and public facilities necessary for relocation, volume of waste to be generated, magnitude of pollution and/or public nuisance (noise, air quality, etc.), magnitude of additional traffic volume due to the construction, and clearance of vegetation.

4.5.2 Setting of Alternatives

(1) Basic Policy for Flood Risk Mitigation

Overall goal of the project is to mitigate flood risks in the Cagayan de Oro River based on the following basic policies for Flood Risk Management:

1） Increase of flow capacity of river channel
2） Control of flood inflow from river basin
3） Increase of flood outflow discharge of river channel
4) Improvement of drainage functions in inundation area
5） Evacuation from high flood risk area

(2) First Screening of Candidate Components

To realize the above basic policies, candidate components for flood risk mitigation are enumerated in Table 4.5.1. Among these measures, first screening was conducted in order to preliminarily evaluate adaptability for the Cagayan de Oro River taking into consideration the characteristics and issues of the flooding in the basin. The criteria of flood risk management and climate change adaptation, and socio-environmental conditions, operation and maintenance, organization institutional aspect and cost are adopted for the first screening. Detail of the first screening is presented in Table 4.5.2

Table 4.5.1 Selection of Candidate Alternatives

No.	Basic Policy for Flood Risk Mitigation	Conceivable Measures	Objective Area	Construction Phase	Result of 1st Screening
1	Increase of flow capacity of river channel	1-a. Construction of dike and flood wall	Lower stretch	Short-middle term	(〇selected) To be adopted as candidate alternatives
		1-b. Rehabilitation, improvement of existing river structures	Lower stretch	Urgent	supplement measures for 1-a
		1-c. Excavation/dredging of river channel	Lower stretch	Short-middle term	To b implemented as maintenance work
2	Control of flood inflow from river basin	2-a. Construction of flood control dam	Upper basin	Long term	(〇selected) To be adopted as candidate alternatives
		2-b. Effective use of existing retarding basin	Lower –Middle stretch	Short-middle term	supplement measures for 1-a

No.	Basic Policy for Flood Risk Mitigation	Conceivable Measures	Objective Area	Construction Phase	Result of 1st Screening
		2-c.Watershed management	Upper basin	Long term	To be studied as non structural measures.
3	Increase of outflow discharge of river	3-a.Construction of flood diversion channel (without river improvement)	Lower stretch	Long term	(〇selected) To be adopted as candidate alternatives
4	Improvement of drainage functions in inundation area	4-a. Construction of storm storage and infiltration facilities	Lower stretch	Short-middle term	Not applicable
		4-b. Installation/Improvement of drainage channel and outlet, and construction of sluice gates	Lower –Middle stretch	Short-middle term	supplement measures for 1-a
		4-c. Construction of drainage pumping station	Lower stretch	Short-middle term	Not applicable
5	Evacuation from high flood risk area	5-a. Relocation of residents from high flood risk area	Lower stretch	Short-middle term	To be studied as non structural measures.
		5-b. Improvement of flood forecasting and warning system	Whole basin	Short-middle term	To be studied as non structural measures.
		5-c. Enhancement of flood disaster reduction management	Whole basin	Short-middle term	To be studied as non structural measures.
		5-d.Construction/improvement of evacuation centers and evacuation roads	Whole basin	Short-middle term	To be studied as non structural measures.

Source: JICA Survey Team

Based on the result of the first screening for alternative components in the M/P, the following three measures would be adopted.

- River improvement, targeting for the downstream areas of CDO River basin, shall be a measure to attain the aforementioned prerequisite conditions in terms of the design flood scale.
- A flood control dam aims to mitigate flood risk for Cagayan de Oro City at the middle to upstream area of CDO River, and can be a measure to cope with the prerequisite conditions above.
- A flood diversion channel aims to increase a discharge capacity of flood and in general divert flood waters before a river flows down in urban areas. In the alternative of CDO River, based on topographical conditions, it can be expected that, from the right bank between Kagayan Bridge and Ysalina Bridge, a flood diversion channel flows down directly to Macajalar Bay after passing the city areas.

Watershed management (2-c) would be a measure to be effective for retarding small or middle scale flood by planting, reforestation, measures in combination with farming, etc. over upstream areas of CDO River basin. Reforestation has an effect of improving water retention capacity of watershed at an early stage of rainfall, and if areas and timing to implement the measure are optimized and required maintenance is approximately done, it is expected to be effective for retarding the flood inflow at the early stage of rainfall. However, it is difficult to predict the effect quantitatively and in general it takes time to see the effect. Consequently, although watershed conservation is effective as flood mitigation measure, the degree of flood mitigation effect is not always clarified. Thus, it is considered separately as a non-structural measure.

Conceivable measures of evacuation from high flood risk area (5-a to 5-d) are studied as non-structural measures as well as the water shed management (2-c). Excavation/dredging of river channel (1-c) is proposed as a maintenance work taking into consideration of the future sediment conditions. The measures of rehabilitation, improvement of existing river structures (1-b), effective use of existing retarding basin (2-b) and installation/improvement of drainage channel and outlet, and construction of sluice gate (4-b) are considered as supplement measures for construction of dike and flood wall (1-a).

Table 4.5.2 First Screening of Candidate Components for Flood Mitigation Measures

Flood Mitigation Measures	Flood Risk Management/ Climate Change Adaptation	Socio-environmental Conditions	Cost/Operation and Maintenance/ Organization and Institutional Policy	Result of First Screening
1. Increase of flow capacity of river channel				
1-a River improvement by Construction of dike and flood wall	・ Existing dike system is intermittently installed and not continuous, and flow capacity of existing river channel is only for 2-5 year flood. ・ Continuous dike system should be constructed along both banks including the exiting elevated banks in the objective area. ・ Floodwall is applicable in some areas where many commercial/residential building are located, to reduce relocation and resettlements. ・ For climate change adaptation, earth dike is more preferable measure than the floodwall due to the merits of maintenance and heightening.	・ Necessity to layout the proposed dike to reduce relocation and resettlements ・ Consideration for socio-environmental condition	・ Existing organization of DPWH is capable to implement similar scale of flood mitigation works and O&M.	(〇selected) To be adopted as candidate for examination of alternatives
1-b Rehabilitation, improvement of existing river structures	・ Inevitable to restore the damaged revetments during flood in Sendong ・ At some of existing bridges, abutments and revetments of bridge are encroaching the river channel and block the waterway of river. There structures should be improved not to obstruct the flow of water.	・ Necessity to layout the proposed dike to reduce relocation and resettlements	・ At present, DPWH Regional Office is implementing rehabilitation works of some damaged river structures using their fund.	supplement measures for 1-a

Flood Mitigation Measures	Flood Risk Management/ Climate Change Adaptation	Socio-environmental Conditions	Cost/Operation and Maintenance/ Organization and Institutional Policy	Result of First Screening
1-c Excavation/dredging of river channel	• River channel in the downstream stretch which is located at outlet of delta, is potentially aggregated or silted due to sediments delivered from the upstream. Channel excavation and dredging would be one of basic components.	• Consideration for socio-environmental condition • Necessity of sediment disposal areas • Coordination with sand mining activities in the river channel	• Existing organization of DPWH is capable to implement similar scale of flood mitigation works and O&M. • Operation cost would be very high if only this measure is adopted.	To b implemented as maintenance work

Flood Mitigation Measures	Flood Risk Management/ Climate Change Adaptation	Socio-environmental Conditions	Cost/Operation and Maintenance/ Organization and Institutional Policy	Result of First Screening
2. Control of flood inflow from river basin				
2-a Construction of flood control dam	• To cope with extra-ordinary flood, river improvement works would be insufficient due to constraint of present site conditions. Construction of flood control dam in the upstream will be necessary to be studied. • There are several potential dam sites in the upstream, and among there is an existing plan of hydropower dam in the mainstream of the CDO River. • The construction of dam is one of effective measures to cope with the extreme flood considering the climate change.	• More detail study is necessary to consider socio-environmental condition • Mitigation of relocation and resettlements	• Necessity on coordination with relevant agencies for allocation of dam capacity and operation • The construction cost of dam is very high, but the benefit of hydropower generation as well as flood control can be considered.	(〇selected) To be adopted as candidate for examination of alternatives
2-b Effective use of existing retarding basin	• In the upper basin, there are few potential sites for retarding basin. • In the downstream stretch, there are several existing natural retarding basins which can be utilized as flood peak regulation . • The construction of retarding basin is one of effective measures to cope with the extreme flood considering the climate change.	• Consideration for socio-environmental condition • Mitigation of relocation and resettlements	• Maintenance works of facilities and removal of siltation in the retarding basin shall be necessary.	supplement measures for 1-a

Flood Mitigation Measures	Flood Risk Management/ Climate Change Adaptation	Socio-environmental Conditions	Cost/Operation and Maintenance/ Organization and Institutional Policy	Result of First Screening
2-c Implementation of watershed management	• Watershed management is to be a main component for flood mitigation measures in the upstream basin, which would contribute to regulate run-off from the basin and mitigate soil erosions. • For climate change adaptation, the Basin-wide approach including watershed management is one of the essential measures for flood risk management.	• This will preserve the forest area from encroachment	• Necessity on coordination with relevant agencies for watershed managements	To be studied as non structural measures.

Flood Mitigation Measures	Flood Risk Management/ Climate Change Adaptation	Socio-environmental Conditions	Cost/Operation and Maintenance/ Organization and Institutional Policy	Result of First Screening
3. Increase of flood outflow discharge of river				
3-a Construction of flood diversion channel	• There is a conceivable route for construction of flood diversion channel in east side of the city proper, where floodwater had passed through in 1916 according to a past record. • Increase of flood outflow discharge of river would be effective from the view of flood risk mitigation in the CDO city.	Proposed route of the flood diversion channel passing through the center of city proper would cause a tremendous number of resettlement and relocation of commercial and industrial facilities, and also construction of many large bridges are needed.	• Construction cost of flood diversion channel is very expensive due to replacement costs for a lot of bridges and structures.	(〇selected) To be adopted as candidate for examination of alternatives
4. Improvement of drainage functions in inundation area				
4-a Construction of storm storage and infiltration facilities	• Effect of storm storage and infiltration facilities is very limited comparing with the magnitude of flood.	—	• Maintenance works of facilities and removal of siltation shall be necessary.	(×: not applicable) • Priority of this option is low because of limited effect.
4-b Improvement of drainage channel and outlet, and construction of sluice gates	• Inundation in the city area is caused even in regular rainfall due to inadequate drainage channels and outlets. • Installation/improvement of drainage system should be considered in connection with construction of dyke system.	—	—	• supplement measures for 1-a
4-c Construction of drainage pumping station	• Drainage by pumping station is not so effective in this area considering the topographic features which make possible for local rainfall water to drain to river as gravity flow.	—	• Cost of operation and maintenance of pumping station is very high.	(×: not applicable) • Priority of this option is low because of limited effect.

Flood Mitigation Measures		Flood Risk Management/ Climate Change Adaptation	Socio-environmental Conditions	Operation and Maintenance/ Organization and Institutional Policy	Result of First Screening
5. Evacuation from high flood risk area					
5-a	Relocation of residents from high flood risk area	• Relocation from high flood risk area is most effective measures to minimize loss of human lives considering the lesson and learnt from damage of TS Sendong and TY Pablo.	• Necessity of clear identification of flood risk area • Consideration for land use in high flood risk area	• Regulation and guideline for usage and maintenance of high flood risk area	To be studied as non structural measures.
5-b	Improvement of flood forecasting and warning system	• FFWS is one of the effective measures to mitigate flood risk and loss of human lives	—	• Coordination with other relevant agencies and LGUs • O&M after installation	To be studied as non structural measures.
5-c	Enhancement of flood disaster management	• Enhancement of disaster management is one of the effective measures to mitigate flood risk and loss of human lives	—	• Coordination with other relevant agencies and LGUs	To be studied as non structural measures.
5-d	Construction /Improvement of evacuation centers and evacuation roads	• Construction or improvement of evacuation center and evacuation road is one of the effective measures to mitigate flood risk and loss of human lives	—	• Coordination with other relevant agencies and LGUs	To be studied as non structural measures.
6. Keep present condition （without measure）					
	Without any measures	• Flooding would occur frequently (existing flow capacity of the channel in the downstream is around 2-5 year flood) • Extreme loss of human lives and damages on the structures and assets in case of occurrence of extra-ordinal flood	—	—	（〇selected) To be adopted as candidate for examination of alternatives

Source: JICA Survey Team

(3) Setting of Alternatives

Considering the target for flood risk management mentioned above, and various other conditions in the CDO River basin, the following ones are set as candidate programs:

1) Alternative 1: River improvement by widening of the river area to cope with Sendong scale flood (approx. 50 years return period)

2) Alternative 2: River improvement by heightening of river banks by structures to cope with Sendong scale flood (approx. 50 years return period), and

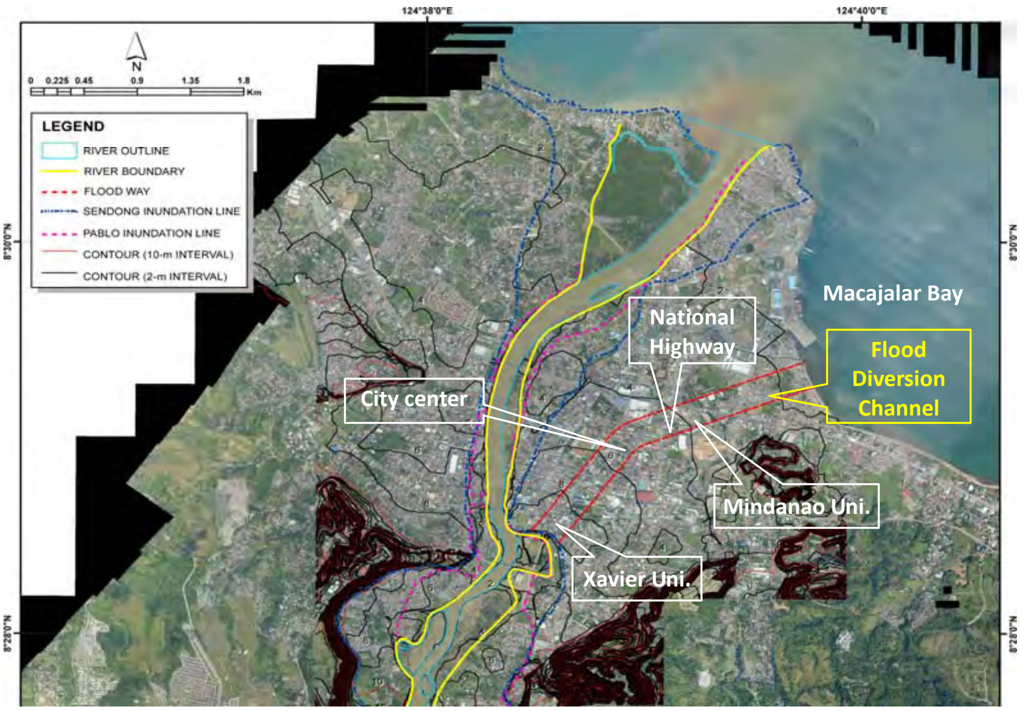
3) Alternative 3: River improvement and utilization of existing dam construction plan (Bulanog-Batang Hydropower Development Project) to cope with Sendong scale flood (approx. 50 years return period).

