THE REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS (DPWH)
DAVAO CITY

PROJECT FOR MASTER PLAN AND FEASIBILITY STUDY ON FLOOD CONTROL AND DRAINAGE IN DAVAO CITY

FINAL REPORT
SUMMARY

JULY 2023

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
PACIFIC CONSULTANTS CO., LTD.

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FINAL REPORT
ON
THE PROJECT FOR MASTER PLAN AND FEASIBILITY STUDY ON FLOOD CONTROL AND DRAINAGE IN DAVAO CITY

SUMMARY

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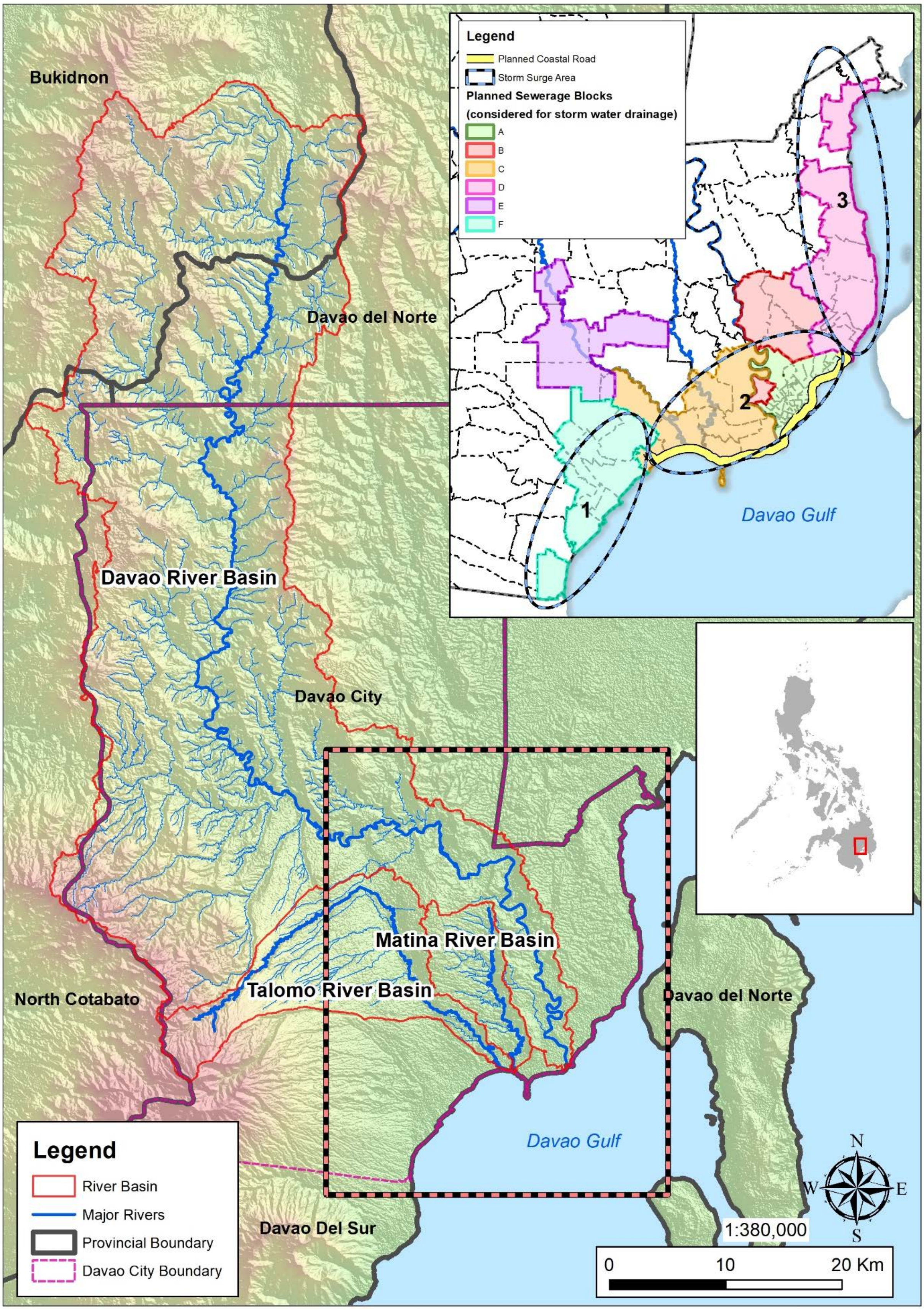
ABBREVIATIONS AND TERMINOLOGY

ADB	Asian Development Bank
AIDS	Acquired Immunodeficiency Syndrome
ASU	Ancillary Services Unit
B/C	Benefit／Cost
BDRRMC	Barangay Disaster Risk Reduction Management Council
BFAR	Bureau of Fisheries and Aquatic Resources
BM	Benchmark
BOC	Bureau of Construction
BOD	Bureau of Design
BWPDC	Bukidnon Watershed Protection and Development Council
CAD	Computer Aided Design
CADT	Certificate of Ancestral Domain Title
CCAM	Climate Change Adaptation, Mitigation
CCC	Climate Change Composition
CCTV	Closed-Circuit TeleVision
CDRRMC	City Disaster Risk Reduction Management Council
CDRRMO	City Disaster Risk Reduction Management Office
CENRO	City Environment & Natural Resources Office
CEO	City Engineering Office
CESO	Career Executive Service Officer
CIP	Conservation International Philippines
CLUP	Comprehensive Land Use Plan
CNC	Certificate of NonCoverage
C/P	Counterpart
CPDO	City Planning Development Office
CSSDO	City Social Services Development Office
DAO	DENR Administrative Order
DCDRRMO	Davao City Disaster Risk Reduction Management Office
DCCEO	Davao City City Engineering Office
DCPDO	Davao City Planning Development Office
DCWMC	Davao City Watershed Management Council
DGMC	Davao Gulf Management Council
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DEO	District Engineering Office
DFL	Danger Flood Level
DGCS	Design Guideline, Criteria and Standards
DIAS	Data Integration & Analysis System
DILG	Department of Interior and Local Government
DOST	Department of Science and Technology
DOTr	Department of Transportation
DPWH	Department of Public Works and Highways
DRBFFWC	Davao River Basin Flood Forecasting and Warning Center
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DSWD	Department of Social Welfare and Development
DTM	Digital Terrain Model
ECA	Environmental Critical Areas
ECC	Environmental Certificate Clearance
ECP	Environmental Critical Projects
EIRR	Economic Internal Rate of Return
EISS	Environmental Impact Statement System
EMB	Environmental Management Bureau

ENPV	Economic Net Present Value
EORC	Earth Observation Research Center
ESSD	Environmental and Social. Safeguards Division
FC	Foreign Cost
FCMC	Flood Control and Management Cluster
FCMO	Flood Control Management Office
FFWC	Flood Forecasting and Warning Center
F/S	Feasibility Study
GCP	Ground Control Point
GHG	Greenhouse Gas
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GSMaP	Global Satellite Mapping of Precipitation
HEC-HMS	Hydrologic Engineering Center- Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HIV	Human Immunodeficiency Virus
HWL	High Water Level
ICC	Investment Coordination Committee
ICHARM	International Centre for Water Hazard and Risk Management
IDIS	Interface Development Interventions Inc.
IEC	Information, Education, and Communication
IEE	Initial Environmental Examination
IFSAR	Interferometric Synthetic Aperture Radar
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
ISF	Informal Settler Family
ITR	Interim Report
IUCN	International Union for Conservation of Nature
JAXA	Japan Aerospace Exploration Agency
JICA	Japan International Cooperation Agency
JICS	Japan International Cooperation System
JMA	Japan Meteorological Agency
JPT	JICA Project Team
JPY	Japanese Yen
JRA	Japanese Re-Analysis
JST	Japan Standard Time
KBA	Key Biodiversity Area
KEC	Korean Engineering Company
LC	Local Cost
LDRRMF	Local Disaster Risk Reduction and Management Fund
LGU	Local Government Unit
LiDAR	Light Detection and Ranging
MCM	Million Cubic Meters
MDRRMC	Municipality Disaster Risk Reduction Management Council
MGB	Mines and Geosciences Bureau
MHW	Mean High Water
MHHW	Mean Higher High Water
MinDA	Mindanao Development Authority
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MLW	Mean Low Water
MLLW	Mean Lower Low Water
M/M	Minutes of Meetings
M/P	Master Plan
MSL	Mean Sea Level
MRP	Mindanao Railway Project

NAMRIA	National Mapping and Resource Information Authority
NCCAP	National Climate Change Action Plan
NCIP	National Commission on Indigenous Peoples
NDC	Nationally Determined Contribution
NDRRMF	National Disaster Risk Reduction and Management Fund
NDRRMP	National Disaster Risk Reduction and Management Plan
NEDA	National Economic Development Authority
NEPC	National Environmental Protection Council
NFSCC	National Framework Strategy on Climate Change
NGO	Non Governmental Organization
NHA	National Housing Authority
NIA	National Irrigation Administration
NOAA	National Oceanic and Atmospheric Administration
NSO	National Statistics Office
NWRB	National Water Resources Board
NWSA	National Water Security Act
OCD	Office of Civil Defense
ODA	Official Development Assistance
OIC	Officer in Charge
OJT	On-the-Job Training
ORI	Ortho-Rectified Image
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PCUP	Presidential Commission for the Urban Poor
PD	Presidential Decrees
PD	Project Description
PDRRMC	Provincial Disaster Risk Reduction Management Council
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PHP	Philippine Peso
PIA	Project Impact Analysis
PPA	Philippine Ports Authority
PPD	Project Preparation Division
PRECIS	Providing Regional Climates for Impacts Studies
PRS	Philippine Reference System
PSCG	Pre-stressed Concrete Girder
RAP	RoW Action Plan / Resettlement Action Plan
RBCO	River Basin Control Office
RCDP	Regional Cities Development Project
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
R/D	Record of Discussion
RDC	Regional Development Council
RO	Regional Office
ROW	Right-Of-Way
RTK	Real Time Kinematic
SCS	Soil Conservation Service
SEA	Strategic Environmental Assessment
SLR	Sea Level Rise
SLSC	Standard Least-Squares Criterion
SRTM	Shuttle Radar Topography Mission
SWAN	Simulating WAves Nearshore
SWMM	Storm Water Management Model
TDD	Tagum-Davao-Digos
TGBM	Tide Gauge Benchmark
TOR	Terms of Reference
TWG	Technical Working Group
UAV	Unmanned Aerial Vehicle

UP	University of the Philippines
UPMO	Unified Project Management Office
US$	United States Dollar
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
UTM	Universal Transverse Mercator
WGS	World Geodetic System



Project Area

＜Part I : Master Plan Study and Feasibility Study＞

Chapter 1 Introduction

1.1 Background of the Project

The Philippines has suffered devastating damage from natural disasters. During the 10 year-period from 2005 until 2015, a total of 20,000 people were dead and missing, 75 million people have been affected, and the economic loss has reached 182 billion pesos. The main cause of disaster is strong wind and flooding in which 70% of the affected people suffered damage by typhoons and monsoons, and 24% suffered damaged by storm surges and high waves.

The Project site, Davao City, located in the southern part of Mindanao Island, is the third largest city in the Philippines, and the largest city on Mindanao Island. Davao City had been less affected by flooding in the past, but flood damage has recently increased due to changes in typhoon tracks. In 2011, 30 people were killed by the flooding of the Davao and Matina Rivers, more than 2,500 people were affected by the flooding of Davao River in 2013, and 22,911 families were affected by flooding due to Typhoon Vinta in December, 2017. In addition, there are several problems such as inland flooding, insufficient drainage systems, and storm surges due to the geographical features of the 60 km coastline.

Even though flood disaster has occurred frequently in Davao City, a Master Plan for integrated flood control has not been developed. Although the budget for flood control in the Department of Public Works and Highways (hereinafter referred to as DPWH) has increased, the budget has not been fully used due to the lack of development of the Master Plan. Ten of 18 major river basins in the Philippines have developed Master Plans for flood control from the 1980s to the early 1990s. After that, 5 rivers (Cagayan, Agusan, Pasig-Marikina-Laguna Bay, Tagoloan, and Cagayan de Oro) have reviewed and updated their Master Plans, and the preparation of the Master Plan and Feasibility Study for the 5 rivers was conducted by DPWH with the support of JICA through technical cooperation projects as of 2017. For the improvement of drainage systems, although a Master Plan for the six districts inside Davao City had been developed by Davao City, a Master Plan for flood control in Davao River has not been developed. Further, it is highly expected to develop the Master Plans for flood control of major rivers/principal rivers including Davao River, and to enhance DPWH's capacity for development of the Master Plans for flood control by DPWH themselves.

Under the above circumstances, the Government of the Republic of the Philippines (GOP) requested assistance from the Japanese Government on the Master Plan and Feasibility Study on Flood Control and Drainage in Davao City. In response to the official request of the Government of the Republic of the Philippines, JICA conducted a detailed planning survey on the Project and confirmed and signed the minutes of meetings (M/M) on the 11th of August 2017, and signed the Record of Discussion (R/D) on the 23rd of April 2018.

<u>Signification of flood management and flood control measures in the development plans of the Philippines and Davao City</u>

In the development plan of the Philippines, flood management is positioned as one of the targets for promoting infrastructure development as one of the fields of water resources. Timely investment to flood management based on the master plan is required, using the ratio of countermeasure implementation areas to flood risk areas as an index. In addition, the development plan of Davao City stipulates disaster-resistant urban management and a comfortable urban environment as one of the development strategies. This Project is directly related to this strategy and contributes to the reduction of flood damage in Davao City, which in turn contributes to the development of Davao City.

1.2 Objective of the Project

Objective of the Project is to mitigate flood damage in Davao City by the implementation of flood control measures through development of the Master Plan for Davao River, Matina River and Talomo River basin and conducting the Feasibility Study on urgent and/or priority project(s).

(1) Goal of the Proposed Plan

The Master Plan and the results of Feasibility Study will be approved by GOP.

(2) Goal which will be attained by utilizing the Proposed Plan

Flood damage in Davao City will be mitigated.

(3) Outputs

1. The Master Plan of the flood control and drainage in Davao City which includes a flood control Master Plan for Davao River, Matina River and Talomo River basins.
2. The Feasibility Study on urgent and/or priority project(s).
3. Capacity enhancement of concerned DPWH personnel/Officials in the development of Flood Control and Drainage Master Plan

1.3 Project Area

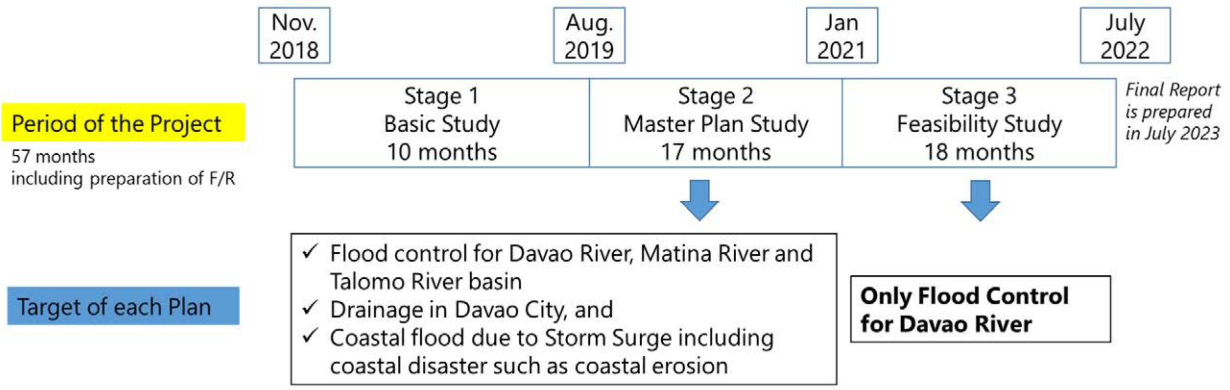
Target area of the Project is Davao City, Davao River Basin, Matina River Basin and Talomo River Basin with about 2,444 km^2 including (in Davao City urbanized area of approximately 131 km^2.

1.4 Implementation Structure

Counterpart agencies of the Project are DPWH and Davao city.

1.5 Project Schedule

The Project was commenced in November 2018 and completed in July 2023 after extension of more than 2years from the original schedule. Final project schedule is shown in Figure 1.5.1.



Source: Project Team

Figure 1.5.1 Overall Schedule of the Project

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

[Stage 1] Basic Study Stage :	November 2018 to August 2019 (10 months)
[Stage 2] Master Plan Study Stage :	September 2019 to January 2021 (17 months)
[Stage 3] Feasibility Study Stage :	February 2021 to July 2022 (18 months) (Final Report was prepared in July 2023 after discussion on DFR, EIS process and the Advisory Committee for Environmental and Social Considerations in Japan)

The work items for each Stage is shown in Table 1.5.1.

Table 1.5.1 Work Items (Stage1, Stage2, Stage 3 and Entire period)

Work Items	Content of Work
Stage 1: Basic Study	
1-1	Review of existing documents and preparation of the Inception Report
1-2	Introduction of the Inception Report (IC/R)
1-3	Collection and arrangement of basic information, survey of damage situation
1-4	【Riverine Flood】 Evaluation of existing flood control measures
1-5	【Riverine Flood】 River/Topographic survey (longitudinal profile and cross-sectional survey, riverbed material survey, spot elevation survey, etc.)
1-6	【Riverine Flood】 Hydro-meteorological statistical analysis
1-7	【Riverine Flood】 Estimation of sediment discharge
1-8	【Riverine Flood】 Discussion on target design level and design rainfall
1-9	【Riverine Flood】 Proposal of design criteria
1-10	【Riverine Flood Research for implementation of project / operation and maintenance management framework
1-11	【Riverine Flood Preliminary survey of river boundary
1-12	【Inland Flood Evaluation of existing drainage improvement plan and activities
1-13	【Inland Flood】 Rainfall and runoff analysis
1-14	【Inland Flood】 Discussion on target design level
1-15	【Inland Flood】 Research for implementation of project / operation and maintenance management framework
1-16	【Coastal Flood】 Coastal area survey (wave, tide level, tidal flow etc.)
1-17	【Coastal Flood】 Discussion on the target design condition for oceanographic features such as tide level, target waves and target return period for storm surges
1-18	【Coastal Flood】 Survey on the status of existing facilities and houses along coastal areas
1-19	Proposal of evaluation criteria for alterative countermeasures
1-20	Preparation, submission, explanation and discussion of Progress Report (P/R)
Stage 2: Master Plan Study	
2-1	Collection and arrangement of additional data and information, and setting of target design level
2-2	Study on alternatives for structural measures
2-3	Study and proposal on non-structural measures
2-4	【Riverine Flood】 Run-off and flood inundation analysis
2-5	【Riverine Flood】 River bed variation analysis
2-6	【Riverine Flood】 Geotechnical investigation
2-7	【Riverine Flood】 Preliminary facility plan of proposed structural measures
2-8	【Inland Flood】 Analysis of inundation
2-9	【Inland Flood】 Study on countermeasures for each drainage district
2-10	【Inland Flood】 Geotechnical investigation
2-11	【Inland Flood】 Preliminary facility plan of proposed structural measures
2-12	【Coastal Flood】 Evaluation of the impact of existing projects and future development plans in coastal areas
2-13	【Coastal Flood Numerical analysis on storm surges and coastal erosion from the view point of coastal protection
2-14	【Coastal Flood】 Preliminary facility plan of structural measures
2-15	Comparison of alternatives considering environmental and social consideration based on Strategic Environmental Assessment concept
2-16	Formulation of Integrated Flood Control Master Plan
2-17	Preliminary cost and benefit analysis
2-18	Additional survey on existing structures
2-19	Selection of priority project(s) and clarification of necessity of change in category under JICA's Environmental and Social Consideration Guidelines
2-20	Scoping on environmental monitoring items for selected priority project(s)
2-21	Support for preparation of a simple resettlement action plan

Work Items	Content of Work
2-22	Preparation, submission, explanation and discussion of Interim Report (IT/R)
2-23*	Examination of measures to promote implementation of Master Plan – grand design of relocation site development
(*Work item 2-23 was added as a new work item by the amendment of the contract in February 2021.)	
Stage 3: Feasibility Study of the Priority Project	
3-1	Preliminary design of structural measures
3-2	Setting of implementation schedule
3-3	Formulation of construction plan and procurement plan
3-4	Proposal of operation and maintenance plan and cost estimation
3-5	Preliminary project cost estimation and disbursement schedule
3-6	Project evaluation
3-7	Prediction and evaluation of important environmental impact and proposal of mitigation measures and monitoring plan
3-8	Preparation, submission, explanation and discussion of the Draft Final Report (DF/R)
3-9	Preparation, discussion and submission of the Final Report (F/R)
Entire period	
4-1	On-the-job training (OJT) and technology transfer
4-2	Support for organizing meetings such as Steering Committee
4-3	Counterpart training sessions in Japan

Source: Project Team

1.6 Composition of Steering Committee and Technical Working Group

(1) Composition of Steering Committee

The Steering Committee was agreed to be organized in the M/M on the 11th of August 2017, and its composition was set by DPWH Special Order No. 167, Series of 2018, which was issued on December 10th, 2018.

The main functions of the Steering Committee written in the Special Order are as follows:

a) To review, discuss and approve the reports;
b) To review the progress of the Project;
c) To exchange views and ideas on major challenges that may arise during the implementation period of the Project;
d) Ensure the success and desired outcome of the Study.

The Steering Committee meeting was held five times on the 23rd of January 2019, the 3rd of September 2019, the 24th November 2020, the 10th of February 2021 and the 8th of November 2022.

(2) Composition of Technical Working Group (TWG)

TWG was agreed to be organized in the M/M on the 11th of August 2017, aiming at assisting the Steering Committee, and its composition was set by DPWH Special Order No. 167, Series of 2018.

The TWG meeting was held three times on the 25th of January 2019, the 29 th of August 2019 and the 21st of November 2019.

Chapter 2 Basic Study and Analysis on Present Conditions

2.1 Project Location

Most of the target area of the Project, which consists of Davao City urbanized area, Davao River Basin, Matina River Basin and Talomo River Basin, is situated in the Davao Region that is one of six Regions in the Mindanao Islands. The target area administratively spreads mostly to Region XI, and partially to Region X and Region XII, and is specifically located under Davao City and the three provinces of Bukidnon, Davao del Norte and Cotabato. Most of the target area is dominated in Davao city that is a chartered city and the third largest city in the Philippines. Urbanized area of the Davao City is located in the coastal area in the Southern part of the target area.

2.2 Natural Condition

2.2.1 River Condition

The southeastern part of the target area where the urban area of Davao City spreads, the lower part of the Davao River, the Matina River Basin and the southeastern part of the Talomo River Basin are relatively flat low-lying areas. The lower reaches of the three rivers and most of the urban areas targeted by inland drainage are at an altitude of 100 m or less.

Basic data for Davao, Matina and Talomo rivers are summarized in Table 2.2.1.

Table 2.2.1 Basic Data for Targeted Three Rivers

River	Length (km)	Basin Area (km^2)	Specific Discharge during Flood * ($m^3/s/km^2$)					
			Return Period (years)					
			2	5	10	25	50	100
Davao	191	1755	0.84	0.96	1.06	1.22	1.35	1.47
Matina	24	70	3.66	4.18	4.59	5.30	5.85	6.39
Talomo	54	204	2.42	2.76	3.04	3.50	3.86	4.22

*: Calculated by using method in “Specific Discharge Curve, Rainfall Intensity Duration Curve, Isohyet of Probable 1-day Rainfall, March 2003, DPWH & JICA”

Source: Project Team

2.2.2 Climate Condition

The climate of the project area belongs to the tropical climate, and it is classified into Type IV climate classification on the climate classification map of PAGASA. Type IV is generally a climate where precipitation is evenly distributed throughout the year and has no dry season, as does Type II, which is distributed along the eastern coast of the Philippines.

According to the meteorological data of Davao City, DAVAO DEL SUR Meteorological Observatory in PAGASA from 2008 to 2012, the annual average temperature is 28 °C, and the average temperature in each month is 27 °C to 29 °C. The annual variation in temperature is small and the precipitation is about 100 mm or more every month throughout the year. The average annual rainfall is about 1850 mm. The average monthly rainfall in April, when the rainfall is the lowest, is 110 mm, and the average monthly rainfall in June, when the rainfall is high, is about 200 mm. The rainfall trend in Davao City is that the period from May to late October has high rainfall and the period from November to April has relatively low rainfall.

2.2.3 Natural Environmental Condition

(1) Natural Resources

The Study Area, Davao City and surroundings, enjoys a tropical rain forest ecosystem, and has rich natural resources and biodiversity. However, recent rapid development and urbanization have led to the degradation of forest resources and biodiversity. Coverage area of forest (open and closed forest) decreased by 16% in the Study Area in 2016.

DENR cooperated with Davao City and other LGUs to conserve forest resources. According to the Conservation Areas of DENR, the forests in the City are classified as “Primary Conservation Areas” and “Secondary Conservation Areas”, and Management Basic Policies are formulated for each class. Secondary conservation forest is adapted to be used for sustainable development for eco-tourism.

The greening program has been continuously promoted since 2011, and is mainly carried out in the middle stream of the Davao River.

According to the IUCN Red Data List, total of 282 wildlife have been reported as protected species (threatened, endangered); 6 species are categorized as threatened species.

Mangrove is observed near the river mouth of Matina and Talomo. A NGO group has taken actions for conservation in the manner of reforestation, nursery, etc.

(2) Geology and Topography

The topographical future of the Study Area is composed of mountains in northern and western parts and lowlands in southern part. Mt. Apo, the highest mountain in the Philippines, of which the highest point is 2,954 m from the sea level, lies on the western area. The elevation of this area is mostly 1,000 m or higher above sea level. Due to the Mountainous topographical feature, most of the Study Area is steep, with slopes more than 18% in which the area development/activity are limited. While low land, in the southern area, shows flat features. This area is urbanized and/or have been rapidly developed.

The River Channel was meandering from the place where the Bolton Bridge (around 2 km from the actual River Mouth) is currently built, and in 1940, the river channel swung eastward. Consequently, it can be remarked that the actual urbanized left side of the current Davao River was originally an unused lowland highly exposed to flood risk.

(3) Natural Disaster

1) Earthquake

Some active faults are existed in the Study Area. Significant earthquakes in 2013 and 2018 (magnitude 5.7 and 7.2 respectably) occurred at the east-south-east sea bed form the Davao; whereas in recent years the seismic point of recent earthquake happened between October and December 2019 is located around Mt. APO (Active volcano, but no record of eruption in the recorded history); monitoring network has been strengthened.

2) Landslide

Mechanism of Landslide depends on natural topographical conditions, such as soil, slope, elevation, etc.; therefore, the high risk area lies on northern area.

2.2.4 Pollution

(1) Air Pollution

Recent population increase has led increase of traffic volume; and this situation has caused increase of air pollution. The condition, however, in Davao City could be said appropriate air environmental level.

(2) Water Quality

In the three (3) rivers, level of Fecal Coliform showed higher value and exceeded the standard level because of source of domestic water discharge to the river; other items showed appropriate level. It was found high level of TSS concentration. Since no significant gap of TSS between upstream and downstream or higher concentration of TSS happened in the upstream where less significant human activity was found: such high concentration may be caused by some geological and geographical features (inflow of the sand from the mountainous area, e.g.).

2.3 Social Condition

2.3.1 Socio-economic Condition

(1) Population

Davao region consists of Davao City, the third biggest city (the largest administration boundary), is popular as an economic central area in Mindanao Island. This area, especially Davao City, has enjoyed a rapid population increase and urbanization. The population increase from Year 2010 to 2015 was estimated at approximately 2.3% and the population in 2016 is 1,633 thousand.

Population density in the urban area/barangays was 43 persons/ha on average compared to 1.5 persons/ha on average in rural area. The most dense area was Poblacion, where the average is about 61 persons/ha.

(2) Economy

Major economic sources in the Study Area are 1) Services (consisting of 50.2% in Davao City (NSO, 2017)), Industry (32% in Davao City) and Agriculture and Fishery (17.8% in Davao City).

Agriculture and fishery are two of the key economic activities in Davao, which could be affected by either floods or its control measures.

1) Agriculture

The agricultural production areas are concentrated in the inner and upper portions of Davao City, particularly in Marilog, Calinan, Baguio, etc., which areas are known for rice/ crop, corn, coconuts, banana, etc.

2) Fishery

Davao Gulf is known as important fishing grounds in the country. The Davao Regional Development Plan reported the annual fisheries production in the whole of Davao region approximately at 67,468 tons (in 2012 total of commercial and municipal fishing, aquaculture). Among the valuable catch in the gulf are yellow fin tuna, anchovy, and herring. Tilapia and Hito in fresh/ blackish water are also typical fishing production in this area. According to the Registration Program by BFAR, approximately 22.7 thousand fisher folk have been registered; around 9.9 thousand of them have been in Davao del Sur including Davao City.

DENR XI as well as BFAR have warned that water pollution, sedimentation and improper fishing practices degrade coral and sea grass area where are important habitats of aquatic biota.

(3) Indigenous Peoples

The Indigenous Peoples (IPs) communities are the largest and most important stakeholders especially in the upstream of Davao River. The five (5) groups have resided in six (6) ancestral dominant area located in mostly the northern area and ridge of Mt. Apo.

(4) Resettlement, Informal Settlers

Approximately 60 thousand of households of informal settlers (ISFs) were confirmed in the Davao City as of 2017 (Davao City and NAMRIA）.

Dwelling area of the ISFs are mostly observed along the rivers and the coastal area. The Davao City issued ordinance in 1992 to take action of relocation of the ISFs from the viewpoint of encouragement of public development and disaster prevention. The ordinance declares compensation of their asset, income recovery support and provision of relocation site with houses and infrastructures for the ISFs who had resided before 1992. However, the number of ISFs has still increased. It is said barangay cannot properly control the informal migration in their territory because their budget allocation from the central government depends on the population.

(5) Tourism and Recreation

Popular nature tourism sites are the Philippine Eagle Center, Davao Crocodile Park and the Davao Butterfly Garden, Malagos Garden Resort; more than 120,000 tourists visit annually. A number of beach resorts operate along the Davao City coast line and on the opposite side in Samal Island. Many private resort spots have been rapidly built along the river side. Davao City as well as other LGUs in the Study Area have concentrated on establishing eco-tourism; CPDO has designated a forest conservation area which is utilized for community-based sustainable eco-tourism in cooperation with IPs groups.

(6) Commercials, Services and Industries

Approximately 31,500 business establishments are operated in Davao City. 93% of these are micro-enterprises (average number of employees: 3 workers and capital: less than 500,000 Pesos), engaged mainly in handicrafts, food processing, trading and services.

Major large scale enterprises are involved in processing agricultural and forest products such as Mt. Apo Fruits, Davao Fruits, Lapanday Agricultural and Development Corp., which are all located in Buhangin. The city's secondary centers for instance Buhangin, Calinan, and Malagos, function as some medium-scale urban facilities and services, such as secondary or tertiary schools, sub-government centers, hospitals, and integrated food and transport terminals.

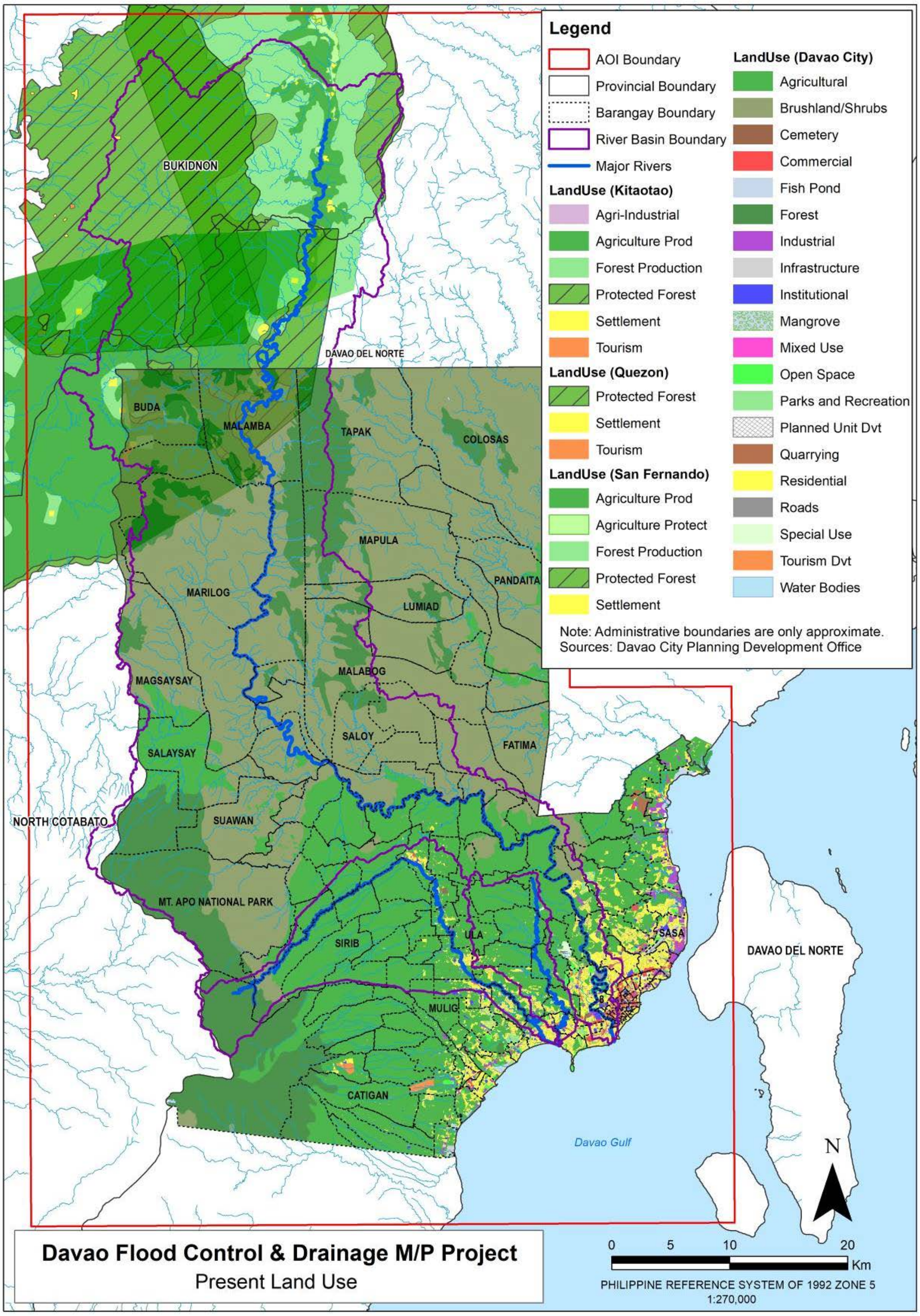
(7) Gender

Philippines is known as "the most advanced respected gender in Asian countries"; it was evaluated the 16^{th} out of the 153 countries (Japan: 121^{st}) and top 1 in ASEAN countries according (Global Gender Gap 2020). The most highly evaluated factor was "high participation level in social-economic activities".

On the other hand, evaluation score on welfare and security fields has been decreased. Disadvantage of care to especially handicapped females comparing to males has been pointed out.

2.3.2 Land Use

In the Davao City Infrastructure Development Plan and Capacity Building Project (JICA, 2018), a present land use map for Davao City in 2017 was prepared as shown in Figure 2.3.1. In this Project, in addition to the land use data for Davao City in 2017, land use data of the river upstream collected through the Project will be combined and treated as the present land use condition for this Project.



Source: Davao City Infrastructure Development Plan and Capacity Building Project, June 2018

Figure 2.3.1 Present Land Use in Davao City-Overall City (2017)

2.4 Development Plan

(1) Subdivision Development

Urban development is rapidly advancing in the target area, and large-scale residential area development is currently in progress along the river in the section from 13 to 25 km from the mouth of the Davao River.

(2) Transport Infrastructure

There are many transport infrastructure development plans in the target basin. Besides the road construction implemented by DPWH RO / DEO, there are the following four projects that have bridges crossing the target river and are considered to be related to this Project. These four projects are regarded as the flagship projects in the Davao Region of the Regional Development Council (RDC) XI. (These projects are listed up in Annex B: Davao Region's Flagship Projects, 2019-2022 of RDC XI Resolution No. 66, Series of 2018.)

Table 2.4.1 List and Status of Flagship Transport Infrastructure Projects

Project Title *1	IA *2	Funding Source *2&*3	Present Status *3
A. Davao City Bypass Construction Project	DPWH	ODA (Japan Loan) & Locally Funded	Under Construction
B. Davao City Coastal Bypass Road Project	DPWH	Locally Funded	Under Construction / Detailed Design
(Davao River Bridge (Bucana Bridge))	DPWH	ODA (China grant) & Locally Funded	Detailed design started in 2022 and will complete on 2025.
C. Mindanao Railway Project	DOTr	ODA	ROW acquisition completed 2021in the segment of Tagum-Davao-Digos.
D. Davao City Expressway Project	DPWH	ODA (China grant)*3	F/S finished in June, 2020. Under NEDA Board`s ICC approval

*1: RDC XI Resolution No. 66, Series of 2018
*2: Presentation material (2017) by NEDA
*3: Interview to DPWH

Source：Project Team

(3) River Basin and Watershed Management and Development

DENR formulated the Davao River Basin Management and Development Plan in 2015, and necessary measures and funds for 15 years ahead are considered in this plan. Among them, as the infrastructure development related to this project, the development of irrigation system, water retarding basin to mitigate flooding and hydropower development are proposed.

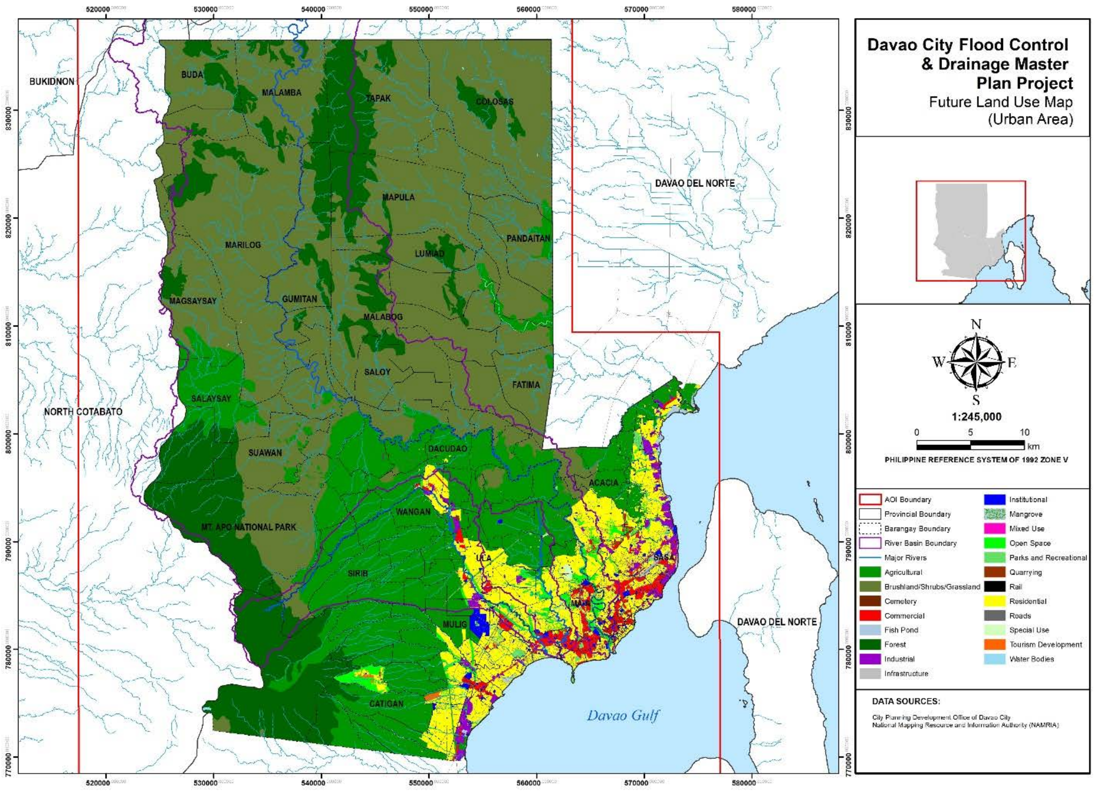
For the irrigation systems, a total of 13 systems with an area of about 1,250 ha have been proposed. If all systems are developed, it is estimated that when all the systems become fully operational, a maximum of 17,028 tons per year will be added to the annual rice production in the basin.

For the water retarding basin to mitigate flooding, five possible sites have been proposed, and early implementation is recommended in this plan. For the implementation, it is proposed that site identification / investigation and feasibility study shall be conducted. One of the five sites is located at the same site as the proposed retarding basin in the M/P of this project. DENR estimated that the construction of the retarding basin at this site will require 315 million pesos.

For the hydropower development, it is reported that private companies are investigating for construction, at Lamanan Barangay located in the middle of the Davao River. It is estimated that the power generation of 160 MW is expected, and 17,748 million pesos of funds are needed. The hydropower plant is planned in Lamanan Barangay which is located in the middle stream of Davao River, and outside the target area to be protected by structural measures of this Project, there will be no direct impact with each other.

(4) Future Land Use Plan

In the Davao City Infrastructure Development Plan and Capacity Building Project (JICA, 2018), a land use map in 2045 was prepared as shown in Figure 2.4.1. In this Project, future land use condition will be set referencing this information.



Source: Davao City Infrastructure Development Plan and Capacity Building Project, June 2018

Figure 2.4.1 Land Use Plan Map in 2045

2.5 Topographic and River Surveys

2.5.1 Collection of available Existing Maps and Relevant Survey Data

Prior to the commencement of the actual work, the existing topographic map, ortho-photo imagery, ground control point, bench mark, sea chart and tide observation data collected from National Mapping and LiDAR data from University of Philippines was collected.

2.5.2 Summary of Topographic and River Survey

The topography and river surveys were carried out, to acquire river cross section and profile data, ground height, city drainage, shoreline, bathymetric and ortho-photo data, etc., necessary to implement the M/P study and F/S on this Project. The Works is subcontracted to a local survey firm and carried out for the period from January 2019 to May 2019. The Works consisted work items and quantity as shown in Table 2.5.1.

Table 2.5.1 Work Items and Quantity (Topographic and River Survey)

Work Item	Quantity/Unit
1. River Topographic Survey (River Longitudinal and Cross Sectional Survey along 23km of Davao River, 13.5km of Matina River and 11km of Talomo River)	
1.1 River Longitudinal (Profile) Survey	
(1) Davao River (Station No. 0+000 – 23+000)	23.0 km
(2) Matina River (Station No. 0+000 – 13+500)	13.5 km
(3) Talomo River (Station No. 0+000 – 11+000)	11.0 km
1.2 River Cross Sectional Survey	
(1) Setting up of 500m Station No. Peg (Cross Section Points)	96 points
(2) Davao River (Interval: 500m along the River, Width: 200m)	46 sections
(3) Matina River (Interval: 500m along the River, Width: 100m)	28 sections
(4) Talomo River (Interval: 500m along the River, Width: 100m)	22 sections
1.3 Ortho-photo Mapping by UAV (Davao River: 23km+ Matina River 13.5km + Talomo River 11km = 47.5km x width: 1km=47.5 km2)	47.5 km2
2. **Topographic Survey 1** (Ground Height Survey) (Confirmation of ground height on DOST LiDAR and NAMRIA IFSAR data covering the Davao, Matina and Talomo River Basin)	
(1) Davao River Basin (Leveling from 500m Station No. Peg)	50 points
(2) Matina River Basin (Leveling from 500m Station No. Peg)	10 points
(3) Talomo River Basin (Leveling from 500m Station No. Peg)	30 points
3. **Topographic Survey 2** (City Drainage Survey in Pabliacion and Agdao Districts)	
3.1 Setting up of Drainage Cross Section points and Inventory Ground Control Points	50 points
3.2 Drainage Cross Sectional Survey (5 drainage x 5 cross sections = 25 cross sections in total)	25 sections
3.3 Inventory Survey for Manhole/Culvert (5 drainage x 5 sites=25 locations in total)	25 locations
4. Topographic Survey 3 (Shoreline Survey along the Coastal Road and Davao North Coast)	
4.1 Ortho-photo Mapping by UAV (Length:40km x width: 1km = 40km2)	40 km2
4.2 3D Sectional Measurement for Profile Sections	
(1) From South of Davao City to the entry points of Coastal Road (Ground Survey 3D measurement)	10 km
(2) Construction site of Coastal Road to the North of Davao City (Ground Survey 3D measurement)	12 km
(3) From the End of Coastal Road to the North of Davao City (Photogrammetric 3D measurement)	18 km
4.3 Cross Sectional Survey	
(1) Setting up of Cross Section Points (Interval: 500m along the Shoreline)	84 points
(2) From South of Davao City to the entry points of Coastal Road (Interval: 500m along the Shoreline, Width: 100m)	21 sections
(3) Construction site of Coastal Road to the North of Davao City (Interval: 500m along the Shoreline, Width: 100m)	25 sections
(4) From the End of Coastal Road to the North of Davao City (Interval: 500m along the Shoreline, Width: 100m)	37 sections
5. Topographic Survey 4 (Bathymetric Survey along the Coastal Road and Davao North Coast)	
5.1 Sounding Survey (Length:40km x Width: 250m=10 km2)	10 km2
5.2 Preparation of Sounding Cross Sections (Width=250m)	
(1) From South of Davao City to the entry points of Coastal Road (Interval: 500m along the Shoreline, Width: 250m)	21 sections
(2) Construction site of Coastal Road to the North of Davao City (Interval: 500m along the Shoreline, Width: 250m)	25 sections
(3) From the End of Coastal Road to the North of Davao City (Interval: 500m along the Shoreline, Width: 250m)	37 sections
6. Survey Report (Including all Outputs)	2 sets

Source：Project Team

2.5.3 Riverbed Material Survey

(1) Objectives and Items of Survey

The riverbed material survey was conducted on the following items for providing basic data for riverbed fluctuation analysis and sediment yield study.

- Riverbed material grain size analysis (sieve analysis)
- Specific gravity test

(2) Target Area

The riverbed material sampling was conducted at a pitch of approximately 1 km for the three target rivers. The riverbed material sampling points are as shown below.

- Davao River : 0.0 km to 23.0 km: 24 points
- Matina River : 0.0 km to 13.5 km: 14 points
- Talomo River : 0.0 km to 11.0 km: 11 points

(3) Survey Result

As for the riverbed material grain size distribution and soil classification ratio in the Davao River, most of the riverbed material consists of clay, silt, and sand up to approximately 15 km from the river mouth. At the upstream section of 15 km from the river mouth, the composition ratio of gravel is increasing. The D50 (the particle size of 50% in suspension; average particle size) is 2 to 10 mm at sections containing a high ratio of gravel, where upstream of approximately 15 km from the river mouth, while the D50 is about 0.1 mm at other section composed of clay, silt, and sand.

In the Matina River, although there is no clear change of composition ratio of riverbed material as there is in the Davao River, the composition ratio of gravel is large around 4.5km from the river mouth and from 7.5km to 8.5km. The composition of the riverbed material shifts from clay and silt to gravel from approximately 5 km from the river mouth, and the grain size increases with the augmentation of gravel in the section from 10 km to upstream. The D50 is 1 to 4 mm at sections consisting a high ratio of gravel from about 10 km upstream from the river mouth, and the D50 is about 0.1 mm at sections composed of clay, silt, and sand on the downstream side.

In the Talomo River, the composition of riverbed material changes around 6 km from the river mouth. Most of the riverbed material at the section downstream of 6 km from the river mouth consists of clay, silt, and sand, which the ratio of sand is higher compared with Davao River and Matina River. At the upstream section of 6 km from the river mouth, the composition ratio of clay and silt drastically decreases and, instead, the ratio of sand and gravel increases. The D50 is 2 to 8 mm at sections consisting a high ratio of gravel from about 6 km upstream from the river mouth, and the D50 is about 0.1 mm at downstream sections composed of clay, silt, and sand.

As for the results of the specific gravity test, the specific gravity of the material of the Davao River, the Matina River and the Talomo River is about 2.8 (g/cm^3) which is slightly larger than the general value. This is probably because there are many gravel in the rivers due to volcanic activity.

2.6 Geological Conditions

In the target area of this project, road and bridge constructions by DPWH-RO and embankment and revetment constructions by DPWH-DEO have been / are being carried out, geological survey being conducted for those constructions as well. Nevertheless, a geotechnical survey report integrating the survey results (incl. standard penetration test, particle size distribution, liquid / plastic limit test, moisture content test) has only been compiled for a few surveys and that, in most cases, the survey results can only be confirmed through borehole logs and assumed geological sections reflected in the design drawings. There seems to be confusion in the utilization of survey results, as implied by the identical geological sections appearing in the drawings of different sections. This implies that survey results may not be used correctly.

2.6.1 Davao River

Although it is difficult to accurately understand the geological conditions along the Davao River due to above mentioned confusion of the data, the geological features of the area in general are assumed as follows,

- ✓ Depth of bearing layer (N > 30 for sand, and N > 20 for silt and clay) is, in most sections, less than 10 meters from the ground level. As a exception, there are some data indicating the depth of bearing layer to be at 15 to 25 meters from the ground level only for sections between the river mouth to 3.0 km, in between data with bearing layer at less then 10 meters.
- ✓ The thickness of soft silt / clay layer that exists above the bearing layer is less than 5 meters for most sections. An only exception can be seen at around 1.5 km left bank where the thickness soft silt / clay layer is more than 10 meters due to available data.

2.6.2 Talomo River

As for the assumed geological cross section of 2+700 to 2+900 km (Left bank) of the Talomo River, a soft to medium sandy silt having an N value of about 4 to 15 is found in the surface layer of 2 to 6 meters, and a medium to dense silty sand having an N value of 14 to 30 or more is found below.

2.6.3 Matina River

A soft clay layer with an N value of 2 to 4 can be seen continuously to the bottom of borehole at about 11 m from the ground surface at around 0 +800 km (right bank). Similar geological conditions are assumed in the design documents of upstream section (above 2km), although there seems to be a confusion in the utilization of data, such as identical cross section in different sections.

2.6.4 Summary/Issue of Geological Conditions of the Target Area

It is assumed that, for all of three rivers, the subsurface ground consists of around 5 m of soft layer on the top. The thickness of the soft layer can potentially be greater and reach more than 10 m along Matina River, implying that measures against soft ground may potentially be required in the design of structural measures.

2.7 Riverine Flood Analysis

2.7.1 Inundation and Damage of Riverine Flood

(1) Record of Flood

In Davao River Basin, major floods have been recorded in 2002 and 2017. Major floods were recorded in Talomo River Basin in 2000 and 2002, and in Matina River Basin in 2002 and 2011. In December 2017, Typhoon Vinta caused enormous damage, especially in Davao River. An outline of the damage recorded by the riverine flood of each basin is summarized below based on flood disaster records for the period 2000 - 2018 provided by CDRRMO in Davao City.

1) Davao River Basin

In Davao River, Vinta Typhoon of December 2017 affected 21,768 families which corresponds to two-thirds of the total number of affected families (30,503). Although the number of reported incidents is large (30 flood incidents from 2000), the total number of casualties is 7 and the occurrence of floods affecting families is low.

In Davao River Basin, the frequency of flood damage is high in the urbanized downstream area covering the Barangays of Ma-a, Tigatto, BRGY 2 and BRGY 5. Although if there are some barangays with a number of floods reported in the middle reaches such as Tamuguan, flood reports are concentrated in the lower part of the Davao River basin where the urbanized area is located.

2) Matina River Basin

In Matina River, the floods of 2000 and 2011 were the biggest in terms of affected families. Compared to the Basins of Davao River and Talomo River, the number of affected families is small. However, the number of incidents reported in the three Barangays of Matina Pangi, Matina Aplaya and Matina Crossing is large.

The most destructive flood in the Matina River basin is the flash flood of June 2011 which caused 26 deaths by drowning in Matina Crossing and 2 in Matina pangi (Since the total number of casualties since 2000 is 31, the number of casualties caused by the flood of 2011 represents 90% of the total).

3) Talomo River Basin

In Talomo River, from the viewpoint of affected families, the flood of January 2002 is prominent with 10,315 affected families which represents around 60% of the total number of affected families (18,315). Although the number of incidents reported since 2010 is 22 which is equivalent to 70% of the total number of 32 flood incidents, the number of affected families since 2000 is 1,013 which is equivalent to 6% of the total number since 2000.

In the Talomo River Basin, although flood incidents are widely reported not only in the downstream but also in the middle stream, in particular, in the most downstream Talomo Barangay, the number of flood incidents is the biggest (10) and the flood of January 2002 affected 10,264 families (around 60% of the total 18,053 affected families since 2000).

(2) Large-Scale Flood and Characteristic of Flood Damage

1) Flood Damage in Typhoon Vinta in Davao River Basin (December 22, 2017)

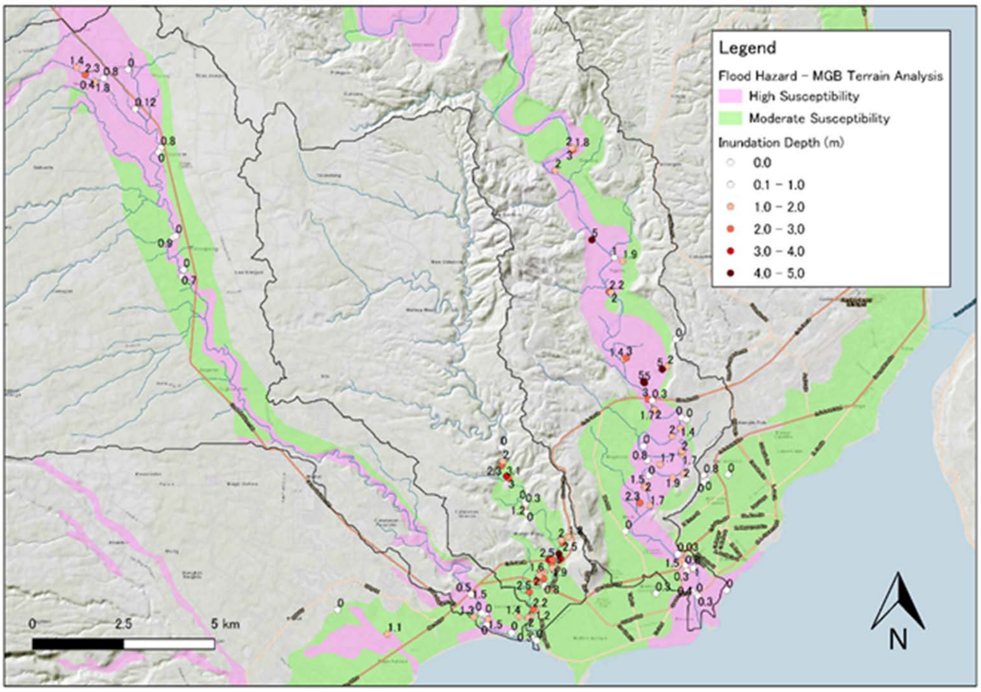
The largest flood in recent years in the Davao River basin is the flood caused by the typhoon Vinta in December 2017. Typhoon Vinta passed through the northern part of the basin at a central pressure of 990 hPa and the maximum daily rainfall during the typhoon Vinta was recorded on December 21.

The flood caused by Vinta was a large-scale flood and was nearly the largest flood in the past with a probability of about 40 years (based on the results of the statistical analysis on Water Level and Discharge conducted by the Project Team). The barangays that were heavily damaged are Waan, Tigatto, Maa, Poblacion (district) and Bucana. Especially in the Tigatto area, the existing dike had blocked drainage and the area was flooded for a long time (up to about 2 days according to the interview survey result). According to the data of CDRRMO, the monetary damage to Davao City due to the flood was calculated at about 79 million pesos for agricultural damage, about 9 million pesos for animals/livestock/poultry damage, about 116 million pesos for infrastructure damage, and about 204 million pesos in total when PAGASA recorded 39.4 mm/day at Davao City Station, 112.4 mm/day at Malaybalay Station, and 114.5 mm/day at Tagum Station.

There were no records on affected families and other flood damage for the Basins of Matina River and Talomo River.

(3) Characteristics of Flood and its Damage by Flood Mark Survey Results

Depth and duration of inundation were confirmed by interviews with residents in the three target rivers. Figure 2.7.1 shows the survey results of maximum inundation depth caused by the past floods. As a result, data along the Davao River shows the situation at the time of the typhoon Vinta in 2017 and data along the Matina River indicates the situation at the time of flood in 2011.

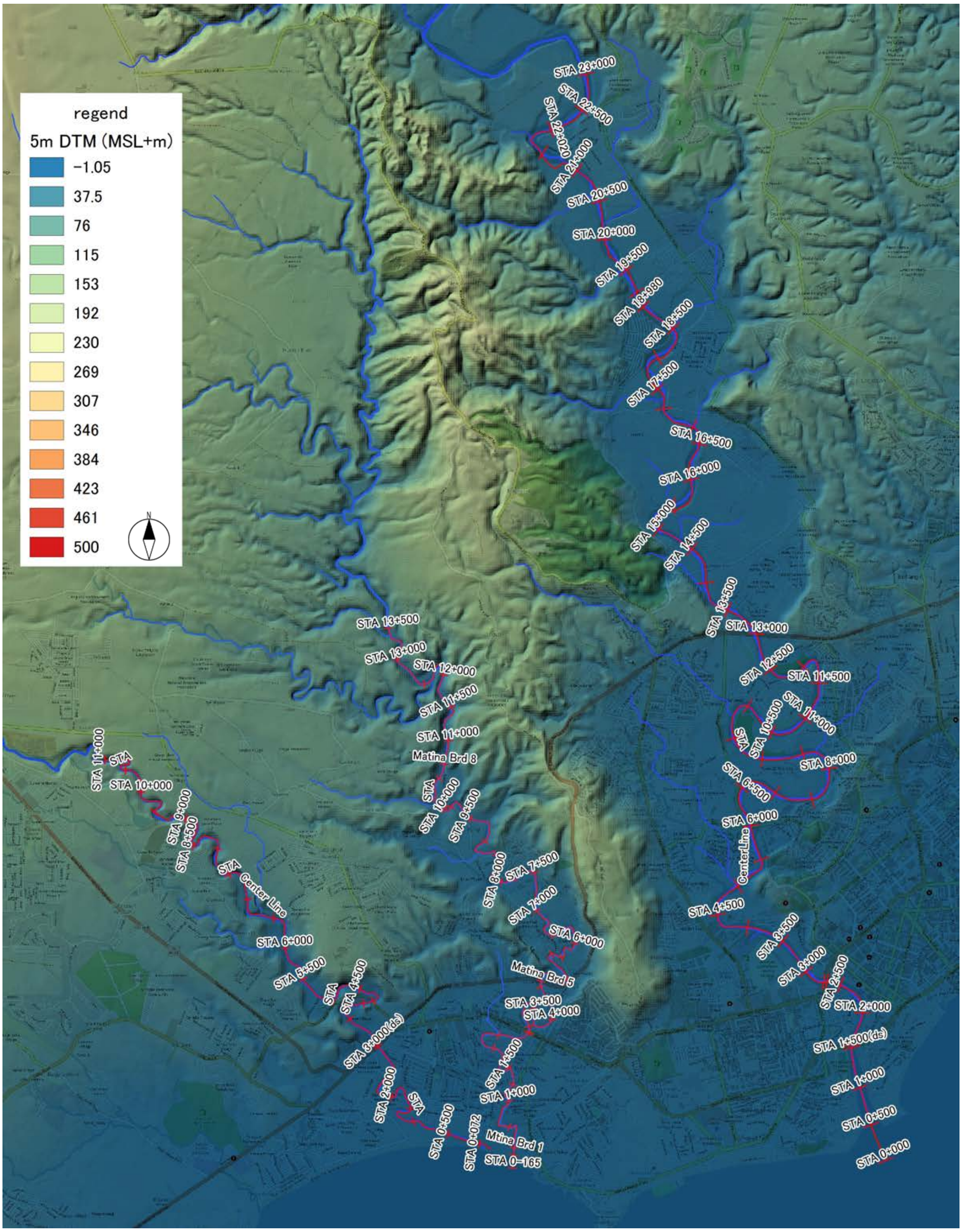


Source: Project Team

Figure 2.7.1 Historical Maximum Inundation Depth by Past Floods as a Result of Flood Mark Survey

2.7.2 Geography of Floodplain

Topographic maps were created based on IFSAR and LiDAR data (hereinafter referred to as the thematic map), and river topographical surveys were conducted. The DEM, which is generated from the thematic map, and the location of the river cross-section survey are shown in Figure 2.7.2



Source: Project Team

Figure 2.7.2 Topographical Map of Flood Plain and Location of River Cross-section Survey

The topographical features from the upstream end of the river cross-section survey to the river mouth in each targeted river for flood analysis are described below.

(1) Davao River

The topography of the upstream end of the river cross-section survey, which is near the exit of the mountainous river, shapes the valley bottom which is considered to be formed by erosion from the river.

The riverbed gradient changes around 15 km from the river mouth (from 1/800 of the upstream to 1/4000 of the downstream), and then the river flows down the relatively gentle plain where Davao City is formed and pours into the Davao Gulf. The floodplain upstream of the riverbed gradient transition point forms a valley bottom plain with a width of 1.5 km to 2.0 km along the river, and the flood type is classified as a downflow-type flood. Downstream of the gradient transition point, the flood type should be classified as diffusive-type flood inferred from the topographical gradient. On the other hand, expansion of inundation will be suppressed by hilly land at the left bank side of the section from 3 km to 8 km from the river mouth. In addition, there is a narrow portion of the bottom width of the river valley immediately upstream of the cross point of the Davao City Diversion Road, which is located around 13 km from the river mouth, and it is supposed that flood water would go back to the river here. This return of flooding water to the river could progress the meandering in the section from 6 km to 13 km from the river mouth.

(2) Matina River

The riverbed gradient is relatively steep throughout the study section, and there is a gradient transition around 10 km from the river mouth (from 1/440 of the upstream to 1/700 of the downstream). The topography upstream from the gradient transition point forms a narrow valley shape, and the downstream is a valley bottom plain with a bottom width of about 500 m to 1 km. An urban area has developed in the depositional plain which is the downstream section of about 4 km from the river mouth. The flood type from the upstream end to the exit to the depositional plain of the river is classified as a downflow-type in which flood water flows along the river. Flooding which occurs near the river mouth should be classified as a diffusive-type flood from the character of the flood plain. Meanwhile, since the riverbed gradient remains steep at around 1/700, the flood water could not expand and will flow down into the river mouth directly although flood water easily spreads in the depositional plain in general.

(3) Talomo River

The riverbed gradient suddenly changes about 6.5 km from the river mouth (from 1/70 of the upstream to 1/700 of the downstream). The topography of the upstream from the gradient transition point forms a narrow valley shape, and the downstream is a valley bottom plain with a bottom width of about 500 m to 1 km. Similar to the Matina River, an urban area has developed in a depositional plain that expands in the downstream section of about 3.5 km from the river mouth. The flood type from the upstream end to about 3.5 km from the river mouth should be classified as a downflow-type flood, and the flood type near the river mouth should be classified as a diffusive-type flood from the character of the flood plain. Meanwhile, since the riverbed gradient still keeps steep of around 1/700, it is likely that the flood water directly flows down into the river mouth.

2.7.3 Existing Flood Countermeasures

In the downstream part of the three target rivers, construction of concrete dikes was carried out as a partial flood countermeasure in the past. In addition, from 2017, gabion-made revetments and small dikes are being constructed by DPWH DCDEO I.

As for the flood control works for riverine flood by DCDEO I, a total of 10 construction work projects were implemented with a total construction cost of 348 million pesos in 2017. In 2018, a total of 41 construction work projects with a total cost of 1,989 million pesos were implemented. As for the 41 construction work projects, 23 are for Davao River, 4 are for Matina River and 1 is for Talomo River. Most of the construction work projects are the construction of revetments and dikes.

2.7.4 Basic Analysis

The information and data which is required for conducting the study and analysis regarding riverine flooding have been collected and the hydrological statistical analysis was examined.

(1) Hydro-meteorological Data

The data collection of rainfall data and flow discharge/water level data which shall be the basis of hydrological and hydraulic analysis was conducted. There are three rainfall gauging stations managed by PAGASA into and around the target river basins of this project as shown in Figure 2.7.3. Although the published data by PAGASA is daily rainfall data only, hourly data of each gauging station during several past floods and annual maximum rainfall was separately provided by PAGASA.

As or the water level/flow discharge observation situation of the three target, although the observation data is a daily average value, the maximum water level/flow discharge data were obtained from DPWH BOD and RO for some of the past floods.

For reference, since Davao City is located in a lower latitude region, flood damages caused by typhoons seldom occur basically, through the city had damaged severely due to the typhoon Vinta. There are only 3 typhoons that passed within 150km from the center of Davao City, therefore, it is very difficult to find a relation between typhoon tracks and flood damage. Even so, it can be said that when a typhoon passes on the upper basin of the Davao River, like the Vinta, severe damage will occur by the typhoon.

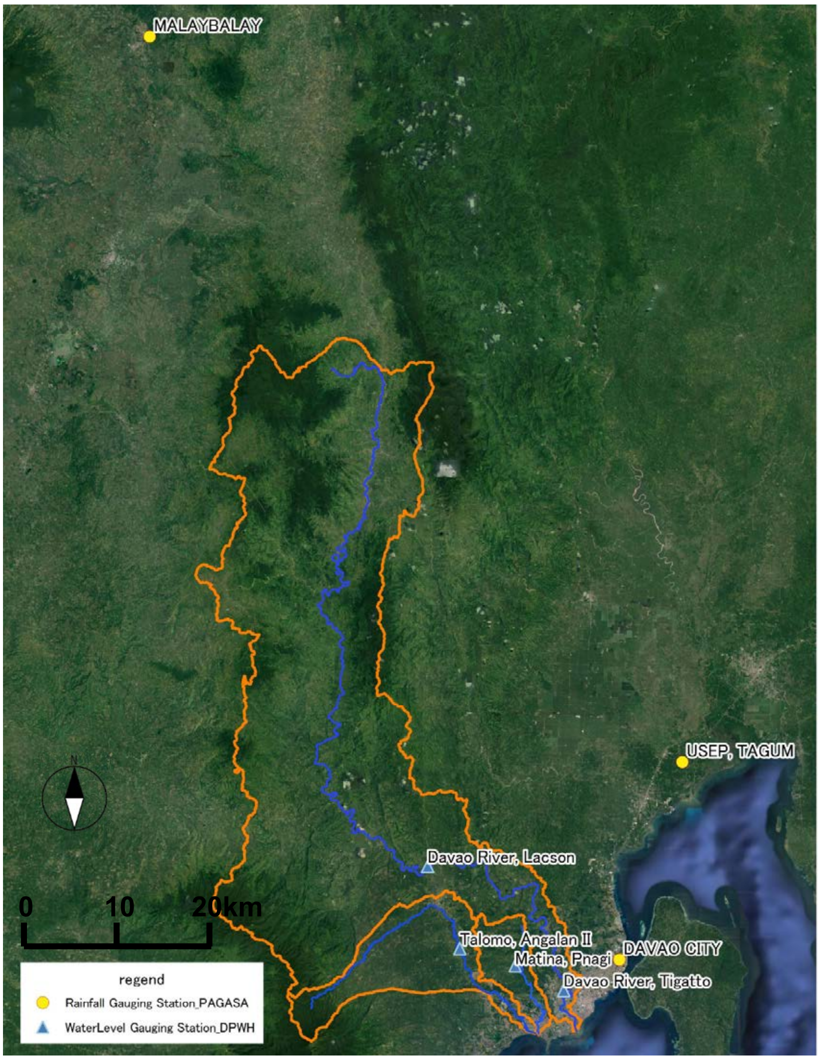
(2) Rainfall Analysis (including Basin Average Rainfall, Statistical Analysis)

1) Daily Rainfall Statistical Analysis (by Thiessen method)

The objects of rainfall analysis are required to have a long term observed record. In terms of this, Davao City, Tagum, and Malaybalay stations are selected as the objects of rainfall analysis in this study. The basin average rainfall is calculated by the Thiessen method using the rainfall data of rainfall gauging stations near the basin, then the annual maximum daily rainfall was picked out. According to the results of a statistical analysis using the annual maximum basin average rainfall from 2001 to 2018 calculated above, the average daily rainfall amount will be 154 mm/day with 50-year probability and 171 mm/day with 100-year probability.

Upon comparing the Davao River basin average rainfall and damage record caused by flooding, there is an inconsistency in the relation between the magnitude of the flood damage and the basin average rainfall amount. In addition, the basin average rainfall amount of the typhoon Vinta, in which the number of affected families was 21,768, was only 82.7mm/day and this was evaluated as approximately 3-year probability.

Therefore, it can be recognized there is no correlation between the damage situation in past floods and the basin average rainfall calculated by the Thiessen method. As the cause of this, it can be considered that the Thiessen method with applicable gauging stations cannot capture the spatial distribution of basin rainfall in the case of the Davao River basin. Since all gauging stations, which obtain rainfall data in this study, are located outside of the basin, the basin average rainfall which is calculated by using the rainfall data of these gauging stations, in particular, the Davao River basin which is over 1,700 km^2, shall be taken as the proper complement of spatial distribution.



Source: Project Team

Figure 2.7.3 Location of Rainfall and Water Level Gauging Station

2) Complement of spatial rainfall distribution by GSMaP

In order to capture the spatial rainfall distribution within the basin more accurately, it is thought that using the Global Satellite Mapping of Precipitation (GSMaP) which is developed by synthesizing rainfall data acquired by satellites provided by the Earth Observation Research Center (EORC) of the Japan Aerospace Exploration Agency (JAXA).

As a result of the consideration, the rainfall statistical analysis is executed applying the complemented PAGASA's rainfall since complementing PAGASA's rainfall data by GSMaP indicated certain improvement of inconsistency, especially to the largest scale of floods in the past.

The probable basin average rainfall is calculated through the statistical analysis using the annual maximum rainfall which is calculated utilizing the corrected PAGASA rainfall data.

Even though statistical analysis is performed with various plotting methods, since the sample data is the annual maximum data, the most compatible plotting method which is formulated based on the extreme value theory like Gumbel distribution, Generalized extreme value distribution (GEV), and sqrt-exponential type distribution of maximum shall be applied.

Result of basin average rainfall statistical analysis in each river is shown in Table 2.7.1.

Table 2.7.1 Result of Basin Average Rainfall Statistical Analysis (Davao, Matina and Talomo River)

Davao River	Jackknife Estimate (mm)			
	Exp	Gumbel	SqrtEt	Gev
2-yr	72.5	76.0	76.6	74.0
5-yr	93.3	94.5	100.2	92.9
10-yr	109.0	106.8	117.3	107.3
15-yr	118.2	113.8	127.5	116.1
25-yr	129.8	122.3	140.7	127.5
50-yr	145.5	133.8	159.4	143.6
80-yr	156.2	141.6	172.5	154.8
100-yr	161.2	145.3	178.9	160.2

Matina River	Jackknife Estimate (mm)			
	Exp	Gumbel	SqrtEt	Gev
2-yr	90.5	97.0	93.7	91.5
5-yr	128.7	131.1	123.4	125.3
10-yr	157.7	153.7	145.0	153.5
15-yr	174.6	166.4	157.9	171.5
25-yr	195.9	182.2	174.5	195.9
50-yr	224.8	203.4	198.0	232.3
80-yr	244.4	217.6	214.6	259.1
100-yr	253.7	224.4	222.7	272.4

Talomo River	Jackknife Estimate (mm)			
	Exp	Gumbel	SqrtEt	Gev
2-yr	73.7	77.4	78.0	77.0
5-yr	95.5	96.9	101.7	96.9
10-yr	112.1	109.8	119.0	110.3
15-yr	121.8	117.1	129.3	117.8
25-yr	134.0	126.1	142.6	127.1
50-yr	150.5	138.2	161.3	139.4
80-yr	161.7	146.4	174.5	147.4
100-yr	167.1	150.3	181.0	151.1

Source: Project Team

(3) Water Level, Runoff Analysis (including Statistical Analysis)

Figure 2.7.3 shows the locations of the water level/flow discharge stations in the target river basins. The data observed at Lacson station, which has been on the Davao River for 17 years, and the data at Angaran II station, which has been on the Talomo River for 32 years is provided by DPWH.

Table 2.7.2 shows the results of statistical analysis using the observed values at the Lacson station. “Pre-flow discharge” in the table is the discharge calculated using the HQ relation based on the annual maximum water level / discharge data set from 2001 to 2009 provided by DPWH BOD, and “re-flow discharge” is the discharge calculated by the HQ relation that was reviewed after verification by the runoff model in this Project. In this Project, the plan is examined using the discharge value of "re-flow discharge". From the results of statistical analysis, it is estimated that the maximum water level reproduction period at the Lacson station in Typhoon Vinta is about 40 years.

Table 2.7.2 Probable Water level/Flow Discharge at Lacson Gauging Station on Davao River

return period	gauge height (m)	pre-flow discharge (m3/s)	re-flow discharge (m3/s)
2	4.00	627	651
5	4.80	887	1,027
10	5.37	1,099	1,346
25	6.11	1,415	1,825
30	6.25	1,484	1,923
Vinta	**6.40**	**1,561**	**2,032**
50	6.65	1,686	2,220
80	7.01	1,886	2,505
100	7.18	1,985	2,645
200	7.69	2,310	3,090

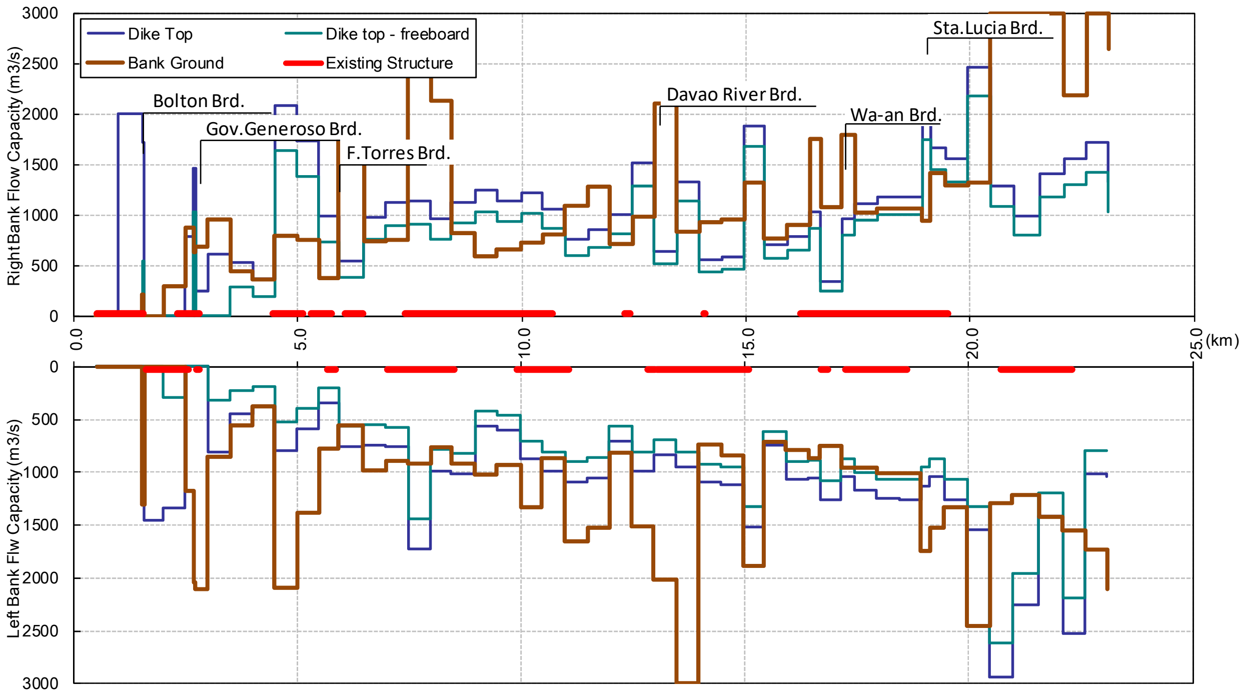
Source: Project Team

2.7.5 River Flow Capacity Evaluation

The current river flow capacity is evaluated to obtain basic data for master plan formulation.

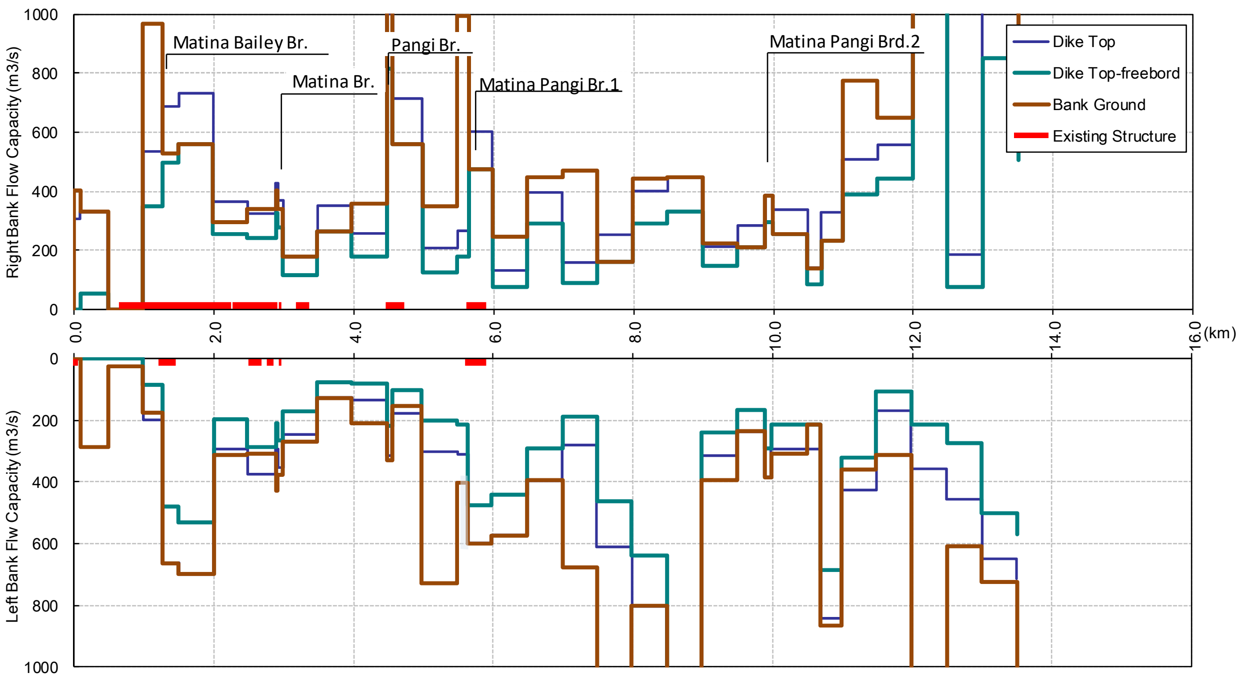
The river flow capacity evaluation shall calculate the flow discharge equivalent to the evaluation height in each cross-section after figuring out the relationship between flow discharge and water level (H-Q relationship) by one-dimensional non-uniform flow calculation.

The result of the flow capacity calculation are shown in Figure 2.7.4 to Figure 2.7.6.



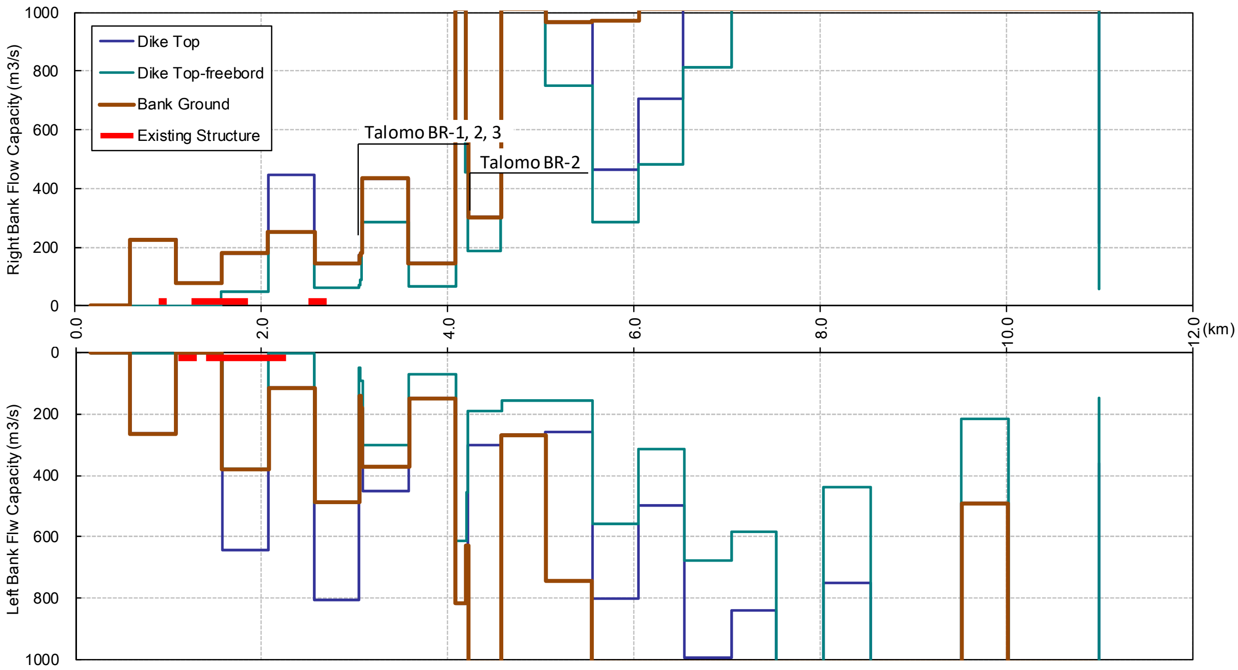
Source: Project Team

Figure 2.7.4 Flow Capacity of the Davao River



Source: Project Team

Figure 2.7.5 Flow Capacity of the Matina River



Source: Project Team

Figure 2.7.6 Flow Capacity of the Talomo River

2.7.6 Hydrological and Hydraulic Model

The Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) shall be applied for the runoff analysis of this project from the viewpoint of the software which has achievement in the Philippines, and is being provided free of charge, and naturally also has the proper function for runoff analysis.

(1) Rainfall and Runoff Model

The runoff analysis model of HEC-HMS has incorporated a basin model and a river model. The basin model consists of: runoff-volume models, which are to calculate the amount of loss due to infiltration and evapotranspiration; the direct-runoff models, which are to calculate the runoff directly from the effective rainfall; and the base-flow models, which are corresponding to the groundwater runoff. In this project, models indicated in the table below are applied for each phenomenon.

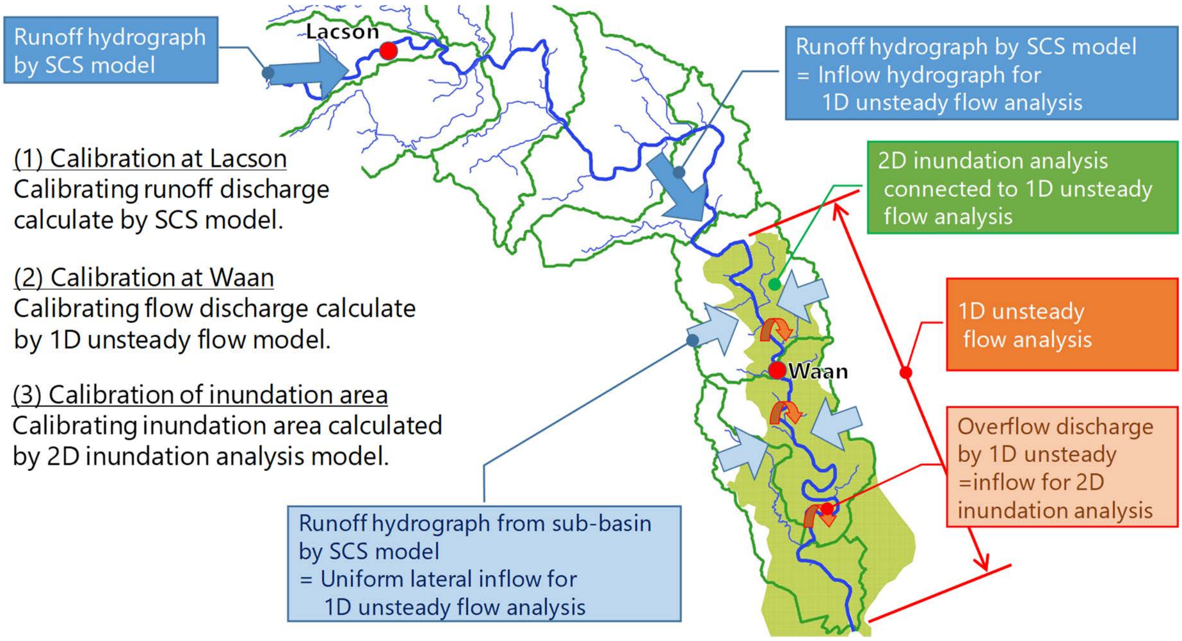
Table 2.7.3 Applied Models of HEC-HMS

Basin model	Loss model	SCS Curve Number model
	Direct runoff model	SCS unit hydrograph model
	Base-flow model	Exponential recession model
River model		Lag-time model

Source: Project Team

(2) Hydraulic Model (Flood model)

The hydraulic analysis model for the Davao River is as shown in Figure 2.7.7, the target section of river improvement, for which the river topographic survey was carried out in this project, is modeled as an unsteady flow model for considering the storage function of the channel itself. This section is also connected to the 2D flood plain model for flood analysis.



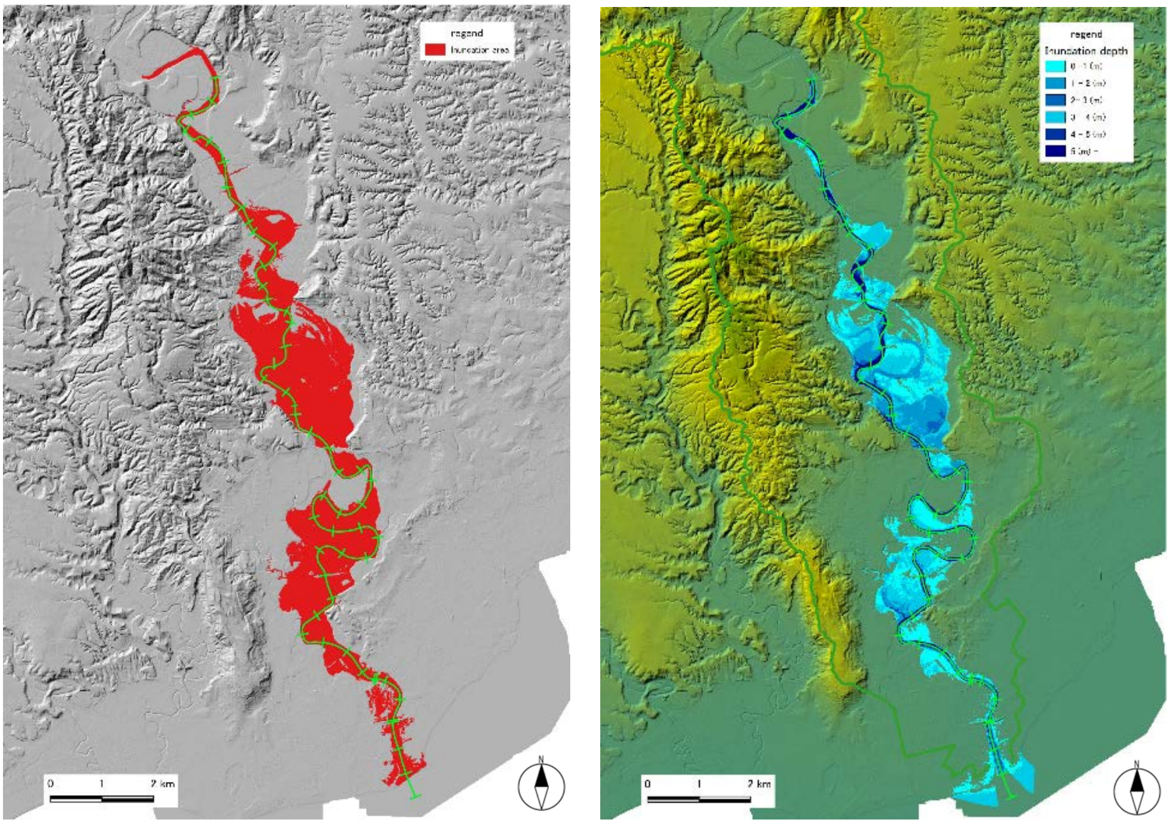
Source: JICA Project Team

Figure 2.7.7 Summary of Hydraulic Analysis Model for Davao River

(3) Verification of the Hydraulic Model

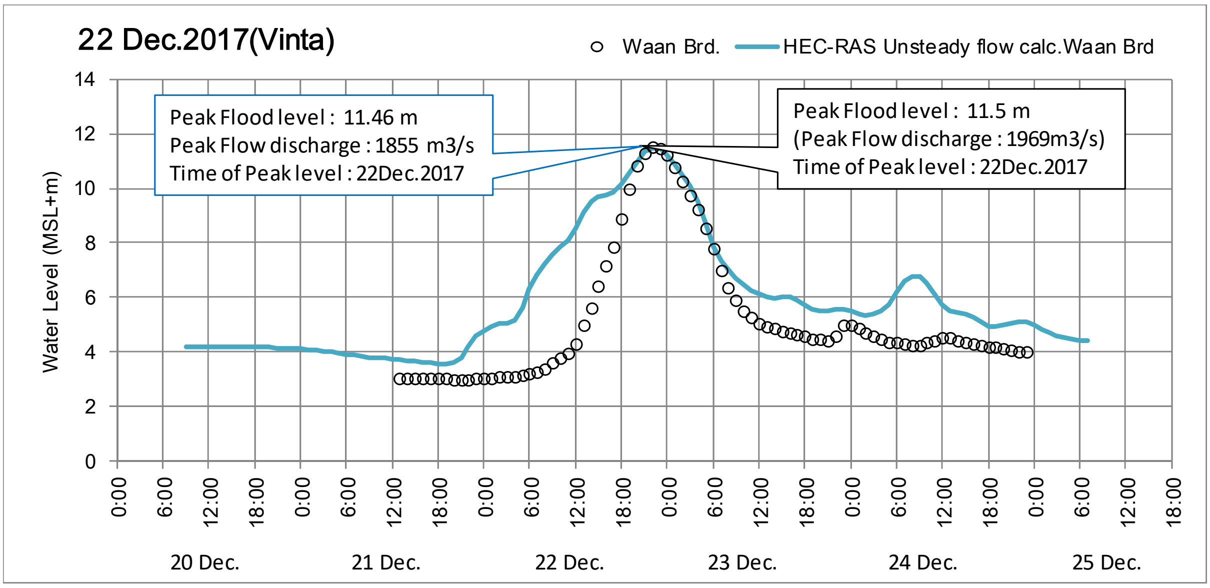
Regarding the verification of the coefficients and lag-time of the runoff analysis model for the Davao River, the flood of Dec.22 2017 (Typhoon Vinta) is selected as the flood events for verification and verification points are set as Wa-an Bridge gauging station and Lacson gauging station.

As a result of adjusting the coefficients of the runoff model, the inundation area equivalent to the inundation area at the time of typhoon Vinta estimated from the flood-mark/interview survey was reproduced as shown in Fig. 2.7.8, and time-series variation in the water level during flood time was also reproduced as shown in Fig. 2.7.9.



Source: JICA Project Team

Figure 2.7.8 Estimated Flood Area by Typhoon Vinta based on Interview and Flood-mark Survey (Left) and Hydraulic Simulation (Right)



Source: JICA Project Team

Figure 2.7.9 Simulation Result of 1D unsteady model (Wa-an Bridge)

Regarding the Matina River and the Talomo River, since there is no available hydrological data for hydraulic model verification, the coefficients on the model for the Davao River basin are applied mutatis mutandis.

2.7.7 Probable Flood Hydrograph (Riverine flood)

(1) Summary of Probable Rainfall and Discharge

Table 2.7.4 shows the summary of probable rainfall and peak discharge of each target river. Probable flood hydrograph and probable peak discharge were calculated with the verified runoff model, which was described in section 2.7.6. The model hyetographs for each probability, which will be described later, were created with each probable rainfall amount.