4) Alternative 4: Dam construction without river improvement works to cope with Sendong scale flood (approx. 50 years return period).

5) Alternative 5: Construction of flood diversion channel without river improvement works to cope with Sendong scale flood (approx. 50 years return period).

Among these alternatives, the alternative 4 is not adopted as an alternative because river planning should consider integration of river system from upper basin to lower basin.

As for the alternative 5, the diversion channel would pass through the city center, considering the topographic conditions, with the width of approx. 220 m and the length of approx. 2.8km as shown on the figure below. It would, however, cause substantial resettlement of residents and relocation of infrastructures, and splitting of city center. Consequently, this measure cannot be regarded as an adequate measure because the social environment impacts are crucial, and flood diversion channel, therefore, is not adopted as an alternative of this project.



Source: JICA Survey Team

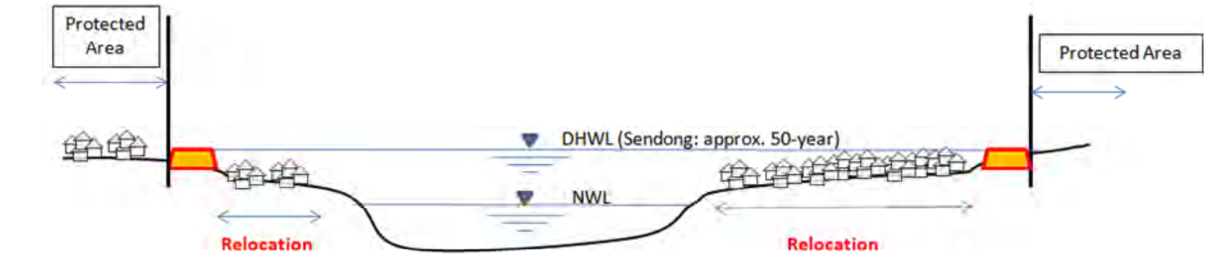
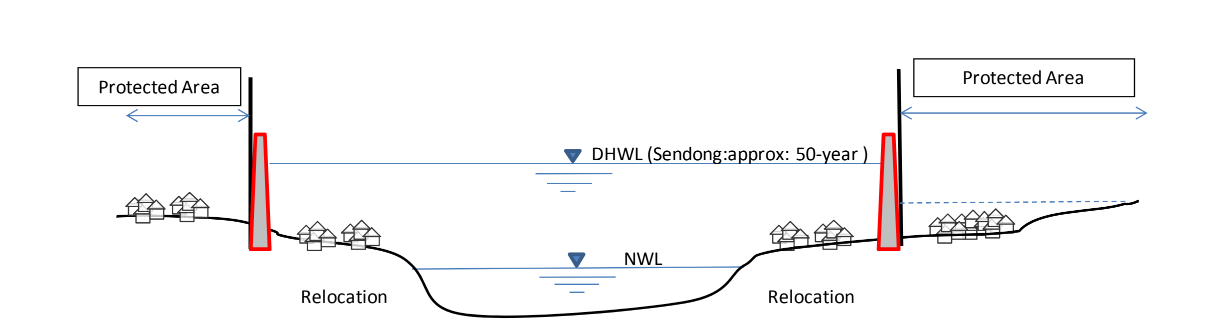
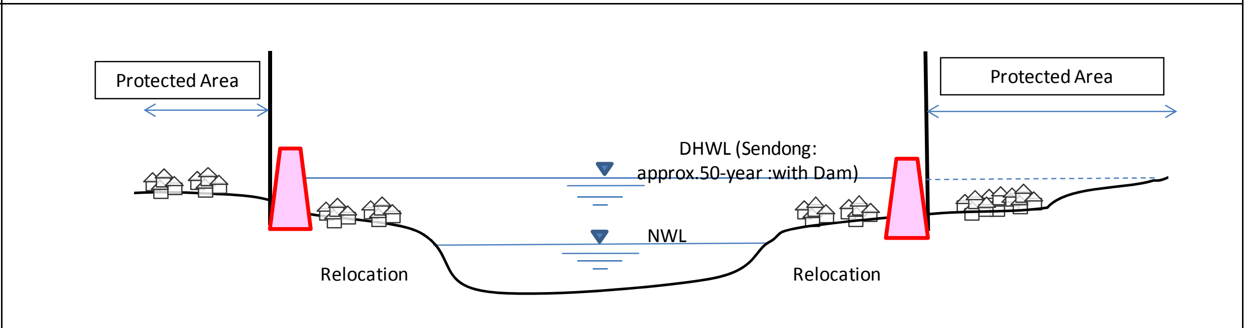
Figure 4.5.2 Anticipated Location of Flood Diversion Channel in Alternative of Construction

As the results, the examination of alternatives for the components in the M/P is done for three(3) alternatives. Details are described in the Table 4.5.3. The table also shows the alternative of "Without Project" as reference for the examination of alternatives.

Table 4.5.3 Description of Alternatives (Candidate Programs)

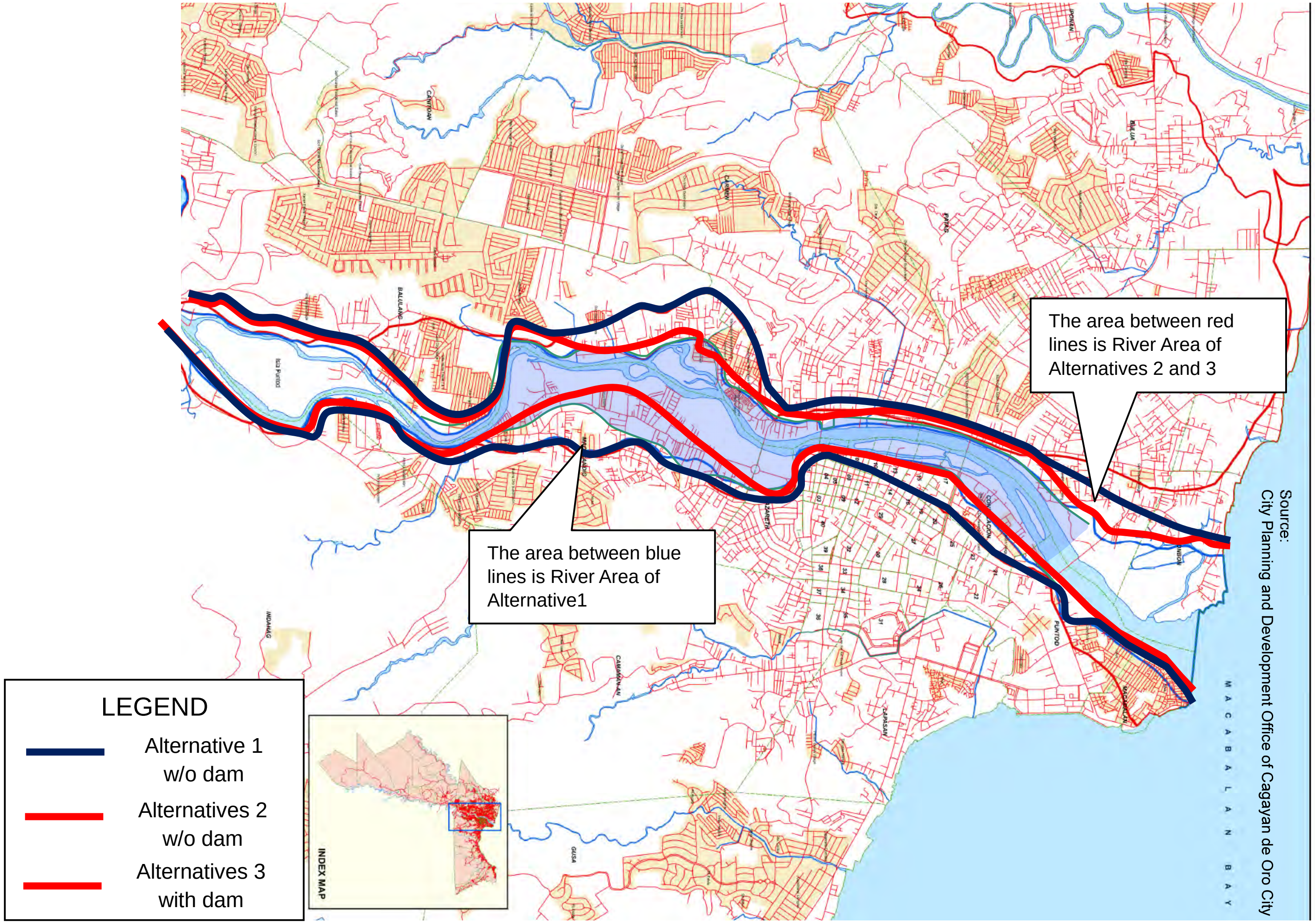
Alternative	Alternatives	Detailed Explanation
1	River improvement by widening of the river area to cope with Sendong scale flood (approx. 50 years return period)	This is a measure to implement flood control only by river improvement by widening the river area of approx. 300 – 1,000 m with no dike or small dike as shown on the Figure 4.5.3 The location of the project area is from the river mouth to the Pelaez bridge with the length of approx. 12 km. Figure 4.5.4 shows the river area for this alternative.
2	River improvement by heightening of river banks by structures to cope with Sendong scale flood (approx. 50 years return period)	This is a measure to implement flood control only by river improvement by structural measures of dike and floodwall constructions with an average height of 5.0 m. Figure 4.5.3 and 4.5.4 show the schematic pictures this concept and the river area of this alternative, respectively.
3	River improvement and utilization of existing dam construction plan to cope with Sendong scale flood (approx. 50 years return period)	This is a measure to implement flood control by river improvement to cope with 25 years scale of flood, and utilization of existing dam construction plan (Bulanog-Batang Hydropower Development Project) to cope with Sendong scale flood (approx. 50 years return period). Dike and floodwall has an average height of 3.5 m. The concept of the river area is shown on Figure 4.5.3. The river area of this alternative is the same as that of alternative 2. The location of the existing dam construction plan is shown on Figure 4.3.1.
-	No action (Without Project)	No action for flood risk management. The existing condition of river banks to be able to cope with 2 to 5 years of flood scale will continue without any improvement under this alternative.

Source: JICA Survey Team

Alternatives	Illustration of Cross Section
Alternative 1 *Widening river area to cope with extreme flood* *without dam*	
Alternative 2 *Dike Heightening along the River Boundary* *without dam*	
Alternative 3 *Dike Heightening along the River Boundary* *with dam*	

Source: JICA Survey Team

Figure 4.5.3 Concept of Alternative River Cross Sections



Source: JICA Survey Team

Figure 4.5.4 The Location of River Area where the Resettlement/Relocation are needed

4.5.3 Examination of Alternatives

(1) Comparison of Alternatives

Table 4.5.4 shows the examination results of the three alternatives (candidate programs). Based on the comparison of alternatives, the following results are obtained:

Regarding the alternative 1, it cannot be recommended since the following reasons:

- This alternative is to widen river area up to extent of Pablo inundation area considering occurrence of extreme flood, but more than 7,600 houses should be relocated.
- Social impacts are critical and it would take time for realization.
- The resettlement and ROWA costs are the biggest, around 19,000 million Pesos and additional cost for relocation site developments would be necessary. The project cost is the most expensive.

As for the alternative 2, it cannot be recommended since the following reasons:

- Social impacts are critical due to relocation of existing infrastructures such as roads and bridges, and it would take time for realization.
- Potential flood risk is the highest among the alternatives. The DHWL will be much higher than the ground level in surrounding area. The flood risk level in case of extreme flood will be level 4 in which it is very difficult to evacuate.

Further, as to the alternative 3, the following merits are enumerated:

- This alternative is the most practical one for fulfillment because social impacts are less than other alternatives.
- Potential flood risk level will be level 3 or less. This alternative can significantly mitigate calamity providing flood forecasting, and early warning systems and evacuation system.
- Cost is the least.

Table 4.5.5 shows the examination results of the alternative of No Action, “Without Project.” Cagayan de Oro City was repeatedly hit by heavy rains in recent years and has been damaged by major flood disasters such as those due to Tropical Depression Urduja (2009), TS Sendong (2011), and TY Pablo (2012). At the time of TS Sendong, more than half of the population of CDO City proper (approx. 600, 000 nos.) were affected and the casualty amounted up to 1,268 persons. The anticipated loss and damages will include not only a lot of casualty but also fatal cause of constraint for the economic development of the CDO City.

(2) Result of the Comparison

In the alternative of “No Action,” the situation will not change where frequent flooding disaster will continue. Considering the recent climate change due to the global worming as they pointed out, the risk of flooding might be worsened in the future. Thus, the alternative of “No Action” is not recommended.

Among the three alternatives for flood risk management, the alternative 3 (River improvement and utilization of existing dam construction plan to cope with Sendong scale flood) is recommended as the optimum alternative as shown in Table 4.5.4.