Table 2.7.4 Summary of Probable Rainfall and Discharge

T (yrs)	Davao			Matina			Talomo		
	Probable Rainfall (mm/24hr)	+ Climate Change (mm/24hr)	Probable Discharge (m3/s)	Probable Rainfall (mm/24hr)	+ Climate Change (mm/24hr)	Probable Discharge (m3/s)	Probable Rainfall (mm/24hr)	+ Climate Change (mm/24hr)	Probable Discharge (m3/s)
	GEV	110%	Wa-an Br.	RIDF	110%	MatinaPangi Br.	RIDF	110%	Mintal
2	84.50	92.95	821	77.18	84.90	113	69.06	75.96	82
5	105.50	116.05	1387	100.65	110.72	190	90.06	99.07	178
10	119.80	131.78	1831	115.66	127.23	246	103.49	113.84	259
25	138.00	151.80	2439	134.61	148.07	320	120.45	132.49	376
50	151.10	166.21	2904	148.26	163.09	377	132.66	145.93	474
100	163.60	179.96	3367	162.31	178.54	435	145.23	159.75	577

Source: JICA Project Team

(2) Model Hyetograph

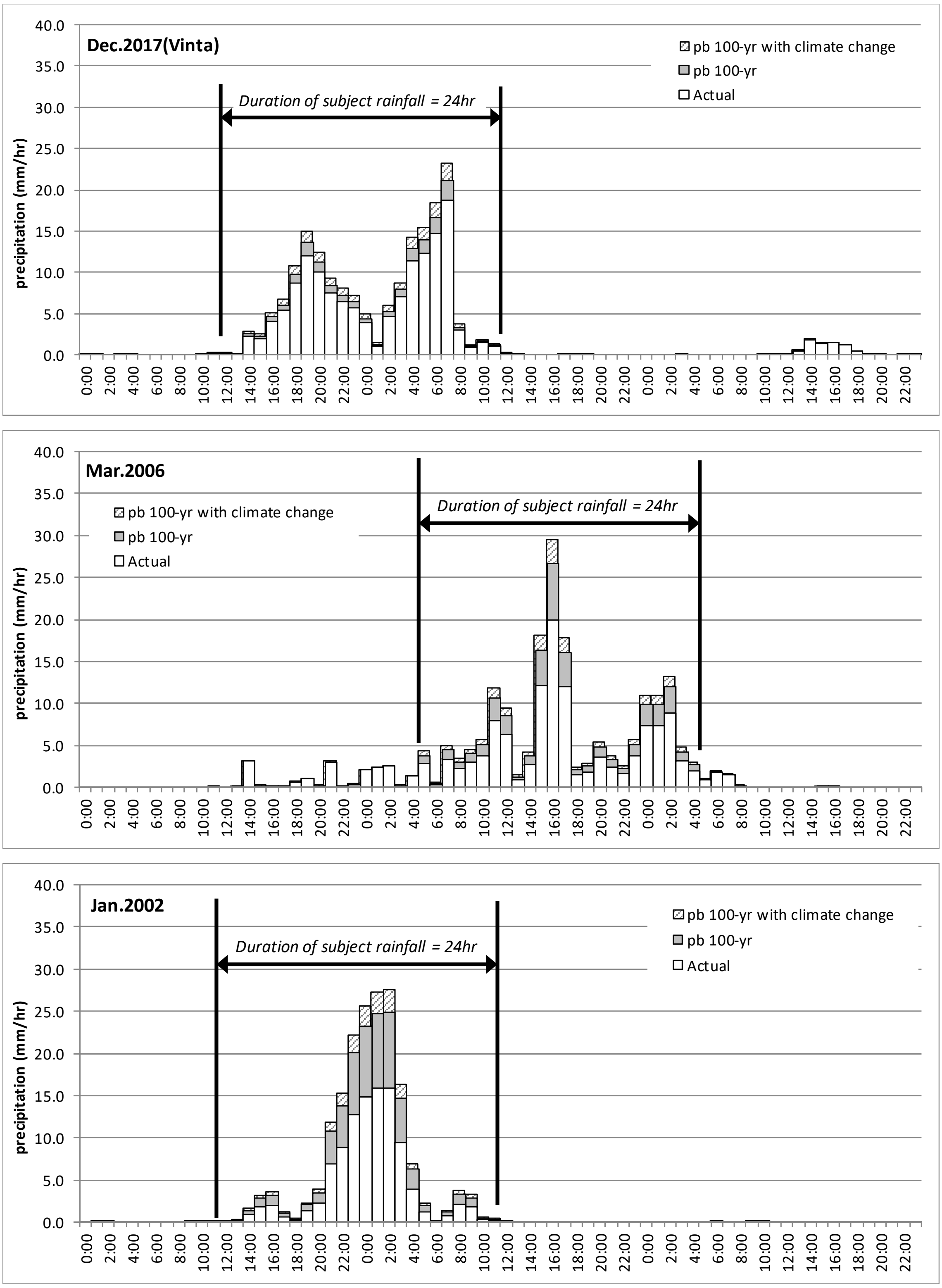
The design flood patterns are selected among the past floods after 2001, which are able to be complemented utilizing GSMaP based on the daily rainfall data. Since most of the selected floods' rainfall continue time is less than 24 hours, the object time for expansion is determined as 24 hours.

In order to prevent rain after expansion from becoming unrealistic, the design rainfall patterns were selected from three floods which are comparatively large on the probable scale flood. The design rainfall amount is increased by 10% considering the climate change effect which is described in section 2.7.9.

Table 2.7.5 Summary of Design Flood Patterns of Davao River

Typical Rainfall Pattern	Rainfall (mm/24hr)	Expand coefficient	Note
Dec.2017 (Vinta)	145.1	1.24	100-yr rainfall amount = 163.60 (mm/24hr)*110% = 179.96 (mm/24hr)
Mar.2006	121.8	1.48	
Jan.2002	104.4	1.72	

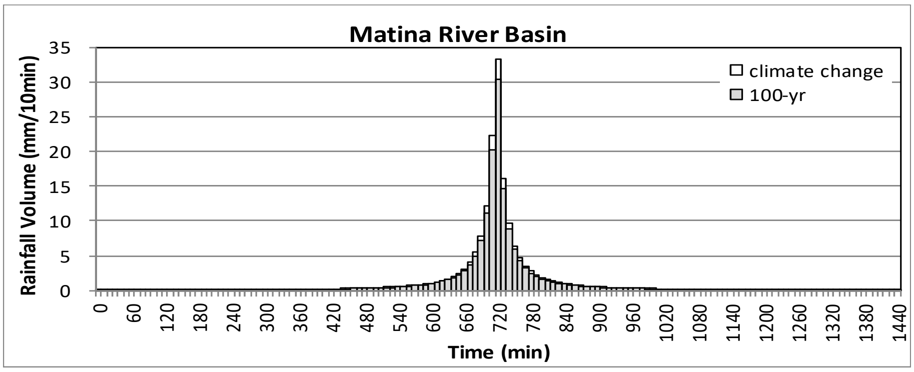
Source: JICA Project Team

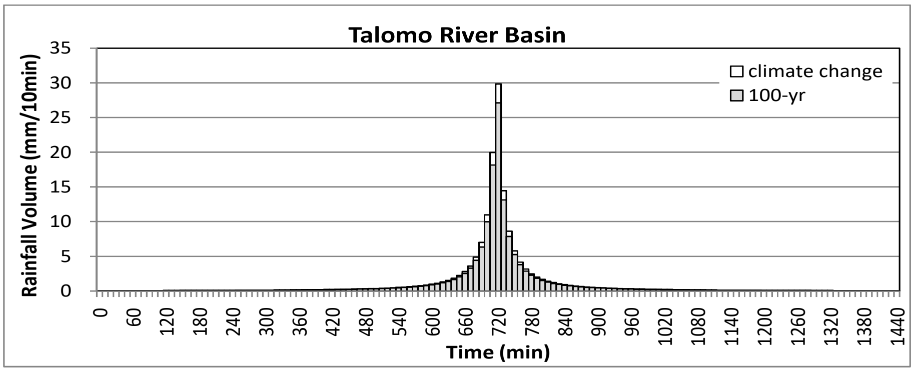


Source: JICA Project Team

Figure 2.7.10 Design Flood Patterns of Davao River

Regarding the Matina River and the Talomo River, the design flood pattern is made by the Alternating Block method utilizing RIDF of the Davao City gauging station due to their river basin scales. The 10% increase because of climate change is also considered, like the Davao River case.



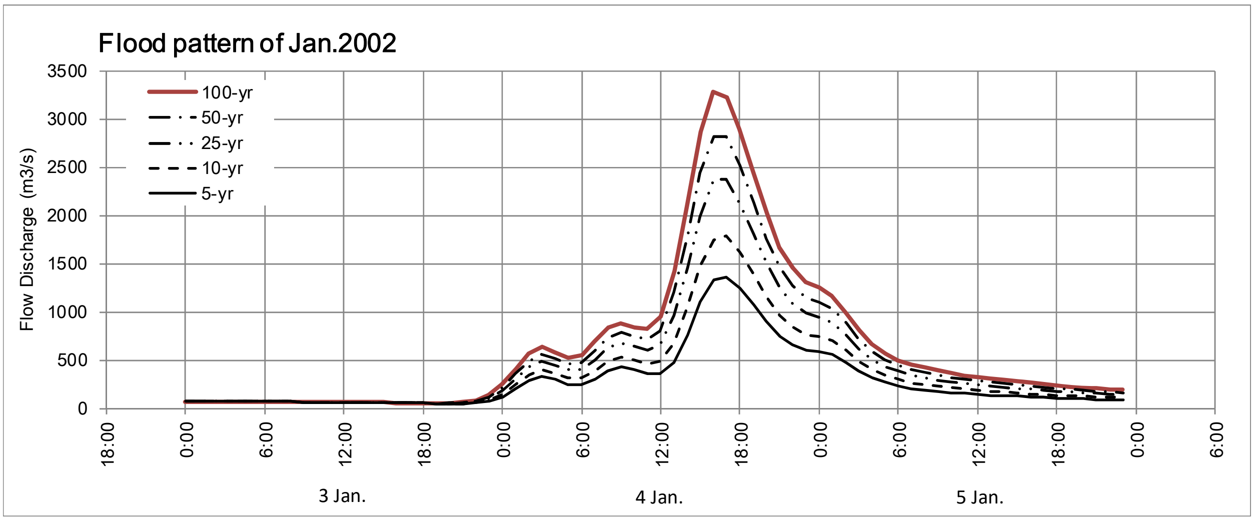


Source: JICA Project

Figure 2.7.11 Design Flood Patterns (above: Matina River, below: Talomo River)

(3) Basic Discharge

Regarding the Davao River, runoff analysis was examined with each design flood pattern whose rainfall amount was expanded up to the 100-yr scale (179.96mm/24hr). As a result of the analysis, the peak flow discharge of a 100-yr flood scale at Wa-an Bridge is 3,367(m^3/s), which is that of the pattern of 2002. The hydrograph of the pattern of 2002 for each probable scale is shown in Figure 2.7.12.

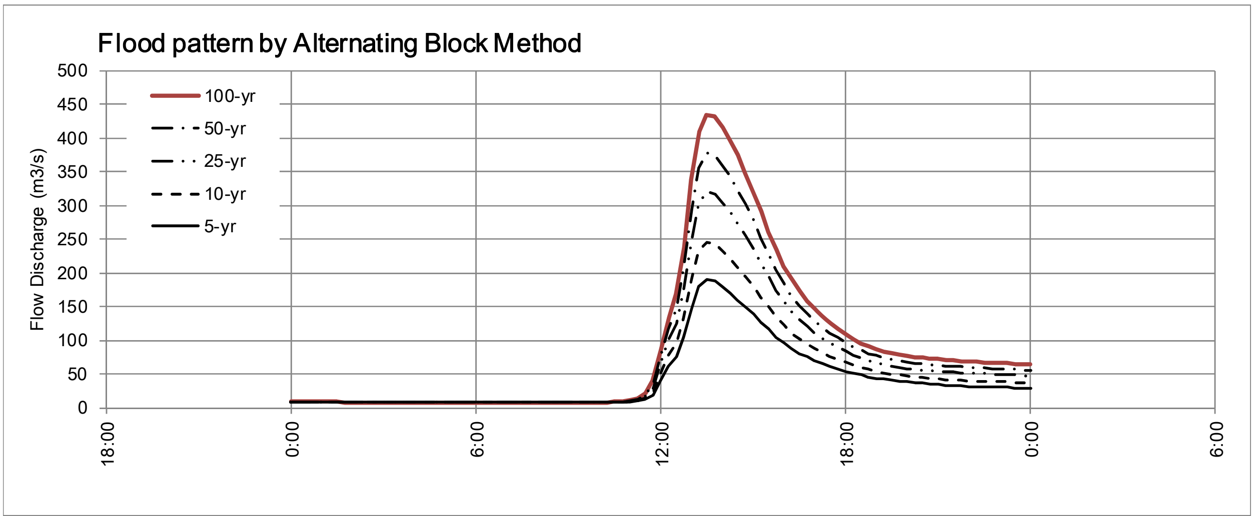


Source: JICA Project

Figure 2.7.12 Hydrograph of Each Probable Scale of Davao River

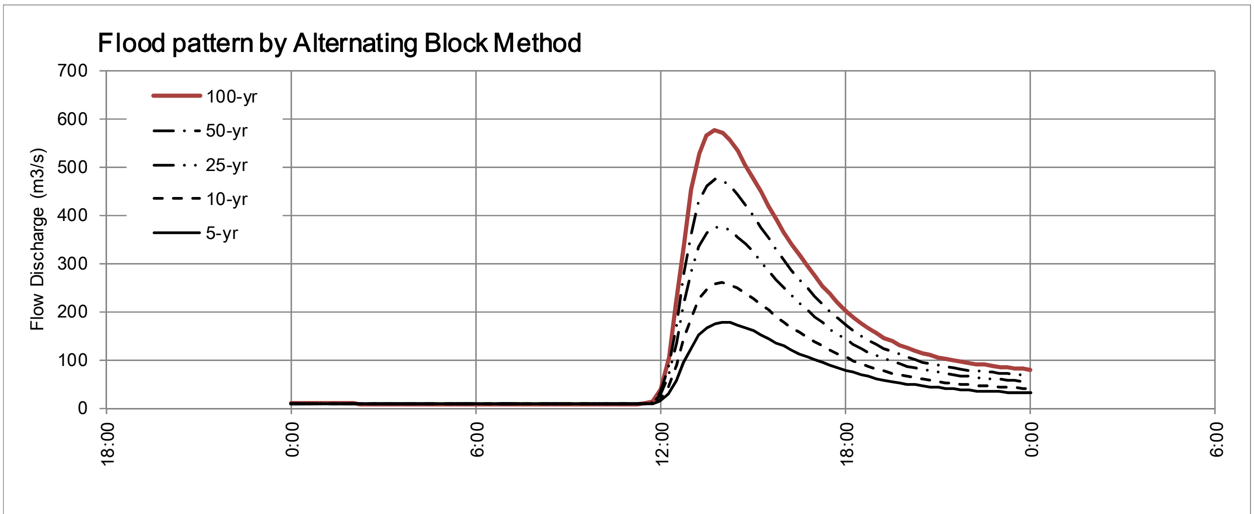
The above hydrograph is the value at Waan Bridge (Tigatto gauging station), which is the control point of the Davao River. In the Davao River, several tributaries with a catchment area of less than about 10 km^2 flow into the downstream of the Waan Bridge. Since the peak flow of the tributary occurs before the main river, the inflow from the tributary has almost no effect on the peak flow of the main river downstream of the Waan Bridge. Therefore, the peak discharge from the downstream of the Waan Bridge to the river mouth is almost the same as the peak discharge of the Waan Bridge.

Same as the Davao River, the hydrograph of each probable scale of the Matina River and the Talomo River is shown in Figure 2.7.13 and Figure 2.7.14. The peak flow discharge of the 100-yr flood scale is calculated as 435(m^3/s) on the Matina River and 577(m^3/s) on the Talomo River respectively.



Source: JICA Project

Figure 2.7.13 Hydrograph of Each Probable Scale of Matina River



Source: JICA Project

Figure 2.7.14 Hydrograph of Each Probable Scale of Talomo River

The above hydrographs of the Matina and Talomo Rivers are the values at the control points of Angalan II (Tugbok) and Matina Pangi Bridge (Pangi), respectively. The area of river basins of the Matina and Talomo Rivers are not so large, and flow hydrographs of discharge from tributaries and residual basins downstream of the control points affect the peak discharge of the main river, so the peak discharges downstream of the reference points are larger than those of the reference points. At the river mouths of the Matina and Talomo rivers, the peak discharges in 100-year probable rainfall are estimated at 550 (m^3/s) for the Matina River and 690 (m^3/s) for the Talomo River.

2.7.8 Flood Simulation and Flood Risk Analysis

Flood simulation is executed for the river section which is the object for river. For the upper section of the Davao River, the flood simulation is also examined and the delineated estimated flood-prone areas identified to prevent an increase in flood risk with future development.

(1) Flood Simulation

1) Object River Section

The object sections are indicated in Table 2.7.6, which were carried out in the river topographic survey in this Project.

Table 2.7.6 Object Section for Flood Simulation

River	River Station of calculate reach	Reach length (km)	Number of Cross-section	Survey date
Davao	sta.0+000 ~ sta.23+000	23.09	52	Apr.2019
Matina	sta.0-165 ~ sta.13+500	13.68	37	Mar.2019
Talomo	sta.0+072 ~ sta.11+000	10.84	25	Feb.2019

Source: JICA Project

2) Object Flow Discharge

Since the M/P targets the 100-year flood scale, 5 cases were examined: 5-year, 10-year, 25-year, 50-year, and 100-year scale of floods are considered. 1D unsteady flow analysis is executed with inflow from the upstream end of the object section and from sub-basins along the section, which calculated by the rainfall-runoff model, then the overflow volume is simulated on the flood plain by 2D unsteady analysis.

3) Coefficient of Roughness

The coefficient of roughness applied for the 1D unsteady analysis of the river water level is set as the value of 0.030 - 0.036 for ensuring reproducibility which has been determined by verification of the runoff model. The general value of flood plain, 0.06 is applied for 2D unsteady flood analysis.

4) Water level at River mouth

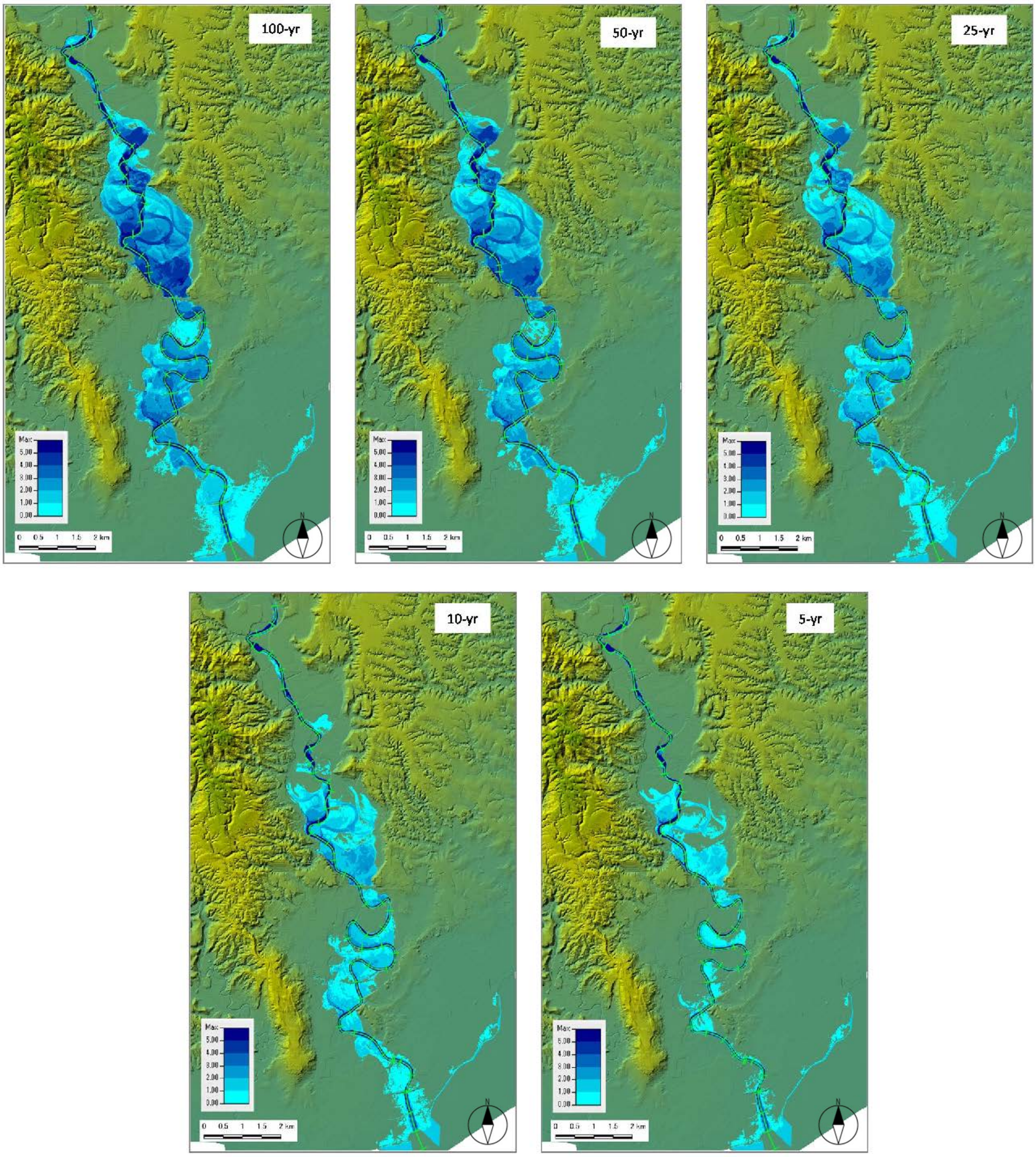
Since it is hard to logically determine an estimated tide level variation at the river mouth, the river mouth water level as the boundary condition of the simulation is set as the MHHWL, adding the climate change effect (MSL+0.981m).

5) Flood Analysis Result

The flood analysis result for each probability is shown in Figure 2.7.15 to Figure 2.7.17.

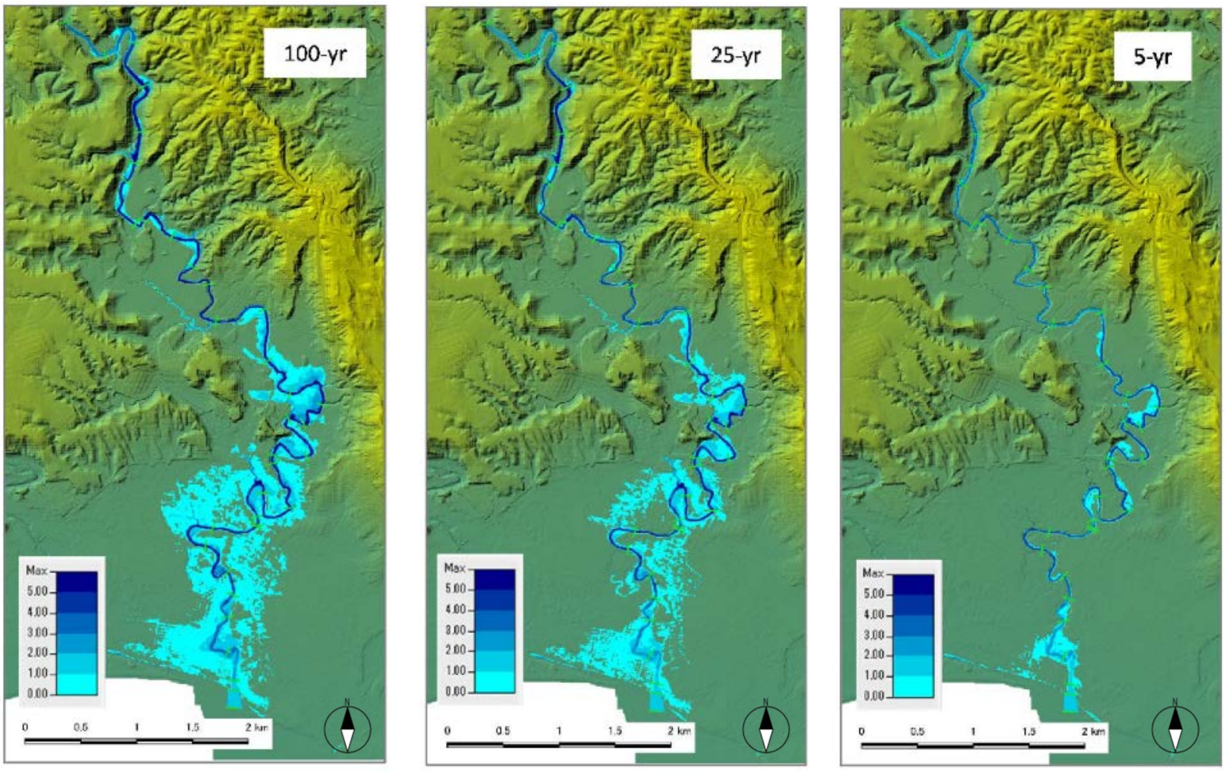
According to the simulation result, it could be said that there is a higher risk at the upstream section of Crocodile Park. In addition, the Jade Valley where is presently a residential area is a lower land and a flood-prone area, flood control would be an essential matter in this area. There is comparatively low risk of riverine flood against the flood of 25-yr or less probability at the downstream section of the Crocodile Park in the current condition, nevertheless, the flood risk could increase due to the development of the upper basin or river improvement.

Regarding the Matina River and the Talomo River, the existing residential area would be inundated by a flood of a 10 to 25-year scale. Thus, it is desirable to eliminate the possible flood damage.



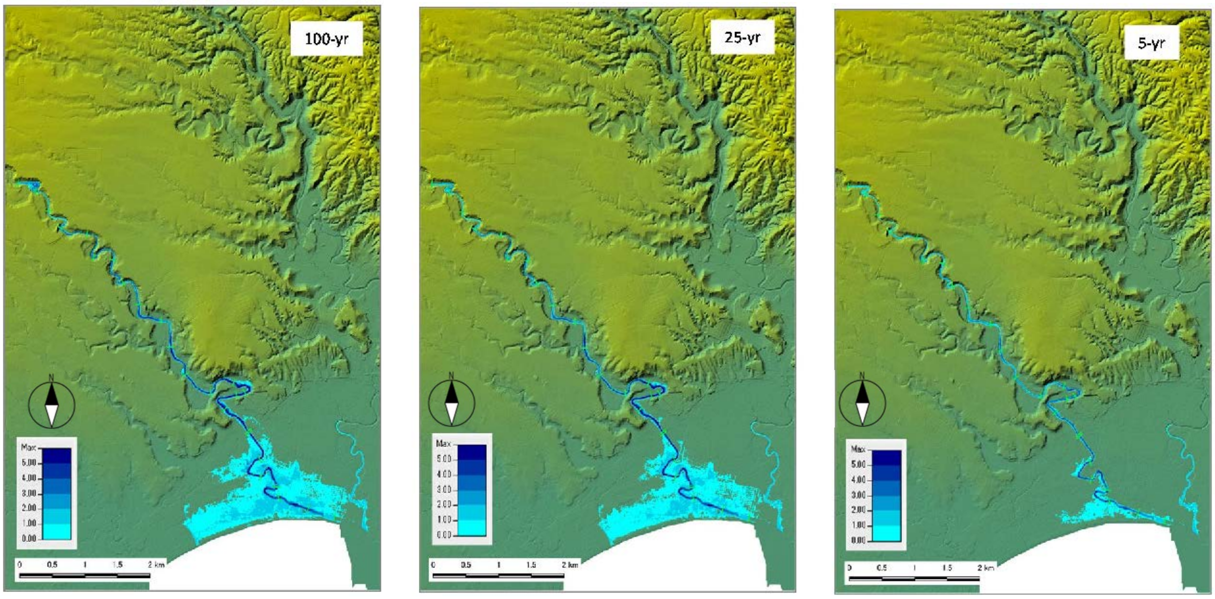
Source: JICA Project

Figure 2.7.15 Probable Flood Analysis Result of Davao River



Source: JICA Project

Figure 2.7.16 Probable Flood Analysis Result of Matina River



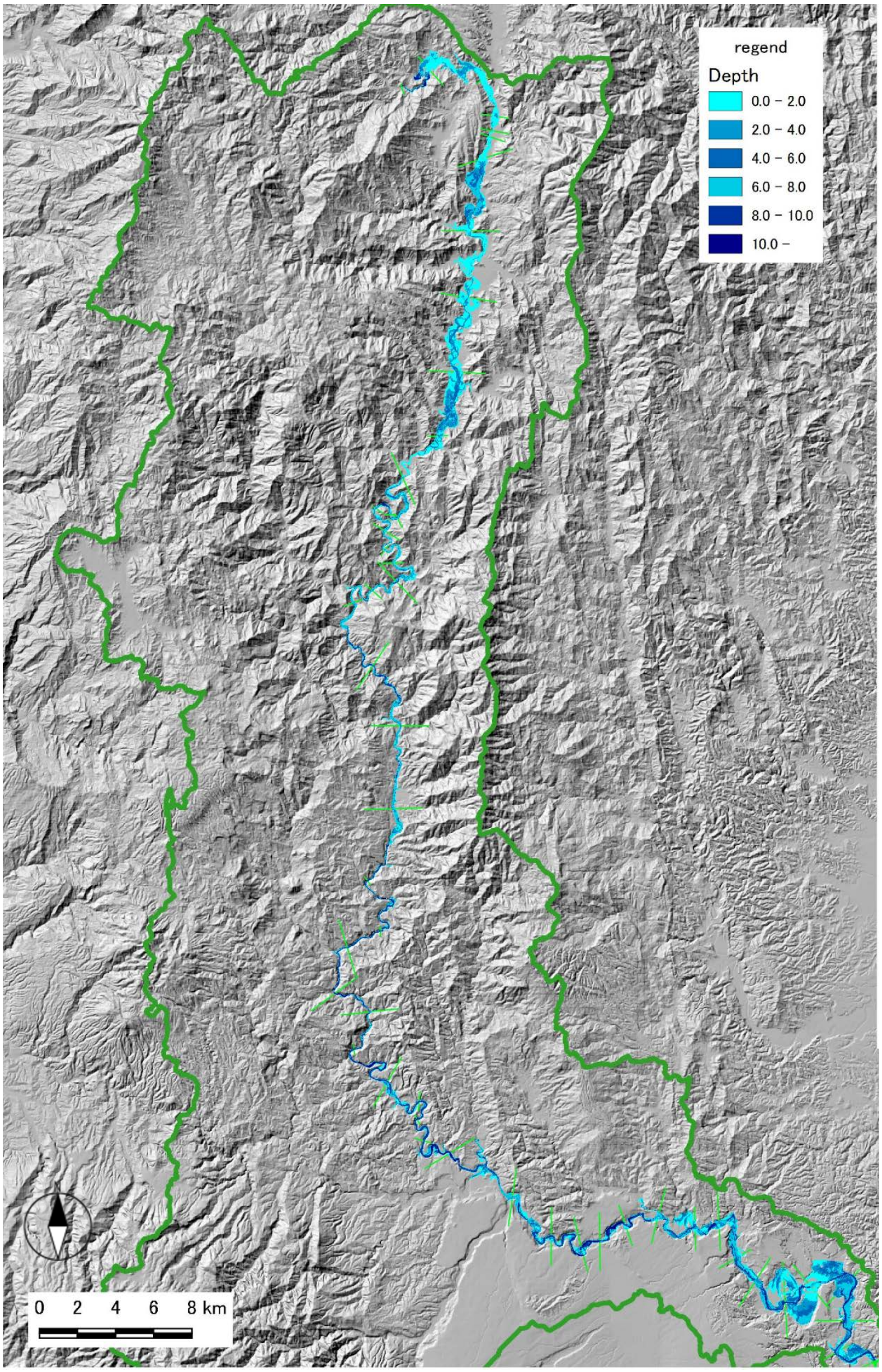
Source: JICA Project

Figure 2.7.17 Probable Flood Analysis Result of Talomo River

(2) Flood Risk at Upper basin of the Davao River

At the moment, there is no large-scale development plan on the upper basin of the Davao River, but even so it is desirable to prevent flood risk in the future by designating the riverine flood-prone area as a conservation area beforehand. From this perspective, the delineation of the estimated inundation area was done in the upper basin. The estimated inundation area by 100-yr flood is indicated in the Figure

2.7.18. According to the flood analysis result, the section from the upstream end to the point of about 25km forms the valley bottom plain and riverine flooding is expected in this plain. Therefore, it is judged that development activities should be suppressed.



Source: JICA Project

Figure 2.7.18 Estimated Inundation Area in Upper Basin of Davao River (100-yr Flood)

2.7.9 Climate Change Impact Analysis

Considering the project target year for planning (set to 2045) and development period of the facilities which will be constructed by the target year, the adopted period for the climate change projection should be 2036-2065.

In this Project, it is proposed that the conditions of climate changes in 2036-2065 are assumed based on the moderate emission scenario (RCP4.5) in the PAGASA's Study as follows:

- ✓ Mean Temperature: is assumed to increase by 1.2 degrees compared to the condition in 2000.
- ✓ Rainfall: is projected to decrease, however, the rainfall intensity in the heavy rainfall event tends to increase. It is assumed that the probable rainfall for annual maximum daily rainfall increases by 10% from the climate condition in 2019.
- ✓ Mean sea level: is assumed to be 0.2m higher than the level in 2000, and 0.1m higher than the level in 2019.

2.7.10 Major Issues on Riverine Flood

The major issues on riverine flood have been identified, on the basis of field reconnaissance, flood mark survey, hydrological and hydraulics analysis, interviews to stakeholders and workshops, as shown below.

1) Improvement of Present Situation of Implementation of Flood Control Measures with Different Design Levels
2) Increase in Insufficient Flow Capacity for Large Scale Runoff
3) Recovery of Decreasing Natural Retarding Function
4) Planning of Measures Harmonizing with Development along the River and in the Surrounding area, with the Viewpoint of Urban Planning
5) Consideration in Possible Increase in Runoff by Land use and Climate Change
6) Control of Development in Flood Risk Area
7) Sharing Information related to Flood
8) Consideration in Artificial Factors such as Cutting Trees, Improper Waste Disposal and Informal Settlement
9) Enhancement of Flood Control Planning Capacity
10) Better Operation and Maintenance Activities
11) Better Coordination for Project Implementation including Land Acquisition and Resettlement

2.8 Sediment Production and Sediment Yield in the Basin

2.8.1 General

For conducting appropriate operation and maintenance, and for controlling a flood occurrence in a watershed, it is necessary to estimate sediment yield.

2.8.2 Past Study of Sediment Production

A past study conducted by Tan and Guanzon shows the average sediment load of the Davao Gulf at 5.3 kg/s in 2003 (Villanoy, 2009)[1]. According to DPWH RO-XI records, the estimated maximum sediment transported by Davao River is about 70 kg/s from 2001 to 2004, with the average at 10kg/s.

In the past, DPWH RO-XI has conducted an observation of sediment discharge amount for rivers flowing through Davao city, and the Davao River and the Talomo River among the three target rivers of

[1] Orient Integrate Development Consultants, INC., "Formulation of Davao River Basin Management and Development Plan", Feb.2015

this project were included in that observation. Using Q-Qs function which was obtained by the result of observation, the annual estimated sediment discharge from 2002 to 2009, and the annual average sediment discharge during that period were calculated. The annual average sediment discharges of Davao River and Talomo River are 492 thousand ton/year and 32 thousand ton/year, respectively.

As a reference, commercial extracted sand and gravel volume in 2018 is summarized based on the City Environment and Natural Resources Office (CENRO) of Davao. One of the reasons why there is a difference between the approved extracted volume and the actual extracted volume is that some permittees have not taken out riverbed material as much as the volume permitted, in addition to the minimum permission volume is 10,000m3/year.

Table 2.8.1 Commercial Extracted Sand and Gravel Volume in 2018

River Name	Number of Permittee	Approved Volume (m3)	Extracted Volume (m3)	Extracted Volume (ton)
Davao River	61	596,200	267,109	747,905
Matina River	4	40,000	2,691	7,535
Talomo River	1	10,000	8,828	24,718

Source: CENRO

2.8.3 Estimation of Sediment Production and Sediment Yield

As for estimation of sediment production and sediment yield in the target area, the erosive quantity of sediment is calculated by using the Universal Soil Loss Equation (USLE). As the result, the estimated sediment yield is 1,781 thousand tons per year in the entire target basins, 1,720 thousand tons per year in the Davao River basin, 41 thousand tons per year in the Matina River basin, and 20 thousand tons per year in the Talomo River basin.

2.8.4 Riverbed Changes

(1) Consideration of Riverbed Changes

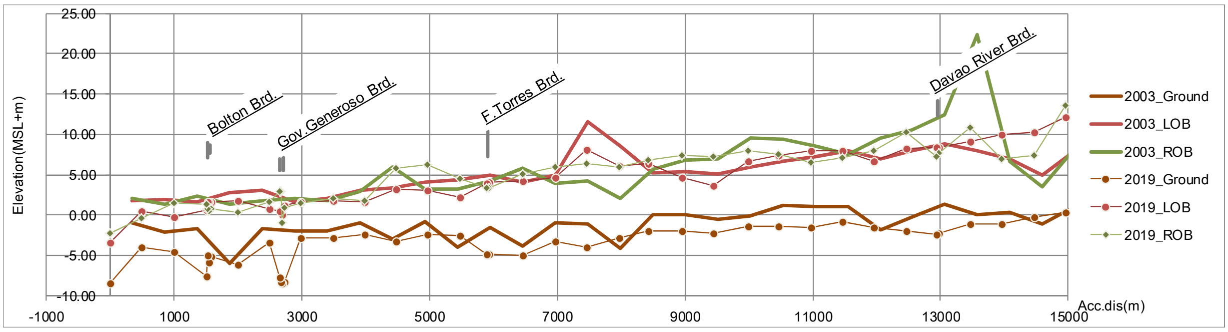
1) Current Condition of River mouth Deposition

Temporal variation of the river mouth of target rivers were supposed by aerial photos. There is no significant extension trend of the delta of the Davao River from 2002 to 2018. Conversely, regarding the Matina River and the Talomo River, it is recognized that these river mouth delta has extended in 2017 comparing with 2000.

2) Channel variation by Comparison of River Topographical Survey

For considering the channel variation over time, in the case of the Davao River, there is an available past river survey result in 2003 survey result. Survey results of 2003 and 2019 in this Project was compared.

The longitudinal profile of the downstream section from the Davao River Bridge is shown in Figure 2.8.1. According to this, a riverbed degradation is significant from 8.5 km to 14 km and the depth of degradation is 2 to 2.5 m. However, as written Section 2.7.3 Existing Flood Countermeasure, since a larger-scale flood occurred in 2002, it is assumed that the riverbed condition of 2003 survey was temporary change caused by that flood. The local scours around the bridges also are found in the survey of this project. Although the storage of continuous river survey data of the Davao River in the future is required to understand the change of riverbed, from the viewpoint of available data at the moment, the riverbed trends degrading and that trend is significant around bridges.



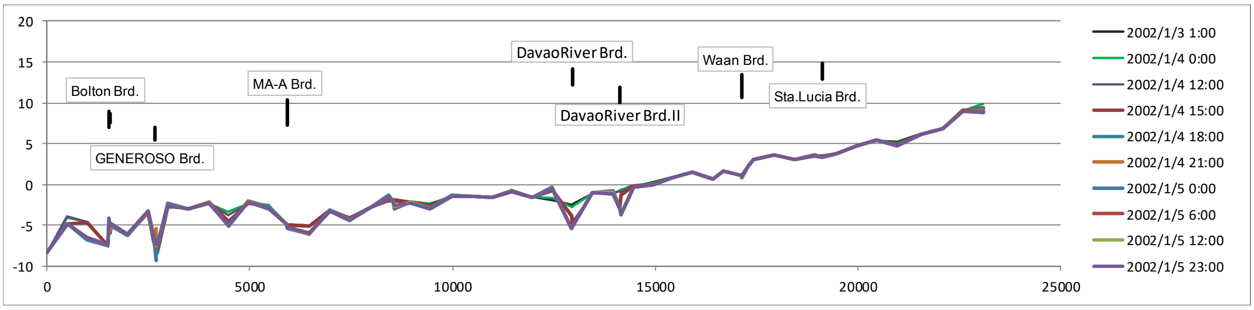
Source: Project Team

Figure 2.8.1 Comparison of Longitudinal Profile of Davao River

(2) Riverbed Change Analysis

Using the result of the riverbed material survey, the sediment transportation analysis model was created to study the riverbed changes. The HEC-RAS 1D hydraulic model, which is the same model as the flood simulation, is applied to the analysis. The inflow sediment discharge at the upstream end is estimated by the flow discharge (Q) - sediment discharge (Qs) function which determined in Section 2.8.2 Past Study of Sediment Production.

As a result of the sediment transportation analysis, it is recognized that scours occurred around the bridge parts and those started immediately after the peak of the hydrograph. While, there is no significant scour/degradation at the other portion. Therefore, it is expected that the riverbed would be maintained against even the design scale flood.



Source: Project Team

Figure 2.8.2 Analysis Result of Riverbed Analysis (Davao River)

2.9 Inland Flood Analysis

2.9.1 Inland Flood and Damage

Frequent inland flooding still exists in Davao City, although a lot of efforts have been made in the past to alleviate the problem.

According to the information provided by DPWH and the Davao City City Engineering Office (DCCEO), though the depth of inundation is less than 0.5m and the duration for many of the frequent floods is a few hours at maximum, it affects traffic conditions and economic activities, and thus requires improvement for securing proper urban function. For example, the frequent inundation to the La Verna area disrupts traffic on the access road to the airport in Davao City, which therefore needs urgent improvement.

2.9.2 History of Storm Water Drainage Improvement

(1) Storm Water Drainage Improvement

In Davao City, the storm water drainage system has been improved on the basis of the storm water drainage master plan prepared in 1982 (M/P1982). Table 2.9.1 briefs the history of storm water drainage improvement in Davao City.

Table 2.9.1 Brief History of Storm Water Drainage Improvement in Davao City

Year	Outline
1982	Preparation of Storm Water Drainage Master Plan (M/P1982) which mainly targeted main drainages in Davao City under World Bank funded project for the Regional Cities Development Project (RCDP) Target Drainage Area: Roxas Drainage Main, Agdao Drainage Main (Agdao and Dacudao), Jerome Drainage Main (Lanang), Insular Creek (Mamay Creek) Target Safety Level for drainage channel : 2 year return period
1980s	Implementation of the M/P1982 under RCDP
1998	Preparation of Storm Drainage Master Plan for Davao City (M/P1998) including Detail design for 25 priority projects and Preparation of master plan for 6 drainage areas which were not covered by M/P 1982 Target Drainage Area: Lizada, Dumoy, Matina Aplaya, Ma-a, Buhangin Proper (Upper catchment of Insular Creek), Panacan (Only for the area which directly drains to the sea) Target Safety Level for drainage channel: 25 year return period for main drainage and 10 year return period for lateral drainage are explored to apply. Hoverer, 2 year return period was actually adopted for many cases flowing M/P 1982.
2000	Implementation of rehabilitation of 20 drainage channels (Project Cost 0.118Billion Php)
2001	Study of main drainage system by Task Force Drainage Target Drainage Area: Agdao Drainage Main (For improvement of Obrero area), Jerome Drainage Main (Lanang), Insular Creek (Mamay Creek), Sasa Creek, Pagamican Creek (Part of Panacan river basin)
2004	Implementation of 18 storm water drainage improvement projects (Project Cost 0.250Billion Php)
2016 -	Implementation of storm water drainage improvement projects by DPWH-DEO Average Annual Investment in 2016-2020: 0.46Billion Php

Source: Project Team

(2) Sewerage System

The development of sewerage system in the central part of Davao City has been proposed for long time, it has not yet been implemented, however. On the basis of the Infrastructure development plan for Davao City in 2018 supported by JICA, the necessity of the sewerage system was reconfirmed. To promote the development of the sewerage system, JICA conducted the data collection survey in 2019. In the study, the separate sewerage system, which deals with storm water and sewerage separately, in the central part of Davao City was recommended in principle.

2.9.3 Drainage Inventory

DPWH-RO in coordination with DCCEO has been made effort on preparing the drainage inventory, in accordance with the recommendation provided in M/P1998. In the present project, the additional information was obtained by the drainage inventory, which includes manhole survey and cross-sectional survey of channel for Poblacion and Agdao areas. The drainage network model data for the Poblacion and Agdao areas have been almost completed. As for the drainage network model data for the Poblacion and Agdao areas, the total numbers of node and link are 1415 and 1741, respectively. The total length of the links is 131.1km: open channel 22.8%, closed conduit 6.9% and pipe 70.3%.

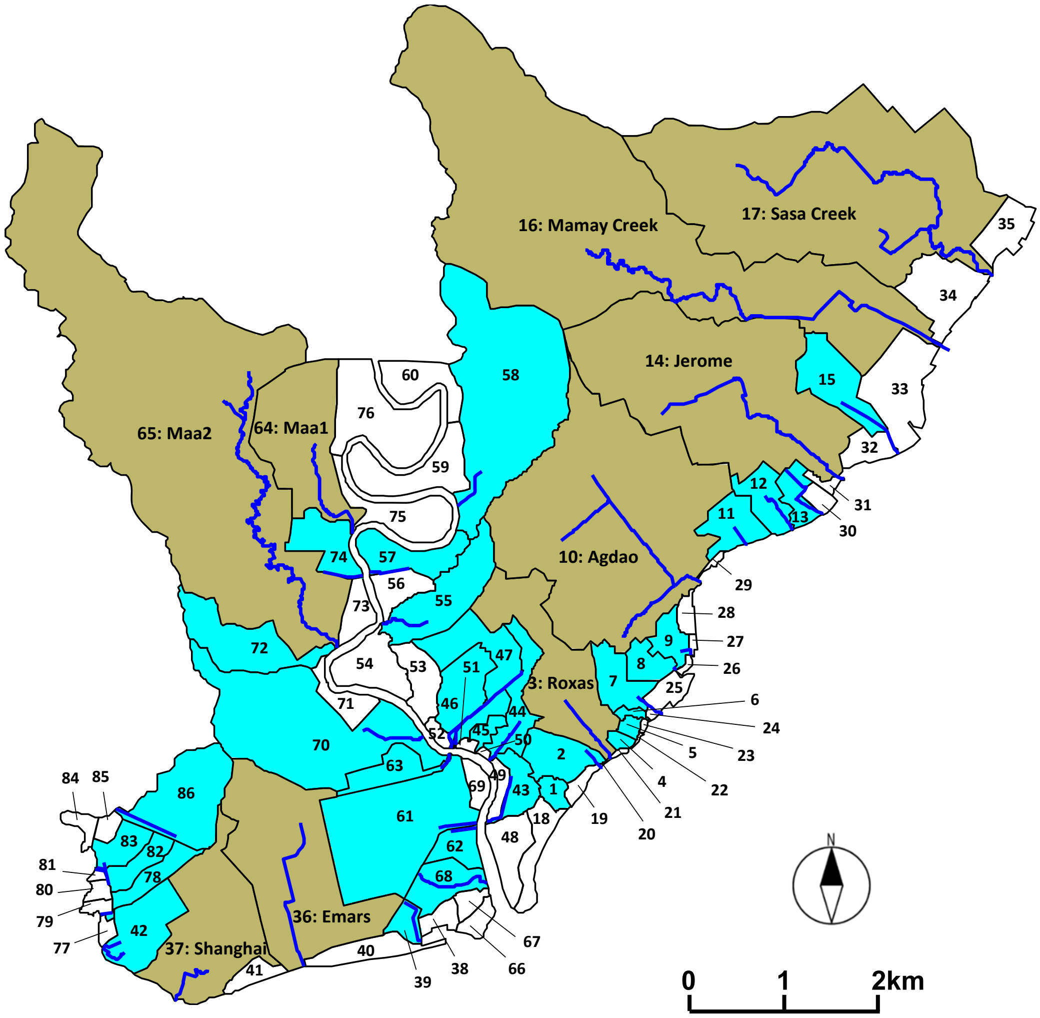
The sediment deposition was observed in about 70% of all pipes. Among the observed pipes, the percentage of the sedimentation in the pipes is as follows.

- Ratio of Deposition - Less than 25% : 33.1% in the total surveyed pipe length
- Ratio of Deposition - 25-75% : 47.9% in the total surveyed pipe length
- Ratio of Deposition - More than 75% : 19/0% in the total surveyed pipe length

2.9.4 Drainage System

(1) Delineation of Drainage Area

By referring to the results of the drainage inventory survey, topographic condition by the Lidar and road network, the boundary of the drainage area was delineated for the area surrounding the downstream reach of Davao River, which is bounded from the Sasa Creek area at the east end to the left bank area of the lower Matina River at the west end. The delineated drainage boundaries are presented in Figure 2.9.1.



Source: Project Team

Figure 2.9.1 Delineated Drainage Area Boundaries

(2) Category of Drainage Area and Channel

The delineated drainage areas have different magnitude of area and channels. The category of the drainage area is proposed as follows.

- Main Drainage Area: Drainage area which was studied as main drainage area in M/P 1982 or M/P1998
- Secondary Drainage Area: Except main drainage area, the drainage area which has clear drainage channel that reaches to the outlet of the drainage area such as outfall
- Tertially Drainage Area: Other residual drainage areas besides the main and secondary drainage areas

In M/P1982, the drainage channel was categorized into the following two; Main drainage – principle drainage channel which drains the most of runoff in the drainage area and reaches to the outlet of the drainage area with more than about 50ha in area, and Lateral drainage – other drainage channels. In the present study, the drainage channels are proposed to be categorized as follows.

- Main Drainage Channel: In main drainage area, principle drainage channel which drains the most of runoff in the drainage area and reaches to the outlet of the drainage area
- Secondary Main Drainage Channel: In secondary drainage area, principle drainage channel which drains the most of runoff in the drainage area and reaches to the outlet of the drainage area
- Lateral Drainage Channel: Other drainage channels

2.9.5 Rainfall Analysis

(1) Probable Rainfall

In Davao City, there is only one meteorological station, Davao station by PAGASA, which has enough rainfall data to discuss short term rainfall intensity. In the present study, the statistical data for short term rainfall intensity at Davao station were obtained from PAGASA. The latest data are shown in Table 2.9.2, which are based on the observed data in 61 years from 1951 to 2012.

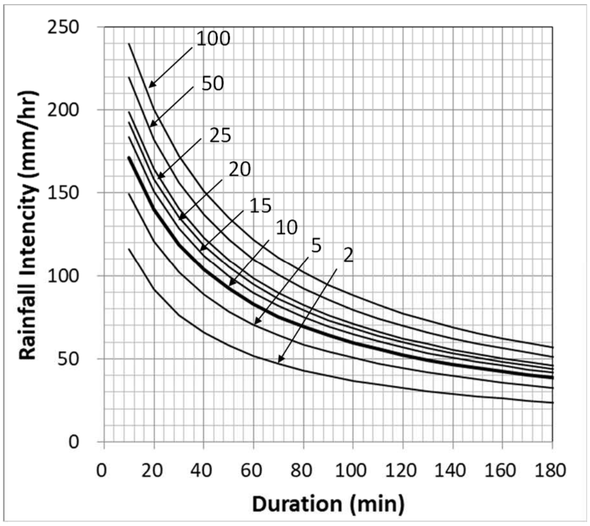
Table 2.9.2 Statistical Data on Short Term Rainfall Intensity at Davao Station

T (yrs)	10 mins	20 mins	30 mins	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	19.5	30.0	38.2	53.2	65.2	71.6	80.3	85.8	91.4
5	25.1	39.3	51.0	73.2	88.8	96.4	108.7	114.9	121.1
10	28.8	45.4	59.4	86.5	104.5	112.8	127.5	134.1	140.7
15	30.9	48.9	64.2	94.0	113.3	122.1	138.1	145.0	151.8
20	32.4	51.3	67.6	99.3	119.5	128.6	145.5	152.6	159.5
25	33.5	53.2	70.1	103.3	124.2	133.6	151.2	158.5	165.5
50	37.0	59.0	78.1	115.8	138.9	149.0	168.8	176.5	183.9
100	40.5	64.7	85.9	128.1	153.5	164.2	186.3	194.4	202.1

Source: PAGASA

(2) Rainfall Intensity Duration Curve

The probable rainfall shown in Table 2.9.2 is approximated by the Cleaveland type equation. The best fitted coefficients were determined in order to minimize the root mean square error. Figure 2.9.2 shows the best fitted approximation curves. The correlation coefficients are more than 0.999.



Davao Station
provided by PAGASA
(based on 61 years data
: 1951-2012)

$$r\ (mm/hr) = \frac{a}{(t^n + b)}$$

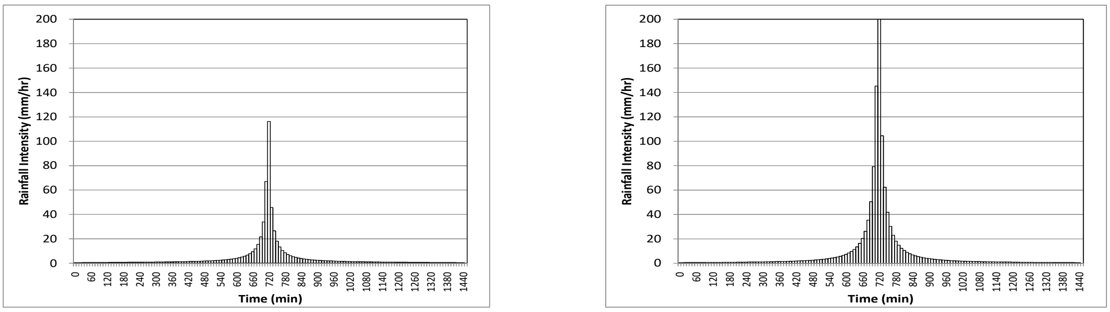
T	a	b	n	r
yr				
2	2920.67	17.260	0.895	0.9998
5	4783.01	23.593	0.926	0.9996
10	6179.89	27.341	0.942	0.9995
15	7013.70	29.297	0.949	0.9994
20	7614.52	30.601	0.954	0.9994
25	8086.05	31.570	0.958	0.9993
50	9581.49	34.372	0.968	0.9992
100	11121.43	36.900	0.976	0.9992

Source: Project Team

Figure 2.9.2 Rainfall Intensity Duration Curves

(3) Model Hyetograph

For the discussion on storm water drainage planning, the model hyetograph with a center concentrated type was prepared on the basis of the rainfall intensity duration curves. The model hyetographs for the extreme event with 2 and 25 year return period are presented in Figure 2.9.3.



2 year return period **25 year return period**

Source: Project Team

Figure 2.9.3 Model Hyetograph

2.9.6 Runoff Analysis and Inundation Simulation

(1) General

In the present project, the macro model for analyzing main drainage channel and the micro model for examining hydraulic behavior of drainage network are introduced, as shown in Table 2.9.3. All models introduced are well-known and used worldwide. They are basically free software or relatively inexpensive commercial software.

Table 2.9.3 Hydrological and Hydraulic Models introduced in the Present Study

	Item	Model	Target Area
Macro Model	1. Inundation analysis due to overflow from main drainage channels 2. Evaluation of design flood discharge along main drainage	HEC-HMS HEC-RAS	Roxas drainage area Agdao drainage area Jerome drainage area Mamay Creek drainage area Sasa Creek drainage area Emars drainage area Shanghai drainage area Maa1 drainage area Maa2 drainage area
Micro Model	Analysis of drainage network including both main and lateral drainage channels	SWMM (Flo2D may be introduced for 2D inundation analysis, which can be used with SWMM)	Poblacion area Agdao area (Matina area) (The area in which the detail drainage network model data exist)

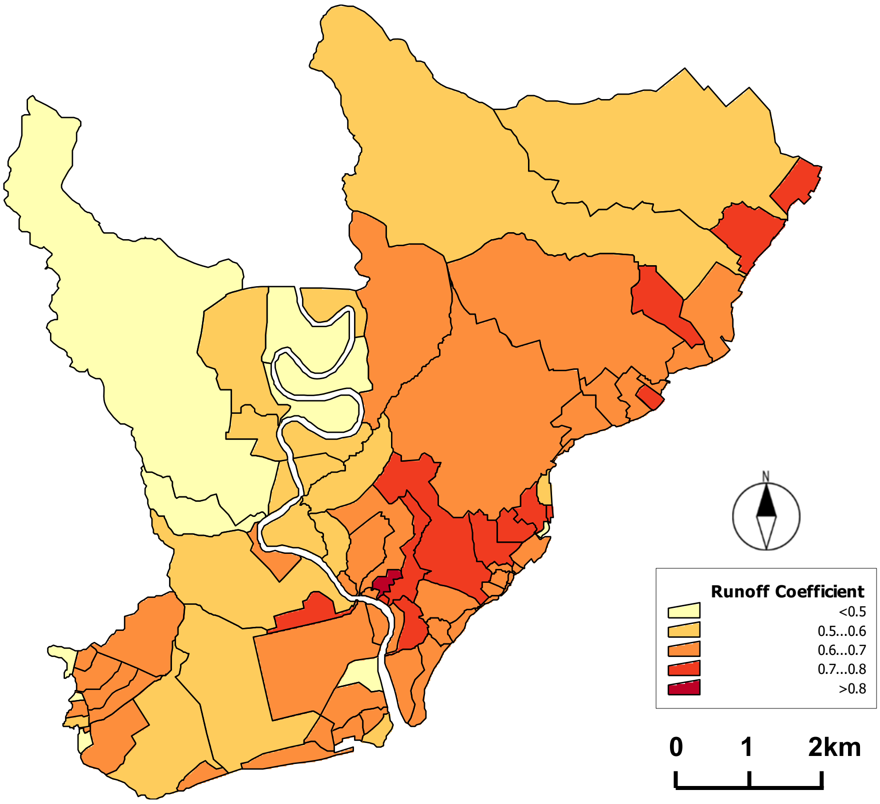
Source: Project Team

For all analysis, the constant runoff coefficient model is adopted for the loss model in rainfall-runoff modelling, by referring to M/P1982 and M/P 1998.

(2) Runoff Coefficient

The land use map in 2017 has been prepared in the Infrastructure development plan for Davao City in 2018 supported by JICA. In the present study, the land use map in 2017 is used as the existing land use condition. The runoff coefficients by respective land use category were adopted in the present study, by referring to DGCS and M/P1998.

The spatially averaged runoff coefficient for respective drainage area is calculated using the adopted values, which is presented in Figure 2.9.4.



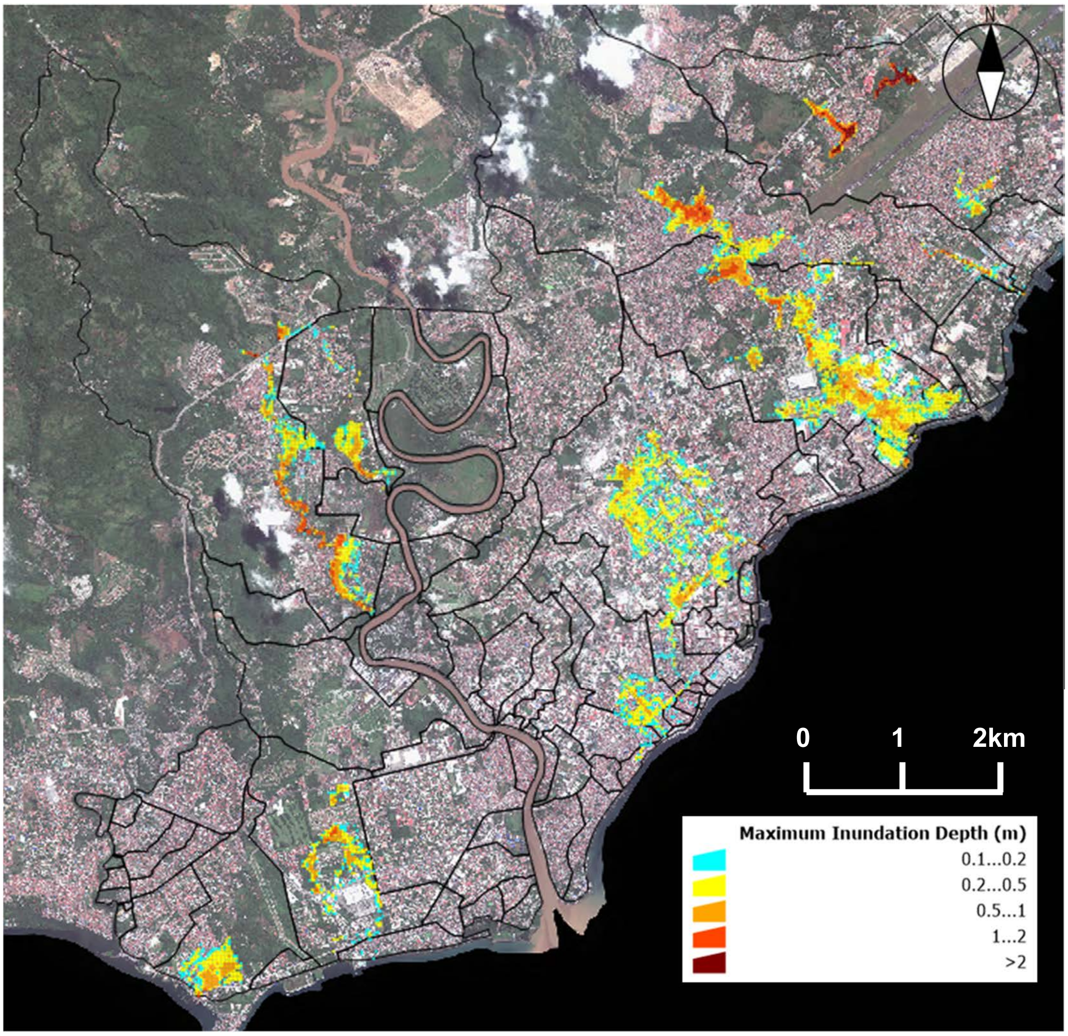
Source: Project Team

Figure 2.9.4 Runoff Coefficient by Drainage Area (Existing Condition)

(3) Macro Model

The entire part of the main drainage area has been sub-divided to some sub-catchment areas, then the runoff from each of the sub-catchment area is modelled. As for the rainfall-runoff model for the sub-catchment, the constant runoff coefficient model for loss model and SCS unit hydrograph method for hydrograph have been employed.

As the hydraulic model, 1D and 2D coupling flood simulation model by employing HEC-RAS has been employed. The hydraulic behavior in the main drainage channel is analyzed by 1D unsteady flow model and the overflow from the main drainage channel is simulated by plane 2D model. An example of the simulated inundation condition is shown in Figure 2.9.5.



25 year return period (Climate change considered, Future land use condition)

Source: Project Team

Figure 2.9.5 Example of Simulated Inundation due to Overflow from Main Drainage Channel

Using the same model, the basic design flood discharge has been set by assuming that there is no overflow from the main drainage channel.

(4) Micro Model

The drainage network model data shown in Section 2.9.3 are inputted to SWMM, then 1D drainage network analysis is conducted. As for the rainfall-runoff model for sub-catchment, the constant runoff coefficient model for loss model and built-in model in SWMM for estimation of hydrograph are employed.

As examples of the simulated results, the results of the following two cases with the climate change considered and with the future land use condition applied.

- Case 1: Existing condition
- Case 2: All sediment in pipes are removed

As shown in Table 2.9.4, if all sediment in the pipes is removed, the total flood volume would decrease with about 30% for an extreme event with a 2 year return period. However, for more severe extreme events, the rate of decrease in flood volume is reduced and the flood volume tends to be determined by the original discharge capacity of drainage channels.

Table 2.9.4 Total Flood Volume

Case	2 year return period	10 year return period	25 year return period
1: Existing condition	0.125	0.293	0.392
2: All sediment in pipes are removed	0.083	0.237	0.329

Source: Project Team
Unit: MCM

2.9.7 Major Issues

The major issues on storm water drainage have been identified, on the basis of field reconnaissance, drainage inventory, hydrological and hydraulics analysis, interviews to stakeholders and workshops, as shown below.

1) Increase in Insufficient Drainage Capacity for Large Scale Runoff
2) Recovery of Decreasing Natural Rainwater Retarding Function
3) Consideration on Limited Space for Channel Improvement in Highly Urbanized Area
4) Recovery of Reduced Channel Capacity due to Clogging of Drainage Channel
5) Control of Development and Consideration of Disaster Prevention in Infrastructure Development Project in Flood Risk Area
6) Sharing Information on Inundation
7) Consideration in Possible Increase in Runoff by Landuse and Climate Change
8) Improvement of Insufficient Construction Method
9) Better O&M Activities by Better Design etc.
10) Better Coordination for Complicated Implementation of Storm Water Drainage Project

2.10 Coastal Disaster Analysis

2.10.1 Coastal Disaster and Damage

(1) Definition of Coastal Disaster

In general, disasters that occur on coasts include high waves, storm surges, tsunamis, coastal erosion and so on. When high waves, high tides, or tsunamis exceed the ground height or facility height of coastal area, inundation occurs, which leads damage to public facilities, and to assets such as people and houses. If storm surges and wave components are overlapped on the astronomical tide level, and flood damage to land will occur.

(2) Past Incidents of Coastal Matters

This project obtained coastal disaster case data of Davao city since 2005 from DCDRRMO. According to DCDRRMO, a total of 54 incidents regarding monsoon waves have occurred since 2005. The largest number of 24 cases a year occurred in 2012 and the economic losses in 2006 and 2012 are relatively high.

(3) Summary of Past Coastal Disaster in Davao

The past coastal disasters on the Davao coast had frequently occurred from July to October, and the factors are as follows.

- High tide: The mean sea level tends to rise on average from June to October
- Monsoon waves: SW waves in April-October, and NE waves in October-March.
- Bay shape: It is difficult for waves to develop inside the bay, and waves from the SSE reach from outside of the bay because the bay mouth is open in this direction.

- Offshore wave occurrence distribution: The occurrence distribution of wave directions SW to E occurs from May to October, with a peak in August.
- Typhoon: A few rare typhoons passing nearby generate high waves in October and November
- Erosion and sedimentation: The estuary has a lot of sediments. In response to the waves from around S direction, the sand drifts to the northeast.

2.10.2 Analysis of Condition of Facilities and Houses along Coastal Area

(1) Coastal Road Projects

The Davao Coastal Road Project was started in 2017 and is ongoing at present. There are some bridges with a gap planned along the road. Sea water comes through the open gap to the area behind the road during high tide. Therefore, it is impossible to completely prevent the high tide by only the coastal road.

(2) Talomo & Matina River Mouth

Sandbanks are formed in the estuary of the Talomo and Matina Rivers, and their shapes are variable. The slope of the estuary seems to be rather gentle. From the aerial photos in the past, the estuary closure in this area has been observed since around 2014.

(3) Davao River Mouth

The shape of the estuary of the Davao River is relatively stable and its slope around the estuary is quite gentle. A new revetment has been constructed on the right bank in the estuary of the Davao River. In addition, the historical maintenance dredging had been carried out in Davao river mouth.

(4) Coastal Local Road

There is a 0.8 m parapet installed on the coastal local road. According to the interview to local people, since the parapet was set up, such flooding events beyond the parapet have not occurred. However, there is a lot of drainage holes along the coastal local road, which leads to inundation through them during high tide. The beach slope is relatively steep, which seems to be about 1/10 to 30 and it is assumed that coastal erosion has occurred.

(5) Santa Ana Port

Santa Ana Port is currently used for the ferries to Samal Island and others. The port has two piers for ferries in front of the reclamation area. The port has a series of coastal seawalls. Upright parapets in Magsaysay Park are installed.

(6) Houses

In order to investigate the situation of the existing houses accumulated in the coastal area, the aerial photographs around the coastal area were carried out using the UAV. There are the three areas that are particularly densely populated. The first is the area between the left bank of the Talomo River and the right bank of the Matina River, and the area at the left bank of the Matina River. Several settlers such as fishermen are here, and they particularly use a high-floored house in the coastal area so as to prevent flooding during high tide. The second is the estuary of the Davao River, especially on the left bank, where there are large settlements and many people. The habitants in the coastal area also adopts high-floured houses, which are built about 1 to 2 m high from the ground level. The third is the region that extends north and south of Santa Ana Port. This area has a relatively large water channel, and pumping stations for inland drainage are constructed at the coast of this region. As in the other areas, there are many fishermen and the ships they use.

2.10.3 Exiting Countermeasures for High Tide / Storm Surge and Coastal Erosion

No large-scale of measures against storm surges and coastal erosion have been implemented in the past. The projects that affect storm surge and coastal erosion on the Davao coast are described below.

(1) Davao Coastal Road

The Davao Coastal Road Project was started in 2017 and continues with construction. The coastal road is not a storm surge protection facility, and large-scale bridges are planned in the Davao River and Matina-Talomo river mouth, and some small-scale bridges are planned for the access of landside residents, which means that the road itself does not have a storm surge protection function. Therefore, countermeasures for storm surge (e.g. sluice gate, dike, seawall) are necessary considering the characteristics of opens. However, the effect of wave reduction is quite large. The waves acting on the land side of the coastal road are significantly reduced except for the opening. Furthermore, if the beach is prone to erosion, further erosion does not occur by constructing the road. Further detail study about the future characteristics of erosion and sedimentation will be conducted by the shoreline analysis at the second stage of master plan formulation.

(2) Jetty

Some parts of the Davao coast have jetties constructed for sandbanks. Some piers for ferries are not made of piles, but landfill structures from the ground level. As a result, these structures can separate coastal area so as to lead to sedimentation at the area of upstream of sand transportation and erosion at the area of downstream of sand transportation. If coastal area has problem with sedimentation/ erosion around these structures like jetties, the direction of sand transportation should be explored.

2.10.4 Tide Analysis

(1) Astronomical Tide

According to NAMRIA, which is responsible for determining tide throughout the Philippines, the official tide levels in Davao are based on the data from the 1970-1988 series, as shown in Table 2.10.1.

Table 2.10.1 Official Tide Parameter (NAMRIA)

Series	1970-1988
MHHW	0.78
MHW	0.65
MSL	0.00
MLW	-0.65
MLLW	-0.76

Source: NAMRIA

(2) Observation Data

NAMRIA has been conducting tidal observations from 1948 to the present in Davao. This study uses the observation data from 1948 to 2017 provided by NAMRIA, and the following analysis is based on it.

(3) Tidal Datum

As mentioned above, the Davao's tide datum is based on the MSL calculated in the 1970-1988 series which is the only official datum (NAMRIA), and it was confirmed that BMs are also based on the same MSL. Therefore, this study will use the 1970-1988 series of NAMRIA for the examination MSL.

(4) Historical Data

The basic characteristics of 1948-2017 observation data provided by NAMRIA are analyzed. The annual mean sea level over the target period is rising during the observation period with the yearly variation and the ratio was 0.0031 m / year.

(5) Statistical Analysis

In order to set the design water level of the target scale, a probabilistic statistical analysis is performed based on the observed tide level data, and the probable tide level for a specific reproduction period in Davao is calculated. In the calculation, the Generalized Extreme Value distribution (GEV) is used which includes three extreme value distributions unified. For probabilistic statistical analysis, the annual maximum tide from 1948 to 2017 at Davao tide station was used. The probable tide level for each particular return period is shown in Table 2.10.2. The 50-year and 100-year probable values are MSL + 1.41 m and + 1.43 m, in which the difference between them is small, 2 cm.

Table 2.10.2 Probable Return Periods of Tide

Return period (year)	1	10	25	50	100
Tide (MSL+m)	1.20	1.36	1.39	1.41	1.43

Source: Project Team

2.10.5 Wave Analysis

Waves have not been observed in the vicinity of Davao, and NAMRIA has just begun observation in 2018 at Surigao in northern Mindanao Island. This study will use the long-term reanalysis wave data by the Kyoto University which utilized the reanalyzed meteorological data (JRA-55, JMA), in order to analyze the wave conditions of the target coast.

Through statistical analysis and wave transformation analysis, the design wave near the Davao coast was estimated as shown in Table 2.10.3.

Table 2.10.3 Probable Return Periods of Nearshore Wave Heights (Direction in E-SE)

Return period (year)		1	10	25	50	100	Kr·Kd
Near shore Wave Height (m)	E	0.29	0.43	0.58	0.77	1.06	0.18
	ESE	0.28	0.46	0.66	0.93	1.39	0.18
	SE	0.39	0.58	0.76	0.99	1.35	0.24
	SSE	0.36	0.49	0.60	0.73	0.92	0.22
	S	0.35	0.45	0.56	0.69	0.91	0.18
	SSW	0.22	0.30	0.37	0.48	0.64	0.11
	SW	0.10	0.14	0.18	0.23	0.30	0.05

Source: Project Team

2.10.6 Tidal Current Analysis

Regarding tidal currents, although observation has not been conducted in this project, some significant information on tidal currents is described in the chart provided by NAMRIA. The characteristics of the tidal current in Davao Bay are as follows.

- The direction of the tidal current is northward in flow tide and southward in ebb tide.
- The tidal current is faster in the straits between Samal Island and Davao City. (Up to 2.5 knots)
- In the other sea areas, no noticeably fast tidal current has occurred.

Thus, it is assumed that a tidal flow that affects the sediment transport on Davao coast is not found because it is at most 2.5 knots in the narrow strait. It is found that it is not the main factor of the beach erosion and sedimentation.

2.10.7 Climate Change Impact Analysis

The impacts of climate change affecting coastal disasters include sea level rise (SLR), changes of typhoon and low atmospheric pressure and monsoon intensities, which associate the changes of storm surges and high waves, and the resulting coastal erosion and sedimentation characteristics. However, this section will focus on the consideration of sea level rise as described in DGCS.

(1) Sea Level Rise from 1988 to Present

The present astronomical tide uses the official tide level 1970-1988 series of NAMRIA. Therefore, it is necessary to consider the sea level rise after 1988 to the present before any discussion of future sea level rise. This project will formulate the sea level rise from now as follows, using the annual average sea level rise of 0.0031 m / year based on the observation data.

SLR (present) = 0.0031*(2019-1988) = 0.0031*31 = 0.0961 ≈ 0.1 m

This study will propose the SLR at present should be applied at 0.1 m; the official tide level of NAMRIA (1970-1988 series) plus 0.1 m should be used for the astronomical tide.

(2) Sea Level Rise in Future

In addition to the SLR of the present, the future SLR should be considered in this Project.

There are three types of SLR candidates to be considered in this project as shown in Table 2.10.4. The target year is assumed to be 2045. It is noticed that the values include the SLR from around 2000 which is estimated at 0.1m in this project. This should be discussed taking into account not only for coastal disasters, but also riverine and inland flooding.

Table 2.10.4 Candidates of Sea Level Rise to be considered in This Study

Alternatives	SLR from around 2000	SLR from Present	Description
1. Historical Trend	-	0.1m in around 2045	Increase rate: 0.0031m/year 0.0031*27years (2045-2019) =0.084m
2. Recent Prediction	0.2m in around 2045	0.1m in around 2045	PAGASA prediction in Davao
3. DGCS	0.3m in 2050	(0.2m in 2050)	Following DGCS

Source: Project Team

2.10.8 Numerical Analysis on Storm Surge and Coastal Erosion from the View Point of Coastal Protection

The following section evaluates the present and future defense structures of the Davao coast using the target scales according to the section “3.3 Target Design Level” with conducting a series of numerical analysis on storm surge and coastal erosion.

The most impact factor in the coastal area of Davao City is the Coastal Road. Therefore, Davao City's coastal area is largely divided into three parts. Storm surge and coastal erosion analysis will be conducted in the following 3 zones. Furthermore, this study will examine the cases with/without existing and future projects in order to understand the impact of these projects.

Zone 1: From Davao City South to starting point of Coastal Road
Zone 2: Coastal Road construction sections
Zone 3: End point of Coastal Road -North Davao City

(1) Storm Surge Inundation

1) Outline

As mentioned above, no storm surges due to typhoons have occurred on the Davao coast. Therefore a storm surge inundation simulation is conducted for normal astronomical high tide levels, or design tide levels that are set as the target level. The following three cases are performed. Case 1 is to perform the inundation simulation for the target scale set as the current condition before the construction of the Davao Coastal Road and estimate the inundated condition. Case 2 is to perform the inundation simulation with Davao Coastal Road completed and evaluate the effects of the coastal roads. Case 2 will also clarify which area the inundation situation is remarkable. Case 3 is to perform inundation simulations not only at the 100-year probable tide of the target level, but also at 1-year, 10-year, 25-year, and 50-year probable tide for use in B / C analysis. Obviously, no inundation due to storm surge in the residential and industrial area will occur after implementing the countermeasures of this project.

2) Models

The study used the analysis model described in "Guide for Development of Storm Surge Inundation Area Map" in Japan. This model is based on the equations of motion and continuity equations that apply nonlinear long-wave theory, and incorporates various effects into the vertically integrated shallow water theory.

3) Calculation Conditions

The tide level to be examined is a 100-year probable tide level, but inundation simulation was also performed for the probable tide level for 1 to 50 years (see Table 2.10.2) for B / C studies only in case 3. Case 3 was also implemented for tidal levels taking into account climate change (+0.1 m for all tidal levels). The ground elevation data used in this project was integrated using LiDAR and IFSAR data. The roughness coefficient was set based on the current land use classification data and based on the "Guideline for Creating Storm Surge Inundation Area Map".

4) Results

Table 2.10.5 shows the inundation area and the number of damaged buildings as a summary of the analysis results for each case.

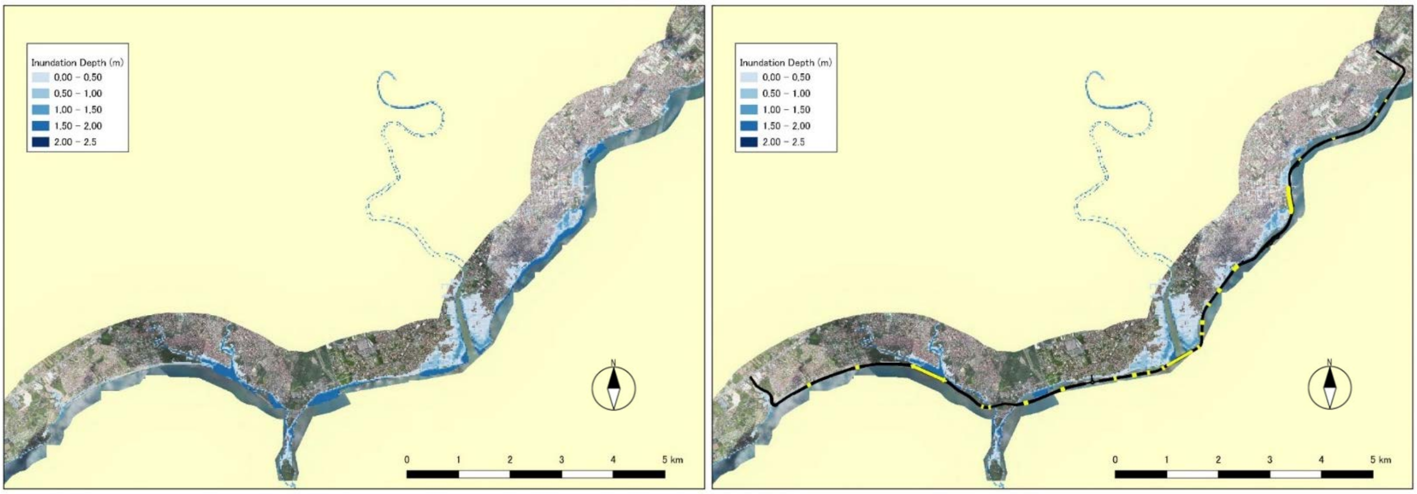
Table 2.10.5 Summary of Inundation Simulation

Case	Return period (year)	Inundation Area (km^2)	No. of Affected Buildings (1000 blds.)
1	100	2.2	18.2
2	100	2.2	18.2
3	1	1.5	11.5
	10	2.0	15.8
	25	2.1	17.0
	50	2.2	17.7
	100	2.2	17.7

Source: Project Team

5) Impact Evaluation

Figure 2.10.1 shows the impact of the inundation situation before and after the construction of Coastal Road, focusing the Coastal Road section. Coastal Road has several openings, such as bridges, from which seawater can come around. Therefore, even after the construction of Coastal Road, the inundation area did not change significantly. Coastal road alone has little effect to protect the inundation along the Davao City coast, and other measures are necessary.



Source: Project Team

Figure 2.10.1 Comparison of Maximum Inundation (top: case 1, bottom: case 2)

(2) Coastal Erosion

1) Outline

The following three cases were carried out to investigate the current and future shoreline changes regarding coastal erosion analysis. Case 1 is for the model construction and validation by carrying out the shoreline analysis of the present condition (before the construction of Davao Coastal Road) from the past coastline. After that, using the developed model, the future shoreline analysis without any interventions (e.g. coastal road) was conducted to evaluate future coastline. Finally, the shoreline analysis is performed under the conditions after the completion of Coastal Road to evaluate the impact of Coastal Road on the shoreline (case 3). By comparing Case 2 and Case 3, the impact of Coastal Road construction on shoreline changes on the Davao coast is examined. Each case also grasps the sections where erosion and sedimentation are remarkable.

2) Models

This study used, as a shoreline change analysis model, a 1-line model applied to the analysis of long-term shoreline prediction. The outline of the analysis model is as follows.

- i) Sand transport along coast is the only factor of beach profile change.
- ii) Sand transport occurs at the only representative target depth.
- iii) Regarding the beach profile, the slope does not change, and it keeps its shape, and moves parallel to the shore.

The shoreline model is mainly composed of the three calculation parts of 1) Calculation of wave transformation, 2) Calculation of coastal sand transport and 3) Calculation of shoreline change. Shoreline change is calculated with repeating these steps.

3) Calculation Conditions

Case 1 was performed for model development and verification of the coefficient of sediment transport and the amount of sediment discharge from the 2 main rivers (Davao River and Matina-Talomo River), and then predicted the future of Cases 2 and 3. For the prediction calculation, a long-term shoreline change trend was grasped, targeting 10 years after reaching the equilibrium state. Therefore, as the tide level, the average tide level was applied, and the annual energy average wave (set from the reanalyzed wave data described above) was also applied for the wave condition. In Case 1 and Case 2, shoreline change analysis were performed with MSL + 0.0m as the target shoreline. However, in the case 3 (after the Coastal Road construction), the shore line analysis used MSL-2.0m as the target counter line because some sections have no sand at MSL + 0.0m. Using the results examined the impact of Coastal Road construction.

4) Results: Case 1

In Case 1, the calculation model was developed by performing the analysis of past shoreline changes along the coast of Davao City, using the coastline from 1950 to 2014 obtained from Davao City. As the analysis results, although there are differences in quantity and characteristics in detail, the model expressed the characteristics of the sedimentation and erosion for entire area.

5) Results: Case 2 (Future Prediction without Coastal Road)

As the results of analysis of the future change of the shoreline without the Coastal Road construction in Case 2, at the mouth of the Davao River, sedimentation occurs due to sediment discharge from the river, indicating that the supplied sediment is transferred to the east and west of the river. The sedimentation is about 30 to 100 m at the estuary. In other area, there is no significant change in the shoreline.

6) Results: Case 3 (Future Prediction with Coastal Road)

As the analysis results of the future change of the shoreline after the construction of Coastal Road in Case 3, at the mouth of the Davao River, sedimentation occurs due to sediment discharge from the river, indicating that the common sediment tends to move eastward and westward. The sedimentation is about 30-80m at the estuary. In other area, there is no significant change in the shoreline except for the slight sedimentation at the south side of Coastal Road.

Comparing the results of Case2 and Case3 to understand the impact of Coastal Road construction on shoreline changes, there seems to be no significant change. The impact of Coastal Road construction on future shoreline changes seems to be relatively small.

2.10.9 Key Issues in Coastal Disasters

The followings are the major issues related to coastal disasters identified through basic surveys, field inspections, field surveying, numerical analysis, interviews with stakeholders, workshops, etc.

1) Adequate flood protection facilities
2) Enhancement of flood protection capacity with securing the continuity of facilities (e.g., handling inundation from breakup at drainage channels, drainage holes, etc.)
3) Measures for lowland housing densely located in coastal areas
4) Development regulations in flood risk areas (coastal lowlands)
5) Sharing information on flooding
6) Clarification of the implementation system for coastal flooding countermeasures
7) Improvement of Design Guideline for Coastal Facilities
8) Clarification of maintenance and management systems and implementation methods
9) Consideration of the possibility of increased coastal flood due to climate change

2.11 Design Criteria of Flood Countermeasure (Riverine flood, Inland flood, High Tide / Storm Surge)

2.11.1 Conditions of Existing Structures

In the target area of the project, there are existing structure measures against riverine flood, inland flood and coastal flood that have been constructed in the past, such as embankment, revetment, drainage channels, etc. This chapter describes the types of major structure measures that have been constructed against each of the riverine flood, the inland flood and the coastal flood, together with issues identified with regard to the conditions of those structures.

(1) Issues and Conditions of Structure Measures

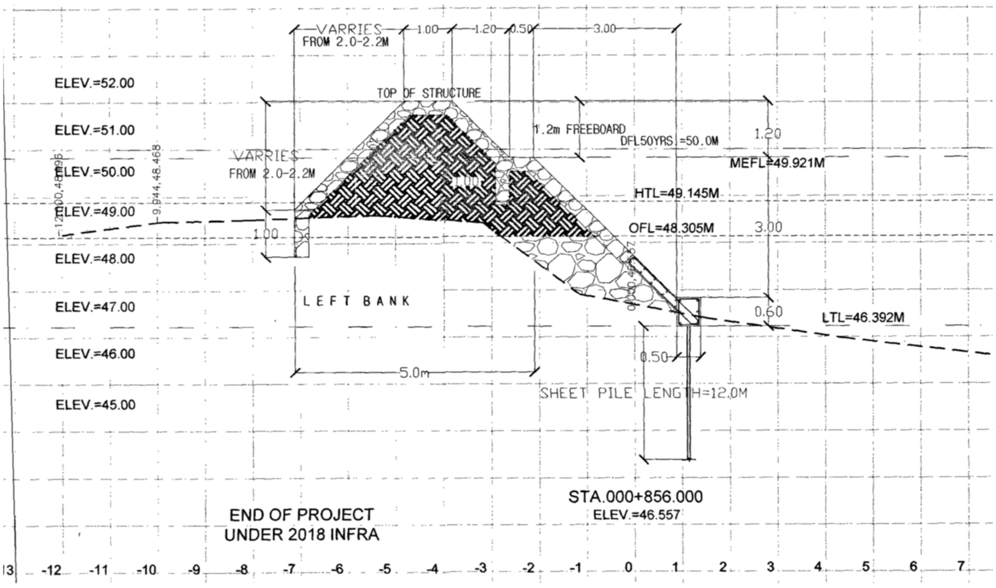
1) Riverine Flood

There are existing embankments and revetments being developed intermittently along each of the three rivers as measures against riverine flood. On top of that, underground box-culvert floodway exists at a meandering section of Talomo River aiming to divert floodwater in the downstream. There are no existing flood retarding ponds, flood gates or weirs for the three rivers.

a) Embankment and Revetment (Concrete Revetment)

There are two main types of structures that can be seen along the three target rivers, the concrete revetment and gabion pile-up. Concrete revetment is the type of structure widely adopted for old constructions that have been completed before the DPWH-DEO's extensive construction projects launched in 2017.

The standard cross section of concrete-revetment type embankment is shown in the following figure from the design documents provided by DPWH-DEO. Rubble concrete is used here with steel sheet piles as foundation. The embedded depth of the steel sheet pile is 12m, but it is considered to be designed and used as bearing piles and they are not designed as cantilever sheet piles that support earth pressure from the embankment, thus scour depth is unlikely to be considered in the design.

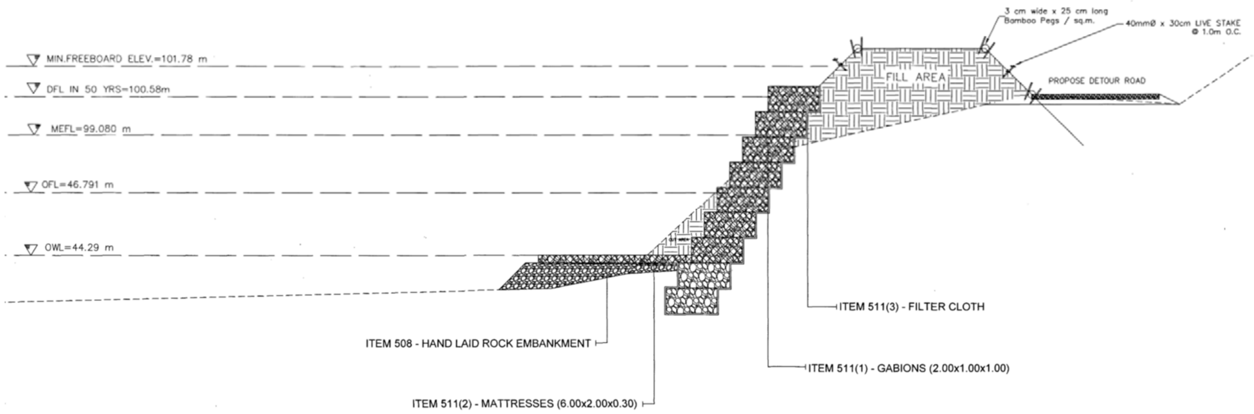


Source：DPWH DEO

Figure 2.11.1 Standard Cross Section of Concrete-Revetment Type Embankment

b) Embankment and Revetment (Gabion Pile-up)

Gabion pile-up is the type of structure widely adopted in a series of construction started by DPWH-DEO in 2017. The standard cross section of gabion pile-up type embankment is shown in the following figure from the design documents provided by DPWH-DEO. The foundation is also gabion-shaped, and the depth of penetration is 2m (2 steps). In addition, a gabion mattresses are installed in front of the revetment.



Source：DPWH DEO

Figure 2.11.2 Standard Cross Section of Gabion Pile-up Type Embankment

c) Underground floodway

An underground box-culvert floodway is installed on the left bank of Talomo River, the inlet being located at around 2+650k and the outlet at around 1+850k.

d) Cross-river Structure; Bridge

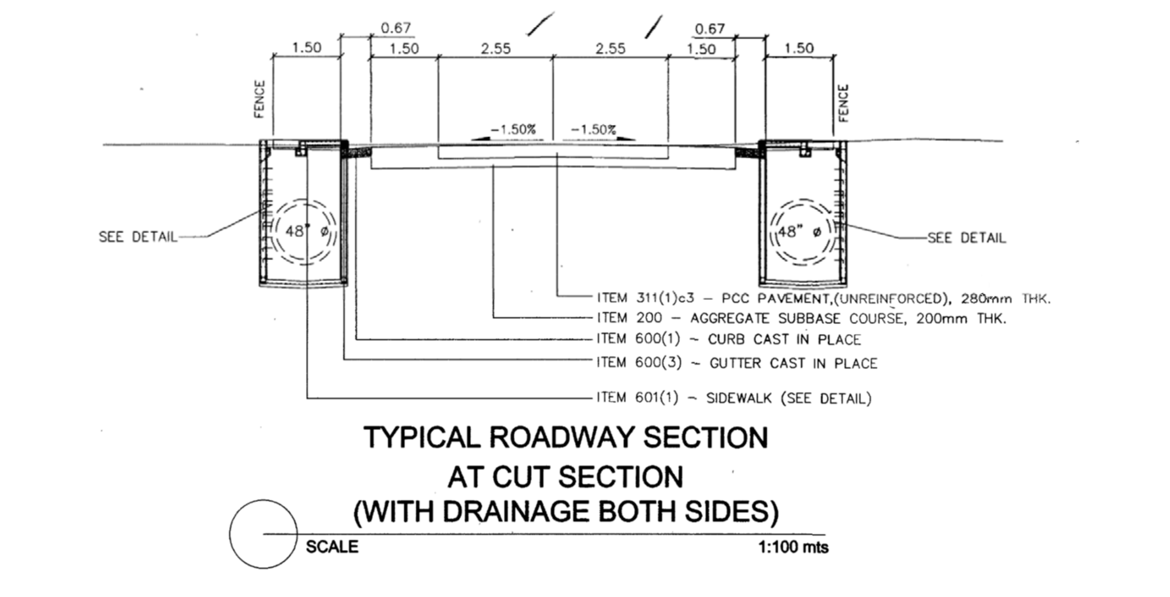
With regard to cross-river structures along target rivers, a number of bridges cross over the channel. Davao River particularly has many piers, abutments, and protection revetments located inside the channel. For the design of pier foundations constructed inside the channel, DPWH design standards (Design Guidelines, Criteria and Standards 2015) stipulates to estimate and consider the scour depth, which is also the case with planned constructions mentioned in 2.4, whose general drawings assume about 2.4 m of scour depth corresponding to 100-year flood for a bridge over Davao River.

2) Inland Flood

Existing structure measures related to inland flooding include road side gutters, catch basins, tributary and main drainage channels (open channel and buried pipe lines). The drainage system is connected to rivers or the coast where water is drained by gravity. However, the development of structures is falling behind and the dimension of existing structures is inadequate, therefore inland flooding remains an issue. Conditions of existing structure measures are described here based on collected information and site observation.

a) Road side gutters, catch basins and drainage channels

The standard cross section including road side gutters, catch basins and pipe-culvert drainage channels is shown in the following figure from the design documents provided by DPWH-DEO. As shown in the figure, the precast pipelines are generally installed right under the sidewalk or road shoulder on both sides, while it is also common to see them installed under the road center for a smaller road that has only one-lane width. Structural details are specified in the standard design of DPWH, and accordingly, all of the design compiled by DWPH-DEO is based on it.



Source：DPWH DEO

Figure 2.11.3 Standard Cross Section of Inland Flood Structure Measures (Gutter, Catch Basin and Pipeline)

b) Connection with River and Coast (Drainage Outfall)

Tributary and main drainage channels are all connected to river or coast at their outfall where water is drained by gravity. Although there are no existing pumping station or sluice gate for the purpose of discharging water from drainage channel to river or coast, one pumping station is being planned by DPWH-DEO along Davao River. Sluice gates are also being planned along the coast.

3) Coastal Flood

For structure measures against coastal flood, construction of the coastal road by DPWH-RO is underway as described in 2.10 on top of existing structures (sea wall and jetee). The coastal road has concrete revetment, wave-breaker and foot protection on its sea side in order to protect the road from waves, but the facility as a whole does not ensure protection against storm surge due to openings (bridges) placed to allow residents' (fishermen's) access.

(2) Overview of Existing Structure Measures against Riverine Flood

In the target three rivers, embankments and revetments have been constructed along certain section as countermeasure against riverine flood. On top of that, DPWH-DEO (DEO (I)) has launched an extensive embankment / revetment construction projects since 2017 for a number of rivers under its jurisdiction.

Design and construction projects by DPWH-DEO is based on datum level set independently in each project, and protection height of structure measures lacks longitudinal consistency, which remains a serious issue.

1) Davao River

In Davao River, there are only embankment and revetment, and there no flood retarding pond, floodway or flood gate.

Structure types of the revetment are classified into two major types, concrete revetment and gabion pile-up. The concrete revetments can be seen at urban and residential areas along the downstream of Davao River, from the river mouth up to around the 3 km point for existing structures as well as for planned structures. In the upstream of that, most of the structures are gabion pile-up type, except for the existing revetments in the vicinity of old urban areas and residential areas.

In sections where concrete revetments are being constructed, there are restrictions on the site (i.e. the gabion pile-up type has earth embankment with wider footprint area), houses and roads exist right behind the revetment (i.e. the gabion pile-up type is not designed to bear traffic and building load, making it impossible to have houses and roads in the very vicinity) and difficulty in the foundation construction (i.e. there's no high-water riverbed and difficult to build a cofferdam for dry construction), which are considered to be the reason why concrete revetment was adopted. On the other hand, gabion pile-up type is less expensive and thus considered to be adopted in places where there are no restrictions.

2) Talomo River and Matina River

Except a floodway in Talomo River, all listed structures are embankments and revetments.

There are two major types of revetment structures for Talomo River and Matina River as well, concrete revetment type and gabion pile-up type. Concrete revetments are mainly located at urban area along Talomo River as well as in the upstream and downstream of bridges along Matina River. On the other hand, gabion pile-up type is mostly used in recent constructions.

Many of the concrete revetments of both rivers are constructed in old days (before 2014 or unknown) and, in addition to the restrictions on the site and its land use, it is considered that gabion pile-up was not among the commonly used revetment types at that time and the selection of structure may have been done in this background. In recent construction along both rivers, the gabion pile-up type is considered to be adopted on the premise that affected houses are relocated and that there are no restrictions on the site.

2.11.2 Current Situation of Design Guidelines

DPWH's design guidelines for structure measures against each type of flood is as follows, as per confirmed by DPWH-BOD.

Table 2.11.1 DPWH's Design Guidelines for Structure Measures (Riverine Flood, Inland Flood and Coastal Flood)

No.	Name of Guidelines	Riverine Flood	Inland Flood	Coastal Flood
1	Design Guidelines, Criteria and Standards, Volume 3 Water Engineering Project, DPWH 2015 (DGCS Vol.3)	●	●	●
2	Technical Standards and Guidelines for Planning and Design, Volume 1: Flood Control, DPWH-JICA 2010	●	●	
3	Philippine Port Authority (PPA) Engineering Standards for Port and Harbor Structures – Volume II (2009)			●

Source：Project Team

(1) Riverine Flood

For the design of structure measures against riverine flood, Design Guidelines, Criteria and Standards, Volume 3 Water Engineering Project (hereinafter mentioned as "DGCS Vol.3) is the only official guideline adopted by DPWH-BOD, although DPWH-BOD explained that Technical Standards and Guidelines for Planning and Design, Volume 1: Flood Control (DPWH-JICA 2002) is also referred, the document referred in the preparation of DGCS Vol.3. In the DGCS Vol.3, only the basic concept of design (eg. mentions on the necessity to conduct seepage analysis in the design of embankment, to conduct stability analysis in the design of gabion wall and sheet piles) is described, without giving the details of analysis models and calculation conditions such as design load combinations. The specific analysis and calculation methods are currently to be determined by individual engineer, while DPWH-BOD is not recommending any specific analysis and calculation methods or softwares.

For facilities that are not detailed in DGCS, namely flood retarding basin, overflow dike and dam, there are no other guidelines and accordingly, design criteria is proposed independently for similar projects in the past (such as Parañaque floodway).

DPWH-BOD has an intention to update the contents of DGCS, especially for items with insufficient descriptions, which is not planned specifically.

(2) Inland Flood

For structure measures against inland flood, the guidelines adopted by DPWH-BOD is the same DGCS Vol.3 as for structure measures against riverine flood. DGCS Vol.3 has a chapter dedicated for the drainage where basic concept of the design is explained.

In addition, DPWH has a standard design for gutters, catch basins, drainage channels (pipe-culvert and box-culvert), inlet and outlet structures and flap gates, which is referred when determining specifications of basic structures.

(3) Coastal Flood

For structure measures against coastal flood, although DGCS Vol.3 is the guidelines adopted by DPWH-BOD, the same guidelines as for riverine flood, DGCS Vol.3 mentions to refer Philippine Port Authority (PPA) Engineering Standards for Port and Harbor Structures – Volume II (2009) as well. According to DPWH-BOD, they explained that DGCS Vol.3 is the first guidelines to be referred in the design of structures while PPA is referred for items that are not detailed in DGCS Vol.3. PPA (2009) basically follows the contents of Technical Standards and Commentaries for Port and Harbour Facilities in Japan, although the documents are under request for collection.

DGCS Vol.3 has only 14 pages in the chapter 7 dedicated for coastal structures, the description being quite limited. On the other hand, PPA (2009) which follows Japanese technical standards has extended contents with several hundred of pages. Since DPWH does not have a department specialized in coastal engineering and they have very few costal engineers, it is challenging for them to understand the contents of PPA (2009) and apply it to structure design. It is therefore common practice for them to simply apply structures that have been constructed for other projects, according to hearing from DPWH.

2.12 Present Condition of Non-structural measures

For considering the detailed activities on non-structural measures, the present activities implemented by the government of the Philippines and donors are investigated in this Section.

(1) End-to-end monitoring system for forecasting and early warning

Regarding the meteorological and hydrological observation in the target area of the Project, the Davao River Basin Flood Forecasting and Warning Center (DRBFFWC) was established under PAGASA in 2018, and seven water level gauges and seven rainfall gauges have been installed under support of JICS. Among them, six water level gauges and five rainfall gauges in the Davao river basin, one water level gauges and two rainfall gauges in Talomo river basin, and no gauges in Matina river basin, were installed.

The data above is being monitored by DRBFFWC and CDRRMO as a real-time observation system. Based on these data, a flood advisory or flood bulletin is issued by DRBFFWC, and the information is disseminated to the related organizations through OCD, and to barangays through CDRRMO by mobile phone, land phone, e-mail, messenger applications and others.

On the other hand, the condition of Davao river is changing due to ongoing construction work of DPWH DEO since 2017. Therefore, the danger water levels set by PAGASA are not getting matched with the latest river channel conditions. The water level data at Waan Bridge over the Davao River during heavy rainfall in January 2019 had exceeded the red (Critical) danger level by more than three meters, however water was not overflowing at that time according to interviews with the residents.

Compared with Davao River, Talomo River and Matina River don’t have enough lead-time to take prompt DRR actions before flooding since the flood wave propagation time is relatively short. Especially for Matina River, when there were more than 30 fatalities in the 2011 flood, therefore it is necessary to establish EWS in such short-medium rivers even though there are no water level observation stations along Matina River.

(2) Evacuation Centers

In Davao City, 91 facilities are currently designated as shelters, and it is estimated that a total of 78,460 people can be accommodated. Of these, covered courts, gymnasiums, and schools are mainly designated.

In addition, new shelters are being constructed to prepare for future large-scale disasters. In the Los Amigos area, located in the middle reaches of Talomo River, expansion of an existing shelter and construction of a new shelter are underway, and shelter construction is also planned in the Ma-a and Mahayag areas.

On the other hand, the population living in the hazard prone area of landslide and flood in Davao city calculated based on the hazard map prepared by DOST and MGB is estimated to be about 430,000, therefore the capacity of shelters may not be enough.

(3) Hazard maps and risk assessment, Davao City IEC Program, Earthquake and fire drills and other multi-hazard drills

In Davao City, there are several existing flood hazard maps as described below. First, MGB conducted hazard assessment based on topographical, soil quality and disaster historical information, and created a 1:10,000 scale hazard map for floods and landslides. However, this hazard map was created before typhoon Vinta, therefore MGB recognizes that updating is necessary. The other is the flood hazard map created in 2015 in the DREAM program led by the University of the Philippines (UP). It has been created with 5-year, 25-year, and 100-year probability using the HEC-MHS model and ground data from LiDAR. In addition, flood hazard maps and storm surge hazard maps were also organized in Project NOAH implemented by DOST, and can be viewed on their website.

As mentioned above, several organizations create maps with different methods and accuracy and distribute them to barangays, and it is not linked to effective disaster prevention activities such as evacuation drill due to the lack of understanding on how to utilize them.

Also, the distribution of educational materials to residents and the implementation of training are effective as awareness activities. As current situation, flood-fighting drills are not conducted although earthquake drills led by Davao city are conducted once a year.

In addition, as an IEC activity related to flood, IFI (International Flood Initiative), whose secretariat is ICHARM in Japan, collaborates with DPWH, PAGASA and DOST XI to build a platform related to water resilience and disasters, and is conducting activities such as development of the Online Synthesis System (OSS) and conducting e-learning and workshop.

(4) Greening Program

In the Davao River Basin, DENR has confirmed that 135,469 ha, or 76% of the basin area of 175,960 ha, is a forest area. Of this forest land, 32% is distributed in the upper Bukidnon and the remaining 68% in the middle and lower parts of the basin, Davao del Norte and Davao City.

DENR formulated the Davao River Basin Management and Development Plan in 2015, and measures and funds required for 15 years were proposed. In this plan, activities for forest protection of 33,327 ha, forestlands rehabilitation of 20,000 ha, forestlands productive development of 17,800 ha and mangrove rehabilitation of 25 ha were proposed.

As for mangrove conservation, as mentioned above in section 2.3.2, the coastal road projects with a distance of approximately 12 km along the coastline of Davao City are ongoing, and there is concern that this will have a major impact on mangroves. In the view of DENR officer, mangrove conservation will be considered again after the completion of the said coastal road project. Moreover, it is mentioned in the CLUP formulated by Davao City that the expansion of informal settlers along the coast is causing damage to mangroves.

(5) Relocated/regulated households

In the three rivers targeted by this project, there are clearly residents who are illegally occupied within the limits along river set by the Water code. The current situation is confirmed visually. The quantitative grasp will continue to be investigated in the Stage 2.

(6) Retrofitted existing public infrastructures and facilities

According to the estimation of the infrastructure development project, the urban area of Davao City is expected to be about doubled from 14,057 ha in 2017 to 28,190 ha in 2045. With the progress of urbanization, there is a concern that the flood arrival time will be faster and the runoff to the river will increase due to the reduction of the water holding and retarding functions in the basin.

In Davao City, the ordinance for the proper harvesting, storage and utilization of rainwater was established in 2009, and the installation of a rainwater catchment system is stipulated in the construction of private residences, commercial and industrial buildings, etc., as an effective flood mitigation measure. Then, under Executive order No. 45 from Davao City, the Implementing rules and Regulations (IRR) of the above-mentioned ordinance was issued in 2014. The issuance of this IRR promotes the installation of a rainwater catchment system, and Davao City has issued a building permit to facilities with 2,497 cases in 2015 and 3,879 cases in 2016. On the other hand, according to the research results of 2018 by Ateneo de Davao University et al., it is reported that the proportion implemented properly is only about 30% of the subjects. In Davao City's view, it is considered necessary to finalize a technical manual for planning and installation of rainwater catchment systems and to build a database to manage existing rainwater catchment systems.

In Davao City, the preparation and approval of city ordinance concerning the mainstreaming, promoting, and institutionalizing permeable pavement system is underway. Since this ordinance has not been approved, the content has not yet been released to the public. Regardless of the presence or absence of this ordinance, cases have also been confirmed where private companies in Davao City have independently created permeable pavement systems for parking lots.

(7) Desilting of rivers and natural waterways

Davao City has established the Ancillary Service Unit (ASU) under the City Mayor's Office in 2017 through Executive Order No. 05 in order to maintain the drainage network and to properly secure the sidewalk space. The drainage network is cleaned up with the CEO's equipment and 200 human resources under the ASU. ASU has issued a monthly report from 2018 which mentions the locations of clean-up activities, the date, the total amount of waste extracted, and the total length of cleaned drainage channels. It is reported that the waste of 2,875 m3 was extracted and the drainage channel with a total extension of 52,990 m was cleaned in 2018, mainly at locations where urban flood damage was serious, and the activities are still ongoing.

In addition, 300 volunteers have been taking part in the first Saturday and third Saturday mornings to clean up rivers and the coast in Davao City since October 2017. This activity is conducted in accordance with Executive Order No. 41, and Davao City provides a daily allowance to the participants.

On the other hand, in the ASU's opinion, the above-mentioned cleaning and maintenance activities alone cannot cover all drainage channels in Davao City, and cooperation from the barangay level and awareness raising activities for the residents are necessary. In addition, illegal disposal of construction materials such as gravel and sand by construction companies also has a major impact on drainage systems, and it is considered necessary to further strengthen the monitoring system.

2.13 Current Main Laws, Regulations and Orders related to Flood (Riverine Flood/Inland Flood/Storm Surge and High Tide)

2.13.1 Current Main Laws/Regulations/Orders

(1) National Government Level

1) Presidential Decree 1067 (Water Code of the Philippines)

The Water Code of the Philippines known as Presidential Decree 1067 was passed in order to establish the basic principles and framework relating to the appropriation, control and conservation of water resources to achieve the optimum development and rational utilization of these resources. The Code defines the extent of the rights and obligations of water users and owners including the protection and regulation of such rights. The Code also serves as a basic law governing the ownership, appropriation, utilization, exploitation, development, conservation and protection of water resources and rights to land related thereto.

2) Philippine Disaster Risk Reduction Management Act of 2010 (RA 10121)

The enactment of Republic Act 10121 otherwise known as the Philippine Disaster Risk Reduction and Management Act of 2010 laid out the basis for a paradigm shift from disaster preparedness and response to disaster risk reduction and management (DRRM). In accordance to the NDRRMF, the NDRRMP articulated four distinct yet mutually reinforcing priority areas, namely, (a) Disaster Prevention and Mitigation; (b) Disaster Preparedness; (c) Disaster Response; and (d) Disaster Recovery and Rehabilitation. Each priority area has its own long term goal, which when put together will lead to the attainment of the goals and vision of DRRM.

3) Republic Act 9729 (Climate Change Act)

In 2009, the Republic Act 9729 or the Climate Change Act was enacted into law. The law mandates mainstreaming climate change (CC) considerations into government policy and planning. This piece of legislation provided the foundation in the creation of the Climate Change Commission, the National Framework Strategy on Climate Change (NFSCC) for 2010-2022, and the National Climate Change Action Plan (NCCAP) for 2011-2028.

As a result of these policy reforms, the scope of the government's climate change response has been further defined across agencies and at the national and local levels. Contained in the NFSCC and the NCCAP are several time-bound targets of the government in relation to climate change adaptation, mitigation, and disaster risk reduction (CCAM-DRR).

4) Presidential Decree 1152 of 1977 Environmental Code of the Philippines

The Environmental Code of the Philippines stipulates provision regarding flood control. Section 34 provides measures in flood control program in addition to the pertinent provisions of existing laws:

- Control of soil erosion on the banks of rivers, the shores or lakes and the sea-shores;
- Control of flow and flooding in and from rivers and lakes;
- Conservation of water which, for purposes of this Section shall mean forms of water, but shall not include captive water;
- Needs of fisheries and wildlife and all other recreational uses of natural water;
- Measures to control the damming, diversion, taking, and use of natural water, so far as any such act may affect the quality and availability of natural water for other purposes; and
- Measures to stimulate research in matters relating to natural water and soil conservation and the application of knowledge thereby acquired.

In addition to the above mentioned Presidential Decrees and Republic Acts, Table 2.13.1 provides other related significant Presidential Decrees, Republic Acts, Department Orders, Executive Orders and others related to flood control management issued by various agencies and departments.

Table 2.13.1 List of Relevant Laws, Regulations and Orders on Flood Control

PD/RA/DO/EO	Title	Issuing Agency
PD 1586 1978	Environmental Impact Statement System	-
RA 11038 2018	Expanded National Integrated Protected Areas System Act	-
RA 10752 2016	The Right-of-Way Act	-
DO 116 S2018	Tree Cutting and Earth-balling Permit Application Process and Requirements for DPWH Infrastructure Projects	DPWH
DO 124 S2017	Directing the Use of the DPWH Right-of-Way Acquisition Manual by All Concerned.	DPWH
DO 57 S2016	Environmental Impact Assessment (EIA) for DPWH Projects and Tree Cutting Permit Application	DPWH
DO 23 S 2015	Flood Control and Drainage Slope Protection Policy	DPWH
DO 139 S2014	Guidelines on River Dredging Operations for Flood Control	DPWH
AO 05 2019	Implementing Rules and Regulations of RA 7586, RA11038	DENR
AO 15 2017	Guidelines on Public Participation under the Philippine Environmental Impact System	DENR
AO 13 1992	Establishment of Buffer Zone within Forest Land	DENR
EO 510 2006	Creation of River Basin Control Office (RBO)	DENR
MC 30 2020	Interim Guidelines on Public Participation in the implementation of the Philippine Environmental Impact Statement System (PD1586) during the state of national public health emergency	DENR EMB

Source: Compiled by JICA Project Team

(2) Local Government Unit Level

The Local Government Unit enacted ordinances and policies to support and localized the implementation of the National laws and regulations related to flood control. Table 2.13.2 provides a summary of major local policies and ordinances relative to flood control management in the city.

Table 2.13.2 Local Policies and Ordinances Passed by the City Council of Davao City Related to Flood Control and Drainage

Local Ordinance	Title
Ordinance #0298-09	Proper Harvesting, Storage and Utilization of Rainwater in Davao City
Ordinance #0333-15	Creating a Technical Working Group to facilitate the process of Desilting Operations in the Rivers and Streams in the Watershed Areas in Davao City
Ordinance #0310-07	Watershed Code of Davao City or Watershed Protection, Conservation and Management
Ordinance #0361-10	Davao City Ecological Solid Waste Management
Ordinance #117-01	Water Resource Management and Protection Code of Davao City

Source: Compiled by JICA Project Team

2.13.2 Legal Aspects related to River Boundary

The significant legal basis in river boundary is broadly illustrated in the Civil Code of the Philippines (RA 386), which are stipulated in Title 2 and 4 of the Civil Code shown in Table 2.13.7. and these were enhanced by the provision of the Water Code of the Philippines (PD 1067) under Chapter 2 and 4, ownership and control of waters, respectively.

The Water Code of the Philippines as well as the proposed National Water Security Act of 2013 have not explicitly provided the definition of river area nor delineated river boundaries of river areas, however, there are various efforts undertaken by various agencies to define its administrative boundaries. Such efforts aimed at effectively and efficiently respond to the issues and problems of the river basin and ensure appropriate management of the river resource.

The Davao River Basin is shared by Davao City, Province of Bukidnon and Davao del Norte. At present, a dispute over water rights and water control existed between the Province of Bukidnon and Davao del Norte, of which the area is now managed and controlled by the Province of Bukidnon. With the existing disputes of the two provinces mentioned, the Davao River Basin Alliance becomes a significant avenue assuming the joint responsibility for ensuring that the river and its watershed are sustainably managed and controlled.

2.14 Condition of Framework for Project Implementation and Maintenance related to Flood (Riverine Flood, Inland flood, Storm Surge and High Tide)

2.14.1 Main Organizations

(1) Department of Public Works and Highways (DPWH)

1) Department of Public Works and Highways (DPWH)-Central Office

The Department of Public Works and Highways (DPWH) is one of the three departments of the government undertaking major infrastructure projects. It is mandated to undertake (a) the planning of infrastructure, such as national roads and bridges, flood control, water resources projects and other public works, and (b) the design, construction, and maintenance of national roads and bridges, and major flood control systems.

The Department of Public Works and Highways functions as the engineering and construction arm of the Government tasked to continuously develop its technology for the purpose of ensuring the safety of all infrastructure facilities and securing for all public works and highways the highest efficiency and quality in construction.

To support the National Government policies on `Build, Build and Build Thrust`, DPWH has aggressively implemented its infrastructure program and has increased tremendously its budget more than five times from about 90B in 2011 to approximately 480B in 2018. The budget fell in 2019, but has since been on the rise again.

2) Unified Project Management Office-Flood Control Management Cluster, DPWH-UPMO-FCMC

Under the new mandate, all flood control related management is under the Unified Project Management Office-Flood Control Management Cluster with the following roles and functions:

- Provide technical comments, advise the M/P and F/S on related flood control projects
- Coordinate the planning, design, construction, organization and maintenance of proposed measures related to flood control projects in coordination with concern agencies
- Manage the proposed measures related to flood control projects.

The Office of the Project Director is supported by a core staff and an operation support staff. The core staff is five functional units namely; administrative support unit, planning and programming support unit, procurement support unit, contract management unit and monitoring and reporting unit. On the other hand, the operation support staff is composed of the flood control management office, project managers, construction operations for foreign-assisted projects, construction operations for locally funded projects and operation and maintenance.

3) Department of Public Works and Highways-Regional Office XI

The Regional Office of the Department of Public Works and Highways (DPWH) is currently responsible for the planning, design, construction and maintenance of infrastructure, especially the national highways, flood control and water resources development system, and other public works in accordance with national development objectives. In view of the decentralization law, the Regional Office of DPWH envisions to complimenting the initiatives undertaken by the local government units.

In 2017, the Region received the highest budget allocation of Php 42.6B out of the total budget of Php 382.4B. Region XI garnered the highest budget allocation of Php 42.6B which is approximately 30% of the total budget for Mindanao.

4) District Engineering Office (DEO)

There are two District Engineering Office (DEO) in Davao City, which are Davao City DEO and Davao City II DEO. Davao City DEO covers the 2 districts in Davao City namely, District 1 consists of the Poblacion and Talomo areas, covering an approximate 54 barangays; District 2 consists of areas in Agdao, Buhangin, Bunawan and Paquibato with approximate coverage of 46 barangays. Davao City II DEO covers District 3 which is composed of Baguio, Calinan, Marilog, Toril and Tugbok servicing a total of 82 barangays. In terms of manpower, Davao City DEO is composed of an approximate 97 staff and 508 job orders. The Planning and Design Unit at the DEO plays a vital role in the overall planning and design of flood control measures.

(2) Local Government Unit of Davao City

The enactment of the 1991 Local Government Code represent a major step forward in decentralization in the Philippines as it mandates the Local Government Units the local autonomy in managing local affairs by devolving planning functions, expenditures and taxing including flood control planning and management.

The Code also provides a provision that public work and infrastructure projects and other facilities funded by the national government under the annual General Appropriation Act, other special laws, pertinent executive orders, and those wholly or partially funded from foreign sources, are not covered under Section 17, except in cases where the local government unit concerned is duly designated as the implementing agency for such projects, facilities, programs and services.

Given the provision of the Code, LGUs are in close coordination with national agencies in implementing projects which are partially funded by the national government and those are foreign assisted projects. In the context of Davao City, delineation of functions and responsibilities of DPWH is contained in the Department Order 23 of 2015 that provides the policies, guidelines and procedures for the implementation of flood control, drainages/slope protection projects funded and proposed by the national government under the DPWH Infrastructure Program.

The functions of flood control management in Davao City are managed and are under the responsibility of four major department in the City Government namely:

1) City Engineers Office (CEO)

The City Engineer's Office is the engineering arm of the City Government of Davao. Its functions are outlined in Article 7, Section 477 of the Local Government Code.

2) City Disaster Risk Reduction and Management Office (CDRRMO)

The Republic Act 10121 known as the Philippine Disaster Risk Reduction and Management Act of 2010, Section 12 (c-6) mandates the establishment of Local Disaster Risk Reduction and Management Office. The Act authorizes the formulation and implementation of a comprehensive and integrated Local Disaster Risk Reduction and Management.

In the context of Davao City, the City Disaster Risk Reduction Management Office (CDRRMO), together with the relevant stakeholders have initiated the formulation of the Davao City Risk Reduction Management Plan 2017-2022. The plan was prepared on the basis of the flood hazard map, landslide susceptibility map, terrain classification, and liquefaction susceptibility and erosion susceptibility maps.

3) City Planning and Development Office (CPDO)

The City Planning and Coordinator's Office (CPDO) served as the Secretariat for the Legislative Council mandated to formulate the Comprehensive Land Use Plan (CLUP) and the Local Development Council mandated to formulate the Comprehensive Development Plan (CDP). The CPDO is tasked to perform all related development planning matters and planning processes under the Local Government Code.

In the context of flood control management, CPDO has a major role in terms of land use and zoning. Currently, CPDO in coordination with the DENR is formulating the forest land use plan that will provide further guidelines and policies in the utilization and conservation of forest areas. This effort was initiated to magnify the delineation of alienable and disposal land and to focus attention in the strict policies in the utilization of forest areas.

4) City Environment and Natural Resources Office (CENRO)

The CENRO plays a vital role in flood control management in Davao. To date, CENRO is updating its 10 year Integrated Social Waste Management Plan and hopes to address the following concerns of 1) Improvement in the collection and transportation of municipal waste, 2) Improvement in the sanitary land fill, 3) Enhancement in the municipal recycling facilities, 4) Establishment of waste to energy facility and 5) Strengthening education, information and communication program on solid waste management.

2.14.2 Other Related Organizations

(1) Department of Science and Technology (DOST)/PAGASA

The Executive Order No. 128 mandates the Department of Science and Technology (DOST) to "provide central direction, leadership and coordination of scientific and technological efforts and ensure that the results are geared towards the utilization in areas of maximum economic and social benefits for the people".

The DOST host the country's Atmospheric, Geophysical, Astronomical Services Administration (PAGASA) whose functions are to provide adequate, up-to-date data, and timely information on atmospheric, astronomical and other weather related matters in order to help the people and the government prepare for disaster caused by typhoons, landslides, storm surge, extreme climate events, climate change, among others.

(2) Department of Environment and Natural Resources (DENR)

The Department of Environment and Natural Resources (DENR) is the primary agency responsible for the conservation, management, development, and proper use of the country's environment and natural resources, specifically forest and grazing lands, mineral resources, including those in reservation and watershed areas, and lands of the public domain, as well as the licensing and regulation of all natural resources as may be provided for by law in order to ensure equitable sharing of the benefits for the welfare of the present and future generations.

The DENR plays a pivotal role in the conservation and preservation of all major watershed and catchment areas, river basin in the country and in Davao City, it played a proactive role in the protection of the Davao River Basin and launched various efforts in the development and sustainability of river and catchment basin.

(3) National Commission of Indigenous Peoples (NCIP)

The NCIP was established under Republic Act 8371 to protect and promote the interest and well-being of the indigenous peoples. The importance of NCIP in flood control management lies on the fact that majority of the people in the upland areas in Davao belongs to various indigenous groups. Coordinative efforts are essential in order to bring in the indigenous community in mainstreaming them into the discussion of protecting, conserving the watershed areas.

(4) National Water Resources Board (NWRB)

The NWRB, formerly the National Water Resource Council is the primary agency task to manage the water resources in the Philippines. It coordinates and regulates all water related activities in the country that has an effect in the physical environment and economy. It was created to supervise the implementation of the Water Code.

(5) Non-government Organizations

Davao City hosts various developmental NGOs working to protect, conserve and preserve watershed areas.

2.15 Study for Project Evaluation Criteria

2.15.1 General

Project evaluation is conducted to evaluate and select the most appropriate one among the proposed structural and non-structural menus.

(1) Principles

A comprehensive project evaluation reflecting different points of view such as the expected flood protection level, and socio-economic and environmental impacts and others, is conducted to find out the best combination of countermeasures which can enable the achievement of the required flood protection level during the M/P target period.

Since the target and basic principles of countermeasures against River Floods, Rainwater Urban (Inland) Flooding and Storm Surge differ, evaluation axis, criteria and methodology differ.

The common methodology and process are explained in this section.

(2) Methodology and Process

The following figure shows the alternative evaluation process.

Step 1: Proposal of possible Countermeasures (Individual)

By reflecting River Basin Characteristics, Needs and other factors, possible countermeasures (Individual) are proposed.

Step 2: Dismissal of Countermeasures difficult to implement based on “pre-requisites”

Pre-requisites indispensable to implement countermeasures are set and countermeasures which cannot complete those requirements are abandoned.

Step 3: “Schematic” Evaluation

Based on the results of a qualitative schematic evaluation, the advantages and disadvantages of each countermeasures are analyzed, and the most adequate individual countermeasures (2 or 3).

Step 4: Proposal of Combination of Countermeasures

Resulting from the Schematic Evaluation (Step 3), combination of countermeasures is considered and proposed.

Step 5: “Detailed” Evaluation

The comprehensive evaluation of countermeasures is conducted by using quantitative and fair / objective evaluation criteria, as much as possible.

Step 6: Selection of the most adequate countermeasures

The most adequate countermeasures of the Flood Control Plan is selected.

Source: Project Team

Figure 2.15.1 Process of Alternatives Evaluation

2.15.2 Setting of Evaluation Criteria

The evaluation criteria or axis were considered by reviewing: (1) NEDA’s ICC (Investment Coordination Committee) Project Evaluation Procedures and Guidelines (of 2004, revised in 2016), (2) DPWH’s priority project selection criteria, (3) Reports of past flood control projects in the Philippines (such as the preparatory survey for flood risk management project for Cagayan de Oro river (FRIMP-CDOR)), and (4) evaluation criteria used in Japan (such as the ones proposed in September 2010 by the Advisory Committee on the Future Flood Management).

Since (4) covers the items proposed in (1), (2) and (3), the evaluation criteria proposed are basically the ones used in Japan but contextualized into the Philippines’ context.

In addition, as a result of the review of past studies in the Philippines and Japan, there are many cases in which the evaluation criteria are not weighted, and due to the difficulties to justify the weighting, all evaluation criteria are assessed with the same degree of importance.

The following evaluation axis are proposed to assess the countermeasures selected in the M/P. The evaluation results of the M/P are shown in Section 3.15.

Table 2.15.1 Evaluation axis of the M/P

Axis	Explanation
A. Flood Protection Level (Expected damage reduction)	Expected damage reduction, timing when the effects of countermeasures appear are compared.
B. Economic Effectiveness	Total cost, cost for land acquisition and relocation are compared.
C. Feasibility in regards with legal and social restrictions	Scale of land acquisition and relocation, Prospects on the coordination with land owners and other stakeholders are considered.
D. Feasibility from the technical viewpoint to construct countermeasures	In addition to the engineering degree of difficulty, the actual capacities of related agencies in term of human resources, budgetary limitations and others are assessed.
E. Sustainability	By analyzing the actual resources (human and budgetary) allocated to infrastructures' maintenance and renewal, and future possible coordination schemes, issues and rooms for improvement related to countermeasures sustainability are assessed.
F. Flexibility	Flexibility of the countermeasures (such as modifications of structures scale) to deal with future uncertainties (such as sea level rise and changes in rainfall pattern due to Climate Change and High urbanization along rivers and seashore) is considered.
G. Social and Natural Environment Impacts	Based on the SEA results, impacts to society and natural environment are assessed.

Source: Project Team

Chapter 3 Master Plan

3.1 Approach to Master Plan

3.1.1 General

Objectives of the Project are to formulate an integrated flood control master plan covering riverine floods, inland floods and coastal floods for Davao River, Matina River and Talomo River basins, and to conduct feasibility study on urgent and/or priority project(s) for the Davao river.

3.1.2 Premises and Conditions for Master Plan

(1) Target Area

The target areas of the M/P are the Davao City urbanized area, the Davao River Basin with a basin area of 1,755 km^2, the Matina River Basin with a basin area of 70 km^2, and the Talomo River basin with a basin area of 204 km^2. The area of the whole target area is about 2,200 km^2.

(2) Type of Plan

In this Project, in order to formulate the plan for gradually developing optimal flood control measures without reworking, toward the final flood control target / target design level in the target river basins, it is proposed to formulate two phased plans. One plan is a long-term plan to show policy to propose optimal combination of flood control measures targeted at the final design level of floods, will be called "framework plan (F/P)". Another plan is a concrete plan to propose flood control measures to be implemented until a certain target year, which is halfway through the achievement of all the measures targeted at final design level of floods and will be called "master plan (M/P)". In this regard, however in case that measures to be planned in the F/P can be implemented until target year of the M/P, F/P become the same as M/P and will be just called as “M/P”.

(3) Target Year of the Plans

As mentioned in the above (2), in this Project, F/P and M/P will be prepared. F/P will be situated as a future final figure of the basins, therefore, specified target year will not set. Target year will be set only for M/P. The target year for M/P is set to 2045 by the following reason.

(4) Land Use

The present land use condition of Davao City in 2017 and the future land use plan with 2045 as the target year are organized in the Davao City Infrastructure Development Plan and Capacity Building Project (IM4Davao) (2018, JICA). In this Project, while respecting the present land use condition and future land use plan prepared in the IM4Davao as well as referencing new land use plan of CLUP2019-2028 to have been prepared, planning activities will be carried out using those data as basic data.

3.1.3 Characteristics and Issues of Flood Damage

In Davao City, which is located downstream of the target three rivers, existing flood measures of both structural and non-structural measures are not sufficient, and Davao City suffers frequent flood damage. In recent years, flood control by DPWH DCDEOs, which are structural measures mainly consisting of revetment and dikes along rivers, has progressed, but since it was not planned by comprehensively examining the characteristics of the basins, as well as it is in the process of development, flood risk is still high. With regard to inland flooding, damage is remarkable in the Davao city urbanized area, and extensive damage frequently occurs especially in the Poblacion and Agdao areas, which hinders economic activities. On the other hand, no serious damage has been reported due to floods by storm surges and coastal erosion along the coastal area.

3.1.4 Basic Principles for Formulation of Master Plan

Following five basic principles are established for formulation of integrated flood control master plan for the target area.

(1) Formulation of integrated flood control master plan including measures against riverine flooding, inland flooding and coastal flooding by storm surge and coastal erosion

(2) Consideration for Climate Change Adaptation in Planning and Design for Flood Control Structure Structures

(3) Consideration of the optimal combination of structural and non-structural measures based on the evaluation from a broader perspective

(4) Formulation of well-coordinated plan for smooth project implementation based on consensus building among stakeholders

(5) Formulation of a plan that contributes to the revision of related plans as needed while maintaining consistency with existing related plans

Of the above, "Consideration for Climate Change Adaptation" in (2) is noted below.

- **Consideration for Climate Change Adaptation in Planning and Design for Flood Control Structures**

Through discussion with DPWH, PAGASA and other related organizations, it was finally decided that "incorporating into the design" is applied in this Project.

The conditions of climate changes in 2036-2065 which was set as the planning conditions for F/P and M/P with the target year of 2045 are as follows:

- ✓ Mean Temperature: to increase by 1.2 degrees compared to the condition in 2000.
- ✓ Rainfall: the probable rainfall for annual maximum daily rainfall increases by 10% from the climate condition in 2019.
- ✓ Mean sea level: to be 0.2m higher than the level in 2000, and 0.1m higher than the level in 2019.

3.1.5 Basic Concept of Riverine Flood Control Master Plan

(1) Objective of Riverine Flood Control

The objective of the flood control is defined as follows.

To reduce severe damage and loss due to inundation by riverine flood, to secure proper urban function as regional center and to contribute to further proper development

(2) Strategies of Riverine Flood Control

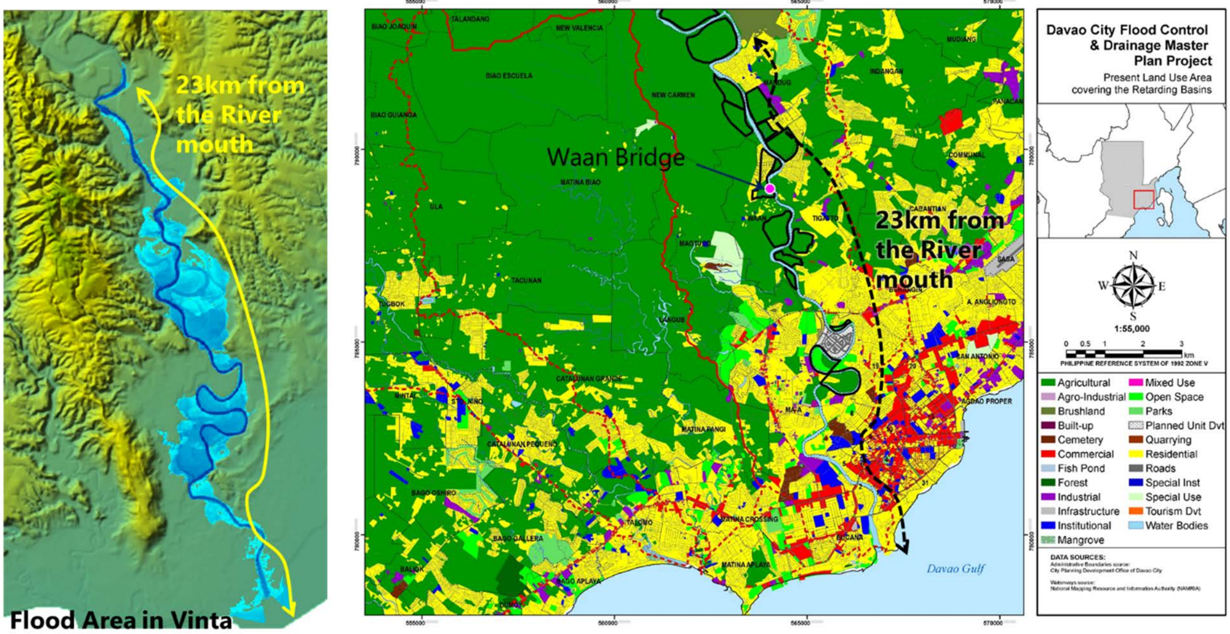
Considering the identified major issues, the strategies to achieve the objective of the riverine flood control are set as follows.

- To implement optimal measures to increase flow capacity of river channel and to increase flood water detention capacity with consistent design level
- To promote non-structural measures to ensure effectiveness of structural measures and to further reduce damage and loss
- To improve entire cycle of planning, design, construction and O&M by capacity enhancement of relevant organizations

On the basis of the strategies, the riverine flood control plan, which consists of structural measures and non-structural measures, is formulated.

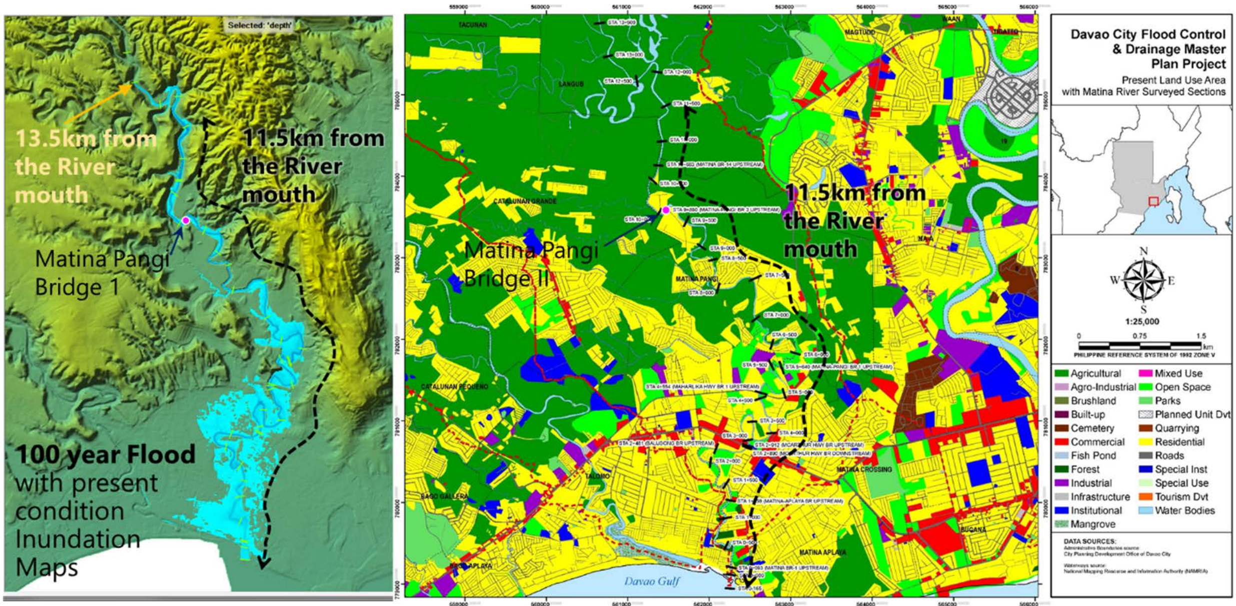
(3) Target Area of Riverine Flood Control Master Plan

In the Master Plan for riverine flood control, structural measures and non-structural measures are proposed targeting at Davao, Matina and Talomo rivers. Structural measures targets at downstream area of each river where is frequently and severely damaged by riverine floods, whereas non-structural measures targets at all river basin areas. Area to be protected by structural measures in each river are shown in Figure 3.1.1 to Figure 3.1.3. These area were identified from inundation records, inundation analysis results, present land use condition, future land use plan, topographic conditions and so on. Area to be protected for Davao river is a section from river mouth to 23km, for Matina river is a section from river mouth to 11.5km and for Talomo river is a section from river mouth to 6km.



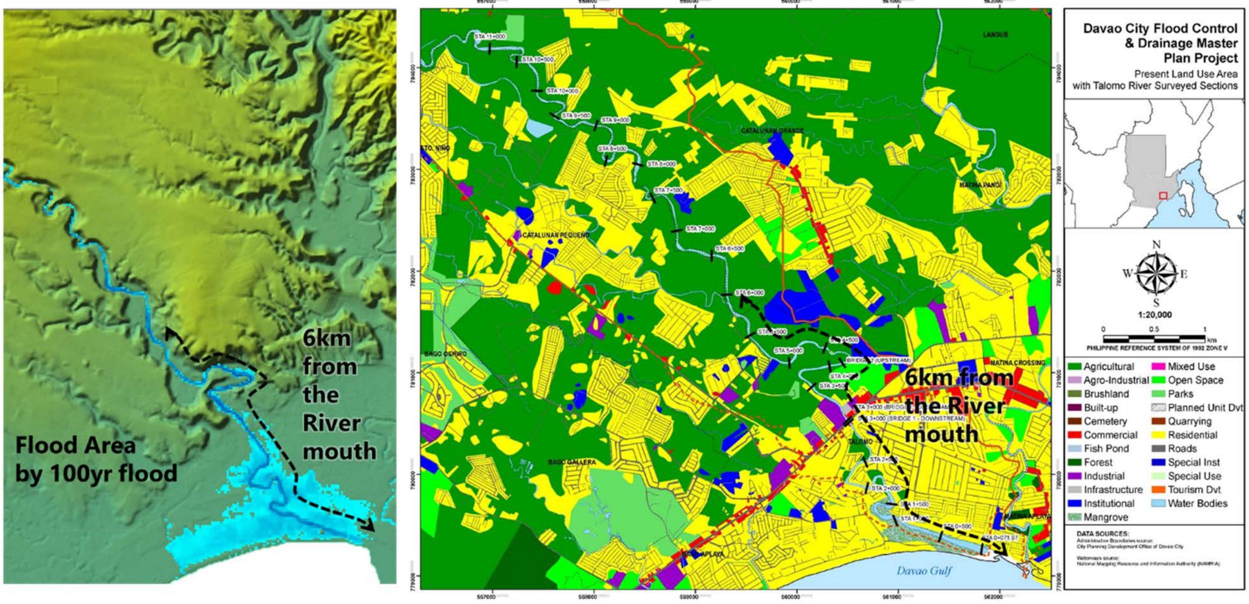
Source: Project Team

Figure 3.1.1 Area to be Protected by Structural Measures in Davao River



Source: Project Team

Figure 3.1.2 Area to be Protected by Structural Measures in Matina River



Source: Project Team

Figure 3.1.3 Area to be Protected by Structural Measures in Talomo River

3.1.6 Basic Concept of Storm Water Drainage Improvement Plan

(1) Objective of Storm Water Drainage Improvement

The objective of the storm water drainage improvement is defined as follows.

To reduce severe damage and loss due to inundation by storm water and to secure proper urban function as regional center

(2) Strategies of Storm Water Drainage Improvement

Considering the identified major issues, the strategies to achieve the objective of the storm water drainage improvement are set as follows.

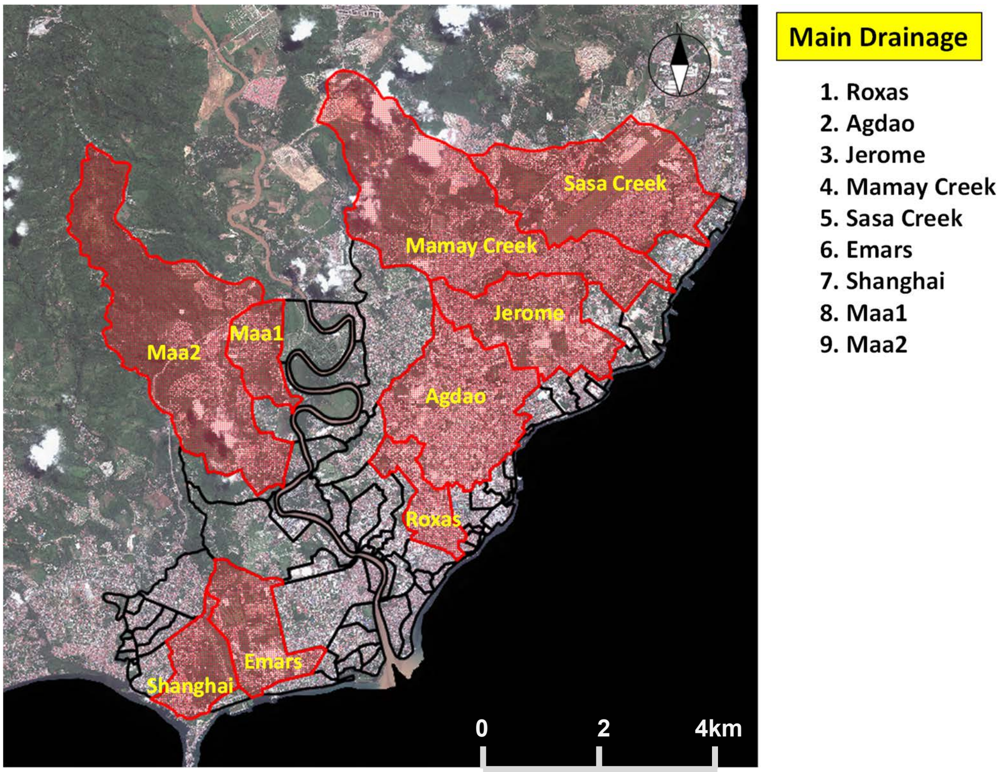
- To upgrade drainage system mainly by securing and enhancing rainwater retarding function
- To secure the original capacity of drainage by proper O&M such as periodic cleaning of drainage channels
- To promote non-structural measures to ensure effectiveness of structural measures and to further reduce damage and loss
- To improve entire cycle of planning, design, construction and O&M by capacity enhancement of relevant organizations

On the basis of the strategies, the storm water drainage improvement plan, which consists of structural measures and non-structural measures, is formulated.

(3) Target Area of Storm Water Drainage Improvement Master Plan

The Master Plan for storm water drainage improvement mainly targets the midtown of Davao City (Poblacion area and its surrounding area) as well as nine main drainage areas shown in Figure 3.1.4. The followings are examined.

- As for the nine main drainage areas, countermeasures for mitigation of inundation caused by overflow from main drainage channels are proposed.
- As for the area where the drainage inventory survey was conducted in the midtown of Davao City, priority areas for mitigating local inundation are identified utilizing the results of inventory survey.



Source: Project Team

Figure 3.1.4 Target Area of Storm Water Drainage Improvement Master Plan

3.1.7 Basic Concept for Coastal Disaster

(1) Objectives of Coastal Disaster Countermeasures

The objectives of the countermeasures against coastal disaster are set as follows.

To reduce the damage caused by coastal inundation and ensure appropriate use of coastal areas according to land use, such as residence and industry

(2) Strategy of Coastal Disaster Countermeasures

In order to achieve the objectives of coastal disaster countermeasures, the strategies for coastal inundation improvement based on the main issues will be set as follows.

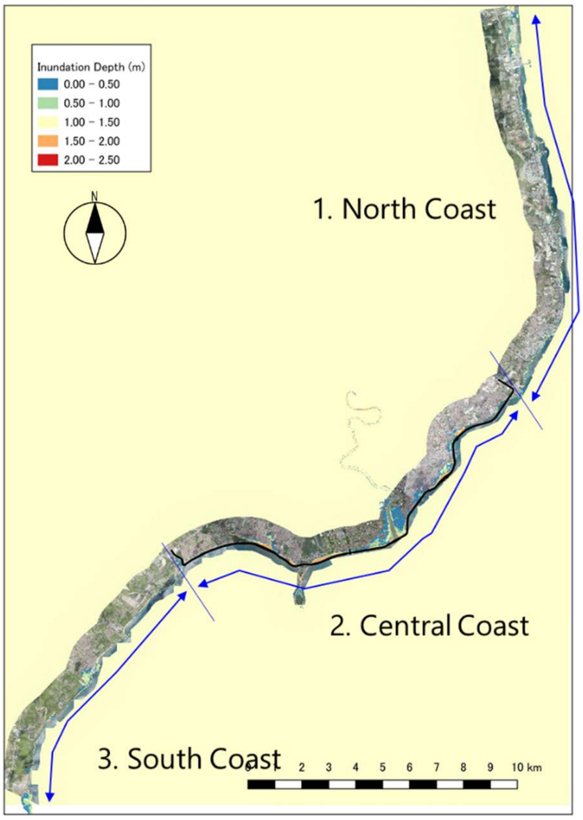
- Development of sequent coastal structures that can protect against inundation (including drainage facilities)
- Promotion of non-structural measures to ensure the effectiveness of structural measures and further reduce damage
- Improvement of the planning, design, construction, and maintenance cycle by enhancement of the capacity of related organizations

Based on this strategy, a series of coastal disaster countermeasure plan including both the structural and non-structural countermeasures is formulated.

(3) Target Area of the M/P of Coastal Disaster

This M/P for Coastal disaster countermeasures proposes coastal inundation countermeasures for the coastal area of Davao City shown in Figure 3.1.5, divided into three areas according to their characteristics.

- There are almost no coastal protection facilities in the northern and southern areas, so flood protection measures will be proposed by installing new coastal protection facilities.
- The central area includes a Coastal Road section, and coastal inundation protection measures will be proposed based on the possibility of sequent protection with Coastal Road.



Source: Project Team

Figure 3.1.5 Target Area of the M/P of Coastal Disaster

3.1.8 Design Guidelines Proposed for Structural Measures

Based on the current situation of design guidelines as confirmed in 2.11.2, design guidelines proposed for the planning and design of structural measures for riverine flood, inland flood (storm water drainage) are summarized as below.

(1) Riverine Flood

For the implementation of the project, items that are not detailed in DGCS's guidelines will be proposed with reference to Japanese design standards listed in Table 3.1.1, as confirmed by DPWH-BOD.

Table 3.1.1 Japanese Codes and Guidelines that may be applied for Riverine Flood

No.	Name of codes and guidelines	Remarks
1	Revised Explanation of Cabinet Order concerning Structural Standards for River Management Facilities, etc: (Japan River Association 1999)	Dam and other structures
2	Technical Standard of Disaster-prevention Regulating Pond, : (Japan River Association 2001)	Retarding Basin
3	Design Mechanics of Revetment, (Japan Institute of Country-ology and Engineering 2007)	Revetment
4	Design and Construction Guidelines for Gabion Pile Up Revetment (Ministry of Construction 1988)	Gabion
5	Design Guidelines for Restoration Works (National Association of Disaster Prevention, 2021)	Sheet Pile
6	Guidelines on Retaining Wall, Handbook for Road Engineering (Japan Road Association 2012)	Floodwall, Gabion Pile-up
7	Technical Criteria for River Works: Practical Guide for Design (MLIT 2021)	Dam

Source：Project Team

(2) Inland Flood

As for design of structure measures against inland flood, items that are not detailed in DPWH's guidelines will be proposed with reference to Japanese design standards, as is also the case with riverine flood. Table 3.1.2 shows Japanese codes and guidelines to be referred, except those already cited for riverine flood.

Table 3.1.2 Japanese Codes and Guidelines that may be applied for Inland Flood

No.	Name of codes and guidelines	Remarks
1	Design Guidelines of Flexible Sluiceway Structure (Japan Institute of Country-ology and Engineering 1998)	Sluice Gate
2	Handbook for Road Engineering, General Outline (Japan Road Association 2009)	All drainage facilities

Source：Project Team

(3) Coastal Flood

For the design of coastal structures, items that are not detailed in DPWH's guidelines will be proposed with reference to Japanese design standards listed in Table 3.1.3, as confirmed by DPWH-BOD.

Table 3.1.3 Japanese Codes and Guidelines that may be referred for Coastal Flood

No.	Name of codes and guidelines	Remarks
1	Technical Standards and Commentaries for Coastal Structures in Japan (National Association of Agriculture and Coast Conservation, National Association of Fisheries infrastructure, National Association of Sea Coast, The Ports and Harbours Association of Japan:2018)	
2	Technical Standards and Commentaries for Port and Harbour Facilities in Japan	

Source：Project Team

3.2 River Boundary

3.2.1 General

This Project proposes setting river boundary with the aims of clarifying river area and conducting proper river management inside clarified river area. This activity will contribute to 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 of land use and development in the river area not to obstruct flood flow, iv) securing necessary construction area for river structures such as dike embankment, flood plain, revetment, sluice gate, etc., and v) preserving natural retarding function of the river and surrounding area of the river.

In this Project, river widening for area to be protected by structural measures and retarding ponds in the upstream and inside of the area to be protected are proposed as major structural measures against riverine flood as described later. In this Project, the river boundary will be examined at following two levels for area to be protected by structural measures and its upstream area based on the proposed plan of structural measures.

Level 1: Within the area to be protected by structural measures, where is determined considering present land use and future land use plan

- To establish river alignment and to clarify area of retarding ponds, and then to set and recommend the river boundary for indicating river area consists of inner area of the river bank and necessary area for river structures like retarding ponds. Easement is assumed to be set outside the river boundary.

Level 2: Upstream area of the area to be protected by structural measures in Davao River

- To identify flood inundation areas along the rivers and to set and recommend the recommended river conservation zone which includes river areas in order to maintain the flood retarding function of river and surrounding river area as natural retarding ponds.

3.2.2 Establishment of River Boundary

Through examination of alternatives of structural measures, optimal alignment and width of river channel was investigated. Then, recommended river boundary was set as an alignment of recommended structural measures. Also, recommended river conservation zone in the upstream area of area to be protected by structural measures in Davao river was set based on the possible inundation area by 100 year scale flood.

3.3 Target Design Level

After examination and discussion with reference to the design level in DGCS, 2015 and DPWH Memorandum for Upgrades on Flood Control and Road Drainage Standards dated on June 21, 2011, it was agreed among related organizations in the Steering Committee meeting held in September 2019 at the end of Stage 1 that the design level of the F/P is set to those as shown in Table 3.3.1. As for M/P, it was agreed in the above Steering Committee meeting that the design level is decided considering the economics and environmental and social impacts.

The design level of M/P which is the results of investigation and discussion with related organizations in Stage 2 is shown in Table 3.3.2. The design level of the M/P finally becomes the same design level as F/P as explained later in Section 3.4.

Table 3.3.1 Design Level for F/P

Flood Type		Design Level to be applied
Flood in 3 rivers【Riverine flood】	Davao River	100-year flood
	Matina River	
	Talomo River	
Inland flood in the city【Inland flood】		for Main Drainage Channel: 25-year flood
Coastal conservation and storm surge measures【Coastal flood】		100 year (corresponding to "Urban Areas" of DGCS)

Source: Project Team

Table 3.3.2 Design Level for M/P

Flood Type		Design Level to be applied
Flood in 3 rivers 【Riverine flood】	Davao River	100-year flood
	Matina River	
	Talomo River	
Inland flood in the city【Inland flood】		for Main Drainage Channel: 25-year flood
Coastal conservation and storm surge measures【Coastal flood】		100 year

Source: Project Team

(1) Peak Discharge of Target Design Level for Three Rivers

Peak discharges of target design level for three rivers to be applied in F/P and M/P were investigated. Table 3.3.3 shows the peak discharge of the target design level of each river at each control point considering the climate change impact.

Table 3.3.3 Peak Discharge of Target Design Level for Each River (Final Target Discharge in this Project under the condition with Impact of Climate Change)

River	Control Point		Target for F/P		Target for M/P	
	Name	Distance from river mouth	Design Level	Peak discharge (m^3/s)	Design Level	Peak discharge (m^3/s)
Davao	Waan Bridge	17km	100-year flood	3,400m^3/s	100-year flood	3,400m^3/s
Matina	Matina Pangi Bridge II	9.9km	100-year flood	440 m^3/s	100-year flood	440 m^3/s
Talomo	Mintal Bridge	13.4km	100-year flood	580 m^3/s	100-year flood	580 m^3/s

Source: Project Team

3.4 Structural Measures of Riverine Flood in Davao River

The examination of alternatives for structural measures (examination of alternatives as a combination plan for structural measures) against riverine flood for Davao, Matina and Talomo rivers was carried out according to the following procedure.

1. As for each assumed structural measure, to examine the scale of a structural measure in case of its independent implementation, including its technical limitations as well as to evaluate each structural measure schematically. This examination aims at basic analysis to examine the selection of flood control methods and the optimal combination of measures in the next step mentioned below.
2. To examine and make alternative plans for the combination of structural measures and examine the optimal combination using the evaluation axis and indicators.

Meanwhile, the discharge amount of target design flood is a basic condition in considering structural measures. Since the design flood discharge was studied using limited hydrological information in this Project, however, target design flood discharge might be revised after fully enhancing and stocking hydrological information in future. In some cases, the target flow rate may be revised. Widening of river channel and construction/heightening of dike, which are alternative measures, have a great impact on the area, therefore it was duly considered when planning of structural measures not to implement widening the river channel or heightening the dike repeatedly in future even if the target design flood discharge is revised.

3.4.1 Examination of Alternatives of Structural Measures for Framework Plan in Davao River

(1) Examination of Individual Flood Control Measure

The examination of individual flood control measure of riverine flood in the Davao River focuses on five types of structural measures which are dike/flood wall, river channel improvement (widening), retarding pond, dam and diversion channel (underground channel) targeting the 100-year flood (3,400 m3/s peak discharge including the impact of climate change).

1) Examination Result of Individual Flood Control Measure

As a result of the examination for five types of individual structural measures, it was found that any of the measures could cope with 100-year flood, but had the following challenges.

- Dike / Flood wall:
  An average height of about 7m and a maximum of about 12m are required. It is a very high dike / flood wall, and the risk is extremely large in case of the dike break.
- Widening:
  It is necessary to widen the present average river width of about 80m to about 210m. The number of affected buildings will be more than 5,000, which has a large social impact.
- Retarding pond & Dam:
  The cost is two to three times as much as dike / flood wall or widening.
- Diversion channel (Underground diversion channel):
  The cost is about ten times as much as retarding pond or dam

Based on the above examination results, it can be judged that each individual flood control measure is difficult to cope with the target design flood discharge by solo implementation of the measure, therefore, it is necessary to examine an optimal combination that can cope with the 100-year flood by considering combination of four types of flood control measures except for diversion channel of which the cost is extremely high.

(2) Examination of Combination of Flood Control Measure

1) Examination of Restriction of Each Structural Measure for Examination of Combination

In the examining of the optimal combination of structural measures, the individual measures were re-examined based on the examination in the previous section.

A. Floodwall

The restriction of the flood wall height is examined. In the examination, the target water level is tried to set lower than the past flood water level so as not to increase the flood risk in the area, which means that the target water level is set to be less than or equal to the actual water level at Vinta, the largest flood in the Davao River since 2000. The water level of Vinta is almost equal to the calculated water level at discharge amount of 1,500 m^3/s. Therefore, the height of flood wall was decided to set to allocate the discharge amount of 1,500 m^3/s at the maximum. In this case, the required flood wall height is 2.7m on average and 6.7m at maximum, including the free board (1.0m).

B. River Improvement (Widening)

The required widening width is examined. As an preliminary examination, the required widening width and the number of affected buildings were estimated by the discharge scales of 2,800 m^3/s, 2,000 m^3/s, and 1,700 m^3/s in case of widening the river at the same distance from the center line of the current river channel to both banks. Considering the number of affected buildings and the easement width at the downstream of the Davao River specified in the Zoning Ordinance of Davao City being 30 m from the bank, the maximum widening width of the river for examination of combination will be set to 25 m on one side (2,000 m^3/s with an average river width of 130 m).

C. Retarding Pond

The analysis of the number of affected buildings, the presence or absence of a development plan, and the present development status in each of the 26 candidate site for retarding pond along the Davao River was conducted. For selecting a specific development site for retarding pond, the priority will be lowered for locations where the number of affected buildings is large or where future development is expected.

D. Dam

The impact on the natural and social environment at the proposed dam site and ponding area was confirmed. As a result, it was confirmed that the ponding area includes restricted areas that may have serious environmental and social impacts.

Regarding this restricted area, the introduction of structures will not be excluded for the purpose of flood control measures, but careful introduction and impact assessment will be required, and it might take considerable time in case the assessment results require measures to mitigate the impact.

2) General Examination of Tendency of Cost of Individual/Combined Implementation of Structural Measures

In the examination of the optimal combination of structural measures, the construction cost (direct construction cost, land acquisition cost, building compensation cost, bridge replacement cost (if necessary) was confirmed, and the tendency was analyzed.

A. Tendency of Measures for Increasing Flow Capacity of River Channel (Tendency for Flood wall and Widening)

As the result of comparison of the construction cost by flood wall and river widening, it can be said that the river widening is inexpensive in case the flood discharge is accommodated only by the river channel.

B. Tendency of Measures for Flood Water Detention Facilities (Tendency of Retarding Pond and Dam (and Diversion Channel)

As the result of comparing the construction cost of the retarding ponds, dam and diversion channel with the scale of each discharge amount, it can be said that retarding ponds are inexpensive if the river channel has a flow capacity of 1,400 m^3/s or more and the remaining discharge amount is accommodated by the detention facility.

C. Tendency of Optimal Flood Discharge Distribution accommodated by River Channel and Flood Water Detention Facility

The optimal distribution of flood discharge by river channel and detention facilities was examined by combining the river widening which is lowest-cost measures among measures accommodated by river channel and the retarding ponds which are lowest-cost measures among detention facilities.

In case the discharge allocated by the river channel is about 1700 m^3/s or more, the total value is gently constant (almost flat). From the viewpoint of cost, it is appropriate to make the river channel allocation more than about 1700 m^3/s.

D. Tendency of Optimal Flood Discharge Distribution accommodated by River Channel and Flood Water Detention Facilities (Other Facilities)

As a comparison, the cost of combining river channel and detention facility using dam or diversion channel was examined. If the entire discharge amount is allocated by the river channel, it is the cheapest compared to the accommodation by dam or diversion channel.

3) Concept of Combination of Structural Measures

In the examination of the optimal combination of structural measures, the following three concepts were set and compared.

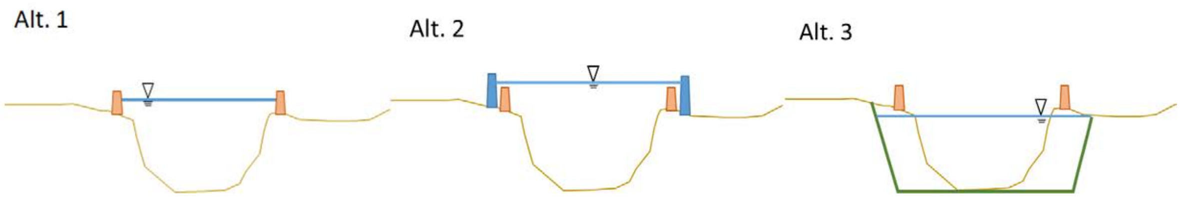
Alt.1: Considering present condition that land use is already highly advanced, priority should be given to minimizing land acquisition and resettlement and to allow floods to flow along present river channel (riverbanks).
By reinforcement works of present dike/revetment works, 3-5 year scale flood will be flowed down by river channel, and **flood water detention facilities** will be installed in the basin in order to secure the target flood control safety level that exceeds 3-5 year scale flood.
HWL is about present dike height or present river bank height.

Alt.2: Considering present condition that land use is already highly advanced, priority should be given to allow floods to flow along present river channel (riverbanks).
By increasing flow capacity by installation of new dike, 5-10 year scale flood will be flowed down by river channel, and **flood water detention facilities** will be installed in the basin in order to secure the target flood control safety level that exceeds 5-10 year scale flood.
HWL about 1.5 m higher than present dike height or present river bank height.

Alt.3: As land use is already highly advanced and its further advancement is expected in the future, priority should be given to maximizing the flow of floods by river channel and minimizing flood risk while keeping HWL low.
By widening width of river channel, 5-15 year scale flood will be flowed down by river channel, and **flood water detention facilities** will be installed in the basin in order to secure the target flood control safety level that exceeds 5-15 year scale flood.
HWL is about present ground level of inland area.

In any combination, dredging needs to be implemented for the purpose of rapid improving river flow capacity.

Figure 3.4.1 shows a comparison of the design cross sections of the above three policies. Looking at the planned high water level of the three policies, Alt.2 is the highest and Alt.3 is the lowest. The difference between them will be about 3m, which is depending on locations.



Source: Project Team

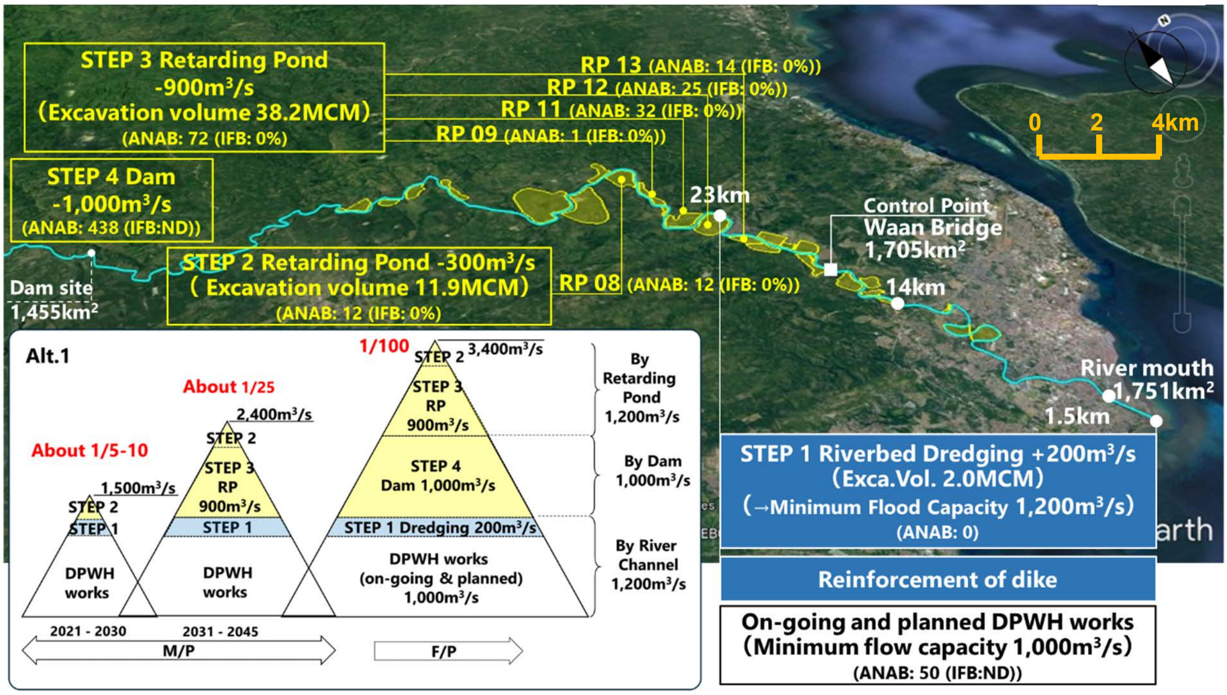
Figure 3.4.1 Comparison of Cross Section of Each Concept

4) Alt.1: Combination of Reinforcement of Present Dike and Flood Water Detention Facilities

For Alt.1, respecting the existing, ongoing and planned river works by DPWH DEO I (hereinafter referred to as “DEO works”), a certain level of flood control safety is ensured by reinforcement works in places where the flow capacity is insufficient due to the lack of DEO works, river channel dredging and introduction of water detention facilities.

For the target design flood discharge of 3,400 m3/s, the flow capacity of the river channel will be increased up to 1,000 m3/s by the reinforcement work, and 200 m3/s will be secured by the dredging, then the remaining discharge amount 2,200 m3/s will be accommodated by the detention facilities. In this examination of Alt.1, four kinds of combinations of dike reinforcement, river channel dredging, and water detention facilities were set and compared.

Figure 3.4.2 shows the implementation schedule and the facility plan, of which is the recommended combination of Alt.1 as the result of the above examination of comparison of four kinds of combinations. The cost of the recommended combination of Alt.1, which includes direct construction cost, land acquisition cost and compensation cost for building, is estimated at 38 Billion Php and affected building number is about 600, respectively.



Note: ANAB: Assumed Number of Affected Buildings, IFB: Informal Building, ND: No data

Source: Project Team

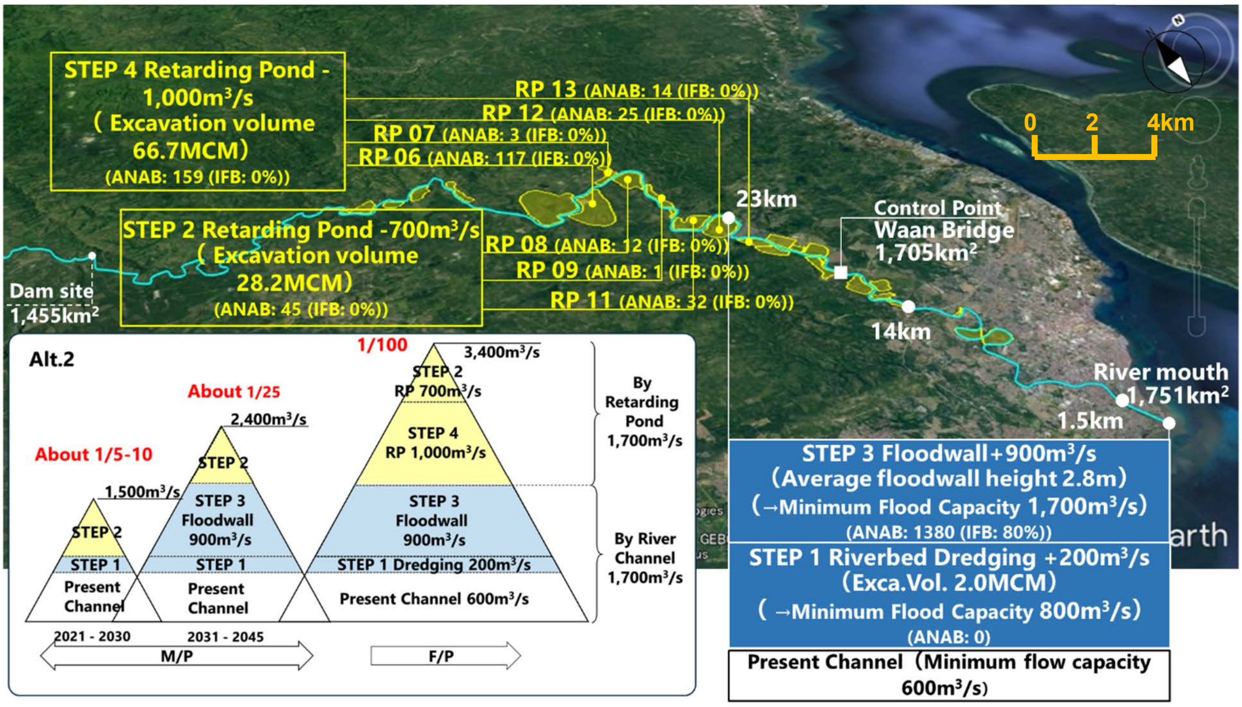
Figure 3.4.2 Facility Plan of Alt.1

5) Alt.2: Combination of New Dike and Flood Water Detention Facilities

For Alt.2, a certain level of flood control safety is ensured by newly constructed flood wall, river channel dredging and water detention facilities.

The flow capacity of the river channel will be increased from the current capacity 600 m^3/s to 1,500 m^3/s by the newly constructed flood wall, and 200 m^3/s will be secured by the dredging, then the remaining discharge amount 1,700 m^3/s will be accommodated by the detention facilities. In this examination of Alt.2, four kinds of combinations of new flood wall construction, river channel dredging, and water detention facilities were set and compared.

Figure 3.4.3 shows the implementation schedule and the facility plan, of which is the recommended combination of Alt.2 as the result of the above examination of comparison of four kinds of combinations. The cost of the recommended combination of Alt.2, which includes direct construction cost, land acquisition cost and compensation cost for building, is estimated at 36 Billion Php and affected building number is about 1,600, respectively.



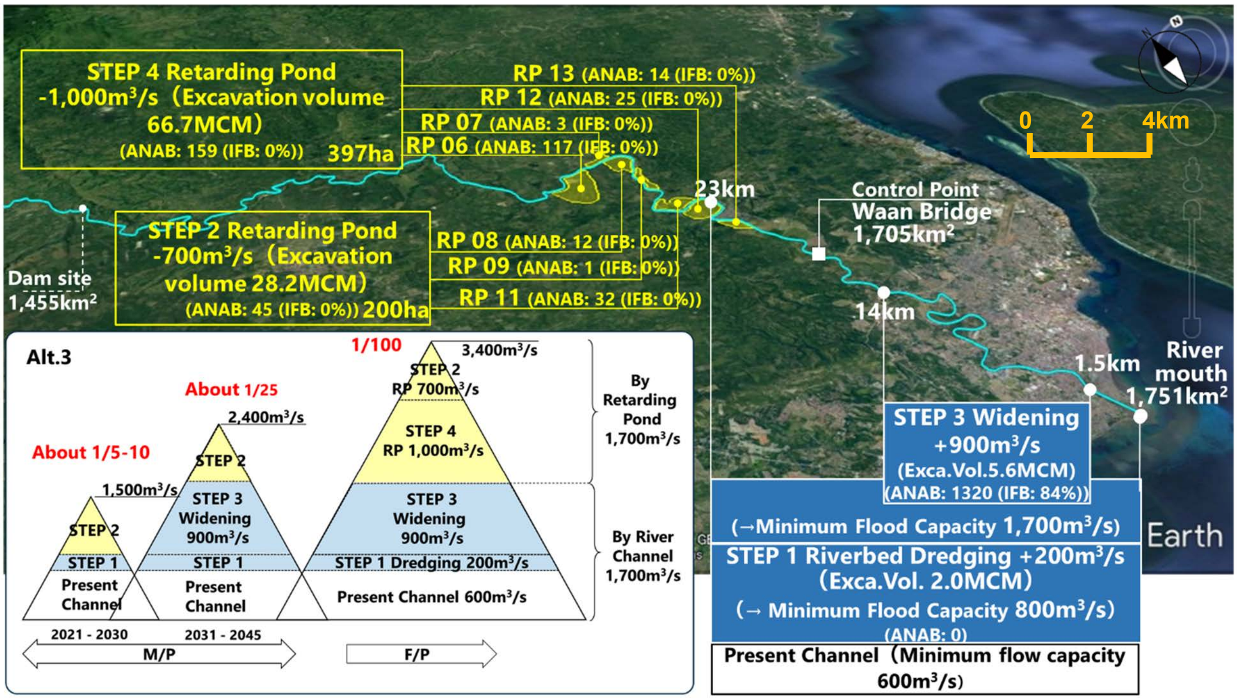
Note: ANAB: Assumed Number of Affected Buildings, IFB: Informal Building, ND: No data
Source: Project Team

Figure 3.4.3 Facility Plan of Alt.2

6) Alt.3: Combination of River Widening and Flood Water Detention Facilities

For Alt.3, a certain level of flood control safety is ensured by river widening, dredging and water detention facilities. The flow capacity of the river channel will be increased from the current capacity 600 m3/s to 1,700 or 2,000 m3/s by the river widening and dredging, and the remaining discharge amount 1,700 or 1,400 m3/s will be accommodated by the detention facilities. In this examination of Alt.3, four kinds of combinations of river widening, dredging, and water detention facilities were set and compared.

Figure 3.4.4 shows the implementation schedule and the facility plan, of which is the recommended combination of Alt.3 as the result of the above examination of comparison of four kinds of combinations. The cost of the recommended combination of Alt.3, which includes direct construction cost, land acquisition cost and compensation cost for building, is estimated at 28 Billion Php and affected building number is about 1,600, respectively.



Note: ANAB: Assumed Number of Affected Buildings, IFB: Informal Building, ND: No data
Source: Project Team

Figure 3.4.4 Facility Plan of Alt.3

7) Optimal Combination of Structural Measures for F/P

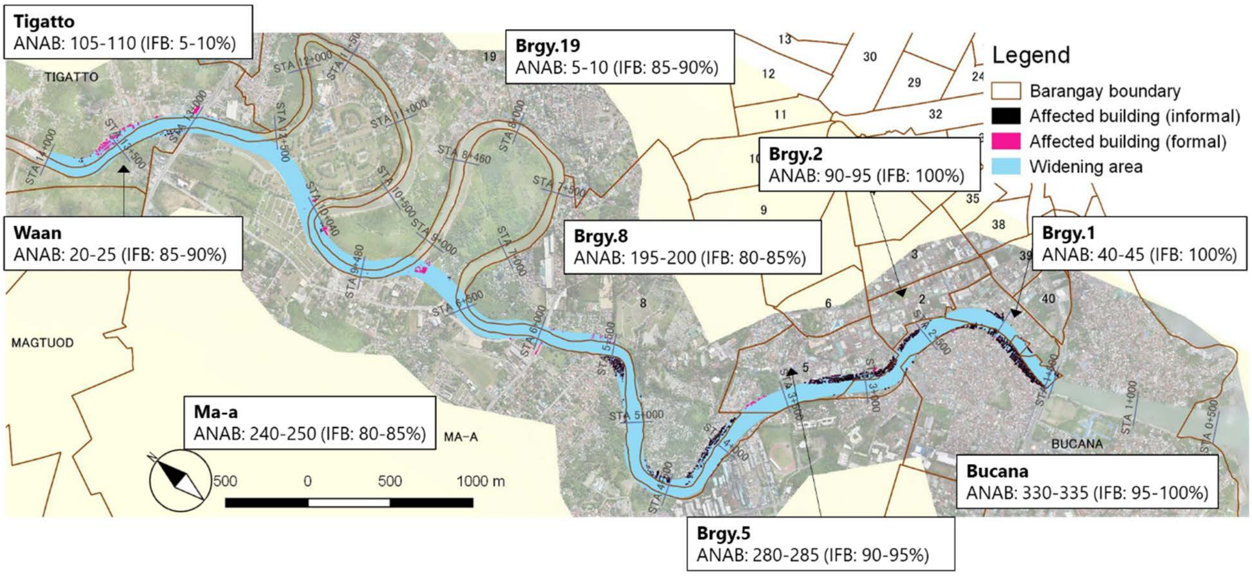
Comparing the recommendations of Alt.1 to Alt.3, the recommendation of Alt.3 is the cheapest. In addition, as for Alt.3, the river channel can accommodate 10-year flood, and in the unlikely event that large-scale floods occur continuously, it is more advantageous for river channels to have a large flow capacity. Furthermore, the risk (water level rise) at the time of flood occurrence including the worst case flood exceeding the target design level can be minimized, and the burden on operation and maintenance is reduced. Taking into account the above things, Alt.3 is recommended.

Regarding the river mouth, in any case of Alt.1 to Alt.3, the structure of MSL + 3.0m (design high tide level 1.53m + wave component about 1.0m + free board about 0.5m) as countermeasures against storm surge and waves (a flood wall along the river at the same height as the storm surge dike) is required.

For this dike at the river mouth, it was not included in the F/P since the construction of the dike and promenade downstream of the Bolton Bridge is currently being constructed by DPWH DEO (planned to be connected to the coastal road).

8) Detailed Examination for River Widening Works of Alt.3

In Alt.3, which is recommended as the optimal combination plan, relocation in urban areas will be a major issue. Distribution of affected buildings and assumed number of affected buildings by barangay are shown in Figure 3.4.5. A supplementary explanation of the content of the measures in Alt.3, and a measure to promote smooth relocation is described as below.



Note: ANAB: Assumed Number of Affected Buildings, IFB: Informal Building
Source: Project Team

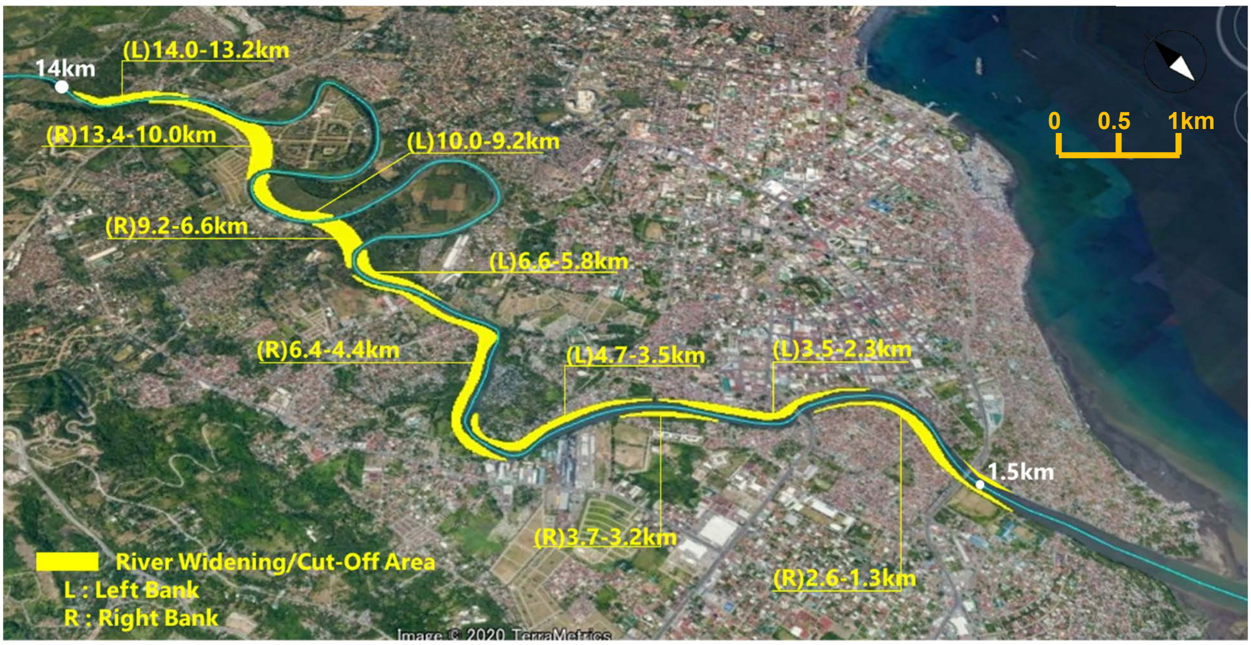
Figure 3.4.5 Distribution of Affected Buildings and Assumed Number of Affected Buildings by Barangay

A. Examination of River Alignment and Construction Method for River Widening Works

In the examination of the widening, the optimal alignment was examined by combining cut-off works, with reference to the Open space / Easement along the river tentatively indicated in CLUP 2019-2028, which is currently being prepared by Davao City.

One-sided widening work is recommended considering minimization of the volume of works, utilization of the existing/ongoing dike and revetment, and reducing the number of affected buildings.

Figure 3.4.6 shows the layout of one-sided widening works.



Source: Project Team

Figure 3.4.6 Alignment of River Widening Works (Sections of Cut-off Works and One-sided Widening Works)

B. Utilization of Present River Channel after Cut-off Works

The section from 6.5km to 12.5km from the river mouth which is located downstream side of the crocodile park is a meandering section. In the widening work, this section will be a cut-off section. By cutting off this section, the existing river channel can be used for other purposes. In this Project, it is proposed that the existing river channel will be used as a relocation site for resettlements generated by the project implementation. Further examination for utilization of the existing river channel is described in Section 3.17.

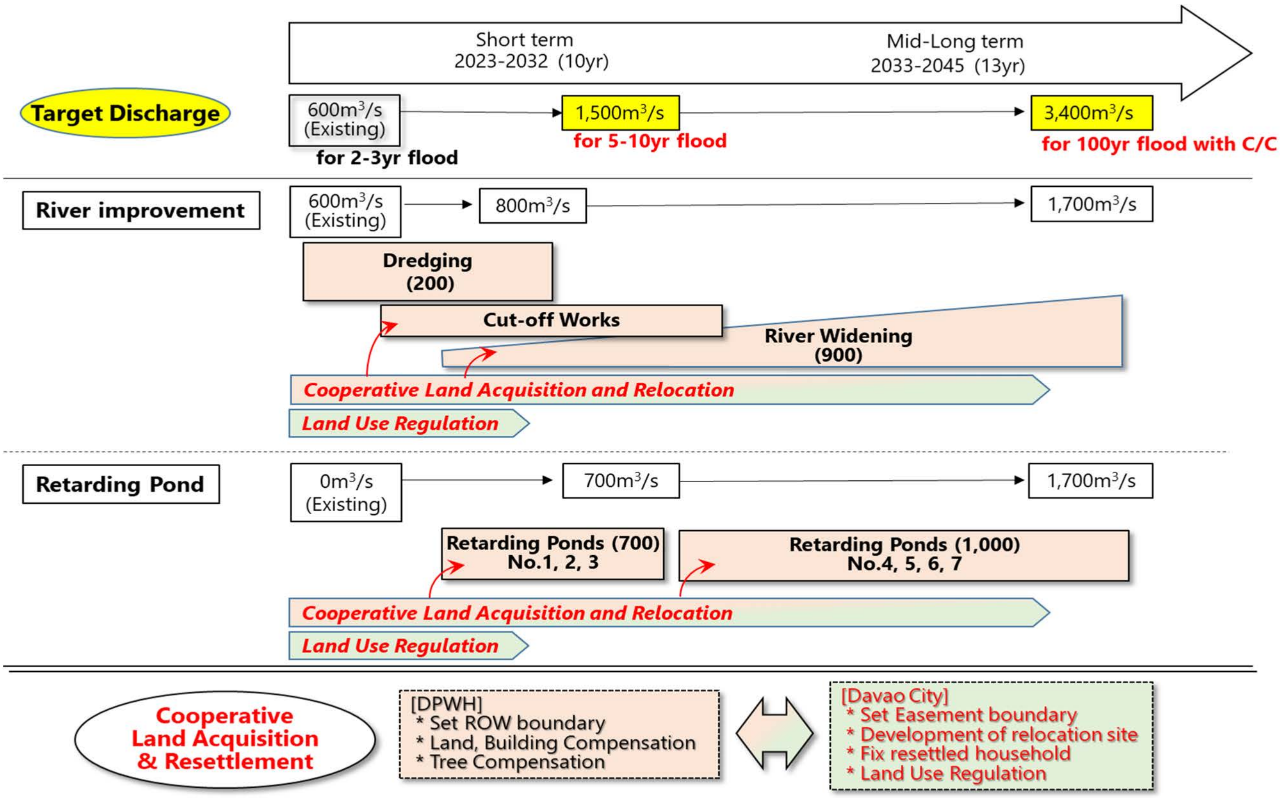
C. Other Proposals for Promoting Resettlement

In order to promote relocation, group relocation to the vicinity of the proposed measures-implemented area and vertical relocation (construct multi-story residential buildings near the relocation site) can be also considered.

If these measures allow for a smooth relocation, it is desirable to implement all the flood control measures as early as possible for rapid production of effect.

The implementation schedule is shown in Figure 3.4.7, as the short-term project, improvement of riverbeds (river dredging) and development of retarding ponds will be carried out while implementing measures related to resettlement such as the creation of resettlement sites by the cut-off works, and all related measures such as widening and the remaining retarding ponds projects will be implemented within the period of the master plan. The facility layout is the same as Figure 3.4.4.

If construction works can be carried out in the process shown in Figure 3.4.7, it will be possible to create a safe city that can cope with 100-year flood within the M/P stage. In this case, the target of F/P can be achieved within the target period of the M/P, that is, the M/P and the F/P will be the same.



Source: Project Team

Figure 3.4.7 Implementation Schedule of Alt.3 in case of Early-Stage Implementation of River Widening Works

3.4.2 Examination of Master Plan

Based on the examination in Section 3.4.1, structural measures for riverine flood control M/P in the Davao River will be a combination of widening (including dredging and cut-off works prior to widening) and retarding ponds, as shown in Table 3.4.1.

Table 3.4.1 Riverine Flood Control Master Plan in Davao River (Structural Measures)

	Short-Term Measures	Mid-Long Term Measures
Implementation Period (Target Year)	2023-2032 (2032)	2033-2045 (2045)
Design Level	5-10 year scale flood	100 year scale flood
Design Flood Discharge	1,500m^3/s	3,400m^3/s
Target Area	From river mouth to 23km	ditto
Measures	・Dredging (from river mouth to 23km ・Cut-off works ・Installation of retarding ponds	・River widening (from Bolton bridge to 14km) ・Installation of retarding ponds
Project Cost (Financial Cost)	11.58 billion Php	37.15 billion Php (including short-term measures)
Project Cost (Economic Cost)	10.54 billion Php	33.90 billion Php (including short-term measures)
Economic Evaluation (EIRR)	18.54%	15.55% (including short-term measures)
Economic Evaluation (ENPV) (Discount rate: 10%)	18.40 billion Php	17.44 billion Php (including short-term measures)
Economic Evaluation (B/C) (Discount rate: 10%)	2.042	1.509 (including short-term measures)

Source: Project Team

As described in Section 3.16, the short-term measures in Table 3.4.1 were selected as priority projects, and the detailed examination was conducted in the Stage 3: Feasibility study for Priority Projects mentioned in Chapter 4. As a result of the examination, the project cost and economic evaluation of the Short-Term Measures were reviewed, and the project cost and economic evaluation of the Mid-Long Term Measures were also reviewed with reference to the examination result of the Short-Term Measures. Table 3.4.2 shows the results of the review based on the examination of Stage 3.

Table 3.4.2 Riverine Flood Control Master Plan in Davao River (Structural Measures) (Revised)

	Short-Term Measures	Mid-Long Term Measures
Project Cost (Financial Cost)	21.60 billion Php	60.35 billion Php (including short-term measures)
Project Cost (Economic Cost)	20.24 billion Php	56.55 billion Php (including short-term measures)
Economic Evaluation (EIRR)	15.32 %	15.37 % (including short-term measures)
Economic Evaluation (ENPV) (Discount rate: 10%)	9.99 billion Php	12.98 billion Php (including short-term measures)
Economic Evaluation (B/C) (Discount rate: 10%)	1.895	1.728 (including short-term measures)

Source: Project Team

The details of the above measures in Table 3.4.1 are shown in Table 3.4.3.

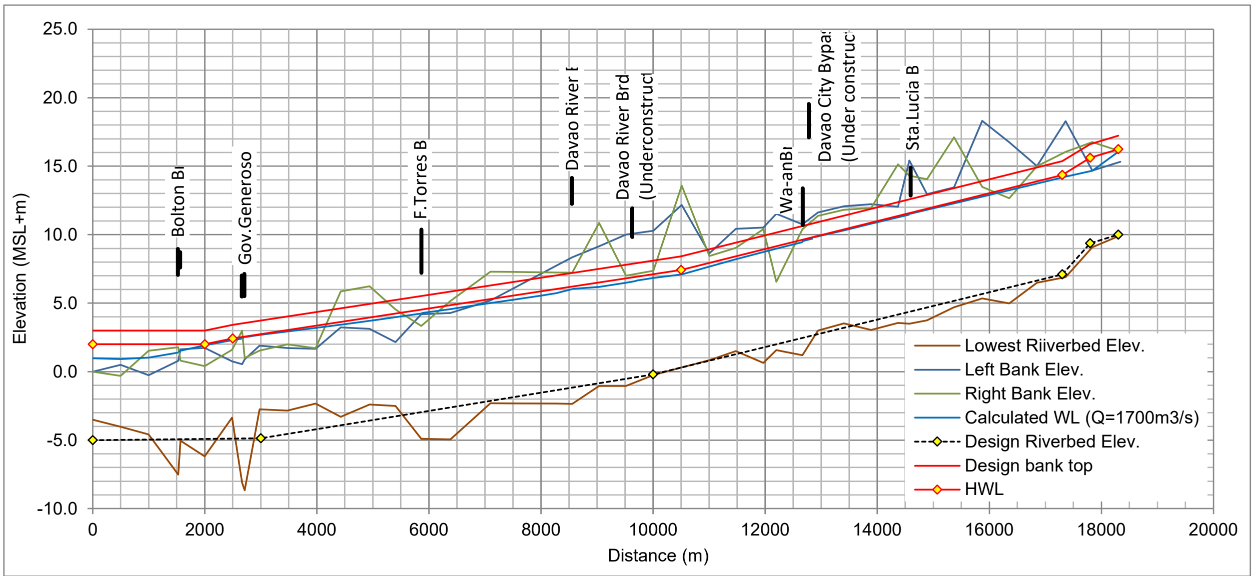
Table 3.4.3 Details of Structural Measures in Davao River

Item	Content
Short-Term Measures	
Dredging	Target Section: From river mouth to 23km Dredging Volume: 2 million m3

Item	Content
Cut-off works	Target Section: 6+500 – 12+700
Installation of Retarding Ponds	Number of Retarding Ponds to be Installed: 3 Location (Distance from river mouth & bankside): 29.0km (Right bank), 27.2km (Left bank), 23.8km (Left bank) Area: 200ha in total Excavation Volume: 28.2 million m3 in total
Mid-Long Term Measures	
River Widening	Target Section: From Bolton bridge to 14km Widening Width: Riverbed width 96.4m, Water depth about 7.2m, Width between top of riverbanks about 110.8m Shape of Cross Section: Inverted trapezoid with slope of 1:1 Excavation Volume: 5.6 million m^3 Number and Name of Bridges to be Replaced: 2 bridges (F. Torres bridge (6k), Davao river bridge (13.0k))
Installation of Retarding Ponds	Number of Retarding Ponds to be Installed: 4 Location (Distance from river mouth & bankside): 32.2km (Right bank), 31.0km (Left bank), 21.8km (Right bank), 20.2km (Right bank) Area: 397ha in total Excavation Volume: 66.7 million m3 in total

Source: Project Team

The design longitudinal profile of the Davao River (design riverbed elevation and HWL) is shown in Figure 3.4.8.