Table 4.5.4 Comparison of Alternatives based on Examination Results

Alter-native	Breakdown	Alternative 1	Alternative 2	Alternative 3
Land use	Existing land use in and around the project	Open space along the river, residential area as well as commercial and business land use.	Open space along the river, residential area and partly commercial area.	Open space along the river, residential area and partly commercial area, and forest land for dam reservoir area
Technical aspects	Target of flood risk management	Target of flood risk management (Sendong scale flood of approx. 50 years of return period) can be attained but it would take time for agreement of stakeholders.	Target of flood risk management (Sendong scale flood of approx. 50 years of return period) can be attained.	Target of flood risk management (Sendong scale flood of approx. 50 years of return period) can be attained
	Potential flood risk (in alternative of extreme flood)	Risk in alternative of overtopping and/or dike break is low (Risk level 1) because of small dike or no dike.	Risk in alternative of overtopping and/or dike break is high (Risk level 4) because of the highest structures (5.0 m on average)	Risk in alternative of overtopping and/or dike break is moderate (Risk level 3) because of relatively low of structures (3.5 m on average) than alternative 2.
Construction cost	River improvement	River improvement: 8.7 billion PHP. Land acquisition: 12.9 billion PHP. Relocation : 6.1 billion PHP.	River improvement: 15.9 billion PHP. Land acquisition:2.0 billion PHP Relocation : 0.9 billion PHP	River improvement: 4.7 billion PHP. Land acquisition:2.0 billion PHP Relocation : 0.9 billion PHP
	Cost related to dam reservoir	N/A	N/A	Cost for dam (decrease of power production due to flood control storage: 1.1 billion PHP
	Total	27.7 billion PHP + development cost of relocation site: 4.2 billion PHP	18.8 billion PHP	8.7 billion PHP
Environmental and social aspects	Social Environment	Land acquisition: 440 ha Resettlement: 7,600 units, Relocation of infrastructure: Major roads and local roads, and many public facilities Traffic disturbance: critical due to necessity of rearrangement of road network.	Land acquisition: 75 ha Resettlement: 1,200 units. Relocation of infrastructures: 3 bridges on the CDO River and local roads Traffic disturbance: critical due to detour during re-construction of bridges	Land acquisition: 75 ha Resettlement: 1,200 units. Relocation of infrastructures: local roads. Traffic disturbance: not significant
	Natural Environment	Impacts on vegetation: minor (only for vegetation clearance of small dike)	Impacts on vegetation: Not significant (approx. 8-9 ha of clearance)	Impacts on vegetation: Not significant (approx. 7.1 ha of clearance). No additional loss of vegetation for dam reservoir because of the utilization of existing dam construction plan (Bulanog-Batang Hydropower Development Project).

Alter-native	Breakdown	Alternative 1	Alternative 2	Alternative 3
	Public Pollution	Waste generation : critical due to demolition of structures, Pollution (air, noise, etc.): significant due to traffic disturbance and waste generation	Waste generation: moderate Pollution (air, noise, etc.): Significant due to traffic disturbance and waste generation	Waste generation: moderate, Pollution (air, noise, etc.): not significant due to less traffic disturbance or waste generation
Optimum Alternative and its reason		Not recommended: • Social impacts are critical and it would take time for realization. • Cost is expensive.	Not recommended: • Social impacts are critical and it would take time for realization. • Potential flood risk (in alternative of overtopping and/or dike break) is high.	Recommended: • Social impacts are the least than other alternatives. • Cost is the least.
		Among the three alternatives for flood risk management, the alternative 3 (River improvement and utilization of existing dam construction plan to cope with Sendong scale flood) is recommended as the optimum alternative considering the merits of moderate flood risk level in case of extreme flood event and less construction cost as well as less social impacts.		

Note) Figures in the table are the results of preliminary calculation of the JICA Survey Team
Source: JICA Survey Team

Table 4.5.5 Environmental and Social Status without Project (No Action)

Category	Content of impacts	Remarks
Social impacts	• Number of resettlement unit: Not needed. But there are resettlement units of approx. 4,000 due to the TS Sendong already, meaning the resettlement may generate due to flood event from now on, too. • Infrastructures to be relocated: Not needed. But there were many social infrastructures affected by the flooding even the alternative of "without project." • Impacts on economic activities: Damages on local economy due to flooding (refer to flood damage alternative of recent floods below) are anticipated to frequently occur from now on, too.	
Natural environment / Pollution	• Impacts on natural environment : no impacts by vegetation clearance, pollution, etc. because of no construction work.	
Flood damage	• Because it does not change the status quo (against the flood of approx. 2 -5 years-scale), damages are predicted for flood by TY Pablo class and even for smaller floods in the future. • Recent flood disasters are as follows: - Damage and loss due to Tropical Depression Urduja (2009): deaths; 3 persons, affected families; 34,959 families, affected persons; 174,839 nos., estimated damages: n/a. - Damage and loss due to TS Sendong (2011): deaths; 1,268 persons, affected families; 38,236 families, affected persons; 342,400 nos., estimated damages: 1,689 million PHP. - Damage and loss due to TY Pablo (2012): deaths; 7 persons, affected families; 14,246 families, affected persons; 55,188 nos., estimated damages: 2,150 million PHP. • Infrastructures such as major bridges might be damaged, • Business opportunity is repeatedly lost after flooding occurs. • Sanitary condition will be deteriorated after the flooding.	• Fear of residents along the river for flood damage is not removed.

Source of data on disaster: Office of Civil Defense (OCD), etc.

4.6 Proposed Structural Measures

As the results of first screening and alternative study for the structural measures and taking into account the present situations on the objective areas and the budget source, three (3) phases of implementation is formulated i.e. urgent, short-middle term and long term measures. The short-middle term measures are classified into core components and supporting components considering the functions to attain flood risk management of the Cagayan de Oro River.

4.6.1 Urgent Measures

Rehabilitation and Improvement of Existing River Structures

Damaged existing dikes and retaining walls during TS Sendong should be rehabilitated and/or improved to cope with a 25-year design flood.

At present, DPWH Regional Office 10 is conducting the rehabilitation works in the following area:

Table 4.6.1 On-going Rehabilitation Works (as of Sept. 2013)

R1: Macabalan	rehabilitation of damaged dikes
L2: Carmen (downstream)	rehabilitation of damaged dikes and urgent necessity to protect the area
L3: Carmen (upstream; Left upstream of the Ysalina Bridge)	urgent necessity to close the gap section between existing dikes by temporary dike (baby dike)

Source: JICA Survey Team

4.6.2 Short-Mid Term (Core Components)

River improvement in downstream (for floods of 25- year probability)

Construction of Dike and Floodwall

As the result of the study for dike alignment, DHWL and cross section with consideration of the natural ground level and connection with the urgent rehabilitation works , the plan of dike system with dike and floodwall is proposed as follows,:

Dike	left bank	:	3,940 m
	right bank	:	5,230 m
Floodwall	left bank	:	390 m
	right bank	:	4,320m

Construction of New Road/Raising of Existing Road for Evacuation

The proposed measure along the left bank of the river mouth is road raising and construction of evacuation roads in low-laying area instead of construction of the new dike along the existing bank. This is because that the area belongs to the environmental protected area covered by mangroves. It is to be considered of the soft foundation therein for the dike construction and of an effective use of the natural retarding basin in this area.

4.6.3 Short-Mid Term (Supporting Components)

As the supporting components of the structural measures in the short-middle term, construction of drainage gate and outlets, improvement of existing Kagay-an Bridge approach, and construction of retarding basin shall be implemented to complement the effects of the core components.

Installation of Drainage Gate and Outlets

There are several local creeks and local drainages discharging to the river at present. In connection with the construction of dike, installation/improvement of drainage outlets with gate should be considered at the same time of the construction of dike system. Installation of five (5) gates is proposed in the left bank and 17 gates in the right bank.

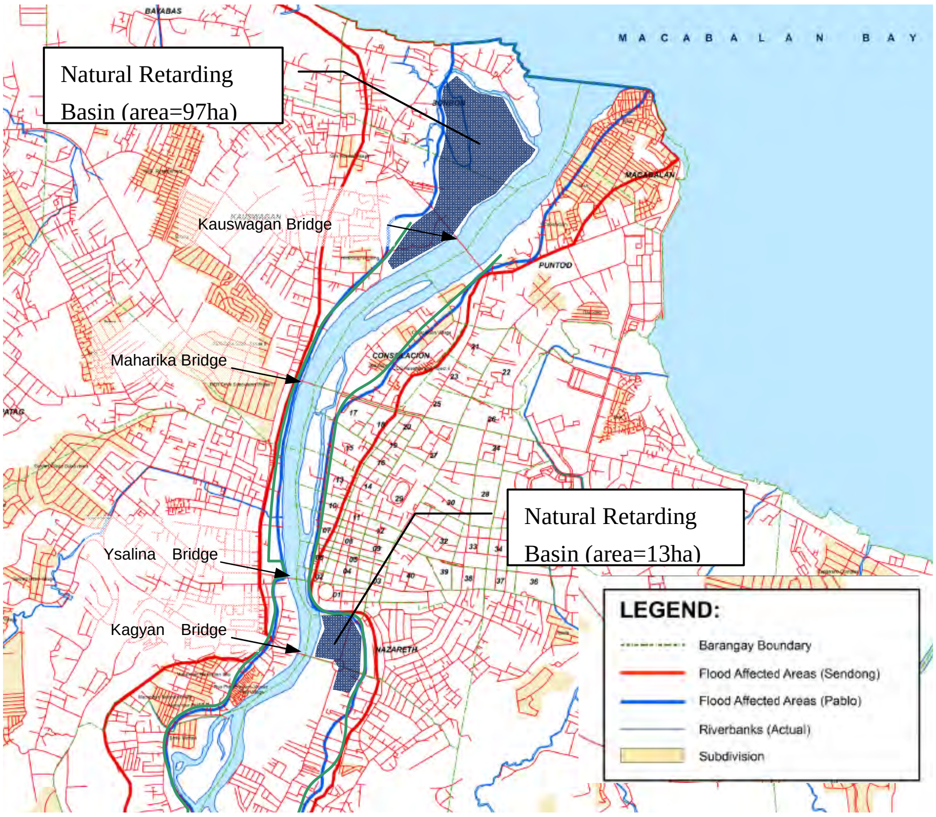
Improvement of the existing Kagayan Bridge

The proposed improvement of the Kagayan Bridge will contribute to decrease water level in the upstream of the bridge and resolve the occurrence of the fast flow velocity at immediately downstream of the box culvert. The people living in high flood risk area located in upstream and downstream of the bridge shall be relocated to safe place and the river area will be managed properly. In addition, the intersection located at the end of the approach road on the right bank will be passable and the bridge can be used as a part of emergency transportation network and evacuation place the during design flood.

Effective Use of Existing Retarding Basin

The retarding basin with 97 ha in the area located in the downstream left bank of the river mouth shall be preserved as natural retarding basin. The functions of this retarding basin are i) mitigation of flood peak water level in surrounding area, ii) preservation of mangrove area which is identified as protected area by DENR, being utilized for livelihoods for the local residents.

Another natural retarding basin in the area is located at upstream of the Cathedral, which potential area as a retarding basin is around 13 ha. However, this area is viable to regulate the flood water located at immediately upstream of the bottle neck section at the Ysalina Bridge and also for storage of local rain water.



Source: JICA Survey Team

Figure 4.6.1 Location of Existing Retarding Basin

4.6.4 Long Term Measures

(i) TS Sendong as Target Safety Level

The target safety level or return period of the design flood discharge applied in the Master Plan is the level which is equivalent to the largest recorded flood caused by TS. Sendong which flood scale is assessed to be 50-year probable flood or more. However, the safety level to be secured by the structural measures will be 25 year only in downstream reach of the Cagayan de Oro River in Cagayan de Oro City area. It is required in the upstream reaches to regulate a flood peak discharge of TS. Sendong scale flood to the peak discharge of 25 year probability or less so as not to cause flooding damages in the downstream reaches.

(ii) Existing Dam Plan and Proposed Sites

At present, the existing dam facilities in the upstream of the Cagayan de Oro River basin are only small-scale hydropower dams and intake weirs in the tributary Bubunawan River.

As for the existing plan and study for the high dam which would have discharge regulation capacity, a feasibility study was conducted for a hydropower dam at the confluence of Batang-Blanog Rivers by NPC-NORMECA (Northern Mindanao Electric Cooperatives Association). The proposed Batang-Bulanog dam would have a storage capacity of a 100 million cu.m class. Though the purpose of the existing plan for dam development is hydro power generation so far, it could be considered to add flood control purpose on the dam as one of flood risk mitigation measures of Cagayan de Oro River basin.

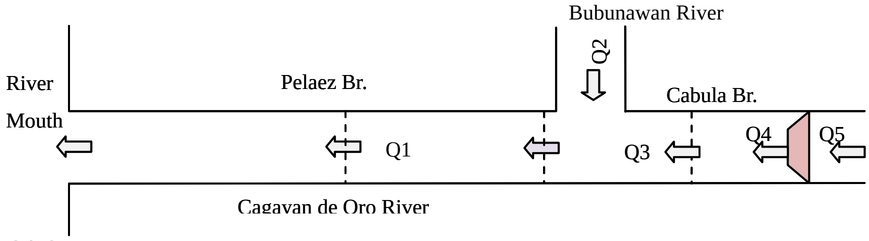
(iii) Flood Regulation Effect by Dam Reservoir

The dam reservoir will regulate a peak inflow discharge of TS. Sendong scale probable flood at dam site to a certain outflow discharge so that the peak flow discharge in the downstream section would be reduced to discharge equivalent to 25-year probable flood.