Source: Project Team

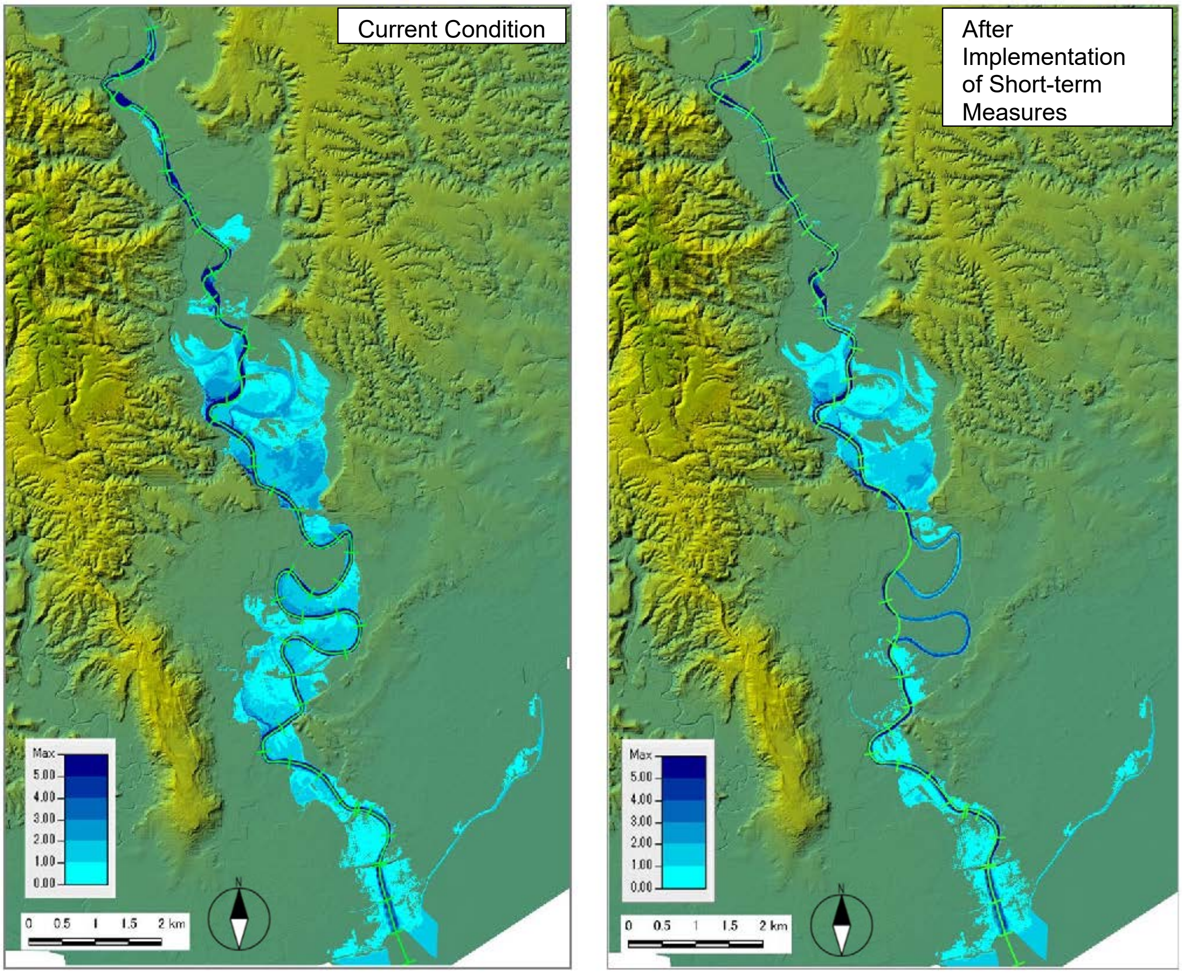
Figure 3.4.8 Longitudinal Profile of Davao River with Design Riverbed and HWL in M/P

After the short-term measures and mid-long term measures shown in Table 3.4.1 are implemented, area to be protected in the Davao River can expect to become basically safe for 100 year scale flood as shown in Table 3.4.4.

After only the short-term measures shown in Table 3.4.1 are implemented, area to be protected in the Davao River not only becomes basically safe for a flood discharge of 1,500 m3/s (5-10 year scale flood), but also can expect a certain degree of damage reduction even in occurrence of higher scale floods.

Figure 3.4.9 and Table 3.4.4 show the inundation condition of the current condition and after implementation of short-term measures with various scale floods. Reduction of inundation area is more remarkable in case of the smaller scale floods such as the 10 year scale flood, whereas reduction of inundation area can be confirmed also in the case of 100 year scale flood.

It can be said that the areas where flooding has stopped after the implementation of the measures are where flood risk is greatly reduced. Although it is premised that the measures will be implemented, these areas can be prioritized from the viewpoint of flood risk when promoting regional development in the future. It is expected that the results of this study will be reflected and utilized in a development plan and a future plan in the Davao City.



Source: Project Team

Figure 3.4.9 Comparison of Inundation Condition with 10 year Scale Flood between Current Condition and after Implementation of Short-Term Measures in Davao River

Table 3.4.4 Comparison of Inundation Condition between Current Condition and after Implementation of Short-Term Measures and Mid-Long Term Measures in Davao River (Inundation Area and Number of Inundated Buildings)

Flood scale	Inundation Area (ha) (more than 0.10m inundation depth)			Number of Inundated Buildings (hundred buildings) (more than 0.10m inundation depth)		
	Present Condition	After Short-term Measures	After Mid-Long term Measures	Present Condition	After Short-term Measures	After Mid-Long term Measures
100 year	624	571	0	260.6	253.3	0
50 year	573	508	0	246.0	228.1	0
25 year	500	418	0	211.5	186.3	0
10 year	413	232	0	171.0	109.4	0

Source: Project Team

3.5 Structural Measures of Riverine Flood in Matina River

Examination of the structural measures for the Matina River will be implemented in the same manner as for the Davao River.

3.5.1 Examination of Alternatives of Structural Measures for Framework Plan in Matina River

(1) Examination of Individual Flood Control Measure

The examination of individual flood control measure of riverine flood in the Matina River focuses on four types of structural measures which are dike/flood wall, river channel improvement (widening), retarding pond and dam, excluding diversion channel (underground channel) which was obviously disadvantaged in terms of cost in consideration of the Davao River, targeting the 100-year flood.

1) Examination Result of Individual Flood Control Measure

Challenges and Evaluations for the individual flood control measures are summarized as follows.

- Dike / Flood wall: The cost is the largest among the four measures, and the number of affected buildings is also the largest.
- Widening: The number of affected buildings is more than half of the dike / flood wall, and the cost is about one third of the dike / flood wall.
- Retarding pond: The individual measure could not cope with 100-year flood even if all candidate sites could be developed.
- Dam: The individual measure could not cope with 100-year flood. The cost is about twice as the widening.

Based on the above, there are restrictions and limitations in any of the individual measures, and a combination of measures is required as examined in the below.

(2) Examination of Combination of Flood Control Measure

1) Examination of Restriction of Each Structural Measure for Examination of Combination

In the examining of the optimal combination of structural measures, the individual measures were re-examined based on the examination in the previous section.

A. Retarding pond

The analysis of the number of affected buildings and the presence or absence of a development plan in each of the 26 candidate sites for retarding pond along the Matina River was conducted.

Almost all of the candidate sites on the Matina River are planned as development areas. For selecting a specific development site for retarding pond, since there is no significant difference in conditions, priority will be given to places where the area is large and where one project can be expected to have a high effect, and the upstream area where the expected effect is as large as possible.

B. Dam

Through the examination of the impact on the natural and social environment at the dam site and ponding area, it was confirmed that restricted areas that could have serious social and environmental impacts are not included in the ponding area for the dam site in the Matina River basin.

2) General Examination of Tendency of Cost of Individual/Combined Implementation of Structural Measures

In the examination of the optimal combination of structural measures, the construction cost was confirmed, and the tendency was analysed.

A. Tendency of Measures for Increasing Flow Capacity of River Channel (Tendency for Flood wall and Widening)

As the result of comparison of the construction cost by flood wall and river widening, it can be said that the river widening is inexpensive about 1/3 to 1/2 in case the flood discharge is accommodated only by the river channel.

B. Tendency of Measures for Flood Water Detention Facilities (Tendency of Retarding Pond and Dam)

As the result of comparing the construction cost of the retarding ponds and dam, it can be said that retarding ponds are much inexpensive compared with dam as the detention facility.

C. Tendency of Optimal Flood Discharge Distribution accommodated by River Channel and Flood Water Detention Facility

The optimal distribution of flood discharge by river channel and detention facilities was examined by combining the river widening which is lowest-cost measures among measures accommodated by river channel and the retarding ponds which are lowest-cost measures among detention facilities. As the result, in case the discharge allocated by the river channel is about 270 to 350 m^3/s, the total value is gently constant (almost flat).

3) Concept of Combination of Structural Measures

In the examination of the Davao River, the combination of widening and retarding pond was the cheapest. In the unlikely event that large-scale floods occur continuously, it is more advantageous for river channels to have a large flow capacity. Furthermore, the risk (water level rise) at the time of flood occurrence including the worst case flood exceeding the target design level can be minimized, and the burden on operation and maintenance is reduced. Taking into account the above things, the combination of widening and retarding pond was recommended. All of the above conditions apply to the Matina River, so that the combination of widening and retarding pond is recommended for the structural measures in the Matina River.

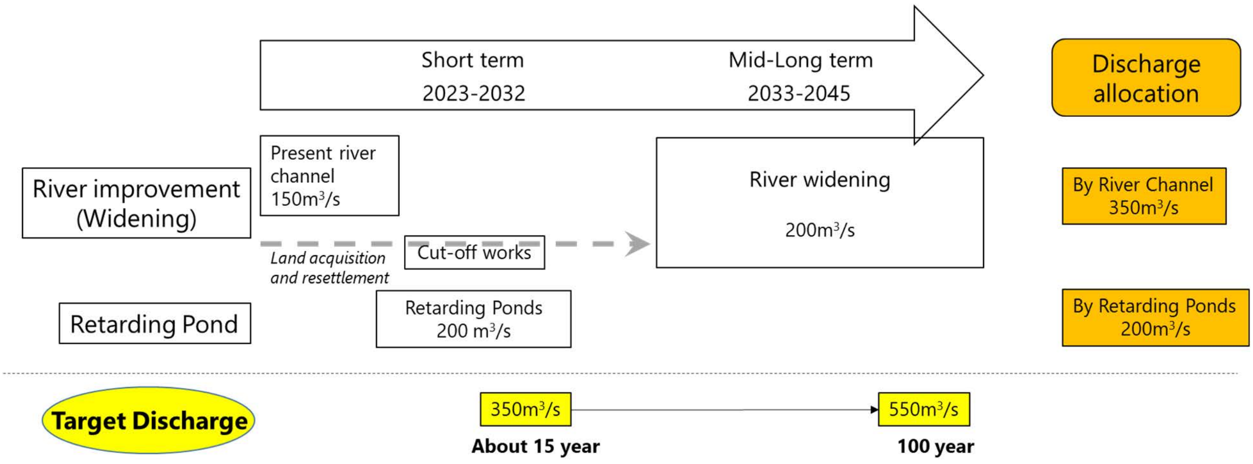
As described in the cost comparison in 2) above, in the combination of widening and retarding pond, it is advantageous to increase the flow capacity of the river channel to about 350 m3/s by widening, and to accommodate the rest at the retarding ponds.

Based on the scale of the required retarding ponds, the ease of inflow and outflow of the flood flow (long shape along the river channel), the inflow from the hinterland and tributaries, and the integration of the candidate retarding ponds, the optimal combination of widening and retarding ponds was examined. Table 3.5.1 shows the scale of the combination, cost and number of affected buildings. Figure 3.5.1 and Figure 3.5.2 show the implementation schedule and the facility plan. It will be possible to create a safe city that can cope with 100-year flood within the M/P stage by 2045. Therefore, the target of F/P can be achieved within the target period of the M/P, that is, the M/P and the F/P will be the same.

Table 3.5.1 Combination of Alternatives in Matina River

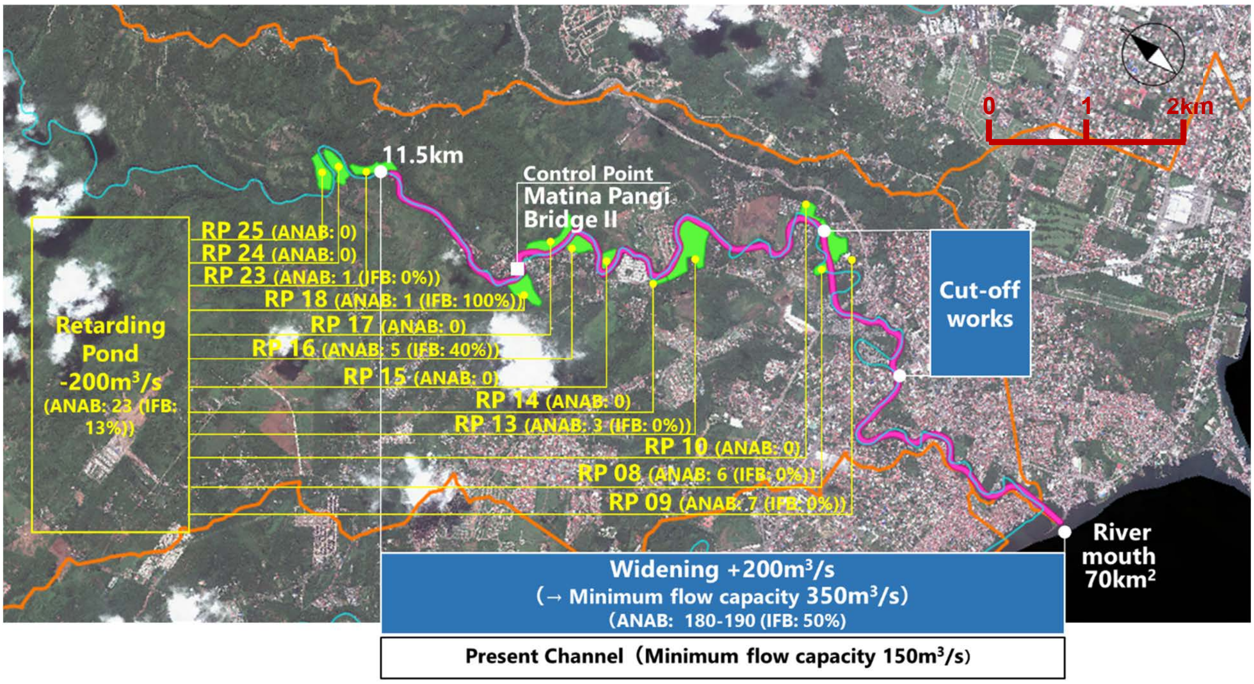
Combination of Structural Measures		Cost (Billion Php)	Affected buildings (Number)
Widening (Number of Bridge Replacement)	Retarding Pond		
350m^3/s = 150 m^3/s (present capacity) + 200 m^3/s (widening) (6 Bridges) (6m (3m each) widening in average)	200m^3/s (12 Regarding Ponds (No.8, 9, 10, 13, 14, 15, 16, 17, 18, 23, 24&25))	2.1 (1.6+0.5)	210

Source: Project Team



Source: Project Team

Figure 3.5.1 Preliminary Implementation Schedule in Matina River



Note: ANAB: Assumed Number of Affected Buildings, IFB: Informal Building

Source: Project Team

Figure 3.5.2 Facility Plan in Matina River

Regarding the river mouth, the structure of MSL+3.0m (design high tide level 1.53m + wave component about 1.0m + free board about 0.5m) as countermeasures against storm surge and waves (a flood wall along the river at the same height as the storm surge dike) is required.

This flood wall at the river mouth will be introduced in accordance with the widening work and will be installed on both banks for about 1 km from the river mouth. The cost is estimated at 0.4 Billion Php.

3.5.2 Examination of Master Plan

Based on the examination in Section 3.5.1, structural measures for riverine flood control M/P in the Matina River will be a combination of widening and retarding ponds, as shown in Table 3.5.2.

Table 3.5.2 Riverine Flood Control Master Plan in Matina River (Structural Measures)

	Short-Term Measures	Mid-Long Term Measures
Implementation Period (Target Year)	2023-2032 (2032)	2033-2045 (2045)
Design Level	15 year scale flood	100 year scale flood
Design Flood Discharge	$350m^3/s$	$550m^3/s$
Target Area	From river mouth to 11.5km	ditto
Measures	・Cut-off works ・Installation of retarding ponds (Twelve locations)	・River widening (from river mouth to 11.5km) ・Flood wall at river mouth
Project Cost (Financial Cost)	1.26 billion Php	3.58 billion Php (including short-term measures)
Project Cost (Economic Cost)	1.15 billion Php	3.28 billion Php (including short-term measures)
Economic Evaluation (EIRR)	14.91%	11.06 % (including short-term measures)
Economic Evaluation (ENPV) (Discount rate: 10%)	2.35 billion Php	1.71 billion Php (including short-term measures)
Economic Evaluation (B/C) (Discount rate: 10%)	1.73	1.12 (including short-term measures)

Source: Project Team

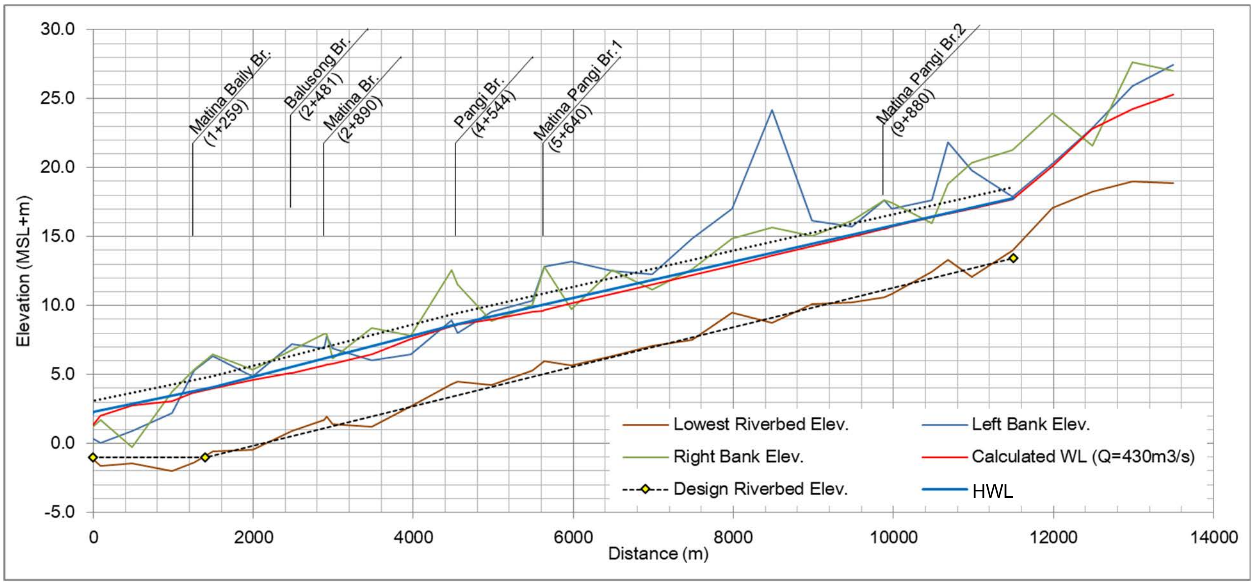
The details of the above measures are shown in Table 3.5.3.

Table 3.5.3 Details of Structural Measures in Matina River

Item	Content
Short-Term Measures	
Cut-off works	Target Section: 2+900 – 5+900
Installation of Retarding Ponds	Number of Retarding Ponds to be Installed: 12 Location (Distance from river mouth & bankside): 12.2km (Left bank), 11.8km (Right bank), 11.4km (Left bank), 9,9km (Right bank), 9.8km (Left bank), 9.0km (Right bank), 8.5km (Left bank), 8.0km (Right bank), 7.8km (Right bank), 6.0km (Left bank), 5.6km (Left bank), 5.3km (Left bank) Area：33ha in total Excavation Volume: 2.3 million m^3 in total
Mid-Long Term Measures	
River Widening	Target Section: From river mouth to 11.5km Widening Width: Riverbed width 22.8m, Water depth about 4.5m, Width between top of riverbanks about 33.4m Shape of Cross Section: Inverted trapezoid with slope of 1:1 Excavation Volume: 1.4 million m^3 Number and Name of Bridges to be Replaced: 3 bridges (Balusong Bridge (2.5k), Matina Br. (2.9k), Matina Pangi Br.2 (9.9k))
Installation of Flood Wall at river mouth	Target Distance: From river mouth to about 1.0km Height of Flood Wall: MSL+3.0m

Source: Project Team

The design longitudinal profile of the Matina River (design riverbed elevation and HWL) is shown in Figure 3.5.3.



Source: Project Team

Figure 3.5.3 Longitudinal Profile of Matina River with Design Riverbed and HWL in M/P

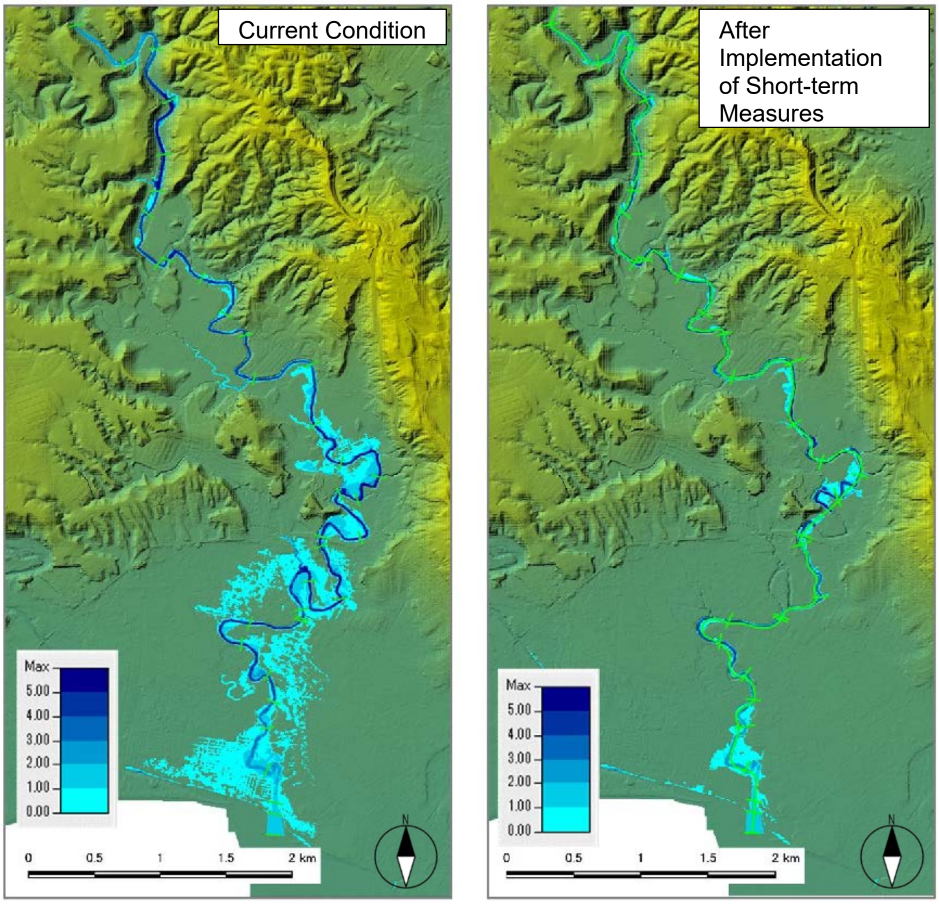
After the short-term measures and mid-long term measures shown in Table 3.5.2 are implemented, area to be protected in the Matina River can expect to become basically safe for 100 year scale flood as shown in Table 3.5.4.

After only the short-term measures shown in Table 3.5.2 are implemented, area to be protected in the Matina River not only becomes basically safe for a flood discharge of 350 m3/s (about 15 year scale flood), but also can expect a certain degree of damage reduction even in occurrence of higher scale floods. Figure 3.5.4 and Table 3.5.4 show the inundation condition of the current condition and after implementation of short-term measures with various scale floods. Remarkable reduction of inundation area can be confirmed in all the cases.

Table 3.5.4 Comparison of Inundation Condition between Current Condition and after Implementation of Short-Term Measures and Mid-Long Term Measures in Matina River (Inundation Area and Number of Inundated Buildings)

Flood scale	Inundation Area (ha) (more than 0.10m inundation depth)			Number of Inundated Buildings (hundred buildings) (more than 0.10m inundation depth)		
	Present Condition	After Short-term Measures	After Mid-Long term Measures	Present Condition	After Short-term Measures	After Mid-Long term Measures
100 year	108	42	0	40.3	11.5	0
50 year	101	28	0	37.7	6.4	0
25 year	71	20	0	25.8	4.7	0

Source: Project Team



Source: Project Team

Figure 3.5.4 Comparison of Inundation Condition with 25 year Scale Flood between Current Condition and after Implementation of Short-Term Measures in Matina River

3.6 Structural Measures of Riverine Flood in Talomo River

3.6.1 Examination of Alternatives of Structural Measures for Framework Plan in Talomo River

(1) Examination of Individual Flood Control Measure

The examination of individual flood control measure of riverine flood in the Talomo River focuses on four types of structural measures which are dike/flood wall, river channel improvement (widening), retarding pond and dam, excluding diversion channel (underground channel) which was obviously disadvantaged in terms of cost in consideration of the Davao River, targeting the 100-year flood.

1) Examination Result of Individual Flood Control Measure

Challenges and evaluations for the individual flood control measures are summarized as follows.

- Dike / Flood wall: The cost is about four times as the widening, and the number of affected houses is the largest among the four measures.
- Widening: The number of affected buildings is more than half of the dike / flood wall, and the cost is about a quarter of the dike / flood wall.
- Retarding pond: The individual measure could not cope with 100-year flood even if all candidate sites could be developed.

- Dam: The individual measure could not cope with 100-year flood. The cost is about nine times as the widening.

Based on the above, there are restrictions and limitations in any of the individual measures, and a combination of measures is required as examined in the below.

(2) Examination of Combination of Flood Control Measure

1) Examination of Restriction of Each Structural Measure for Examination of Combination

In the examining of the optimal combination of structural measures, the individual measures were re-examined based on the examination in the previous section.

A. Retarding Pond

The analysis of the number of affected buildings and the presence or absence of a development plan in each of the 15 candidate sites for retarding pond along the Talomo River was conducted.

For selecting a specific development site for retarding pond, since there is no significant difference in conditions, priority will be given to places where the area is large and where one project can be expected to have a high effect, and the upstream area where the expected effect is as large as possible.

B. Dam

Through the examination of the impact on the natural and social environment at the dam site and ponding area, it was confirmed that restricted areas that could have serious social and environmental impacts are not included in the ponding area for the dam site in the Talomo River basin.

2) General Examination of Tendency of Cost of Individual/Combined Implementation of Structural Measures

In the examination of the optimal combination of structural measures, the construction cost was confirmed, and the tendency was analysed.

A. Tendency of Measures for Increasing Flow Capacity of River Channel (Tendency for Flood wall and Widening)

As the result of comparison of the construction cost by flood wall and river widening, it can be said that the river widening is inexpensive about 1/3 or less in case the flood discharge is accommodated only by the river channel.

B. Tendency of Measures for Flood Water Detention Facilities (Tendency of Retarding Pond and Dam)

As the result of comparing the construction cost of the retarding ponds and dam, it can be said that retarding ponds are much inexpensive compared with dam as the detention facility.

C. Tendency of Optimal Flood Discharge Distribution accommodated by River Channel and Flood Water Detention Facility

The optimal distribution of flood discharge by river channel and detention facilities was examined by combining the river widening which is lowest-cost measures among measures accommodated by river channel and the retarding ponds which are lowest-cost measures among detention facilities. As the result, in case the discharge allocated by the river channel is about 580 to 690 m^3/s, the total value is gently constant (almost flat), and the case of 650 m^3/s is the cheapest.

3) Concept of Combination of Structural Measures

All of the conditions for combinations in the examinations in the Davao River and the Matina River can be applied to the Talomo River, so that the combination of widening and retarding pond is recommended for the structural measures in the Talomo River.

As described in the cost comparison in 2) above, in the combination of widening and retarding pond, it is advantageous to increase the flow capacity of the river channel to about 580 m3/s by widening, and to accommodate the rest at the retarding ponds.

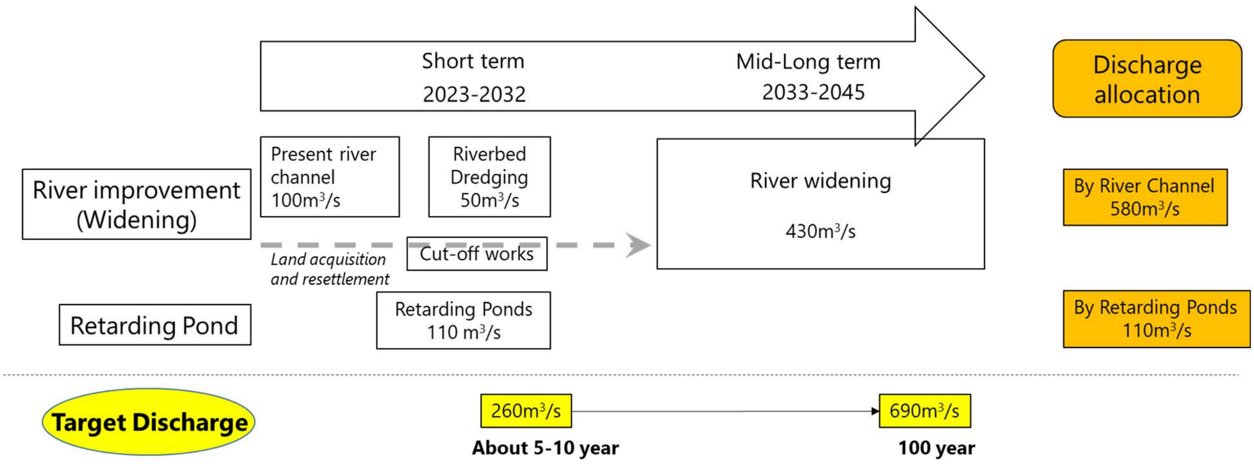
Based on the scale of the required retarding ponds, the ease of inflow and outflow of the flood flow (long shape along the river channel), the inflow from the hinterland and tributaries, and the integration of the candidate retarding ponds, the optimal combination of widening and retarding ponds was examined.

Table 3.6.1 shows the scale of the combination, cost and number of affected buildings. Figure 3.6.1 and Figure 3.6.2 show the implementation schedule and the facility plan. It will be possible to create a safe city that can cope with 100-year flood within the M/P stage by 2045. Therefore, the target of F/P can be achieved within the target period of the M/P, that is, the M/P and the F/P will be the same.

Table 3.6.1 Combination of Alternatives in Talomo River

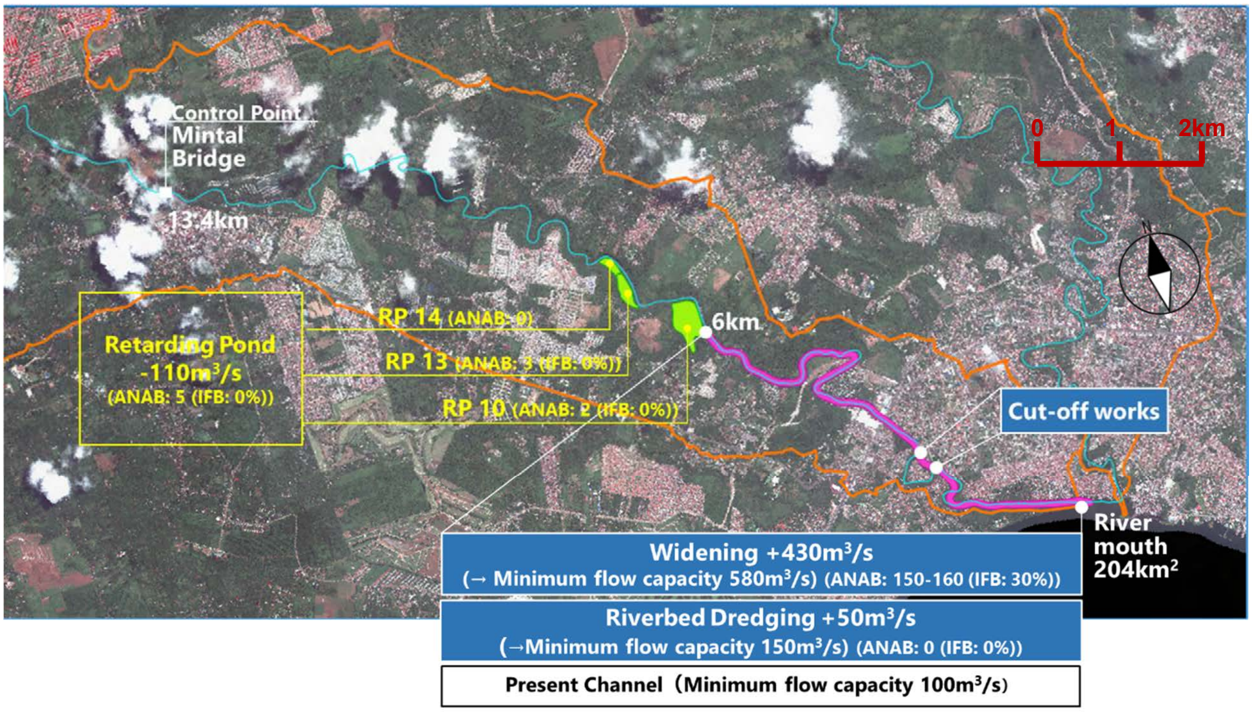
Combination of Structural Measures		Cost * (Billion Php)	Affected buildings (Number)
Widening (Number of Bridge Replacement)	Retarding Pond		
$580m^3/s$ = 100 (present capacity) + 50 (dredging) + 430 (widening) (1 Bridges) (9m (4.5m each) widening in average)	$110m^3/s$ (3 Regarding Ponds (No.11, 13&14))	1.3 ((0.1+0.9)+0.3)	160

Source: Project Team



Source: Project Team

Figure 3.6.1 Preliminary Implementation Schedule in Talomo River



Note: ANAB: Assumed Number of Affected Buildings, IFB: Informal Building

Source: Project Team

Figure 3.6.2 Facility Plan in Talomo River

Regarding the river mouth, the structure of MSL+3.0m as countermeasures against storm surge and waves is required. This flood wall at the river mouth will be introduced in accordance with the widening work and will be installed on both banks for about 2 km from the river mouth. The cost is estimated at 0.06 Billion Php.

3.6.2 Examination of Master Plan

Based on the examination in Section 3.6.1, structural measures for riverine flood control M/P in the Talomo River will be a combination of widening and retarding ponds, as shown in Table 3.6.2.

Table 3.6.2 Riverine Flood Control Master Plan in Talomo River (Structural Measures)

	Short-Term Measures	Mid-Long Term Measures
Implementation Period (Target Year)	2023-2032 (2032)	2033-2045 (2045)
Design Level	5-10 year scale flood	100 year scale flood
Design Flood Discharge	260m^3/s	690m^3/s
Target Area	From river mouth to 6.0km	ditto
Measures	・Dredging (from river mouth to 6.0km) ・Cut-off works ・Installation of retarding ponds (Three locations)	・River widening (from river mouth to 6.0km) ・Flood wall at river mouth
Project Cost (Financial Cost)	0.60 billion Php	1.66 billion Php (including short-term measures)
Project Cost (Economic Cost)	0.54 billion Php	1.52 billion Php (including short-term measures)
Economic Evaluation (EIRR)	16.52%	14.93% (including short-term measures)

	Short-Term Measures	Mid-Long Term Measures
Economic Evaluation (ENPV) (Discount rate: 10%)	0.99 billion Php	1.19 billion Php (including short-term measures)
Economic Evaluation (B/C) (Discount rate: 10%)	1.91	1.59 (including short-term measures)

Source: Project Team

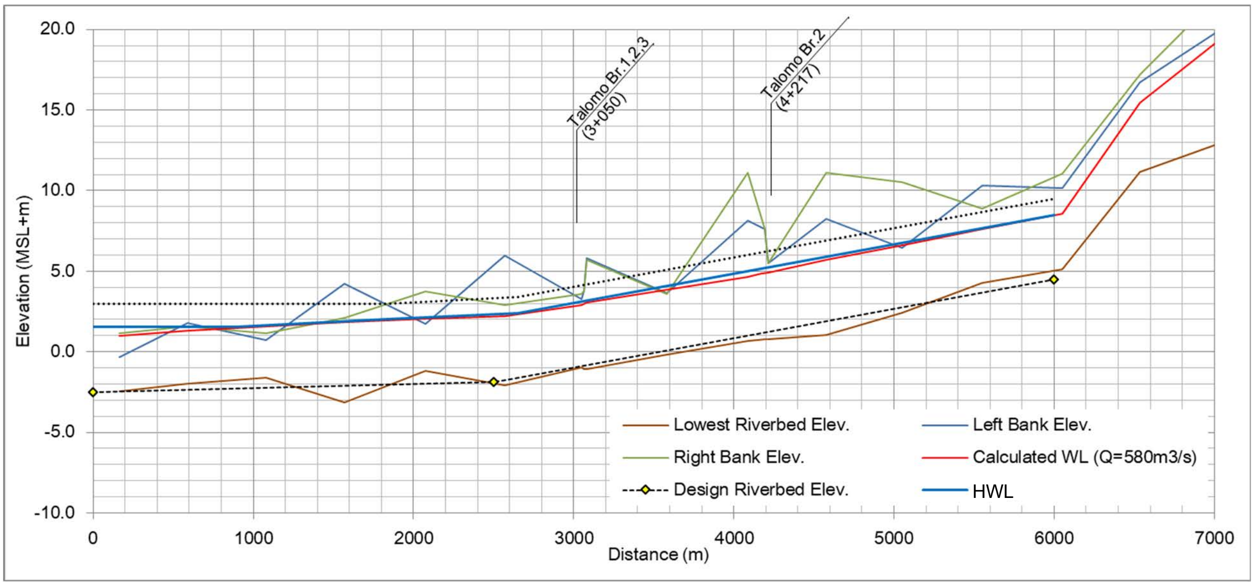
The details of the above measures are shown in Table 3.6.3.

Table 3.6.3 Details of Structural Measures in Talomo River

Item	Content
Short-Term Measures	
Dredging	Target Section: From river mouth to 6.0km Dredging Volume: 0.2 million m^3
Cut-off works	Target Section: 1+800 – 2+600
Installation of Retarding Ponds	Number of Retarding Ponds to be Installed: 3 Location (Distance from river mouth & bankside): 7.2km (Right bank), 6.9km (Right bank), 5.5km (Right bank) Area: 12ha in total Excavation Volume: 12.3 million m^3 in total
Mid-Long Term Measures	
River Widening	Target Section: From river mouth to 6.0km Widening Width: Riverbed width 41.0m, Water depth about 4.0m, Width between top of riverbanks about 51.0m Shape of Cross Section: Inverted trapezoid with slope of 1:1 Excavation Volume: 0.8 million m^3 Number and Name of Bridges to be Replaced: 1 bridge (Talomo Bridge 1,2,3 (3k))
Installation of Flood Wall at river mouth	Target Distance: From river mouth to about 2.0km Height of Flood Wall: MSL+3.0m

Source: Project Team

The design longitudinal profile of the Talomo River (design riverbed elevation and HWL) is shown in Figure 3.6.3.



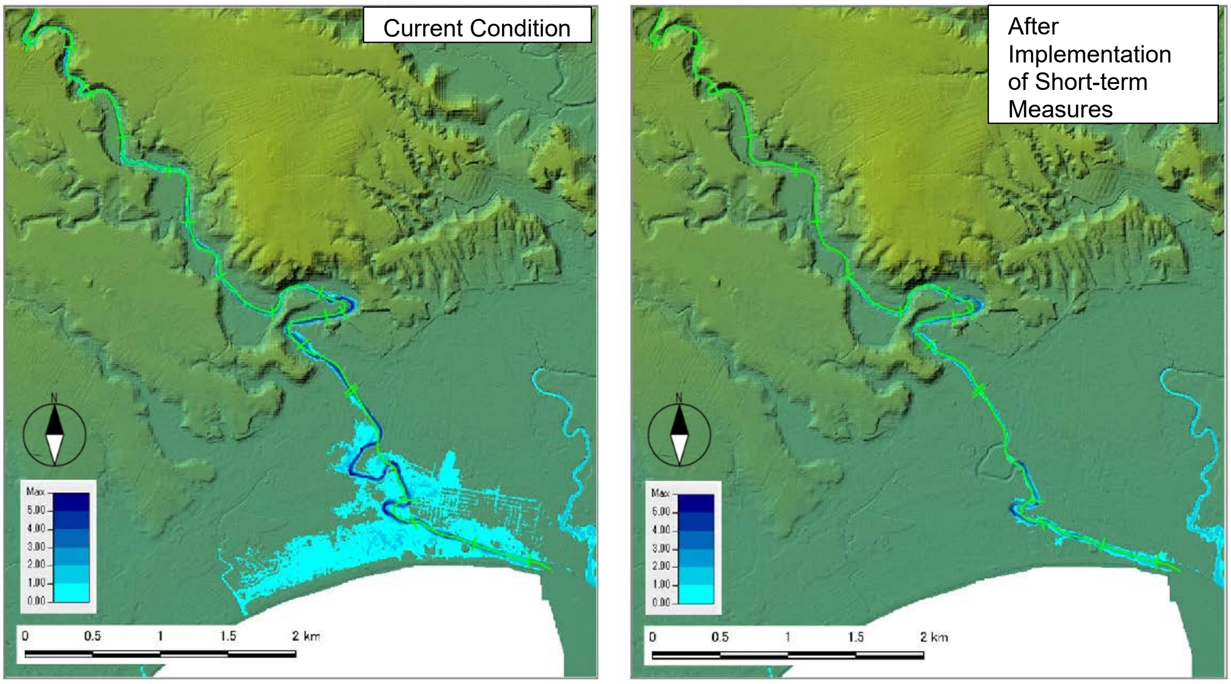
Source: Project Team

Figure 3.6.3 Longitudinal Profile of Talomo River with Design Riverbed and HWL in M/P

After the short-term measures and mid-long term measures shown in Table 3.6.2 are implemented, area to be protected in the Talomo River can expect to become basically safe for 100 year scale flood as shown in Table 3.6.4.

After only the short-term measures shown in Table 3.6.2 are implemented, area to be protected in the Talomo River not only becomes basically safe for a flood discharge of 260 m3/s (5-10 year scale flood), but also can expect a certain degree of damage reduction even in occurrence of higher scale floods.

Figure 3.6.4 and Table 3.6.4 show the inundation condition of the current condition and after implementation of short-term measures with various scale floods. Reduction of inundation area is more remarkable in case of the smaller scale floods such as the 10 year scale flood, whereas reduction of inundation area can be confirmed also in the case of 50 year scale flood.



Source: Project Team

Figure 3.6.4 Comparison of Inundation Condition with 10 year Scale Flood between Current Condition and after Implementation of Short-Term Measures in Talomo River

Table 3.6.4 Comparison of Inundation Condition between Current Condition and after Implementation of Short-Term Measures and Mid-Long Term Measures in Talomo River (Inundation Area and Number of Inundated Buildings)

Flood scale	Inundation Area (ha) (more than 0.10m inundation depth)			Number of Inundated Buildings (hundred buildings) (more than 0.10m inundation depth)		
	Present Condition	After Short-term Measures	After Mid-Long term Measures	Present Condition	After Short-term Measures	After Mid-Long term Measures
100 year	128	118	0	59.5	53.7	0
50 year	126	90	0	58.3	39.3	0
25 year	107	11	0	49.6	6.5	0
10 year	56	1	0	24.8	1.1	0

Source: Project Team

3.7 Structural Measures of Storm Water Drainage Improvement

3.7.1 Outline of Structural Measures

(1) Menu of Structural Measures

1) General

The storm water drainage improvement is largely divided into the following two categories; a) Measures to flow runoff faster by improving flow capacity of drainage channel, and b) Measures to reduce discharge in drainage channel by installing rainwater storage facilities along drainage channel and/or in catchment area.

Although the drainage channel does not have enough capacity for severer extreme events, the space for channel widening is quite limited. In addition, the natural rainwater runoff retarding function is decreasing, and its recovery is an important task. Considering these, the strategy is set to upgrade drainage system mainly by securing and enhancing rainwater runoff retarding function.

The channel improvement is prioritized if it is available. However, the installation of rainwater storage facilities is considered in the case that the channel improvement is difficult though the existing capacity is not enough.

2) Outline of Rainwater Runoff Storage Facilities

The structure of the rainwater storage facilities is largely divided into on-site storage and off-site storage by the way of storing rainwater. The on-site storage catches rainwater at which rainfall occurs or with least movement of water after rainfall. On the other hand, the off-site storage stores the rainwater after runoff is concentrated to drainage channels.

Among the above-mentioned facilities, the on-site storage which is installed at around houses and commercial facilities in green area, parking area or underground is usually planned with the development plan for residential and/or commercial area. Thus, this type is not the target of project implemented by DPWH RO/DEO. It is also difficult to install the storage facilities after the development works have been completed.

The application of the off-site storage facilities is examined as alternative structural measures for improving storm water drainage, in consideration of condition of catchment area of storm water drainage such as availability of vacant space, landuse along existing drainage channel and constrains for land acquisition. For all drainage areas, combination of different type of structure measures is examined, considering constrains in environment and available land space.

(2) Hydraulic Conditions for Structural Measures

The hydraulic conditions for examining alternative structural measures are as follows.

1) Design High Water Level for Main Drainage Channel

In order to minimize the backwater effect to lateral drainage channels, the design high water level is set at the bank level in principle, except for the portion where there is existing dykes.

The reach where extreme high tide and flood level in Davao River affect to the water level in the drainage channel, the influence is separately considered to set the design high water level.

2) Downstream Boundary Condition of Hydraulic Calculation

The downstream boundary condition for hydraulic calculation is given as follows.

- At Davao Gulf: MHHW=0.98m (Mean higher high water level relative to the mean sea level during 1970-1988 with climate change considered)
- At Davao River: Free flow with uniform flow assumption

3) Channel Roughness

The following Manning's coefficients for channel roughness are assumed.

- Improved Open Channel: 0.025
- Natural or Unimproved Open Channel: 0.03 – 0.04
- Closed channel and culvert: 0.015

3.7.2 Alternative Structural Measures for Framework Plan

The Framework Plan is a long-term target without setting a target year. As the Framework Plan for the main drainage channel in the main drainage areas, the measures to prevent overflow from the main drainage channel for the extreme storm event with 25 year return period are examined.

Examination for alternative structural measures was carried out by each of the main drainage areas. An example of the examination in Roxas drainage area is presented below.

(1) Roxas Drainage Area

1) Characteristics of Drainage Area and Causes of Inundation

The Roxas drainage area is located at the center of Poblacion district., and it drains to Davao Gulf. The drainage area is 1.40km^2. The characteristics of the Roxas drainage area are shown in Table 3.7.1.

Table 3.7.1 Characteristics of Roxas Drainage Area

Drainage Area (km^2)	1.40
Average Slope of Drainage Area (%)	0.60
Total Length of Main Drainage Channel (m)	860
Drainage Outlet	Davao Gulf
Ratio of Occupation of Urban Type Landuse[a] for Existing Condition (%)	86
Runoff Coefficient (Existing Landuse (2017))	0.71
Runoff Coefficient (Future Landuse (2045))	0.73
Basic Design Flood Discharge for 25 Year Return Period (Under Future Landuse (2045) with Climate Change Considered) (m^3/s)	36
Expected Annual Damage by Inundation due to Overflow from Main Drainage Channel (Existing Landuse (2017)) (Million Php)	0.059
Expected Annual Damage by Inundation due to Overflow from Main Drainage Channel (Future Landuse (2045)) (Million Php)	0.059

[a]: Commercial, Industrial, Residential, Mixed use, and Road

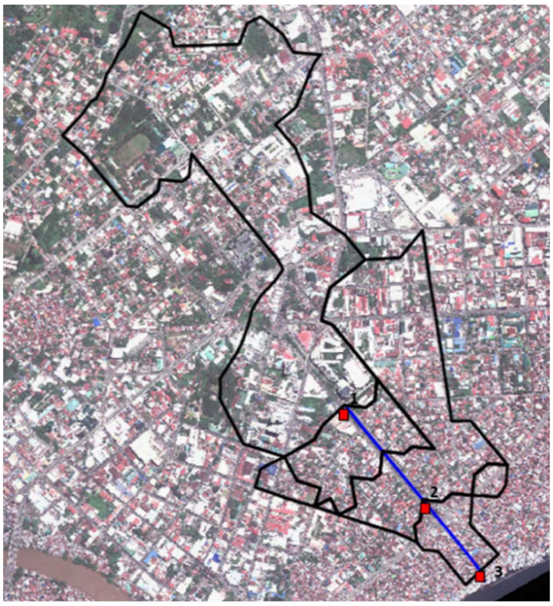
Source: Project Team

Figure 3.7.1 shows the delineation of sub-drainage areas, and the design flood discharge for the alternatives explained later as well as the basic design discharge that assumes no overflow from the channel at the representative points along the main drainage channel, under the future landuse condition with the climate change considered.

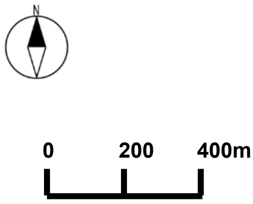
Figure 3.7.2 presents the expected inundation area due to overflow from the main drainage channel for 25 year return period. The reach with about 300m in length from the outlet consists of box culverts and a covered open channel. Because the flow capacity in this reach is quite limited, it is expected that the wide area is inundated in the existing condition.

The coastal road project by DPWH is on-going. In this project, the connection road between the coastal road and Quezon Blvd. will be constructed along the existing Roxas drainage main channel. According to DPWH, together with the road construction, new box culverts which have enough flow capacity for 25 year return period (tentative dimension: W3.2m x H1.8m x 4 cells) will be installed under the road. With this new box culverts, it is expected that there will be no inundation due to overflow from the main drainage channel for 5 year return period.

Figure 3.7.3 shows the expected inundation area due to overflow from the main drainage channel for 25 year return period after the coastal road project will be completed. The measures to address the remaining inundation is examined in the following section.

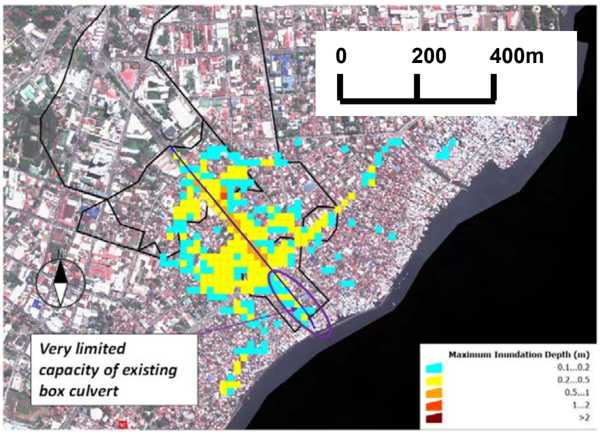


	1	2	3
Chainage (km)	0.86	0.38	0
Basic Design Flood Discharge (m^3/s)	22	25	36
ALT-1 : Design Flood Discharge (m^3/s)	22	25	36
ALT-2 : Design Flood Discharge (m^3/s)	22	14	36
ALT-3 : Design Flood Discharge (m^3/s)	22	13	32



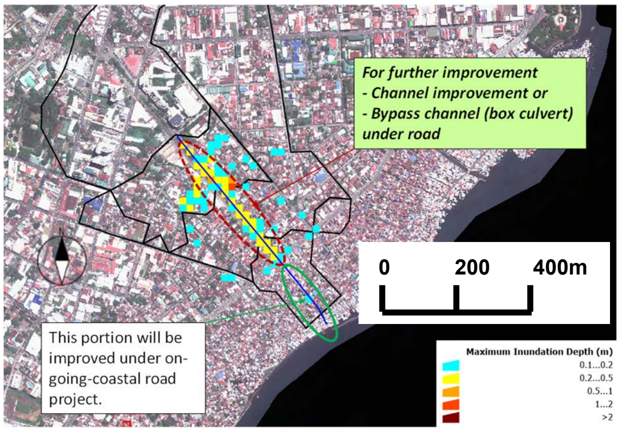
Source: Project Team

Figure 3.7.1 Delineation of Sub-Drainage Areas, Basic Design Flood Discharge and Design Flood Discharge for Roxas Drainage Area



Source: Project Team

Figure 3.7.2 Expected Inundation Area due to Overflow from Main Drainage Channel for 25 Year Return Period (Existing Condition) for Roxas Drainage Area



Source: Project Team

Figure 3.7.3 Expected Inundation Area due to Overflow from Main Drainage Channel for 25 Year Return Period (After Completion of Coastal Road Project) for Roxas Drainage Area

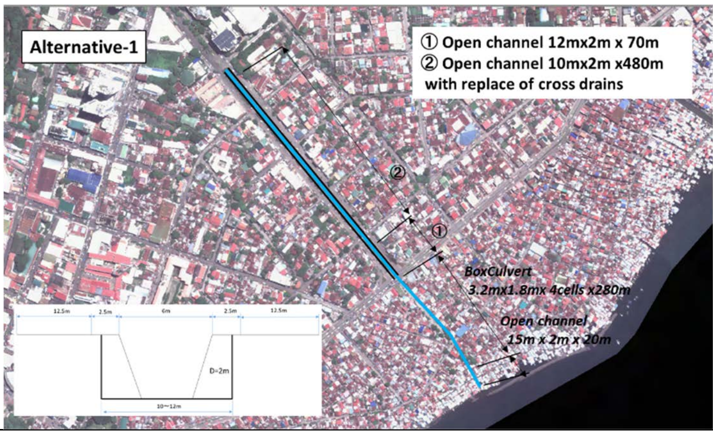
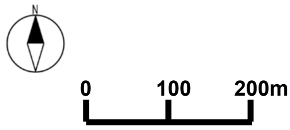
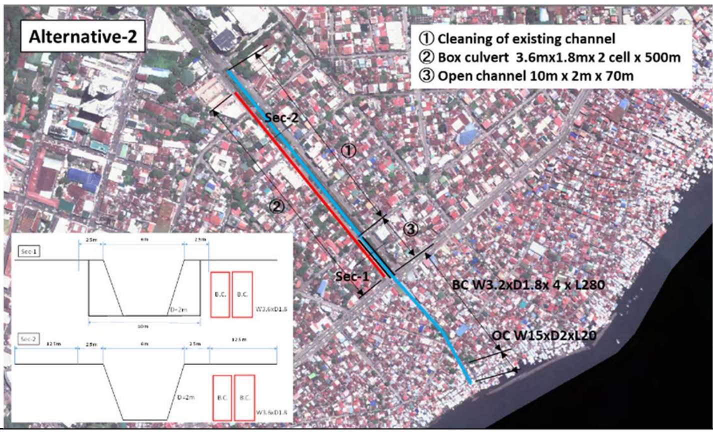
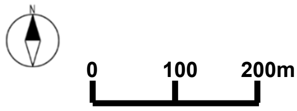
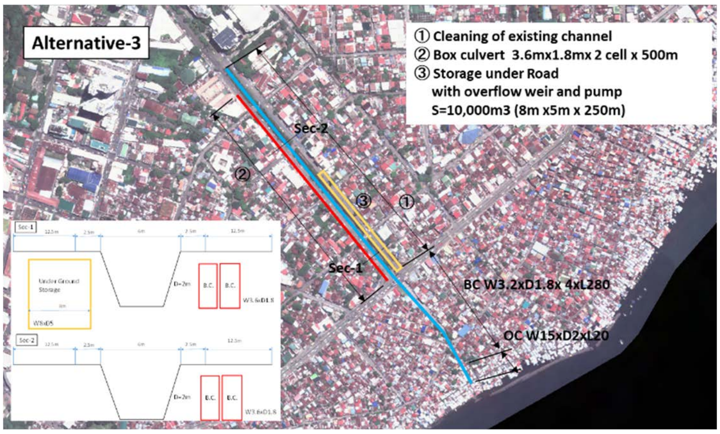
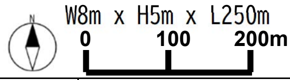
2) Alternative Measures

The following three alternatives are considered.

- Alterantive-1: Drainage Channel Improvement
- Alterantive-2: Bypass Channel (Culvert) and Partial Drainage Channel Improvement
- Alterantive-3: Bypass Channel (Culvert) and Retarding Basin (Closed Type) under Road

Table 3.7.2 shows the conceptual layout of the proposed structures for each of the alternatives.

Table 3.7.2 Alternative Measures in Roxas Drainage Area

Alt.	Conceptual Layout of Structures	Menu of Measures
1		① Drainage Channel Improvement W12m x H2m x L70m ② Drainage Channel Improvement W10m x H2m x L480m Including improvement of cross drains 
2		① Dredging of Existing Channel ② Bypass Channel(Box Culverts) W3.6m x H1.8m x 2cells x L500m ③ Drainage Channel Improvement W10m x H2m x L70m 
3		① Dredging of Existing Channel ② Bypass Channel(Box Culverts) W3.6m x H1.8m x 2cells x L500m ③ Retarding Basin (Closed Type) under Road Storage Capacity=10,000m^3 W8m x H5m x L250m 
	 	Condition around Roxas Channel

Source: Project Team

The construction cost and land acquisition / compensation cost are preliminary estimated for each of the alternatives as shown in Table 3.7.3.

Table 3.7.3 Preliminary Estimated Cost for Construction and Land Acquisition / Compensation (Roxas Drainage Area)

Alternative	Preliminary Estimated Cost (Billion Php)		
	Construction Cost	Land Acquisition /Compensation Cost	Total
1	0.109	0	0.109
2	0.088	0	0.088
3	0.385	0	0.385

Source: Project Team

Among the alternatives, the alterantive-2 is recommended since the preliminary estimated cost (total of the construction and land acquisition / compensation cost) is the lowest.

The alterantive-1 requires the removal of the existing trees along the Roxas channel, which may negatively affects to the landscape in the surrounding area. Furthermore, the total cost is higher than the altrenative-2. Therefore, It is not recommended.

The total cost for alternative-3 is the highest among the alternatives. However, there is no impact on the existing trees along the Roxas channel. If the existing tress in the reach whose channel improvement is proposed in the alterantve-2 are not allowed to be disturbed, the alternative-3 could be only available solution despite of its relatively high cost.

3.7.3 Structural Measures for Master Plan

(1) Improvement of Main Drainage Channels

1) Scale and Economic Aspect of Full Menu of Framework Plan

The total project cost for implementing the full menu of the Framework Plan for all of main drainage areas, of which example is showed in Section 3.7.2, is estimated at about 17 Billion Php.

The simple economic analysis, which assumes that the initial investment concentrates in the first year and the benefit appears in the rest of project period (50years are assumed), shows that B/C=1.17 for the entire projects in case that the social discount rate is 10%. The investment to the full menu of the Framework Plan is thus economically viable. Table 3.7.4 presents the project cost and B/C for each of the main drainage areas. In the analysis, the present landuse condition to estimate the annual damage reduction is assumed.

Table 3.7.4 Project Cost and B/C for Each of Main Drainage Areas in Case that Full Menu of Framework Plan is implemented

		Annual Damage Reduction (Billion Php)	Cost (Billion Php)					Annualized Cost (Economic) (Billion Php)	B/C
			Const-ruction Cost	Land Acquisition/ Compen-sation Cost	Project Cost (Financial)	Project Cost (Economic)	Annual O& M Cost		
1	Roxas	0.003	0.088	0	0.124	0.113	0.4	0.012	0.29
2	Agdao	0.469	3.385	0.409	5.203	4.749	16.9	0.496	0.95
3	Jerome	0.641	2.516	0.860	4.451	4.086	12.6	0.425	1.51
4	Mamay Creek	0.303	1.136	0.404	2.026	1.860	5.7	0.193	1.57
5	Sasa Creek	0.084	0.474	0.033	0.703	0.641	2.4	0.067	1.25
6	Emars	0.085	0.113	0.482	0.665	0.627	0.6	0.064	1.33
7	Shanghai	0.068	0.055	0.129	0.213	0.200	0.3	0.020	3.33
8	Maa1	0.039	0.200	0.040	0.324	0.296	1.0	0.031	1.26
9	Maa2	0.194	2.036	0.246	3.129	2.856	10.2	0.298	0.65
	Total	**1.886**	**10.003**	**2.603**	**16.839**	**15.427**	**50.0**	**1.606**	**1.17**

Remark: It is assumed that the annual O&M cost is 0.5% of the construction cost.
Source: Project Team

Assuming that the full menu of the Framework Plan will be implemented by 2045 which is the target year of the Master Plan, it is required to invest 17/23=0.74 Billion Php annually in average. It is about 1.5 times as large as the average annual budget for the projects for storm water drainage improvement by DPWH-DEO in the last 5years.

2) Master Plan

As shown in 1), the investment to the full menu of the Framework Plan is economically viable. The required annual investment in average to implement the full menu of the framework plan by 2045 is not unrealistic, since it is about 1.5 times as large as the average annual budget for the projects for storm water drainage improvement by DPWH-DEO in the last 5years.

Considering the above-mentioned condition, the Master Plan is set as same as the Framework Plan, which targets to achieve the safety level of 25 year return period for the main drainage channels by 2045.

3) Step-wide Implementation

As for the implementation of the Master Plan, the proposed projects are divided into the short term (2023-2032) and the long-term (2033-2045).

The short-term projects are selected so as to prevent overflow from main drainage channels for the extreme event with 5 year return period among the full menu of the Framework Plan.

As for the deep excavation type of retarding basin whose construction cost is high, the following set-wise implementation is considered.

- Phase-1: Acquisition of necessary land area and construction of shallow excavation type of retarding basin
- Phase-2: Upgrade to deep excavation type of retarding basin which has enough storage volume to meet the requirement of the Framework Plan

When the implementation of the Phase-1 can achieve the safety level of 5 year return period, only Phase-1 is implemented in the short-term.

For the implementation of the proposed retarding basins, it is necessary to secure the land for the construction and to prevent land development. It is highly recommended to reflect the proposed retarding basins into the land use plan and regulation in Davao City as early as possible.

The total project cost for the selected short-term projects is about 8.8 Billion Php. The simple economic analysis, which assumes that the initial investment concentrates in the first year and the benefit appears in the rest of project period (50years are assumed), shows that B/C=2.15 for the short-term projects in case that the social discount rate is 10%. The B/C for all main drainage areas exceeds 1. Table 3.7.5 presents the project cost and B/C for each of the main drainage areas. In the analysis, the present landuse condition to estimate the annual damage reduction is assumed.

Table 3.7.5 Project Cost and B/C for Each of Main Drainage Areas for Short-Term Projects

		Annual Damage Reduction (Billion Php)	Cost (Billion Php)					Annualized Cost (Economic) (Billion Php)	B/C
			Const-ruction Cost	Land Acquisition/ Compen-sation Cost	Project Cost (Financial)	Project Cost (Economic)	Annual O& M Cost		
1	Roxas	0	0	0	0	0	0.0	0	N/A
2	Agdao	0.440	1.176	0.409	2.088	1.917	5.9	0.199	2.21
3	Jerome	0.621	1.520	0.860	3.046	2.809	7.6	0.291	2.13
4	Mamay Creek	0.289	0.198	0.316	0.611	0.570	1.0	0.059	4.94
5	Sasa Creek	0.084	0.286	0.015	0.419	0.382	1.4	0.040	2.10
6	Emars	0.085	0.113	0.482	0.665	0.627	0.6	0.064	1.33
7	Shanghai	0.068	0.055	0.129	0.213	0.200	0.3	0.020	3.33
8	Maa1	0.038	0.196	0.001	0.277	0.252	1.0	0.026	1.44
9	Maa2	0.182	0.874	0.246	1.491	1.366	4.4	0.142	1.28
	Total	**1.807**	**4.418**	**2.458**	**8.811**	**8.122**	**22.1**	**0.841**	**2.15**

Remark: It is assumed that the annual O&M cost is 0.5% of the construction cost.
Source: Project Team

(2) Improvement of Local Inundation in the Central Area of Davao City

The proper maintenance and removal of deposition in the existing drainage channel are fundamental measures to mitigate the local inundation due to the lack of flow capacity of lateral drainage channel. These are discussed in the section of "Non-Structural Measures" as one of non-structural measures.

For further improvement of drainage capacity, it is necessary to upgrade the lateral drainage channels.

In the present project, the priority areas for the upgrade of the lateral drainage channels are identified, considering the hot spots where the expected inundation depth exceeds the allowable depth during the extreme event with 25 year return period even after the main drainage channels are improved. On the basis of this result, the following four areas are identified as the priority areas for the countermeasures against local inundation in the Poblacion district.

- 1.F. Torres Street (Roxas and Quirino_L_B drainage area)
- 2.Elpido Quirino Avenue (Roxas and Anda drainage area)
- 3.Ramon Magsaysay Avenue (Roxas, Ponce and Magsaysay drainage area)
- 4. Corner of Leon Garcia Street and St. Ana Street (St. Ana drainage area)

The countermeasures are installation of storage pipe under road and/or small scale closed type of retarding basin spot by spot in order to reduce the inundation depth.

(3) Implementation Scheme

The following types for implementation scheme on the proposed structural measures are considered, depending on the level of construction and project cost.

- Type-1: The project which is expected to be implemented by DWPH-DEO
- Type-2: The project which is expected to be implemented by DWPH-DEO with technical support
- Type-3: The project which is expected to be implemented by DWPH-RO/HQ

(4) Operation and Maintenance for Proposed Structural Measures

Table 3.7.6 shows the items to be considered for operation and maintenance for proposed structural measures.

Table 3.7.6 Items to be Considered for Operation and Maintenance for Proposed Structural Measures

Type of Structure	Items	
	Ordinary time	During/After flood events
Retarding basin	✓ Periodical inspection of structures such as riprap, concrete wall, gates and overflow weir ✓ Periodical inspection of drainage pumps in case of closed type and deep open type retarding basin ✓ Periodical cleaning of retarding basin including removal of sediment and garbage ✓ Prevention of illegal activities inside the retarding basin	During flood event ✓ Sharing information of status of retarding basin with relevant organizations in real time After flood event ✓ Operation of gates and pumps and monitoring of drainage of stored water by gravity or pumps just after the flood event ✓ Checking the status of structures and pumps ✓ Urgent removal of deposited sediment and garbage, especially around the gates and pumps to ensure their proper function
Open channel	✓ Periodical inspection of structures such as riprap, concrete wall and cross drain. ✓ Prevention of illegal activities along the channel ✓ Periodical cleaning of deposited sediment and garbage	During flood event ✓ Sharing information of status of channel with relevant organizations in real time After flood event ✓ Checking the status of structures
Closed channel including diversion tunnel	✓ Periodical inspection of manhole, inlet structure and overflow weir ✓ Periodical cleaning of deposited sediment and garbage inside the channel	During flood event ✓ Sharing information of status of channel with relevant organizations in real time After flood event ✓ Checking the status of structures and pumps ✓ Urgent removal of deposited sediment and garbage, especially around the overflow weir to ensure their proper function

Source: Project Team

(5) Project List

The project list for the structural measures on storm water drainage improvement in the Master Plan is presented in Table 3.7.7.

(6) Implementation Schedule

The implementation schedule for the structural measures on storm water drainage improvement in the Master Plan is presented in Figure 3.7.4.

Table 3.7.7 Project List for Structural Measures on Storm Water Drainage Improvement in the Master Plan

Project			Work Item	Project Cost (Billion Php)	Short Term 2023-2032	Long Term 2033-2045	Imp. Type
A	**Main Drainage Improvement**			**16.839**	**8.811**	**8.028**	
	A-1	**Roxas Drainage Area**		**0.124**	**0**	**124**	
	A-1-1	Channel Improvement and Installation of Bypass Channel	Dredging (L480m) Box Culvert (W3.6mxH1.8mx2cellsxL500m) Channel Improvement (W10m x H2m x L70m)	**0.124**		x	①
	A-2	**Agdao Drainage Area**		**5.203**	**2.088**	**3.115**	
	A-2-1	Installation of Retarding Basin① (Phase-1)	Retarding basin (shallow open) (V=40,000m^3, A=20,000m^2, H=2m)	**0.336**	x		①
	A-2-2	Upgrading of Retarding Basin① (Phase-2)	Retarding basin (deep open) (V=72,000m^3, A=20,000m^2, H=3.6m)	**0.575**		x	②
	A-2-3	Installation of Retarding Basin②	Retarding basin (closed) (V=10,000m^3, A=2,500m^2, H=4m)	**0.440**		x	③
	A-2-4	Installation of Retarding Basin③ (Phase-1)	Retarding basin (shallow open) (V=8,000m^3, A=5,000m^2, H=1.6m)	**0.057**	x		①
	A-2-5	Upgrading of Retarding Basin③ (Phase-2)	Retarding basin (deep open) (V=15,000m^3, A=5,000m^2, H=3m)	**0.213**		x	②
	A-2-6	Installation of Retarding Basin④	Retarding basin (closed) (V=13,000m^3, A=5,000m^2, H=2.6m)	**0.571**		x	③
	A-2-7	Installation of Underground Rainwater Storage along Dacudao Creek (Phase-1)	Retarding basin (closed) (V=10,000m^3, W4mxH5mxL500m)	**0.398**	x		③
	A-2-8	Installation of Underground Rainwater Storage along Dacudao Creek (Phase-2)	Retarding basin (closed) (V=28,000m^3, W4mxH5mxL1,400m)	**1.111**		x	③
	A-2-9	Installation of Underground rainwater storage in catchment area of Old Agdao Channel (Phase-1)	Retarding basin (closed) (V=22,500m^3, W3mxH3mxL2,500m)	**0.513**	x		②
	A-2-10	Installation of Underground rainwater storage in catchment area of Old Agdao Channel (Phase-2)	Retarding basin (closed) (V=9,000m^3, W3mxH3mxL1,000m)	**0.204**		x	②
	A-2-11	Improvement of Lower Agdao Channel	Open channel (W12mxH2-3mxL350m) Box culvert (W3mxH2.5mx2cellsxL350m) Bridge along channel (W5mxL350m) Improvement of cross drain (1place) Box culvert (W3mxH2.5mx1cellxL150m)	**0.647**	x		③
	A-2-12	Improvement of Old Agdao Channel	Dredging (L500m) Regulation Pond (A=5,000m^2) Improvement of cross drain (1place) Box culvert (W3mxH2.4mx1cellxL400m)	**0.136**	x		①
	A-3	**Jerome Drainage Area**		**4.451**	**3.046**	**1.405**	
	A-3-1	Installation of Retarding Basin① (Phase-1)	Retarding basin (shallow open) (V=6,000m^3, A=6,000m^2, H=1m)	**0.221**	x		①
	A-3-2	Upgrading of Retarding Basin① (Phase-2)	Retarding basin (deep open) (V=33,000m^3, A=6,000m^2, H=5.5m)	**0.432**		x	②
	A-3-3	Installation of Retarding Basin② (Phase-1)	Retarding basin (shallow open) (V=18,000m^3, A=9,000m^2, H=2m)	**0.057**	x		①
	A-3-4	Upgrading of Retarding Basin② (Phase-2)	Retarding basin (deep open) (V=40,000m^3, A=9,000m^2, H=4.5m)	**0.433**		x	②
	A-3-5	Installation of Retarding Basin③ (Phase-1)	Retarding basin (shallow open) (V=30,000m^3, A=15,000m^2, H=2m)	**0.227**	x		①
	A-3-6	Upgrading of Retarding Basin③ (Phase-2)	Retarding basin (deep open) (V=64,000m^3, A=15,000m^2, H=4.3m)	**0.540**		x	②
	A-3-7	Installation of Retarding Basin④	Retarding basin (deep open) (V=48,000m^3, A=8,000m^2, H=6m)	**0.874**	x		③
	A-3-8	Installation of Retarding Basin⑤	Retarding basin (deep open) (V=15,000m^3, A=3,000m^2, H=5m)	**0.371**	x		③
	A-3-9	Installation of Retarding Basin⑥	Retarding basin (deep open) (V=88,000m^3, A=16,000m^2, H=5.5m)	**0.781**	x		③
	A-3-10	Improvement of Lower Jerome Channel	Box Culvert (W3mxH2.3mx1cellxL610m) Chanel Improvement (W5mxH2.5-3mxL1,000m) Improvement of cross drain (14places)	**0.516**	x		①
	A-4	**Mamay Creek Drainage Area**		**2.026**	**0.611**	**1.415**	
	A-4-1	Installation of Retarding Basin①	Retarding basin (dam) (V=41,000m^3, A=20,000m^2, H=6m)	**0.089**	x		②
	A-4-2	Installation of Retarding Basin②	Retarding basin (dam) (V=26,000m^3, A=22,000m^2, H=2m)	**0.089**	x		②
	A-4-3	Installation of Retarding Basin③	Retarding basin (dam) (V=68,000m^3, A=30,000m^2, H=5m)	**0.083**	x		②
	A-4-4	Installation of Retarding Basin④	Retarding basin (shallow open) (V=33,000m^3, A=15,000m^2, H=2.2m)	**0.068**	x		①
	A-4-5	Installation of Retarding Basin⑤ (Phase-1)	Retarding basin (shallow open) (V=6,000m^3, A=3,000m^2, H=2m)	**0.015**	x		①
	A-4-6	Upgrading of Retarding Basin⑤ (Phase-2)	Retarding basin (deep open) (V=15,000m^3, A=3,000m^2, H=5m)	**0.286**		x	②
	A-4-7	Installation of Retarding Basin⑥	Retarding basin (shallow open) (V=24,000m^3, A=16,000m^2, H=1.5m)	**0.049**	x		①
	A-4-8	Installation of Retarding Basin⑦ (Phase-1)	Retarding basin (shallow open) (V=33,000m^3, A=22,000m^2, H=1.5m)	**0.123**	x		①
	A-4-9	Upgrading of Retarding Basin⑦ (Phase-2)	Retarding basin (deep open) (V=130,000m^3, A=22,000m^2, H=6m)	**0.942**		x	③
	A-4-10	Installation of Retarding Basin⑧	Retarding basin (shallow open) (V=15,000m^3, A=10,000m^2, H=1.5m)	**0.108**		x	②
	A-4-11	Channel Improvement	Dyke (H2mxL220m) Improvement of cross drain (5places)	**0.094**	x		①
	A-4-12	Instalation of Bypass Channel in Middle Mamay Creek	Box Culvert (W3.3mxH1.7mx1cellxL660m)	**0.079**		x	①

Project			Work Item	Project Cost (Billion Php)	Short Term 2023-2032	Long Term 2033-2045	Imp. Type
	A-5	**Sasa Creek Drainage Area**		**0.703**	**0.419**	**0.284**	
	A-5-1	Completion of Remaining Portion of Retarding Basin① in La Verna Area	Retarding basin (deep open) (V=65,000m^3, A=13,000m^2, H=5m)	**0.381**	x		②
	A-5-2	Installation of Retarding Basin② in La Verna Area	Retarding basin (deep open) (V=20,000m^3, A=5,000m^2, H=4m)	**0.284**		x	②
	A-5-3	Channel Imrovement and Instalation of Bypass Channel in Pampanga Area	Dredging (L320m) Improvement of cross drain (1place) Box Culvert (W2mxH1.5mx1cellxL310m) Box Culvert (W2mxH1.3mx1cellxL230m)	**0.038**	x		①
	A-6	**Emars Drainage Area**		**0.665**	**0.665**	**0.000**	
	A-6-1	Installation of Retarding Basin①	Retarding basin (shallow open) (V=30,000m^3, A=15,000m^2, H=2m)	**0.274**	x		①
	A-6-2	Installation of Retarding Basin②	Retarding basin (shallow open) (V=20,000m^3, A=10,000m^2, H=2m)	**0.110**	x		①
	A-6-3	Installation of Retarding Basin③	Retarding basin (shallow open) (V=36,000m^3, A=18,000m^2, H=2m)	**0.192**	x		①
	A-6-4	Instalation of Bypass Channel	Box Culvert (W2mxH2mx1cellxL1,060m)	**0.090**	x		①
	A-7	**Shanghai Drainage Area**		**0.213**	**0.213**	**0.000**	
	A-7-1	Installation of Retarding Basin	Storage Volume=50,000m^3 Dyke (H2mxL800m) Excavation (V=20,000m^3)	**0.164**	x		①
	A-7-2	Channel Imrovement and Instalation of Bypass Channel	Box Culvert (W3mxH1.7mx1cellxL450m) Dredging (L300m)	**0.049**	x		①
	A-8	**Maa1 Drainage Area**		**0.324**	**0.277**	**0.047**	
	A-8-1	Installation of Retarding Basin① (Phase-1)	Retarding basin (shallow open) (V=4,000m^3, A=2,000m^2, H=2m)	**0.008**	x		①
	A-8-2	Completionof of Remaining Portion of Retarding Basin① (Phase-2)	Retarding basin (shallow open) (V=10,000m^3, A=5,000m^2, H=2m)	**0.047**		x	①
	A-8-3	Installation of Retarding Basin②	Retarding basin (shallow open) (V=20,000m^3, A=10,000m^2, H=2m)	**0.029**	x		①
	A-8-4	Improvement of Channel	Chanel Improvement (W4mxH2.5mxL810m) Improvement of cross drain (1place)	**0.240**	x		①
	A-9	**Maa2 Drainage Area**		**3.129**	**1.491**	**1.639**	
	A-9-1	Installation of Retarding Basin①	Retarding basin (dam) (V=15,000m^3, A=8,000m^2, H=5m)	**0.036**	x		②
	A-9-2	Installation of Retarding Basin②	Retarding basin (dam) (V=11,000m^3, A=6,000m^2, H=5m)	**0.048**	x		②
	A-9-3	Installation of Retarding Basin③	Retarding basin (deep open) (V=36,000m^3, A=6,000m^2, H=6m)	**0.504**	x		③
	A-9-4	Improvement of Upper Maa2 Channel①	Dyke (H2mxL200m)	**0.071**	x		①
	A-9-5	Improvement of Upper Maa2 Channel②	Box Culvert (W3mxH1.7mx1cellxL450m) Improvement of cross drain (1place)	**0.034**	x		①
	A-9-6	Installation of Underground Diversion Channel	Tunnel Channel (D2.6mxL1,200m)	**1.122**		x	③
	A-9-7	Installation of Retarding Basin④	Retarding basin (shallow open) (V=12,000m^3, A=6,000m^2, H=2m)	**0.016**	x		①
	A-9-8	Installation of Retarding Basin⑤	Retarding basin (shallow open) (V=8,000m^3, A=4,000m^2, H=2m)	**0.036**	x		①
	A-9-9	Installation of Retarding Basin⑥	Retarding basin (shallow open) (V=26,000m^3, A=13,000m^2, H=2m)	**0.057**	x		①
	A-9-10	Installation of Retarding Basin⑦	Retarding basin (shallow open) (V=11,000m^3, A=5,000m^2, H=2.2m)	**0.049**	x		①
	A-9-11	Installation of Retarding Basin⑧	Retarding basin (shallow open) (V=20,000m^3, A=10,000m^2, H=2m)	**0.051**	x		①
	A-9-12	Installation of Retarding Basin⑨ (Phase-1)	Retarding basin (shallow open) (V=16,000m^3, A=8,000m^2, H=2m)	**0.041**	x		①
	A-9-13	Upgrading of Retarding Basin⑨ (Phase-2)	Retarding basin (deep open) (V=40,000m^3, A=8,000m^2, H=5m)	**0.516**		x	②
	A-9-14	Improvement of Lower Maa2 Channel	Chanel Improvement (W9mxH3mxL1,300m) Improvement of cross drain (1place) Dredging (L500m)	**0.547**	x		①

Source: Project Team

	Project	Imp. Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
							2027					2032					2037					2042			2045
A	Main Drainage Improvement																								
A-1	**Roxas Drainage Area**																								
A-1-1	Channel Imrovement and Instalation of Bypass Channel	①											(2)												
A-2	**Agdao Drainage Area**																								
A-2-1	Installation of Retarding Basin① (Phase-1)	①	(4)																						
A-2-2	Upgrading of Retarding Basin① (Phase-2)	②											(6)												
A-2-3	Installation of Retarding Basin②	③											(2)												
A-2-4	Installation of Retarding Basin③ (Phase-1)	①	(1)																						
A-2-5	Upgrading of Retarding Basin③ (Phase-2)	②											(3)												
A-2-6	Installation of Retarding Basin④	③											(2)												
A-2-7	Installation of Underground Rainwater Storage along Dacudao Creek (Phase-1)	③	(2)																						
A-2-8	Installation of Underground Rainwater Storage along Dacudao Creek (Phase-2)	③											(3)												
A-2-9	Installation of Underground rainwater storage in catchment area of Old Agdao	②	(6)																						
A-2-10	Installation of Underground rainwater storage in catchment area of Old Agdao	②											(2)												
A-2-11	Improvement of Lower Agdao Channel	③	(3)																						
A-2-12	Improvement of Old Agdao Channel	①	(2)																						
A-3	**Jerome Drainage Area**																								
A-3-1	Installation of Retarding Basin① (Phase-1)	①	(3)																						
A-3-2	Upgrading of Retarding Basin① (Phase-2)	②											(5)												
A-3-3	Installation of Retarding Basin② (Phase-1)	①	(1)																						
A-3-4	Upgrading of Retarding Basin② (Phase-2)	②											(5)												
A-3-5	Installation of Retarding Basin③ (Phase-1)	①	(3)																						
A-3-6	Upgrading of Retarding Basin③ (Phase-2)	②											(6)												
A-3-7	Installation of Retarding Basin④	③	(2)																						
A-3-8	Installation of Retarding Basin⑤	③	(2)																						
A-3-9	Installation of Retarding Basin⑥	③	(2)																						
A-3-10	Improvement of Lower Jerome Channel	①	(6)																						
A-4	**Mamay Creek Drainage Area**																								
A-4-1	Installation of Retarding Basin①	②	(1)																						
A-4-2	Installation of Retarding Basin②	②	(1)																						
A-4-3	Installation of Retarding Basin③	②	(1)																						
A-4-4	Installation of Retarding Basin④	①	(1)																						
A-4-5	Installation of Retarding Basin⑤ (Phase-1)	①	(1)																						
A-4-6	Upgrading of Retarding Basin⑤ (Phase-2)	②											(3)												
A-4-7	Installation of Retarding Basin⑥	①	(1)																						
A-4-8	Installation of Retarding Basin⑦ (Phase-1)	①	(2)																						
A-4-9	Upgrading of Retarding Basin⑦ (Phase-2)	③											(2)												
A-4-10	Installation of Retarding Basin⑧	②											(1)												
A-4-11	Channel Imrovement	①	(1)																						
A-4-12	Instalation of Bypass Channel in Middle Mamay Creek	①											(1)												
A-5	**Sasa Creek Drainage Area**																								
A-5-1	Completion of Remaining Portion of Retarding Basin① in La Verna Area	②	(4)																						
A-5-2	Installation of Retarding Basin② in La Verna Area	②											(3)												
A-5-3	Channel Imrovement and Instalation of Bypass Channel in Pampanga Area	①	(1)																						
A-6	**Emars Drainage Area**																								
A-6-1	Installation of Retarding Basin①	①	(3)																						
A-6-2	Installation of Retarding Basin②	①	(1)																						
A-6-3	Installation of Retarding Basin③	①	(2)																						
A-6-4	Instalation of Bypass Channel	①	(1)																						
A-7	**Shanghai Drainage Area**																								
A-7-1	Installation of Retarding Basin	①	(2)																						
A-7-2	Channel Imrovement and Instalation of Bypass Channel	①	(1)																						
A-8	**Maa1 Drainage Area**																								
A-8-1	Installation of Retarding Basin① (Phase-1)	①	(1)																						
A-8-2	Completionof of Remaining Portion of Retarding Basin① (Phase-2)	①											(1)												
A-8-3	Installation of Retarding Basin②	①	(1)																						
A-8-4	Improvement of Channel	①	(3)																						
A-9	**Maa2 Drainage Area**																								
A-9-1	Installation of Retarding Basin①	②	(1)																						
A-9-2	Installation of Retarding Basin②	②	(1)																						
A-9-3	Installation of Retarding Basin③	③	(2)																						
A-9-4	Improvement of Upper Maa2 Channel①	①	(1)																						
A-9-5	Improvement of Upper Maa2 Channel②	①	(1)																						
A-9-6	Installation of Underground Diversion Channel	③											(3)												
A-9-7	Installation of Retarding Basin④	①	(1)																						
A-9-8	Installation of Retarding Basin⑤	①	(1)																						
A-9-9	Installation of Retarding Basin⑥	①	(1)																						
A-9-10	Installation of Retarding Basin⑦	①	(1)																						
A-9-11	Installation of Retarding Basin⑧	①	(1)																						
A-9-12	Installation of Retarding Basin⑨ (Phase-1)	①	(1)																						
A-9-13	Upgrading of Retarding Basin⑨ (Phase-2)	②											(6)												
A-9-14	Improvement of Lower Maa2 Channel	①	(6)																						

Remarks: (*) in the bar in the figure indicates expected project duration in year.

Source: Project Team

Figure 3.7.4 Implementation Schedule

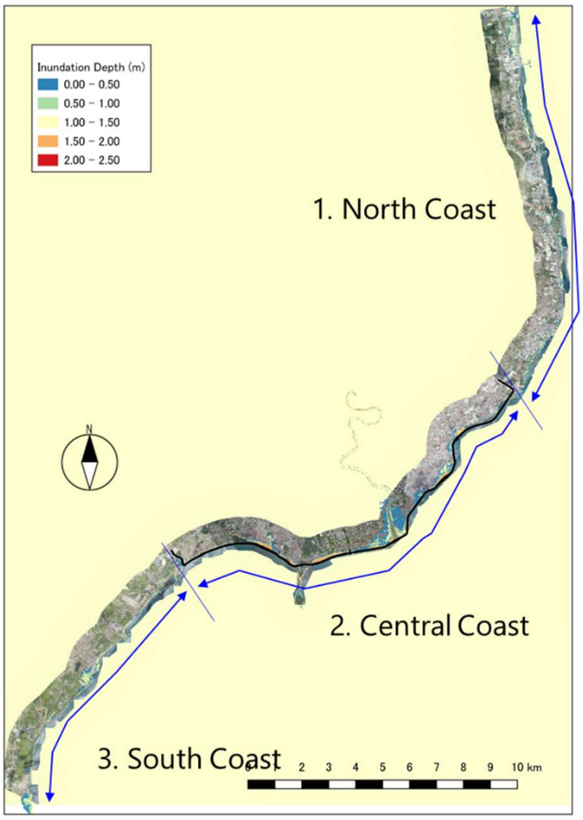
3.8 Structural Measures of Coastal Disaster

3.8.1 Alternative Study of Structural Measures

As for the structural measures for coastal disaster which can be considered in this project, Dike / Seawall is an effective measure for storm surge protection against Davao coast where waves are not so remarkable, and concrete blocks may be applicable for several sections with severe wave. Furthermore, it is effective to control sand transport by means of jetty in the sections where coastal erosion is prominent.

(1) Target Area

By dividing the coast of Davao City into the following three areas, the structural alternatives are to be studied. Although some alternatives for the Coastal Road section can be considered, , the expected countermeasures for coastal protection by storm surge in the northern and southern coast are basically Dike / Seawall.

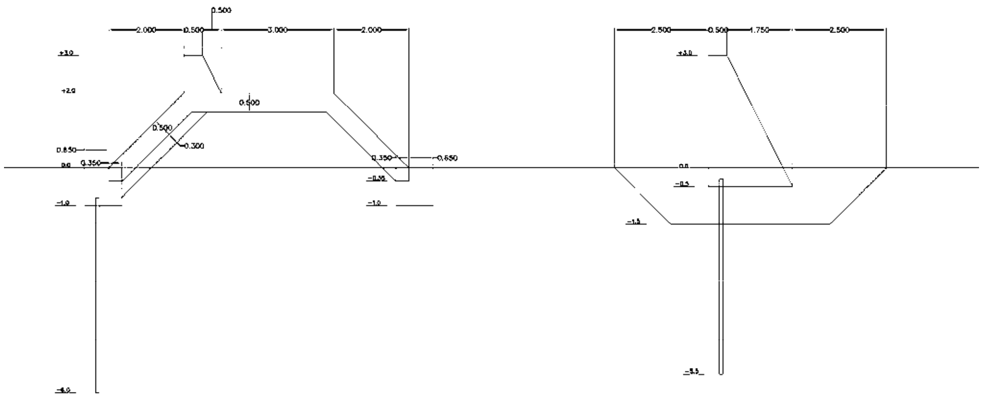


Source: Project Team

Figure 3.8.1 Locations of Target Area

(2) Structure of Coastal Dike/ Seawall

This study applied a slope type for relatively large space and a vertical type for relatively narrow space, as typical representative cross sections, and the typical cross sections are shown in Figure 3.8.2. The typical cross sections include sheet pile for seepage control. In the detail design stage, the necessity and necessary length of sheet pile should be investigated by seepage analysis. Both pre-cast or cast-in-place concrete are no problem for coastal dike, but the joint-bars are necessary to be unified with main structures.



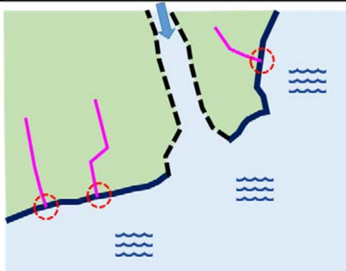
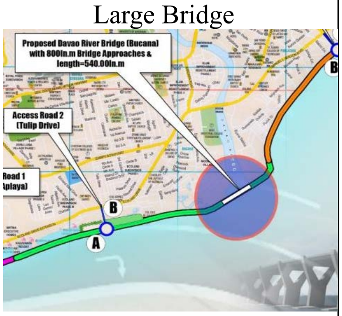
Source: Project Team

Figure 3.8.2 Typical Cross Sections of Coastal Dike (L: Sloping type, R: Vertical type)

(3) Structure of Structural Measure in Openings

There are several openings along the coast, such as estuaries and drainage channels. In particular, the Coastal Road section has many openings, and its countermeasure against coastal flooding are required to provide a series of prevention functions for storm surge. There are three major alternatives of countermeasures for opening as shown in Table 3.8.1, and it is necessary to conduct Alternative analysis considering their suitability.

Table 3.8.1 Alternative Countermeasures in Openings

	1) Back Levee	2) Tide Gate	3) Flap Gate
Image			
Applicability along Coastal Road	Large Bridge 	Small Bridge 	Outfall of Box culvert 

Source: Project Team

3.8.2 Countermeasures in Each Area

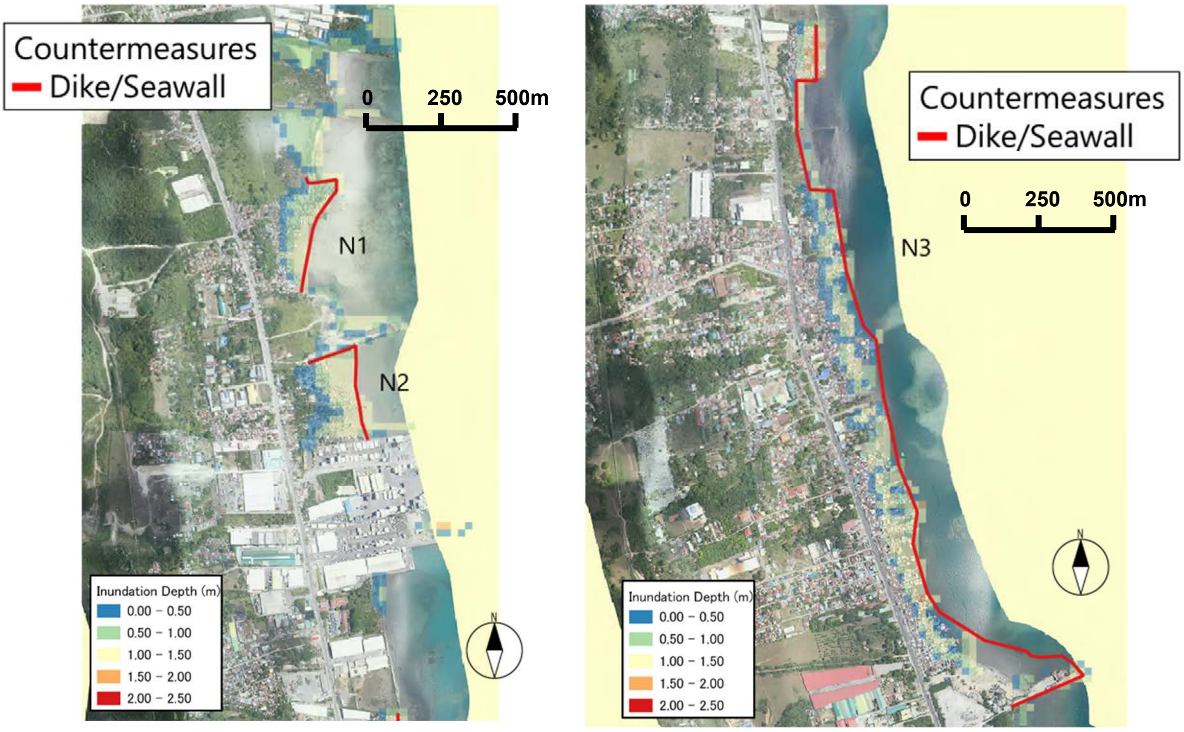
(1) Countermeasures in North Coast

Table 3.8.2 shows the inundation situation in this area and the direction of countermeasures based on the inundation simulations of storm surge discussed in 2.10. As shown in Table 3.8.2, there is basically no need for countermeasures in this area, but countermeasures are considered as a reference in case of future land use change. As mentioned above, the northern area has the characteristic that elevated houses are densely packed along the coast of the natural beaches, so the basic measure is to install a coastal levee in front of those residential areas. The specific facility layout for measures is planned as shown in Figure 3.8.3.

Table 3.8.2 Inundation Status and Direction of Countermeasures (North Coast)

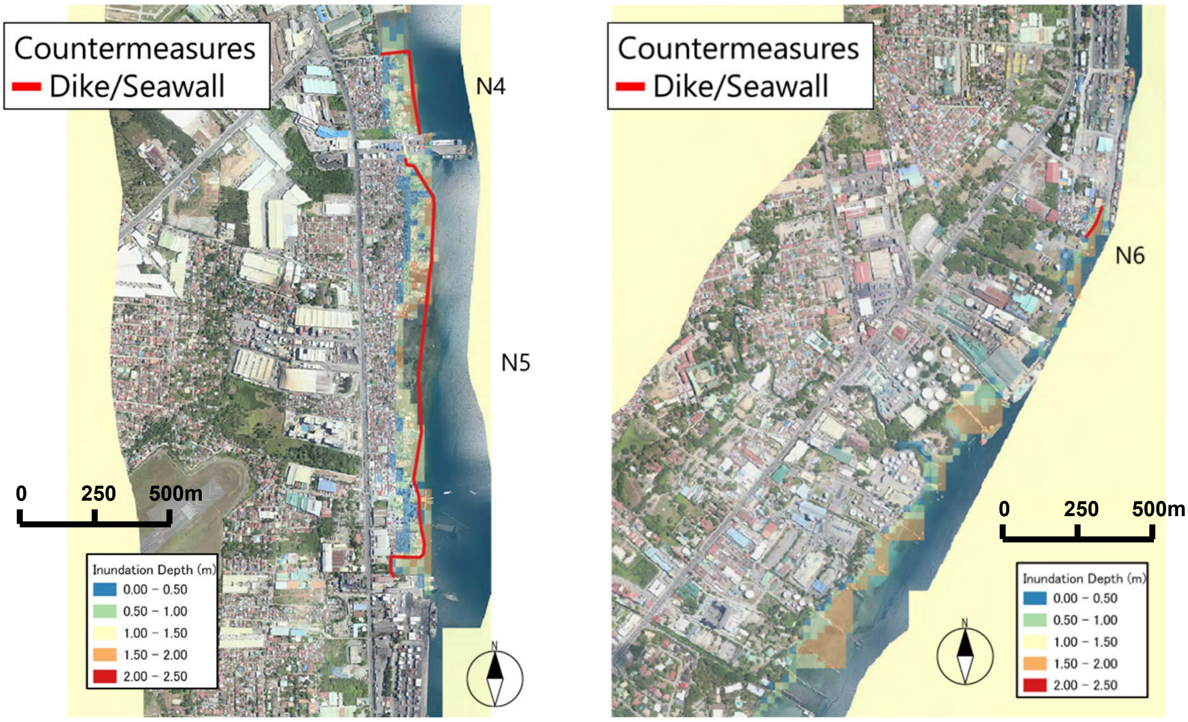
Items	Description
Inundation Status	✓ Storm surge inundation has occurred mainly in lowlands along the coast. ✓ The inundation area is small only in the coastal area, and the inundation does not reach the main road just behind. ✓ In the flooding area, the elevated houses have been adopted and no substantial inundation in their houses has occurred.
Surroundings	✓ Elevated houses are densely located along the coast. ✓ Davao City designated these area as a residential area or industrial area in the zoning map
Direction of Countermeasures	✓ No countermeasures for inundation are basically required since no inundation damage has occurred. ✓ However, as these land area is recognized as available land in the zoning map, elevated house might not be used when land use changes in the future. ✓ In that case, it is necessary to install a coastal dike in front of the coastline to protect the land behind from flooding.

Source: Project Team



Source：Project Team

Figure 3.8.3 Alignment Plans of Countermeasures in North Coast (1)



Source: Project Team

Figure 3.8.3 Alignment Plans of Countermeasures in North Coast (2)

Table 3.8.3 Outline of Countermeasure Projects in North Coast

Target Area	Type	Length (m)	Height (m)
N1	Dike (Wide)	540	1.5
N2	Dike (Wide)	510	1.2
N3	Dike (Wide)	3,100	1.5
N4	Dike (Wide)	390	2.1
N5	Dike (Wide)	1,640	1.7
N6	Dike (Wide)	120	2.1

Source: Project Team

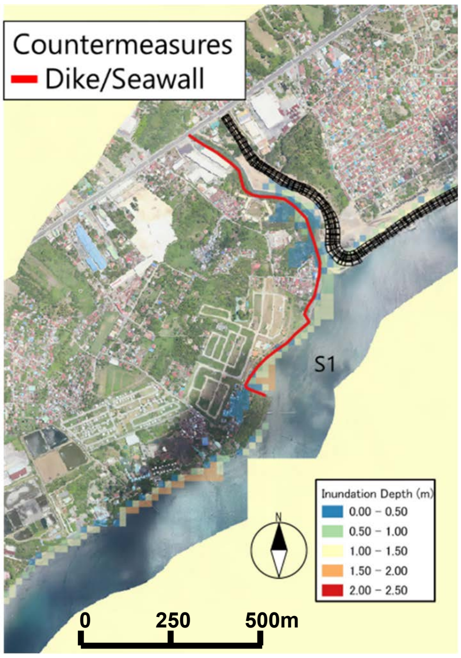
(2) Countermeasures in South Coast

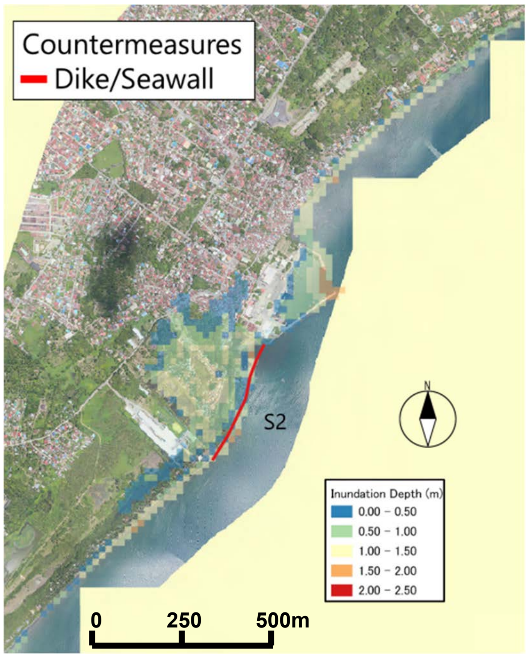
Table 3.8.4 shows the damage situation in the area and the direction of countermeasures based on the storm surge inundation simulation studied in 2.10. Since the inundation area in the south area is local, the countermeasures to install a coastal dike in front of the residential area in inundation area are fundamentally adopted. The specific facility layout for measures is planned as shown in Figure 3.8.4.

Table 3.8.4 Inundation Status and Direction of Countermeasures (South Coast)

Items	Description
Inundation Status	✓ Storm surge inundation has occurred in two main areas along the coastal lowlands. ✓ The inundation area is concentrated only in the relatively small coastal area. ✓ Other areas is relatively high ground and have no inundation.
Surroundings	✓ Elevated houses are adopted in several coastal area. ✓ Davao City designated these area as a residential area or industrial area in the zoning map
Direction of Countermeasures	✓ As the area is recognized as usable land in the zoning map, coastal dikes are necessary in front of the coastline to protect the land behind from flooding. ✓ The continuity and consistency with the river dike must be considered in the inundation area at the estuary.

Source: Project Team





Source: Project Team

Figure 3.8.4 Alignment Plans of Countermeasures in South Coast

Table 3.8.5 Outline of Countermeasure Projects in South Coast

Target Area	Type	Length (m)	Height (m)
S1	Dike (Narrow)	1,450	1.4
S2	Dike (Narrow)	490	2.6

Source: Project Team

(3) Countermeasures in Central Coast

Table 3.8.6 shows the inundation situation in the area and the direction of countermeasures based on the inundation simulations of storm surge discussed in 2.10. The inundated areas in the central area are relatively large. In addition, since the central coast has a Coastal Road section, it is necessary to take measures considering the continuity with Coastal Road. The specific facility layout for countermeasures is planned as shown from Figure 3.8.5 to Figure 3.8.7.

Table 3.8.6 Inundation Status and Direction of Countermeasures (Central Coast)

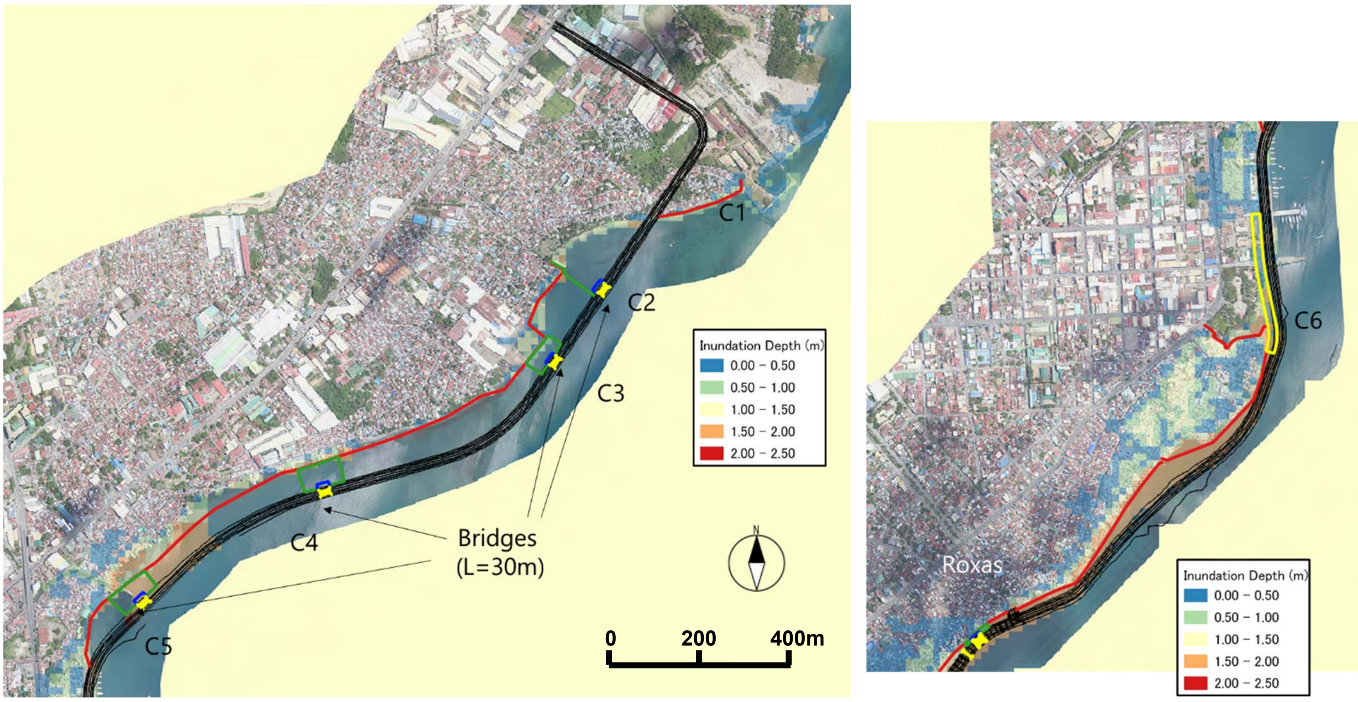
Items	Description
Inundation Status	✓ Storm surge inundation has occurred in several areas, especially in lowlands along the coast. ✓ The inundation area such as on both banks of the Davao River, Agdao area, and around Magsaysay Park, are relatively large. ✓ The west side of Talomo and Matina River is relatively high ground and no inundation has occurred.
Surroundings	✓ In several coastal areas, elevated houses are adopted, but ordinary houses are used on the land side. ✓ The coastal area is designated as a residential area or industrial area in the Davao City zoning map.
Direction of Countermeasures	✓ As the area is recognized as usable land in the zoning map, coastal dikes are necessary in front of the coastline to protect the land behind from flooding. ✓ Take into account integrated protection with Coastal Road. Openings (bridges, box culverts, etc.) need to be closed if Coastal Road is expected to function against storm surge. ✓ In the inundated area at the estuary, the continuity with the river dike must be considered.

Source: Project Team

Table 3.8.7 Alternative Study of Countermeasures in Central Coast

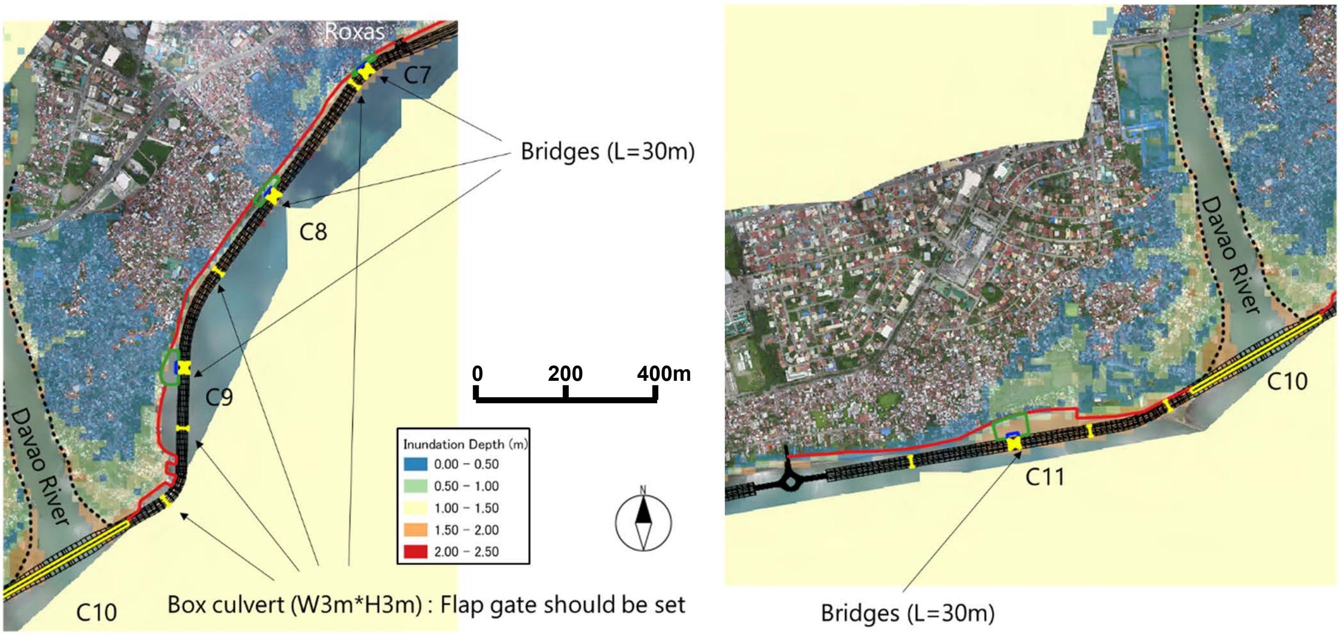
Alternative Countermeasures		Description
A	Back Levee (Dike/Seawall)	✓ Dike/ Seawall is installed along coastal line. ✓ The structure is the simplest and most typical. ✓ The length of measures would be long compared to the other alternatives.
B	Coastal Road with Sluice Gate	✓ Sluice gates are installed at open gaps along Coastal Road. ✓ The structure is relatively complicated. ✓ The length of measures would be short compared to the other alternatives.
C	Coastal Road with Minimized Back Levee	✓ Dike/ Seawall is installed not along coastal line, but at open gaps along Coastal Road. ✓ The structure is the simplest and most typical as well as back levee. ✓ The length of measures would be medium compared to the other alternatives.

Source: Project Team



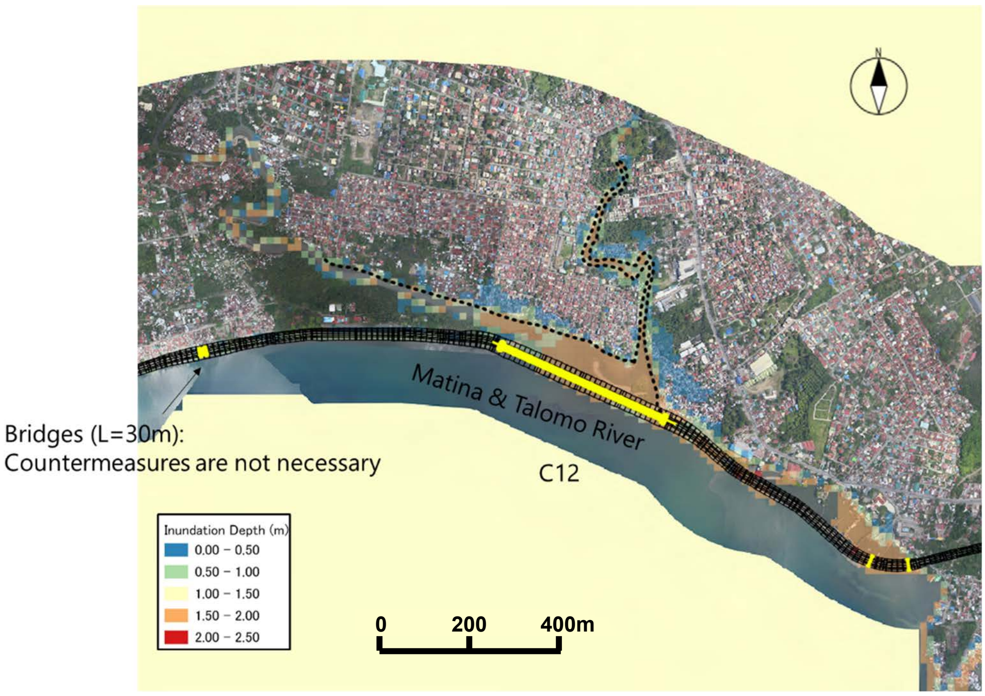
Source: Project Team

Figure 3.8.5 Alignment Plans of Countermeasures in Central Coast (1)



Source: Project Team

Figure 3.8.6 Alignment Plans of Countermeasures in Central Coast (2)



Source: Project Team

Figure 3.8.7 Alignment Plans of Countermeasures in Central Coast (3)

Table 3.8.8 Alternative Countermeasures in Central Coast

Target Area	Alternative 1 Back Levee	Alternative 2 Sluice Gate	Alternative 3 Minimized Back Levee
C1	Dike (Narrow)	-	-
C2	Dike (Narrow)	Sluice Gate	Dike (Wide)
C3		Sluice Gate	Dike (Wide)
C4		Sluice Gate	Dike (Wide)
C5		Sluice Gate	Dike (Wide)
C6	Dike (Wide)	-	-
C7	Dike (Wide)	Sluice Gate	Dike (Wide)
C8		Sluice Gate	Dike (Wide)
C9		Sluice Gate	Dike (Wide)
C10	Dike (Narrow)	-	-
C11	Dike (Narrow)	Sluice Gate	Dike (Wide)
C12	Dike (Narrow)	-	-

Source: Project Team

3.8.3 Alternative Analysis of Countermeasures

The following section discusses and selects the best recommendation through comparative study, for the above-mentioned alternatives in the central area, based on the construction cost and other viewpoints etc. No comparison studies will be conducted for the north and south coasts since there are no alternatives.

(1) Construction Cost

The construction cost of countermeasure was calculated for each area. Table 3.8.9 shows the summary of the central area respectively. Table 3.8.10 shows the construction costs of the north and south areas.

Table 3.8.9 Summary of Construction Costs in Central Coast

Target Area	Alternative 1 Back Levee	Alternative 2 Sluice Gate	Alternative 3 Minimized Back Levee
C1	₱40M		
C2	₱290M	₱750M	₱30M
C3		₱750M	₱40M
C4		₱750M	₱50M
C5		₱750M	₱70M
C6	₱230M		
C7	₱250M	₱750M	₱30M
C8		₱750M	₱30M
C9		₱750M	₱50M
C10L	₱30M		
C10R	₱40M		
C11	₱180M	₱750M	₱40M
C12L	₱30M		
C12R	₱50M		
Total	₱1,140M	₱6,420M	₱760M

Source: Project Team

Table 3.8.10 Summary of Construction Costs in North and South Coast

Target Area	Type	Length (m)	Unit Cost (PHP/m)	Cost (M PHP)
N1	Dike (Wide)	540	110,000	60
N2	Dike (Wide)	510	110,000	60
N3	Dike (Wide)	3,100	110,000	350
N4	Dike (Wide)	390	120,000	50
N5	Dike (Wide)	1,640	110,000	190
N6	Dike (Wide)	120	120,000	20
Target Area	**Type**	**Length (m)**	**Unit Cost (PHP/m)**	**Cost (M PHP)**
S1	Dike (Narrow)	1,450	110,000	160
S2	Dike (Narrow)	490	140,000	70

Source: Project Team

(2) Comprehensive Comparison

There are three alternatives for the central coast, and these alternatives were compared with the economic, environmental, and utilization viewpoints. The summary of the results is shown in Table 3.8.11. The comparison of each alternative is shown in Table 3.8.12.

Table 3.8.11 Results of Alternative Comparison in Central Coast

Items	Description
Evaluation	- Although the minimized back levee can be an optimum measure, the implementation needs discussion with stakeholders. - Therefore, the master plan of coastal flood in this project will recommend to select a normal back levee considering the implementation. - The stages of F/S and/or D/D will need further detail discussion with stakeholders about the best countermeasures so as to minimize the lengths of back levees.
Further Consideration	- Drainage facilities should be installed so as to maintain current drainage function toward sea. - Sanitary problem behind back levees should be considered before implementation. - Preliminary cost benefit analysis will prioritize the countermeasures. - Preservation of Mangrove in the target area need to be considered when the countermeasures are determined.

Source: Project Team

Table 3.8.12 Results of Comprehensive Comparison of Countermeasures in Central Coast

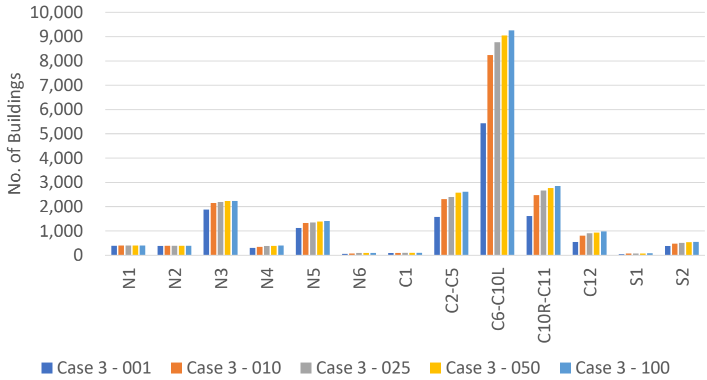
Countermeasures		Length	Construction Cost	Relocation	Fishery Activity	Evaluation
A	Back Levee (Dike/Seawall)	Longest	₱1,140M	Few	Poor	It should be applied at the long bridges (e.g. river mouth)
B	Coastal Road with Sluice Gate	Shortest	₱6,420M	Few	Good	The cost is too expensive. Not good for the target area
C	Coastal Road with Minimized Back Levee	Medium	₱760M	Few	Fair (Limited)	It can be an optimum countermeasure if the limited fishery activity is allowed there.

Source: Project Team

(3) Damage in Each Area

The inundation area and the number of damaged buildings were analyzed in each area for the tide level of 1 to 100 years in Case 3 based on the storm surge inundation simulations discussed in 2.10, and Figure

3.8.8 shows the number of damaged buildings. The following studies will use the results with sea level rise due to climate change. The most damage in both the flooded area and the number of houses is in area of C6-C10L.



Source: Project Team

Figure 3.8.8 Damage in Each Area (Damage Buildings)

(4) Results of Economic Analysis

Assuming that initial investment in the first year and same benefits will be generated for the next 50 years, the overall B/C will be about 2.7. The discount rate is 10%, the land use category is current and the target tide is considered climate change. The annual averaged damage reduction in each area was estimated considering the current inundation status that 1 year probable tide causes no damage in these area.

Table 3.8.13 Cost and B/C in Each Area

Area		Annual Averaged Damage Reduction (Million Pesos)	Cost (Million Pesos)					Annual Cost (Economical Price) (Million Pesos)	B/C
			Construction cost	Land acquisition and compensation costs	Project Cost (Financial Price)	Project Cost (Economical Price)	Annual Maintenance Cost		
1	N1	16	60	0	85	77	0.3	8.1	1.95
2	N2	15	60	0	85	77	0.3	8.1	1.87
3	N3	64	350	0	494	449	1.8	47.0	1.36
4	N4	9	50	0	71	64	0.3	6.7	1.29
5	N5	27	190	0	268	244	1.0	25.5	1.07
6	N6	1	20	0	28	26	0.1	2.7	0.47
7	C1	5	40	0	56	51	0.2	5.4	0.84
8	C2-C5	59	290	0	409	372	1.5	38.9	1.51
9	C6-C10L	262	510	0	719	654	2.6	68.5	3.83
10	C10R-C11	203	220	0	310	282	1.1	29.5	6.88
11	C12	46	80	0	113	103	0.4	10.7	4.27
12	S1	19	160	0	226	205	0.8	21.5	0.87
13	S2	33	70	0	99	90	0.4	9.4	3.49
	Total	758	2,100	0	2,961	2,692	10.5	282	2.69

Note) Annual maintenance cost is 0.5% of construction cost

Source: Project Team

(5) Selection of Priority Area

The priority project area is selected. In addition to B/C, considering the ratio of inundated area to the cost and the number of damaged buildings, comprehensive prioritization was implemented based on the following conditions. The result of the final prioritization is shown in Table 3.8.14.

- Connecting the next areas ensure the project consequence.
- Focus on the mitigation effect on damaged buildings rather than inundation areas.
- Since North coast has not suffered any damage, Central and South coast have priority.
- Although B/Cs do not exceed 1.0 in a few areas, the validity of the project has been confirmed in all areas (i.e., B/C ≈ 2.7), and B/C is not considered in the priority of each area.

Table 3.8.14 Prioritization of Coastal Projects in Each Area

Area	Rank (Inundation)	Rank (Buildings)	B/C	Integrated Rank
N1	7	8	1.95	7
N2	5	9	1.87	8
N3	10	10	1.36	11
N4	8	5	1.29	9
N5	9	7	1.07	10
N6	13	11	0.47	12
C1	11	12	0.84	4
C2-C5	6	4	1.51	
C6-C10L	3	1	3.83	1
C10R-C11	2	2	6.88	2
C12	4	3	4.27	3
S1	12	13	0.87	6
S2	1	6	3.49	5

Source: Project Team

3.8.4 Preliminary Facility Plan of Structural Measures

(1) Overall Facility Plan

Based on the above, Table 3.8.15 shows a list of the preliminary facility plan for coastal structure countermeasures.

Table 3.8.15 Project List of Preliminary Facility Plan of Coastal Structure Measures

Rank	Area	Cost (MPHP)	Type	Length (m)
1	C6-C10L	510	Dike (Wide)	4,320
2	C10R-C11	220	Dike (Narrow)	1,870
3	C12	80	Dike (Narrow)	670
4	C1	40	Dike (Narrow)	350
	C2-C5	290	Dike (Narrow)	2,550
5	S2	70	Dike (Narrow)	490
6	S1	160	Dike (Narrow)	1,450
7	N1	60	Dike (Wide)	540
8	N2	60	Dike (Wide)	510
9	N4	50	Dike (Wide)	390
10	N5	190	Dike (Wide)	1,640
11	N3	350	Dike (Wide)	3,100
12	N6	20	Dike (Wide)	120

Source: Project Team

(2) Project Schedule

Table 3.8.16 shows the draft project schedule for the implementation period of this project over 25 years in this master plan (up to 2045). This schedule was based on the following conditions.

- The project will be implemented in the order of the coastal priority, in the order of Central Coast, South Coast, and North Coast.
- The project period is affected by the budget allocation, but here the average budget is assumed to be around 200M PHP per year. (The maximum budget for one project of DPWH RO is 200M PHP)
- Since no damage has occurred in North Coast, it is necessary to consider the necessity of the project taken into consideration future land use and residential conditions when implementing the project.

At the beginning of this master plan (2023), the Coastal Road near C1-C5 area will be under construction, and the section of Coastal Road near C6-C10L and C10R-C11 area, which have high priority, has been completed. This master plan will be started after construction of Davao Coastal Road. However, depending on future discussions with DPWH, the high-priority projects can be started before or under construction of Coastal Road.

Table 3.8.16 Draft Implementation Schedule of Coastal Projects in M/P

Area	Rank	Period	2022			2025					2030					2035					2040					2045
		(year)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
N1	7	1.0																								
N2	8	1.0																								
N3	11	2.0																								
N4	9	1.0																								
N5	10	1.0																								
N6	12	1.0																								
C1	4	1.0																								
C2-C5	4	2.0																								
C6-C10L	1	3.0																								
C10R-C11	2	2.0																								
C12	3	1.0																								
S1	6	1.0																								
S2	5	1.0																								

Note) Project implementation for N1 to N6 will be considered as a reference because it depends on future land use.

Source: Project Team

3.9 Non-structural measures

3.9.1 Target and role of Non-structural measures

The non-structural measures in the M/P will cover Davao city including the Davao River, the Talomo River and the Matina River, targeting riverine flood, inland flood and storm surge.

For considering the detailed activities on non-structural measures, implementation contents, implementation schedule, target areas, and planned conditions of the proposed structural measures in the M/P will be carefully reviewed to achieve the optimal combination of structural and non-structural measure. Also, early implementation of non-structural measures is expected without waiting for the completion of structural measures since the construction work requires relatively long years. In addition, it is expected that the effect of structural measures will be improved by introducing non-structural measures prior to structural measures.

Specifically, activities with the following three perspectives will be proposed as the non-structural measures.

(A) For situation changed by implementation of the proposed structural measures

The structural measures consist of short-term (2023 to 2032) and medium/long-term (2033 to 2045) in the M/P, then the non-structural measures are required according to the changing discharge capacity of river channel, inundation area, and land use condition depending on the progress of implemented structural measures in each term.

(B) For outside area where the structural measures are not implemented

In case of the structural measures for the Davao River, the target area is limited to 23km from the river mouth so that non-structural measures are required for outside the target area of structural measures, especially for the upstream area.

(C) For securing effectiveness of the proposed structural measures

Since the land cover situation and the clogging situation in drainage channels, etc. are examined based on certain preconditions in planning the structural measures, non-structural measures are required so as not to deteriorate them in the future.

3.9.2 Listing of Non-structural measures

Based on the three perspectives described above, a list of non-structural measures will be made. Various activities related to non-structural measures are in progress or already planned in Davao City. Therefore, those existing activities that need to be continuously implemented will be included as non-structural measures in this M/P.

For each activity of the listed non-structural measures, considering the current status and challenges, countermeasure approaches are summarized in Table 3.9.1, Table 3.9.2, and Table 3.9.3 for each of the three perspectives.

Table 3.9.1 (A) Approaches for situation changed by implementation of the proposed structural measures

Countermeasure approaches
A-1. Additional installation of water level gauges
➢ Installation of water level gauges upstream and downstream of the retarding basins newly proposed as the structural measures ➢ Re-installation of existing water level gauges to a nearby bridge when rebuilding a bridge due to river widening works proposed as the structural measures
A-2. Setting warning water level in Davao river corresponding to the latest river and social conditions
➢ Review of warning water level of water level gauges at Waan Bridge and Maharlika highway Bridge, etc. ➢ Establishment of organization to periodically review warning water levels through information/data sharing among stakeholders
A-3. Establishment of real time inundation monitoring system
➢ Timely sharing of road inundation status with stakeholders including residents ➢ Introduction of CCTV system to all BDRRMs in Davao city ➢ Expand CCTV system around river structures and use it for flood response activities
A-4. Capacity enhancement project on disaster preparation and response focusing on flood warning for Davao, Talomo and Matina river
➢ Implementation of technical cooperation project for PAGASA and CDRRMO ➢ Strengthening of flood forecasting capacity, strengthening of information dissemination capacity through implementation of drill, designation of role allocation among the related organizations through preparation of timeline action plan, formulation of guidelines on flood forecast and warning system including small and medium rivers, etc.
A-5. Formulation of city evacuation plan considering the latest inundation estimation
➢ Formulation of Davao City Evacuation Plan with reference to the inundation estimation for riverine flood, inland flood and storm surge calculated in this project
A-6. Construction of additional evacuation shelters with enough stock pile and facility

Countermeasure approaches
➢Construction of a new evacuation shelters based on the evacuation plan formulated above A-5 ➢Accepting wide-area evacuation and developing evacuation shelters considering long-term evacuation
A-7. Updating Davao city flood response plan and contingency plan corresponding to the latest situation
➢Clarification of time-series role assignment of related organizations during floods based on heavy rain and water level information provided by PAGASA
A-8. Preparation of IEC materials on the proposed structural measures and non-structural measures
➢Preparation of brochures to inform the contents of M/P to residents and related organizations ➢Utilization at the Community DRR training institute planned in Davao City Disaster Risk Reduction and Management Plan 2020-2025 (Local residents bring back IEC materials and utilize them for self-study)
A-9. Formulation and Update of flood hazard map for riverine, inland and coastal with evacuation information
➢Formulation of a hazard map integrating the inundation estimation for riverine flood, inland flood and coastal flood ➢Formulation and updating of hazard maps according to progress in structural measures and worst case flood exceeding the target design level ➢Identification of important infrastructure facilities (evacuation centers, hospitals, disaster response agencies, etc.) located in the inundation area, Promotion of infrastructure that can function even when flooded
A-10. Establishment of stone monuments for historical flood record
➢Installation of a stone monuments indicating the inundation depth and area related to the past maximum floods such as typhoon VINTA (assuming to be installed at about 6 places along the Davao River exceeding the inundation depth of 3m based on the flood mark survey results)
A-11. Planning and Implementation of flood fighting drill
➢Planning and conducting flood fighting drills, including issuing warnings, disseminating information, inspecting river structures and flood defense equipment, and evacuating residents, etc.
A-12. Rehabilitation/Transplanting of existing mangrove
➢Enhancement of the breakwater effect along the Davao City coast through rehabilitation of 30 ha mangroves based on the existing Davao City Forest Land Use Plan ➢Transplanting of existing mangroves overlapping the coastal structures proposed in this M/P
A-13. Land use control along the proposed structural measures
➢Regulation of land use to implement structural measures (retarding basins, river channel widening, etc.) proposed in this M/P
A-14. Development of resettlement area
➢Development of the resettlement area in accordance with resettlement caused by this M/P
A-15. Promotion of Comprehensive Land Use Plan and Zoning Ordinance
➢Appropriately regulation of land use taking into account the river boundaries set by this M/P
A-16. Capacity enhancement project on riverine flood, rainwater drainage and coastal management in Davao
➢Implementation of technical cooperation project for DPWH and CEO on design, construction, operation and maintenance, project evaluation, and role allocation among related organizations in riverine flood, rainwater drainage and coastal management

Source: JICA Project Team

Table 3.9.2 (B) Approaches for outside area where the structural measures are not implemented

Countermeasure approaches
B-1. Planning and establishment of Community-Based Flood Early Warning System for tributaries of Davao river, Matina river and Talomo river
➢Establishment of an observation and information sharing system by residents themselves using simple water gauges and rain gauges ➢Additional installation of rain gauges in the middle basin of the Talomo River and Matina River (assuming one each) ➢Establishment of warning system based on heavy rainfall information using rainfall observation data

Countermeasure approaches
➢ Formulation of barangay level information dissemination manual
B-2. Installation and utilization of meteorological radar for more detailed forecasting and warning
➢ Utilization of X-band radar for more detailed rainfall information for forecasting and warning in combination with existing ground observations ➢ Utilization of X-band radar to grasp rainfall characteristics in the Davao River tributary, the upper and middle basins of the Matina and Talomo river where the structural measures are not implemented in the M/P

Source: JICA Project Team

Table 3.9.3 (C) Approaches for securing effectiveness of the proposed structural measures

Countermeasure approaches
C-1. Promotion of forest conservation based on the Davao River Basin Management and Development Plan and Forest Land Use Plan
➢ Promotion of appropriate forest land use and regulation of large-scale development and land use change based on the existing plans ➢ Promotion of 33,327 ha of forest conservation, 20,000 ha of forest restoration, and 17,800 ha of forest creation based on the Davao River Basin Management and Development Plan
C-2. Promotion of Rainwater Catchment System with establishment of its database
➢ Control runoff to rivers and drainage channels by promoting Rainwater Catchment System ➢ Further promotion and management in areas where no Rainwater Catchment System is installed, through database establishment ➢ Improvement of the installation rate of Rainwater Catchment System through formulation and finalization of a technical manual on planning and installation
C-3. Promotion of Permeable Pavement System with establishment of its
➢ Control runoff into rivers and drainage channels by promoting Permeable Pavement System ➢ Further promotion and management in areas where no Permeable Pavement System is installed, through database establishment ➢ Improvement of the installation rate of Permeable Pavement System through formulation of a technical manual
C-4. Development of retarding pond in subdivision area
➢ Control runoff into rivers and drainage channels by promoting retarding pond with the development of new residential subdivisions ➢ Sharing existing cases as good practice with stakeholders (in the upstream areas of Mamay creek, developers have voluntarily set up retarding pond in their subdivision) ➢ Examining the establishment of a new city ordinance or the revision of an existing one (There is a case study of the ordinance proposal in Cavite)
C-5. Successive budgeting and Implementation for cleaning maintenance of drainage channels
➢ Continuation of removing debris from drainage networks to properly discharge flood volume planned in this M/P
C-6. Support for implementation of cleaning activities by volunteers, NGOs and Barangays
➢ Promotion of community-level cleanup activities in areas where government cleanliness is inadequate
C-7. Promotion of solid waste management plans
➢ Promotion of cleaning of waterways and reduction of illegal dumping according to the formulated solid waste management plan

Source: JICA Project Team

3.9.3 Timeframe and role allocation of Non-structural measures

The non-structural measures listed in the previous section are organized into the seven categories. Table 3.9.4 shows the implementing organizations and timeframe for each non-structural measures activity item summarized through the workshop with related organizations and a series of C/P meetings.

Table 3.9.4 Timeframe and role allocation of Non-structural measures

1. Flood forecasting and warning	Main	Sub	2023 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 2045 ~	Number
(a) Additional installation of water level gauges	PAGASA DOST	CDRRMO	Completion of Structural measures; Completion of Structural	A-1
(b) Setting warning water level in Davao river corresponding to the latest river and social conditions	PAGASA	DPWH CDRRMO	Completion of Structural measures; Completion of Structural	A-2
(c) Planning and establishment of Community-Based Flood Early Warning System for tributaries of Davao river, Matina river and Talomo river	PAGASA CDRRMO	Barangays		B-1
(d) Installation and utilization of meteorological radar for more detailed forecasting and warning	PAGASA	CDRRMO		B-2
(e) Establishment of real time inundation monitoring system	CDRRMO Barangays	DPWH		A-3
(f) Capacity enhancement project on disaster preparation and response focusing on flood warning for Davao, Talomo and Matina river	Technical cooperation by donor			A-4

2. Evacuation planning	Main	Sub	2023 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 2045 ~	Number
(a) Formulation of city evacuation plan considering the latest inundation estimation	CDRRMO	CSSDO CPDO		A-5
(b) Construction of additional evacuation shelters with enough stock pile and facility	CSSDO	DPWH OCD		A-6
(c) Updating Davao city flood response plan and contingency plan corresponding to the latest situation	CDRRMC members			A-7

3. Awareness activities	Main	Sub	2023 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 2045 ~	Number
(a) Preparation of IEC materials on the proposed structural measures and non-structural measures	DPWH	CDRRMO	Completion of Structural measures	A-8
(b) Formulation and Update of flood hazard map for riverine, inland and coastal with evacuation information	MGB DPWH	CDRRMO	Completion of Structural measures; Completion of Structural; Completion of Structural	A-9
(c) Establishment of stone monuments for historical flood record	CDRRMO	DPWH		A-10
(d) Planning and Implementation of flood fighting drill	CDRRMO	DPWH		A-11

4. Forest and mangrove conservation	Main	Sub	2023 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 2045 ~	Number
(a) Promotion of forest conservation based on the Davao River Basin Management and Development Plan and Forest Land Use Plan	DENR	CENRO, Bukidnon Province		C-1
(b) Rehabilitation/Transplanting of existing mangrove	DENR	CENRO		A-12

5. Land use control	Main	Sub	2023 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 2045 ~	Number
(a) Land use control along the proposed structural measures	CPDO	DPWH		A-13
(b) Development of resettlement area	CPDO	DPWH	Completion of Structural measures; Completion of Structural	A-14
(c) Promotion of Comprehensive Land Use Plan and Zoning Ordinance	CPDO	DPWH		A-15

6. Runoff control through on-site storage and permeable pavement system	Main	Sub	2023 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 2045 ~	Number
(a) Promotion of Rainwater Catchment System with establishment of its database	CEO	CPDO DPWH		C-2
(b) Promotion of Permeable Pavement System with establishment of its database	CEO	CPDO DPWH		C-3
(c) Development of retarding pond in subdivision area	CEO	CPDO DPWH		C-4

7. Cleaning maintenance of drainage channels, river and coastal area	Main	Sub	2023 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 2045 ~	Number
(a) Successive budgeting and Implementation for cleaning maintenance of drainage channels	DEO ASU/CEO	Barangays		C-5
(b) Support for implementation of cleaning activities by volunteers, NGOs and Barangays	CPDO ASU	CDRRMO		C-6
(c) Promotion of solid waste management plans	CENRO	CPDO		C-7
(d) Capacity enhancement project on riverine flood, rainwater drainage and coastal management in Davao	Technical cooperation by donor			A-16

Implementation   Continuation of the existing activity

Source: JICA Project Team

3.9.4 Ordinance and Institutional Framework Strengthening

(1) Ordinance and Policy Framework Support

The Davao City government together with the DPWH and related agencies has relatively illustrates strengths in terms of enabling ordinances and policies that facilitates effective management and control over water related resources, but the political will of enforcing them remains weak. Hence, in order to support and enable enforcement as well as facilitate development of new policies and ordinances required for a consistent and responsive policy environment to the rapidly changing institutional and policy environment, the promotion and implementation of various mechanisms especially in areas where structural measures are being implemented. The M/P supports and advocates the implementation of the following measures:

- Periodic reviews of statutes and ordinances
- Establish flood prevention standards and developing manuals and guidelines
- Policy advocacy changes on flood zoning
- Sustainable investments and budget to support the implementation and enforcement of flood related ordinances and policies

(2) Strengthening of Institutional Arrangement

Recognizing the complex and multidisciplinary tasks of flood risk protection particularly in implementing a mix of structural and non-structural measures, mechanism of coordination, communication and consensus-building between and among the different line government agencies, local government units, non-government organizations and the community, both at the national and the local level, will be strengthened.

In the case of Davao City, coordination, communication and collaborative efforts between and among the District Engineers Office, the City Government through City Engineers Office and City Planning and Development Office, City Disaster Risk Reduction and Management Office, Department of Environment and Natural Resources and other relevant attached agencies of the DENR are relatively strong and hence should be sustained.

In order to sustain the efforts of collaboration and cooperation among these significant institutions, this M/P supports and promotes the implementation of the following measures:

- Enhance the capacity of the institutions in carrying out flood control measures
- Creation of new alliance and sustaining the ones that are positively contributed to the flood control management goals

3.10 Formulation of the Master Plan

3.10.1 Proposed Projects

Integrated flood control master plan for the Davao, Matina and Talomo river basins are formulated by compiling the study results up to the previous section. The M/P consists of structural measures and non-structural measures shown in Table 3.10.1 targeting riverine flood in the three rivers, inland flood in the Davao city, and storm surge.

Table 3.10.1 Integrated Flood Control M/P

Target		Short-term Measure (2023-2032）	Mid/Long-term measure (2033-2045)
Structural measure			
Flood in 3 rivers 【Riverine flood】	Davao River	- Dredging - Cut-off Work - Retarding Ponds (three locations)	- River Widening - Retarding Ponds (four locations)
	Matina River	- Cut-off Work - Retarding Ponds (twelve locations)	- River Widening - Flood Wall at river mouth
	Talomo River	- Dredging - Cut-off Work - Retarding Ponds (three locations)	- River Widening - Flood Wall at river mouth
Inland flood in the city 【Inland flood】	Roxas Drainage Area	-	- Channel Improvement and Installation of Bypass Channel
	Agdao Drainage Area	- Installation of Retarding Basin - Improvement of Lower Channel	- Installation of Retarding Basin
	Jerome Drainage Area	- Installation of Retarding Basin - Improvement of Lower Channel	- Installation of Retarding Basin
	Mamay Creek Drainage Area	- Installation of Retarding Basin - Improvement of Upper Creek	- Installation of Retarding Basin - Installation of Bypass Channel
	Sasa Creek Drainage Area	- Installation of Retarding Basin - Channel Improvement and Installation of Bypass Channel	- Installation of Retarding Basin
	Emars Drainage Area	- Installation of Retarding Basin - Installation of Bypass Channel	-
	Shanghai Drainage Area	- Installation of Retarding Basin - Channel Improvement and Installation of Bypass Channel	-
	Maa1 Drainage Area	- Installation of Retarding Basin - Channel Improvement	- Installation of Retarding Basin
	Maa2 Drainage Area	- Installation of Retarding Basin - Channel Improvement	- Installation of Underground Diversion Channel - Installation of Retarding Basin
Coastal conservation and storm surge 【Coastal flood】	North area	-	Dike (Wide)
	Central area	Back Levee (Dike (Narrow / Wide))	-
	South area	-	Dike (Narrow)
Non-Structural measure		- Flood forecasting and warning - Evacuation planning - Awareness activities - Forest and mangrove conservation - Land use control - Runoff control through on-site storage and permeable pavement system - Cleaning maintenance of drainage channels, river and coastal area	

Source: Project Team

3.10.2 Staged Development Plan

The M/P is implemented in stages, divided into short-term, mid/long-term. The project implementation schedule is shown in Figure 3.10.1 as a staged development plan in the M/P.

Target		Measures	Period																						
			Short term										Mid/Long term												
			2023	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Structural measure																									
Flood in 3 rivers 【Riverine flood】	Davao River	Dredging	■	■	■	■	■	■	■	■	■														
		Cut-off Work	■	■	■																				
		Retarding Ponds (three locations)	■	■	■	■	■	■	■	■	■	■													
		River Widening										■	■	■	■	■	■	■							
		Retarding Ponds (four locations)											■	■	■	■	■	■	■	■	■	■	■		
	Matina River	Cut-off Work	■	■	■																				
		Retarding Ponds (twelve locations)	■	■	■	■	■	■	■	■	■														
		River Widening										■	■	■	■	■	■	■							
		Flood Wall at River Mouth											■	■											
	Talomo River	Dredging	■	■	■	■																			
		Cut-off Work	■	■	■																				
		Retarding Ponds (three locations)					■	■	■	■	■														
		River Widening										■	■	■	■	■	■	■							
		Flood Wall at River Mouth											■	■											
Inland flood in the city 【Inland flood】	Roxas Drainage Area	Channel Improvement and Installation of Bypass Channel											■	■	■	■	■	■	■	■	■	■			
	Agdao Drainage Area	Installation of Retarding Basin, Improvement of Lower Channel	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
	Jerome Drainage Area	Installation of Retarding Basin, Improvement of Lower Channel	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
	Mamay Creek Drainage Area	Installation of Retarding Basin, Bypass Channel, Improvement of Upper Creek	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
	Sasa Creek Drainage Area	Installation of Retarding Basin, Bypass Channel, Channel Improvement	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
	Emars Drainage Area	Installation of Retarding Basin, Bypass Channel	■	■	■	■	■	■	■	■	■	■													
	Shanghai Drainage Area	Installation of Retarding Basin, Bypass Channel, Channel Improvement	■	■	■	■	■	■	■	■	■	■													
	Maa1 Drainage Area	Installation of Retarding Basin, Channel Improvement	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
	Maa2 Drainage Area	Installation of Retarding Basin, Underground Diversion Channel, Channel Improvement	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Coastal conservation and storm surge 【Coastal flood】	North area	Dike (Wide)																■	■	■	■	■	■	■	
	Central area	Dike (Narrow / Wide)	■	■	■	■	■	■	■	■	■														
	South area	Dike (Narrow)										■	■	■											
Non-Structural measure		Flood forecasting and warning	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Evacuation planning	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Awareness activities	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Forest and mangrove conservation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Land use control	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Runoff control through on-site storage and permeable pavement system	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Cleaning maintenance of drainage channels, river and coastal area	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Source: Project Team

Figure 3.10.1 Staged Development Plan in the M/P (Project Implementation Schedule)

3.11 Project cost estimation

3.11.1 Condition and assumption for cost estimation

(1) Cost estimation method of Project cost

The project cost will be estimated by method indicated in Table 3.11.1 considering "Cost estimation manual for preparatory survey for cooperation" (2009.3 JICA) and "Flood Control and Drainage Construction Cost Estimation Manual" (2017 DPWH).

Table 3.11.1 Cost estimation method of each cost

Cost items	Detail items	Cost estimation method
Project Implementation and Management Cost		Project cost which is the overhead expense of the project implementer, shall be estimated at 3.5% of the amount of construction/procurement cost, administration cost for design and contingency.
Preparation Cost	Land Acquisition Cost	Land acquisition cost shall be estimated multiplying the area of each land use required for the project implementation by unit land cost of each land use. Unit land cost of each land use shall be 1.2 times the cost stipulated by the Davao city ordinance[2] in order to set as a realistic price considering the actual situation. Land acquisition cost for the informal habitant shall not be estimated, but land acquisition cost at the relocation area (new address) shall be estimated.
	Compensation Cost	Compensation cost shall be estimated to be the reacquisition price, consisting of cost of materials, indirect construction cost, VAT, transfer taxes, etc., as well as planting cost for crops and trees to be cut down. Required cost for building transfer shall be estimated at the cost that is required to build a new building with the same lot area of the existing building at the relocation area (new address). Required cost for new building construction shall be estimated referring to the building construction cost stipulated by the Davao city ordinance.
	Removal Cost	Removal cost shall be estimated at 20% of the cost required for building transfer.
	Inspection Cost for Environmental Consideration	Inspection cost for environmental consideration shall be included in the project implementation and management cost.
Construction / Procurement Cost		Construction/procurement cost shall be estimated at the amount of direct cost including material cost and contractor's profit that are stipulated by the DPWH Cost Estimation Manual[3]. Contractor's profit shall be estimated at 10% of the direct cost including the material cost referring to the DPWH Cost Estimation Manual. Strictly speaking, the contractor's profit depends on direct cost, namely, in case the direct cost is 5 million pesos or less, the contractor's profit is 10% of the direct cost and in case the direct cost is more than 5 million pesos, that is 8% of the direct cost. However, in this study, the rate shall be 10% regardless of the direct cost.
Administration Cost for Design	Administration Cost for Civil Design	Detail design cost shall be estimated at 10% of construction/procurement cost. Construction management cost shall be estimated at 8% of construction/procurement cost.
	Administration Cost for Building Design	Administration cost for building design shall be included in the detail design cost.
	Administration Cost for Equipment Design	Administration cost for equipment design shall be included in the construction management cost.
Contingency		Contingency shall be estimated at 10% of the amount of construction/procurement cost and administration cost for design. Breakdown of contingency are price contingency and physical contingency. Price contingency shall be estimated at 50% of the contingency (5% of construction/procurement cost) and physical contingency shall be also 50% of the contingency.
Technical Training Cost		Technical training cost shall not be estimated related to the structural measures. Technical training cost related to the non-structural measures shall be estimated properly.
Operation and Maintenance Cost		Annual operation and maintenance cost shall be 0.5% of construction/procurement cost.

Source: Project Team

2 Ordinance No.0257-17 Schedule of Market Values for Urban Lands by Class
3 Flood Control and Drainage Construction Cost Estimation Manual 2017 (Department of Public Works and Highway)または Road Construction Cost Estimation Manual 2015 (Department of Public Works and Highway)

1) Land Acquisition Cost

Land acquisition cost was estimated multiplying each land use area by 1.2 times the each unit land cost, since generally 1.2 times the each land cost has been required for actual land acquisition.

2) Compensation

In this study, only the expense required for building relocation shall be included in the compensation costs.

3.11.2 Project cost estimation of measures against riverine flood

In order to determine an optimal combination of countermeasures against flooding (measures against riverine floods, storm water drainage improvement and measures against coastal floods) in the master plan, it is necessary to consider the required cost for the implementation of each measure. In this section, based on the above purpose, a required study to estimate the approximate costs of each measure has been carried out. When comparing the approximate costs in the master plan study, the cost shall be the amount of construction/procurement cost, land acquisition cost and compensation.

(1) River Bed Dredging (Dredging)

- Construction/procurement cost

By the riverbed dredging work, the riverbed in the current river channel will be dredged to the depth of the design riverbed level with the both bank slope of 1:1 by a backhoe on a barge. Therefore, the construction/procurement cost was estimated multiplying the dredged soil volume by the unit cost of dredging (direct construction cost including material cost).

- Land acquisition and compensation

These costs shall not be estimated because land acquisition and compensation are not necessary for the dredging.

(2) River Improvement (Flood wall construction)

- Construction/procurement cost

< Flood wall construction >: Because of the flood wall construction, a flood wall will be constructed to the height determined adding free board to the design flood level at both banks. Under the above assumption, the construction/procurement cost was estimated.

< Rebuilding existing bridges >: The cost required to rebuild existing bridges shall be included in the construction/procurement cost. The necessity of rebuilding existing bridges was judged comparing the lower edge level of existing bridges and the level that is determined adding freeboard to the design flood level. Namely, in case the lower edge level of an existing bridge is lower than the design flood level plus freeboard, it was determined that rebuilding was necessary. The re-building cost shall be estimated summing the expenses required to remove the existing bridge and construct a new bridge.

- Land acquisition cost

Considering the work situation of flood wall construction, the area with the width of 10m from the existing riverbank edge shall be acquired. Assuming that land use is residential in all areas required for acquisition, the land acquisition cost was estimated.

- Compensation

Compensation cost was estimated by multiplying the lot area of existing buildings in the project area by the average unit construction cost of. And only this expense shall be estimated as compensation cost.

(3) River Improvement (River widening)

- Construction/procurement cost

Based on the following concept, river widening area was determined.

- Plane alignment of river shall be as straight as possible after river improvement
- Reduce construction cost and simplify construction work by concentrating the river widening area to one side.

The construction work method of river widening is depending on river widening width. The expenses required for the excavation of the land area, dredging under water, installing revetment and installing/removal temporary coffering (steel sheet pile) have been estimated.

- Land acquisition cost

In case of river widening in Davao river, land acquisition width shall be the width obtained by adding required width for construction work to the upper width of trapezoidal cross section required to flow design flood discharge. And land acquisition cost was estimated multiplying land area of each land use by 1.2 times of the unit land cost of each land use. Trapezoidal cross section required to flow design discharge was determined as followings. Design river bed width at the design river bed level was set and upper width of trapezoidal cross section was set by connecting both edges of design river bed to the design flood water level by the both bank slope with gradient of 1:1.

- Compensation

Compensation cost was estimated multiplying lot area of existing buildings in the project area by average unit construction cost of buildings. And only this expense shall be estimated as compensation cost.

(4) Retarding Pond

- Construction/procurement cost

The construction/procurement cost required for the construction of a retarding pond was estimated by multiplying the excavation soil volume by unit cost. The unit cost per excavation soil volume was determined as follows:

- As a trial estimation, the expense required for the construction of four retarding ponds including excavation, installing overflow dike, installing revetment/dike at the periphery of retarding pond and installing drainage gate was estimated.
- The total construction cost of four retarding ponds divided by the total excavation soil volume was estimated, and 1.1 times of the estimated value to include the contractor’s profit, was set to the unit construction/procurement cost of retarding pond.

- Land acquisition cost

The total excavation area required for the construction of retarding pond shall be acquired. Assuming that the land use of all required area is agricultural land, the land acquisition cost was estimated by multiplying the required area by 1.2 times of the unit land cost.

- Compensation

Compensation cost was estimated as the cost required for relocation by multiplying the building lot area in the land acquisition area by the average unit land cost of each building type. Only this cost was estimated as compensation.

(5) Dam

- Construction/procurement cost

The project cost of dam construction shall be estimated by the calculation of the dam body volume depending on the topography on the dam site and required reservoir capacity (Flood control capacity plus sedimentation capacity), and the relation between the dam body volume and project cost referring to Japanese experience. The construction/procurement cost including material cost shall be estimated from the estimated project cost. In the Mindanao Islands there is no example of a concrete dam with a height of 50m or more, and the strength of foundation rock (shearing strength etc.) is not clear, therefore, the type of dam shall be determined as a fill dam. The detail procedure for the estimation of construction/procurement cost is as follows.

- Optimal candidate site for dam construction was selected from plural candidates.
- Relation between dam height and reservoir capacity at the selected dam site was determined.
- Required capacity for the flood control depending on the controlled discharge was calculated based on the flood discharge hydrographs. The effective reservoir capacity was determined by adding the sedimentation capacity to the flood control capacity.
- The dam body volume was calculated based on the current ground level on the dam axis assuming the slope gradient of the upstream dam surface is 1:2.5, the downstream surface is 1:3.0 and crest width of dam is 10m.
- Construction/procurement cost was estimated by multiplying the dam body volume by the unit cost.

- Land acquisition cost

The required area, namely for the lot of the dam body and submerged area under the surcharge water level shall be acquired. Assuming that the land use of all required area is agricultural land, the land acquisition cost was estimated by multiplying the required area by 1.2 times of the unit land cost.

- Compensation

As compensation, the required cost for the relocation of existing buildings and the cost for the construction of new bridges instead of using the existing road under the surcharge water level.

< Relocation of existing buildings >: The compensation cost was estimated as a cost required for the relocation by multiplying the building lot area in the land acquisition area by the average unit land cost of each building type.

< Required cost to substitute submerged road by new bridge >: This cost was estimated by multiplying the submerged area (calculated multiplying road length by the width of 10m) of the existing road by the unit construction cost of a steel road bridge referring to Japanese experience.

(6) Floodway (Diversion channel)

- Construction/procurement cost

The construction/procurement cost required for the construction of a floodway shall be estimated as the amount for the underground tunnel channel and open channel.

The cost of the tunnel channel was estimated by multiplying the inner cross section area by unit construction cost. The unit construction cost was set referring to Japanese experience. The cost required for the construction of an open channel was estimated referring to the DPWH Cost Estimation Manual.

In the study on flood control in Davao river, four routes (Route A,B,C and D) were set as candidates for the floodway. Route B was selected as the most economical way, comparing the construction costs of the four routes. Therefore, targeting route B, the construction/procurement cost depending on discharge allocated to floodway was estimated.

(7) Project cost of measures against riverine flood

Cost of each alternative from Alt.1 to Alt.3-4 composed of multiple structural measures were compared in the section of “3.4 Structural Measures of Riverine Flood in Davao River”. Project cost of each alternative were estimated based on the above method to compare project cost of each alternative. Project cost estimation result regarding alternative 3-1 that is recommendation in all alternatives.

Table 3.11.2 Project cost of alternative 3-1 composed of structural measures

Estimation items	Estimation details		Amount（Bil.PhP）		Cost estimation methods
Project implementation management cost of Filippines Government				1.099	3.5% of the amount of construction/procurement cost, administration cost for design and contingency.
Preparation cost	Land acquisition cost	River widening (Target discharge 1700m3/s)	1.088	1.781	Estimated multiplying the area of each land use by unit land cost of each land use. Unit land cost of each land use shall be 1.2 times the cost stipulated by the Davao city ordinance. Land acquisition cost for the informal habitant shall not be estimated, but land acquisition cost at the relocation area (new address) shall be estimated.
		Parapet (Target discharge 1700m3/s)	0.066		
		Retarding pond (Controled discharge 1700m3/s)	0.627		
	Compensation cost	River widening (Target discharge 1700m3/s)	0.693	0.914	Estimated at the cost required for building transfer. Required cost for building transfer shall be estimated at the cost that is required to build a new building with the same lot area of the existing building at the relocation area. Required cost for new building construction shall be estimated referring to the building construction cost stipulated by the Davao city ordinance.
		Parapet (Target discharge 1700m3/s)	0.088		
		Retarding ponds (Controled discharge 1700m3/s)	0.133		
	Removal cost			0.183	20% of the cost required for building transfer
	Inspection cost for environmental consideration			-	Included in the project implementation and management cost.
Construction/procurement cost	River widening (Target discharge 1700m3/s)		2.142	24.195	Estimated at the amount of direct cost including material cost and contractor’s profit that are stipulated by the DPWH Manual. Contractor’s profit shall be estimated at 10% of the direct cost including the material cost.
	Parapet (Target discharge 1700m3/s)		0.227		
	Bridge rebuilding (Target discharge 1700m3/s)		1.479		
	Retarding ponds (Controled discharge 1700m3/s)		20.347		
Administration cost for design	Administration cost for civil design	Detail design cost	2.420	4.355	10% of construction/procurement cost
		Construction management cost	1.936		8% of construction/procurement cost
	Administration cost for building design		-		Included in the detail design cost
	Administration cost for equipment design		-		Included in the construction management cost
Contingency	Price contingency		1.428	2.855	Contingency shall be 10% of the amount of construction/procurement cost and administration cost for design. Price contingency shall be 50% of the contingency (5% of construction/procurement cost) and physical contingency shall be also 50% of the contingency.
	Physical contingency		1.428		
Technical training cost				-	Not be estimated related to the structural measures. Technical training cost related to the non-structural measures shall be estimated
Total (excluding value added tax)				35.382	Amount of project implementation management cost, preparation cost, construction/procurement cost, administration cost for design, contengency and technical training cost
Value added tax				1.769	5% of Amount of total cost (excluding value added tax)
Project cost				37.151	
Construction/procurement cost, Land acquisition cost and Compensation cost（refer to Table3.4.12)				27.073	

Source: Project Team

(8) Utilizing Japanese Technology

In the cut-off section (6km to 13km) of the Davao river, it may be optimal to utilize Japanese technology namely Hat-type sheet pile revetment considering constraint on land acquisition, bank stability against rapid stream due to steep gradient after cut-off and workability on channel switching work.

Table 3.11.3 Project cost of priority project and construction/procurement cost related to Japanese technology

Estimation items	Estimation details			Project cost（Bil.PhP）								
				Without Japanese technology				Utilizing Japanese technology				
				Total section		Priority project section		Total section		Priority project section 6 to 13km section where Hat-type steel sheet pile revetment is installed and retarding pond No.8		
												Cost related to Japanese technology (Cost related to Hat-type steel sheet pile revetment)
Project implementation management cost of Filippines					1.099		0.145		1.189		0.235	
Preparation cost	Land acquisition cost	River widening (Target discharge 1700m3/s)		1.088	1.781	0.160	0.252	1.088	1.781	0.160	0.252	
		Parapet (Target discharge 1700m3/s)		0.066		-		0.066		-		
		Retarding pond (Controled discharge 1700m3/s)		0.627		0.092		0.627		0.092		
	Compensation cost	River widening (Target discharge 1700m3/s)		0.693	0.914	0.005	0.013	0.693	0.914	0.005	0.013	
		Parapet (Target discharge 1700m3/s)		0.088		-		0.088		-		
		Retarding ponds (Controled discharge 1700m3/s)		0.133		0.008		0.133		0.008		
	Removal cost				0.183		0.003		0.183		0.003	
	Inspection cost for environmental consideration				-		-		-		-	
Construction/procurement cost	River widening (Target discharge 1700m3/s)			2.142	24.195	0.581	3.200	4.113	26.166	2.552	5.171	2.098
	Parapet (Target discharge 1700m3/s)			0.227		-		0.227		-		
	Bridge rebuilding (Target discharge 1700m3/s)			1.479		-		1.479		-		
	Retarding ponds (Controled discharge 1700m3/s)			20.347		2.619		20.347		2.619		
Administration cost for design	Administration cost for	Detail design cost		2.420	4.355	0.320	0.576	2.617	4.710	0.517	0.931	0.931
		Construction management cost		1.936		0.256		2.093		0.414		
	Administration cost for building design			-		-		-		-		
	Administration cost for equipment design			-		-		-		-		
Contingency	Price contingency			1.428	2.855	0.189	0.378	1.544	3.088	0.305	0.610	
	Physical contingency			1.428		0.189		1.544		0.305		
Technical training cost					-		-		-		-	
Total (excluding value added tax)					35.382		4.566		38.030		7.213	3.029
Value added tax					1.769		0.228		1.901		0.361	0.151
Project cost					37.151		4.794		39.931		7.574	3.180

(a) Cost related to Japanese technology 3.029
(b) Project cost 7.213
(a/b) Construction/procurement cost related to Japanese technology／Project cost 0.420

Source: Project Team

3.11.3 Project cost estimation of storm water drainage improvement

(1) Estimation method of construction/procurement cost

The construction/procurement cost shall be estimated by multiplying the quantity of each construction work by unit cost. Unit construction/procurement cost shall be determined as follows.

- Channel improvement

An approximate formula that can calculate unit construction/procurement cost per length depending on the depth of the channel was determined.

- Box culvert

Unit construction/procurement cost of installing a box culvert per inner volume area per length was set.

- Dam (Dike of retarding basin)

An approximate formula that can calculate the unit construction/procurement cost per length depending on the height of the dam was determined based on the cost estimation results in case the dam height is 2m and 6m. The unit construction/procurement costs per length were estimated in the case with and without sluice pipe. The unit cost with sluice pipe was used for the section of 10m including sluice pipe and unit cost without sluice pipe was used for other section.

Unit cost per dam length in case with sluice (mil.pesos/m)=0.0693×Dam height(m)+0.1275
Unit cost per dam length in case without sluice (mil.pesos/m)=0.0263×Dam height(m)+0.0075

- Dam (Spillway)

The unit construction/procurement cost of spillway was determined.

- Underground storage facility

The unit construction/procurement cost of the underground storage facility per inner space area per length was determined.

- Side wall of deep digging type retarding basin (in case underground water level is high)

The approximate formula that can calculate the unit construction/procurement cost per length depending on the depth of the retarding basin was determined assuming construction in the area where the underground water level is high.

Unit cost per length (Million pesos/m)=0.0997×Depth of retarding basin(m)+0.0971

- Side wall of deep digging type retarding basin (in case underground water level is low)

The approximate formula that can calculate the unit construction/procurement cost per length depending on the depth of the retarding basin was determined assuming construction in the area where the underground water level is low.

Unit cost per length (Million pesos/m)=0.028×Depth of retarding basin(m)+0.029

- Unit construction/procurement cost of other work items

Table 3.11.4 Unit construction/procurement cost of other work items

Item	Unit cost		Remark
Rubble Concrete	2,977	Pesos/m3	Refer to DPWH Cost Estimation Manual
Stone Masonry	3,112	Pesos/m3	Refer to DPWH Cost Estimation Manual
Excavation	184	Pesos/m3	Refer to DPWH Cost Estimation Manual
Dredging	520	Pesos/m3	Refer to DPWH Cost Estimation Manual
Underground tunnel	125,000	Pesos/m3	
Pump	94,000,000	Pesos/m3/s	
Pump for RB	1,157	Pesos/m3	
Gabion	2,841	Pesos/m3	Refer to DPWH Cost Estimation Manual
Removal of Massonry	372	Pesos/m3	
Dyke 2m(Wall type one side)	126,000	Pesos/m	Height is 2m、Only one side
Embankment (Soil)	573	Pesos/m3	Refer to DPWH Cost Estimation Manual
Flap gate	1,000,000	Pesos/m2	
Gate	4,000,000	Pesos/m2	
Bridge removal	140,000	Pesos/m2	
Bridge construction	140,000	Pesos/m2	
Road	10,000	Pesos/m2	Pavement cost: 5,000PhP/m2、Other works: 5,000PhP/m2

Source: Project Team

(2) Land acquisition cost and compensation

- Land acquisition cost

The land acquisition cost shall be estimated by multiplying each land use area by 1.2 times the unit land cost.

- Compensation

In this study, only the expense required for building relocation shall be included in the compensation costs.

(3) Cost estimation results of each measure

The construction/procurement costs and the land acquisition costs of each storm water drainage improvement are estimated by each drainage area and each alternative measures.

(4) Project cost of the storm water drainage improvement

The project cost estimated using cost estimation methods shown in is as shown in Table 3.11.5.

Table 3.11.5 Project cost of storm water drainage improvement

<table>
<tr><th rowspan="2">Estimation items</th><th rowspan="2" colspan="2">Estimation details</th><th colspan="18">Amount（Bil.PhP）</th></tr>
<tr><th colspan="2">Roxas drainage area</th><th colspan="2">Agdao drainage area</th><th colspan="2">Jerome drainage area</th><th colspan="2">Mamay Creek drainage area</th><th colspan="2">Sasa Creek drainage area</th><th colspan="2">Emars drainage area</th><th colspan="2">Shanghai drainage area</th><th colspan="2">Shanghai drainage area</th><th colspan="2">Shanghai drainage area</th></tr>
<tr><td colspan="3">Project implementation management cost of Filippines Government</td><td colspan="2">0.004</td><td colspan="2">0.154</td><td colspan="2">0.114</td><td colspan="2">0.052</td><td colspan="2">0.022</td><td colspan="2">0.005</td><td colspan="2">0.002</td><td colspan="2">0.009</td><td colspan="2">0.092</td></tr>
<tr><td rowspan="4">Preparation cost</td><td colspan="2">Land acquisition cost</td><td rowspan="3" colspan="2">0.000</td><td rowspan="3" colspan="2">0.409</td><td rowspan="3" colspan="2">0.860</td><td rowspan="3" colspan="2">0.404</td><td rowspan="3" colspan="2">0.033</td><td rowspan="3" colspan="2">0.482</td><td rowspan="3" colspan="2">0.129</td><td rowspan="3" colspan="2">0.040</td><td rowspan="3" colspan="2">0.246</td></tr>
<tr><td colspan="2">Compensation cost</td></tr>
<tr><td colspan="2">Removal cost</td></tr>
<tr><td colspan="2">Inspection cost for environmental consideration</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td></tr>
<tr><td colspan="3">Construction/procurement cost</td><td colspan="2">0.088</td><td colspan="2">3.385</td><td colspan="2">2.516</td><td colspan="2">1.136</td><td colspan="2">0.474</td><td colspan="2">0.113</td><td colspan="2">0.055</td><td colspan="2">0.200</td><td colspan="2">2.036</td></tr>
<tr><td rowspan="4">Administration cost for design</td><td rowspan="2">Administration cost for civil design</td><td>Detail design cost</td><td>0.009</td><td rowspan="4">0.016</td><td>0.339</td><td rowspan="4">0.609</td><td>0.252</td><td rowspan="4">0.452</td><td>0.114</td><td rowspan="4">0.204</td><td>0.047</td><td rowspan="4">0.085</td><td>0.011</td><td rowspan="4">0.020</td><td>0.006</td><td rowspan="4">0.010</td><td>0.020</td><td rowspan="4">0.036</td><td>0.204</td><td rowspan="4">0.366</td></tr>
<tr><td>Construction management cost</td><td>0.007</td><td>0.271</td><td>0.201</td><td>0.091</td><td>0.038</td><td>0.009</td><td>0.004</td><td>0.016</td><td>0.163</td></tr>
<tr><td colspan="2">Administration cost for building design</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Administration cost for equipment design</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Contingency</td><td colspan="2">Price contingency</td><td>0.005</td><td rowspan="2">0.010</td><td>0.200</td><td rowspan="2">0.399</td><td>0.148</td><td rowspan="2">0.297</td><td>0.067</td><td rowspan="2">0.134</td><td>0.028</td><td rowspan="2">0.056</td><td>0.007</td><td rowspan="2">0.013</td><td>0.003</td><td rowspan="2">0.006</td><td>0.012</td><td rowspan="2">0.024</td><td>0.120</td><td rowspan="2">0.240</td></tr>
<tr><td colspan="2">Physical contingency</td><td>0.005</td><td>0.200</td><td>0.148</td><td>0.067</td><td>0.028</td><td>0.007</td><td>0.003</td><td>0.012</td><td>0.120</td></tr>
<tr><td colspan="3">Technical training cost</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td></tr>
<tr><td colspan="3">Total (excluding value added tax)</td><td colspan="2">0.118</td><td colspan="2">4.955</td><td colspan="2">4.239</td><td colspan="2">1.930</td><td colspan="2">0.670</td><td colspan="2">0.634</td><td colspan="2">0.203</td><td colspan="2">0.309</td><td colspan="2">2.980</td></tr>
<tr><td colspan="3">Value added tax</td><td colspan="2">0.006</td><td colspan="2">0.248</td><td colspan="2">0.212</td><td colspan="2">0.096</td><td colspan="2">0.033</td><td colspan="2">0.032</td><td colspan="2">0.010</td><td colspan="2">0.015</td><td colspan="2">0.149</td></tr>
<tr><td colspan="3">Project cost</td><td colspan="2">0.124</td><td colspan="2">5.203</td><td colspan="2">4.451</td><td colspan="2">2.026</td><td colspan="2">0.703</td><td colspan="2">0.665</td><td colspan="2">0.213</td><td colspan="2">0.324</td><td colspan="2">3.129</td></tr>
</table>

Source: Project Team

3.11.4 Project cost estimation of measures against coastal flood

The project cost of measures against coastal flood estimated using cost estimation methods shown in Table 3.11.1 is as shown in Table 3.11.6.

Table 3.11.6 Project cost of measures against coastal flood

Estimation items	Estimation details		Amount (Bil.PhP) N1 area		N2 area		N3 area		N4 area		N5 area		N6 area	
Project implementation management cost				0.003		0.003		0.016		0.002		0.009		0.001
Preparation cost	Land acquisition cost			0.000		0.000		0.000		0.000		0.000		0.000
	Compensation cost													
	Removal cost													
	Inspection cost for environmental			-		-		-		-		-		-
Construction/procurement cost				0.060		0.060		0.350		0.050		0.190		0.020
Administration cost for design	Administration cost for civil	Detail design cost	0.006	0.011	0.006	0.011	0.035	0.063	0.005	0.009	0.019	0.034	0.002	0.004
		Construction management cost	0.005		0.005		0.028		0.004		0.015		0.002	
	Administration cost for building		-		-		-		-		-		-	
	Administration cost for equipment		-		-		-		-		-		-	
Contingency	Price contingency		0.004	0.007	0.004	0.007	0.021	0.041	0.003	0.006	0.011	0.022	0.001	0.002
	Physical contingency		0.004		0.004		0.021		0.003		0.011		0.001	
Technical training cost				-		-		-		-		-		-
Total (excluding value added tax)				0.081		0.081		0.470		0.067		0.255		0.027
Value added tax				0.004		0.004		0.024		0.003		0.013		0.001
Project cost				0.085		0.085		0.494		0.071		0.268		0.028

Estimation items	Estimation details		Amount (Bil.PhP) C1 area		C2-C5 area		C6-C10L area		C10R-C11 area		C12 area		S1 area		S2 area	
Project implementation management cost				0.002		0.013		0.023		0.010		0.004		0.007		0.003
Preparation cost	Land acquisition cost			0.000		0.000		0.000		0.000		0.000		0.000		0.000
	Compensation cost															
	Removal cost															
	Inspection cost for environmental			-		-		-		-		-		-		-
Construction/procurement cost				0.040		0.290		0.510		0.220		0.080		0.160		0.070
Administration cost for design	Administration cost for civil	Detail design cost	0.004	0.007	0.029	0.052	0.051	0.092	0.022	0.040	0.008	0.014	0.016	0.029	0.007	0.013
		Construction management cost	0.003		0.023		0.041		0.018		0.006		0.013		0.006	
	Administration cost for building		-		-		-		-		-		-		-	
	Administration cost for equipment		-		-		-		-		-		-		-	
Contingency	Price contingency		0.002	0.005	0.017	0.034	0.030	0.060	0.013	0.026	0.005	0.009	0.009	0.019	0.004	0.008
	Physical contingency		0.002		0.017		0.030		0.013		0.005		0.009		0.004	
Technical training cost				-		-		-		-		-		-		-
Total (excluding value added tax)				0.054		0.390		0.685		0.296		0.107		0.215		0.094
Value added tax				0.003		0.019		0.034		0.015		0.005		0.011		0.005
Project cost				0.056		0.409		0.719		0.310		0.113		0.226		0.099

Source: Project Team

3.12 Preliminary Economic Evaluation

3.12.1 Basic Conditions for Economic Evaluation (Common)

The main purpose of economic evaluation through a cost-benefit analysis is to examine/justify the investment efficiency of the proposed project components from the viewpoint of the National economy.

3.12.2 Economic Cost (Common)

Since the factors to convert financial cost to economic cost differ based on the funding sources (Local Currency and Foreign Currency), the project cost is divided into Local Cost (LC) and Foreign Cost (FC) by reflecting the funding sources. Actually, the Local Currency and Foreign Currency Ratio is not fixed yet. Therefore, in this report, financial cost is converted to economic cost by using a simplified manner. Furthermore, contingency cost and tax are excluded from the economic cost.

3.12.3 Economic Benefit (Common)

(1) Assets in the target area

Documents and data were collected and studied in order to understand the on the distribution of assets in the target area and to conduct the economic evaluation of the M/P for flood control projects (Davao River, Matina River and Talomo River), drainage projects (9 drainage areas) and coastal inundation projects (14 areas).

(2) Benefits Computation

In a broad sense, the economic effects brought by the implementation of flood control projects can be divided into two parts; stock effects (eg. effect to prevent damage to assets in the floodplain), and flow effects (eg. effects associated with the project implementation). The stock effect include direct and indirect effects to reduce damage from flooding such as the intensification of land use (attracting new businesses and population) as a result of the empowerment of protective measures against flood (eg. Improvement of flood control reliability).

The economic benefit or "expected annual average damage reduction" of the proposed M/P for flood control projects (Davao River, Matina River and Talomo River), drainage projects (9 drainage areas) and coastal inundation projects (14 areas) is calculated by comparing the assumed economic amount of damage of when "no project is implemented (without case)" and when "projects are implemented (with case)". The assumed economic amount is calculated by using the simulation results of each type of inundation (eg. River flood, inland flooding and coastal inundation).

a. Properties Survey

The data on property calculated per each calculation mesh (25 meters x 25 meters) of the flood simulation model are aggregated in order to compute the damage amount. The properties considered to conduct the benefits computation of this study are 8 properties as shown in Table 3.12.1.

b. Set of unit price (appraised value of each property)

Table 3.12.1 shows the appraised value of each property per square meter. The appraised value was set by reflecting the average floor area and purpose of each building type.

Table 3.12.1 Appraised Value of each property

		Appraised value of each building type and agricultural land	Appraised value of other assets(*)
1.	Residential buildings	7,560 PhP/m^2	1,500 PhP/m^2
2.	Commercial buildings	16,000 PhP/m^2	12,500 PhP/m^2
3.	Institutional buildings	24,490 PhP/m^2	18,500 PhP/m^2
4.	Infrastructures/ public facilities	25,860 PhP/m^2	- PhP/m^2
5.	Industrial buildings	13,060 PhP/m^2	12,000 PhP/m^2
6.	Agricultural / livestock / fisheries buildings	6,430 PhP/m^2	- PhP/m^2
7.	Mixed use buildings	16,470 PhP/m^2	10,900 PhP/m^2
8.	Agricultural land	100 PhP/m^2	- PhP/m^2

Source: Davao City Ordinance No.0257-17, Series of 2017

*Note: Appraised value of other assets (such as depreciable assets and inventory assets of households, businesses) were set by referring the "Preparatory Survey for Flood Risk Management Project for Cagayan de Oro River (JICA, 2013)".

c. Computation of the property value per calculation mesh

The property value per calculation mesh (25 meters x 25 meters) of each inundation simulation model is computed based on the data collected and gathered in a. and by using the unit price set in b.

d. Calculation of damage cost

Direct damage to general assets and agricultural products is calculated by multiplying the damage rates depending on the inundation depth by the property value per mesh. Direct damage to large scale infrastructures and public utilities is calculated by multiplying direct damage cost by a ratio set based on the reflection of past disasters.

In this study, the damage rates of the "Manual for Economic Evaluation of Flood Control Investment - Draft (MLIT, 2005)" are used to evaluate the economic effects of flood control measures (Davao River, Matina River and Talomo River) and drainage measures (9 drainage areas), and the rates of the "Cost-Benefit Analysis Guidelines for coastal projects – Revised Edition (MLIT, 2004)" are used to evaluate the coastal measures.

In addition, the damage cost in area where the inundation depth is lesser than 10 centimeters are not counted (eg. In those areas, it is assumed that economic damage do not occur).

Damage cost of buildings (residential, commercial, institutional, infrastructures/ public facilities, industrial buildings, agricultural / livestock / fisheries, and mixed use buildings)

The buildings value is calculated by multiplying the total floor area by the appraised value set in paragraph c. The damage cost is calculated by multiplying the building value by the damage rates defined by inundation depth and shown in Table 3.12.2 .

Table 3.12.2 Damage rates used to calculate building damage (river flood and inland inundation)

Inundation depth	0.10-0.50m	0.50-0.99m	1.00-1.99m	2.00-2.99m	3.00m-
Building damage rates	0.092	0.119	0.266	0.580	0.834
Other assets damage rates	0.145	0.326	0.508	0.928	0.991

Source: Manual for Economic Evaluation of Flood Control Investment -Draft (MLIT, 2005)

Table 3.12.3 Damage rates used to calculate building damage (coastal inundation)

Inundation depth	0.10-0.50m	0.50-0.99m	1.00-1.99m	2.00-2.99m	3.00m-
Building damage rates	0.151	0.229	0.480	1.000	1.000
Other assets damage rates	0.189	0.489	0.889	1.000	1.000

Source: Cost-Benefit Analysis Guidelines for coastal projects – Revised Edition (MLIT, 2004)

Agricultural damage

Direct damage to agricultural products is calculated by multiplying the set land value by the damage rates which is defined by inundation depth and by the number of flooding days.

Table 3.12.4 Damage rates used to calculate agricultural damage (river flood and inland inundation)

Inundation depth	0.10-0.50m	0.50-0.99m	1.00-1.99m	2.00-2.99m	3.00m-
Agricultural land damage rates	0.270	0.350	0.510	0.510	0.510

Source: Manual for Economic Evaluation of Flood Control Investment -Draft (MLIT, 2005)

Table 3.12.5 Damage rates used to calculate agricultural damage (coastal inundation)

Inundation depth	0.10-0.50m	0.50-0.99m	1.00-1.99m	2.00-2.99m	3.00m-
Agricultural land damage rates	0.270	0.350	0.510	0.510	0.510

Source: Cost-Benefit Analysis Guidelines for coastal projects – Revised Edition (MLIT, 2004)

Damage to large scale infrastructures and public facilities

Direct damage to large scale infrastructures and public utilities is calculated by multiplying direct damage cost by a ratio set based on the reflection of past disasters.

Since the majority of the damage to infrastructures caused by Typhoon Vinta is related to river embankment and bridge damage, damage to large scale infrastructures are calculated only to evaluate river flood control measures by multiplying damage to general assets by 0.2.

Indirect Damage

Indirect damage is calculated by multiplying direct damage cost by 0.2.

e. Calculation of benefit

The total benefits is calculated by adding the total sum of the benefits generated during the period subject to the economic evaluation, and the residual values of flood control infrastructures as of the end of the period subject to the economic evaluation.

Expected annual average damage reduction

The expected annual average damage reduction is calculated by aggregating the annual average damage per flood scale. The annual average damage is calculated by multiplying the amount of damage reduction per flood scale (eg. reduction of flood damage cost which can be expected with the implementation of flood control projects) by the occurrence probabilities of flood events.

3.12.4 Results of Economic Evaluation (Common)

As indices to evaluate the cost-benefit analysis, Cost Benefit Ratio, Net Present Value and economic internal rate of return are calculated.

3.12.5 Preliminary Economic Evaluation of Flood Control Measures for Davao River

The preliminary economic evaluation of flood control measures for Davao River is conducted by following the common steps explained from paragraph 3.12.1 to 3.12.4.

(1) Economic cost

Table 3.12.6 shows the financial and economic costs of flood control projects for Davao River.

Table 3.12.6 Financial and economic costs (as of ITR for Davao River)

Project Components		Cost (Billion Pesos)									Annual Cost (Economic Cost) (in Billion Pesos)
		Implementation and Management Cost	Preparation Cost	Construction / Procurement Cost	Administration Cost for Design	Contingency (not included in economic cost)	VAT (not included in economic cost)	Project Cost (Financial Cost)	Project Cost (Economic Cost)	Annual Maintenance Cost	
1	River channel dredging	0.051	0.000	1.112	0.200	0.131	0.075	1.569	1.426	0.006	0.149
2	Channel shortcut	0.026	0.165	0.581	0.105	0.069	0.047	0.993	0.910	0.003	0.095
3	Construction of 3 retarding basins	0.282	0.252	6.202	1.116	0.732	0.429	9.013	8.203	0.031	0.858
4	River channel enlargement	0.098	1.926	2.155	0.388	0.254	0.241	5.062	4.689	0.011	0.484
5	Construction of 4 retarding basins	0.643	0.535	14.145	2.546	1.669	0.977	20.514	18.668	0.071	1.954
	Total	1.099	2.878	24.195	4.355	2.855	1.769	37.151	33.896	0.121	3.540

Source: Project Team

(2) Economic benefit

The expected annual average damage reduction is calculated as shown in Table 3.12.7 by using the simulation results explained in the Section 2.7.8.

Table 3.12.7 Expected annual average damage reduction of Davao River M/P (in Billion PhP)

	Annual average exceedance probability	Amount of Damage (Billion PhP)				Average Damage per reach	Probabilities per reach	Annual Average Damage Reduction	Aggregated annual average damage = Expected annual average damage reduction
		Without Project (1)		With Project (2)	Damage Reduction (1)-(2)				
		General Assets(GA)	Infra+Indirect (GA*0.4)						
W=1/1	1.000	0.000	0.000	0.000	0.000				
W=1/2	0.500	1.515	0.606	0.000	2.120	1.060	0.500	0.530	0.530
W=1/3	0.333	1.716	0.686	0.000	2.402	2.261	0.167	0.377	0.907
W=1/5	0.200	3.272	1.309	0.000	4.580	3.491	0.133	0.465	1.372
W=1/10	0.100	13.466	5.386	0.000	18.853	11.717	0.100	1.172	2.544
W=1/25	0.040	18.051	7.220	0.000	25.271	22.062	0.060	1.324	3.868
W=1/50	0.020	19.762	7.905	0.000	27.667	26.469	0.020	0.529	4.397
W=1/100	0.010	22.437	8.975	0.000	31.412	29.540	0.010	0.295	4.693

Source: Project Team

(3) Results of Economic evaluation

Cost and benefits cash flow of the proposed M/P for Davao River was calculated. The Economic Internal Rate of Return (EIRR) is 15.55 %, Economic Net Present Values (ENPV) is PhP 17.44 Billion and Cost-Benefit Ratio is 1.51. Therefore, the proposed is evaluated as economically adequate.

3.12.6 Preliminary Economic Evaluation of Flood Control Measures for Matina River

The preliminary economic evaluation of flood control measures for Matina River is conducted by following the common steps explained from paragraph 3.12.1 to 3.12.4.

(1) Economic cost

Table 3.12.8 shows the financial and economic costs of flood control projects for Matina River.

Table 3.12.8 Financial and economic costs (as of ITR for Matina River)

Project Components		Cost (Billion Pesos)									Annual Cost (Economic Cost) (in Billion Pesos)
		Implementation and Management Cost	Preparation Cost	Construction / Procurement Cost	Administration Cost for Design	Contingency (not included in economic cost)	VAT (not included in economic cost)	Project Cost (Financial Cost)	Project Cost (Economic Cost)	Annual Maintenance Cost	
1	Channel shortcut	0.015	0.114	0.330	0.059	0.039	0.028	0.585	0.537	0.002	0.056
2	Construction of 12 retarding basins	0.021	0.036	0.454	0.082	0.054	0.032	0.678	0.618	0.002	0.065
3	River channel enlargement	0.044	0.237	0.964	0.174	0.114	0.077	1.609	1.473	0.005	0.153
4	Construction of levee at the river mouth	0.019	0.115	0.417	0.075	0.049	0.034	0.709	0.650	0.002	0.068
	Total	0.098	0.503	2.165	0.390	0.255	0.171	3.582	3.278	0.011	0.341

Source: Project Team

(2) Economic benefit

The expected annual average damage reduction is calculated as shown in Table 3.12.9 by using the simulation results explained in the Section 2.7.8.

Table 3.12.9 Expected annual average damage reduction of Matina River M/P (in Billion PhP)

	Annual average exceedance probability	Amount of Damage (Billion PhP)				Average Damage per reach	Probabilities per reach	Annual Average Damage Reduction	Aggregated annual average damage = Expected annual average damage reduction
		Without Project (1)		With Project (2)	Damage Reduction (1)-(2)				
		General Assets(GA)	Infra+Indirect (GA*0.4)						
W=1/1	1.000	0.000	0.000	0.000	0.000				
W=1/2	0.500	0.215	0.086	0.000	0.300	0.150	0.500	0.075	0.075
W=1/3	0.333	0.315	0.126	0.000	0.441	0.371	0.167	0.062	0.137
W=1/5	0.200	0.454	0.182	0.000	0.636	0.538	0.133	0.072	0.209
W=1/10	0.100	0.676	0.271	0.000	0.947	0.792	0.100	0.079	0.288
W=1/25	0.040	1.199	0.480	0.000	1.679	1.313	0.060	0.079	0.367
W=1/50	0.020	1.634	0.654	0.000	2.288	1.984	0.020	0.040	0.406
W=1/100	0.010	1.807	0.723	0.000	2.530	2.409	0.010	0.024	0.430

Source: Project Team

(3) Results of Economic evaluation

Cost and benefits cash flow of the proposed M/P for Matina River was calculated. The Economic Internal Rate of Return (EIRR) is 11.06 %, Economic Net Present Values (ENPV) is PhP 1.71 Billion and Cost-Benefit Ratio is 1.12. Therefore, the proposed is evaluated as economically adequate.

3.12.7 Preliminary Economic Evaluation of Flood Control Measures for Talomo River

The preliminary economic evaluation of flood control measures for Talomo River is conducted by following the common steps explained from paragraph 3.12.1 to 3.12.4.

(1) Economic cost

Table 3.12.10 shows the financial and economic costs of flood control projects for Matina River.

Table 3.12.10 Financial and economic costs (as of ITR for Talomo River)

Project Components		Cost (Billion Pesos)									Annual Cost (Economic Cost) (in Billion Pesos)
		Implementation and Management Cost	Preparation Cost	Construction / Procurement Cost	Administration Cost for Design	Contingency (not included in economic cost)	VAT (not included in economic cost)	Project Cost (Financial Cost)	Project Cost (Economic Cost)	Annual Maintenance Cost	
1	River channel dredging	0.005	0.000	0.108	0.019	0.013	0.007	0.152	0.138	0.001	0.015
2	Channel shortcut	0.001	0.043	0.016	0.003	0.002	0.003	0.068	0.064	0.000	0.006
3	Construction of 3 retarding basins	0.012	0.013	0.256	0.046	0.030	0.018	0.375	0.342	0.001	0.036
4	River channel enlargement	0.025	0.159	0.555	0.100	0.065	0.045	0.950	0.871	0.003	0.091
5	Construction of levee at the river mouth	0.003	0.030	0.060	0.011	0.007	0.006	0.116	0.107	0.000	0.011
	Total	0.045	0.245	0.995	0.179	0.117	0.079	1.661	1.521	0.005	0.158

Source: Project Team

(2) Economic benefit

The expected annual average damage reduction is calculated as shown in Table 3.12.11 by using the simulation results explained in the Section 2.7.8.

Table 3.12.11 Expected annual average damage reduction of Talomo River M/P (in Billion PhP)

	Annual average exceedance probability	Amount of Damage (Billion PhP)				Average Damage per reach	Probabilities per reach	Annual Average Damage Reduction	Aggregated annual average damage = Expected annual average damage reduction
		Without Project (1)		With Project (2)	Damage Reduction (1)-(2)				
		General Assets(GA)	Infra+Indirect (GA*0.4)						
W=1/1	1.000	0.000	0.000	0.000	0.000				
W=1/2	0.500	0.066	0.026	0.000	0.092	0.046	0.500	0.023	0.023
W=1/3	0.333	0.097	0.039	0.000	0.136	0.114	0.167	0.019	0.042
W=1/5	0.200	0.224	0.090	0.000	0.314	0.225	0.133	0.030	0.072
W=1/10	0.100	0.660	0.264	0.000	0.924	0.619	0.100	0.062	0.134
W=1/25	0.040	1.319	0.528	0.000	1.847	1.385	0.060	0.083	0.217
W=1/50	0.020	1.621	0.648	0.000	2.269	2.058	0.020	0.041	0.258
W=1/100	0.010	1.658	0.663	0.000	2.321	2.295	0.010	0.023	0.281

Source: Project Team

(3) Results of Economic evaluation

Cost and benefits cash flow of the proposed M/P for Talomo River was calculated. The Economic Internal Rate of Return (EIRR) is 14.93 %, Economic Net Present Values (ENPV) is PhP 1.19 Billion and Cost-Benefit Ratio is 1.59. Therefore, the proposed is evaluated as economically adequate.

3.12.8 Preliminary Economic Evaluation of Drainage Measures

The preliminary economic evaluation of drainage measures for nine drainage areas is conducted by following the common steps explained from paragraph 3.12.1 to 3.12.4.

(1) Economic cost

Table 3.12.12 shows the financial and economic costs of drainage measures.

Table 3.12.12 Financial and economic costs (as of ITR for Drainage measures)

	Drainage area	Cost (Billion Pesos)									Annual Cost (Economic Cost) (in Billion Pesos)
		Implementation and Management Cost	Preparation Cost	Construction / Procurement Cost	Administration Cost for Design	Contingency (not included in economic cost)	VAT (not included in economic cost)	Project Cost (Financial Cost)	Project Cost (Economic Cost)	Annual Maintenance Cost	
1	Roxas	0.004	0.000	0.088	0.016	0.010	0.006	0.124	0.113	0.000	0.012
2	Agdao	0.154	0.409	3.385	0.609	0.399	0.248	5.204	4.749	0.017	0.496
3	Jerome	0.114	0.860	2.516	0.452	0.297	0.212	4.451	4.086	0.013	0.425
4	Mamay Creek	0.052	0.404	1.136	0.204	0.134	0.096	2.026	1.860	0.006	0.193
5	Sasa Creek	0.022	0.033	0.474	0.085	0.056	0.033	0.703	0.641	0.002	0.067
6	Emars	0.005	0.482	0.113	0.020	0.013	0.032	0.665	0.627	0.001	0.064
7	Shanghai	0.002	0.129	0.055	0.010	0.006	0.010	0.213	0.200	0.000	0.020
8	Maa1	0.009	0.040	0.200	0.036	0.024	0.015	0.324	0.296	0.001	0.031
9	Maa2	0.092	0.246	2.036	0.366	0.240	0.149	3.129	2.856	0.010	0.298
	Total	0.454	2.603	10.003	1.798	1.180	0.802	16.840	15.427	0.050	1.606

Source: Project Team

(2) Economic benefit

The expected annual average damage reduction of M/P for drainage measures for nine drainage areas is calculated by using the simulation results explained in the Section 2.9.6.