The peak inflow discharge (Q5=2,700 m^3/s) of TS. Sendong scale probable flood would be regulated to (Q4=1,000 m^3/s) so that peak discharge at Pelaez Bridge would be reduced to (Q1=3,300 m^3/s) which will be equivalent to 25-year probable flood as indicated below:

Table 4.6.2 Design Discharge Distribution (Sendong Scale)

Return Period	Case	Pelaez Bridge (Q1)	Bubunawan River (Q2)	Cabula Bridge (upstream of Bubunawan Conf.) (Q3)	Proposed Dam Site (Q4)	Proposed Dam Site (Q5)
25-year	Without	3,300 m^3/s	600 m^3/s	2,700 m^3/s	-	-
Sendong Scale	Without	5,000 m^3/s	900 m^3/s	4,100 m^3/s	-	-
	With Dam	3,300 m^3/s	900 m^3/s	2,400 m^3/s	1,000 m^3/s	2,700 m^3/s



Source: JICA Survey Team

4.6.5 Maintenance Works

Siltation in the downstream of the river is a trend of the Cagayan de Oro River. Visible sediment depositions occur over the river mouth and in downstream of the river. In the master plan, periodic monitoring of cross section survey is proposed and regular maintenance dredging/channel excavation is recommended to remove siltation in the downstream.

4.7 Proposed Non-structural Measures

4.7.1 Flood Management

As discussed as to the structural measures in the Survey, safety level of the structures have been designed at 25-year flood for river improvement measures (50-year flood for Master Plan) in the CDO River Basin. Since it will normally take several years to attain the design level, and even if the target design level would be attained, non-structural measures are still necessary before the level is attained as well as for extra flood after the design level is attained.

RA 10121 or the Philippine Disaster Risk Reduction & Management Act of 2010 enacted on May 2010, mandating all Local Government Units (LGUs) including the barangays to establish Barangay Disaster Risk Reduction & Management Councils (BDRRMCs), and to formulate a Contingency Plan and Comprehensive Development Plan. RA 10121 acknowledged the need to promote the participation of all sectors, all stakeholders at all levels especially the local community. However, it was judged that there is still necessity to improve on institution, role, coordination, information dissemination, etc. for DRRMCs and related agencies, since it has not been long since RA10121 was enacted.

Further, based on the results of assessment of the existing non-structural measures in the CDO River Basin, current situation, problems, measures considered as necessary were identified.

Based on the above, following six (6) major non-structural measures were formulated as a master plan for the CDO River Basin:

i) Reinforcement of DRRMCs
ii) Preparation of Contingency Plan and DRRMP, which includes Preparation/Update of Flood Hazard Map, Evacuation Planning, etc.
iii) Flood Forecasting and Warning System(FFWS)
iv) Community Based Flood Early Warning System (CBFEWS)
v) Information, Education and Communication (IEC)
vi) Land Use Regulation for Flood Plain

Based on the current situation on the budget, human resources, etc., three (3) phases of implementation plan for the CDO River Basin were formulated for the flood management plan as non-structural measures: namely, Urgent Plan for the period from 2013 to 2014, short-mid term plan for the next 5 years from 2015 to 2019, and long term plan for the period from 2020 to 2035 as follows:

Table 4.7.1 Flood Management for the CDO River Basin

No	Non-Structural Measures	Contents of Measures		Urgent Plan	Short-Mid Term Plan	Long Term Plan	Remarks
				2013/2014	2015-2019	2020-2035	
1	Reinforcement of DRRMCs	1.1	Reinforcement of Selected C/M & BDRRMCs (Role, Function, etc.)	○	○		Being implemented by GOP
		1.2	Reinforcement of Communication/Coordination between C/M DRRMC and BDRRMCs (Network, etc.)	○	○		Do above
		1.3	Reinforcement of Communication/Coordination among BDRRRMCs (Vicinity, Up & Down Stream, etc.)	○	○		Do above
		1.4	Reinforcement of Communication/Coordination w/ PAGASA and Other Agencies Concerned (before, during and after Floods, etc.)	○	○		Do above
		1.5	Reinforcement of Communication/Coordination w/ NGOs (during and after Floods, etc.)	○	○		Do above
		1.6	Reinforcement of Communication/Coordination w/ CDORBMC, BWPDC, BWRBF (General Issues, etc.)	○	○		Do above
2	Preparation of Contingency Plan and DRRMP, which includes Preparation/Update of Flood Hazard Map, Evacuation Planning, etc.	2.1	Preparation/Update of Flood Hazard Map	○	○		Being implemented by GOP, but it seems difficult due to accuracy.
		2.2	Evacuation Planning (Number, Location, Capacity of Facilities (Area, Water Supply, Toilet, etc.), Route, Transportation, Role, etc.)	○	○		Do above
		2.3	Emergency Relief Planning	○	○		Being implemented by GOP
		2.4	Plan for the Weak	○	○		Do above
		2.5	Preparation of Contingency Plan	○	○		Do above
		2.6	Preparation of DRRMP	○			Do above
3	FFWS	3.1	Reinforcement of Monitoring on Meteorological and Hydrological Data (Selection of Automatic Rainfall and River Water Step I Station (Number, Location, Specification, etc.)	○	○		Technical assistance seems necessary.
		3.2	Establishment of Database (Acquisition of Data, Data Storing/Transmitting System, etc.)	○	○		Do above
		3.3	Establishment of Flood Warning System, Information Dissemination to LDRRMCs (Rainfall Intensity, River Water Level), IEC to LDRRMCs, etc.	○	○		Do above
		3.4	Reinforcement of Related Agencies (Information Sharing, Flood Fighting, Stakeholder Meetings, etc)	○	○		Do above
		3.5	Procurement Plan of Equipment for FFWS and O&M Plan	○	○		Do above
		3.6	Capacity Development for FFWS PAGASA Staff	○	○		Do above
		3.7	Study on Future Step 2 System	○	○		Do above
		3.8	Study on Future Step 3 System		○	○	Do above
4	CBFEWS	4.1	Selection of Conventional Rainfall and River Water Level Stations	○	○	○	Technical assistance seems necessary.
		4.2	Technical Assistance for Warning by Rainfall, River Water Level, etc.	○	○		Do above
		4.3	Capacity Development for LGUs		○	○	Do above
5	Information, Education and Communication (IEC)	5.1	Information Campaign and Publicity for Proposed Structural Measures (by Web site, leaflet, etc.)		○		Technical assistance seems necessary.
		5.2	Capacity Development by Seminar, Workshop, etc.	○	○	○	Do above
		5.3	Disaster Education w/ DepED/PAGASA, etc. (Understanding of Disaster, Evacuation, Illegal Disposal of Garbege to River, etc.)	○	○	○	Being implemented by GOP
		5.4	Training on Flood Fighting	○	○		Do above
		5.5	Training on Rescue	○	○		Do above
6	Land Use Regulation for Flood Plain	6.1	Database by GIS for Land Use Regulation of Habitual Inundation Areas		○		Technical assistance seems necessary.
		6.2	Study on Land Use Regulation based on Flood Hazard Map		○		Do above
		6.3	Study and Implementation on Heightening of Houses, Buildings, etc.			○	-

Source: JICA Survey Team

4.7.2 Watershed Management

(1) Consideration on the Watershed Management Activities in the CDO River Basin

Based on the reviews of the watershed management activities and natural conditions inside the CDO River Basin, the current status and constraints, necessary measures and present implementation status are summarized. Among the necessary measures, DENR and LGUs are implementing the necessary measures especially to the forestlands, while the activities by the international donors; i.e. ADB, AfD, are also begin conducted and/or planned. AfD plans to formulate the assistances to the agricultural lands inside the forestlands. However, there are less assistance on the watershed management for the A&D areas in the middle and upper watersheds. For the river mouth and coastal areas, APO of CDO City and DENR are implementing the mangrove plantation and formulation of the coastal resource management plans. Mangrove plantation is effective to improve the living environment for the villagers and also habitats of the aquatic plants and animals.

(2) Consideration on the Implementation Plan on the Watershed Management Activities in the CDO River Basin

The implementation plan (Watershed Management) for the CDO River Basin is organized as shown in the following table.

Table 4.7.2 Watershed Management for the CDO River Basin

No. and Location		Activity	Urgent Plan	Short-Mid Term Plan	Long Term Plan	Remarks
			2013-2014	2015-2019	2020-2035	
A. Mid and Upper Watershed						
A-1. Forestland in Mid and Upper Watershed						
1.1 Forests						
	1.1.1	Reforestation by Indigenous Tree Species	✓	✓	✓	Assumed to be done by DENR, ADB and LGU, and AfD future Project
	1.1.2	Implementation of Assisted Natural Reforestation (ANR)	✓	✓	✓	Assumed to be done by DENR, ADB and LGU, and AfD future Project
	1.1.3	Adequate Utilization of the Non-Timber Forest Products (NTFP)	✓	✓	✓	Assumed to be done by DENR, ADB and LGU, and AfD future Project
1.2 Agricultural Lands						
	1.2.1	Introduction of Agro-Forestry		✓	✓	Assumed to be done by ADB and AfD future Project
1.3 Slope Agricultural Land						
	1.3.1	Introduction of Slope Agricultural Methods		✓	✓	Assumed to be done by AfD future Project
1.4 Riparian Areas						
	1.4.1	Enforcement of Riparian Forests by Indigenous tree Species	✓	✓	✓	Being implemented and planned to be done by DENR, MENRO and BENRO

No. and Location		Activity	Urgent Plan 2013-2014	Short-Mid Term Plan 2015-2019	Long Term Plan 2020-2035	Remarks
A-2	A&D Land in the Mid and Upper Watershed					
2.1	Riparian Areas					
	2.1.1	Establishment of Riparian Forests to Mitigate Soil Flow and Sedimentation	✓	✓	✓	Being implemented by MENRO, BENRO, DENR and private sectors, but only in small scale
2.2	Agricultural Areas					
	2.2.1	Establishment of Riparian Forests along the Waterways and Irrigation to mitigate Soil Flow and Sedimentation	✓	✓	✓	Assumed to be done by AfD future Project
2.3	Slope Agricultural Areas					
	2.3.1	Introduction of Slope Agricultural Methods		✓	✓	Assumed to be done by AfD future Project
A-3	Overall for the Mid and Upper Watershed					
3.1	Overall					
	3.1.1	Formulation of CDO River Watershed Management Plan	✓			Being implemented by DENR
	3.1.2	Formulation of Watershed Management Plans for Tributaries of CDO River	✓	✓		Planned to be partially implemented by DENR
	3.1.3	Formulation of the Watershed Management Plans for each Municipality in Bukidnon Province	✓	✓		Partially implemented by ADB
	3.1.4	Formulation of the Watershed Management Plans of each Barangays in Bukidnon Province	✓	✓		Planned to be implemented by BENRO and MENRO
B.	Lower Watershed					
B-1	Riparian Areas of CDO River in the Lower Watershed					
1.1	Riparian Areas					
	1.1.1	Distribution of Seedlings to each Barangay for Establishment of Riparian Forest and Tree Park	✓	✓	✓	Being implemented by CLENRO
B-2	Overall for the Lower Watershed					
2.1	Overall					
	2.1.1	Formulation of the Watershed Management Plan for CDO City		✓		Not planned yet by CLENRO
	2.1.2	Formulation of the Forest Management Plan for CDO City		✓		Not planned yet by CLENRO
C.	River Mouth and Coastal Areas					
C-1	River Mouth and Coastal Areas					
1.1	River Mouth and Coastal Areas					
	1.1.1	Reforestation and Rehabilitation of Mangrove Forests	✓	✓	✓	Being implemented by APO and DENR, but in small scale

No. and Location		Activity	Urgent Plan	Short-Mid Term Plan	Long Term Plan	Remarks
			2013-2014	2015-2019	2020-2035	
C-2	Overall in the River Mouth and Coastal Areas					
2.1	Overall					
	2.1.1	Formulation of the Coastal Resource Management Plans	✓			Being implemented by APO, in coordination with DENR and MBDA

Note: BENRO: Bukidnon Environment and Natural Resource Office, MENRO: Municipal Environment and Natural Resource Office, MAO: Municipal Agricultural Office, CLENRO: City Local Environmental and Natural Resource Office, APO/CAO: Agriculture Productivity Office / City Agriculture Office

Source: JICA Survey Team

4.8 Proposed Master Plan

The Master Plan for flood risk management in the whole basin of the Cagayan de Oro River is formulated herein. The Master Plan is composed of both structural measures and non-structural measures as listed below. Among the proposed measures in the Master Plan, the priority project (the Project) will be selected that should be implemented in short-middle term to effectively mitigate the flood risks in the Cagayan de Oro River Basin.

The general map of proposed measures of the Master Plan is presented in Figure 4.8.1.