(3) Results of Economic evaluation

Cost and benefits cash flow of the proposed M/P for drainage measures was calculated. The Economic Internal Rate of Return (EIRR) is 11.61 %, Economic Net Present Values (ENPV) is PhP 8.63 Billion and Cost-Benefit Ratio is 1.18. Therefore, the proposed is evaluated as economically adequate.

3.12.9 Preliminary Economic Evaluation of Coastal Measures

The preliminary economic evaluation of coastal measures for fourteen areas is conducted by following the common steps explained from paragraph 3.12.1 to 3.12.4.

(1) Economic cost

Table 3.12.13 shows the financial and economic costs of drainage measures.

Table 3.12.13 Financial and economic costs (as of ITR for Coastal measures)

	Area	Cost (Billion Pesos)									Annual Cost (Economic Cost) (in Billion Pesos)
		Implementation and Management Cost	Preparation Cost	Construction / Procurement Cost	Administration Cost for Design	Contingency (not included in economic cost)	VAT (not included in economic cost)	Project Cost (Financial Cost)	Project Cost (Economic Cost)	Annual Maintenance Cost	
1	N1	0.003	0.000	0.060	0.011	0.007	0.004	0.085	0.077	0.000	0.008
2	N2	0.003	0.000	0.060	0.011	0.007	0.004	0.085	0.077	0.000	0.008
3	N3	0.016	0.000	0.350	0.063	0.041	0.024	0.494	0.449	0.002	0.047
4	N4	0.002	0.000	0.050	0.009	0.006	0.003	0.071	0.064	0.000	0.007
5	N5	0.009	0.000	0.190	0.034	0.022	0.013	0.268	0.244	0.001	0.026
6	N6	0.001	0.000	0.020	0.004	0.002	0.001	0.028	0.026	0.000	0.003
7	C1	0.002	0.000	0.040	0.007	0.005	0.003	0.056	0.051	0.000	0.005
8	C2-C5	0.013	0.000	0.290	0.052	0.034	0.019	0.409	0.372	0.001	0.039
9	C6-C10L	0.023	0.000	0.510	0.092	0.060	0.034	0.719	0.654	0.003	0.068
10	C10R-C11	0.010	0.000	0.220	0.040	0.026	0.015	0.310	0.282	0.001	0.030
11	C12	0.004	0.000	0.080	0.014	0.009	0.005	0.113	0.103	0.000	0.011
12	S1	0.007	0.000	0.160	0.029	0.019	0.011	0.226	0.205	0.001	0.021
13	S2	0.003	0.000	0.070	0.013	0.008	0.005	0.099	0.090	0.000	0.009
	Total	0.095	0.000	2.100	0.378	0.248	0.141	2.962	2.692	0.011	0.282

Source: Project Team

(2) Economic benefit

The expected annual average damage reduction of fourteen areas is calculated by using the simulation results explained in the Section 2.10.6.

(3) Results of Economic evaluation

Cost and benefits cash flow of the proposed M/P for coastal measures was calculated. The Economic Internal Rate of Return (EIRR) is 57.22 %, Economic Net Present Values (ENPV) is PhP 3.06 Billion and Cost-Benefit Ratio is 3.76. Therefore, the proposed is evaluated as economically adequate.

3.13 Strategic Environmental Assessment

3.13.1 Environmental Categorization

The project is categorized as "A"; the reason is that the project is composed with the activities which likely causes adverse impacts indicated in the Guidelines for Environmental and Social Considerations (JICA-GL, April 2010).

3.13.2 Environmental Legal Framework in Philippines

(1) Environmental Impact Statement

Philippine legal framework related to environmental control has been structured based on the PD 1151, Environmental Policy and PD 1152, and Environmental Code issued in 1977.

Environmental approval system (called "EIS: Environmental Impact Statement in Philippines) is regulated in the Article 4 in the PD 1151; any public or private projects/ activities shall apply to this approval. The project shall be categorized as below based on the type, scale and location of the project:

- Category A: Projects/ undertakings categorized as ECPs under Precedential Proclamation No. 2146 (1981), etc.;
- Category B: Projects/ undertakings categorized as Non ECPs but located in the ECAs and then likewise to deemed to have significant impacts;
- Category C: Projects/ undertakings not falling under Category A or B (Non ECPs and non ECAs). It is expected to enhance environmental improvement;
- Category D: Projects/ undertakings that are not deemed to have significant impacts according to the screening guideline. These are not covered by the EIS system but shall comply with compliance with other environmental laws and government permission.

Environmental Certificate Clearance (ECC) is issued for the project categorized as A or B; while Certificate of Non-Coverage (CNC) is for category C or D. Central EMB and Region EMB have responsible for category I and rest of categories respectively.

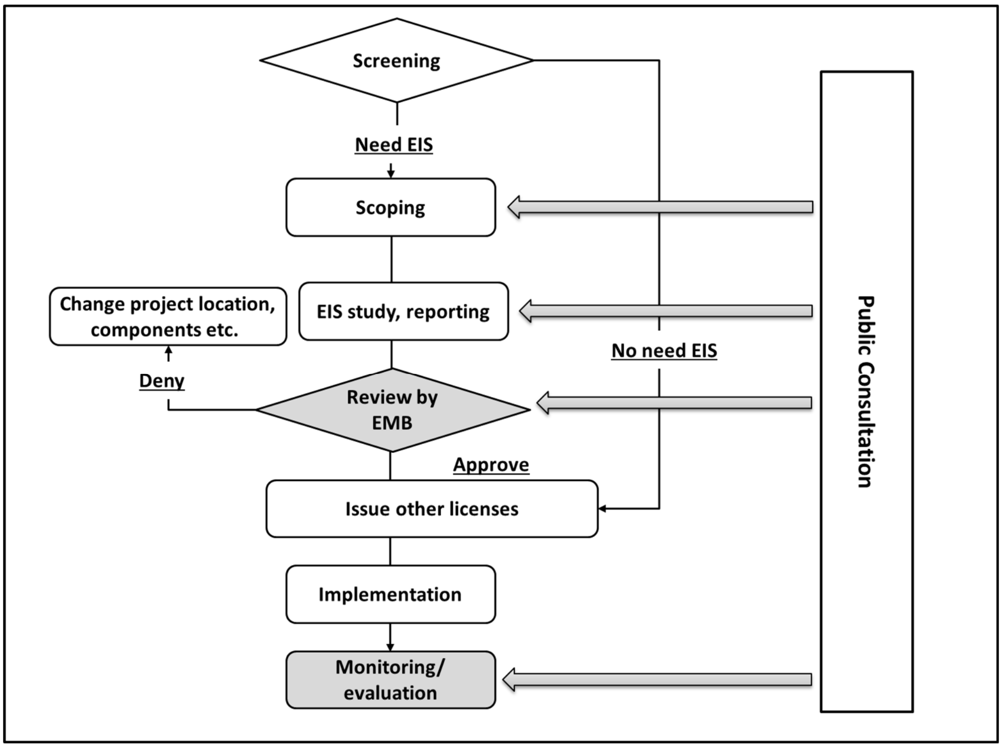
Screening criteria for flood control projects listed in Table 3.13.1, and EIS procedural flow are described in Figure 3.13.1.

Table 3.13.1 Categorization on Flood Control Projects

Group	A	B		D	Remarks
Type	EIS	EIS	IEE checklist	PD	
Screening Criteria					
Dams (including those for irrigation, flood control, water source, hydropower)	≥ 25ha or 20 million m^3	> 5 ha but < 25 ha, or > 5 million m^3 but < 20 million m^3	< 5 ha or 5 million m^3	None	Reservoir flooded, inundated area, water storage capacity Enhance environmental improvement of rehabilitation, judged by EMB (except category I)[1)]

1) EMB judges for issuing CNC based on the Project Description Report (PDR) prepared by the project proponent.

Source: Revised Procedural Manual, 2014



Source: Revised Procedural Manual, 2007

Figure 3.13.1 EIS procedural flow

(2) Resettlement

There has not been permanent lead-agency for land acquisition and resettlement organized; this matter is basically managed through coordination between project proponent and LGU (DPWH and Davao City respectively in the flood control). In addition, the following government organization will be cooperated:

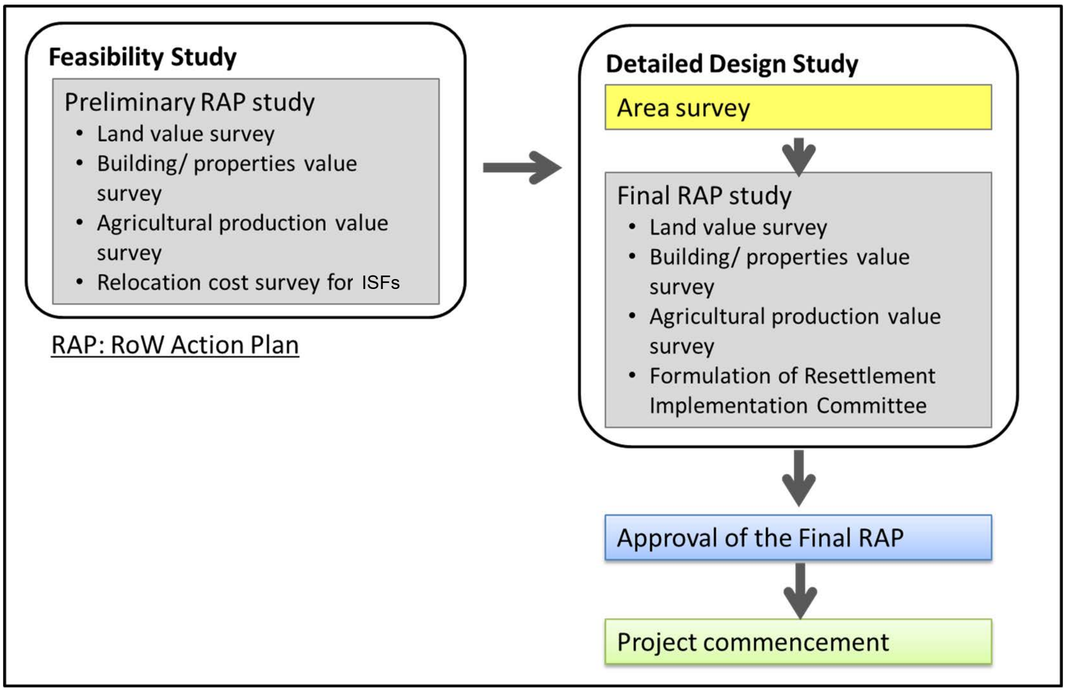
- National Housing Authority, NHA: Housing plan
- Presidential Commission for the Urban Poor, PCUP: Support to ISFs

The Right of Way Act. 2015 has ordered “fast track” and “simplify negotiated sale” by making the price offer and terms of negotiation more ideal and just for the owners of the property. That is to say, it enables to easily compensate based on market-based price, while it must be sure to protect the rights of property owners and the PAPs.

Government organization who is responsible for public projects has published (or is under going to) a guideline. DPWH has published DPWH Right-of-Way Acquisition Manual in 2017. It seeks:

- To provide a working guide upon the rules, procedures, and formats, etc. to the DPWH who are taking action in ROW acquisition.
- To provide a reference for property owners and PAPs on the rules and process in ROW acquisition, including their basic rights and obligations.

Preliminary Resettlement action plan or Right-of-Way Action Plan (RAP) will be made in the stage of feasibility study (F/S) to detailed design (D/D) study; and it shall be finalized based on change of project design in the D/D. Figure 3.13.2 illustrates resettlement procedure.



Source: DPWH Right-of-Way Acquisition Manual

Figure 3.13.2 Procedure of RAP Study (DPWH)

3.13.3 Gap Analysis between JICA Guideline and Philippine System

Gap analysis between JICA Guideline and Philippine System was carried out. Among 8 items, whereas one item of 8 items has 15 sub-items, gaps confirmed in 4 items (2 sub-items) and need to be coped with.

3.13.4 Methods of Environmental Impact Evaluation

The following two (2) methods were used for environmental impact evaluation.

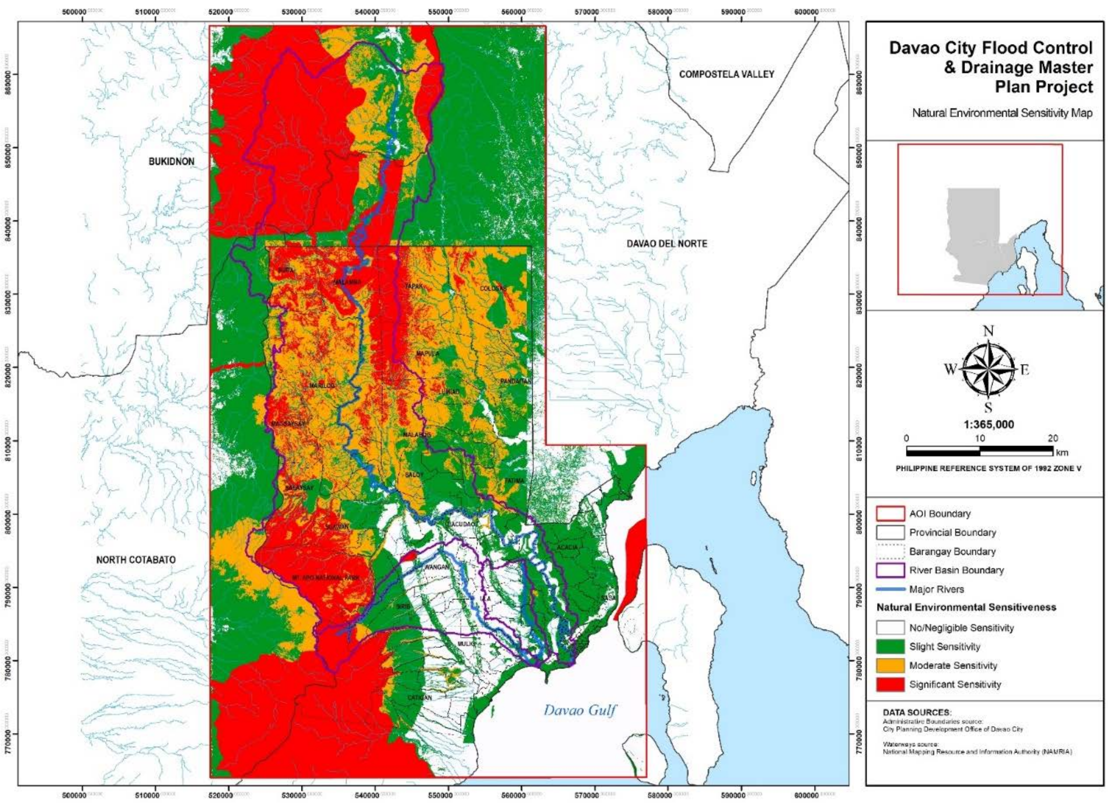
1) Identify of environmental sensitivity by spatial analysis
2) Environmental matrix

(1) Environmental Sensitivity

It is useful to identify environmentally sensitive areas for flood control. Sensitive area was identified by spatial analysis; that information could visually show sensitive area where project/ activity likely causes significant impacts. This approach is expected to smoothly improve project with change of project location, design, etc. in early planning stage. Evaluation factors were given from two field, that is to say, natural environment and socio-economic condition in accordance with Davao's specific nature, sensitiveness against flood control activities and possibly collected as spatial data.

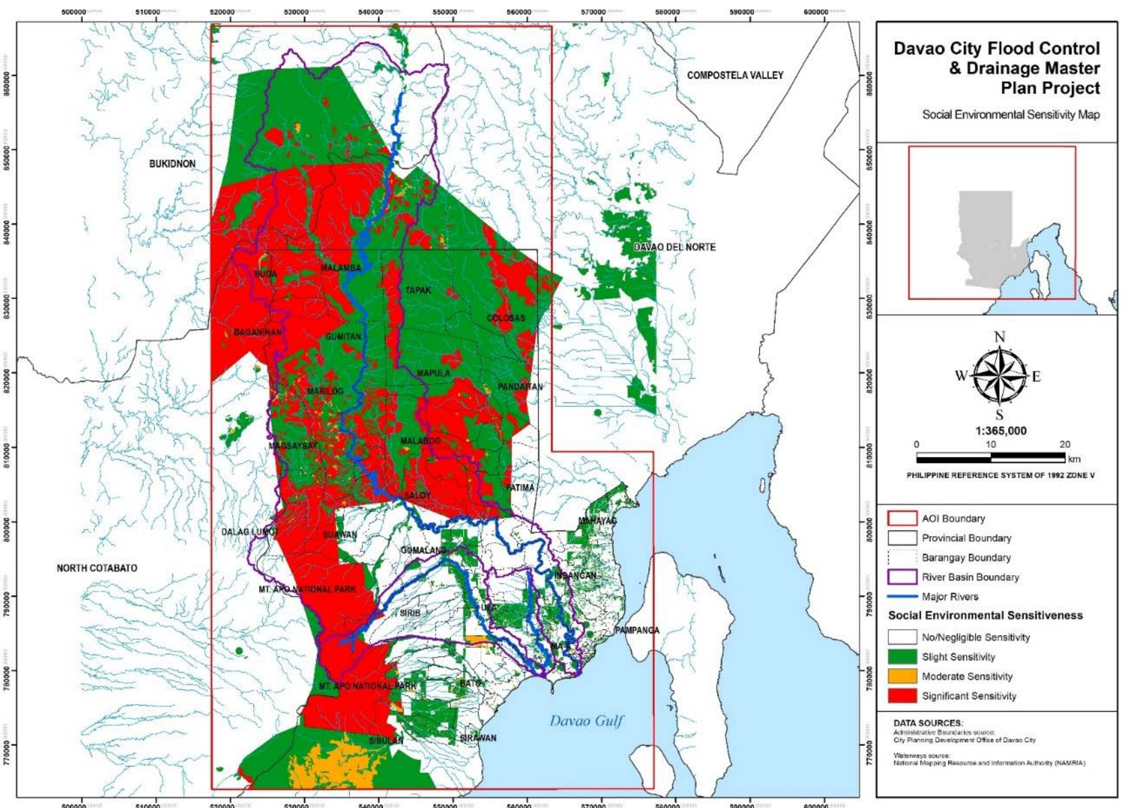
First thematic maps of each evaluation indicator were made by GIS; and then level of environmentally sensitiveness is classified into 10 degrees. Thematic maps were over laid in order to calculate accumulate score. Finally, sensitivity was classified as four (4) levels.

Evaluation of environmental sensitivity was undertaken with two (2) separate fields, that is to say, natural environment and socio-economic condition. The environmental sensitivity maps are given in Figure 3.13.3 and Figure 3.13.4. Protected areas are clearly designated issued control policy, so that those area are automatically categorized as "Significant Area". Evaluation of environmental and social sensitiveness was undertaken in cooperation with the counterparts; and scoring of evaluation factors were repeated with changing score in order the results to match the actual condition.



Source: Project team

Figure 3.13.3 Environmental Sensitivity Map (Natural Environment)



Source: Project team

Figure 3.13.4 Environmental Sensitivity Map (Socio-economic Condition)

(2) Quick Initial Environmental Evaluation

Environmental and social impacts cause by flood control measures shall be properly taken. Quick evaluation was carried out through above spatial analysis and matrix by selected evaluation indicators. Evaluation indicators and method are indicated in Table 3.13.2.

Table 3.13.2 Evaluation Indicator and Method for Quick Evaluation

Evaluation Indicator		Description
Natural Environment	Ecosystem, natural resources, disaster, etc.	Sensitiveness based on the spatial analysis, condition of fauna and flora with vulnerable species categorized under IUCN.
Social Environment	Land acquisition and resettlement, IPs, transportation, local economy, social conflict, etc.	Occupation of land may cause land procurement, resettlement disturbance of traffic, local economy especially agriculture, etc. And unfair allocation of benefit could cause social conflict.
Pollution Control	Water pollution, waste	It is expected to cause limited air pollution and noise disturbance by construction equipment only. No toxic water pollution is expected; while treatment and dispose of soil garbage could be major issue.

Evaluation	Description
N	Environmental impact could be negligible level.
C	Small impact, which level is between “N” and “B”, is expected; further study is necessary. It could be avoided or mitigate by general environmental control.
B	Moderate impacts are expected; it could be avoided or mitigate by general environmental control.
A	Significant impacts which would be likely irreversible, is expected. Sophisticated technology might be necessary.

Source: Project team

3.13.5 Impact Evaluation

(1) Quick Evaluation on Planning Concept

The following table summarizes results of quick impact evaluation (alternative analysis) on planning concept (see Table 3.13.3 in detail).

Table 3.13.3 Alternative Analysis on Planning Concept

Alternative	Spatial sensitivity	Natural Environment	Social Environment	Pollution Control	Overall
Alt. 1	A	A	A	B	A
Alt. 2	C	C	A	B	A
Alt. 3	C	C	A	B	A
Evaluation	Alt.-1 includes dam construction which activity may cause significant impacts on forest and biodiversity conservation and on Ips. Alt.-2 may cause the same scale of resettlement; social impact must be significant. Alt.-3 includes river widening in the downstream; those area has been urbanized with high population density; therefore, large scale of resettlement (approx. 1,600 buildings) is predicted. In addition, change of land use, local economy, and traffic disturbance will be caused by loss of land.				

Source: Project team

(2) Quick Evaluation on Proposed Flood Control Measures

Table below summarizes results of quick evaluation on proposed flood control measure in each field.

Table 3.13.4 Quick Evaluation on Each Flood Control Measure

River Flood

Control Measure	Spatial sensitivity	Natural Environment	Social Environment	Pollution Control	Overall
Dam					
Davao River	A	A	A	C	A
Matina/Talomo River	C	B	B	C	B
Retarding Pond	C	B	B	C	B
Dike Rehabilitation	C	C	C	N	C
Dike/ flood wall	C	C	A	N	A
Dredging	C	C	B	B	B
Widening	B	C	A	B	A
Evaluation	• Dike rehabilitation could cause the least impacts; new installation of dike/ flood wall, while might occupy considerable scale of land. It could lead large scale of resettlement probably same level as river widening (over 1,500 lots). • Proposed dam site along Davao River is located in the ancestral domains area, the impact, hence could be significant and complicated coordination with IP Committee is required. Also, large scale land change occurs, in which situation natural resources, potential of eco-tourism agro-forest, etc. could be degraded. • Retarding ponds could occupy considerable scale of land and lead resettlement; it, while could be minimized by proper design and location to avoid population dense area in middle or upper stream. • One of considerable impacts might be river water pollution by turbid water generated dredging or other construction activities in river; and treatment/ disposal of soil waste. • River widening might occupy considerable scale of land. It could lead large scale of resettlement probably over 1,500 lots. • It was observed plantation of Narra (IUCN category EN) by communities.					

Above evaluation was uniformly taken because concrete and/or actual plan for each three (3) river was not made during M/P stage.
Source: Project team

Inland Flood

Alternatives	Spatial sensitivity	Natural Environment	Social Environment	Pollution	Overall
Retarding pond					
Open type	C	C	B	C	B
Closed type	N	C	N	C	C
Underground drainage	N	C	C	C	C
Underground storage	N	C	C	C	C
Drainage improvement	N	B	B	C	B
Dredging	N	B	C	B	B
Separation Channel[1)]	N	C	C	C	C
Box/ pipe culvert	N	C	N	C	C
Pump	C	C	B	B	B
Evaluation	• Proposed locations of open type retarding ponds are private and unused land in the Davao City urbanized area; that is why, land procurement is necessary. Some of areas are located in the low land and planted where natural water storage function is expected. Therefore, use of such lands for retarding ponds is expected to control improper development if the areas are used as greening and/or buffer zone. • Underground drainage and storage could minimize adverse impacts on ground in terms of disturbance to biodiversity, resettlement, etc. except traffic disturbance during construction phase. On the other hand, geological and hydrological risk such as land subsidence, disturbance of underground water condition shall be considered. • Since Davao city has been urbanized; use of underground space is expected to minimize environmental impacts especially to socio-economic condition.					

1) Separation of the Agdao Channel with Improvement
Source: Project team

Coastal Flood

Control Measure	Spatial sensitivity	Natural Environment	Social Environment	Pollution Control	Overall
Coastal Levee	C	C	B	B	B
Evaluation	• Since certain fishery activities have been observed along the coast; installation of coastal levee must disturb accessibility of fish boat. • Sanitary condition in residential area of informal settlers along the coast is quite poor; polluted water has been directly discharged to the sea in current situation. Proper design of coastal levee important unless water discharge is blocked, and water quality is degraded. • Since coastal levee will be installed out of residential area, on the seaside; resettlement is not basically expected.				

Source: Project team

(3) Quick Evaluation on Non-structural Measurement

Significant environmental impacts likely caused by non-structural measurements will not be expected because those measurements do not require certain level of physical construction. It is, on the other hand, possible to cause imbalance of benefit allocation, disturbance to local community activities, etc. The following table explains possible impacts and expected benefit aside from flood control for seven (7) categories described in "3.9.3 Timeframe and role allocation of Non-structural measures".

Table 3.13.5 Possible Impacts and Expected Benefit aside from Flood Control on Non-structural Measurements

Category	Possible Impacts	Expected Benefit aside from Flood Control
(1) Flood forecasting and warning	• Social disruption by miss information	• Tool for local communication during non-flood season
(2) Evacuation planning	• Impacts caused by construction of evacuation shelters: • Air/ water pollution, waste, noise, disturbance to drainage • Loss of vegetation, natural habitat • Land acquisition, resettlement, etc. • Considering to elders, handicapped, e.g., on design of shelter. • Gap of accessibility to the shelters from each household	• Place for local communication during non-flood season
(3) Awareness activities	• Gap of connection level on the blind and the deaf • Gap of connection on the non-educational people, persons who do not speak public language well such as IPs. • Gap of accessibility to the activities, materials (accessibility to the place, internet condition, etc.)	• Enhancement of local communication through involvement of awareness activities • Transmission/ exchange information from the communities
(4) Forest and mangrove conservation	• Change of ecosystem by planting activities • Land acquisition, resettlement • Loss of benefit by change of land use (convert from agricultural land, e.g.) • Imbalance of benefit allocation from the products (timber, fruits, etc.)	• Recover, rehabilitate of wildlife habitat. • Products from reforestation area
(5) Land use control	• Loss of benefit by change of land use • Land acquisition, resettlement • Loss of income especially on ISFs	• Improvement of living environment • Enhancement of land development potential
(6) Runoff control through on-site storage and permeable pavement system	• Land acquisition, resettlement • Imbalance of allocation of financial support for instalment of private water storage	• Provision of small-scale green area (pocket park) • Improvement of road face
(7) Cleaning maintenance of drainage channels, river and coastal area	• Waste • Traffic disturbance, accident • Injury, infectious disease on participants	• Encouragement of environmental education, public awareness • Enhancement of local communication

Source: Project team

Community involvement/ participation is important for implementation of the non-structural measurement; that is to say, public consultation specifically with local communities, information exchange as well must be key factor for mitigation of environmental impact, raise of benefit and proper allocation of the benefit.

3.13.6 Scoping

Scoping for the flood control measures in the MP was carried out for each of river flood of Davao River, Matina River and Talomo River, inland flood and coastal flood.

3.13.7 Environmental Impact Evaluation

Environmental impact evaluation was taken based on the results of [3.13.3 Methods of Environmental Impact Evaluation]; and evaluation methods were illustrated based on the scoping. Evaluation methods for each area were set for each of river flood of Davao River, Matina River and Talomo River, inland flood and coastal flood.

3.13.8 Results of Environmental and Social Considerations

Results of the study were compiled for each of river flood of Davao River, Matina River and Talomo River, inland flood and coastal flood.

3.13.9 Results of Initial Environmental Evaluation

Results of initial environmental evaluation were summarized for each of river flood of Davao River, Matina River and Talomo River, inland flood and coastal flood.

3.13.10 Environmental Management Plan

Proposed environmental management plan for each component were prepared for each of river flood of Davao River, Matina River and Talomo River, inland flood and coastal flood.

3.13.11 Environmental Monitoring Plan

Proposed environmental monitoring plan for each component were prepared for each of river flood of Davao River, Matina River and Talomo River, inland flood and coastal flood.

3.13.12 Issues Related to Resettlement in the Davao City

Davao City, DPCDO has planned and implemented relocation of informal settlers from high risk area such as river/ coastal side. Total of twelve (12) relocation sites have been provided as of November 2019. It was planned to take study for possible relocation site, census, public consultation for informal settlers, etc. in 2020. The following issues to cause stagnation are highlighted according to interview with DCPDO and in the series of stakeholder coordination meeting:

- Lack of relocation site and its capacity;
- Far distance of relocation site from the original location ISF residences;
- Although eligibility is given to the ISFs who has migrated along the Davao River before 1992; number of ISFs has been getting increase;
- Lack of control capacity of Barangay against illegal residents;
- Improper construction approval and illegal construction in the RoW;
- After settler moves to relocation site; he/she illegally leases or sells properties; and then he/she would come back to the original site.

3.13.13 Proposed Mitigation Measures on resettlement Issues

(1) Hard Approach

According to hearing with DPCDO, one of the critical issues is “lack of relocation site” and “far distance from the original area” as shown above. In order to mitigate these issues, concept of **On-site Relocation** is recommended and shared among DPWH, DPCDO and the Project team. On-site relocation aims to prepare relocation site adjacent to the project site; by this approach it is expected:

- To shorten travel distance to relocation site
- To secure status quo of lifestyle (keep existing work/ school, community relation, etc.)

Project team examined possible on-site relocation model with proposed flood control projects.

It is highlighted that relocation planning shall be integrated with urban redevelopment, land readjustment and traffic control.

(2) Soft Approach

Soft approach aims:

- Enhancement of voluntary relocation;
- Income recovery of resettled persons;
- Mitigation of community conflict, etc.

The following table summarizes proposed soft approach.

Table 3.13.6 Proposed Soft Approaches

Approach	Description
Additional compensation, support	• Compensation/ support in order to encourage PAPs to issue earlier agreement upon voluntary resettling. • It is expected to minimize relocation site provided by Davao City.
Job training/ arrangement	• Support PAPs to be recruited at relocation site, to change occupation from agriculture. • Encouraging income recovery.
Arrangement of micro finance	• Support for involuntary resettlement (procurement of land/ house, e.g.) • Support income recovery
Monitoring by Barangay and/or community for control of illegal migration, use of land and construction	• Control of illegal settlement • Control of illegal occupy, construction which have risk of disaster, incident, etc.
Implementation of early census and issuing Cut-off-Date	• Control of illegal settlement • Clarification of eligible person
Community-based planning	• Encourage consensus building with PAPs • Avoidance or mitigation of community conflict between resettled PAPs and existing community group at relocation site
Public education	• Edification on risk of informal settlement • Encouraging public involvement on flood control

Source: Project team

3.14 Public Consultation

3.14.1 Outline of the Public Consultation

A series of stakeholder meetings (SHMs) as one of the public consultation were undertaken in order to exchange ideas, to disclose information on the process of establishment of the M/P, and so as to integrate their opinions in to the M/P. Member of the stakeholders participating in the SHMs are listed in Table 3.14.1.

Table 3.14.1 Summary of Member of the Stakeholder Meetings

Group		Description
1	Community	Barangay leaders or their nominations as a representative of local communities
2	Government organization	DPWH、Davao City, DENR-EMB, MinDA, MGB, CDRRMC, NCIP, NEDA, NHA, CSWDO[1], BFAR, etc.
3	Private sector, NGOs, etc.	University of South-eastern Philippine, Davao City Chamber of Commerce and Industry, Inc., Commercial Real Estate Builders Association (CREBA), Fisherman's association, etc.

1) City Social Welfare Development Office (CSWDO), it has been merged with CSSDO and CWO.

Source: Project team

SHMs were undertaken from the beginning of [stage 1: Basic Study] in order to reflect stakeholder opinion into the M/P. The meetings were divided into the following 2 or 3 categories:

- First and second series: by type of floods (river flood, inland flood and coastal flood)
- Third series: by area (Davao urban area and coastal area, and middle stream and upstream of the Davao River

Table 3.14.2 summarizes the three (3) series of the SHMs undertaken during basic study and formulation of the M/P.

Table 3.14.2 Outline of the Stakeholder Meetings

Date		Venue	Participants	Agenda
1	Jan. 29, Feb. 20 and Apr. 24 in 2019	Pinnacle Hotel	Barangay leader/ representative, DENR-EMB, NEDA, etc. total of 216 participants	- Overall of the Project - Hearing on the history of floods - Issue findings
2	Jul. 23 to 25, 2019	Pinnacle Hotel	Barangay leader/ representative, DENR-EMB, NEDA, CSWDO, NCIP, Commercial Association, University, etc. total of 247 participants	- Findings of environmental and social issues - Introduction of Japan experiences on flood control activity - Group discussion and presentation
2	Jan. 23 to 24, 2020	Pinnacle Hotel	Ditto, total of 171 participants	- Sharing the results of basic study - Policy on flood control M/P - Initial environmental evaluation and scoping - Group discussion and presentation

Source: Project team

3.14.2 Results of the Stakeholder meetings

Principally there was no certain opposite raised from the participants; while they expressed interest in Japan experiences such as "multiple use of retarding pond" and "effective use of underground space". Table 3.14.3 summarizes the comments from the SHMs.

Table 3.14.3 Overall of the Comments from the Stakeholder Meetings

Comments		Feedbacks
Waste	• Most of the barangay highlighted illegal dumping in the water area as a significant factor to cause floods. • It was also pointe degradation of sanitary condition and cause of infectious diseases by the waste dumping.	• The issue of waste must be key factor on flood control. River cleaning program is one of the most important as non-structural measurement.
Cooperation with local communities	• Public awareness/ involvement must be key factor; barangay can cooperate for flood control. • Coordination with barangay is necessary to implement public awareness, evacuation drill.	• Planning M/P, F/S for the priority projects as well must be taken with cooperation with barangay.

Comments		Feedbacks
Informal settlers	• ISFs along the river must be relocated because of high risk flood prone area. • River widening must be effective measurement; on the other hand, careful planning and implementation of the flood control shall be obtained in order to minimize impact to the ISFs and their negative perception.	• Cooperation and involvement with barangay are essential to control migration of the ISFs.
Resettlement	• People should not reside in the river area. • River widening could be acceptable; however, since involuntary resettlement will occur, so relocation site shall be prepared.	• Design flood mitigation measures and construction methods to minimize the scale of resettlement.
Land use, natural conservation	• It was recommended to install open space, buffer zone in the project site to reduce flood risk. • Conservation of forest and mangroves, reforestation is important for prevention of flood and erosion.	• Land use plan, forest conservation taken by Davao City and DENR shall be incorporated into the flood control measurement. • Design of the measurement, construction method must be considered to minimize the impact to land use and natural conservation. • Forestation and conservation of forest/ mangrove shall be incorporated with non-structural measurements.
Impact to fishing activity	• Compensation to fishermen, provision of anchor station must be considered[1)].	• This opinion shall be reflected into the planning policy of the flood control.
Evacuation center	• Additional centers must be constructed. Two-storied buildings area recommended because of possible inundation. • The location of the center and secure of access route must be clearly distributed to the communities.	• Accessibility to the evacuation center must significant issue especially for elders, handicapped. • Evacuation plan must consider their disadvantages.
Accessibility to river	• Design and construction of dyke, flood wall must secure accessibility to river[2)].	• Few commercial fishing, swimming, other recreation activities were observed according to the basic study. However, this situation might depend on the location and community activities along the river. • Sand mining was observed in the middle stream or upper. • Planning and design must consider accessibility and use of river side from the viewpoint of landscape such as installation of boardwalk.

1) The comment was raised against coastal road project.

2) According to the direct interview to several participants, they expressed positive thinking about river widening. The major reason was because tall dyke, flood wall such as proposed in the alternative 1 and 2 on planning policy could degrade landscape and interrupt accessibility to riverside comparing with river widening.

Source: Project team

Upon the results of the SHMs, the followings were incorporated with the planning policy on the M/P.

- Enhance relocation of ISFs, and properly control the river area;
- Promote community participation on patrol of illegal dumping, river cleaning through public awareness;
- Promote to create green space or buffer zone through reforestation, conservation of forest. Mangrove.
- Design revetment management in consideration with use of and accessibility of the river;
- Harmonize flood control structures with natural conservation such as water-friendly space, and improve accessibility to the river area;
- Minimize impact to fishery activities coastal flood control;
- Encourage coordination with barangay, local communities on implementation of projects, public awareness.

3.15 Master Plan Evaluation (Examination of Alternatives)

3.15.1 Evaluation of Davao River Flood Countermeasures

(1) Zero Option

The option of no implementation of the M/P is not recommended based on the following reasons:

- Annual loss of economy is estimated approximately 10.8 billion pesos.
- Davao City has highly prioritized flood controls as one of the urgent issues.

(2) Evaluation of Flood Countermeasures (Structural) for Davao River

The alternatives explained in Section 3.4 were assessed by using the evaluation criteria set in Section 2.15. Only "Evaluation Results" is shown in table below.

Table 3.15.1 Evaluation of Flood Countermeasures (Structural) for Davao River

1pt	Alt.1: Combination of Reinforcement of Present Dike and Flood Water Detention Facilities(1-3)	Alt.2: Combination of New Dike and Flood Water Detention Facilities(2-1)	Alt.3: Combination of River Widening and Flood Water Detention Facilities(3-1)
Combined Countermeasures	Dike Reinforcement (1,200 m^3/s) Retarding Pond (1,200m^3/s) Dam (1,000m^3/s)	Dike Construction (1,700 m^3/s) Retarding Pond (1,700m^3/s)	River Widening (1,700 m^3/s) Retarding Pond (1,700m^3/s)
Evaluation Results			Although large scale resettlement is required; risk of accidental cases (dyke breach, washout, e.g.) by unexpected floods could be minimized. ◎

Source: Project Team

3.15.2 Evaluation of Matina River Flood Countermeasures

(1) Zero Option

The option of no implementation of the M/P is not recommended based on the following reasons:

- Annual loss of economy is estimated approximately 430 million pesos.
- Davao City has highly prioritized flood controls as one of the urgent issues.

(2) Evaluation of Flood Countermeasures (Structural) for Matina River

Regarding Matina River, by reflecting the alternatives evaluation of Davao River, the combination of river widening and retarding pond is recommended for the viewpoint of project cost and flexibility (refer to Section 3.5). As a result of evaluation according to the evaluation criteria set in Section 2.15, the recommended alternative is evaluated as appropriate.

3.15.3 Evaluation of Talomo River Flood Countermeasures

(1) Zero Option

The option of no implementation of the M/P is not recommended based on the following reasons:

- Annual loss of economy is estimated approximately 280 million pesos.
- Davao City has highly prioritized flood controls as one of the urgent issues.

(2) Evaluation of Flood Countermeasures (Structural) for Talomo River

Regarding Talomo River, by reflecting the alternatives evaluation of Davao River, the combination of river widening and retarding pond is recommended for the viewpoint of project cost and flexibility (refer to Section 3.6). As a result of evaluation according to the evaluation criteria set in Section 2.15, the recommended alternative is evaluated as appropriate.

3.15.4 Evaluation of Storm Water Drainage Improvement

(1) Zero Option

The option of no implementation of the M/P is not recommended based on the following reasons:

- Annual loss of economy is estimated approximately 1.7 billion pesos.
- Davao City has highly prioritized flood controls as one of the urgent issues.

(2) Evaluation of Storm Water Drainage Improvement

The countermeasures for the nine drainage areas shown in Section 3.7 are evaluated according to the evaluation criteria set in Section 2.15. Only "Evaluation Results" for each drainage area is shown below.

1) Roxas

The evaluation results of measures for Roxas drainage area (1.40km^2) which is located at the center of Poblacion district and drains to Davao Gulf, are as follows.

Table 3.15.2 Evaluation of Drainage Countermeasures (Structural) for Roxas Drainage Area

Evaluation Axis	Alternative-1: Drainage Channel Improvement	Alternative-2: Bypass Channel (Culvert) and Partial Drainage Channel Improvement	Alternative-3: Bypass Channel (Culvert) and Retarding Basin (Closed Type) under Road
Evaluation Results	× Not recommended from the viewpoint of cost and impact to landscape.	○ Tree cut is anticipated; but the level could be smaller than Alternative-1.	△ Highest cost but may be selected if any impact to landscape cannot be allowed.

Source: Project Team

2) Agdao

The evaluation results of measures for Agdao drainage area (5.15km^2) which is located at the center of Agdao district and drains to Davao Gulf, are as follows.

Table 3.15.3 Evaluation of Drainage Countermeasures (Structural) for Agdao Drainage Area

Evaluation Axis	Alternative-1: Separation of the Agdao Channel with Improvement	Alternative-2: Pump Drainage from the Old Agdao Channel
Evaluation Results	○ Since the pump is not installed; maintenance and rehabilitation cost could be reduced.	×

Source: Project Team

3) Jerome

The evaluation results of measures for Jerome drainage area (4.21km^2) which is located in the eastern part area of Agdao district and drains to Davao Gulf, are as follows.

Table 3.15.4 Evaluation of Drainage Countermeasures (Structural) for Jerome Drainage Area

Evaluation Axis	Alternative-1: Retarding Basins and Bypass Channel (Culvert)	Alternative-2: Retarding Basins, Channel Improvement and Bypass Channel (Culvert)
Evaluation Results	×	◎ Recommended because of smaller scale of land acquisition and resettlement.

Source: Project Team

4) Mamay Creek

The evaluation results of measures for Mamay Creek drainage area (8.91km^2) which has a catchment from the hilly area in the north of the Diversion Road to the western part of the Davao International Airport, are as follows.

Table 3.15.5 Evaluation of Drainage Countermeasures (Structural) for Mamay Creek Drainage Area

Evaluation Axis	Alternative-1: Retarding Basins, Bypass Channel and Dyke	Alternative-2: Underground Diversion Tunnel, Retarding Basins, Bypass Channel and Dyke	Alternative-3: Retarding Basins, Channel Improvement and Dyke
Evaluation Results	◎ Land acquisition cost is bigger than other alternatives; but scale of resettlement is smaller. This alternative is recommended because of smaller total cost.	×	×

Source: Project Team

5) Sasa Creek

The evaluation results of measures for Sasa Creek drainage area (5.97 km^2) which has a catchment from the hilly area in the north of the Diversion Road to the western part of the Davao International Airport, are as follows.

Table 3.15.6 Evaluation of Drainage Countermeasures (Structural) for Sasa Creek Drainage Area

Evaluation Axis	Measure 1: Retarding Basins of La Verna Measure 2: Bypass Channel, Improvement of Cross Drains and Dredging of Pampanga
Evaluation Results	No alternatives were evaluated because only these measurements could properly supplement existing projects taken by the DPWH.

Source: Project Team

6) Emars

The evaluation results of measures for Emars drainage area (2.42km^2) which is located in the western part area of Matina-Aplaya district and drains to Davao Gulf, are as follows.

Table 3.15.7 Evaluation of Drainage Countermeasures (Structural) for Emars Drainage Area

Evaluation Axis	Alternative-1: Retarding Basins	Alternative-2: Retarding Basins and Bypass Channel (Culvert)
Evaluation Results	×	○ Recommended because of higher flood control effect and smaller project cost.

Source: Project Team

7) Shanghai

The evaluation results of measures for Shanghai drainage area (1.60km^2) which is located in the eastern part area of Matina-Aplaya district and drains to Davao Gulf, are as follows.

Table 3.15.8 Evaluation of Drainage Countermeasures (Structural) for Shanghai Drainage Area

Evaluation Axis	Alternative-1: Channel Improvement and Installation of Diversion Channel	Alternative-2: Retarding Basins and Bypass Channel (Culvert)
Evaluation Results	×	○ Recommended because of smaller project cost.

Source: Project Team

8) Maa1

The evaluation results of measures for Maa1 drainage area (1.41km^2) which is located in the western part area of Maa district and drains to Davao River, are as follows.

Table 3.15.9 Evaluation of Drainage Countermeasures (Structural) for Maa1 Drainage Area

Evaluation Axis	Alternative-1: Channel Improvement	Alternative-2: Retarding Basins and Channel Improvement
Evaluation Results	×	○ Recommended because of smaller project cost.

Source: Project Team

9) Maa2

The evaluation results of measures for Maa2 drainage area (9.03km^2) which is located in the western part area of Maa2 district and drains to Davao River, are as follows.

Table 3.15.10 Evaluation of Drainage Countermeasures (Structural) for Maa2 Drainage Area

Evaluation Axis	Alternative-1: Underground Diversion Tunnel (Larger Scale), Retarding Basins and Channel Improvement	Alternative-2: Underground Diversion Tunnel (Smaller Scale), Retarding Basins and Channel Improvement
Evaluation Results	×	○ Recommended because of smaller project cost.

Source: Project Team

3.15.5 Evaluation of Structural Measures of Coastal Disaster

(1) Zero Option

The option of no implementation of the M/P is not recommended based on the following reasons:

- Annual loss of economy is estimated approximately 2.3 billion pesos.
- Davao City has highly prioritized flood controls as one of the urgent issues.

(2) Evaluation of Structural Measures of Coastal Disaster for Each Area

The measures explained in Section 3.8 are assessed by using the evaluation criteria set in Section 2.15.

1) North Coast Area

Actually, since the damage is almost null, basically there is no need for countermeasures.

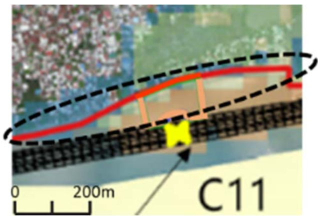
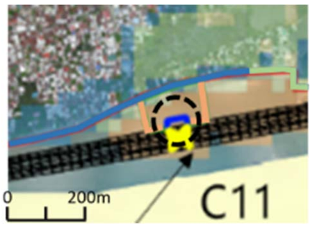
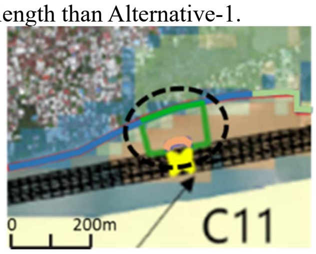
2) South Coast Area

Since the inundation area in the south area is local, the countermeasures to install a coastal dike in front of the residential area in inundation area are fundamentally adopted.

3) Central Coast Area (Coastal Road Section)

Since the central coast area overlaps with the area of coastal road project; proposed flood control shall be designed with consistency with the road. Principle of the flood controls is a combination of installment of coastal dike with slice gate at the orifice of the road which shuts down from the inflow of sea water. Table 3.15.11 summarizes the results of evaluation of the alternatives in the section of C11.

Table 3.15.11 Evaluation of Drainage Countermeasures (Structural) for Coastal Measures

Evaluation Axis	Alternative-1: Construction of coastal dike	Alternative-2: Construction of sluice gate utilizing coastal road	Reference: Improvement plan of Alternative-1 Construction of minimized coastal dike utilizing coastal road
Image plan with C11 section as an example <Legend> Dike Sluice Gate Dike (minimized) Coastal Road Bridge	Construct coastal dike in the red line area 	Construct sluice gate in the blue line area 	Construct coastal dike in the green line area with shorter length than Alternative-1. 
Evaluation Results	○ Recommended due to lower overall costs and possible mitigation measures despite impacts on fisheries	×	◎ Utilizing the Coastal road and limiting the extent of dike construction in Alternative-1 to the opening would reduce the impact on the fishing industry.

*: Since the current residential area, including informal housing, is defined as a residential area in the Davao City Land Use Plan, structures (e.g., dikes) will be constructed on the seaside of the residential area. Therefore, basically no relocation will occur, but this should be reconsidered at the time of each detailed design.

Source: Project Team

Improvement plan of Alternative-1 encourages to reduce the area to be installed coastal dyke, so as to minimize the impact to fishermen's activities (accessibility to a mooring station, e.g.). On the other hand, design of this alternative needs further detailed survey for natural condition, consensus building with local communities, use of coastal area, etc. during further F/S and/or DED stage. Therefore Alternative-1 is recommended in the M/P; and then the project cost was estimated upon condition.

3.16 Priority Project

The priority projects in this Project are selected to focus on riverine flood in the Davao River, considering its scale, the number of residents and economic value and its importance for economic activities. The evaluation axis of selecting priority projects and the selected priority projects are described below.

3.16.1 Evaluation axis for selecting the Priority Project

(1) Structural measure

The priority projects are selected from the structural measures for the M/P using the following evaluation axes.

- High urgency
- Fast effects

- High effects
- Good coordination with priority projects of Non-structural measures (Riverine flood in the Davao River)
- Even if only the structural measures for riverine flood are implemented in advance, they will not have a negative effect or have a positive effect on other types of flood (inland flood, coastal flood)
- Low risk on environmental and social consideration (No risk of increasing environmental and social impacts, or mitigation effects can be expected.)

(2) Non-Structural measure

The evaluation axis is set for selecting priority projects of non-structural measures from the list of activity proposed in section 3.9. As evaluation axes for selecting the priority projects, projects with high urgency, fast effects, and high effects are prioritized. Especially, early implementation of non-structural measures is expected without waiting for the completion of structural measures since the construction work requires relatively long years. As for the high effects, projects that are directly linked to evacuation actions and people's awareness of disaster risk are prioritized.

Meanwhile, riverine flood is targeted as the priority projects also for the non-structural measures taking into account the combination with the structural measures.

3.16.2 Proposal of the Priority Project

(1) Structural measure

As the result of the evaluation, discussion with relative organizations and the steering committee meetings which were held in November 2020 and February 2021, the following three projects were selected as the priority projects targeted for the F/S in Stage 3 of this Project.

- Dredging (It is easy to improve the river flow capacity, the effect is quick, the cost-effectiveness is high, and the urgency is high.)
- Cut-off work (This may lead to the creation of a relocation area. High urgency.)
- Retarding Ponds (three locations) (High urgency.)

In addition to the above three projects, corresponding to the request in the steering committee meetings, it was agreed that downstream part (from Bolton bridge to around 4km from the river mouth) of river widening that is categorized in mid-long term measures could be also targeted in the Stage 3 as an additional priority project but would be more simply investigated at pre F/S level different from F/S level of other priority projects. As for the examination of environmental and social considerations, the above three projects will be studied and evaluated in accordance with the EIS, which is the environmental approval system in the Philippines, whereas environmental and social study for the river widening will be carried out aiming not to apply for the environmental approval but to sort out the issues and use it for future F/S and approval application.

(2) Non-Structural measure

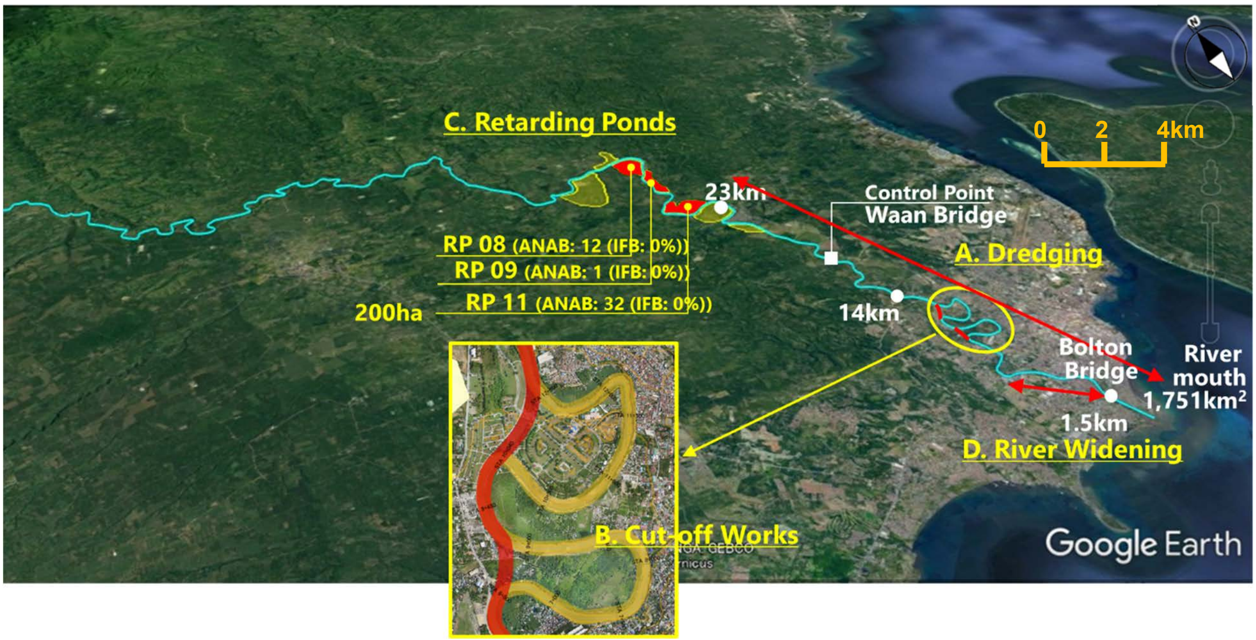
Through the evaluation using the evaluation axes described in 3.16.1, discussion with relative organizations and the steering committee meetings which were held in November 2020 and February 2021, the following projects were selected as priority projects of non-structural measures.

- 1-(a) Additional installation of water level gauges
- 1-(b) Setting warning water level in the Davao river corresponding to the latest river and social conditions
- 3-(a) Preparation of IEC materials on the proposed structural measures and non-structural measures
- 3-(b) Formulation and Update of flood hazard map for riverine, inland and coastal with evacuation information
- 5-(a) Land use control along the proposed structural measures

- 7-(d) Capacity enhancement project on riverine flood, rainwater drainage and coastal management in Davao

3.16.3 Outline of Priority Projects of Structural Measures

Project sites and outline of priority projects are shown in Figure 3.16.1 and Table 3.16.1.



Source: Project team

Figure 3.16.1 Project Sites of Priority Projects

Table 3.16.1 Outline of Priority Projects of Non-Structural Measures

	Sites	Content
A. Dredging	From river mouth to 23km	Dredging volume of about 2 million m^3
B. Cut-off works	7km to 13 km from river mouth	About 700m length in total, About 110m width
C. Installation of Retarding Ponds RP is number of retarding ponds	RP11 : about 24km from river mouth RP09 : about 27km from river mouth RP08 : about 29km from river mouth	Area、 Capacity RP11 : 0.76km^2, 3.80MCM RP09 : 0.39km^2, 1.95MCM RP08 : 0.85km^2, 4.25MCM
D. River Widening* (A part of widening works with 14km for M/P)	From Bolton Bridge (1.5km from river mouth) to 4km from river mouth	About 110m width

*: Only study at pre F/S level is carried out.

Source: Project team

3.16.4 Scoping

(1) Priority Projects under the F/S

1) Draft Scoping

The draft scoping for the “river widening”, retarding ponds” and “cut-off works” were carried out for each of priority projects.

2) Methods of Evaluation and Environmental and Social Consideration Study

Methods of evaluation and environmental and social consideration study (TOR for EIS study) were examined for each of priority projects.

(2) Scoping on the Priority Project in the Pre-F/S

It was agreed between the DPWH to undertaken the pre-F/S for the river widening in the parallel with the F/S. Environmental and social consideration will be taken mainly by data collection and analysis and through the following tasks:

- Finding environmental and social issues likely caused by the river widening;
- Initial scoping for further study;
- Consultation with relevant organizations, barangay, etc.
- Finding resettlement issues, drafting resettlement framework.

The draft scoping on the river widening was carried out.

3.17 Examination of Measures to Promote Implementation of Master Plan

3.17.1 Present situation and Given Condition for Development of Relocation Site

(1) Background for Development of Relocation Site to Promote Implementation of Master Plan

IM4Davao has short term (~2022), medium term (2023-2030), and long term (2031-2045) road development plans covering the period up to 2045.

Among them is the Davao Riverside Boulevard Develoopment Project, which aims to modify the present strong swerve-meandering river to a slight curving configuration and to develop the dike road along the modified river, as well as to reduce the risk of flood damage from the Davao River, strengthen the city's north-south road network, and improve interconnectivity in the east-west direction.

IM4Davao has estimated the cost of the project at 12,060 million pesos. The project entities include DPWH, Urban Development Coordinating Council (UDCC), National Housing Authority (NHA), and Davao City.

While taking into account the above considerations, in order to promote the implementation of the M/P in a certain and positive manner, the JICA Expert Team considered the development of the area surrounding the short-cut project area as relocation sites for the people to relocate due to the shortcut and river widening project.

(2) Conditions for Relocation

Given conditions for relocation are summerised below.

Number of Relocation

- Approximately 50-100 structures will be affected in the cut-off works. Most of these are likely to be houses of Kagan Community. Although the number of structures affected will vary depending on whether the river channel width is 80 or 110 meters, it is desirable to relocate the Kagan houses as close to their original lands as possible. When the river widening is included, approximately a total of 1,600 structures will be affected. While not all of these structures may be relocated to the same area, it is planned that the resettment site can accommodate 1,600 households.

River Cut-off and Drainage

- After the river shortcut in the target area, the old river channel does not carry the flow capacity.
- Because of the need for runoff of incoming rainwater, full reclamation is not possible and partial drainage channels are necessary. Especially for the old river channel on the downstream side, there is an inflow from the existng drainage, and it is necessary to secure a width of about 35 m (sholder clearance) after the confluence point.

Land Ownership

- Regarding the old river channel, ownership will need to be discussed further.
- Since the land owned by the owner of Crocodile Park is dominantin the target area, land for relocation site development will be only secured by accomodating their intentions apporpriately, when the land consolidation and swapping, including the old river channel, is applied.
- In consideration of the land of the Kagan Community, their relocation will be done in the vicinity.

Land Use Regulations

- In the Comprehensive Land Use Plan (CLUP) in Davao City, most of the target area is designated as "Recreational Area" according to recent revisions and the area is not envisioned for residential uses. However, Davao City Planning and Development Office (DPCO) has confirmed that further changes to the uses proposed in the CLUP are possible.

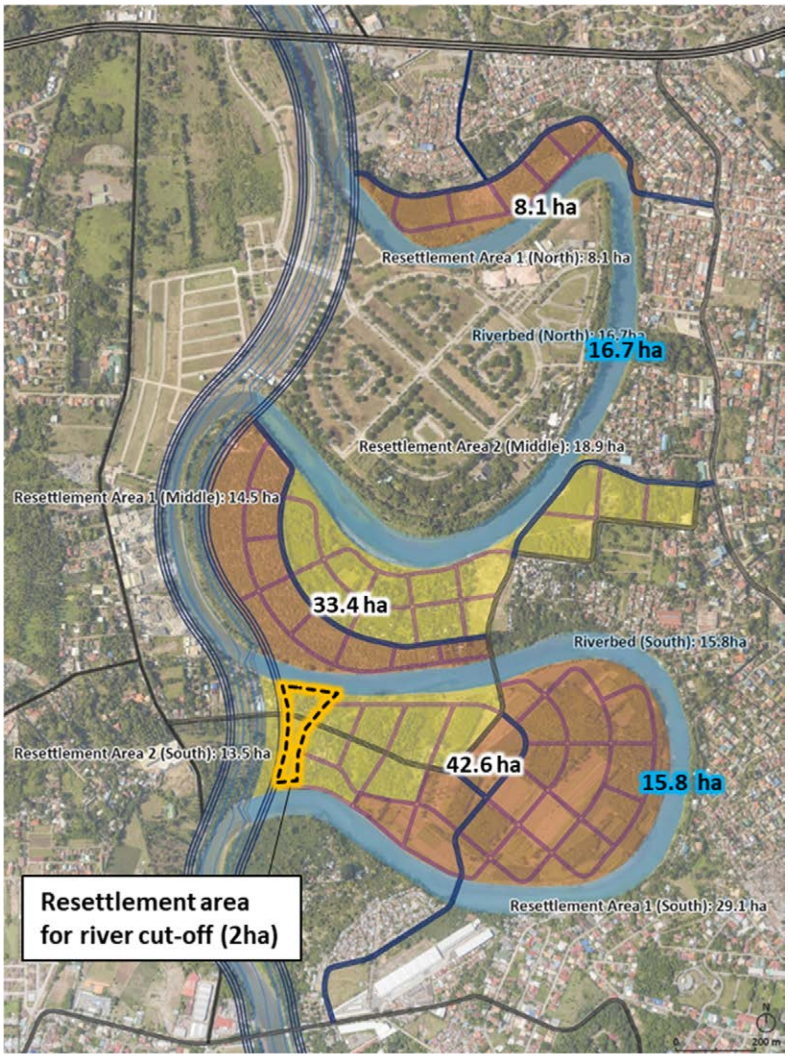
Others

- According to the standard mentined in PO 957 and BP 250, 9% of the total land of an urban development should be alocated for open spaces. In addition, if residential development of a certain size is to be implemented, educational facilities should also be considered.
- Real estate demands are growing steadily, especially for residences, and it seems to be possible to implement residential developments by private sector.

3.17.2 Basic Policy for Development of Resettlement Area

(1) Potential Lands for Relocation and Urbanization

For examination of the relocation site and urban development of this project, lands that has not yet been urbanized was identified (Figure 3.17.1). The land is mainly used for agricultula uses such as plantations, and has not been urbanized due to the risk of flooding.



Source: Project Team

Figure 3.17.1 Potential Lands for Relocation and Urbanization

The area shown in orange is particularly low land, with virtually no houses, and is used for plantations and agriculture. On the other hand, the area shown in yellow has some houses in scatterd. The area indicated by the dashed line is assumed to be used as a relocation site for the Kagan comunity.

It is assumed that land acquisition for river works will be carried out by DPWH and land acquisition for relocation site development will be carried out by Davao City. In addition, it is assumed that Davao City will play a central role in the development of the relocation site and the construction of buildings. It is envisioned that the land preparation will be implemented by DPWH based on a request from Davao City, and that the building maintenance will be a joint project between Davao City and NHA. Also, EIA and RAP may need to be carried out or prepared by implementing agency when necesssary. Details need to be determined through future discussions.

(2) Selection of Relocation and Urbanization Lands and Development Proposals

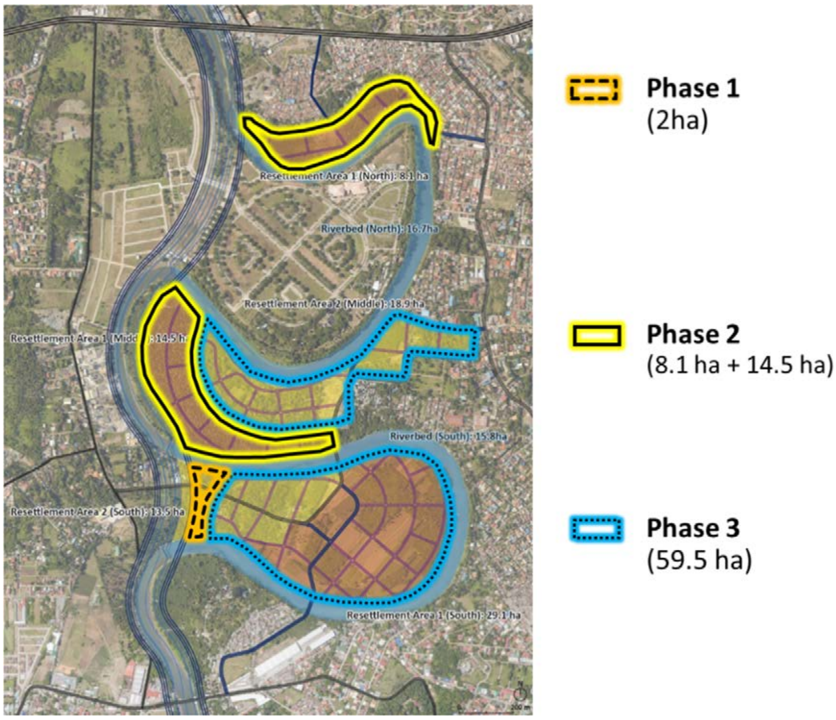
Development of the relocation site, the following options are considered.

1) Option 1: Proposal not to reclaim the old river channel

For the cut-off works of the project, it was also considered that a proposal to utilize the old river channel to secure the river waterflow. Therefore, the option 1 is a proposal to not reclaim the old river channel. Even if the old river channel is reclaimed for urban uses, considering the soil conditions, ground improvement would be necessary for urbanization. Therefore, the option does not specifically consider urbanization.

In this option, if the all potential lands shown in Figure 3.17.1 is used for the relocation site, approximately 1,800 households are accomodated with population density of 100 persons/ha. In the other hand, if population density is set as 150-300 persons/ha, areas to accommodate the 1,600 households, which is a given condition, can be partial. In this case, a surplus lands will be created and can be used as a resettlement area for other informal sectors or as sites for new urban development.

Figure 3.17.2 shows a phase development idea; Phase 1 is to establish relocation sites for the Kagan community in the vicinity of their settlements, Phase 2 is to establish relocation settlements through the river improvement project such as the river wideining, and Phase 3 is to create urban development sites for other uses.



Source: Project Team

Figure 3.17.2 Project Phasing of Relocation and Urbanization Option 1

For this option, while DPWH would be responsible for acquiring the land for the relocated sites for the river improvement project, Davao City would be responsible for acquiring the land for other urban development, or a cooperative scheme with the private sector, such as PPP scheme, would need to be established. Therefore, there is concern that it will take time to coordinate the implementation of the relocation and urbanization.

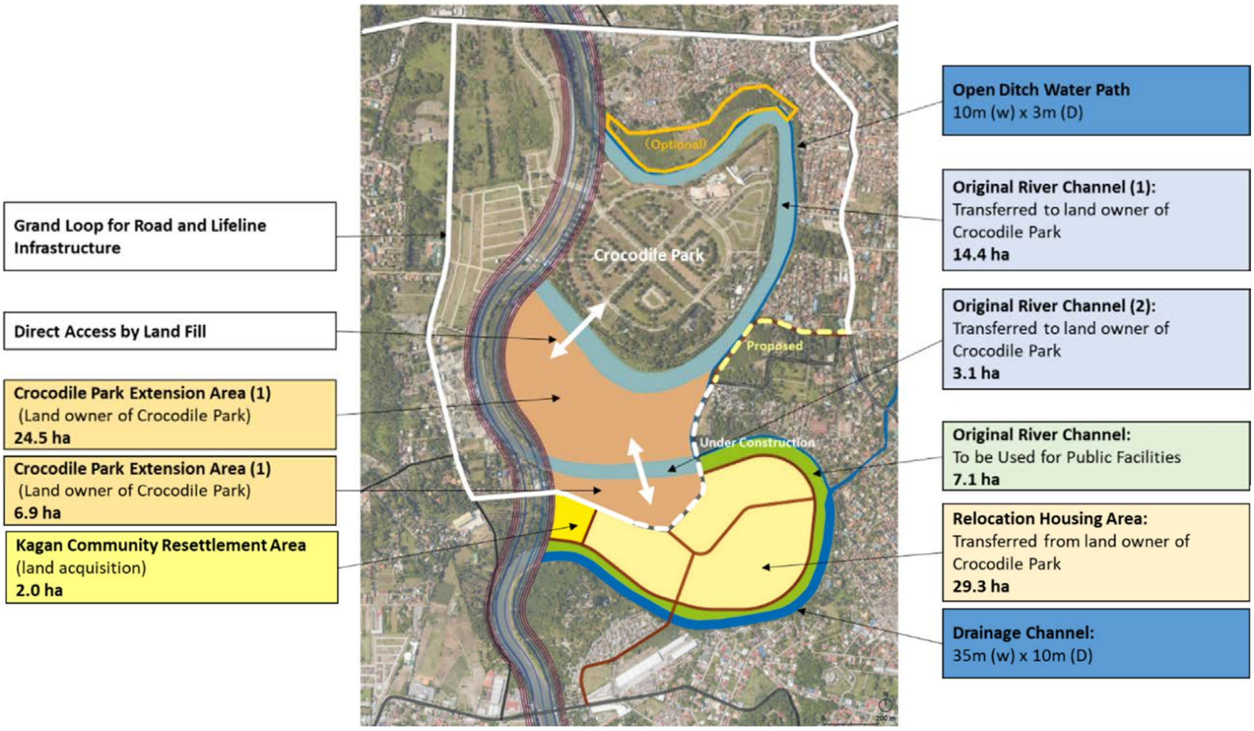
2) Option 2: Proposal to reclaim the old river channel

This project is recommended not to utlilize the old river channel for river water flow. Therefore, the option is a proposal to reclaim the old river channel. This would allow for an integrated urban land use of the surrounding area, and coordination with the land owners, especially the one owns Crocodile Park and other plantation fields, would be particularly important. This concept is described below.

- Regarding the land owned by the owner of Crocodile Park, which can be connected to Crocodile Park by reclaiming the old river channel, it is excluded from the relocation target land because it has its own conception of land utilization.
- The reclaimed land of the old river channel, which is expected to be owned by DPWH, will be

transferred to the owner of Crocodile Park. Instead, the lands owned by Crocodile Park Owner which are surrounded by the old river channel will be transferred to DPWH. It is assumed that this land exchange between DPWH and the owner of Crocodile Park will be applicable.

- At the same time, several measures to maintain the drainage capacity of the hinterland in the old channel will be proposed as a condition of reclamation for the old channel, which will be partly owned by the land owner of Crocodile Park after the land exchange. At present, it is proposed to install drainage channels, but more specific studies will be required for implementation.
- In order to ensure disaster safety and to obtain multiple options for feasible reclamation patterns, DPWH will own and utilize the land in and around the cut-off area in downstream. (This will be referred to as the “relocation block”).
- As mentioned above, the relocation site will be secured through a land exchange. At the same time, DPWH will need to acquire the land for the Kagan community and other privately owned lands.
- The PAH relocation of the Kagan community will be formed adjacent to the same community and within the relocation block.
- Fill the site to HWL + 1m, while preserving the title of the existing land and houses, etc. as much as possible.



Source: Project Team

Figure 3.17.3 Relocation and Urbanization Option 2

3) Recommended Option

Considering the burden of land acquisition by DPWH or Davao City, Proposal 2 would be more feasible. While the owner of Crocodile Park would be able to secure land that can be used in integration with the existing Crocodile Park, the large part of its land at the downstream area would be transferred to DPWH and could be used as the relocation site. By utilizing the old river channel as open space and drainage channel, it will be possible to meet the public space requirements of urban development. Furthermore, it will facilitate the design of relocated residential areas within the relocation block, as well as contribute to improving the environment of the area.

For this reason, Proposal 2 is proposed as the recommended proposal.

(3) Development Scale and Function

The development scale and functuon are described as below.

- Relocation housing of PAH households in Kagan community: Secure approximately 2 ha of land in the downstream area. The number of structures affected by the shortcut is about 50-100, and it assumes that up to 100 households will be relocated. However, some houses are located in the Kagan community which is not directly affected by the cutoff.
- Among the PAHs generated by the River Improvement Project and the construction of the Detention Ponts, residential households in illegal situation will be considered as houses for relocation. It is estimated that approximately 1,600 buildings will be affected. If the relocation block were to accommodate 1,600 households, the population density would be 250 persons/ha, which is a rather high density. Theredore, the district will be developed and improved mainly with 5-story collective houses.
- Assuming 4.5 persons per household, 1,600 households with 7,200 persons will live in the relocation block. Public facilities need to be built commensurate with this number of people.

In addition, if private development is to be integrated, it must comply with the Urban Development and Housing Act of 1992, and the Balanced Housing Development Program Amendments Act of 2016. The provision of housing should take into account the income levels stipulated in these Acts.

3.17.3 Relocation Site Development Plan

(1) Land Use Plan

For preparing the land use plan, the following matters were considered.

- Areas for PAH of the relocation housing for Kagan community will be secured adjacent to the eastern and southern parts of the remaining Kagan community. The possibility of using collective houses as relocation sites will be considered.
- Regarding the old river channel, drainage will secure with 10 m width in upper side of the area, and 35 m width after the confluence with the existing drainage channel. Other parts of the old river channel will be filled as embankments.
- The land along the drainage in the downstream will not be urbanised, and will be utilized as public land for roads, open space, etc., and it secures for connecting roads as a development condition and pursues for areas of water amenity.
- In order to utilize the sites other than the above as collective housing blocks, relatively wide roads are planned as collectors to contribute to smooth traffic flow, including with the surrounding areas. On the other hand, a network of service roads will be formed within the residential block to create a safe environment based on the concept of pedestrian-vehicle separation.
- The center of the relocation block and along the road currently under construction will be used as a centre of the relocation block, and introduction of commercial and public facilities are proposed. This area will also be considered locations for condominiums and other middle-class/high-end residential apartment, depending on discussions with the private developers including the Crocodile Park owner.

Table 3.17.1 Area by Land Use in Relocation Site

Zoning	Area (ha)	ratio	notes
Relocation Block	29.3	66%	Including roads in the district
of which mainly residential areas	*26.8*	*61%*	*Mainly consists of relocated residentials*
of which commercial and public facilities	*2.5*	*6%*	*Provide services for new residents*
Kagan Community Relocation Site	2.0	5%	
Green space / Open space	7.1	16%	Set in old river channel area
Drainage channel at the downstream	5.7	13%	Set in old river channel area
Relocation Block Subtotal	**44.1**	**100%**	
Crocodile Park Owner (North)	24.5	-	
Crocodile Park Owner (South)	6.9	-	
Old river channels transferred to Crocodile Park Owner (North)	14.4	-	
Old river channels transferred to Crocodile Park Owner (South)	3.1	-	
Drainage channel needed to old channel	**3.1**	-	
Crocodile Park Owner's Land Subtotal	52.0	-	
Total	**96.1**	**-**	

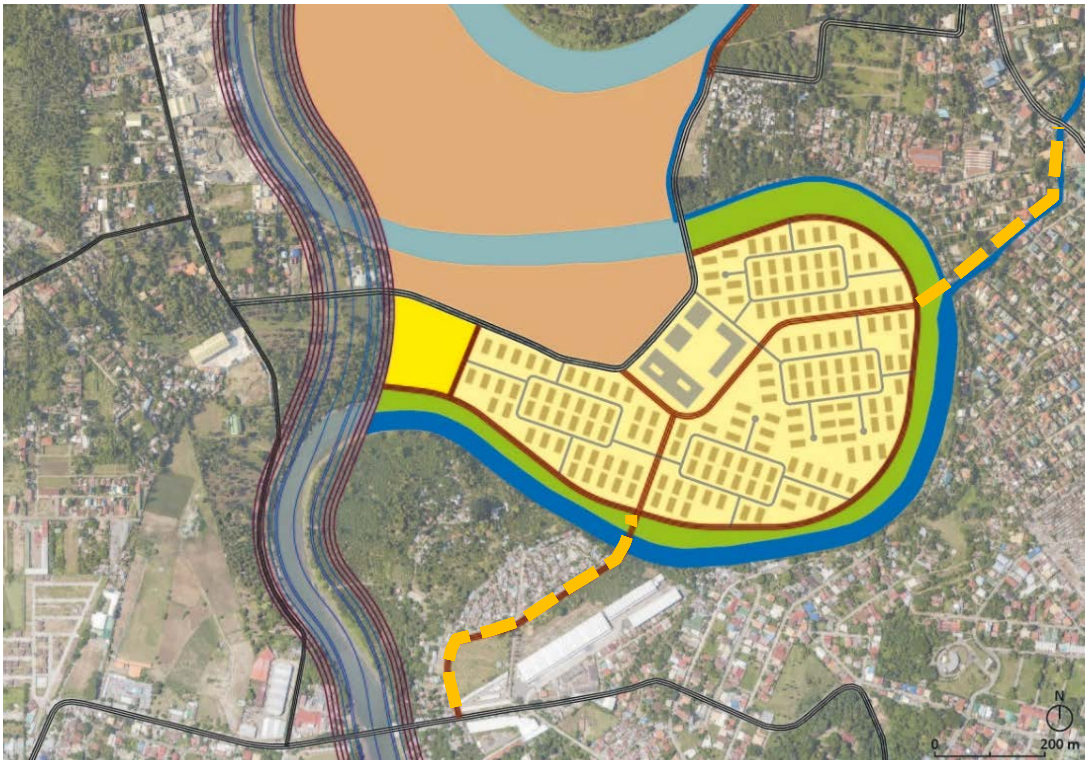
Source: Project Team

(2) Road Plan

The main artery road of Mindanao, AH26, runs east-west in the northern part of the target area, and from this road, the arterial road runs north-south direction in a ladder-like configuration. Therefore, access from the target area is planned to connect to AH26 via this ladder-like arterial roads. The existing road and the bridge crossing the old river channel which is currently under construction, will be called the Grand Loop and it will be the main road connecting between inside and outside of the relocation block. The necessary lifelines should also be located under the Grand Loop. (In Figure 3.17.3, these are indicated by white lines. The white dotted line is under construction and the yellow dotted line is additional proposal.)

The road network in the area will form an inner district arterial roads connecting the bridge installed in the shortcut project and the bridge crossing the old river channel that is currently under construction. And, the arterial road in the area will be extended in two directions to the south and east by branching off. These will be considered that the bridges in future to strengthen access to the outside of the area. The line indicated by the orange dotted in Figure 3.17.4 is an additional new roadway proposal connecting to the outside of the area from the inside arterial road.

A service roads from the arterial road to the residential area will be planned with loops and cul-de-sacs to meet the condition to connect with road for the housings and to prevent through traffic from entering the area. The service road will be treated as a collector road standard since it is in the residential area. It is assumed that paratransit-type public transportation operations like jeepneys will be permitted in the collector road.



Source: Project Team

Figure 3.17.4 Tentative land use and transportation plan in Relocation Block

(3) Land Grading Plan

The subject area has been frequently inundated by floods. In order to use the land for urban land use, it is necessary to prevent inundation by filling the land with soil, while taking disaster prevention into consideration. Assuming that the land area is 1m above the high water level of the main Davao River, the total amount of soil to be filled is 2.92-3.32 MCM, consisting of approximately 2.4 MCM for the old river channel and 0.52-0.92 MCM for the surrounding privately owned lands.

The amount of soil generated by the Davao River shortcut is calculated to be approximately 1 MCM. Considering the amount of consolidation settlement of the fill material, the soil volume will be insufficient. Therefore, the basic policy is to balance the fill by adjusting the area of the old river channel to be reclaimed and the width of the channel that will remain in the old river channel.

Due to the high embankment on the soft ground of the old river channel, it is necessary to carry out a detailed study on measures to prevent subsidence at the time of the detailed design.

The area that needs to be started earliest in this relocation site development project is the Kagan community relocation site development area, but since this needs to be done before the main river shortcut, no filling is assumed for this area.

3.17.4 Infrastructure Development Plan

(1) Water supply

Davao City has been using only groundwater as its water source. Currently, the city has begun withdrawing surface water and the problem of water source capacity, has been resolved, including water purification facilities. According to the Davao City Water District (DCWD), the average daily water consumption for residential use is 0.68 to 0.77 m^3 per household. Assuming the maximum number of households in the relocation block of 1,600 households, a water demand of 1,088 to 1,232 m^3/day would be generated, which will be well covered by the DCWD's water supply plan.

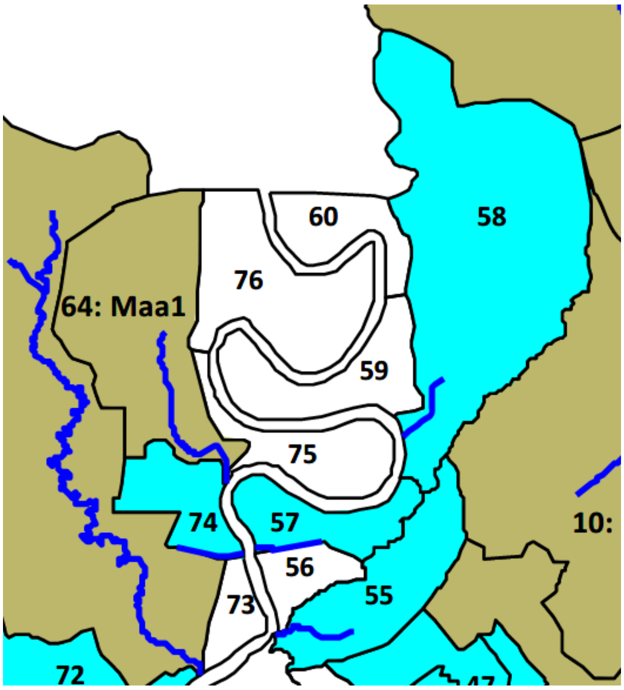
As for the water supply in the vicinity of the subject site, a network of 150 mm PVC pipes is attached to the urban trunk road running north-south from AH26 to the area of Crocodile Park, and this water distribution system will be followed for the water supply of the relocation block. It is assumed that 150 PVC will be laid on the bridge at the shortcut section and connected to the water main under AH26 via the area of Crocodile Park .

Within the target area, the existing water supply network will be maintained for the existing communities. On the other hand, for the new residential areas, water distribution pipes will be installed on the service roads. No communal reservoirs will be installed in the target area, and an elevated water tank will be installed on the rooftop of each apartment building to ensure the necessary water pressure.

According to DCWD, it is customary for the developer to bear the entire cost of constructing the water supply pipe network within the district in housing development projects.

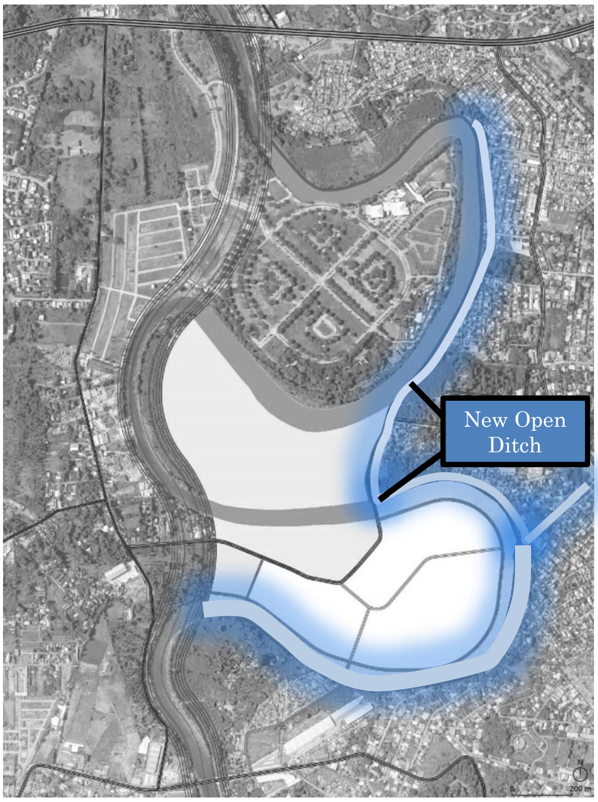
(2) Stormwater drainage

Figure 3.17.5 shows the storm drainage divide in the vicinity of the target area. The drainage zones that are expected to flow into the old channel section are 60 and 59 (both treated within the Dizon Group site), and 58 and 75 (both treated in the relocation block).



Source: Project Team

Figure 3.17.5 Drainage Zone in and around the Target Area



Source: Project Team

Figure 3.17.6 Stormwater Drainage Plan

With regard to the stormwater drainage in and around the target area, the basic policy is to ensure that the drainage of the areas north and south of Crocodile Park (60 + 59 in the figure above) is drawn into the old river channel at the relocation area. To this end, it is proposed to install an open ditch channel at the end of the land fill by the owner of Crocodile Park.

A characteristic of flooding in the Davao River is that rainwater entering in the upstream area of the basin overflows in the downstream urban areas. Thus it is rather safer to dischurge stormwater in the urban area to the Davao River at an earlir stage than to retain it within the urban area and delay the timing of discharge. In this light, no regulating reservoirs will be installed in the relocation block, and the water will be directly discharged to the main Davao River via the remaining water course in the old river channel. Stormwater drainage to the old river channel will be done through roadside ditches.

The project cost will be borne by the developer, but the facilities will be transferred to relevant authorities. DPWH will own and maintain the channel that remains in the old river channel.

(3) Wastewater treatment

Currently, there is no sewerage system in Davao City. Septic tanks are installed and operated at each detached house and at each apartment complex and commercial building. This practise will be followed in the development of the relocation block.

However, since the relocation block will not receive sewage from other areas, installation of a community plant will be worth considered. When the community plant is installed, the sewage pipes will be installed under the service roads and will join the main pipe that will be laid under the road or open space in the reclaimed area along the old river channel. The community plant will be installed in the reclaimed area downstream of the old river channel.

The community plant and the sewage drainage channel will be transferred to Davao City and operated by the Davao City Health Office (DHO). There will be a fee to be colected from each household for use of sewerage treatment system, but this will require further study as there is no precedent.

(4) Power supply

The power shortage in Davao City has been largely alleviated recently. Currently, 12.5 kva of overhead lines are located around the target area, and inside the target area is also supplied with power by overhead lines through the existing roads. Some overhead lines will be cut by the shortcut project, but will be reconnected through by bridges as functional compensation.

Due to maintenance capacity issues of Davao-Light, overhead lines will continue to be used for power distribution within the target area. The power supply within the target area will be connected to the existing 12.5 kva, and existing residences will be maintained in their current condition. For housing complexes, overhead lines will be installed on the district trunk roads and each service road and attached to each building.

(5) Solid waste management

The Carmen final disposal site, which has been expected to be saturated soon, is approved for expansion to an adjacent site and construction is expected to begin soon. This will double its capacity. There is no public facility for intermediate treatment of wastes, but a concentration of junk dealers are active in the New Carmen area, where reusable garbage is informally collected.

Garbage collection in residential areas is based on door-to-door collection. However, according to the Davao City Environmental Office (CENRO), the establishment of collection points at the end of each collector road is desirable from the perspective of improving collection efficiency. This policy will be respected in the relocation block, but collection boxes will be located at in each building, since almost all the houses in the relocation block will be apartment complexes.

3.17.5 Estimated Project Cost

(1) Estimated Project cost for Road and Infrastructure

The implementation cost of the areterial and sevice roads are roughly estimated as shown Table 3.17.2. The standard unit price for road construction indicated in PD957 was used. Infrastructure facilities are also included in the unit cost of road construction.

Table 3.17.2 Estimated Project cost for Road

Road in the Target Area	Length (m)	Unit Cost (mil.PHP/km)	Cost (mil.PHP)	Note
Arterial Road (W=20m)	2,630	30	79	150mm thick concrete pavement
Service Road (W=10m)	3,180	10	32	50mm thick concrete pavement
Sub Total			**111**	

Source: Project Team

(2) Estimated Project cost for Relocation Housing

The relocation housings are planed as 5-story apartment buildings. Based on other relocation projects in the Philippines, it is assumed that a building fotprint is 350m2, and there will be 125 buildings in the relocation block. The unit construction cost is based on Ordinance No. 0257-17, Type IV (steel, concrete, or masonry construction, with walls and ceilings required to be fireproof and noncombustible in principle).

Table 3.17.3 Estimated Project cost for Relocation House

	No. of Housing	Building Footprint (m2)	Total Building Area (m2)	Floors	Total Floor Area (m2)	Unit Cost (PHP/m2)	Cost (mil.PHP)
Relocation Houses	125	351	43,875	5	219,375	16,910	**3,710**

Source: Project Team

(3) Earth Work and Other Costs

Large-scale earthwork need to be carried out in the target area. The cost of earthwork is separately estimated in the cut-off works in the river improvement project. As it will be double-counted, it is not considered in this section. In addition, costs for land clearing, vegetation, etc., need to be estimated in addition to the earthwork.

3.18 Recommendation of Master Plan

3.18.1 Recommendation of Master Plan

Based on the overall results and outputs of the study, the recommendations related to the M/P are described below.

(1) Early implementation of high-priority plans

In this integrated flood control M/P, from the viewpoint of social demand and economic efficiency, the highly urgent plans are the plan for riverine flood in Davao River and the plan for inland flood including to maintain and expand the natural retarding function that is being lost due to rapid development in the city. Each short-term measures and related non-structural measures should be implemented early.

(2) Proper maintenance and functional enhancement of existing river structures

Even for short-term measures, it takes time for the construction to be carried out and the measure to be effective. Target 3 rivers have existing river structures and new river structures are under construction. When the measures proposed by the M/P are implemented, it is necessary to remove some existing and under construction structures, but the existing and under construction structures will be effectively used to reduce flood damage until the removal. In this regard, however, it cannot be said that the existing structures have been sufficiently inspected and repaired. Also, it cannot be said that the function can be fully exerted, for example, a backflow occurs at the time of flood from a drainage pipe connected to an existing revetment without a gate. Proper maintenance activities for river structures and functional enhancement activities such as installation of flap gates in drainage pipes are required.

(3) On-going construction works at the river mouth of the Davao River

This M/P assumes that the dike at the river mouth of the Davao River, which is currently being constructed by DPWH, will be implemented as planned. It is expected that the construction will be carried out to ensure the alignment, river channel width and dike height recommended in the M/P. If the width of the river channel or the height of the dike are not sufficient, it will be necessary to repair the structure and take additional measures, so it is necessary to confirm when the construction is carried out and completed.

(4) Appropriate coordination with projects under implementation / planning (Projects that roads / railways where bridges crossing the target rivers are planned)

In the target area, there are many transportation infrastructure development plans, and many bridges that cross the Davao, Matina, and Talomo rivers are planned. It is necessary to plan and construct appropriate structures so as to secure the necessary river flow capacity planned in this M/P so as not to increase the flood risk. Appropriate coordination including a review of road and railway alignment is to be carried out when necessary.

(5) Forwarding measures to promote implementation of master plan (development of relocation site)

It is necessary to proceed with the development of the relocation site considered as an implementation promotion measure, which will lead to the smooth implementation of the widening works as a mid/long -term measure for the Davao River.

(6) Implementation for Non-structural Measures

The M/P proposed consists of structural measures and non-structural measures. DPWH will play a central role in implementing structural measures in cooperation with Davao City, while the implementation of non-structural measures needs to be supported by various related organizations such as PAGASA and DENR. In the future implementation of the M/P, it is necessary to have a place to regularly monitor and share the implementation status of each related organization and it is expected that a communication and cooperation scheme will be established centered on DPWH and Davao City.

3.18.2 Relationship between Master Plan and Sendai Framework for Disaster Risk Reduction

The "Sendai Framework for Disaster Risk Reduction 2015-2030" adopted at the 3rd UN World Conference on Disaster Risk Reduction outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks. Table 3.18.1 and Table 3.18.2 summarize how the development of this M/P relates to and contributes to the four priority actions and the seven targets, respectively.

Table 3.18.1 Relationship between the Master Plan and the four priority actions of the Sendai Framework for Disaster Risk Reduction

Four priority actions of the Sendai Framework for Disaster Risk Reduction	Relationship with the Master Plan
(i) Understanding disaster risk	Through the formulation of M/P, disaster risk assessments for riverine flood, inland flood, and storm surge were carried out. In addition, understanding of disaster risk was promoted through preparation of hazard maps summarizing the three types of disaster.
(ii) Strengthening disaster risk governance to manage disaster risk	The capacity of C/Ps was strengthened to formulate flood control master plans through the implementation of technical training meetings. In addition, cooperation among flood control related organizations was enhanced while building consensus among stakeholders through the establishment of a steering committee, etc.
(iii) Investing in disaster reduction for resilience	Through the formulation of M/P, investment plan for structural and non-structural measures was proposed. In particular, structural measures are large-scale disaster risk mitigation measures that invest 60.4 billion Php in case of riverine flood for the Davao river.
(iv) Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction	In case the BBB is needed in the future, it is expected to proceed with reference to the M/P. As for the preparedness and response phase, the expansion of water level gauges and the review of flood warnings were proposed as part of non-structural measures.

Source: Project Team

Table 3.18.2 Relationship between the Master Plan and the seven targets of the Sendai Framework for Disaster Risk Reduction

Seven targets of the Sendai Framework for Disaster Risk Reduction	Relationship with the Master Plan
(a) Reduce global disaster mortality	Reduction of disaster damages can be expected by promoting structural measures and non-structural measures proposed by the M/P. At present, it is estimated that about 26 thousand buildings will be inundated by 0.1 m or more due to the 100-year scale riverine flood in case of the Davao River. On the other hand, the number of flooded buildings will be reduced to about 25 thousand by implementing the short-term structural measures, and to 0 by implementing the mid-long term structural measures.
(b) Reduce number of affected people	
(c) Reduce economic loss in relation to GDP	
(d) Reduce damage to critical infrastructure and services disruption	
(e) Increase number of countries with national and local DRR strategies by 2020	The M/P equivalent to the flood control strategy in the Davao, Matina and Talomo River basin was formulated.
(f) Increase international cooperation to developing countries	This project is the international cooperation by JICA.
(g) Increase availability and access to early warning systems and DRR information	The Project proposed to expand water level gauges and review flood warnings as part of non-structural measures.

Source: Project Team

Chapter 4 Feasibility Study

4.1 Priority Project and Preliminary Design of Structural Measures Targeted for Feasibility Study for Riverine Flood in Davao River

4.1.1 Priority Project of Structural Measures Targeted for Feasibility Study for Riverine Flood in Davao River

(1) Overview of Priority Project (Structural Measure) Target for Feasibility Study

As described in Chapter 3 Master Plan, the priority project constitutes riverbed dredging, retarding ponds, and cut-off channels at the meandering portion of the river.

Riverbed dredging work executes dredging of the existing river in the stretch from the river mouth to 23km upstream as much as maintaining the stability of the existing rive structures.

Retarding ponds work installs 3 retarding ponds out of 7 retarding ponds that are planned in M/P. The 3 retarding ponds, which are RP 08, RP 09, and RP 11, have been determined by constructibility, the number of relocation houses and earthwork volume for installation of a unit control volume (see Table 4.1.1).

Cut-off at the meandering portion of the river executes cut-off work from STA 6+500 to STA 12+700, which the river is meandering continuously.

Solving the riverine flood caused by approximately 10-year scale floods is the target of the project, and these countermeasures would be executed for reaching the target.