Table 4.8.1 Master Plan for Flood Risk Management in CDO River

Structural measures	Urgent Work	(1) Rehabilitation of Damaged Structures
	Short-Mid Term (Core Components)	***River improvement in downstream*** ***(for floods of 25- year probability)*** (1) Construction of New Dike/ Retaining Wall (2) Construction of New Road/Raising of Existing Road for Evacuation
	(Supporting Components)	(3) Installation of Gate and Drainage Outlets (4) Improvement of Kagayan Bridge (5) Improvement of Existing Retarding Basin
	Long Term	***Mitigation of Flood run-off in upstream*** ***(for Sendong scale floods of approx 50- year probability)*** (1) Integration of Flood Control Use to the Proposed Dam development Plan
	Maintenance Works	(1) Periodical Monitoring of River Cross Section and Regular Maintenance Dredging/Channel Excavation
Non-structural measures	Short-Mid Term	(1) Preparation/Update of Flood Hazard Map, Evacuation Planning (2) Technical Assistance for FFWS (Initial Stage for Full Spec) (3) Community Based Flood Early Warning System (CBFEWS) (4) Information Campaign and Publicity for the Project (Structural Measures) (5) Technical Assistance for GIS for Land Use Regulation for Habitual Inundation Area (6) Technical Assistance for Riparian Forest Establishment in the Agricultural Lands (7) Technical Assistance for Mangrove Forest Establishment along the Coastal Areas
	Long Term	(8) Watershed Management

Source: JICA Survey Team

Structural Measure

River Improvement Works in Downstream of Cagayan de Oro River

Urgent Works (2014-2015)
Rehabilitation of Damaged Structures

Short-middle term (2016-2021)
[Core Components]
- Construction of New Dike/ Retaining Wall
- Construction of New Road/Raising of Existing Road for Evacuation

[Supporting Components]
- Installation of Gate and Drainage Outlets
- Improvement of Kagayan Bridge Approach
- Improvement of Existing Retarding Basin

Maintenance Works
Periodical monitoring of river cross section and regular maintenance dredging/channel excavation

Mitigation of Flood Run-off in Upstream Basin (for Sendong scale flood of approx.50-year probability)

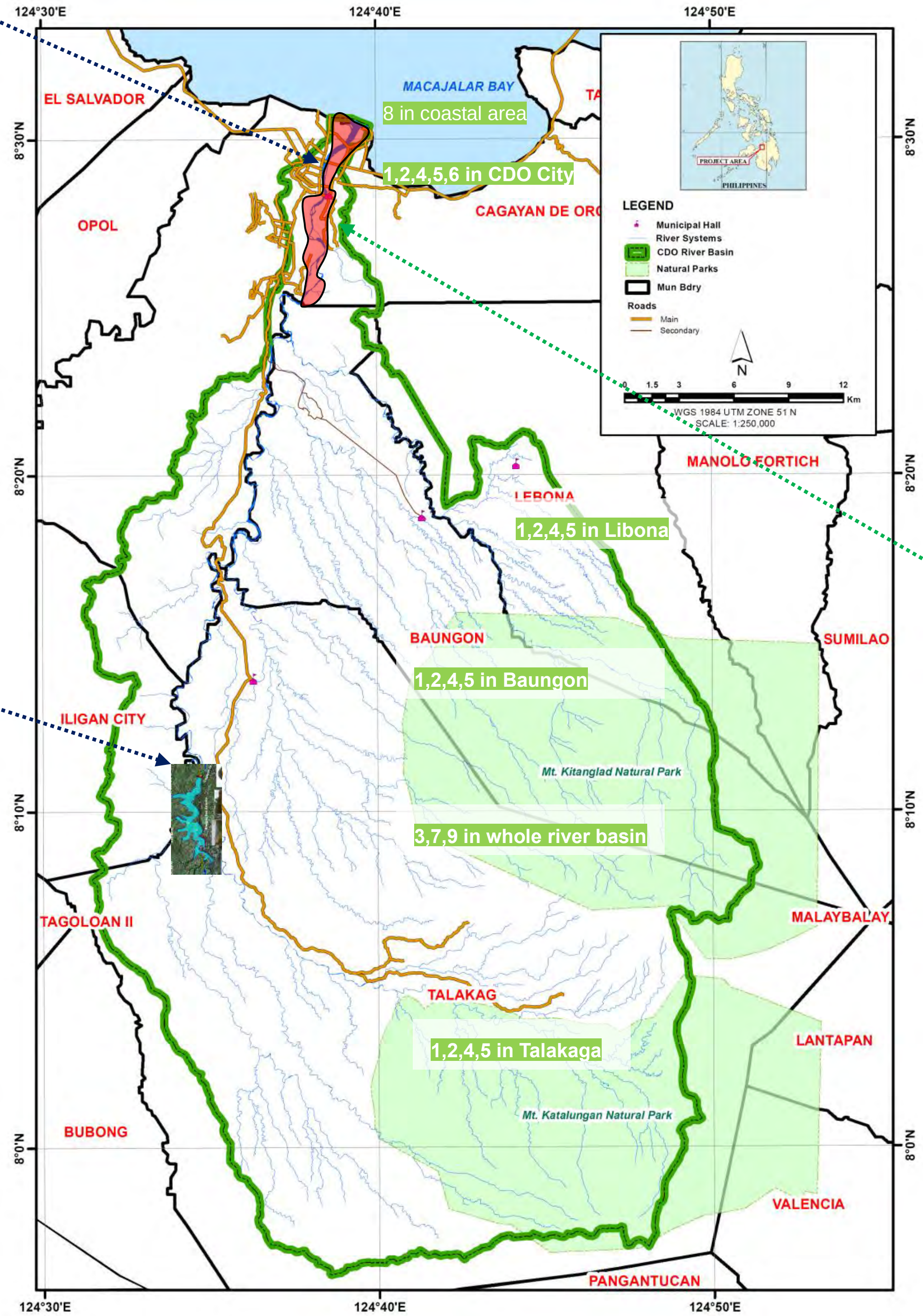
Long –term (2018-2035)
Integration of flood control use to the proposed dam development plan

Resettlement Action Plan

- Preventive resettlement is applied to the Project by safeguarding people's lives and assets from flood disaster in high flood risk area

Environmental Management and Monitoring Plans

- ECC for the FRIMP-CDOR was issued on Oct.31, 2013
- EIS was approved in middle of Nov.2013
- Environmental management and monitoring plans were prepared to mitigate environmental impacts by implementation of the Project



Source: JICA Survey Team

Non-structural Measures

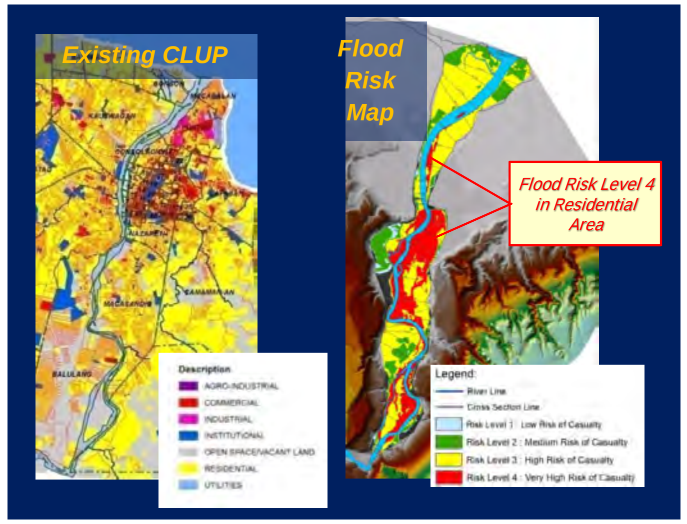
Flood Management

Short-middle term (2016-2021)

1 Reinforcement of DRRMCs [CDO City, Libona, Baungon, Talakag]
2 Preparation of Contingency Plan and DRRMP, which includes Preparation/Update of Flood Hazard Map, Evacuation Planning [CDO City, Libona, Baungon, Talakag]
3 Flood Forecasting and Warning System [PAGASA]
4 Community Based Flood Early Warning System (CBFEWS) [CDO City, Libona, Baungon, Talakag & PAGASA]
5 Information Campaign and Publicity for the Project Libona, Baungon, Talakag]

6. Land Use Regulation for Flood Plain [CDO City]

Comprehensive Land Use Plan and Flood Risk Map in CDO City



Watershed Management

Short-middle term (2016-2021)

7. Technical Assistance for Riparian Forest Establishment in the Agricultural Lands

8. Technical Assistance for Mangrove Forest Establishment along the Coastal Areas

Long- term
9. Watershed management in the river basin/coastal area

Figure 4.8.1 Proposed Master Plan for Flood Risk Management in Cagayan de Oro River (1/2)

Structural Measure

River Improvement Works in Downstream of Cagayan de Oro River

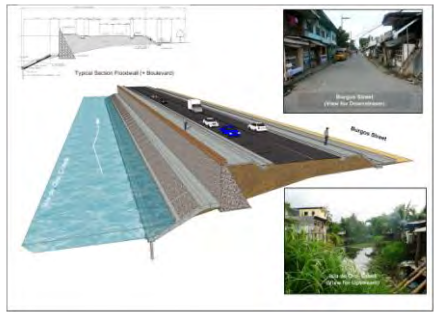
Urgent Works (2014-2015) by DPWH

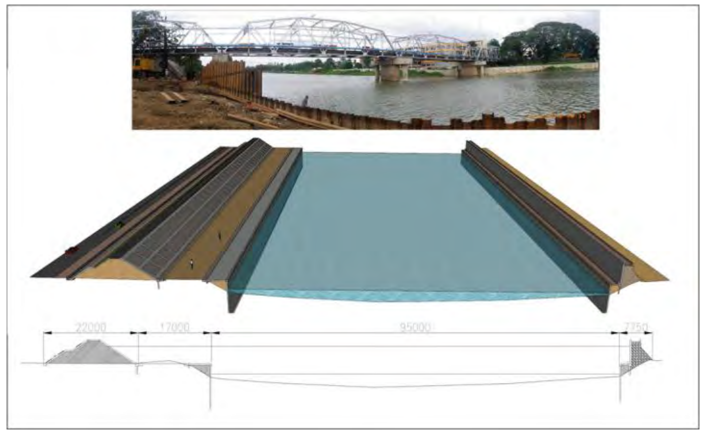
Rehabilitation of Damaged Structures (see blue lines in the map)
- R1&R2 : construction of seawall L=740m
- L2&L3: concrete face rock-fill dike, L=1,918m
- L3 concrete face rock-fill dike, L=421m

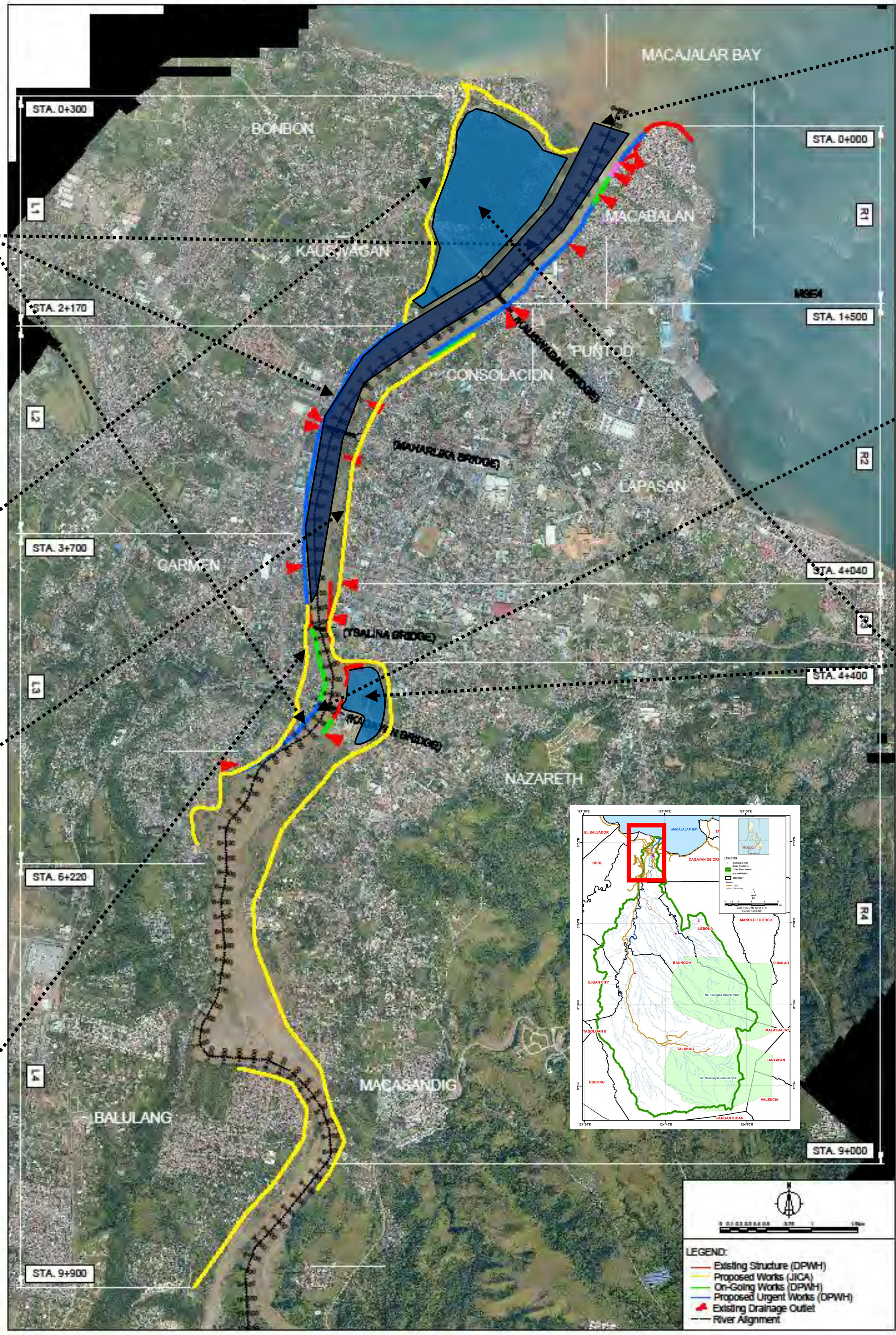
Short-middle term (2016-2021) [Core Components]

Construction of New Road/Raising of Existing Road for Evacuation (L=2,630m)

Construction of New Dike/ Retaining Wall (Dike: L=5,590m, Flood wall: L=4,785m)







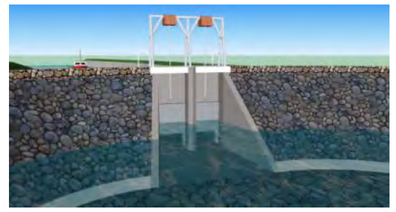
Source: JICA Survey Team

Maintenance Works

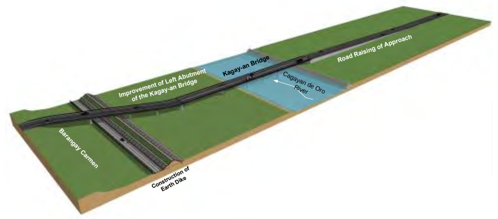
Periodical monitoring of river cross section and regular maintenance dredging/channel excavation

Short-middle term (2016-2021) [Supporting Components]

Installation of Gate and Drainage Outlets
- 16 nos along the river bank (see red triangles in the map), and
- 5 nos in retarding basin



Improvement of Kagayan Bridge Approach



Improvement of Existing Retarding Basins

Item	Without Project	With Project (Short-Middle Term)	With Project (Long Term)
Project	none	River Improvement	River Improvement and Dam
Target Safety Level	2-5 yr (present)	25-yr flood	Sendong Scale (approx. 50-yr flood)
Flood Risk Level	Level 4 (very difficult to evacuate)	Level 3 (possible to evacuate)	Level 3 (possible to evacuate)
Protected Houses (nos.)	-	18,100	21,700
Protected main road (km)	-	7.0 km	9.6 km
Protected Area (ha)	-	Residential/ Commercial Area	Residential/ Commercial Area
		494 ha	614 ha
Protected Residents (person)	-	48,800	60,900

Figure 4.8.1 Proposed Master Plan for Flood Risk Management in Cagayan de Oro River (22)

4.9 Cost Estimation for Master Plan

4.9.1 Conditions and Assumptions for Cost Estimate

(1) Constitution of Project Cost

Costs for construction works were essentially estimated on a unit price basis. The main items of the Project Cost are Direct Construction Cost, Land Acquisition Cost, Government Administration Cost, Engineering Services Cost, Physical Contingency, Price Contingency, and Taxes (VAT). Composition of the unit price was basically referred to the DUPA. The Project Cost estimates were prepared with the following cost composition and conditions:

Table 4.9.1 Cost Composition

No.	Cost Items	Notes
1	Direct construction cost	
1(a)	-Structural measures	
1(b)	- Non-structural measures	
2	Land acquisition cost	Estimated from Replacement cost survey
3	Government administration cost	none
4	Engineering services cost	
5	Subtotal	Summation of Items 1 to 4
6	Physical contingency	1.4 % of Item 1+4 + 8
7	Subtotal	Summation of Items 5 to 6
8	Price contingency	2.1 % p.a. for LC and 1.3 % p.a. for FC
9	Subtotal	Summation of Items 7 to 8
10	Taxes	
10(a)	For construction works	VAT 12% for LC
10(b)	For engineering services	VAT 12% for LC
11	Grand total	Summation of Items 9 to 10

Source: JICA Survey Team

(2) Price Level

The cost estimate is at the price level as of 1st of June, 2013 with the price escalation as of the target year of the project.

(3) Exchange Rate

Exchange rates were referred to the monthly rate for a consultant contract posted on the JICA web site. The ones on 1st of June, 2013 (1 Philippine Peso = 2.274 Japanese Yen, 1 United States Dollar = 97.43 Japanese Yen, hence, 1 United States Dollar = 42.85 Philippine Pesos) were applied in this project.

(4) Currency for Cost Estimate

The project cost component shall consist of local and foreign currency portions. Philippine Peso is used for both the local and foreign currency portions in this estimate. The classifications of local and foreign currency portions are as given below.

i) Local Currency Portion

- All labor costs
- A part of cost for construction materials
- A part of cost for equipment lease
- Value Added Tax (VAT)

ii) Foreign Currency Portion

- A part of cost of construction materials that requires international quality

- A part of cost for equipment lease and services that requires international quality

The ratio of local currency portion and foreign currency portion was defined referring to the previous projects in the Philippines performed under JICA Loan as shown in Table 4.9.2.

Table 4.9.2 Ratio of Local and Foreign Currency Portion for Labor, Material and Equipment

Item	LC Portion	FC Portion
Labor	100	0
Equipment	30	70
Material		
Fuel and Lubricant	20	80
Wood/Stone/Sand	100	0
Stone Material	60	40
Lumber	60	40
Cement	30	70
Re-bar	10	90
Structural Steel	10	90
Chemical Product	10	90
Others	100	0

Source: JICA Survey Team

(5) Reference Guidelines and Manuals

The following guidelines and manuals are used as references and indicated in the cost estimate.

- DPWH Department Order No. 72, Series of 2012 (Amendment to D.O. 29, Series of 2011 Re: Revised Guidelines on the Preparation of Approved Budget for the Contract)
- DPWH Department Order No. 40, Series of 2009 (Guidelines for the Establishment of Construction Materials Price Data, Standard Labor and Equipment Rental Rates)
- Manual on Design and Cost Estimates for JICA Preparatory Study, March 2009
- Manual on Cost Estimates in Civil Works, 2012 Ministry of Land, Infrastructure, Transport and Tourism, Japan
- Manual on Cost Estimates in Civil Works at Harbor, 2012, Ministry of Land, Infrastructure, Transport and Tourism, Japan
- Manual on Cost Estimates, Metropolitan Expressway Company Limited, Japan

4.9.2 Cost Estimation for River Improvement Works

Costs for construction works are essentially estimated on a unit price basis. The main items of the Project Cost are Direct Construction Cost, Land Acquisition Cost, Government Administration Cost, Engineering Services Cost, Physical Contingency, Price Contingency, and Taxes (VAT). Composition of the unit price is basically referred to the DUPA. The construction plan and cost estimate are prepared with cost composition and conditions as presented in Supporting Report Appendix H.

The total project cost is as shown in Table 4.9.3.

Table 4.9.3 Summary of Project Cost for River Improvement

(Unit: Million PhP)

No.	Item	LC	FC	Total
1	River Improvement Works in Lower Reach	781.3	1,035.1	1,816.4
2	River Improvement Works in Upper Reach	627.0	862.4	1,489.3
3	Evacuation Road	106.3	115.3	221.6
4	Improvement of Kagayan Bridge	205.3	381.9	587.2
Construction Cost		1,719.8	2,394.7	4,114.6
5	Consultation Service	151.0	453.0	604.0
6	Land Acquisition and Compensation	2,936.1	0.0	2,936.1
7	Administration (to be allocated from GOP budget)	0.0	0.0	0.0
8	Price Contingency	209.9	188.9	398.7
9	Physical Contingency	29.1	42.5	71.6
10	Tax and Duties (12% of Construction Cost, Engineering Service, Land Acquisition, Compensation, Price Contingency and Physical Contingency)	622.7	0.0	622.7
Total Cost		5,668.6	3,079.1	8,747.7

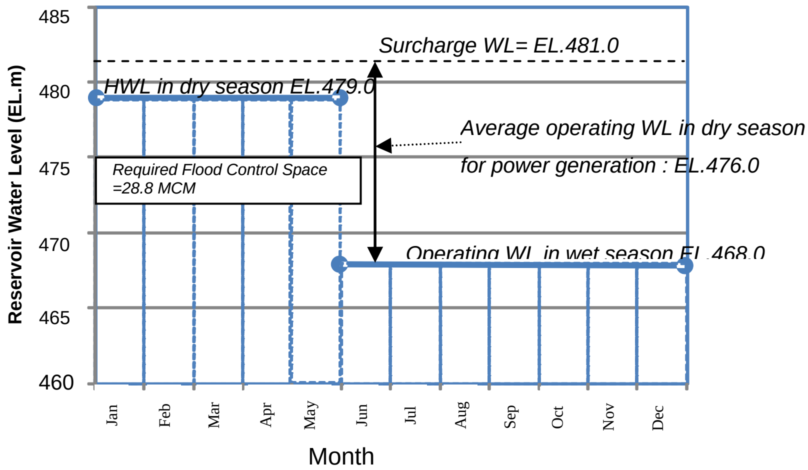
Source: JICA Survey Team

(3) Cost Estimation for Flood Control Dam

In the Master Plan, it is proposed that the existing dam plan for hydropower generation (Batang-Bulanog Dam Plan) will be integrated as multipurpose use with flood control to mitigate flood risk in the Cagayan de Oro River basin.

For economic analysis, the cost of integration of the flood control use with the hydropower generation is preliminary estimated referring to the existing dam plan and cost estimation under the following conditions:

- There would be reduction of energy output of the existing dam plan due to flood control use
- The reduction of energy output due to flood control use is estimated based on a reservoir operation rule to keep reservoir water level lower during wet season in order to regulate the 50-year flood scale of dam inflow to the 25-year flood discharge at base station, which requires flood control space of the dam at about 28.8 MCM; it needs lowering HWL by around 11m during wet season as shown in figure below)
- The dam operation is assumed to be commenced from 2031 based on the implementation schedule. The estimated annual reduction of energy output value from 2031 to 2080 can be converted to net present value at 2013 considering the discount rate of 15%. This NPV is considered as required cost of equivalent to the compensation for integration of the flood control use with the hydropower generation.



Source: The Survey Team

Figure 4.9.3 Schematic Reservoir Space Allocation

The preliminary cost estimation is presented below:

i) Reduction of Energy Output

<u>Existing Dam Plan</u>

Firm Energy	286.7 GWh/year
Secondary Energy (on peak)	140.4 GWh/year
Secondary Energy (off peak)	37.0 GWh/year
Total	464.1 GWh/year

<u>Revised Dam Plan in case of Average Operating Level during wet Season</u>

Firm Energy	
5/12 months x 286.7x(100%)	=119.5 GWh/year (in dry season)
7/12 months x 286.7x (90%)	=150.5 GWh/year (in wet season)
	=270.0 GWh/year
Secondary Energy	
5/12 months x 140.4(on peak)	=58.5 GWh/year (in dry season)
12/12 months x 37.7(off peak)	=37.0 GWh/year (whole season)
Total	365.5 GWh/year

Reduction of Energy Output due to Securing Flood Control Space
: 98.6 GWh/year (=464.1-365.5)

ii) Annual Cost due to Reduction of Energy Output

Reduction of Energy Output : 98.6 GWh/year
Unit value of Energy Output : PhP 16.4/kWh
Annual Cost due to Reduction of Energy Output
: PhP 1,617 Mil/year (=98.6 GWh/yr x 16.4/kWh)

iii) Net Present Value of Annual Cost

The dam operation is assumed to be commenced from 2031 based on the implementation schedule. Annual cost of PhP 1,617 Million from 2031 to 2080 can be converted as Net Present Value (NPV) at 2013 level of PhP 1,001 million with discount rate of 15%. This NPV is considered as investment cost to secure flood control space.

(4) Operation and Maintenance Cost

The operation and maintenance cost covers the cost for maintenance of the structures and annual dredging works. Maintenance of the structures includes the patrol and inspection of the slope protection, embankment, gate and so on. This cost also includes the cost for operation and maintenance of the facility for the management of the project area.

The annual operation and maintenance cost for structures was estimated at zero point five percent (0.5%) of the construction cost referring to the other JICA funded projects in the Philippines. The annual operation and maintenance cost for the dam was estimated at one percent (1.0%) of the construction cost referring to the other similar projects.

4.10 Economic Evaluation on the Master Plan

4.10.1 Basic Conditions for Economic Evaluation

(1) Scope of Work for the Master Plan

The economic analysis is carried out to evaluate the formulated Master Plan which is composed of the Short-Mid. term plan and Long term plan. The scope of the Master Plan is itemized in Table 4.10.1. While the flood control projects carried out by the Department of Public Works (DPWH) are in place now, the analysis undertake the evaluation of economic feasibility based on the cost accrued and benefit attributed to the concerned project.

Table 4.10.1 Scope of Work for the Master Plan

Item	Scope of Work	
	Short-Medium-Term Plan	Long-Term Plan
Project Component	Flood control through river improvement by construction of Dike and Flood wall, etc.	Flood control through river improvement and flood regulation by multi-purpose dam
Project Site	Cagayan de Oro River downstream reach, from River Mouth to Pelaez Bridge for 12 km	Whole Cagayan de Oro River Basin
Construction Duration	5 years (2016~2020)	9 years (2023~2031)
Target Flood Probability (Design Scale)	1/25-year	Sendong scale flood (equiv. 50 or more year)

Source: JICA Survey Team

(2) Assumptions for Economic Evaluation

Variables and assumptive parameters applied to the analysis are shown in the following Table 4.10.2, while referring to the latest data of the Bank of Japan and the IMF, as well as the recent JICA study reports, and others of relevance.

Table 4.10.2 Variables and Assumptive Parameters

	Variables	Assumptive Parameters
1.	Design Scale (Safety Level)	25-year probable flood
2.	Benefit generation period	50 years after construction
3.	Exchange rate (JPY/PhP)	2.274
4.	Physical Contingency (% of base cost)	1.4%
5.	Price Contingency escalation rate (Foreign)	1.3% /year
6.	Price Contingency escalation rate (Local)	2.1% /year
7.	OM cost (% of Direct cost)	0.5%
8.	Discount rate (NPV/BC Ratio, NEDA)	15%
9.	Local cost conversion factor (Direct construction cost)	0.79
10.	Local cost conversion factor (House compensation cost)	0.57
11.	Local cost conversion factor (Administration cost)	0.97
12.	Local cost conversion factor (Consulting service cost)	1.19

Source: JICA Survey Team

(2) Economic Cost

The financial cost has been converted as per international (border) price by applying Standard Conversion Factor (SCF) to local cost portion with a view to eradicating "market distortions in the domestic economy. Further, transfer payments (taxes and duties) and price contingency have been removed from financial cost for EIRR estimation. Cost items by procurement source (foreign and local costs portions) are realigned. Economic and financial costs for Short-Medium Term are given in respective of Tables 4.10.3.

The estimated investment cost of 1,001 Million Peso to secure flood control space in the original dam development plan is adopted for Long-Term Measure.

Table 4.10.3 Economic and Financial Costs for Sort-Medium-Term Plan

(Unit: PhP Million)

Economic Cost	FC	LC	Total
Construction	2,394.7	1,358.6	3,753.3
Land Acquisition		1,122.1	1,122.1
House compensation		551.5	551.5
Consulting Services	453.0	179.7	632.7
Taxes and Duties	-	-	-
Base Cost	2,847.7	3,211.9	6,059.6
Physical Contingency	42.5	21.5	64.0
Base cost + Physical Contingency	2,890.2	3,233.4	6,123.6
Price Contingency	-	-	-
Total Cost	**2,890.2**	**3,233.4**	**6,123.6**

Financial Cost	FC	LC	Total
Construction	2,394.7	1,719.8	4,114.5
Land Acquisition		1,968.6	1,968.6
House compensation		967.5	967.5
Consulting Services	453.0	151.0	604.0
Taxes and Duties		622.7	622.7
Base Cost (BC)	2,847.7	5,429.6	8,277.3
Physical Contingency	42.5	29.1	71.6
Base cost + Physical Contingency	2,890.2	5,458.7	8,348.9
Price Contingency	188.9	209.9	398.8
Total Cost	**3,079.1**	**5,668.6**	**8,747.7**

Source: JICA Survey Team

(3) Investment Schedule

For economic analysis of the Master Plan, the estimated investment cost to secure flood control space is distributed assuming an investment schedule of construction of the dam as shown in Table 4.10.4. In addition, replacement cost of electric and mechanical equipments is considered to be necessary in 2065, 35 years after installation.