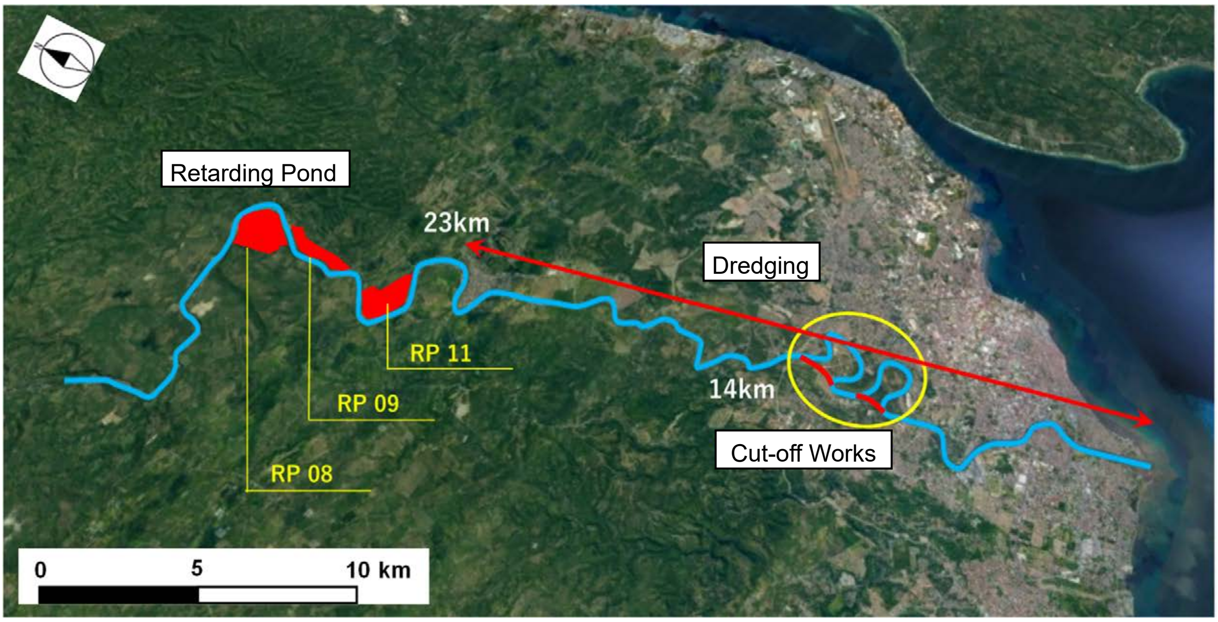
Table 4.1.1 Priority Projects Targeted for Feasibility Study

Item	Target Portion	Remarks
Riverbed Dredging	STA 0+500 – STA 23+000 (L=18.0km) (Target Area of Riverine Flood Control)	STA 0+000 would be excluded since that is located in Davao Bay. The extension of the dredging works reflects the cut-off work.
Retarding Ponds	RP 08 (Right-bank side of STA 29+000), RP 09 (Left-bank side of STA 27+200), RP 11 (Left-bank side of STA 23+800)	
Cut-off Channels	STA 6+500 – STA 12+700 (L=1.3㎞)	The extension of the Cut-off works would be the portion from STA 6+500 to STA 9+260 and STA 9+870 to STA 12+675.

Source: Project Team

(2) Target Area of Priority Project (Structural Measure) Target for Feasibility Study

The target area of the priority project for the feasibility study is shown in Figure 4.1.1.



Source: Project Team

Figure 4.1.1 Conceptual Drawing of Priority Project for F/S

4.1.2 Additional Topographic and River Surveys for Structure Measures of the Priority Project Targeted for Feasibility Study for Riverine Flood in Davao River

For the facilities (Retarding Ponds) subject to F/S as a priority project in the Davao River, the additional topograhic and river survey were condacted on the Reservoir Area. The survey works was subcontracted to a local survey firm and carried out during the period from April 2021 to August 2021 in accordance with the terms, conditions, requirements of the Sub-contract Agreement and Terms of Reference (TOR) under the supervision of the JICA Project Team.. The work items and quantity are as Table 4.1.2.

Table 4.1.2 Work Item and Work Quantity (Additional Topographic and River Survey)

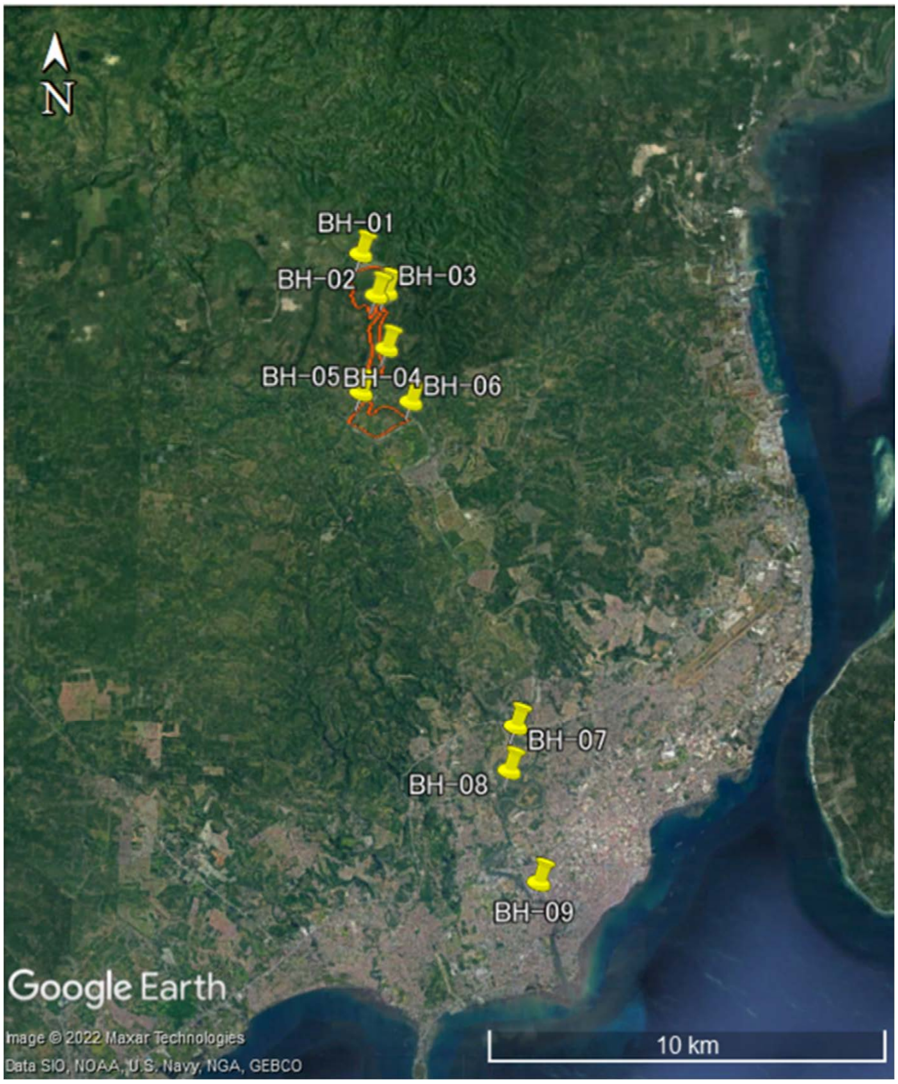
Work Item	Quantity
1. River and Topographic Survey of F/S Targeted Structure (Reservoir Area)	
1.1 River Longitudinal Survey (Station No. 23+000 – 32+000)	9 km
1.2 River Cross Sectional (C/S) Survey (Interval of C/S : 500m pitch, Width : 200m)	19 sections
1.3 River Cross Sectional Survey on Inlet and Outlet (Site:3, Width: 200m)	6 sections
1.4 Ortho-photo Mapping by UAV(including GCP survey:10points)	500 ha

Source: Project Team

4.1.3 Geotechnical Investigation for Structure Measures of the Priority Project Targeted for Feasibility Study for Riverine Flood in Davao River

(1) Outline of Geotechnical Investigation

Geotechnical investigations were carried out for the preliminary design of structures for the priority projects listed in the feasibility study. A total of six boreholes (BH01 to BH06) were drilled at inlet/outlet locations of the retarding ponds (RP08, RP09 and RP11), together with two other locations (BH07 to BH08) in the upstream and downstream sections of the cut-off channel.



Source: Project Team

Figure 4.1.2 Geotechnical survey location maps for priority projects for F/S (BH-1-BH-8)

Table 4.1.3 List of Geotechnical survey location for priority projects for F/S (BH-1-BH-8).

No.	Coordinate Location		Description with type of structure assumed
	N	E	
BH-1	7°12'33.97"N	125°33'20.34"E	Retarding Pond RP08 (Inlet location)
BH-2	7°11'59.61"N	125°33'35.77"E	Retarding Pond RP08 (Outlet location)
BH-3	7°11'57.14"N	125°33'41.92"E	Retarding Pond RP09 (Inlet location)
BH-4	7°11'10.34"N	125°33'42.34"E	Retarding Pond RP09 (Outlet location)
BH-5	7°10'45.94"N	125°33'33.18"E	Retarding Pond RP11 (Inlet location)
BH-6	7°10'30.58"N	125°34'6.42"E	Retarding Pond RP11 (Outlet location)
BH-7	7° 6'0.88"N	125°35'38.43"E	Cut-off channel upstream section (revetment / embankment)
BH-8	7° 5'25.38"N	125°35'33.88"E	Cut-off channel downstream section (revetment / embankment)
BH-9	7° 4'8.12"N	125°35'49.24"E	Channel Widening (revetment / embankment) *Pre-F/S project

Source: Project Team

(2) Geotechnical Investigation on Reservoir Area

The results of the geotechnical investigations at the retarding pond (RP08, RP09 and RP11) locations are shown below.

1) Retarding Pond: RP08

At the retarding pond: RP08, BH-01 and BH-02 were drilled near the inlet and outlet location respectively. The average N value of the sand layer is more than 40 in BH-1 and more than 20 in BH-2, indicating that those sand layers are firm.

2) Retarding Pond: RP09

At the retarding pond: RP09, BH-03 and BH-04 were drilled near the inlet and outlet location respectively. Compared to the geotechnical survey results at the retarding pond: RP08 in the upstream, the presence of gravel layers is limited, and it is instead dominated by sand layers (N-values = 20-40) and silt layers (N-values = 20 and above). The silt layers also have large N-values and are firm, with no presence of soft ground.

3) Retarding Pond: RP11

At the retarding pond: RP11, BH-05 and BH-06 were drilled near the inlet and outlet location respectively. Both locations are composed of alternating layers of gravel, sand and silt layers. The N-values of silt layers are above 10 at the surface of BH-05 and above 20 for those distributed deeper, and there is no soft ground. The N-values of the sand layers also show values above 50 in BH-05 and above 30 in BH-06.

4) Cut-off Channel Location

At cut-off channel locations, BH-07 was drilled in the upstream section and BH-08 in the downstream section. In the upstream section, BH-07, a silt layer (N value = 14-26) is observed at a depth of about 4 m below the surface, and a sand layer (average N value >50) at deeper depths. In BH-08, silt layers (N-value = 10-20) with a thickness of 6-7 m are seen at the surface and at a depth of 10 m and deeper. There is no soft ground in any of these locations.

4.1.4 Hydraulic Study and Setting of Design Conditions for Priority Project (Structural Measure) Target for Feasibility Study

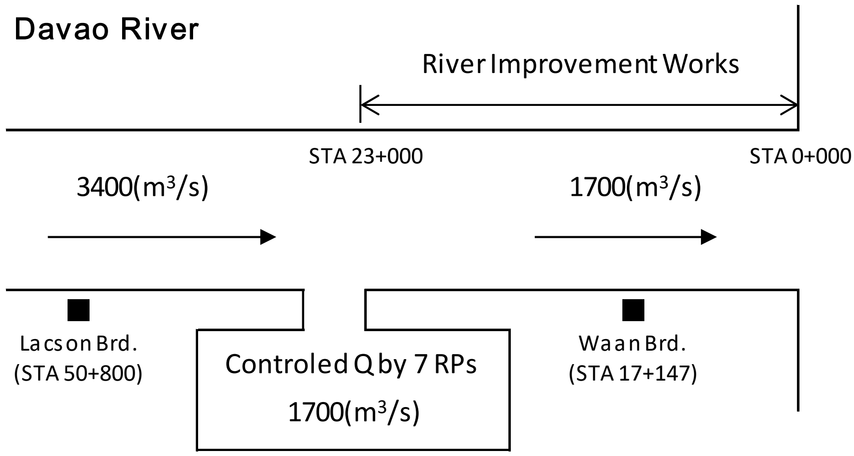
The study of the items indicated below would be carried out for setting the design conditions for the project for F/S.

- ✓ Design river shape (design alignment, design profile, and typical design cross-section)
- ✓ Extent of riverbed dredging (each surveyed cross-section)
- ✓ Water level conditions of retarding ponds (channel water level of inlet/outlet, overflow dike crest level, drainage channel bed level)
- ✓ Design river channel for cut-off reach (typical design cross-section)

(1) Design River Shape

The flood control safety level that is ensured by executing the priority project for F/S would be 5-year to 10-year scale floods. In order to avoid rework for M/P, the design river channel shall be considered with the 100-year scale flood as the target scale for M/P.

As described in Chapter 3 Master Plan, the riverine flood measure in M/P is planned that the design flood discharge of the river channel is 1,700 m^3/s out of the basic design flood discharge of 3,400 m^3/s for the target river reach, which is from STA 0+000 to STA 23+000, and the remaining 1,700 m^3/s would be controlled by retarding ponds. Since the flow capacity of the existing river is 600 m^3/s, as a result of comparison with alternatives of riverbank heightening and channel widening, river channel widening is proposed for flowing 1,700 m^3/s safely by design channel. The way of setting the design river channel is shown below.



Source: Project Team

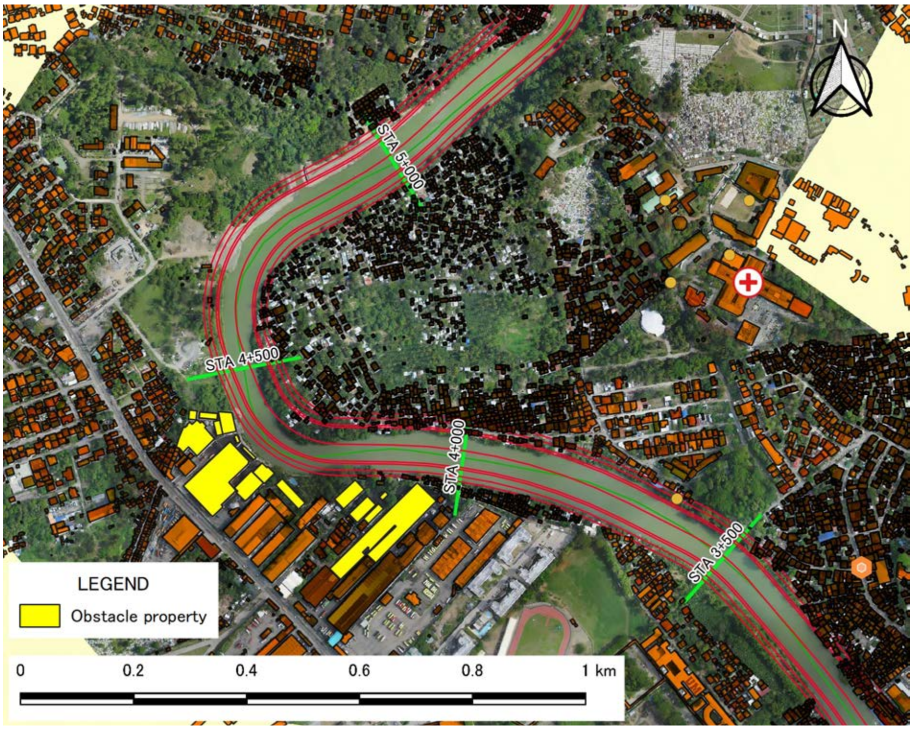
Figure 4.1.3 Design Flood Discharge Distribution of Davao River (100-year scale flood)

1) Plan View Designing

The design alignment of the river channel is set with respect to the existing channel while considering the number of relocation houses due to river improvement work, utilization of the existing revetment, construction period, and project cost, and keeping in mind the widening by one side bank construction. For the river meandering section from STA 6+500 to STA 12+700, cut-off work is applied, and the design river alignment is set to connect smoothly with the existing river channel (see Figure 4.1.4). In

Source: Project Team

Figure 4.1.4 Design River Alignment of Cut-off Portion



Source: Project Team

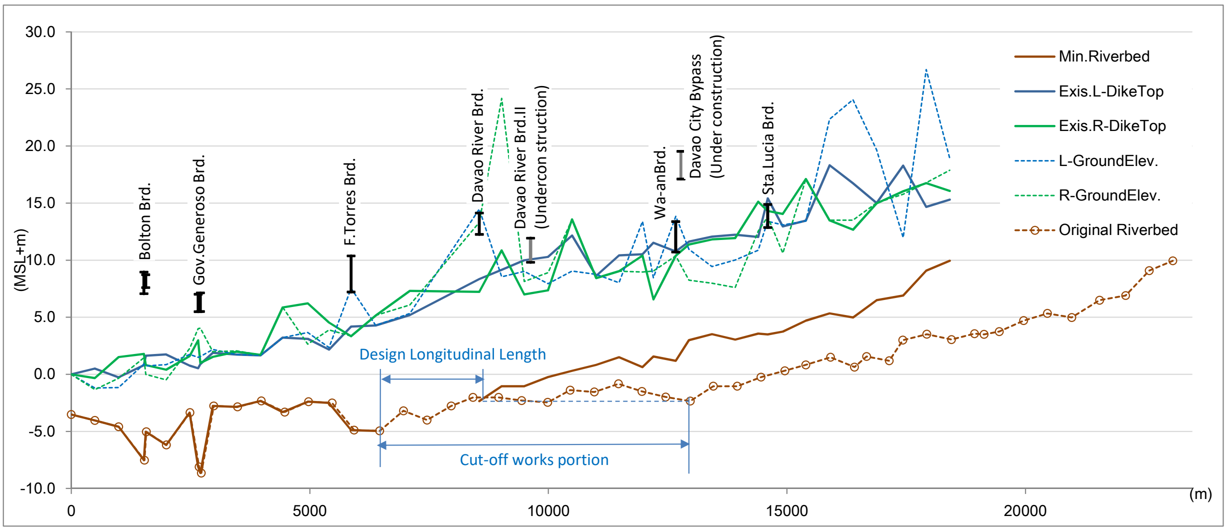
Figure 4.1.5 Location of Obstructive Property along Davao River

2) Longitudinal Profile Designing

The design riverbed elevation and gradient should be generally the same as that of the existing river channel, without major changes to the riverbed gradient or excavation of the riverbed, from the viewpoint of ensuring the stability of the riverbed elevation and biological habitat. The existing longitudinal profile of the target reach can be roughly divided into a downstream section (tidal reach), a midstream section, and an upstream section. The cut-off portion locates in the midstream section, and its length is shorter than that of the existing channel. Therefore, the design profile should be determined in consideration of the stability of the riverbed and the continuity of the biological habitat.

The design river channel is planned to be widened to increase the flow area, and the design high water level is set based on the present ground level. However, since the river mouth needs to be safe even at the high tide level, the design embankment level (revetment height) shall be set for the higher of the design high water level and the design high tide level. In addition, a total of eight bridges (six existing bridges and two bridges under construction) would be constructed in the subject reach. (Here, a bridge in the cut-off portion (near STA 8+500) would also be constructed by DEO, but this bridge is not included in the subject reach.) In order to avoid impacts on the roadside caused by the river widening work, basically, the height of the design water level plus freeboard shall be lower than the height of the bridge girders.

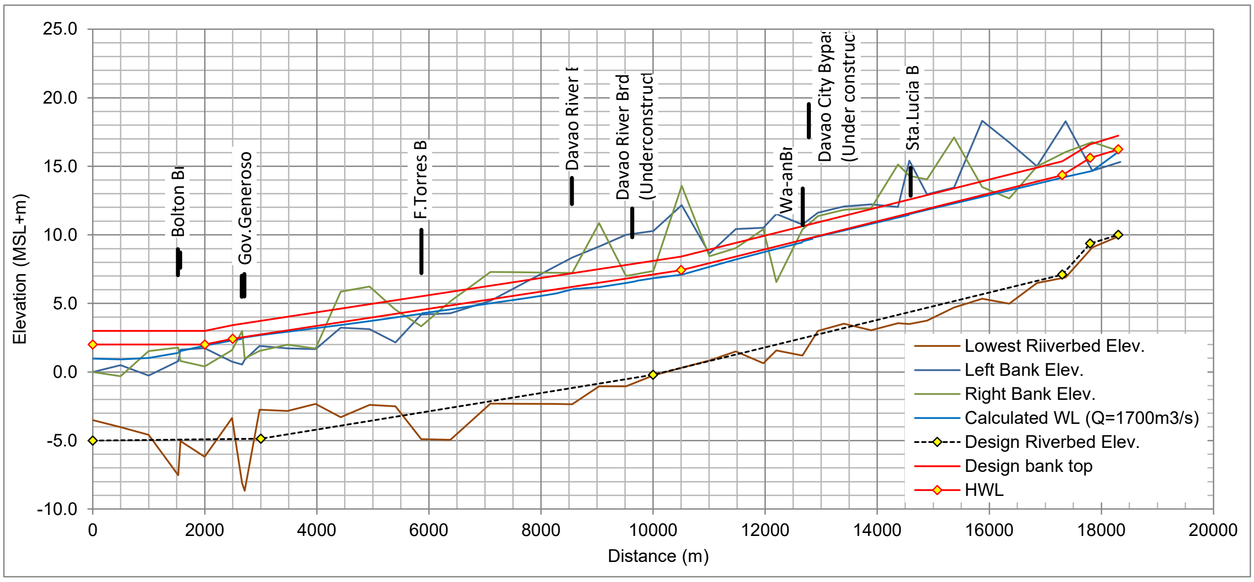
Figure 4.1.6 shows the existing longitudinal profile reflecting the cut-off reach that is set in the design alignment. Based on this, the design profile would be set according to the above-mentioned policy.



Source: Project Team

Figure 4.1.6 River Profile after Cut-off Work

Based on the present deepest riverbed profile after the shortcut, as shown in Figure 4.1.7 the target section (STA 0+000 - STA 23+000: L≒18.3 km) was divided into the downstream (tidal reach), midstream, and upstream sections, and the design longitudinal gradient was set.



Source: Project Team

Figure 4.1.7 Design River Profile of Davao River

Regarding the design riverbank level, the design water depth has been set at 7.2 m (design riverbank level is to be added 1.0 m freeboard to this), which is generally the same level as the existing riverbank shoulder. For near the river mouth, the design riverbank level shall be adopted the higher one by comparing the HWL with the storm surge embankment height (MSL+3.00m). HWL has been set by the calculated river water considering the backwater effect, with the condition of the downstream end water level as the mean high water level (MHHW) of MSL+0.981m (considering future rise due to climate change) the channel applies the typical design cross-section.

3) Typical Design Cross-section

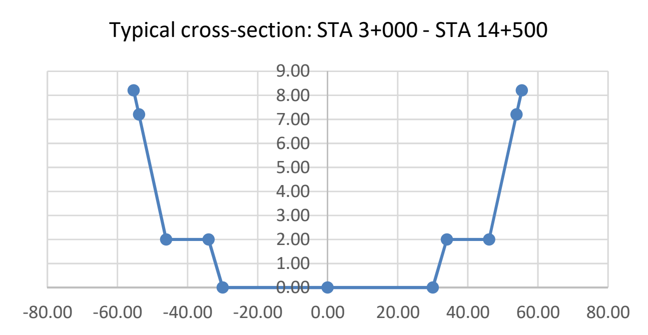
The typical design cross-section is set for each design longitudinal gradient by uniform flow calculation based on the condition that the design flood discharge is constant for the subjected section. In order to increase the river flow area by widening the channel, if the entire riverbed is flattened, the velocity of flow acting on the riverbed during outflow will be too low, which will reduce the effect of the riverbed fluctuation and cause excessive growth of vegetation and tree growth in the river channel, and then may have a negative impact on the flow capacity. Therefore, a standard cross-section with a double-sectional shape is used as a reference for the average width of the existing riverbed in each section where a standard cross-section is applied.

In addition, there are many houses along the river from the river mouth to about STA 14+000 (around 9.5 km from the river mouth), and future development is planned in the land use plan upstream to the upstream end (STA 23+000) of the subjected section. Hence, in order to minimize the social impact of the river training work as much as possible, a riverbank slope (high water revetment) of 1:1.5 was used as the standard slope for the typical cross-section. However, for the low channel, a slope of 1:2.0 is used to create a natural waterfront in the hope of maintaining a good biological habitat. After setting the typical cross-section, the gradient of riverbank slope should be made sloping and access paths to the water edge should be considered appropriately, based on the available land.

The roughness coefficient of the design channel was derived from the composite roughness coefficient calculated by setting the roughness of riverbed, high water channel, and riverbank respectively. The derived composite roughness coefficient was 0.022 to 0.025. Meanwhile, DPWH standard for roughness coefficient of the general river is to be a range of 0.030 to 0.035. Based on this, the roughness coefficient of the design river channel is set at 0.030.

Based on the condition above mentioned, the typical design cross-section for each section was determined as shown below.

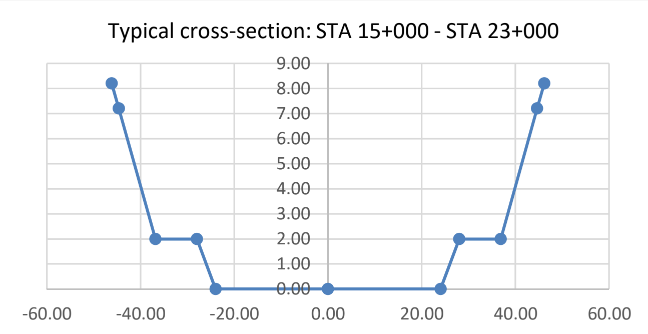
Table 4.1.4 Calculation Sheet of Typical Design Cross-section (STA 3+000 – STA 14+500)



Chanle width:	110.8
Channle water depth:	7.2
low-water channel bed width:	60.0
low-water channel bank slope:	1:2.0
high-water channel bank slope:	1:1.5
Wetted primeter:	111.89
Channel flow area:	648.0
Manning's n:	0.030
Chanle bed gradient:	1/1500
Flow velocity:	2.78
Flow capacity:	1798.55

Source: Project Team

Table 4.1.5 Calculation Sheet of Typical Design Cross-section (STA 14+500 – STA 23+000)



Chanle width:	92.3
Channle water depth:	7.2
low-water channel bed width:	48.0
low-water channel bank slope:	1:2.0
high-water channel bank slope:	1:1.5
Wetted primeter:	93.39
Channel flow area:	527.8
Manning's n:	0.030
Chanle bed gradient:	1/1000
Flow velocity:	3.34
Flow capacity:	1765.16

Source: Project Team

Applying the design river channel that reflects the above-mentioned design alignment, design longitudinal slope, and typical design cross-section, the water level in the condition of design flood discharge was calculated, and the HWL was set to envelop this. The HWL and design riverbank height are shown in Figure 4.1.7.

(2) Riverbed Dredging

1) Determination of Dredging Area

As described in Section 4.1.4(1), the design riverbed has been set generally the same as the existing riverbed gradient. Therefore, target portion of river dredging would be the portion of gentle slope riverbank of the existing river. Here, since reshape of river channel by dredging work is a tentative river improvement, if a riverbank protection were installed, it would need to be removed in the future river improvement work in line with M/P. Hence, the riverbank slope applies to 1:2.0, which is stable under the running water condition.

Here, the following related standards are established for the implementation of riverbed dredging work. The key items of the description of the river channel dredging of each standard is shown below.

"DPWH ORDER 139, Series of 2014":

- Secure a distance of 10m from the existing structure

"JOINT MEMORANDUM CIRCULAR No. 01, Series of 2019: Mar. 14, 2019"

- For existing structures, secure a 10m separation as a buffer zone. However, in case of the river width is narrow and it is difficult to secure a buffer zone, this does not apply if safety is shown by slope stability analysis.
- Do not dredge within a stretch of 1km upstream and downstream from the bridge. However, this does not apply if appropriate analysis shows that dredging does not affect the stability of the bridge and the permission of the relevant organizations is obtained.

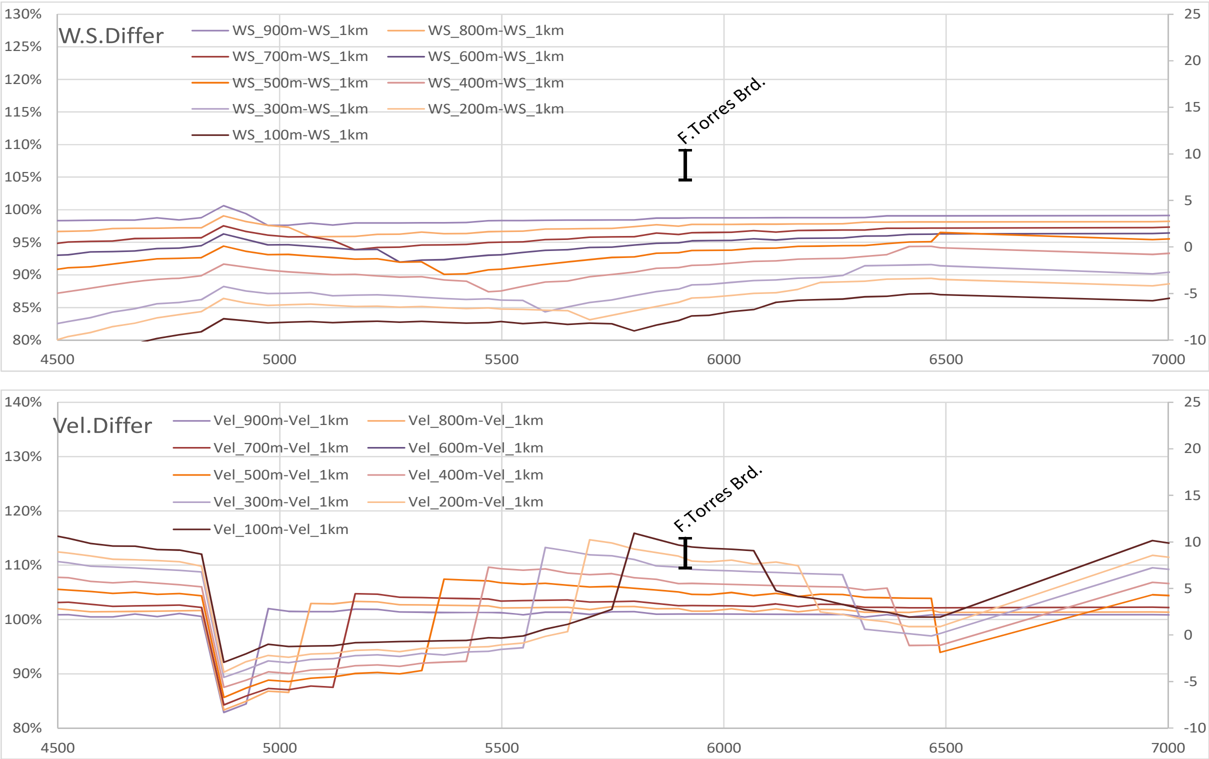
In accordance with the above orders and regulations, the distance from the existing structure at each cross-section shall be at least 10m. Regarding the conservation stretch of 1km upstream and downstream of the bridge in "JOINT MEMORANDUM CIRCULAR No. 01, Series of 2019: Mar. 14, 2019", the description that dredging shall not be performed in principle limits the section where river channel dredging can be performed. If exactly follow this, since the dredging reach would be limited, the effect of reducing the flooding damage cannot be expected. Therefore, a non-uniform flow calculation was examined when the range where dredging is not performed is shorter than 1 km, and the result of the calculations is compared hydraulic specifications (water depth and flow velocity) with the not dredging the range of 1 km upstream and downstream of the bridge.

The flow capacity of the existing river channel with dredging the whole reach including the portion of existing bridge sections is approximately 800 m^3/s, which is corresponding to the run-off discharge by 2-yr scale flood considering climate change; 830 m^3/s, therefore, calculation was done under 2-yr scale flood condition. The variation rate of water level and flow velocity, which is compared with the river channel with preserving 1km upstream and downstream of existing bridges, in cases of conservation stretches shortened by every 100m, were calculated for each 6 existing bridges (the section of about 1km upstream and downstream of each existing bridge). Figure 4.1.8 and Figure 4.1.9 shows examples of calculated results of F.Torres Bridge and Davao River Bridge, respectively.

In most cases, the water levels of the river channel with shortened conservation stretch are lower than that of the river channel with preserving 1km upstream and downstream of existing bridges because of the increase of flow area. Meanwhile, the increase in flow velocity is significant at the sections of the Gov.Generoso Bridge and F.Torres Bridge, however, these variation rates are less than 20%.

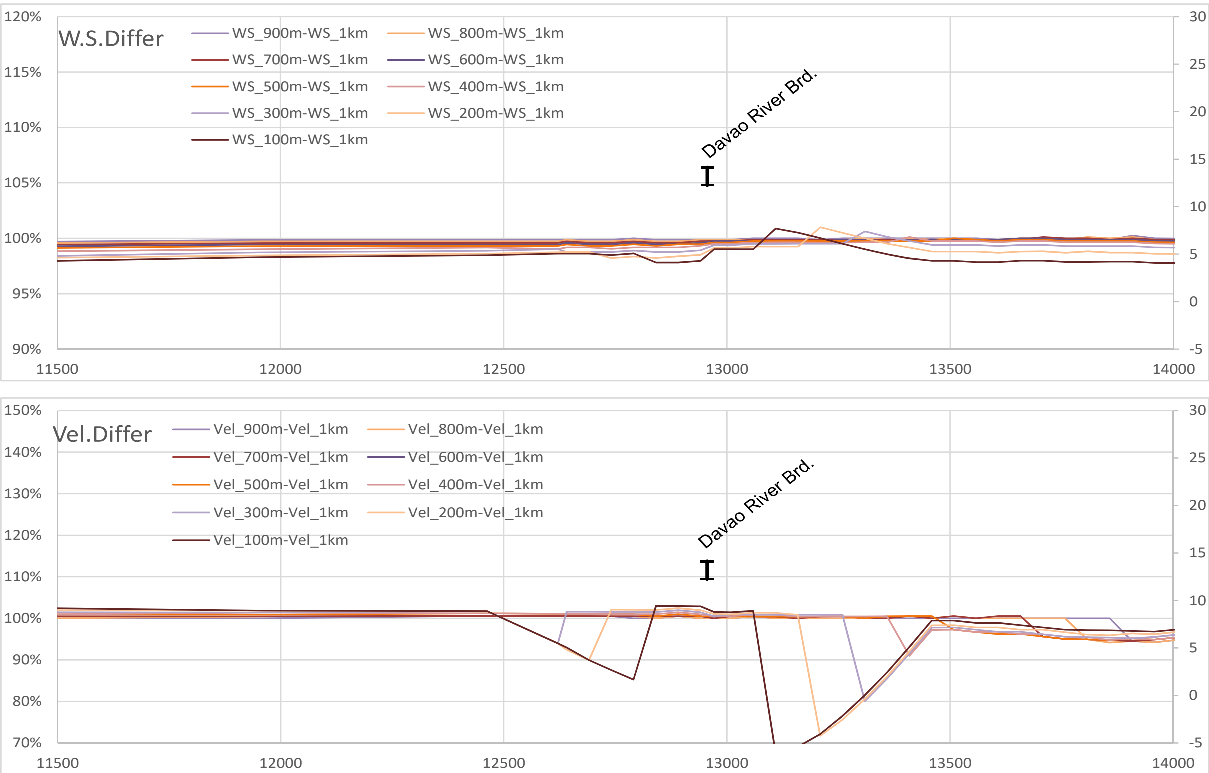
Comparing with the case of preserving 1km upstream and downstream of existing bridges, the increasing ratio is less than 20% even in the case of 100m conservation stretch, and it can be said there is no significant effect of shortened the conservation stretch.

In addition to the study above, from the aspect of the flood security level including the other target works in F/S, cut-off channel and retarding ponds, as a result of the comparison of conservation stretch (refer to Section 4.1.5), the area of conservation stretch for the existing bridges is determined 100m upstream and downstream of the bridges in this project. Here, since the Davao River Bridge obstructs the flow area very much and it is expected significant reduction of inundation area by dredging this cross-section, the cross-section of the Davao River Bridge shall not have any conservation stretch with the premise that riverbed protection would be installed to preserve the stability of bridge piers.



Source: Project Team

Figure 4.1.8 Variation of Hydraulic Value due to Dredging Reach (F.Torres Bridge) (2-yr scale flood) (above: water depth, below: flow velocity)

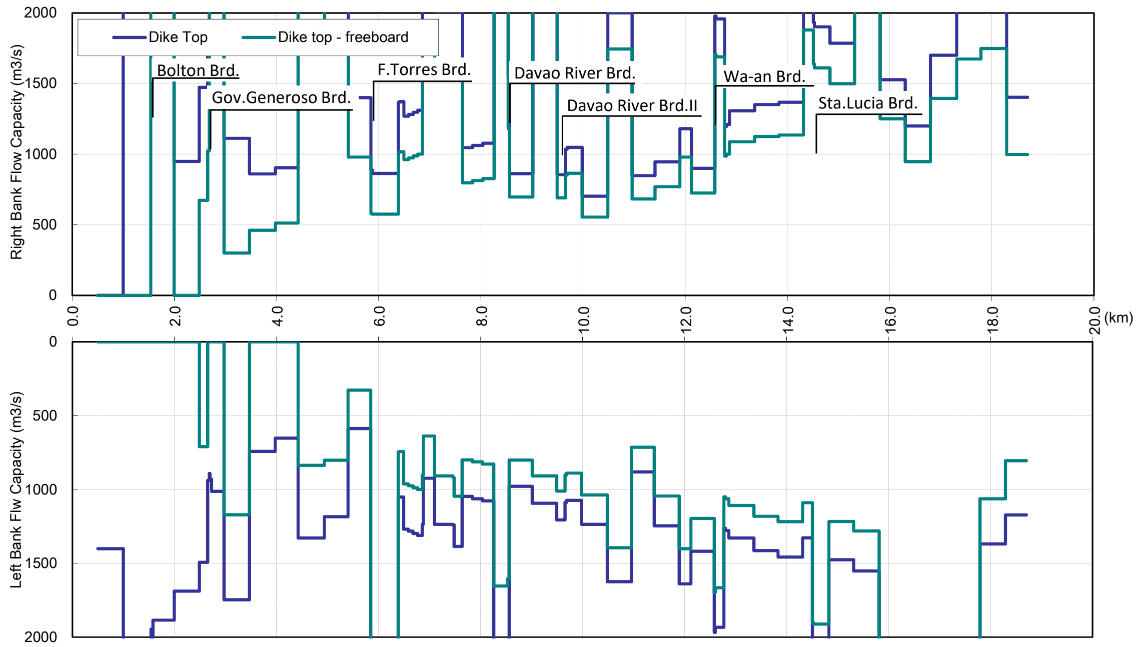


Source: Project Team

Figure 4.1.9 Variation of Hydraulic Value due to Dredging Reach (Davao River Bridge) (2-yr scale flood) (above: water depth, below: flow velocity)

2) Flow Capacity after Dredging Work

Based on the consideration up to the previous section, the dredging area of each cross-section was set, and then the flow capacity of the river after dredging work was calculated. H-Q relational formulas for each cross section were created by one-dimensional non-uniform flow calculation, and the flow capacity was calculated corresponding to the left and right riverbank height and the height of adding clearance to the riverbank height. The minimum flow capacity after dredging the river channel is 587 m^3/s on the left bank of STA5+500, and the average is approximately 700 to 800 m^3/s.



Source: Project Team

Figure 4.1.10 Flow Capacity of Dredged Channel of Davao River

(3) Retarding Ponds

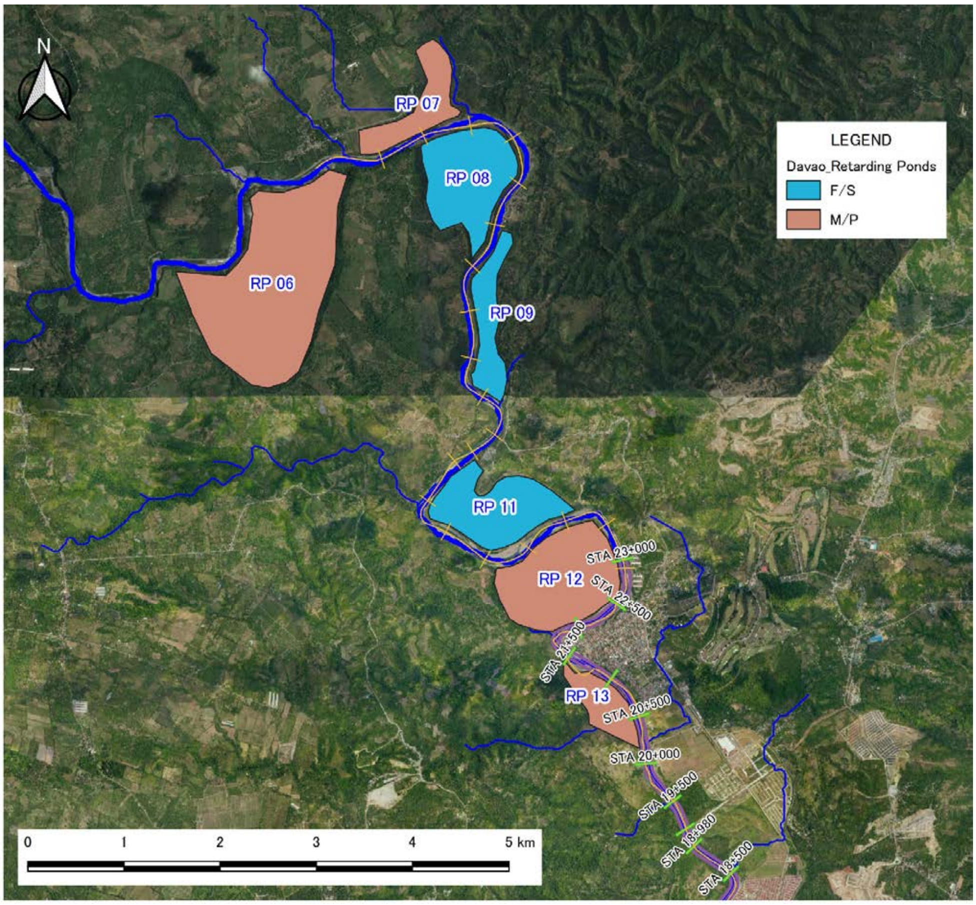
Similar to the study of the design river channel, the inlet facility of the retarding ponds will be examined for the 100-year scale flood, which is the design scale of M/P. As shown in Figure 4.1.3, the design flood discharge of the design river is 1,700m3/s out of the basic design flood discharge of 3,400 m3/s for the target section, STA 0+000 - STA 23+000, and the remaining 1,700 m3/s is to be stored by the retarding ponds. At the candidate sites of retarding ponds set in the M/P, the inlet facility will be examined so that the design flood discharge can be stored. Table 4.1.6 and Figure 4.1.11 show the retarding ponds planned in M/P.

Table 4.1.6 Retarding Ponds in M/P of Davao River

ID	Location*	Planning Area (km^2)	Planning Capacity (MCM)	Planning Water Depth (m)	Note
RP 06	STA 32+200 (Right bank)	2.19	10.95	5.00	
RP 07	STA 31+000 (Left bank)	0.44	2.20	5.00	
RP 08	STA 29+000 (Right bank)	0.85	4.25	5.00	Target of F/S
RP 09	STA 27+200 (Left bank)	0.39	1.95	5.00	Target of F/S
RP 11	STA 23+800 (Left bank)	0.76	3.80	5.00	Target of F/S
RP 12	STA 21+800 (Right bank)	1.03	5.15	5.00	
RP 13	STA 20+200 (Right bank)	0.31	1.55	5.00	
Total		5.97	29.85		

* Distance from the river mouth in current Davao River Alignment

Source: Project Team



Source: Project Team

Figure 4.1.11 Location of Design Retarding Ponds in Davao River Basin

3) Tentatively Setting of Overflow Dike Specification

In order to bring out the flood control function of the retarding ponds as planned, the height and width of the overflow dike of each retarding pond is set by hydraulic analysis. For hydraulic analysis, HEC-RAS is used to build a model that combines a one-dimensional unsteady flow model of river channels and retarding ponds. The overflow dike would be the boundary condition for the transfer of discharge between the river channel model and the retarding pond model. Here, the river channel model is the design river channel of M/P.

Since the purpose of the study of the overflow dike is to adjust the discharge that exceeds the flow capacity of the downstream river channel, the height of overflow dike is set guided by the water level that the river channel discharge at each retarding pond inlet is to be the design flood discharge of 1,700 m^3/s of the downstream channel. Here, for RP12 and RP13 whose inlet is located within the design river channel section, the overflow water level shall not exceed HWL even at the peak inflow to the retarding pond. When the overflow dike height is tentatively set in this way, the overflow width would be set so that the inflow volume against the inflow hydrograph corresponding to the design control volume is expected. Flowchart for setting of overflow dike specification is shown in Figure 4.1.12.

Meanwhile, it is difficult to completely reproduce a complicated flow in the simulation using the hydraulic analysis model. Therefore, it is strongly recommended that a hydraulic model experiment shall be conducted to finalize the specifications of the overflow dike in the detailed design stage.

STEP 0 : Setting of Model for M/P
- River Channel Condion: Proposed river channel in M/P (After Windening works)
- Applied Hydrograph: Jan. 2002 flood pattern (1/100 + CC)
- Retarding Ponds: 7 sites proposed in M/P

STEP 1 : Preparation of river model for M/P
- To inlet of most upstream retarding pond (RP No.6) from the river mouth (RM)
- From RM to STA23+000, Proposed river channel in M/P
- Upstream of STA23+000, prepared by Topo survey result and LIDAR data

STEP 2 : Setting Regulating Condition (initial temporary setting)
- RP6 & RP7: for cutting peak discharge (until 2400m3/s)
- RP8, RP9 & RP11: for cutting discharge over target discharge of 1700m3/s
- RP12 & RP13: for cutting futher discharge

STEP 3 : Setting Overflow dike height of RPs (initial setting of water level to start regulation of each RP)
- RP6 & RP7: To set from proposed capacity
- RP8, RP9 & RP11: Water level cor. to target discharge of 1700m3/s
- RP12 & RP13: HWL minus Overflow depth

STEP 4 : Trial simulation for Deciding Height and Width of Overflow Dike of RPs

STEP 0 : Setting of Model for F/S
- River Channel Condition: Present river channel with F/S projects (After Dredging and cut-off works)
- Applied hydrograph: Jan. 2002 flood pattern (≒1/10)
- Retarding Ponds: 3 sites for F/S

STEP 1 : Preparation of river model for F/S
- To inlet of most upstream retarding pond (RP No.6) from the river mouth (RM)
- From RM to STA23+000, river channel in F/S
- Upstream of STA23+000, prepared by Topo survey result and LIDAR data

STEP 2 : Setting Regulating Condition (initial temporary setting)
- RP8, RP9 & RP11: for cutting discharge over river flow capacity of 800m3/s after dredging

STEP 3 : Setting Overflow dike height of RPs (initial setting of water level to start regulation of each RP)
- RP8, RP9 & RP11: Water level cor. to river flow capacity of 800m3/s
- Widh of overflow dike is the same as width decided by the simulation of M/P

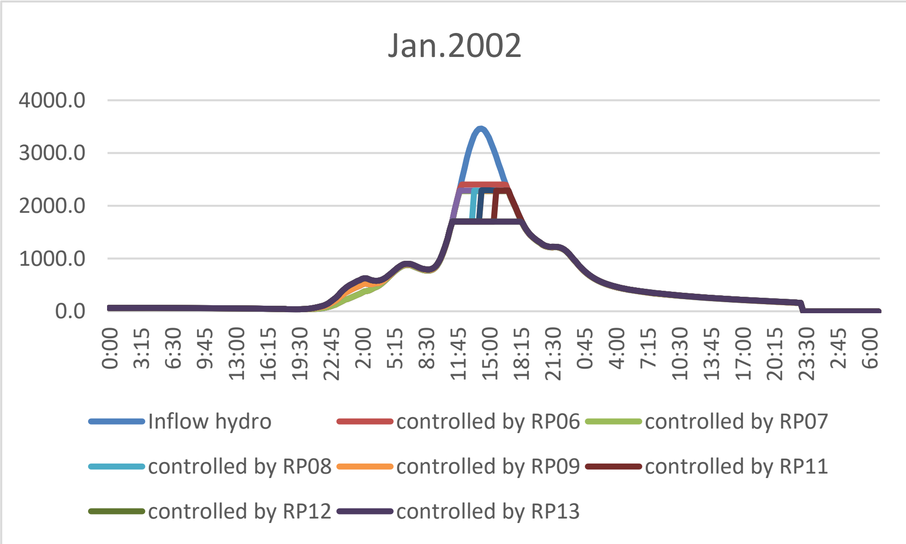
STEP 4 : Trial simulation for Deciding Height of Overflow Dikes of RPs

Source: Project Team

Figure 4.1.12 Flowchart for Overflow Dike Specification Setting

For setting the specification of retarding ponds, the target inflow hydrograph was set to January 2002 type flood since necessary control volume of flood discharge is largest of about 25.7 million m^3 among past flood types extended to 100-yr scale flood. In addition, whether the retarding ponds whose specifications were determined by January 2002 type flood have sufficient flood controlling effect also against March 2006 type flood and December 2017 type flood is to be confirmed.

As for flood controlling method of retarding pond, it is assumed that the peak flow rate was reduced to 2,400 m^3/s by adjusting with RP06, and the peak flow rate was reduced to 2,275 m^3/s by adjusting with RP07, then the discharge, which exceed the design flood discharge of the river channel of 1,700 m^3/s will be sequentially adjusted by the other retarding ponds (RP08 to RP13) as shown in Figure 4.1.13. The overflow dike height of each retarding pond was tentatively set from the H-Q relation obtained by the non-uniform flow calculation of the river channel cross-section near the assumed inlet location, and finally set by unsteady flow calculation considering with the overflow calculation.



Source: Project Team

Figure 4.1.13 Hydrograph Controlled by Tentative Overflow Dike Height

The invert level of the retarding pond is tentatively set by referring to the river water level at the normal flow discharge calculated by the river channel H-Q relationship near the outlet, in order to plan to drain stored water by the gravity after floods. In addition, since flood control will be carried out by multiple retarding ponds in this project, as a result of examining comparative study with the construction cost and the stability of structure depending on the presence or absence of spillway (see Section 4.1.5 for details), spillway will be installed to each retarding basin. The height of the spillway sets the height of 5m above from the invert level of the retarding pond as the same as design water depth of retarding ponds.

4) Unsteady Flow Analysis

The retarding ponds specifications corresponding to the river water level are adjusted by the unsteady flow calculations to obtain the desired flood controlling effect. The purpose of RP 06 and RP 07 is to reduce the peak flow discharge of the target hydrograph by flood controlling. Therefore specifications (overflow dike height and width) of these retarding ponds are adjusted to the existing topographically feasible so that the peak flow discharge after adjustment is close to the tentatively set value. Here, since inflow from other than the inlet is not assumed in the planning, the height of the spillway is set to be higher than the peak channel water level near the outlet (during the target flood).

Table 4.1.7 shows the specification of the retarding ponds corresponding to the M/P. The maximum storage levels in RP 06, RP 09, and RP 12 are planned to exceed the spillway height. This is due to the fact that it is inefficient to control the inflow to the retarding ponds only at the inlet side because of the topographical difference in elevation between the location of the inlet and the outlet. In order to prevent unforeseen breakage of the surrounding dikes and separation dikes of the retarding ponds, the spillways are designed in all retarding ponds in consideration of cases where the waveform differs from the target flood hydrograph, even in the three retarding ponds mentioned above, even if there is an excess flood or the probability of a similar scale. This will reduce the peak of the target hydrograph and make better use of the improvement effect of the downstream river channel.

Table 4.1.7 List of Retarding Ponds Specifications

Retarding Pond ID	Control-start Flow discharge (m3/s)	Design Inlet-wier top (MSL+m)	Design Inlet-wier width (m)	Design RP invert (MSL+m)	Design Spilway (MSL+m)	Maximum RP water level (MSL+m)	Maximum RP storage volume (MCM)
RP 06	1517.99	39.80	500	26.50	31.00	32.22	12.54
RP 07	1929.92	28.40	350	23.00	29.00	28.31	2.36
RP 08	1682.00	27.50	180	20.70	27.00	27.17	4.88
RP 09	1761.51	26.10	300	20.50	24.70	25.39	1.80
RP 11	1488.02	21.90	400	14.80	19.50	19.18	2.94
RP 12	1429.74	19.30	450	9.90	14.00	14.68	4.91
RP 13	1530.25	13.10	400	8.40	12.50	12.35	1.22

Source: Project Team

By applying the above specifications, as a result of the flood control calculations for the March 2006 type flood and the December 2017 type flood, which are large-scale floods other than the January 2002 flood, it is confirmed that the discharge for both flood hydrographs controlled by retarding ponds would be below 1,700 m^3/s, which is the design flood discharge of the downstream river channel.

Based on the results of the flood control calculations for the three hydrographs, the height of the separation dike should be set to satisfy the height obtained by adding 0.6 m as a clearance to the maximum water level at the inlet and outlet as shown in Table 4.1.8.

Table 4.1.8 Separation Dike Height of Retarding Ponds

		RP 06		RP 07		RP 08		RP 09		RP 11		RP 12		RP 13	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
type-2002	Dike top	41.93	32.82	29.76	29.60	29.33	27.77	27.42	25.99	23.35	20.10	20.84	15.28	14.12	13.10
	Max WS	41.33	32.22	29.16	28.75	28.73	27.17	26.82	25.39	22.75	19.36	20.24	14.68	13.52	12.38
	Weir/Spillway	39.80	31.00	28.40	29.00	27.50	27.00	26.10	24.70	21.90	19.50	19.30	14.00	13.10	12.50
type-2006	Dike top	41.63	31.60	29.46	29.60	28.95	27.60	27.19	25.30	23.22	20.10	20.75	15.56	14.10	13.36
	Max WS	41.03	30.74	28.86	28.35	28.35	26.64	26.59	24.35	22.62	19.28	20.15	14.96	13.50	12.76
	Weir/Spillway	39.80	31.00	28.40	29.00	27.50	27.00	26.10	24.70	21.90	19.50	19.30	14.00	13.10	12.50
type-2017	Dike top	41.80	31.60	29.63	29.60	29.16	27.60	27.32	25.30	23.28	20.10	20.78	15.02	14.08	13.10
	Max WS	41.20	30.93	29.03	28.57	28.56	26.77	26.72	24.47	22.68	19.30	20.18	14.42	13.48	12.31
	Weir/Spillway	39.80	31.00	28.40	29.00	27.50	27.00	26.10	24.70	21.90	19.50	19.30	14.00	13.10	12.50
	Design Dike top	42.00	32.90	29.80	29.60	29.40	27.80	27.50	26.00	23.40	20.10	20.90	15.60	14.20	13.40
	Dike top - Weir/Spillway	2.20	1.90	1.40	0.60	1.90	0.80	1.40	1.30	1.50	0.60	1.60	1.60	1.10	0.90

Source: Project Team

5) Retarding Ponds Specification for Short-term Project

As mentioned above, the short-term project plans to dredge the river channel in addition to the installation of retarding ponds (RP 08, RP 09, and RP 11). The target of the short-term project is set at a level equivalent to the 10-year probability scale, and it is desirable to control the 10-year scale flood to a level equivalent to the channel flow capacity after river channel dredging works in order to achieve the control effect of the retarding ponds to be developed in this project. The flow capacity after dredging the river channel is evaluated to be approximately 700-800m^3/s as a result of the study described in "(2)Riverbed Dredging".

Based on the above-mentioned policy, the heights of the overflow dike of the retarding ponds, which are the target of the short-term project, are set as shown in Table 4.1.9.

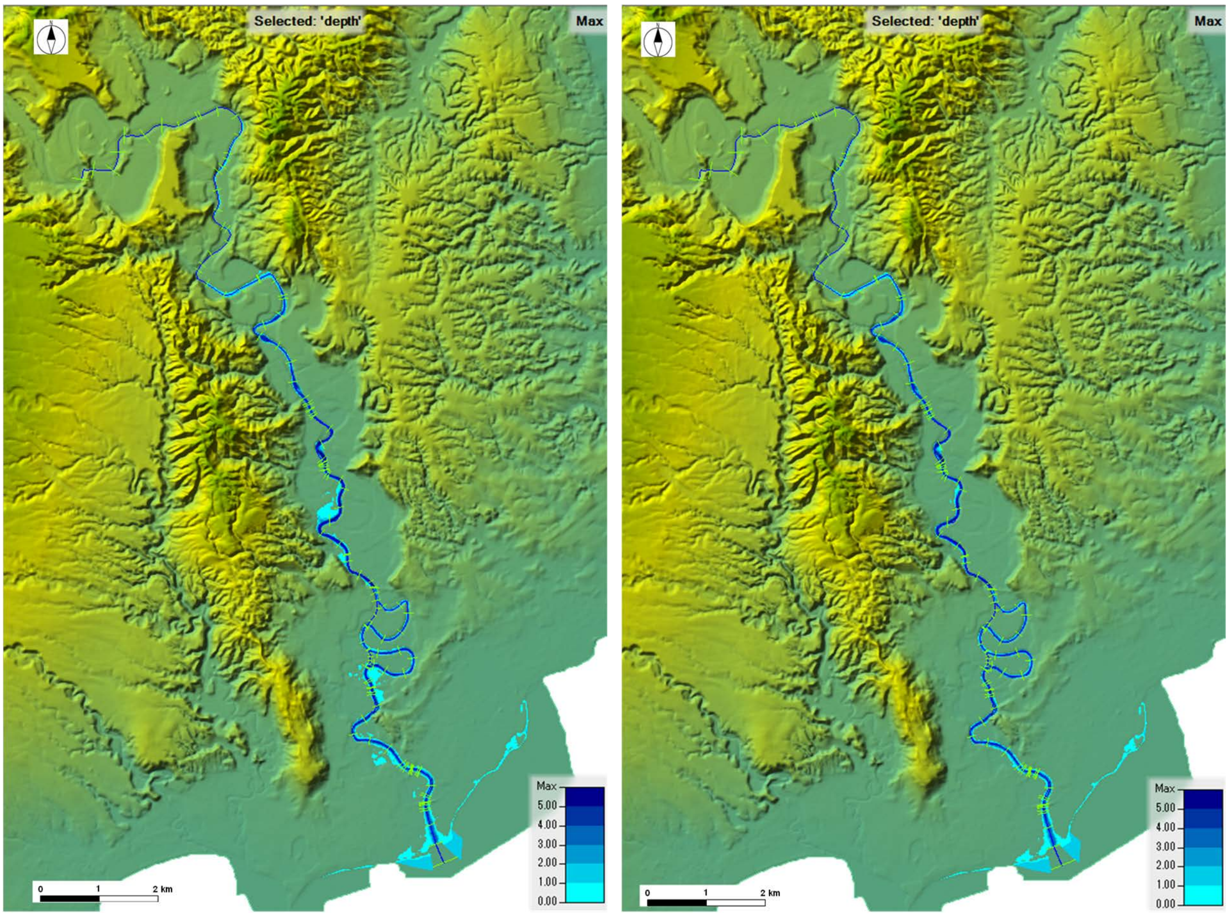
Table 4.1.9 Overflow Dike Height of Target Retarding Ponds for Short-term Project

Retarding Pond ID	Design Inlet dike top for M/P (MSL+m)	Design Inlet wier top for M/P (MSL+m)	Design Inlet wier top for S/T (MSL+m)*	Design RP invert (MSL+m)	Design Spilway top (MSL+m)
RP 08	29.40	27.50	25.40 (2.10)	20.70	27.00
RP 09	27.50	26.10	24.00 (2.10)	20.50	24.70
RP 11	23.40	21.90	20.50 (1.40)	14.80	19.50

note*: Brackets numbers are difference between the wier top of M/P and S/T

Source: Project Team

Figure 4.1.14 shows the results of the inundation analysis by probability scales under the set overflow dike heights. It was confirmed that a flood control safety level of approximately 10-year scale can be obtained after the implementation of the short-term project.



Source: Project Team

Figure 4.1.14 Results of Inundation Analysis of After Short-term Project (Left: 10-yr scale, Right: 10-yr scale): January 2002 Type Flood

(4) Cut-off Works

In the short-term project, cut-off works will be implemented for the portion of continuous river channel bends from STA 6+500 to STA 12+700. In the M/P stage, it was proposed that the existing river channel that is the subject reach for cut-off would be reclaimed for utilizing as a relocation site for settlers who would be affected by the river widening works. However, in the F/S stage, a detailed survey of the site and a comparative study including width of cut-off works and utilization of existing river was conducted (detailed in Section 4.1.5), for a result of that, it was decided that design flood discharge would be run off only by cut-off channel and the existing river could be reclaimed for utilization.

The study of the cut-off portion was conducted for the 100-year scale flood, which is the target scale of the M/P, and the design flood discharge is 1,700 m^3/s, which is the discharge after regulation by the retarding ponds.

1) Plan View Design

As described in "(1)Design River Shape", the design channel alignment of the cut-off portion is set so that it connects smoothly with the existing channel (see Figure 4.1.4).

Cut-off works would be undertaken on the north side (approximately STA 10+040 - STA 12+500) and on the south side (approximately STA 6+500 - STA 9+000). The northern cut-off is located on private land, and the river channel was set so that it would not affect the development of residential areas. In the vicinity of the southern cut-off, the river channel was set to avoid fragmentation of the area inhabited by the Kagan community, which is classified as a Muslim minority, and to minimize relocations.

2) Longitudinal Profile Designing

As described in "(1)Design River Shape", the design longitudinal profile was set in consideration of the change in the design channel length due to the cut-off. Although the elevations of the riverbeds of the cut-off and the existing channel at the connection point are almost the same, it is desirable to maintain the elevation of the riverbed at the design riverbed elevation because the slope of the riverbed becomes steeper due to the cut-off works than the existing channel.

3) Typical Design Cross-section

The design cross-sectional of the cut-off portion is set referring to the typical design cross-sectional for the reach from STA3+000 to SAT14+500 in "(1)Design River Shape" as shown in Table 4.1.4.

4.1.5 Comparison of Alternatives for Priority Project (Structural Measure) Target for Feasibility Study

In this section, alternatives for key structural issues for each of F/S targets, which are riverbed dredging, retarding ponds, and cut-off works are compared and examined.

(1) Riverbed Dredging

Regarding riverbed dredging, the extension of the conservation stretches upstream and downstream of the bridge (the stretch where river dredging will not be performed) is considered as an alternative comparison item. A comparative study of the following alternatives is conducted.

Table 4.1.10 Alternatives of Riverbed Dredging

Alternatives	Alt.1	Alt.1-2	Alt.2	Alt.3
Contents	- conserve 400m upstream and downstream	- conserve 100m upstream and downstream	- conserve 400m upstream and downstream - except Davao River Brd. (w/ riverbed protection)	- conserve 100m upstream and downstream - except Davao River Brd. (w/ riverbed protection)

Source: Project Team

In order to quantitatively evaluate the flood control effects of each alternative, an inundation analysis was conducted. Here, the inundation analysis was conducted after the completion of the priority projects for F/S (retarding ponds and cut-off works), except for the riverbed dredging. By doing so, the effect of each alternative on the degree of flood safety level after the completion of the priority projects for F/S was ascertained.

The results of the comparison of alternatives for riverbed dredging are shown in Table 4.1.11. As a result of the comparison, Alt.3: 100m conserving upstream and downstream of the bridge and no conservation stretch for the Davao Bridge (installation of riverbed protection works) is recommended as the optimal alternative because it can achieve the target of flood safety level of the short-term project, although it is less economical than the other alternatives due to the increased dredging area and installation of riverbed protection works at the Davao River Bridge.

Table 4.1.11 Comparison of Alternatives for Riverbed Dredging

Evaluation axis \ Alternatives	Alt.1: Conserve 400m upstream and downstream	Alt.1-2: Conserve 100m upstream and downstream	Alt.2: Conserve 400m upstream and downstream, except Davao River Brd. (w/ riverbed protection)	Alt.3: Conserve 100m upstream and downstream, except Davao River Brd. (w/ riverbed protection)
A. Flood protection level (expected damage reduction)	Inundation area reduction rate against 10-yr flood: 65%※ Flow velocity increase rate at/around bridges: 110%	Inundation area reduction rate against 10-yr flood: 76%※ Flow velocity increase rate at/around bridges: 116%	Inundation area reduction rate against 10-yr flood: 88%※ Flow velocity increase rate at/around bridges: 110%	Inundation area reduction rate against 10-yr flood: 97%※ Flow velocity increase rate at/around bridges: 116%
B. Economic effectiveness	Direct cost for works: 0.27Billion PhP	Direct cost for works: 0.35Billion PhP	Direct cost for works: 0.29Billion PhP	Direct cost for works: 0.36Billion PhP
C. Feasibility from in regards with social restriction	No house compensation	No house compensation	No house compensation	No house compensation
D. Feasibility from the technical viewpoint to construct countermeasures	Phased construction is available.	Phased construction is available.	Phased construction is available.	Phased construction is available.
E. Sustainability	Sustainable	Sustainable	Sustainable	Sustainable
F. Flexibility	—	—	—	—
G. Social and natural environment impact	The habitat for aquatic organisms (especially benthos) to be conserved is wider than in Alt.1-2 and Alt.3.	The habitat for aquatic organisms (especially benthos) to be conserved is narrower than in Alt.1-2 and Alt.3.	Basically the same as Alt.1	Basically the same as Alt.1-2
Other	—	—	—	—
Evaluation Result				**Although the construction cost is about 30% larger than the minimum one, the inundation area reduction rate is extremely high and the disaster mitigation effect is high.** **◎(Recommended)**

Source: Project Team

(2) Retarding Ponds

Regarding the retarding ponds, it is expected that the installation of spillways could make more efficient flood control since flood control will be performed by not a single retarding pond but by a group of retarding ponds, in addition there are large elevation gap between inlet and outlet in this Project. Therefore, the presence or absence of a spillway is considered as an alternative comparison item and a comparative study including hydraulic analysis is carried out. In the analysis, the facility specifications including spillways are set by the flood control in M/P (against 100-yr scale flood).

Table 4.1.12 Alternatives of Retarding Ponds

Alternatives	Alt.1	Alt.2
Contents	- With spillways	- Without spillways

Source: Project Team

Table 4.1.13 shows a list of the facility specifications obtained from the aforementioned analysis, depending on whether or not a spillway is installed. The results showed that the invert level of RP08 is the same as the case without spillway (Alt.2), in other hands, the invert level of RP09 and RP11 could be increased by 1.1 m and 1.0 m respectively, and the amount of soil excavation could be reduced.

Table 4.1.13 Facility Specifications with/without Spillways

		RP 06		RP 07		RP 08		RP 09		RP 11		RP 12		RP 13	
		Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Alt.1 (w/ spillway)	Max WS	41.33	30.48	29.16	28.74	28.69	26.87	26.82	24.58	22.75	19.36	20.24	13.85	13.52	12.38
	Overtop dike/Spillway	39.80	31.00	28.40	29.00	27.50	27.00	26.10	24.70	21.90	19.50	19.30	14.00	13.10	12.50
	Dike top	42.53	33.42	30.36	29.94	29.89	28.37	28.02	26.59	23.95	20.56	21.44	15.88	14.72	13.58
	RP MAX Stage	32.22		28.31		27.17		25.39		19.18		14.68		12.35	
	RP MAX Storage (MCM)	12.54		2.36		4.88		1.80		2.94		4.91		1.22	
	RP invert	26.50	(-)	23.00	(-)	20.70	(-)	20.50	(-)	14.80	(-)	9.90	(-)	8.40	(-)
	Dike top - invert	16.03	6.92	7.36	6.94	9.19	7.67	7.52	6.09	9.15	5.76	11.54	5.98	6.32	5.18
	River Flow (m^3/s)		2528.66		2119.64		2101.52		1980.30		1687.29		1688.23		1633.58
Alt.2 (w/o spillway)	Max WS	41.66	30.72	29.33	28.95	28.89	27.20	27.38	24.75	22.85	19.48	20.34	13.96	13.61	12.50
	Overtop dike/Spillway	40.15	-	28.50	-	27.50	-	26.30	-	21.75	-	19.10	-	13.10	-
	Dike top	42.86	31.92	30.53	30.16	30.09	28.40	28.58	25.95	24.05	20.68	21.54	15.48	14.81	13.70
	RP MAX Stage	30.69		28.30		26.98		24.74		19.37		14.28		12.37	
	RP MAX Storage (MCM)	10.91		2.31		4.69		1.99		3.73		5.54		1.30	
	RP invert	25.70	(0.80)	23.00	(0.00)	20.70	(0.00)	19.40	(1.10)	13.80	(1.00)	8.90	(1.00)	8.20	(0.20)
	Dike top - invert	17.16	6.22	7.53	7.16	9.39	7.70	9.18	6.55	10.25	6.88	12.64	6.58	6.61	5.50
	River Flow (m^3/s)		2690.91		2229.70		2104.73		2096.97		1767.93		1774.88		1687.07

Source: Project Team

The result of the comparison of alternatives for the retarding ponds is shown in Table 4.1.14. Even considering the construction costs associated with the installation of spillways, it is recommended that Alt.1: with spillways as the optimal alternative because the reduction in construction costs due to the reduced excavation volume is significant, and the overall economic efficiency is superior to the other alternatives.

Table 4.1.14 Comparison of Alternatives for Retarding Ponds

Evaluation axis / Alternatives	Alt.1 With spillways	Alt.2 Without spillways
A. Flood protection level (expected damage reduction)	2032 (F/S) : W=1/5~10 ; 2045 (M/P) : W=1/100	
B. Economic effectiveness	Direct cost for works: 7.09 Billion PhP	Direct cost for works: 7.54 Billion PhP
C. Feasibility from in regards with social restriction	Affected houses: 1	Affected houses: 1
D. Feasibility from the technical viewpoint to construct countermeasures	Phased construction is available.	Phased construction is available.
E. Sustainability	Sustainable	Sustainable
F. Flexibility	After the construction of F/S scale structures, overflow on the separation dike can be avoided due to the effect of the spillways for a certain degree of excess flooding over the corresponding scale.	After the construction of F/S scale structures, overflow on the separation dike can be happened for a certain degree of excess flooding over the corresponding scale.
G. Social and natural environment impact	Amount of soil excavation can be reduced.	Amount of soil excavation can be increase comparing with Alt.1.
Other	—	—
Evaluation Result	**It is highly economical and is expected to reduce the risk of dike breach in the event of excess floods.** ◎ **(Recommended)**	

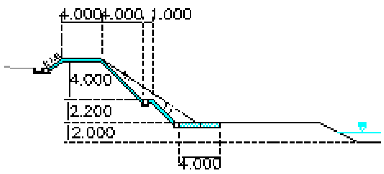
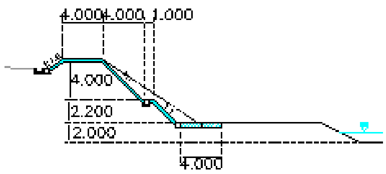
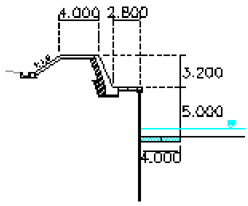
Source: Project Team

(3) Cut-off Works

Regarding the cut-off works, several issues were identified through F/S, including the typical cross-section of the new channel reach (including the revetment structure) and dealing with the existing channel subject to the cut-off works.

Therefore, three alternatives for dealing with the existing channel subject to the cut-off works and the revetment structure of the new river channel were designed and compared as shown in Table 4.1.15.

Table 4.1.15 Alternatives of Cut-off Works

Alterna-tives	Alt.1	Alt.2	Alt.3
Contents	- Inverted trapezoidal double cross-section - Channel width: 111 m + ROW - No expectation of flow capacity of existing river channel (dealing with existing channel after cut-off works as appropriate)	- Inverted trapezoidal double cross-section - Channel width: 80 m + ROW - Expectation of flow capacity of existing river channel (requiring to maintain existing channel after cut-off works)	- Rectangular cross-section with straight wall - Channel width: 80 m + ROW - No expectation of flow capacity of existing river channel (dealing with existing channel after cut-off works as appropriate)
Revetment structure			

Source: Project Team

Figure 4.1.15 shows the design alignments of each alternative.

Source: Project Team

Figure 4.1.15 Design Alignments of Cut-off Portion

The result of the comparison of alternatives for cut-off works is shown in Table 4.1.16. For the north side, Alt.1: Inverted trapezoidal double-section (111m wide + ROW) without expecting the current channel's flow capacity, which is superior to the other alternatives overall in terms of economical effectiveness, sustainability, flexibility, and environmental impact, is recommended as the optimal alternative.

For the south side, although the number of affected houses is larger than the other proposals, based on an overall assessment of economic effectiveness, sustainability, flexibility, and environmental impact, Alt.1: Inverted trapezoidal double-section (111m wide + ROW) without expecting the current channel's flow capacity is recommended as the optimal proposal.

Table 4.1.16 Comparison of Alternatives for Cut-off Works (North side)

Alternatives / Evaluation axis	**Alt.1 : Inverted trapezoidal double cross-section, width: 111 m + ROW No expectation of flow capacity of existing river**	**Alt.2 : Inverted trapezoidal double cross-section, width: 80 m + ROW Expectation of flow capacity of existing river**	**Alt.3 : Rectangular cross-section with straight wall, width: 80 m + ROW No expectation of flow capacity of existing river**
A. Flood protection level (expected damage reduction)	Flow capacity 1700m^3/s (Design flood discharge in M/P (100-yr scale floods)		
B. Economic effectiveness	Direct cost for works: 0.49 Billion PhP (incl. 111m bridge construction cost) Land acquisition/compensation cost: 0.45 Billion PhP Total: 0.94 Billion PhP	Direct cost for works: 0.39 Billion PhP (incl. 81m bridge construction cost) Land acquisition/compensation cost: 0.38 Billion PhP Total: 0.77 Billion PhP	Direct cost for works: 0.66 Billion PhP (incl. 81m bridge construction cost) Land acquisition/compensation cost: 0.38 Billion PhP Total: 1.04 Billion PhP
C. Feasibility from in regards with social restriction	Affected houses: seldom	Affected houses: seldom	Affected houses: seldom
D. Feasibility from the technical viewpoint to construct countermeasures	Phased construction is available.	Phased construction is available.	Phased construction is available.
E. Sustainability	- Maintenance dredging volume is minimum	- Maintenance dredging volume increase 25% comparing with Alt.1	- Maintenance dredging volume increase 25% comparing with Alt.1 - Difficulty and cost for rehabilitation/repairing would be higher than the others since structure of straight wall portion will be sheet pile
F. Flexibility	- Dealing with the existing river channel (reclaiming or maintaining) will be determined on an as-needed basis. If the existing river channel is to be reclaimed, facilities (drainage channels, etc.) to treat rainwater drainage (normal and flood) from the watershed (up to approximately 1.4 km^2) around the meandering portion will be required. - It is relatively easy to deal with the need to revise the cross-section (increase the flow area) in the future.	- Maintenance work to the existing river channel is essential. - It is relatively easy to deal with the need to revise the cross-section (increase the flow area) in the future.	- Dealing with the existing river channel (reclaiming or maintaining) will be determined on an as-needed basis. If the existing river channel is to be reclaimed, facilities (drainage channels, etc.) to treat rainwater drainage (normal and flood) from the watershed (up to approximately 1.4 km2) around the meandering portion will be required. - The straight wall portion will be a sheet pile structure, and it is difficult to respond to the need to revise the cross-section (increase the flow area) in the future.
G. Social and natural environment impact	- Compared to the others, the land acquisition area would be larger, but maintenance of the existing river channel is not required.	- Compared to the others, the land acquisition area would be smaller, but maintenance to control environmental degradation (water quality deterioration, mosquito infestation, etc.) in the existing river channel.	- The land acquisition area would be small as the same as Alt.2, but maintenance of the existing river channel is not required.

Alternatives / Evaluation axis	Alt.1 : Inverted trapezoidal double cross-section, width: 111 m + ROW No expectation of flow capacity of existing river	Alt.2 : Inverted trapezoidal double cross-section, width: 80 m + ROW Expectation of flow capacity of existing river	Alt.3 : Rectangular cross-section with straight wall, width: 80 m + ROW No expectation of flow capacity of existing river
	- Compared to Alt.3, access to the river is easier and more hydrophilic	- Compared to Alt.3, access to the river is easier and more hydrophilic	- Compromising access to the river and the landscape due to the high straight wall.
Other	—		
Evaluation Result	**Although the direct construction cost is about 20% higher than the cheapest one, the M/P design flood discharge can be flow without expecting the flow capacity of the existing channel. The amount of maintenance dredging can be minimized, and rehabilitation, repair, and future cross-sectional revisions are relatively easy. In addition, it has relatively high hydrophilicity.** ◎ **(Recommended)**		

Note: Alt. 3 assumes U-shaped steel sheet piles. If hat-shaped steel sheet piles are used, it is roughly estimated that the construction cost will increase by about 10%, on the other hand, it is expected as advantages that since they are wider than U-shaped steel sheet piles, the number of the sheet piles can be reduced (the construction period can be shortened), and there is no need to consider reduction in cross-sectional performance due to joints (the risk of strength reduction of the steel sheet pile wall due to poor joint construction is low).

Source: Project Team

Table 4.1.17 Comparison of Alternatives for Cut-off Works (South side)

Alternatives / Evaluation axis	Alt.1 : Inverted trapezoidal double cross-section, width: 111 m + ROW No expectation of flow capacity of existing river	Alt.2 : Inverted trapezoidal double cross-section, width: 80 m + ROW Expectation of flow capacity of existing river	Alt.3 : Rectangular cross-section with straight wall, width: 80 m + ROW No expectation of flow capacity of existing river
A. Flood protection level (expected damage reduction)	Flow capacity 1700m^3/s (Design flood discharge in M/P (100-yr scale floods)		
B. Economic effectiveness	Direct cost for works: 0.34 Billion PhP (incl. 111m bridge construction cost) Land acquisition/compensation cost: 0.11 Billion PhP Total: 0.45 Billion PhP	Direct cost for works: 0.25 Billion PhP (incl. 81m bridge construction cost) Land acquisition/compensation cost: 0.10 Billion PhP Total: 0.35 Billion PhP	Direct cost for works: 0.41 Billion PhP (incl. 81m bridge construction cost) Land acquisition/compensation cost: 0.10 Billion PhP Total: 0.51 Billion PhP
C. Feasibility from in regards with social restriction	Affected houses: approx.90	Affected houses: approx.50	Affected houses: approx.50
D. Feasibility from the technical viewpoint to construct countermeasures	Phased construction is available.	Phased construction is available.	Phased construction is available.
E. Sustainability	- Maintenance dredging volume is minimum	- Maintenance dredging volume increase 25% comparing with Alt.1	- Maintenance dredging volume increase 25% comparing with Alt.1

Evaluation axis \ Alternatives	**Alt.1 : Inverted trapezoidal double cross-section, width: 111 m + ROW No expectation of flow capacity of existing river**	**Alt.2 : Inverted trapezoidal double cross-section, width: 80 m + ROW Expectation of flow capacity of existing river**	**Alt.3 : Rectangular cross-section with straight wall, width: 80 m + ROW No expectation of flow capacity of existing river**
			- Difficulty and cost for rehabilitation/repairing would be higher than the others since structure of straight wall portion will be sheet pile
F. Flexibility	- Dealing with the existing river channel (reclaiming or maintaining) will be determined on an as-needed basis. If the existing river channel is to be reclaimed, facilities (drainage channels, etc.) to treat rainwater drainage (normal and flood) from the watershed east area of the meandering portion (2.6 km^2) will be required. - It is relatively easy to deal with the need to revise the cross-section (increase the flow area) in the future.	- Maintenance work to the existing river channel is essential. - It is relatively easy to deal with the need to revise the cross-section (increase the flow area) in the future.	- Dealing with the existing river channel (reclaiming or maintaining) will be determined on an as-needed basis. If the existing river channel is to be reclaimed, facilities (drainage channels, etc.) to treat rainwater drainage (normal and flood) from the watershed east area of the meandering portion (2.6 km^2) will be required. - The straight wall portion will be a sheet pile structure, and it is difficult to respond to the need to revise the cross-section (increase the flow area) in the future.
G. Social and natural environment impact	- Compared to the others, the land acquisition area would be larger, but maintenance of the existing river channel is not required. - Compared to Alt.3, access to the river is easier and more hydrophilic	- Compared to the others, the land acquisition area would be smaller, but maintenance to control environmental degradation in the existing river channel. - Compared to Alt.3, access to the river is easier and more hydrophilic	- The land acquisition area would be small as the same as Alt.2, but maintenance of the existing river channel is not required. - Compromising access to the river and the landscape due to the high straight wall.
Other	If the existing river channel is to be reclaimed, the bridge under construction by DPWH RO XI will be rendered useless.	Maintaining the existing river channel is essential, and the bridge under construction by DPWH RO XI will be rendered useful.	If the existing river channel is to be reclaimed, the bridge under construction by DPWH RO XI will be rendered useless.
Evaluation Result	**Although the direct construction cost is about 30% higher than the cheapest one and the number of affected houses a large, compensation cost would be similar to the others. M/P design flood discharge can be flow without expecting the flow capacity of the existing channel. The amount of maintenance dredging can be minimized, and rehabilitation, repair, and future cross-sectional revisions are relatively easy. In addition,**		

Alternatives / Evaluation axis	Alt.1 : Inverted trapezoidal double cross-section, width: 111 m + ROW No expectation of flow capacity of existing river	Alt.2 : Inverted trapezoidal double cross-section, width: 80 m + ROW Expectation of flow capacity of existing river	Alt.3 : Rectangular cross-section with straight wall, width: 80 m + ROW No expectation of flow capacity of existing river
	it has relatively high hydrophilicity. ◎ (Recommended)		

Note: Alt. 3 on the south side also assumes U-shaped steel sheet piles, like the north side. The conditions (increase in construction costs and advantages) when using the hat-shaped steel sheet piles are the same as for the north side.

Source: Project Team

4.1.6 Preliminary Design of Structure Measures of the Priority Project Targeted for Feasibility Study for Riverine Flood in Davao River

(1) Preliminary Design of Structural Measures (Dredging)

River channel dredging work will be implemented according to the dredging extent and work sequences provided in the previous section, and no structures will be installed in the standard section of dredging. However, the dredging of the bridge section will require the reinforcement of the existing pier foundations by means of additional piles or continuous wall.

(2) Preliminary Design of Structural Measures (Retarding Pond)

1) Structural type of overflow dikes and spillways

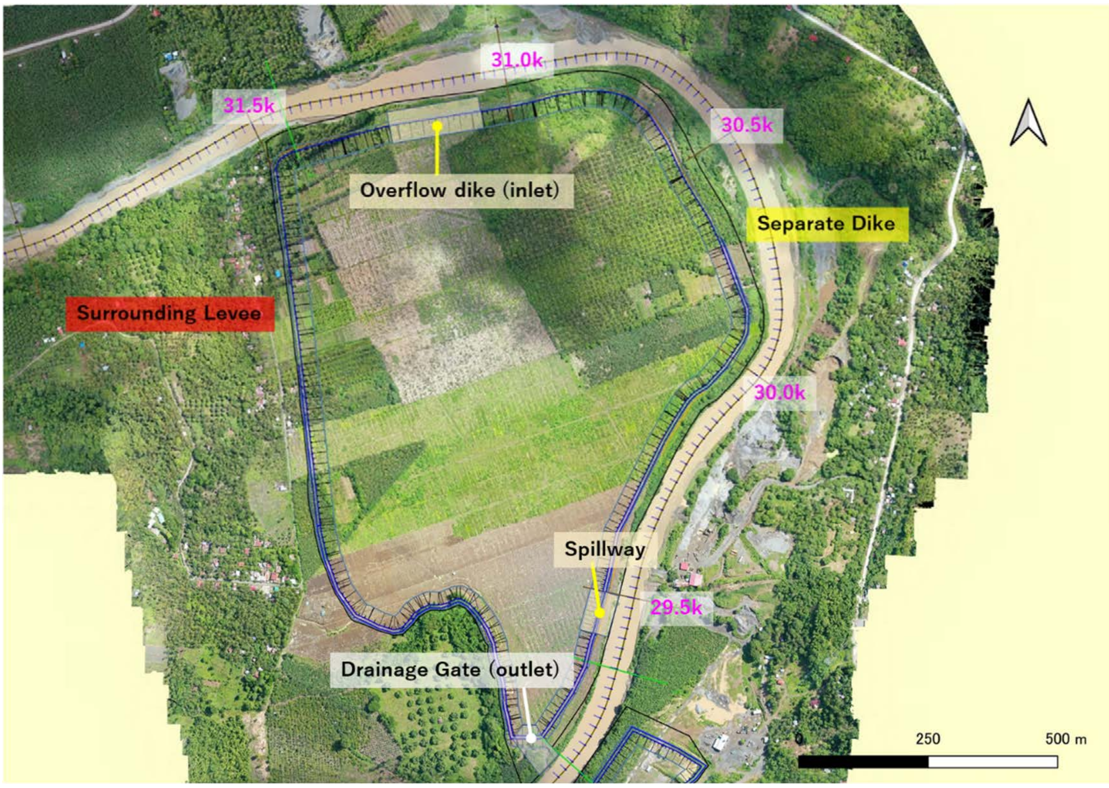
For the structure of overflow dike, concrete-facing type structure is adopted for the F/S study, taking into account the results of geological survey result conducted for the study as well as site constructability, durability and ease of maintenance of the structure based on local conditions, and the construction track record of the project in the Philippines.

Other common structural types of overbank dikes include asphalt-facing, concrete block and gabion types. Selection should be made at the time of detailed design, including consideration of material availability and price. A reference comparison of the concrete fencing type and the gabion type is given below.

2) Outline of structure layout

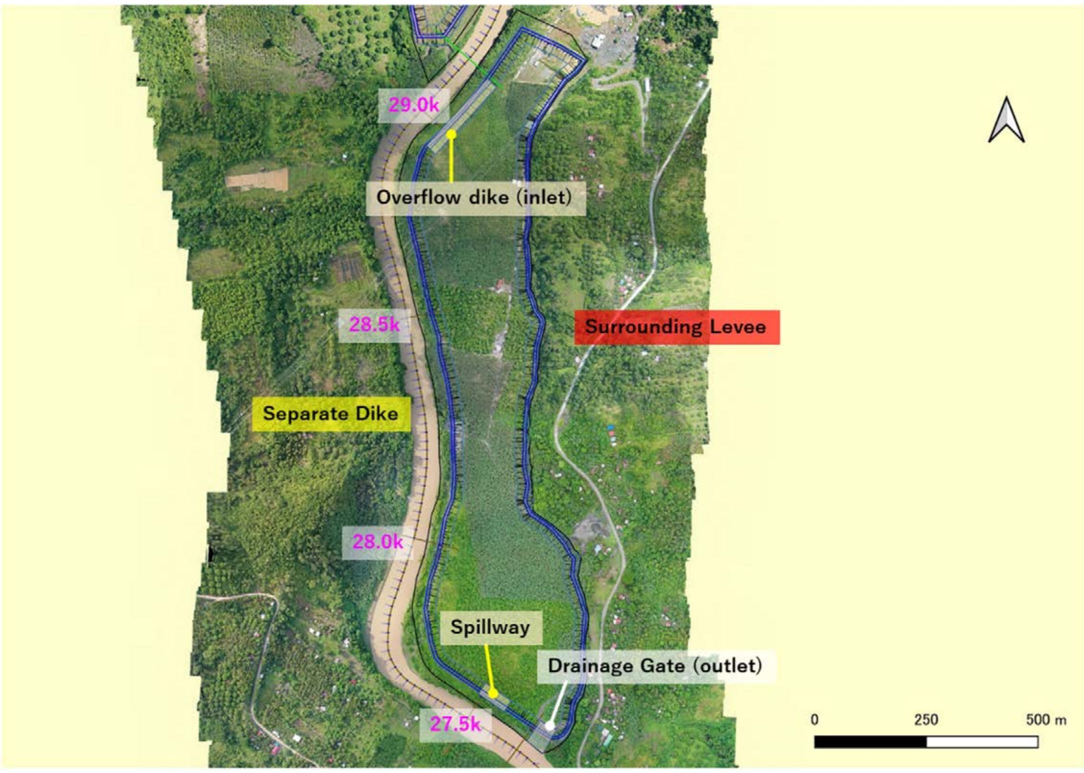
An overview of the structure layout of retarding ponds RP08, RP09 and RP11 is shown below. Each retarding pond consist of overflow dike, separate dike, surrounding levee, spillway and drainage gate. The wide area of the retarding ponds are mainly constructed by excavation due to the elevation of exiting grounds. The results of the structural studies for each facility for respective retarding pond are presented, but the structures shown here need to be examined closely in the detailed design, taking into account the results of additional geological and topographical survey as well as the availability and price of materials at that time.

In addition, environmental aspects and usability for residents were also considered in the layout of the structures. The environment and habitat of aquatic organisms were maintained by installing the embankment of the surrounding levee as close to the retarding pond as possible and maintaining the waterfront area in front of the retarding pond. Also, the usability as a place for residents' recreation was considered by setting the slope of the embankment of the surrounding levee at 1:3.



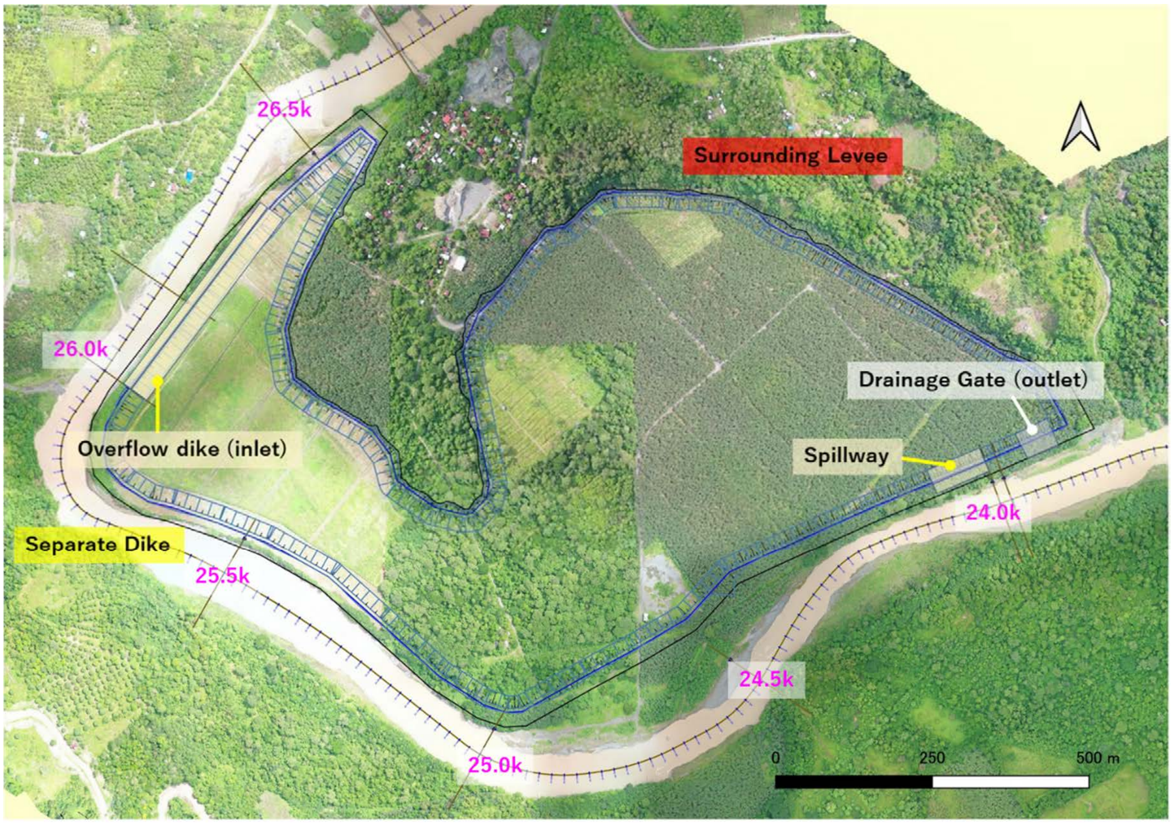
Source: Project Team

Figure 4.1.16 Retarding Pond RP08: Structure Layout



Source: Project Team

Figure 4.1.17 Retarding Pond RP09: Structure Layout



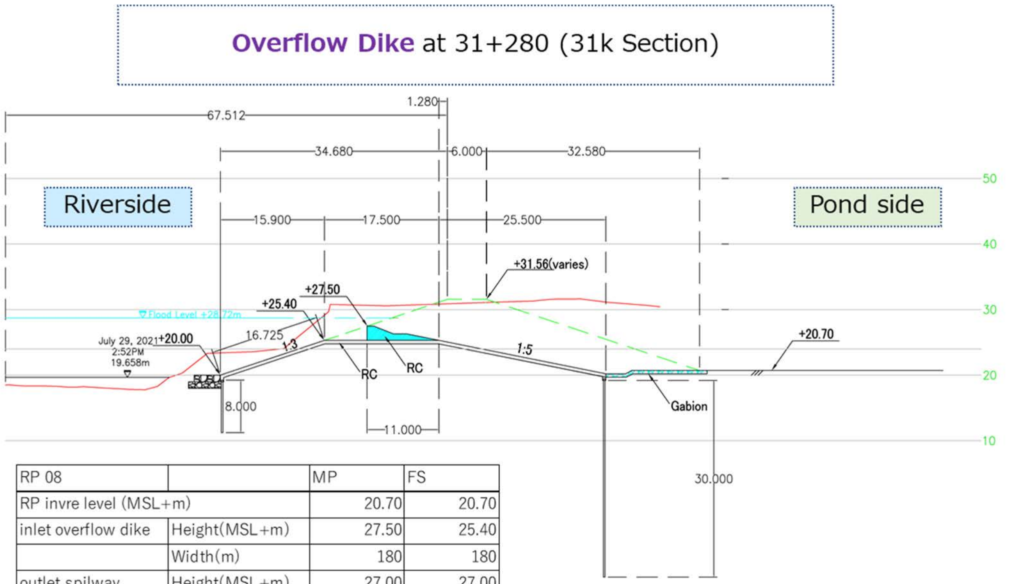
Source: Project Team

Figure 4.1.18 Retarding Pond RP11: Structure Layout

3) Preliminary design of retarding pond: RP08

Near the inlet (overflow dike) location of the retarding pond: RP08, boulders with a diameter of more than 20 cm are observed in the riverbed as well as at along the bank. The results of the geotechnical survey conducted along the riverbank at an elevation of +30.0m indicate the presence of a clayey layer of about 2m at the surface, but below this depth, the layer is mostly dominated by gravels to a depth equivalent to the planned retarding pond bed level (+20.7m), which is consistent with field observations.