Table 4.10.4 Investment Schedule of Master Plan

Year	Short-Medium-Term Plan		Long-Term Plan		Total
	PHP Million	%	PHP Million	%	PHP Million
2013					
2014					
2015	366	6.0%			366
2016	527	8.6%			527
2017	1,688	27.6%			1,688
2018	1,013	16.5%	17	1.7%	1,030
2019	1,490	24.3%	8	0.8%	1,498
2020	1,026	16.8%	17	1.7%	1,042
2021	15	0.2%	36	3.6%	51
2022			13	1.3%	13
2023			70	7.0%	70
2024			128	12.8%	128
2025			128	12.8%	128
2026			128	12.8%	128
2027			128	12.8%	128
2028			128	12.8%	128
2029			128	12.8%	128
2030			68	6.8%	68
2031			4	0.4%	4
Total	6,124	100.0%	1,001	100.0%	7,125

(4) Economic Benefit

The economic benefit to be obtained by implementing the Project was defined as the reduction of flood damage cost. The probable damage under "without the Project" condition was estimated by utilizing the result of flood inundation simulation as shown in Chapter 3. The damage expected to occur under "with the Project" condition was assumed to be zero under the design flood of 50-year return period or less. The flood damages are composed of (1) Damage in fixed assets, (2) other direct damage and (3) indirect damage as shown in Table 4.10.5.

Table 4.10.5 Expected Deduction of Annual Flood Damage Cost

Unit: Million PhP

Type	Category	Return Period(Year)				
		2	5	10	25	50
(1) Direct Damage Cost	Buildings	750.1	1,306.9	1,855.5	3,496.9	6,143.2
	Other Assets	1,443.9	2,429.9	3,485.7	6,402.9	10,364.7
	Total	2,194.0	3,736.8	2,262.5	9,899.8	16,507.9
(2) Other Direct and Indirect Damage Costs		22.0	37.4	53.5	99.1	165.3
Total Damage Cost		2,216.0	3,783.6	5,408.8	10,005.7	16,673.2

Source: JICA Survey Team

On the basis of the above computation on flood damages, the benefit of the projects is estimated as follows:

Table 4.10.6 Benefit Estimation

Unit: Million PhP

Return Period	Pro-bability	Damage without Project	Indirect Damage without Project	Damage with Project	Reduction of Damage Cost	Aver. Damage Cost	Expected Annual Ave Damage Cost	Economic Benefit with Project
2-yr	0.50	2,194.0	21.1	0.0	2,216.0	0	0	0
5-yr	0.20	3,736.8	36.7	0.0	3,774.2	2,995.1	898.5	898.5
10-yr	0.10	5,341.2	52.5	0.0	5,394.7	4,584.4	458.4	1,357.0
25-yr	0.04	9,899.8	98.2	0.0	9,998.9	7,696.8	461.8	1,818.8
50-yr	0.02	16,508.0	165.3	0.0	16,673.3	13,336.1	266.7	2,085.5

Source: JICA Survey Team

The benefits of the Master Plan are summarized as (i) PhP 1,819 million per year for flood control to meet probable 25-year flood as the Short-Middle-Term Plan, (ii) PhP 2,086 million per year for flood control for 50-year probable flood.

(5) Result of Economic Analysis

The analysis of the project is conducted for the period until 2080 with assumption of 50-years project life after the completion of the last package of the civil works.

The economic internal rate of return (EIRR) of the project is presented below as well as in Table 4.9.7, which shows the project is judged economically feasible.

- EIRR : 19.4%
- NPV : PhP1,370.5 million
- BC Ratio : 1.41

Table 4.10.7 Cost Benefit Analysis of Master Plan

(Million Pesos)

Calendar Year	Year in Order	Economic Cost: Short - Middle Term: Project Cost	Economic Cost: Short - Middle Term: OM Cost	Economic Cost: Long Term: Project Cost	Economic Cost: Long Term: OM Cost	Economic Cost: Total	Economic Benefits: Flood Control	Economic Benefits: Hydro Power	Economic Benefits: Total	Net Benefits
2013	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2014	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	2	365.7	0.0	0.0	0.0	365.7	0.0	0.0	0.0	-365.7
2016	3	526.5	0.0	0.0	0.0	526.5	0.0	0.0	0.0	-526.5
2017	4	1,687.5	0.0	0.0	0.0	1,687.5	0.0	0.0	0.0	-1,687.5
2018	5	1,013.0	0.0	16.7	0.0	1,029.7	0.0	0.0	0.0	-1,029.7
2019	6	1,489.7	0.0	8.3	0.0	1,498.0	0.0	0.0	0.0	-1,498.0
2020	7	1,025.8	0.0	16.7	0.0	1,042.5	0.0	0.0	0.0	-1,042.5
2021	8	15.3	0.0	35.6	0.0	50.9	1,818.8	0.0	1,818.8	1,767.9
2022	9	0.0	18.8	13.2	0.0	32.0	1,818.8	0.0	1,818.8	1,786.8
2023	10	0.0	18.8	70.2	0.0	89.0	1,818.8	0.0	1,818.8	1,729.8
2024	11	0.0	18.8	128.0	0.0	146.8	1,818.8	0.0	1,818.8	1,672.0
2025	12	0.0	18.8	128.0	0.0	146.8	1,818.8	0.0	1,818.8	1,672.0
2026	13	0.0	18.8	128.0	0.0	146.8	1,818.8	0.0	1,818.8	1,672.0
2027	14	0.0	18.8	128.0	0.0	146.8	1,818.8	0.0	1,818.8	1,672.0
2028	15	0.0	18.8	128.0	0.0	146.8	1,818.8	0.0	1,818.8	1,672.0
2029	16	0.0	18.8	128.0	5.0	151.8	1,818.8	0.0	1,818.8	1,667.0
2030	17	0.0	18.8	68.0	10.1	96.8	1,818.8	0.0	1,818.8	1,722.0
2031	18	0.0	18.8	4.4	10.1	33.2	2,085.5	0.0	2,085.5	2,052.3
2032	19	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2033	20	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2034	21	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2035	22	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2036	23	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2037	24	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2038	25	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2039	26	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2040	27	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2041	28	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2042	29	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2043	30	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2044	31	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2045	32	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2046	33	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2047	34	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2048	35	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2049	36	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2050	37	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2051	38	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2052	39	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2053	40	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2054	41	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2055	42	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2056	43	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2057	44	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2058	45	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2059	46	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2060	47	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2061	48	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2062	49	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2063	50	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2064	51	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2065	52	0.0	18.8	233.0	10.1	261.8	2,085.5	0.0	2,085.5	1,823.7
2066	53	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2067	54	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2068	55	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2069	56	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2070	57	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2071	58	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2072	59	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2073	60	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2074	61	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2075	62	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2076	63	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2077	64	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2078	65	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2079	66	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
2080	67	0.0	18.8	0.0	10.1	28.8	2,085.5	0.0	2,085.5	2,056.7
Total		6,123.5	1,107.2	1,234.0	517.7	8,982.5	122,463.0	0.0	122,463.0	113,480.5
NPV										1,370.5
EIRR										19.44%
B/C										1.41

4.11 Implementation Schedule of Master Plan

The implementation schedule of the proposed Master Plan is presented in Figure 4.11.1.

The urgent measures being undertaken by DPWH will be completed until third quarter of 2016. While implementing the urgent measures, the short-middle term measures composed of structural and non-structural measures shall be started in 2014. The target completion year of the short-middle term measures is the end of 2021.

The proposed dam construction in the long-term plan will need basic study, social and environmental study and ROW acquisition prior to start construction works. The schedule of the long term plan is proposed from 2015 to 2035.

As well as the said structural and non-structural measures, the operation and maintenance works of the proposed structural measures and periodical monitoring and regular maintenance dredging should be implemented continuously to sustain the function of the Project.

Item	Work Item
1	JICA Preparatory Survey
A	**Urgent Measures (being undertaken by DPWH)**
	- R1(Rehabilitation of Damaged Seawall)
	- L2 (Rehabilitation/Construction of Dike in Carmen downstream)
	- L3 (Rehabilitation Damaged Dike and Temporally Closure (Baby Dike)
	Repair of Cabula Bridge
	Construction of Borja Bridge
B	**Short-Middle Term Measures (to be undertaken by possible JICA Loan)**
B-1	Loan Agreement
B-2	Procurement of Consultant (for D/D)
B-3	Procurement of Consultant (for C/S)
B-4	Detailed Design
B-5	Preparation of PQ and Tender Document
B-6	Construction Supervision
B-7	PQ and Tendering
B-8	Construction Works
B-9	Resettlement and Right of Way Acquisition
B-10	Non-Structural Measures
Item	Work Item
C	**Long Term Plan**
C-1	Basic Study for Hydrological Data/ Geotechnical Investigations
C-2	Feasibility Study for Dam Construction
C-3	Social-Environmental Study/ECC Approval
C-4	Detail Design/Procurement of Contractor
C-5	ROW Acquisition for Dam and Reservoir
C-6	Construction of Dam
C-7	Non-Structural Measures for Long Term Measures
D	**Maintenance Works**
	Operation and Maintenance of Structural Measures
	Periodical Monitoring and Regular Maintenance Dredging/Channel Excavation

Figure 4.11.1 Implementation Schedule of Master Plan

4.12 Priority Project

4.12.1 Evaluation Issues

Among the components of the proposed Master Plan, the urgent and short-middle term measures should be implemented as priority projects for the Flood Risk Management Project for the Cagayan de Oro River.

The proposed project as urgent and short-med term measures was assessed from various angles as shown below:

Table 4.12.1 Evaluation Issues

	Evaluation Issue	Evaluation Item
1.	Mitigation of Flood Disaster Risk (Improvement of social vulnerability)	Decreasing flood disaster impact
2.	Flood Disaster Risk Management (Improvement of disaster prevention power in local area)	Cost of Structural measure and non-structural measure
3.	Adaptation of Climate Change (Easiness for climate change adaptation)	When the future flood discharge is increased by the climate change, structural and non-structural measure, such as heightening of the dike by additional embankment and/or sand bags, are easy or not.
4.	Integrated water resources management	1) River improvement plan is formulated to consider the sustainable society or not. 2) Impact to water cycle system 3) Cooperation with local people and related organizations 4) Balance of measures in the river and in the basin
5.	Natural and social environmental impact	1) Impact of natural environment by the river improvement 2) Social impact, such as land acquisition, resettlement, etc., 3) Impact to the people in the river basin with/without non-structural measure
6.	Possibility of implementation from the technical point of view	1) Same as basic survey stage 2) To evaluate non-structural measure
7.	Organization ad System	The capability of existing executing agency is evaluate to alternatives of the structural and non-structural measures and the capability O&M agency after completion of structural and non-structural measures is also evaluated to carry out sustainable O&M. The problems of system to carry out the future O&M are checked.

Source: JICA Survey Team

4.12.2 Assessment of the Priority Projects

(1) Mitigation of Flood Disaster Risk (Improvement of social vulnerability)

The design flood discharge for the Priority Project is probable 25-year flood, which magnitude is nearly equivalent to that of TY. Pablo in December 2012. Actual inundation area during TY Pablo was about 730 ha (440 ha except for the area within river boundary), while inundation area due to a flood of 25-year return period is estimated at 790 ha (500 ha except for the area the area within river boundary) according to the inundation simulation analysis. Hence, such inundation damages would not be encountered upon completion of the project.

Such benefit of flood damage reduction are brought not only by the structural measures but also by establishment of the river boundary which is the worthy results of the project as well as the establishment of river area to be legalized.

The technical assistance to be conducted as a part of the consulting services in the Priority Project as the non-structural measure would contribute flood damage reduction through the following measures:,

i) Preparation/Update of the flood hazard map and evacuation planning to improve disaster preparedness so that flood damage, particularly human life loss would be reduced

ii) Technical support for introduction of Community Based Early Warning System is expected to reduce flood damage through early information of disaster risk.

(2) Flood Disaster Risk Management (Improvement of disaster prevention power in local area）

Total cost of the Priority project is estimated at about 8,747.7 million in Philippine Pesos including the direct cost for the structural measures of PhP.4,114.5million (equivalent to 9,356.4 million Japanese Yen), the consulting services cost of about PhP.604 million(equivalent to JPY.1,373.5million), land acquisition and compensation cost of PhP.2,936.1 million, indirect cost and contingencies.

Cost for the Non-structural measures is estimated at about PhP50 million, which is equivalent to about JPY.114million, having included in the cost for the consulting service cost.

The Economic Internal Rate of Return (EIRR) is estimated at 18.3 % which is based on the total project cost and flood damage reduction benefit by the project as detailed in Chapter 5.

(3) Adaptation of Climate Change (Easiness for climate change adaptation)

One of the basic principles of formulation of the Master Plan is “Consideration for CCA in Planning and Design for Flood Mitigation Structures” taking into account the strategy in the Philippine Development Plan (2011-2016). The one of major impacts of climate change is increase of occurrence of extra-ordinary flood. In this Survey, the following approaches are applied in planning and design to cope with occurrence of the extra-ordinary flood.

i) The target safety level of the Master Plan is set so as to cope with the largest recorded flood in Northern Mindanao Region, which is TS Sendong flood equivalent to approximately 50-year probable flood.

ii) To attain the target safety level, the objective area of the Master Plan is the whole river basin where the watershed management and integration of flood control use to the proposed dam development plan are proposed.

iii) Basic concepts of the established river boundary in the Master Plan are a) to lower flood water level as much as possible and b) to protect from living and construction of structures in the area where evacuation would be very difficult in case the extra-ordinary flood.

iv) In the said concepts, non-structural measures such as evacuation road, disaster preparedness, flood forecasting and early warning systems will have an important role to protect human lives and mitigate flood damage in case the extra ordinary flood.

In addition, it is recommended to implement both structural and non-structural measures in the Priority Project to cope with the occurrence of extra-ordinary flood according to the following reasons in case only the structural measure would be implemented:

i) Structure will become too big scale,

ii) In case of extra-ordinary flood, water level of the channel will be much higher than the original ground level nearby; in case the flood wall or levee is collapsed, it is anticipated that much serious flood damage would be caused behind levee,

iii) Much high structure will isolate river area from the society behind structure, and cause deterioration of landscape and living situation, and

iv) Replacement of the existing structure, such as bridges shall be required.

(4) Integrated water resources management

i) The Priority Project comprises mainly flood dike system as structural measure covering downstream reach of the Cagayan de Oro River for about 12.0 km from the river mouth. As aforementioned in (3), it would cause a risk of high water level in the river channel by constructing tall dike to protect from extra-ordinary flood, effect of a retarding basin is incorporated to reduce flood water level and dike height although suitable area for the retarding basin is limited.

ii) Construction and installation of drainage sluice gate and/or sluice are included in the Priority Project to be constructed in parallel so that river improvement works by construction of dike system will not prevent drainage of water behind dike, and that the dike and flood wall structure will not be a constraint against drainage facilities to be improved in future.

iii) As one of the non-structural measures to be conducted through consulting services, the technical assistance for Riparian Forest Establishment in the agricultural land will encourage mitigation of fine sand discharge to river so as to control sedimentation in the river course and river mouth area to maintain river flow capacity.

(5) Natural and social environmental impact

i) The Priority Project is based on that present aquatic environment shall be basically sustained without particular change of the present river width or moving river course.

ii) Mangrove forest along the coastal area at left bank of the river will be sustained as the Natural Preservation Area and also to be used as retarding basin. Area in upstream river bank of the Cathedral will be functioned as a retarding basin as well including encouragement of drainage of inland rain water without changing the present condition much.

iii) Environmental impact due to implementation of the project including construction works is assessed and mitigation measure as well as monitoring program are recommended through EIA study in accordance with the JICA Guideline. The said monitoring will be conducted as a part of the consulting services during construction supervision stage.

iv) The scope of works of the Priority Project still requires a certain scale of resettlement, which has been assessed among the alternatives including that with much more resettlement. The assessment was made incorporating mitigation effect of flood high risk by resettlement from the high risk area. Therefore, such resettlement is not only for construction of the project structures but also for reduction of high flood risk to live therein. Taking into consideration such situations including scale of structures, requirement of resettlement and risk mitigation effect, the Priority Project plan is the most appropriate one among those conceivable and practical.

v) Technical assistance for Mangrove Forest Establishment along the coastal areas aims to support people living therein to secure their livelihood as well as to plan quality improvement of ecosystem in the coastal area.

(6) Possibility of implementation from the technical point of view

Particular consideration shall be paid to the following structures in the Priority Project in the aspects of design and construction planning:

i) Weak foundation is found in the Isla de Oro section where flood wall and a boulevard is planned to be constructed. The countermeasure method of construction need to be further studied in the Feasibility Study taking account of technical soundness and viability, economic aspect and environmental impacts conceivable during construction.

ii) As one of the components of the Priority Project is improvement of the Kagay-an Bridge including abutment at left bank and approach road at right bank, extensive design and construction plan are quite necessary not only in structural views but also taking into consideration a countermeasure of creating traffic obstruction.

(7) Organization and System

The Priority Project will be implemented by the Project Management Office for Flood Control (PMO-FC) as the project implementing office under DPWH as the Implementing Agency. Upon completion of project turn-over, DPWH Region X Office would be the one to be fully responsible for the operation and maintenance works. However, indirect and/or direct supportive activities by LGU shall be executed through an agreement (such as MOU) with DPWH concerning work demarcation and so forth of the O&M services. It is probable that related structures in the project to drain of land side water will be managed by LGU of operation and maintenance works.

Alignment of the structural measures of the Priority Project composing of mainly dike system is substantially based on the river boundary established by DPWH. The policy of the river boundary is closely related to the No Built Zone to be legalized to put it in practice by the Cagayan de Oro City, so that early enactment of the Comprehensive Land Use Plan of the Cagayan de Oro City is indispensable.

Furthermore, it is important to establish the River Area legally by DENR so that flood damage mitigation would be also achieved through land use control.

4.13 Conclusion and Recommendation of Master Plan

4.13.1 Conclusion of Master Plan

The Master Plan aiming at flood risk management in the whole basin of the Cagayan de Oro River was formulated in this Survey. The Master Plan is composed of both structural measures and non-structural measures as follows, which details are described in previous sections. The proposed Master Plan was evaluated technical point of view and assessed as economically viable. Social environmental issues were also assessed in initial stage of IEE/EIA study and Resettlement Action Plan mentioned in Chapter 9.

A. <u>Structural Measures</u> : i) Urgent Works
ii) Short-Mid Term Works (Priority Project)
iii) Long Term Works
iv) Maintenance Works

B. <u>Non-structural Works</u> : i) Short-Mid Term Works (Priority Project)
ii) Long Term Works

4.13.2 Recommendation of Master Plan

The Master Plan study for the Flood Risk Management Project for the Cagayan de Oro River enumerates the following recommendations:

(1) Early Implementation of the Priority Project

The priority projects for the flood risk management project for the Cagayan de Oro River, are (1) Urgent rehabilitation of existing damaged structures, (2) River improvement works in the downstream stretch from the river mouth to the Pelaez Bridge, and (3) Implantation of non structural measures from the viewpoint of social demands, economic viability and environmental soundness. There measures shall be implemented as soon as possible.

(2) Study and Planning on Introduction of Flood Control Function to the Proposed Dam Development Plan

The safety level to be secured by the structural measures of the priority Project is designed at 25 year only in downstream reach of the Cagayan de Oro River in Cagayan de Oro City area. While, the target safety level or return period of the design flood discharge being applied in the Master Plan is the level which is equivalent to the largest recorded flood caused by TS. Sendong which flood scale is assessed to be 50-year probable flood or more.

It is required in the upstream reaches to regulate a flood peak discharge of TS. Sendong scale flood to the peak discharge of 25 year probability or less in the downstream reach so as not to cause flooding damages therein. Conceivable measure to meet such flood peak mitigation is to secure regulation effect by dam reservoir in the upstream of the Cagayan de Oro River basin. However, there is no existing dam to provide such discharge regulation capacity.

At present, the existing dam facilities in the upstream of the Cagayan de Oro River basin are only small-scale runoff regulating dams and intake weirs in the tributary Bubunawan River. As for the existing plan and study for the high dam which would have discharge regulation capacity, a feasibility study was conducted for a hydropower dam at the confluence of Batang-Blanog Rivers by NPC-NORMECA (Northern Mindanao Electric Cooperatives Association). The dam will mitigate the flood risks of the extraordinary floods in relation to the climate change in the future, and will have a role to complement the river improvement works in the downstream.

It is recommended to encourage the implementation of the dam development including flood control component and to carry out necessary study and investigation to proceed to the next stage as below:

- Basic studies for hydrologic and sediment load, investigation of topographic and geotechnical conditions, material survey and social and environmental study,
- To advance dialogue and coordination between the related enterprise to hydropower development and DPWH,
- Study for electricity supply and demands,
- Study for water resources and its demands in the future for irrigation and water supply in the basin
- Formulation of the plan for the integrated water resource management and electricity development in the whole basin, and implementation of the feasibility study and the detailed design for the multipurpose dam referring to the existing plan and study of the hydropower dam proposed in the upstream of the Cagayan de Oro River.

(3) Improvement and Enhancement of Hydrological Observation System

In the course of the Survey, it was found that basic hydrological records such as rainfall, flood discharge, flood water level and sediment loads are inadequate and not kept properly. Improvement and enhancement of the hydrological observation system in the basin is recommended for the survey and investigation in the next stage, such as feasibility study and detailed design for the development of the dam, to implement flood forecasting and warning in the basin and to accumulate the observation records. Following activities shall be considered:

- There are only two (2) accredited rainfall observation stations in the upstream basin at Talakag and Bubunawan. The location and spatial distribution of the rainfall station in the CDO River Basin are not uniform. To solve this unbalance, a hydrological study shall be conducted to make a layout plan of the rainfall stations in the basin and required stations shall be installed as soon as it is ready.
- Hourly rainfall records in the basin are very few and limited only for the certain period. Since the characteristics of rainfall pattern in the basin are a relatively short duration with high intensity, increase and improvement of hourly rainfall observation system shall be necessary.
- The number of water level gauge station managed by DPWH in the basin is only one installed at the Cabula Bridge. Since the Cabula Bridge station is located at upstream of the confluence with the Bubunawan River and not including the run-off from its catchment area of 223 km^2 (16.4x% of total), it is recommended to establish a basic control station at the Peraez Bridge. Periodical water level monitoring and discharge observation with cross sectional survey shall be conducted at this basic station.

- In addition, considering the necessity to secure longer lead time for evacuation and prevention from the flood disaster by the flood forecasting and warning, additional water level monitoring stations with telecommunication system in the upstream basin shall be established. The preferable locations of the water level gauge stations are, for example, at the Uguiaban Bridge and Tal-uban Bridge and other bridges in the upstream basin.
- The data and record for sediment load and sediment yield are inadequate to assess soil erosions in the upper basin and sediment movement in the river channel. Periodical monitoring, accumulation and rearrangement of existing data and improvement/increase of monitoring station shall be carried out.
- At present, some rainfall and water level stations are being installed in the basin under DOST projects. The said recommendation shall be implemented incorporating with the DOST projects.

(3) Improvement of Local Drainage and Sewerage System

- In connection with construction of the dike system along the downstream of the Cagayan de Oro River, it is recommended in the Master Plan that the existing sluices and sluice gate will be improved at the outlet of the tributaries and drainage channel to the main stream.
- The study on improvement project of drainage of landside water and sewerage system in the downstream area are required for the further flood risk mitigation measures as well as comprehensive plan formulation and feasibility studies

(4) Incorporation of Policies on River Boundary and River Area in the Comprehensive Land Use Plan

- As one of the main measures employed in the FRIMP-CDOR Project, DPWH has established the River Boundary along the river stretch in downstream reaches. The River Area inside the River Boundary shall be controlled of its land use.
- It is necessary through discussion and exchange of opinions among stakeholders including the concerned agencies, the local government and the local residents that building and living are restricted in the river area as well as land use control and effective use of unused land.
- Definitive area and policies on the river boundary should be incorporated and stipulated in the Comprehensive Land Use Plan of the Cagayan de Oro City which has being under updating.

4.13.3 Recommendations on the Non-structural Measure of Long-term Activities

(1) Coordination and Monitoring on Implementation of Non-structural Measures

In the Master Plan, necessary activities on several issues related to the non-structural measures including flood management and watershed management are proposed. It is important to provide technical assistance for the non-structural measures. Such activities will involve not only DPWH but also PAGASA, DENR and LGUs.

So as to implement such activities of the non-structural measures effectively with suitable coordination with the structural measures, it is expected for DPWH to formulate a monitoring plan and to conduct monitoring activities consequently.

(2) Watershed Management

Aside from the proposed activities for the Japanese Yen loan projects, the following issues are recommended on the watershed management to DPWH, DENR and LGUs which have responsibilities to conserve and manage the natural environment.

i) Mitigation of fine sand sedimentation, recovery of forest area through compliance with the CLUP

As a comprehensive flood mitigation measure, it is important to recover the forest area by planting and reforestation which has an effect of improving water retention capacity of watershed and retarding run-off from upstream area of the Cagayan de Oro River basin.

It is observed that the fine sands flow into the rivers and creeks from the agricultural lands on the middle and upper watershed, and the agricultural lands are considered as one of the sources of fine sands. Therefore, it is recommended that the source areas of the find sands should be restricted by reducing the spread of the large-scale agricultural lands through compliance with the CLUP. Also it is recommended to facilitate with the land owners to consider and establish the measures to reduce flowing the fine sands for the existing agricultural lands and/or for the new agricultural lands if established. Accordingly, it is advisable for DA and LGUs to conduct these activities, in cooperation with DPWH, which manages the river structures in the downstream.

ii) Confirmation of the sources of fine sands and monitoring

The cultivated lands on the plateau are distributed vastly in the northern part of the Mt. Kitanglad, especially the cultivated lands were planted by pineapple, banana fields etc. The cultivated lands on the plateau are assumed to be the source area of the fine materials. Although the fine sands flow down from the agricultural lands through the visual check, no measurement has been conducted to identify the sources and monitor the sand flow and sedimentation. Therefore, in order to formulate and implement the adequate measures to mitigate the fine sand flow, it is recommended to conduct measurement of the fine sand flows and sedimentation. It is advisable for DPWH to conduct these measurements.

iii) Promotion of planting indigenous tree species along the riparian areas by replacing from the bamboos

Deep-rooted indigenous tree species should be planted along the riparian areas, by replacing from the shallow-rooted bamboos and tree species. Therefore it is necessary for DENR to select the adequate species for the riparian areas, establish the seedling production of selected species, establish and examine the methods of planting and maintenance of the selected species.

iv) Formulation of the watershed management plan and forest management plan for CDO City

There are no plans on watershed management and forest management for the whole CDO City. Although there are some issues and items planned in CLUP on the watershed management and forest management, those issues and items are not sufficient for the proper management of the watershed and forests in CDO City. Therefore, it is recommended for CDO City to formulate their own adequate plans on watershed management and forest management inside CDO City.

v) Early realization of the Coastal Resource Management Plan

Although the CRMP is being formulated by APO of CDO City, the CRMP has not yet been approved by the Mayor of the City. In order for the adequate utilization and management of the coastal areas in CDO City, it is recommended for the CRMP approved and implemented at the early stage. Moreover, the formulation and implementation of the CRMP of CDO City will contribute to establish the Bay-wide Coastal Management Plan, which is promoted by MBDA.