A cross-sectional structure of the overflow dike is shown below, considering ground conditions / site situations. The overflow dike will be covered with RC-facing protection with foot protection on riverside using locally procured boulders having the largest diameter. The planned crest level of the overflow dike is +25.40 m in the F/S phase and +27.50 m in the MP phase, and the raising in the MP phase will be carried out by installing a 2.2 m high drop work (RC retaining wall) at crest of F/S-phase overflow dike. Impermeable sheet piles should be installed at toe of the slope on the pond side of the overflow dike / separate dike, embedded into the impermeable soil layer. In addition, if the impervious sheet piles are installed on the river side, these sheet piles will also serve as erosion protection sheet piles, and the size of the sheet pile type is likely to increase. In the detailed design, the location of the impervious sheet piles should be further examined taking into account the location of the normal of bank alignment (in particular, the location of the toe of river side slope and the river bank line) and the elevation of foot protection work.

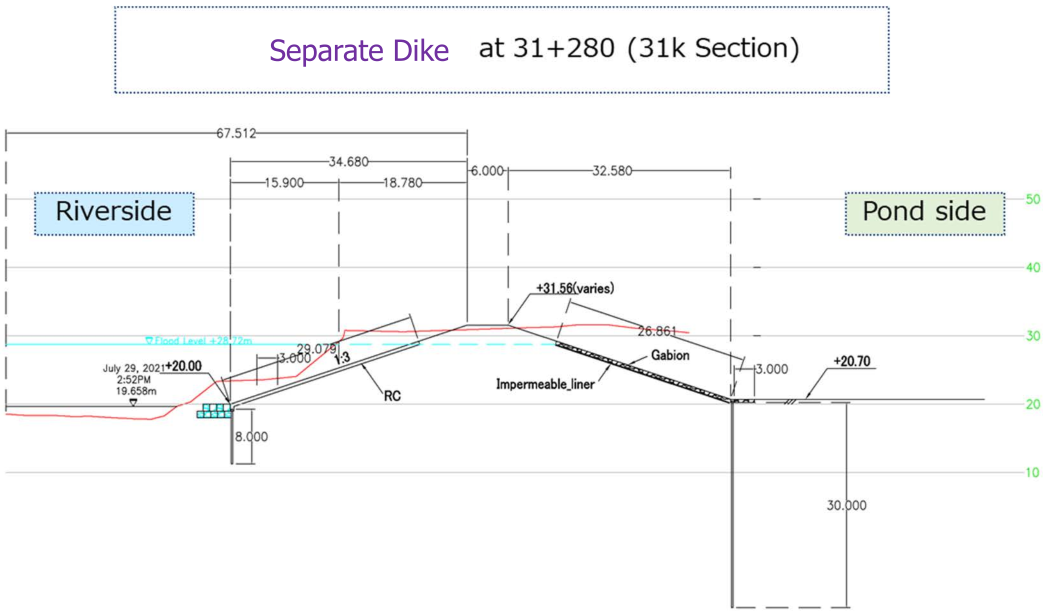


RP 08		MP	FS
RP invre level (MSL+m)		20.70	20.70
inlet overflow dike	Height(MSL+m)	27.50	25.40
	Width(m)	180	180
outlet spilway	Height(MSL+m)	27.00	27.00
	Width(m)	100	100

Source: Project Team

Figure 4.1.19 Standard Cross Section of Overflow Dike at Retarding Pond: RP08

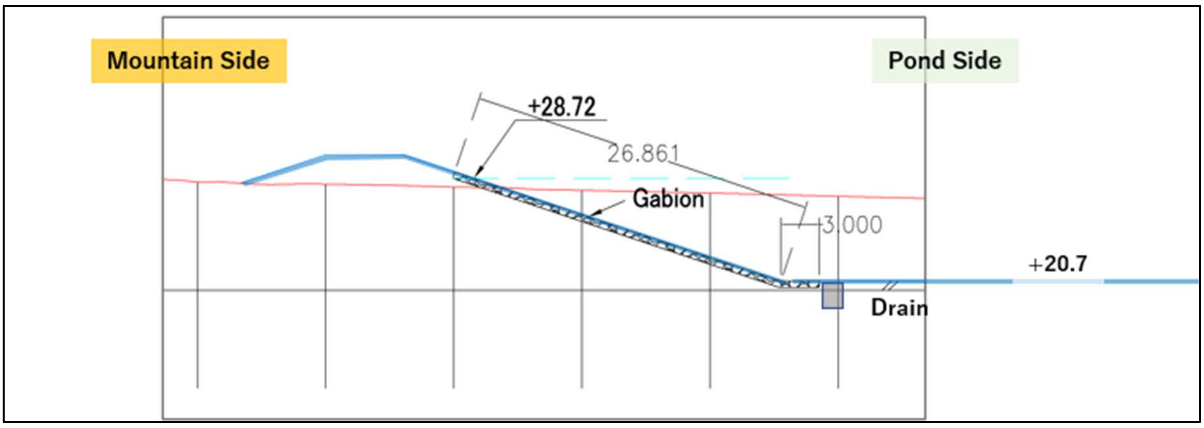
For the separate dike of the retarding pond: RP08, RC revetment will be installed on the river side up to the M/P phase flood level (100-year return period) while gabion revetment with impermeable sheets will be installed on the pond side up to maximum storage level, as shown below. Steel sheet piles and foot protection are installed as well to prevent scouring on the river side, and impermeable sheet piles are to be installed on the pond side down to the impermeable layer to prevent water leakage of the foundation ground from the river side to the pond side. The top of foot protection on the river side is set to be uniformly +20.0 m (equivalent to the level of normal water) for the entire section of the separate dike.



Source: Project Team

Figure 4.1.20 Standard Cross Section of Separate Dike at Retarding Pond: RP08

As for the structure of the surrounding levee, as with the separate dike, gabion revetment is installed up to maximum storage level along the pond-side slope. The main purpose of installing gabions on the surrounding levees is to protect and maintain the slope, such as preventing soil run-off from the slope which may fill up the drainage ditch or preventing excessive growth of vegetation on the slope, and to facilitate management of the location and sectional shape of the slope. The gradient of slope is 1:3.0 on both the mountain side and the pond side. Where the crest elevation is lower than existing ground level, 1:3.0 slope will be cut from the crest to reach the existing ground behind.



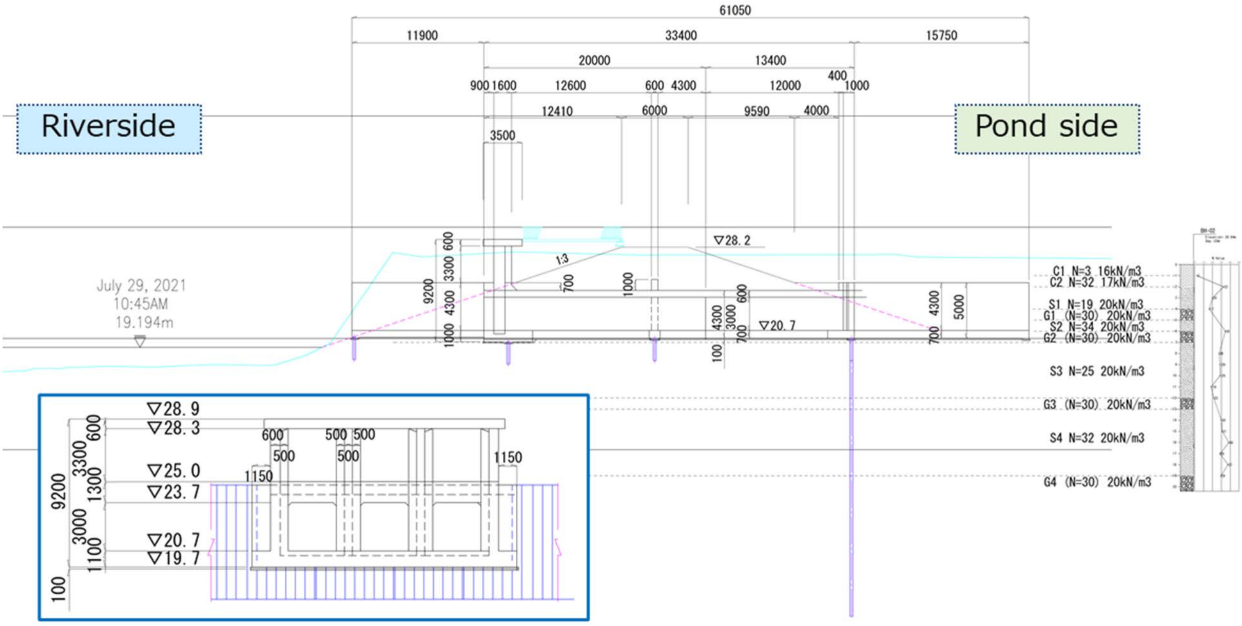
Source: Project Team

Figure 4.1.21 Standard Cross Section of Surrounding Levee at Retarding Pond: RP08

For the spillway to be installed in the downstream part of the retarding pond, the concrete-facing type slope protection is selected, as with the overflow dike.

In addition to a spillway, a drainage facility (sluice gates) is installed at outlet of the pond. During flood events, the gates are fully closed to allow floodwaters to be stored inside the retarding pond. The gates are only raised when the water level on the river side has fallen sufficiently (the river water level then must be below the invert level of the drainage facility). The gate dimension was calculated to allow natural drainage within approximately two days (48 hours) after the raising of the gates, resulting in a cross-sectional dimension of height = 3 m: width = 9 m.

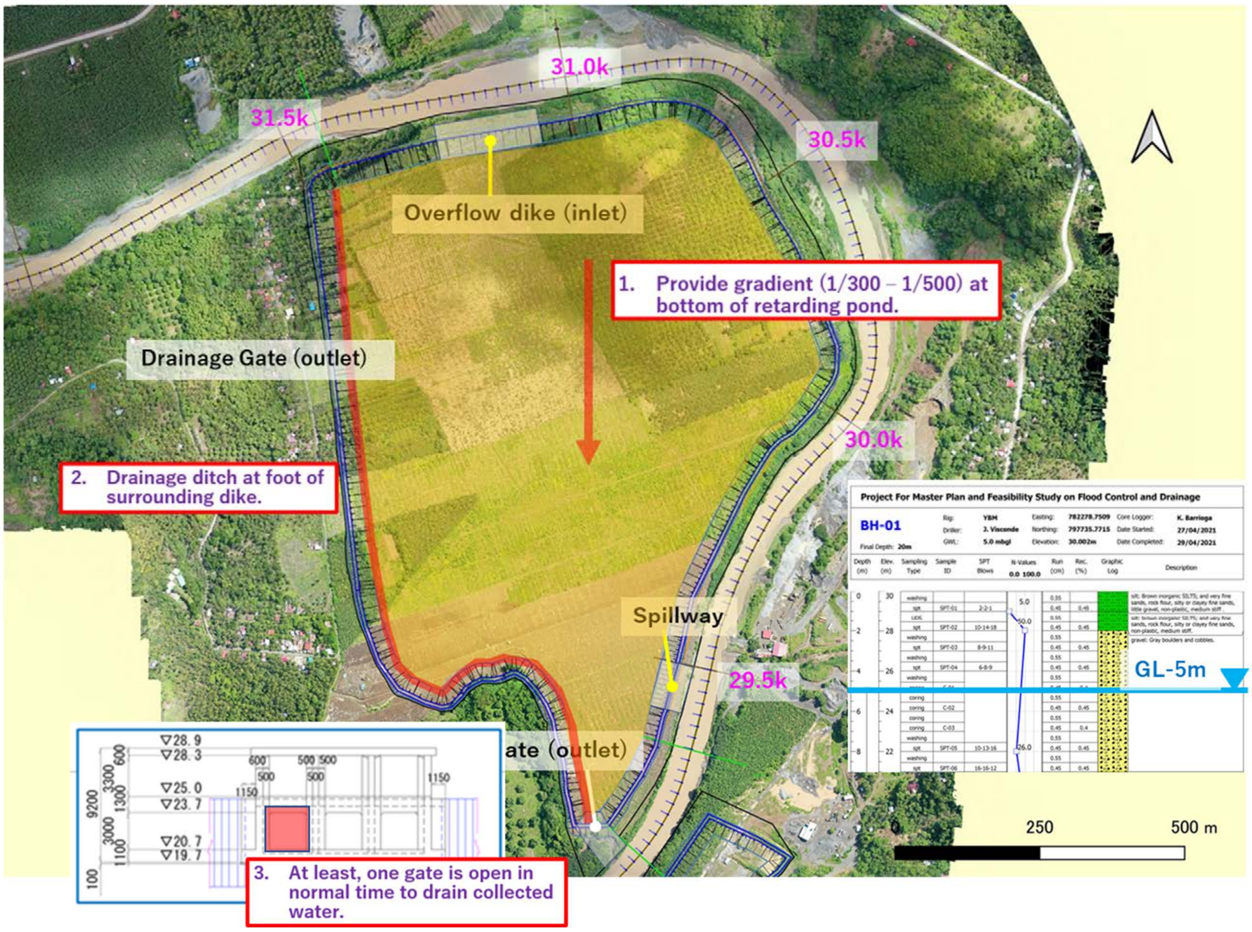
On this basis, a drainage facility with 3 gates of 3m x 3m is assumed for the retarding basin: RP08. According to the results of geotechnical investigations, the ground below the invert level is rather firm with an N value of over 25-30, so spread foundation is assumed for the foundation type. A dust screen shall be installed on the pond side (intake) of the drainage facility. At least one of the drainage gates should be open at normal time to drain groundwater from the pond side.



Source: Project Team

Figure 4.1.22 Standard Section of the Drainage Facility at Retarding Pond: RP08

The results of the geotechnical investigations (BH-01 and BH-02) indicate that the groundwater table in the study area is 4m to 5m below the existing ground level. Groundwater is considered to be recharged from the mountainous area to the west as well as by rainwater inside the pond area. Although the groundwater table level is expected to decrease after the creation of the retarding pond by excavation, following measures should be considered to cope with groundwater inside the pond: (i) a drainage gradient of 1/300 to 1/500 at the bottom of the pond, (ii) a drainage ditch at the toe of surrounding levee, and (iii) raising of the gate in normal time. For retarding pond R08, the permeable formation is considered to be distributed widely at the pond bottom level, and the above measures are used to drain and lower the water table.



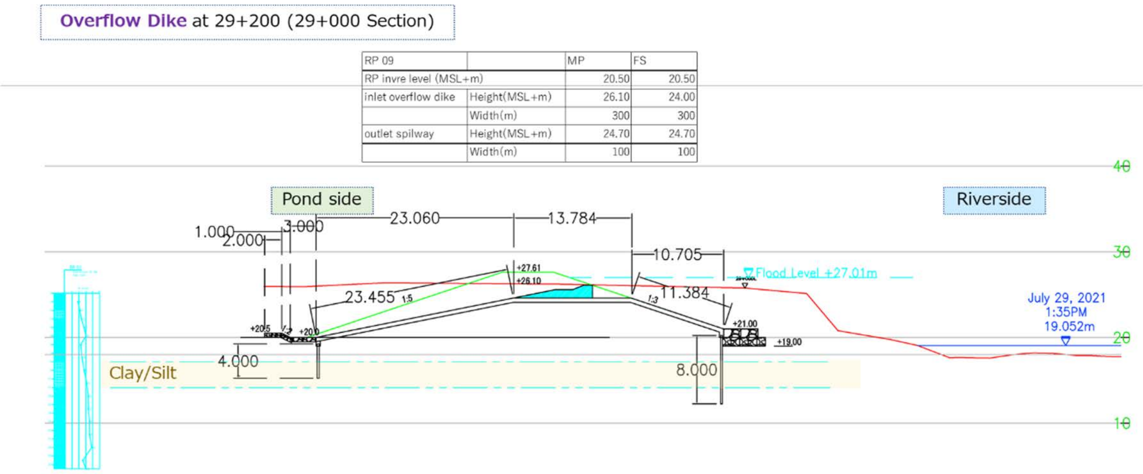
Source: Project Team

Figure 4.1.23 Measures to cope with Groundwater at Retarding Pond: RP08

4) Preliminary design of retarding pond: RP09

Near the inlet (overflow dike) location of the retarding pond: RP09, boulders observed at riverbed / bank are smaller than those observed along the retarding pond RP08 in the upstream. The geotechnical survey results also show that sand and silt layers are the main constituent layers, replacing the gravel layers with boulders observed in the RP08 intake area.

The standard cross-section of the overflow dike is shown below. The overflow dike will be covered with RC-facing protection with foot protection on riverside. The planned crest level of the overflow dike is +24.00 m in the F/S phase and +26.10 m in the MP phase, and the raising in the MP phase will be carried out by installing a 2.1 m high drop work (RC retaining wall) at crest of F/S-phase overflow dike. In addition, as is also the case for RP08, impermeable sheet piles should be installed at toe of the slope on the pond side of the overflow dike / separate dike, embedded into the impermeable soil layer.

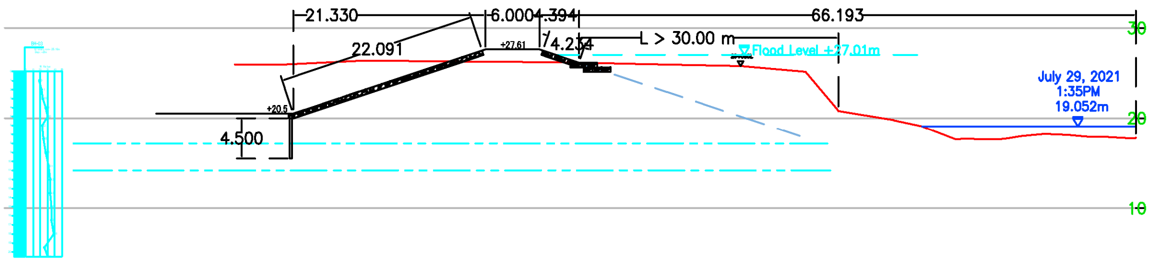


Source: Project Team

Figure 4.1.24 Standard Cross Section of Overflow Dike at Retarding Pond: RP09

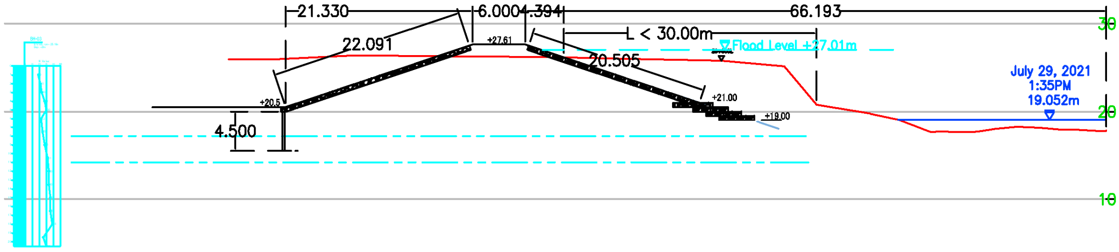
For the separate dike of the retarding pond: RP09, gabion revetment with impermeable sheets will be installed on the river side up to the M/P phase flood level (100-year return period) while the same gabion revetment with impermeable sheets will be installed also on the pond side up to maximum storage level. The gabions and impermeable sheets function together to 1) prevent water from entering the embankment during impoundment and 2) prevent leakage of water that has entered the embankment from the river side, as with RP08.

Riverbank erosion is progressing at some sections of the bank. Therefore, if the distance between the planned cross-section of the separate dike (at intersection with the current ground surface) and the existing bank for low-water channel is narrow (as a reference, less than 30 m), gabion revetment shall be installed on the river-side slope to prevent riverbank erosion (depth of gabion embedment: 17.00m). On the other hand, if the distance between the planned section of the separate dike and the existing bank for low-water channel is sufficiently wide (as a reference, 30 m or more), the existing ground in front of the separate dike shall be left in place and no gabion revetment is to be installed below the existing ground surface. However, it is advisable to monitor the riverbank condition on site over time and implement the necessary measures where riverbank erosion is progressing.



Source: Project Team

Figure 4.1.25 Standard Cross Section of Separate Dike at Retarding Pond: RP09 (Minimum gabion on river side slope)



Source: Project Team

Figure 4.1.26 Standard Cross Section of Separate Dike at Retarding Pond: RP09 (With gabion on river side slope)

The structure of the surrounding levee is the same as the one of RP08.

For the spillway to be installed in the downstream part of the retarding pond, the gabion-type slope protection is selected due to its less frequent use, reduced velocity of overflowing water and sediment diameter compared to the overflow dike, and presumably limited degree of wearing of steel wires, etc. The applicable structural type shall be determined at the detailed design stage, taking into account material availability and the results of flow conditions studied by means of detailed hydraulic experiments, etc.

In addition to a spillway, a drainage facility (sluice gates) is installed at outlet of the pond. The gate dimension was calculated to allow natural drainage within approximately two days (48 hours) after the raising of the gates as in the same as the case of RP08, resulting in a cross-sectional dimension of height = 2.5 m: width = 5 m.

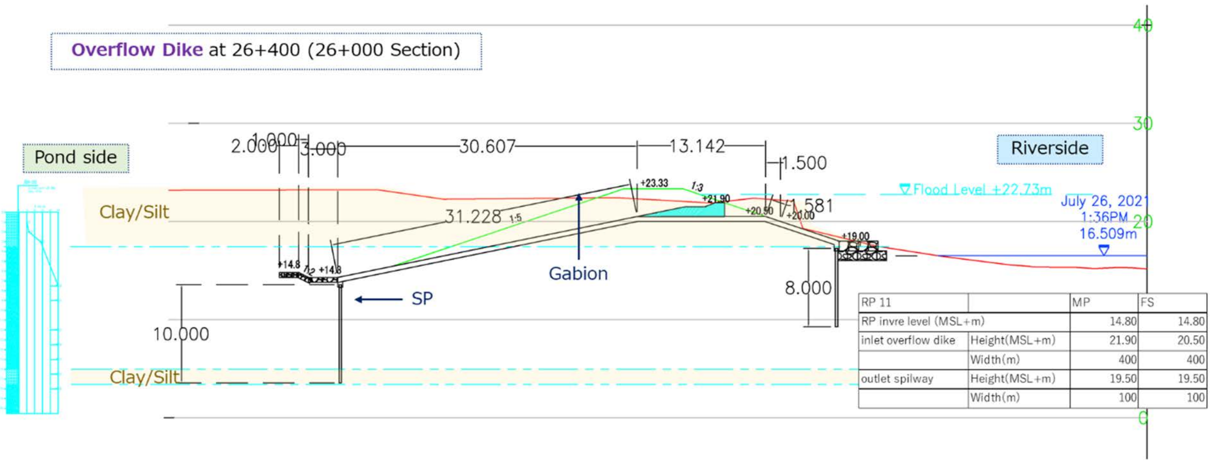
On this basis, a drainage facility with 2 gates of 2.5m x 2.5m is assumed for the retarding basin: RP09. According to the results of geotechnical investigations, the ground below the invert level is rather firm with an N value of over 25-30, so spread foundation is assumed for the foundation type. A dust screen shall be installed on the pond side (intake) of the drainage facility. At least one of the drainage gates should be open at normal time to drain groundwater from the pond side.

As for measures against groundwater, as in RP08, (i) a drainage gradient of 1/300 to 1/500 at the bottom of the pond, (ii) a drainage ditch at the toe of surrounding levee, and (iii) raising of the gate in normal time are to be considered.

5) Preliminary design of retarding pond: RP11

The riverbed and riverbank conditions near the inlet of the retarding pond: RP11 (overflow dike) are similar to those in RP09, and in RP11, riverbank erosion is particularly pronounced from the inlet location to around 25.0km location. The results of the geotechnical survey (elevation of the top of borehole: 20.9 m) show that there is a clayey layer with an N value of more than 10 with a thickness of about 3 m in the surface, and that the layers deeper than that are composed of alternating layers of compacted gravel, sand and clay.

The standard cross-section of the overflow dike is shown below. The overflow dike will be covered with RC-facing protection with foot protection on riverside. The planned crest level of the overflow dike is +20.50 m in the F/S phase and +21.90 m in the MP phase, and the raising in the MP phase will be carried out by installing a 1.4 m high drop work (RC retaining wall) at crest of F/S-phase overflow dike. In addition, as is also the case for RP08, impermeable sheet piles should be installed at toe of the slope on the pond side of the overflow dike / separate dike, embedded into the impermeable soil layer.

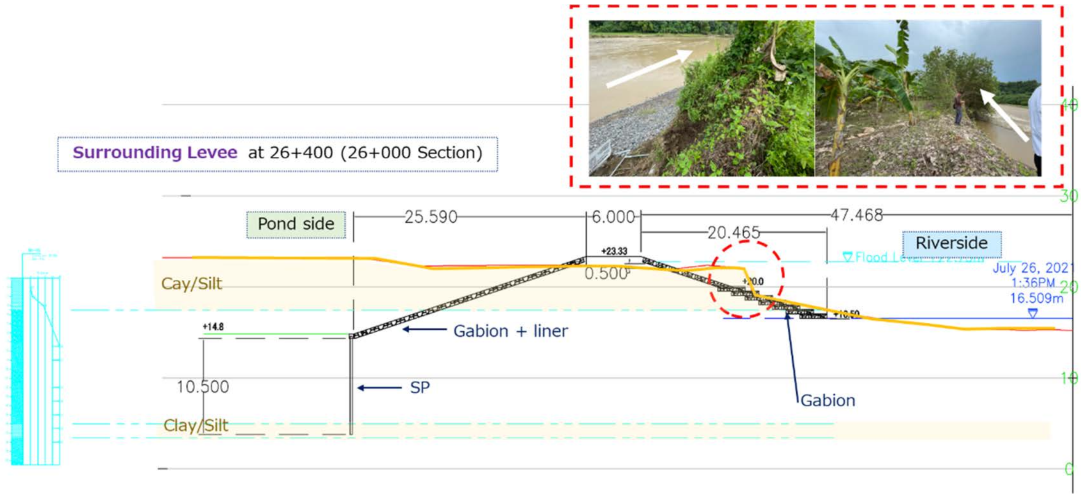


Source: Project Team

Figure 4.1.27 Standard Cross Section of Overflow Dike at Retarding Pond: RP11

For the separate dike of the retarding pond: RP11, gabion revetment with impermeable sheets will be installed on the river side up to the M/P phase flood level (100-year return period) while the same gabion revetment with impermeable sheets will be installed also on the pond side up to maximum storage level. The gabions and impermeable sheets function together to 1) prevent water from entering the embankment during impoundment and 2) prevent leakage of water that has entered the embankment from the river side as with RP08.

The concept of installing a gabion revetment on river side is the same as in RP09. If the distance between the planned cross-section of the separate dike (at intersection with the current ground surface) and the existing bank for low-water channel is narrow (as a reference, less than 30 m), gabion revetment shall be installed on the river-side slope to prevent riverbank erosion. For the RP11, the water surface gradient and topographic gradient in the longitudinal direction changes, with mean water level of about +17.5 m near the inlet and about +12.0 m near the outlet. For this reason, the embedment depth of gabion revetment should also be varied longitudinally.



Source: Project Team

Figure 4.1.28 Standard Cross Section of Separate Dike at Retarding Pond: RP11

The structure of the surrounding levee is the same as the one of RP08 and 09, and the structure of the spillway is the same as the one of RP09.

In addition to a spillway, a drainage facility (sluice gates, 3 gates of 3m x 3m) is installed at outlet of the pond. According to the results of geotechnical investigations, spread foundation is assumed for the foundation type. A dust screen shall be installed on the pond side (intake) of the drainage facility. At least one of the drainage gates should be open at normal time to drain groundwater from the pond side.

As for measures against groundwater, as in RP08, (i) a drainage gradient of 1/300 to 1/500 at the bottom of the pond, (ii) a drainage ditch at the toe of surrounding levee, and (iii) raising of the gate in normal time are to be considered.

(3) Preliminary Design of Structural Measures (Cut-off Works)

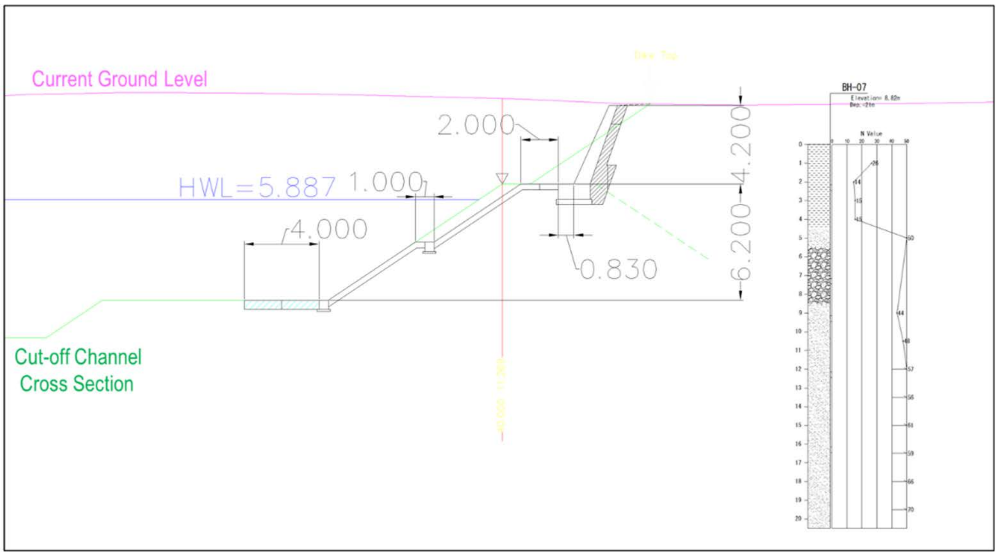
1) Riverbed Measures at Cut-off Locations

The planned longitudinal profile after the cut-off works is set for a section of certain lengths, including the area before and after the cut-off, so that the cut-off sections will not create a local transition point for the riverbed gradient. As the riverbed gradient does not change before and after the cut-off section, the difference in riverbed drop between the upstream and downstream sections is small, and the riverbed height at the diversion and confluence points is set to match the current riverbed height, no drop works will be installed at the diversion/confluence points.

Here, in case of that, the riverbed of the cut-off section, including upstream and downstream of that, would not be stable after the short-term works, there is concern that structures such as revetments might become unstable and the planned flood control effect might not be achieved. As a point of consideration during the detailed design phase, a study on the long-term stability of the riverbed should be conducted and countermeasures should be taken if necessary.

2) Structure of revetment at Cut-off Locations

The cross-sectional geometry of the cut-off section was examined in terms of the revetment structure. Both the upstream and downstream sections are excavated channels where HWL is below the ground level. For the slope of 1.50% at bank below HWL, a concrete revetment (rubble concrete), which is the method used in the Davao River revetment work by DPWH, is used. However, as the height of the revetment exceeds 5 m, a berm shall be provided in the middle of the revetment in accordance with DGCS stipulation. The maximum height of the slope between the HWL and the existing ground level is 4.2 m for the case where diversion to the current river channel is considered, for which a retaining wall shall be installed to minimize the encroachment on the surrounding land. In case the diversion to current river channel is not considered, due to site restrictions, a retaining wall of up to 7.5 m will be needed. The standard cross section of the revetment in the cut-off section is shown below.



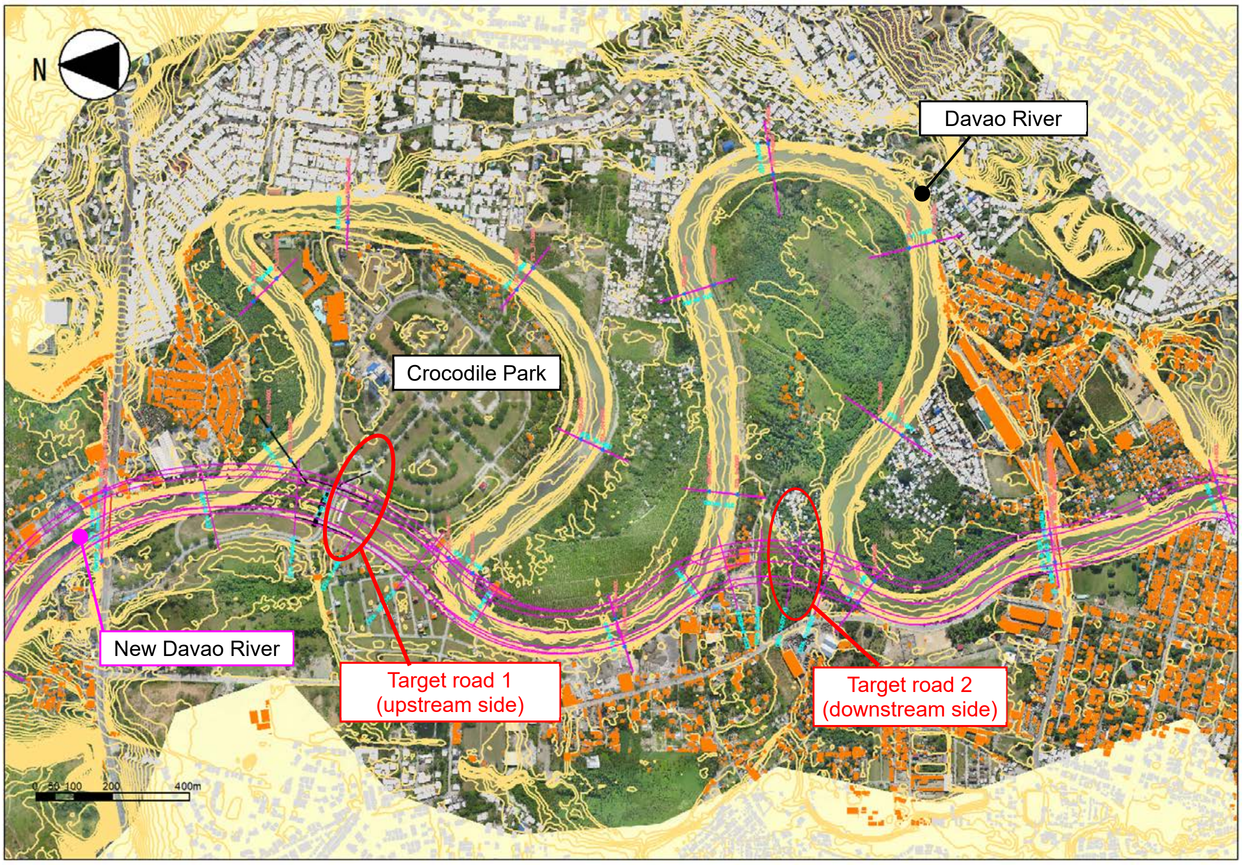
Source: Project Team

Figure 4.1.29 Standard Cross Section at Cut-off Section (Revetment)

(4) Facility design of structural measures (bridges (shortcut section))

1) Overview

In this section, the two roads (bridge section) that will be divided at the cut-off section is designed for. Figure 4.1.30 shows the locations of the two roads.



Source: Project Team

Figure 4.1.30 Location map of Target Roads

2) Design criteria for the bridge

- **Bridge Length**

The abutment positions shall be set based on the planned river cross section as the front of the abutment's vertical wall does not extend forward of the river cross section (slope shoulder).

The bridge lengths to be set based on the abutment locations are 112m for STA 11+188.4 and 116m for STA 8+116.6.

- **Pier location**

Considering the river conditions near the bridge crossing, the minimum standard span length is 28.5 m, which allows for a four-span span.

- **Construction sequence**

Regarding the construction sequence of bridges and river improvement, bridges should be constructed first because temporary construction costs such as temporary abutments and in-river tightening will increase if bridge construction is done in the river.

- **Type of Pier**

Since construct bridges prior to river construction, in-river tightening is not required, and wall piers shall be selected because they are stiffer than the pile-bent type. However, since the piers are located in a river, the piers were adopted column type to reduce the influence of the river's running water.

- **Foundation Pile**

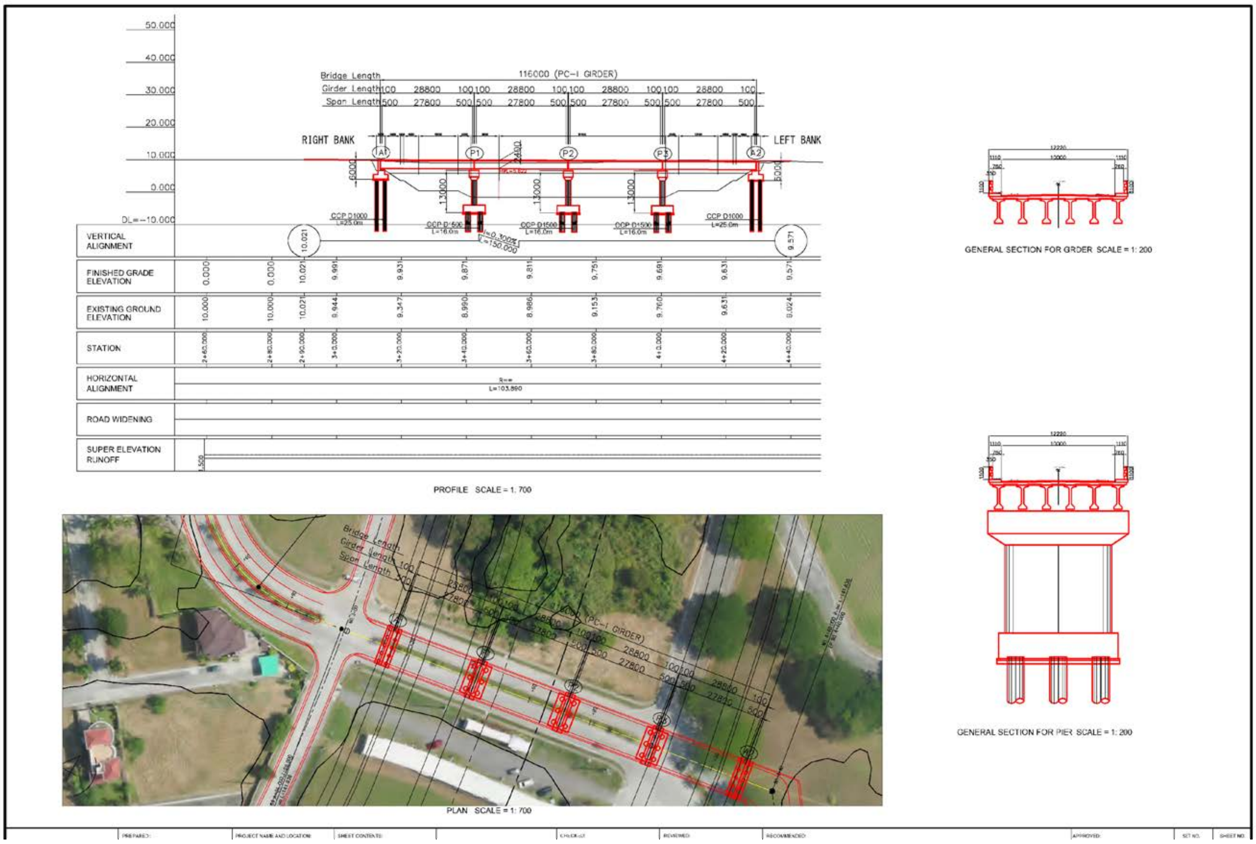
The results of borings conducted in the vicinity of the project site were used as a reference in studying the foundation piles. However, since the downstream geological survey did not identify any ground that could be confirmed as a support layer, the foundation piles length shown in the on-going new bridge construction project near the site were used as a reference.

3) Bridge type

The bridge length and span length of STA 11+188.4 is 112 m (4@28 m) and STA 8+116.6 is 116m (4@29m). PC-I girders were selected as the bridge type considering the span length and the economic aspect.

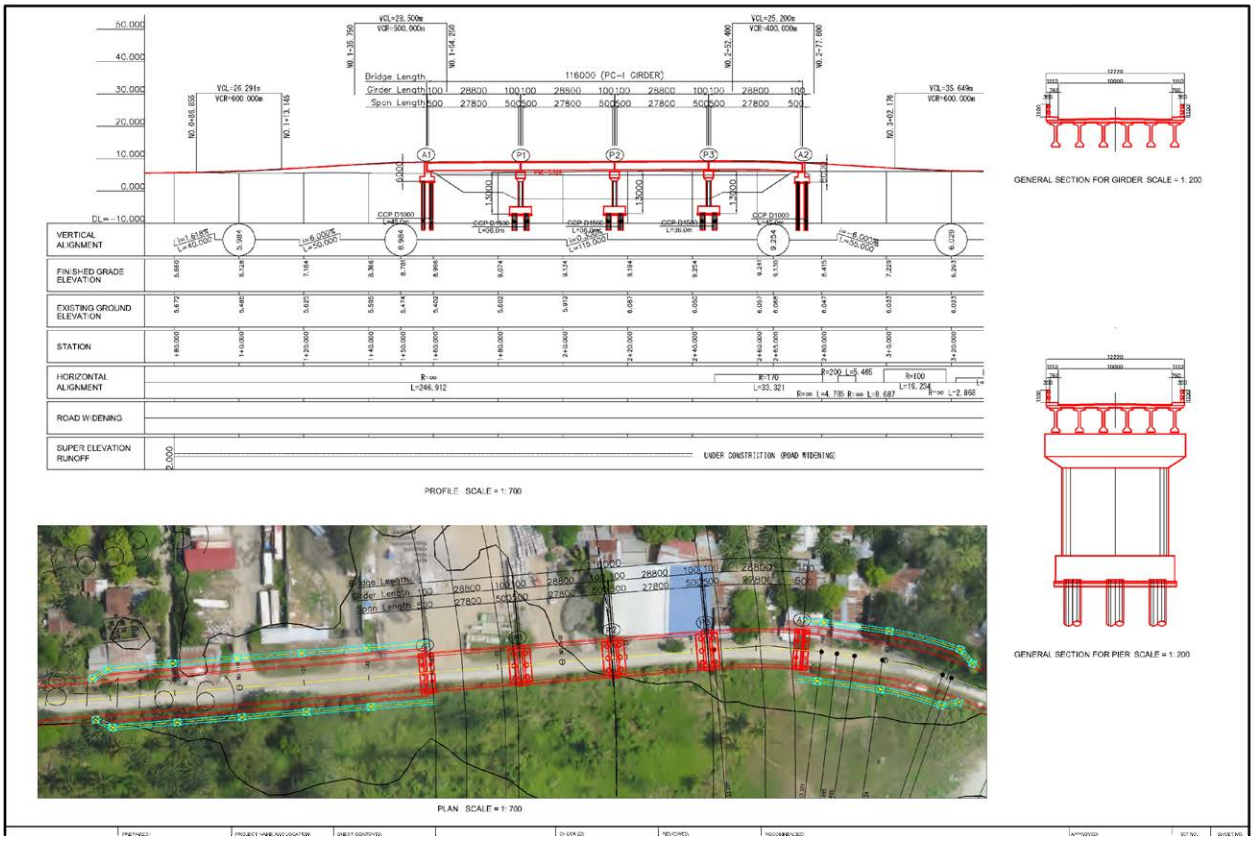
4) Road and bridge design

The general drawings created are shown in Figure 4.1.31 (upstream target road) and Figure 4.1.32 (downstream target road).



Source: Project Team

Figure 4.1.31 General View of STA.11+188.4



Source: Project Team

Figure 4.1.32 General View of STA.8+116.6

4.2 Non-structural Measures for Riverine Flood in Davao River

4.2.1 Priority Projects on Non-structural Measures for Riverine Flood in Davao River

The following six projects are non-structural measures targeted in F/S as the priority projects.

- Additional installation of water level gauges
- Setting warning water level in Davao River corresponding to the latest river and social conditions
- Preparation of IEC materials on the proposed structural measures and non-structural measures
- Formulation and Update of flood hazard map for riverine, inland and coastal with evacuation information
- Land use control along the proposed structural measures
- Capacity enhancement project on riverine flood, rainwater drainage and coastal management in Davao

An overview of related existing activities/necessity of measures, pre-examination through pilot activity, examination of future implementation plan, estimation of necessary budget, and suggestion for future implementation for each of the priority projects are described below.

4.2.2 Additional installation of water level gauges

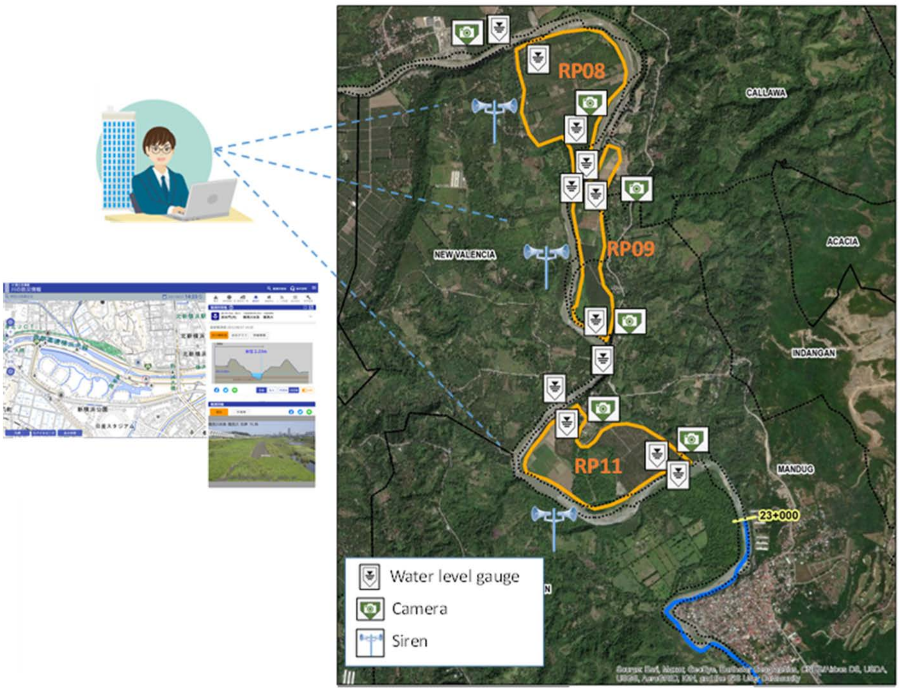
(1) Overview of related existing activities

Regarding existing hydrological observation, the Davao River Basin Flood Forecasting and Warning Center (DRBFFWC) was established under PAGASA in 2018, and six water level gauges have been installed in the Davao River Basin under support of JICS. The water level gauge at Lacson Lamanan

Bridge is located about 10 km upstream of the retarding ponds, and the one at Waan Bridge is located about 5 km downstream, but there are no water level gauges around the retarding ponds.

(2) Results of pre-examination through pilot activity in F/S

Discussions were conducted among the JICA Project team, DPWH RO-XI and Davao CDRRMO to examine the specifications and required project costs. As a result of the discussion, DPWH will procure, install, and manage the necessary equipment, and the data shall be shared with Davao CDRRMO in order to utilize it for disaster preparedness and response activities. In addition to the water level gauges, cameras, sirens, and data server are required to monitor the retarding ponds, and an overview of the system is shown in Figure 4.2.1.



Source: JICA Project Team

Figure 4.2.1 Image for Monitoring System of Retarding Ponds

For each retarding pond, two ultrasonic type water level gauges on the overflow dike and outside of drainage gate, two pressure type water level gauges inside of the retarding pond, two cameras around overflow dike and drainage gate, and one siren are planned to be installed.

(3) Examination of future implementation plan

Table 4.2.1 shows an implementation plan for the introduction of monitoring system. The installation of new water level gauges and the re-installation of the existing water level gauge will proceed in line with structural measures for retarding ponds construction and river channel widening.

Table 4.2.1 Implementation Plan for Installing New Water Level Gauges and Monitoring System

Year	Classification of measures	Content of Work
2023-2024	Structural measures	Detailed design of the three retarding ponds proposed as the priority project
2025-2026	Non-Structural measures	Detailed examination of specifications and installation location of the retarding pond monitoring system including water level gauges

Year	Classification of measures	Content of Work
2025-2032	Structural measures	Construction of the three retarding ponds
2032-2033	Non-Structural measures	Procurement and installation of the retarding pond monitoring system
2034-2038	Structural measures	Construction of Davao River channel widening and replacement of bridges
2039	Non-Structural measures	Reinstallation of PAGASA's existing water level gauge on the rebuilt bridge

Source: JICA Project Team

(4) Estimation of necessary budget

The total cost of the monitoring system for the three retarding ponds was calculated to be approximately 42.92 million Php. From the viewpoint of system maintenance in the future, the cameras, sirens, and server are selected from those that have been introduced by the Davao CDRRMO before.

(5) Suggestion for future implementation

The procurement of the monitoring system shall basically be carried out by DPWH, who will be the manager of the retarding ponds. As described later in Section 4.6, it is proposed that DPWH RO-XI will acquire the budget and DEO will be in charge of the operation and maintenance of the retarding ponds, so that the similar system on budget acquisition and operation is expected for the monitoring system.

In addition, four additional retarding ponds are planned as a mid-long term measure in the Master Plan, so that it will be necessary to consider expanding this monitoring system in the future. It is expected that the experience of working with the monitoring system for the three retarding ponds will be utilized to expand to the remaining four retarding ponds.

4.2.3 Setting warning water level in Davao River corresponding to the latest river and social conditions

(1) Overview of related existing activities

The six water level gauges were installed by PAGASA along Davao River in 2018. However, there is a concern that the flood warning water level set at these observatories does not match with the latest river channel and social conditions, leading to missed or false warnings.

(2) Results of pre-examination through pilot activity in F/S

The flood warning water level at Waan Bridge and Davao River Bridge were re-examined using the results of the river cross sectional survey conducted in this project, in line with the PAGASA setting manual (method of setting the flood warning water level of yellow, orange, and red according to 40, 60, and 80% of the river channel capacity).

The flood warning water level re-examined at the Waan Bridge was officially approved by PAGASA in September 2021. The proposed flood warning water level of the Davao River Bridge was officially approved by PAGASA in March 2022.

(3) Examination of future implementation plan

Since the river improvement project of Davao River will be continuously implemented until 2045, the flood warning water level of PAGASA shall also be updated as the river channel capacity changes. The PAGASA water level gauges that are mainly affected by the Master Plan river improvement project are the Waan Bridge observatory and the Davao River Bridge observatory. Table 4.2.2 shows an implementation plan for resetting the flood warning water level. The flood warning water level will be reset regularly in line with the structural measures for dredging and river channel widening work proposed in the Master Plan.

Table 4.2.2 Implementation Plan for Resetting Flood Warning Water Level

Year	Classification of measures	Content of Work
2023	Non-Structural measures	Reset of flood warning water levels at all PAGASA water level gauges (6 locations) in the Davao River Basin
2025-2031	Structural measures	Implementation of dredging in Davao River
2028	Non-Structural measures	Reset of flood warning water levels at Waan Bridge observatory and Davao River Bridge observatory according to the progress of the dredging project (1st)
2030	Non-Structural measures	Reset of flood warning water levels at Waan Bridge observatory and Davao River Bridge observatory according to the progress of the dredging project (2nd)
2032	Non-Structural measures	Reset of flood warning water levels at Waan Bridge observatory and Davao River Bridge observatory according to the progress of the dredging project (3rd)
2034-2038	Structural measures	Implementation of river channel widening in Davao River
2039	Non-Structural measures	Reset of flood warning water levels at Waan Bridge observatory and Davao River Bridge observatory according to the progress of the river channel widening project (4th)

Source: JICA Project Team

(4) Estimation of necessary budget

In order to reset the flood warning water level, it is necessary to carry out a river cross sectional survey at each observatory point. Assuming 18,000 Php per cross section with reference to the survey carried out by the project team, the required project budget is calculated to be 252,000 Php by conducting the survey of 14 cross sections in total. It is expected that this project cost be funded by PAGASA.

(5) Suggestion for future implementation

In order to regularly reset the flood warning water level in the future, it is necessary for DPWH to regularly share with PAGASA the changes in the river channel capacity due to the river improvement projects based on the Master Plan.

In addition, through comparison between the reset flood warning water level and the water level rise event in the recent flood, it was estimated to be about 2 hours to rise from the yellow Flood Monitoring level to the orange Flood Alert level, and another 2 hours from the orange Flood Alert level to the red Flood Warning level. Although lead-time for information dissemination and evacuation action seem to be secured, further discussions and examinations are required in the future among the parties concerned for setting the further precise and effective flood warning water level.

From the perspective of establishing a flood warning system that contributes to proper disaster prevention actions by local residents, it is important not only to technically refine the flood warning water level of PAGASA, but also to carry out awareness activities with the local residents and local governments who receive the warnings and need to take appropriate disaster prevention actions. It is required to update the flood warning system through referring to the viewpoint from the residents side and the past knowledge formed in the local area. As a concrete example, the residents of Tamugan barangay located in the middle part of the Davao River and Waan barangay located in the lower part communicated with each other, and the local residents have empirically recognized that the water level in the Waan barangay will rise 3-4 hours after the water level rises in the Tamugan barangay. In addition to waiting for information from the government, residents need to collect necessary information by themselves. Also, it is expected to carry out public awareness activities and knowledge sharing related to flood warnings and evacuation with the residents.

4.2.4 Preparation of IEC materials on the proposed structural measures and non-structural measures

(1) Overview of related existing activities

In order for the Master Plan proposed in this project to be smoothly implemented, it is important that the residents and related organizations are fully informed and that they understand the plan. Through the preparation of pamphlet and poster as IEC materials that introduce the measures proposed in this Master Plan, it is expected to be an effective tool for disseminating information to residents and related organizations.

(2) Results of pre-examination through pilot activity in F/S

The first draft of IEC materials was prepared. Two types of IEC materials were prepared, the first is a public awareness material related to flood control measures, and the second is a material introducing the Master Plan formulated in this Project.

Regarding the public awareness IEC material, it was prepared according to the contents shown in Table 4.2.3.

Table 4.2.3 Contents of IEC Material for Public Awareness on Flood Control Measures

Type of IEC material	Public awareness on flood control measures
Target audience	• Flood-prone households along Davao River in 100-year scale inundation area • Community Integrated DRR Training Institute planned to be established by the city government of Davao • Media, etc.
Objective of the material	Awareness and understanding improvement from the following viewpoints • Basic concepts on flooding • Current and projected flooding situation in Davao City • Key and relevant actions before/during/after flooding that they can undertake within their household and/or communities, incorporating LGU's existing initiatives • Emergency services and hotlines that they can access within Davao City prior to and in times of flood emergencies
Contents of the material	• The number of pages: 3 • What is flood/flooding? • What are the types and causes of floods/flooding? • Flood risk/hazard map • Who are the (most) affected population? • Major floods in the past in Davao City • Flood prevention/preparedness categorized in three (3) phases: before, during, and after a disaster for household and barangay levels • Davao City Early Warning System (EWS) • Emergency Hotline Numbers, etc.

Source: JICA Project Team

Regarding the IEC material introducing the Master Plan formulated in this project, it was prepared according to the contents shown in Table 4.2.4.

Table 4.2.4 Contents of IEC Material for Introducing the Flood Control Master Plan

Type of IEC material	Pamphlet introducing the flood control Master Plan
Target audience	• Davao City Citizens • Community Integrated DRR Training Institute planned to be established by the city government of Davao • Disaster management related organizations • Media, etc.

Objective of the material	Promote understanding of the flood control Master Plan
Contents of the material	• The number of pages: 8 • Purpose of flood control Master Plan, target area, implementing agencies involved • Project schedule/ staged development • Proposed structural measures and its functions/benefits including Riverine Flood in Davao River, Matina River, and Talomo River, Storm Water Drainage Improvement, Structural Measures for Coastal Disaster, and Non-structural measures • Project cost estimation

Source: JICA Project Team

Regarding the language of the IEC materials, the C/P recommended to translate to local Visaya language, so that the Visaya language version was prepared as well as the English version. Also, the black-and-white version was prepared in addition to the colour version.

(3) Examination of future implementation plan

It is required to update the contents of the IEC materials as the river improvement project of Davao River will be continuously implemented until 2045. Table 4.2.5 shows an implementation plan for the future updates based on the first draft of the IEC materials prepared in this feasibility study.

Table 4.2.5 Implementation Plan for Update of IEC Materials

Year	Classification of measures	Content of Work
2022	Non-Structural measures (Feasibility Study)	Preparation and distribution of the first draft of IEC materials
2023-2032	Structural measures	Implementation of the short-term structural measures
2033	Non-Structural measures	Update and distribution of IEC materials based on the completion of the short-term structural measures
2033-2045	Structural measures	Implementation of the mid-long term structural measures
2039	Non-Structural measures	Update and distribution of IEC materials based on the progress of the mid-long term structural measures (completion of all planned retarding ponds)
2046	Non-Structural measures	Update and distribution of IEC materials based on the completion of the mid-long term structural measures

Source: JICA Project Team

(4) Estimation of necessary budget

IEC materials will be distributed four times by the completion of the Master Plan in 2045. The target audience of the IEC materials will be the residents living in the 100-year scale inundation area along Davao river, and disaster management related organizations in Davao city. The required budget for printing IEC materials is calculated to be 30.40 million Php as it is assumed to be distributed to 10,000 households / organizations four times. Regarding the unit cost for printing IEC materials, the poster for public awareness is 360 Php (Tarpaulin A1 paper, 3 pages printed), and the pamphlet introducing the flood control Master Plan is 400 Php (300GSM Thickness-Semi Gloss A4 paper 8 pages). Since most of the distribution target will be residents of Davao City, the cost is expected to be funded by the Davao CDRRMO.

(5) Suggestion for future implementation

The IEC materials will be effective to utilize at the Community Integrated DRR Training Institute that is planned to be established according to the Davao City Disaster Risk Reduction and Management Plan 2020-2025. As of 2021, the above training institute is still in the planning stage, and construction and detailed examination of the training content have not progressed. It is expected that these IEC materials will be installed in the institute in the future so that the visiting local residents can take them home and learn independently.

In addition, the contents of the IEC materials need to be updated as the river improvement project for Davao River will be implemented until 2045. Based on the first draft of the IEC materials, it is expected that DPWH and Davao CDRRMO will work together to continuously update.

As related existing activities, DENR-XI has prepared IEC materials for prohibiting tree logging and promoting greening programs. Forest conservation in the upstream area of Davao River is an effective measure for flood control, so that it is expected to carry out community awareness activities by utilizing these existing IEC materials in addition to the one prepared in this feasibility study.

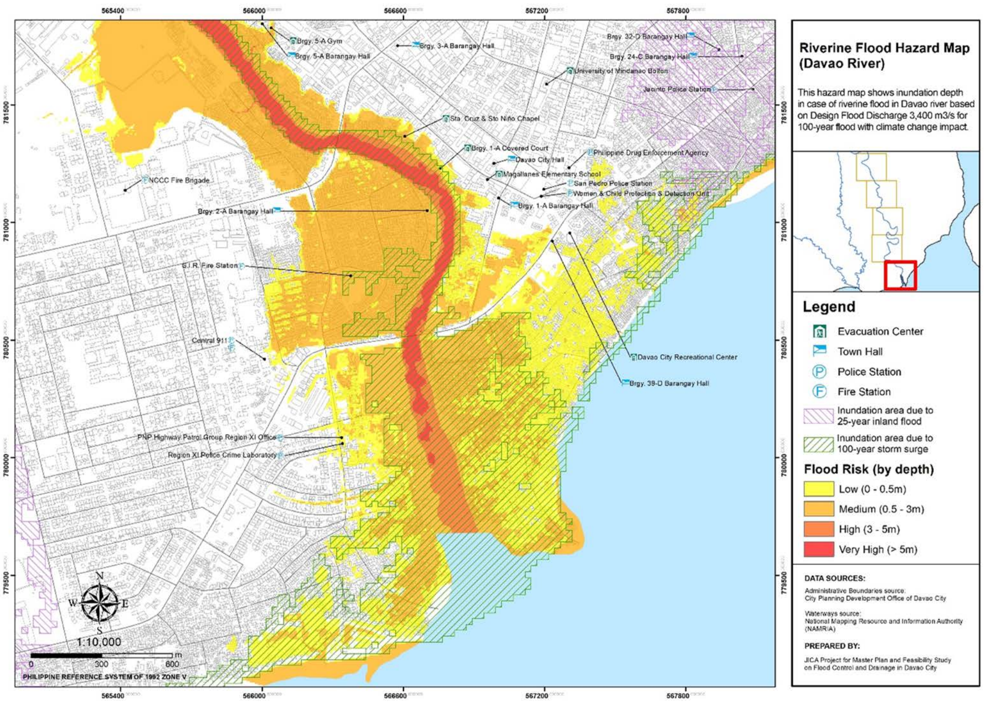
4.2.5 Formulation and Update of flood hazard map for riverine, inland and coastal with evacuation information

(1) Overview of related existing activities

While there are multiple existing flood hazard maps in Davao City, it is necessary to update them regularly in line with the latest river improvement works by DPWH and the progress of structural measures proposed in the Master Plan.

(2) Results of pre-examination through pilot activity in F/S

The first draft of the hazard map was prepared. The hazard map was formulated along Davao River, which integrates three types of disasters, using the results of inundation simulation for riverine flood, inland flood, and storm surge that have been carried out in this project. Information of evacuation centers provided by the city government of Davao was also included in this hazard map. 100-year scale inundation for riverine flood and storm surge, and 25-year scale inundation for inland flood were integrated into 1:10,000 scale hazard map by dividing the area from the mouth of Davao River to 23 km into five areas. An example of the prepared hazard maps is shown in Figure 4.2.2.



Source: JICA Project Team

Figure 4.2.2 Flood Hazard Map Integrating Riverine Flood, Inland Flood, Storm surge and Evacuation Information

(3) Examination of future implementation plan

It is required to update the hazard map as the river improvement work for Davao River will be continuously implemented until 2045. Table 4.2.6 shows an implementation plan for future updates based on the first draft of the hazard map formulated in this feasibility study.

Table 4.2.6 Implementation Plan for Update of Hazard Maps

Year	Classification of measures	Content of Work
2022	Non-Structural measures (Feasibility Study)	Preparation and distribution of the first draft of hazard maps
2023-2032	Structural measures	Implementation of the short-term structural measures
2033	Non-Structural measures	Update and distribution of hazard maps based on the completion of the short-term structural measures
2033-2045	Structural measures	Implementation of the mid-long term structural measures
2039	Non-Structural measures	Update and distribution of hazard maps based on the progress of the mid-long term structural measures (completion of all planned retarding ponds)
2046	Non-Structural measures	Update and distribution of hazard maps based on the completion of the mid-long term structural measures

Source: JICA Project Team

(4) Estimation of necessary budget

The hazard maps will be distributed three times by the completion of the Master Plan in 2045. These will be distributed to residents who live in the 100-year scale inundation area along Davao river and disaster management related organizations in Davao City. The required budget related to printing hazard maps is calculated to be 39 million Php, which is assumed that the unit cost for printing the hazard map will be 500 Php (1 set of 5 sheets of 300GSM Thickness-Semi Gloss A3 paper) and distributed three times to 26,000 households / organizations. Since most of the distribution target will be residents of Davao city, the cost is expected to be funded by the Davao CDRRMO.

(5) Suggestion for future implementation

It is required to update the hazard maps as the river improvement work for Davao River will be continuously implemented until 2045. In this Project, practical technical training sessions such as hydrological and runoff inundation analysis was conducted as part of strengthening the capacity of C/P. Utilizing this experience, it is expected that DPWH officials will carry out the runoff inundation analysis according to the progress of the river improvement work, and update the hazard maps in cooperation with the city government of Davao.

In addition, it was confirmed that some evacuation centers were located within the inundation area, through preparation of the hazard maps in this feasibility study. The six evacuation centers have a possibility to be inundated in the case of 100-year scale riverine flood, and one evacuation center have a possibility to be inundated in the case of 100-year scale storm surge. In the future, it is necessary to consider in evacuation plan how to handle these evacuation centers under the risk of flooding.

4.2.6 Land use control along the proposed structural measures

(1) Overview of related existing activities

In order for the structural measures such as retarding ponds, cut off works, and river channel widening proposed in the Master Plan to be implemented smoothly, it is important to properly regulate land use on these proposed areas. In particular, it is important to coordinate between the Master Plan proposed by this project and the CLUP, comprehensive land use plan in Davao City.

(2) Results of pre-examination through pilot activity in F/S

In order to properly consider the land use plan based on the flood risk assessment, the flood risk information of MGB referred to in CLUP was compared and verified with the flood inundation simulation results conducted in this Project. As the results of verification, multiple areas not covered by the MGB Flood susceptibility map can be confirmed among the 100-year scale flood inundation areas calculated by this Project.

Through sharing the results of this comparative verification with the officials in charge of MGB-XI, they decided to update the MGB flood susceptibility map with reference to the flood inundation results calculated by this Project. MGB-XI held multiple discussions with the MGB Headquarters from January to February 2022 to revise the inundation areas in the above three barangays, and the flood susceptibility map is planned to be updated and published within 2022. In the future, CLUP will need to be updated in accordance with the updated flood susceptibility map.

(3) Examination of future implementation plan

It is required to update the land use plan as the river improvement project for Davao River will be continuously implemented until 2045. Table 4.2.7 shows an implementation plan for future updates.

Table 4.2.7 Implementation Plan for Update of the Land Use Plan

Year	Classification of measures	Content of Work
2022	Non-Structural measures	CLUP revised (from CLUP2013-2022 to CLUP2019-2028)
2023-2024		CLUP revision based on short-term structural measures and flood inundation analysis results by this Project
2025		CLUP revision (from CLUP2019-2028 to CLUP2025-2034)
2032	Structural measures	Implementation of the short-term structural measures
2032-2033	Non-Structural measures	CLUP revision based on the mid to long-term structural measures proposed by this Project
2034		CLUP revision (from CLUP2025-2034 to CLUP2034-2043)
2043	Structural measures	Completion of mid-long term structural measures

Source: JICA Project Team

(4) Estimation of necessary budget

Since the land use plan is updated by the city government of Davao, no specific budget is required for the update. The cost of issuing Zoning certificate for the proposed area of structural measures will also be unnecessary because it is a public project.

It is expected that the city government of Davao will appropriately allocate human resources involved in land use plan updates.

(5) Suggestion for future implementation

The latest CLUP 2019-2028, revised in 2022, includes land use regulations that take flood risk into consideration. On the other hand, it was found that the MGB flood susceptibility map, which is referred to as flood risk information in the CLUP, is not inclusive since there are areas where flood risk is not properly assessed through comparison with the flood inundation calculation results by this Project team. In the future, it is necessary to update the flood risk information in the CLUP with reference to the flood inundation calculation results by this Project team, and to appropriately promote land use restrictions in high risk flood areas.

In addition, although the structural measures will be gradually implemented by 2045 in accordance with the proposed Master Plan, the residual flood risk is still high by 2032 even after the short-term measures are completed. Targeting to the residual risk by 2045, it is expected that land use control will be actively promoted in high risk flood areas.

4.2.7 Capacity enhancement project on riverine flood, rainwater drainage and coastal management in Davao

(1) Overview of related existing activities

Through this project, the Master Plan for riverine flood, rainwater drainage, and coastal flood management has been formulated in Davao City. On the other hand, it is important to promote these implementations and strengthen the capacity of the implementing organizations in the future.

(2) Results of pre-examination through pilot activity in F/S

Although DPWH's capacity for riverine flood and coastal disasters has been strengthened in recent years, technical support for rainwater urban drainage management is limited. Therefore, Project Team advised assumed necessary activities for capacity enhancement of urban drainage management based on activities in this Project.

(3) Examination of future implementation plan

DPWH will prepare an application form and submit/request it to a cooperation agency/donor for realization of the capacity enhancement project and it is expected that the capacity enhancement project will be implemented after few years.

(4) Estimation of necessary budget

Since DPWH will prepare and submit the application form, the budget for proposal of the capacity enhancement project is not necessary. The budget related to the project itself will be examined by DPWH and the cooperation agency/donor.

(5) Suggestion for future implementation

Through the implementation of the capacity enhancement project related to urban drainage management, it is expected to create a good practice involving local governments in the pilot area and proceed with efforts with an eye on future nationwide expansion.

4.2.8 Summary of Examination Results for Priority Projects on Non-structural Measures in F/S

The following is a summary of examination results for priority projects on non-structural measures in feasibility study.

Table 4.2.8 Summary of Examination Results for Priority Projects on Non-structural Measures in F/S

No.	Priority project on non-structural measures	Results of pre-examination in F/S	Future implementation plan	Necessary budget	Suggestion for future implementation
1	Additional installation of water level gauges	Examination of specifications and quantity of monitoring systems (water level gauge, camera, siren, data server) for the three retarding ponds proposed as priority project for structural measures	· Detailed examination of the monitoring system specifications and installation location in 2025-2026 · Procurement and installation of the monitoring system in 2032-2033:	42.92 million Php	· Examination of the possibility of budget acquisition through support from Japanese government · Consider expanding monitoring system for four retarding ponds not included in priority project
2	Setting warning water level in Davao River corresponding to the latest river and social conditions	Reexamination and approval of PAGASA flood warning water levels at Waan Bridge and Davao River Bridge	· Reexamination of flood warning water level according to the progress of structural measures in 2023, 2028, 2030, 2032, 2039	0.25 million Php	· Further discussions and examinations among related organizations in consideration of lead time for information dissemination and evacuation
3	Preparation of IEC materials on the proposed structural measures and non-structural measures	Preparation of the first draft of IEC materials for public awareness on flood control measures and for introduction of the flood control Master Plan	· Update and distribution of the IEC materials according to the progress of structural measures in 2022, 2033, 2039, 2046	30.40 million Php	· Utilization of the IEC materials at the Community Integrated DRR Training Institute · Establishment of continuous update system for the IEC materials · Collaboration with existing materials such as for greening programs
4	Formulation and Update of flood hazard map for riverine, inland and coastal with evacuation information	Formulation of hazard map along Davao River that integrates three types of disasters using the inundation simulation results of riverine flood, inland flood, and storm surge	· Update and distribution of hazard maps according to the progress of structural measures in 2022, 2033, 2039, 2046	39.00 million Php	· Establishment of continuous update system for hazard maps · Review of evacuation plan
5	Land use control along the proposed structural measures	Update and revision of MGB flood risk information referenced in CLUP based on the results of flood inundation simulation conducted in this project	· Revision of CLUP according to the progress of structural measures in 2025, 2034	Unnecessary	· Update of CLUP based on the updated MGB flood risk information · Strong land use regulations in high risk flood areas
6	Capacity enhancement project on riverine flood, rainwater drainage and coastal management in Davao	Advice of necessary activities for capacity enhancement project for urban drainage management	· Implementation of capacity enhancement project in a few years	TBC by DPWH and a cooperation agency/ donor	· Create a good practice involving local governments in the pilot area and promote initiatives with an eye on future nationwide expansion

Source: JICA Project Team

4.3 Operation and Maintenance

4.3.1 Current Operation and Maintenance Practice on Flood Control Works in Davao River

(1) Current Implementation System of Flood Control Projects in Davao River

DPWH District Engineering Office (DEO) has been conducting plan, design and construction for flood control works in the Davao River. Since the project scale DPWH-DEO can deal with is limited to the project cost of 100 million pesos, the entire works has been divided into the project whose cost is less than 100 million pesos. The works has been mainly construction of dyke and revetment.

(2) Current Implementation System of Operation and Maintenance of Flood Control Works in Davao River

1) Operation and maintenance of flood control facilities

The flood control facilities constructed by DPWH project is basically operated and maintained by DPWH.

2) Major repair works of flood control facilities

The major repair works of severely damaged flood control facilities are implemented as asset projects. The planning section of DPWH-DEO conducts plan and design. The planning division of DPWH-RO oversees the plan and design of DPWH-DEO.

3) Maintenance dredging of river channel

The dredging work is mainly implemented by administration. The dredging of river channel has been planned and proposed by the planning section of DPWH-DEO and the planning division of DPWH-Regional Office (RO), and has been implemented by the Equipment Management Division (EMD) of DPWH-RO.

It should be noted that the Technical Working Group for coordinating desilting activities in the rivers and streams in Davao City was created in 2018 by Davao City EO 2018-09.

4) Control of Illegal Activities along Channel and Quarrying / Mining of Riverbed by Private Sectors

The illegal activities along the Davao River are basically controlled by Davao City. DPWH-DEO can monitor the illegal activities in the river area and recommend necessary actions to Davao City.

5) Problems related to Operation and Maintenance for Flood Control Works based on Current Operation and Maintenance Practice in Davao River

The following problems related to operation and maintenance for flood control works based on the current operation and maintenance practice in the Davao River was identified.

a) Operation and maintenance of flood control facilities:

- The database for inventory of flood control facilities is just being started operation. Its use should be promoted to ensure proper maintenance.

b) Maintenance dredging of river channel

- Frequent siltation of river mouth
- Unserviceable old dredger for river mouth of the Davao River
- Insufficient budget for dredging project (less than 10% of requested budget is approved.)

c) Control of Illegal Activities along Channel and Quarrying / Mining of Riverbed by Private Sectors

- Possible instability of river channel due to quarrying and mining of riverbed by private company
- Uncontrollable illegal activities including informal settling along the channel

- Insufficient monitoring of river channel change

(3) Experiences on Operation and Maintenance of Flood Control Works in Other Rivers

Some flood control facilities constructed by the project handled by FCMC-UPMO are handed over to the DPWH-RO and the operation and maintenance of the facilities is mainly conducted by DPWH-RO and DEO. Typical example of this case is Iloilo River flood control project.

In some cases, the flood control facilities are handed over to the relevant LGUs and the operation and maintenance of the facilities is mainly conducted by LGUs based on the agreed Memorandum of Agreement (MOA). It is said that the Ormoc flood control project is the typical good example that LGUs mainly conduct the operation and maintenance successfully. Some other projects such as Cavite flood control project follow this good example.

However, also according to FCMC-UPMO, there have been many cases that the operation and maintenance by LGUs does not function properly as follows.

In major river basin which is relatively large scale, the operation and maintenance mainly by LGUs seems not function properly, in general.

4.3.2 Operation and Maintenance for Proposed Flood Control Works in Davao River

(1) Work Items for Proposed Flood Control Works in Davao River

The proposed flood control works in the Davao River are as follows.

a) Retarding pond

b) River channel improvement: Dredging, Cut-off work and River widening

The operation and maintenance should be properly conducted for these proposed works in addition to the existing facilities.

(2) Assumed Role among DPWH Offices considering Current Practice on Operation and Maintenance for Flood Control Works in Davao River

Considering the current practice on operation and maintenance for flood control works in the Davao River, the role among DPWH offices are assumed as shown in Table 4.3.1.

Table 4.3.1 Assumed Role among DPWH Offices considering Current Practice on Operation and Maintenance for Flood Control Works in Davao River

	Construction	O&M (Regular)	O&M (Major Repair)
Retarding pond / Cut-off Work / Channel Widening	FCMC-UPMO (FS, DD, construction) RO/DEO (assisting for securing ROW)	FCMC-UPMO (Monitoring, Support budgeting) RO (Budgeting, Monitoring) DEO (Implementation)	FCMC-UPMO (Monitoring, Support budgeting) RO/DEO (Plan) DEO (Implementation)
Dredging	FCMC-UPMO or Planning Div.-RO (Plan) EMD-RO (Implementation)	FCMC-UPMO (Monitoring, Support budgeting) Planning Div.-RO/ Planning Sec.-DEO (Plan, Monitoring) EMD-RO (Implementation)	

Source: Project Team

(3) Required Regular Operation and Maintenance Activities

Table 4.3.2 shows the required regular operation and maintenance activities for the flood control facilities in the Davao River.

Table 4.3.2 Required Regular Operation and Maintenance Activities for Flood Control Facilities in Davao River.

Type of Works	Items	
	Ordinary time	During/After flood event
Retarding Pond	1) Periodical inspection of structures such as riprap, concrete wall, gates and overflow dike 2) Monitoring of illegal activities inside the retarding pond 3) Periodical cleaning of retarding pond including removal of sediment and garbage	During flood event 1) Sharing information of status of retarding pond including water level around retarding ponds with relevant organizations in real time After flood event 2) Operation of gates and monitoring of drainage of stored water by gravity just after the flood event 3) Checking the status of structures 4) Urgent removal of deposited sediment and garbage, especially around the gates to ensure their proper function
River Channel Improvement	1) Periodical inspection of structures such as riprap, concrete wall and cross drain. 2) Monitoring of illegal activities along the channel 3) Monitoring of quarrying and mining of river by private sector and making recommendation 4) Monitoring and evaluation of change in river topography	During flood event 1) Sharing information of status of channel with relevant organizations in real time After flood event 2) Checking the status of structures

Source: Project Team

(4) Maintenance Dredging

The necessary maintenance dredging volume was preliminary estimated using HEC-RAS One-dimensional quasi-unsteady sediment transport analysis. The estimated volume for annual maintenance dredging is shown in Table 4.3.3.

Table 4.3.3 Estimated Volume for Annual Maintenance Dredging

	Only dredging	Dredging + Cut-off Work	Dredging + Cut-off Work + Channel Widening
Estimated Annual Maintenance Dredging Volume (TCM (Thousand m^3)/year)	125	165	155
Note	No maintenance dredging of the planned cut-off reach.	The maintenance dredging of the old channel is not included.	The maintenance dredging of the old channel is not included.

Source: Project Team

(5) Expected Volume of Sediment Deposition in Retarding Ponds

The expected volume of sediment deposition was also preliminary estimated. The expected annual volume of sediment deposition in retarding ponds is estimated at about 6 thousand cubic meter(TCM)/year for the three retarding ponds for the priority project.

(6) Issues on Operation and Maintenance for Proposed Flood Control Works in Davao River

The issues on operation and maintenance for the proposed flood control works in the Davao River are shown below.

1) Capacity enhancement of regular operation and maintenance
2) Securing budget for major repairs and maintenance dredging

3) Proper coordination among DPWH-RO, DEO and relevant offices

4.3.3 Proposed Organizational Framework for Operation and Maintenance for Proposed Flood Control Works in Davao River

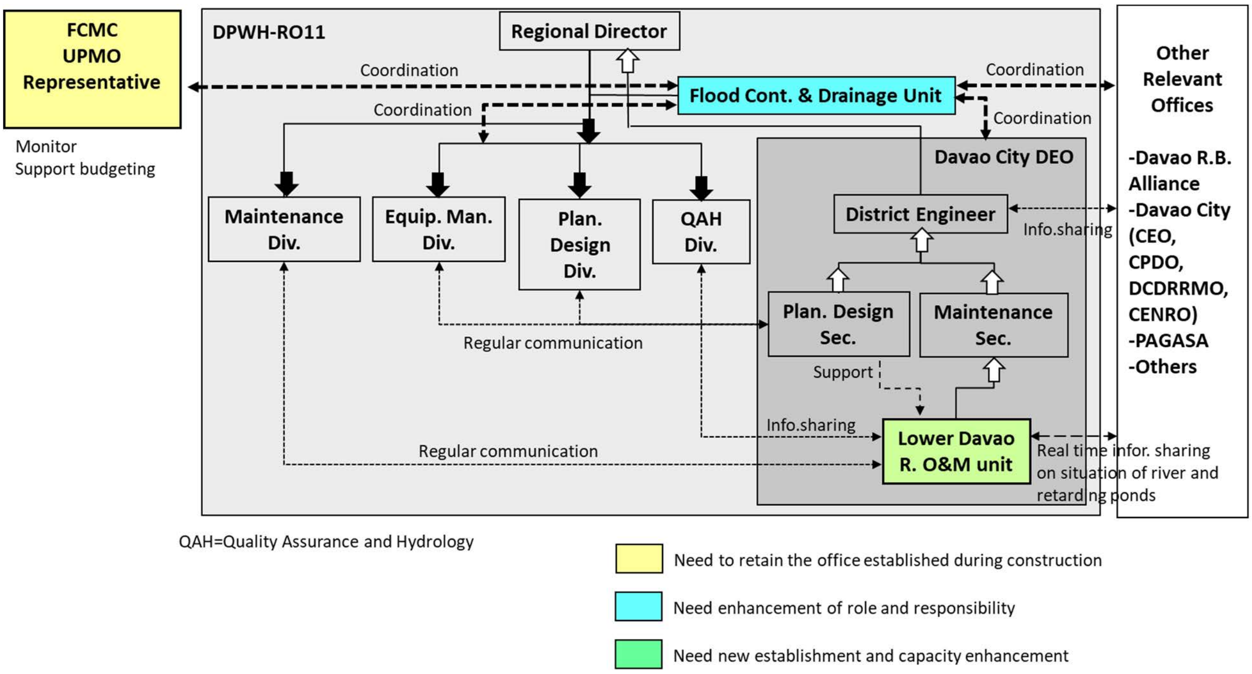
(1) DEO to be responsible for the Lower Davao River

The proposed retarding ponds are located somehow between the territory of Davao City DEO and Davao City II DEO. Considering that the lower Davao River is mostly in the territory of Davao City DEO, it is recommended that Davao City DEO be responsible for all the proposed retarding ponds and the lower reach of the Davao River (Downstream reach from 30km point from the river mouth).

(2) Proposed Organizational Framework for Operation and Maintenance

The proposed organization framework for operation and maintenance is presented in Figure 4.3.1 and the proposed role of each office is shown in Table 4.3.4.

It is proposed to create exclusive new unit which is responsible for the implementation of operation and maintenance of flood control works in the Lower Davao River under the Maintenance Section of Davao City DEO.



Source: Project Team

Figure 4.3.1 Proposed Organization Framework for Operation and Maintenance

Table 4.3.4 Proposed Role of FCMC-PMO, Relevant Divisions, Sections and Units in DPWH-RO and DEO

	UPMO/Division / Section / Unit	Role
FCMC	UPMO	• Monitor O&M activities of the Lower Davao River • Support budgeting for O&M activities, especially for major repair work
RO	Flood Control & Drainage Unit	• Coordinate O&M activities on flood control and drainage among DPWH FCMC-UPMO, RO/DEO and with other relevant offices
	Maintenance Division	• Coordinate and monitor the regular maintenance activities of flood control facilities, including managing inventory of flood

	UPMO/Division / Section / Unit	Role
		control facilities and securing budget for regular and emergent maintenance work • Secure budget for all O&M activities by MOOE (Maintenance and Other Operating Expenses)
	Equipment Management Division	• Maintain dredging equipment • Implement dredging operations
	Planning and Design Division	• Coordinate and monitor the planning and design of major repair works of flood control facilities and maintenance dredging
	Quality Assurance and Hydrology Division	• Manage hydrological data
DEO	Lower Davao River O&M unit	• Conduct regular operation and maintenance activities for Lower Davao River
	Maintenance Section	• Supervise the activities of Lower Davao River O&M unit
	Planning and Design Section	• Support the activities of the Lower Davao River O&M unit, especially for monitoring of river channel • Plan and design of major repair works of flood control structures and maintenance dredging

Source: Project Team

4.3.4 Recommendation

(1) Securing Budget for Operation and Maintenance

(2) Enhancement of Regular Operation and Maintenance

1) Monitoring of river channel change

2) Inspection of flood control facilities

3) Monitoring of illegal activities along river channel and quarrying and mining of riverbed by private sector

4) Collaboration with other relevant offices

(3) Procurement of Appropriate Dredging and Other Support Equipment for Davao River

1) River dredger for river mouth of Davao River

2) Other Support Equipment

(4) Organizational Strengthening

1) Amendment of roles of Flood Control and Drainage Unit in DPWH-RO XI

2) Allocate funds for additional manpower in view of creation of Lower Davao River Basin O&M Unit in Davao City DEO and enhancement of Flood Control and Drainage Unit in DPWH-RO XI

4.4 Construction Plan and Cost Estimate

4.4.1 General

This chapter describes the construction plan and cost estimation for the Riverbed Dredging, Cut-off Works and Retarding Ponds selected as the priority projects for the Davao River, after clarifying the construction procedures based on the local conditions. In the construction planning and cost estimation, the process and construction method should be reviewed in consideration of necessary construction conditions, such as access to the construction site and the method of procurement of materials and equipment.

4.4.2 Construction Plan and Schedule

(1) Scope of Work

For the major works in this project, i.e., River Channel Dredging, Cut-off, and Retarding Pond, the summary of the project (Contents of major works) are shown in Table 4.4.1, and the major construction quantities are shown in Table 4.4.2, respectively.

Table 4.4.1 Summary of the Project

Item	Descriptions	
Dredging	Scope：River Mouth ~ 23km	
	Dredging Volume：1,270,000m^3	
Cut-off	Scope：6+500 – 12+700, Cut-off in meandering river section	
	Excavation Volume： 1,010,100 m^3	
Retarding Ponds	Scope、Location （Distance from River Mouth, Right/ Left bank）：	RP 08: 29.0km (Right bank)
		RP 09: 27.2km (Left bank)
		RP 10: 23.8km (Left bank)
	Excavation Volume：Total 12,171,000 m^3	

Source: Project Team

Table 4.4.2 Quantity of Major Works of the Project

	Item	Unit	Quantity			
			Dredging	Cut-off	Retarding Basin	**Total**
1	Dredging-soils (using Backhoe on Barge)	m3	686,000			686,000
2	Dredging-soils (using Pump Dredger)	m3	584,000			584,000
3	Channel Excavation (Loading and Transportation)	m3	890,000			890,000
4	Embankment (at Disposal area)	m3	890,000	1,001,100	12,090,000	13,981,100
5	Channel Excavation (Excavation-Loading-Transportation)	m3		1,010,100	12,171,000	13,181,100
6	Embankment (for Dike)	m3		9,000	81,000	90,000
7	Concrete Revetment (t=30cm)	m3		14,287	38,001	52,287
8	Gabion (t=50cm) - Foot Protection	m3		6,684	269,841	276,525
9	Concrete Block - Slope Toe Protection	m3		2,001	2,516	4,517
10	RC Wall (Reinforced concrete)	m3		7,514	47,000	54,514
11	RC Wall back-filling (crushed stone)	m3		4,704	268,663	273,367
12	RC Wall base (crushed stone)	m3		729	21,150	21,879
13	Steel Sheet Piles , Furnished	m		8,125		
14	Steel Sheet Piles, for temporary works, without materials	m		8,125		
15	Bridge	LS		1		1
16	Sheet Pile (Slope Protection), Type-3	m			47,000	
17	Sheet Pile (Slope Protection), Type-2	m			268,663	
18	Impermeable Liner	m2			297,151	297,151
19	Installing Drainage Gate	m2			48	48

Source: Project Team

(2) Basic Conditions of Construction Plan

1) Working Days

The working days is determined in consideration of Sundays (6 days per week), national holidays, maintenance days for machinery, etc., and days when it is suspended due to rainfall. Table 4.4.3 summarizes the number of days that can be constructed per year to be used in the preparation of the construction plan for this project. The target types of work were excavation work, dredging work, embankment work (including soil disposal work), concrete work, revetment work, drainage work, and road work.

Table 4.4.3 Workable Days of Each Type of Work in a Year

	Sunday	Holiday	Machine Maintenance Day	Rainy Day (>10mm)	Rainy Days on Non-Working Day	Rainy Days on Working Day	Additional Suspended Day	Workable Day / Year
Structural Excavation	52	18	12	36	4	32	8	243
Dredging	52	18	12	36	4	32	0	251
Embankment/ Backfill	52	18	12	36	4	32	8	243
Concrete Works	52	18	12	36	4	32	0	251
Revetment Works	52	18	12	36	4	32	0	251
Drainage Works	52	18	12	36	4	32	8	243
Road Works	52	18	12	36	4	32	8	243

Source: Project Team

2) Working Hours

In consideration of the normal working hours in the Philippines, the working hours shall be set at 8 hours per day.

3) Access Road

The construction site under this plan is located along the Davao River, and a construction access road will be required from the main road to the construction site and along the river. The width of the road is assumed to be 10 m.

4) Disposal Sites

The project will generate a large amount of excavated sediment due to the large amount of excavation work to be performed. The total volume is about 14 million m^3 in Dredging, Cut-off, and Retarding Pond.

The locations of the disposal sites are to be determined by DPWH prior to the start of construction. However, candidate sites are proposed here for reference. Currently, possible candidate soil dumping sites are Option 1 through Option 4, and a summary of each is shown below.

Option 1: Existing/Planned Disposal Sites

The existing or planned disposal sites are determined on a construction-by-construction basis and are already assigned to each project; therefore, they will be difficult to be used for this project.

Option 2: Residential Land Development and Other Future Projects

Potential embankment sites may arise that could be used for future residential land development or other projects. In particular, the potential for use in residential land development may be high, but it is not possible to identify the location or predict the amount of soil to be used at this time.

Option 3: Coastal Reclamation

A proposal for coastal reclamation in Davao City was considered. For the eight low elevation coastal reclamation parcels shown in Figure 4.4.1, the amount of soil used would be approximately 940,000 m^3 if fill were to be placed to 1.5 m above mean sea level. This is very small compared to the total excavation volume and cannot be used as the main soil disposal site.

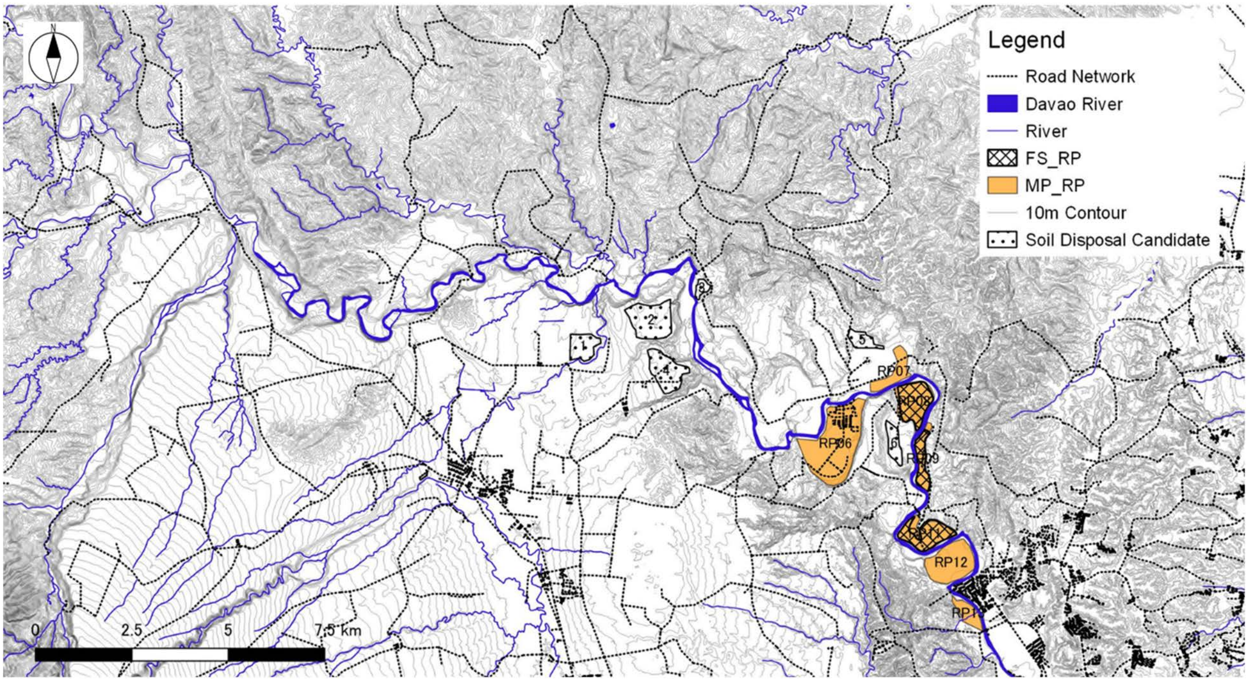
Source: Project Team

Figure 4.4.1 Potential Reclamation Locations along the Davao Coast

Option 4: New Disposal Sites

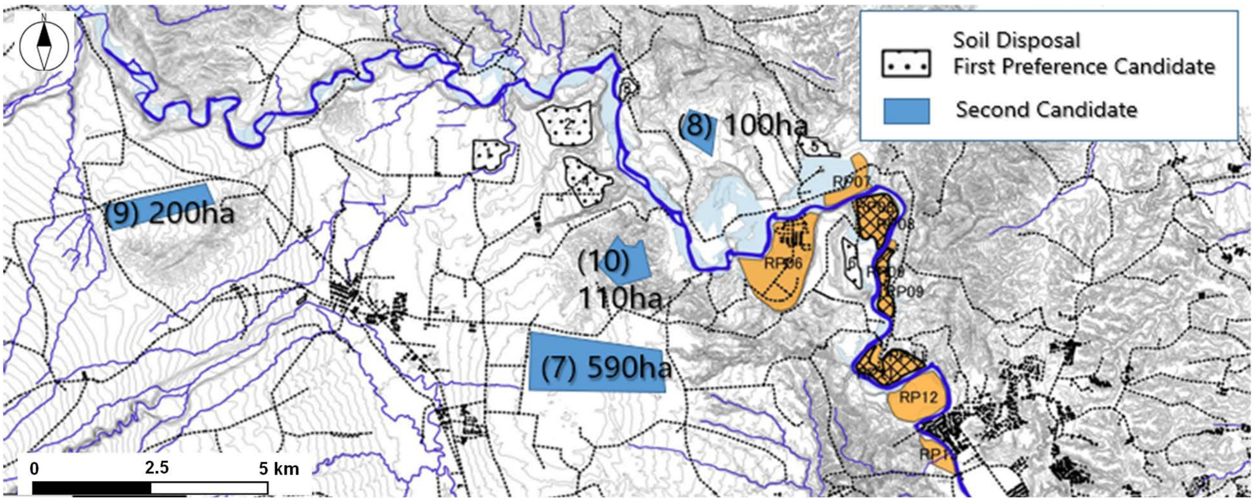
New disposal sites were considered, and the current proposed candidates (first preference candidates) are shown in Figure 4.4.2. In the study, natural environmental sensitivity, social environmental considerations, current land use, future land use (CLUP 2019-2028), inundation conditions during major floods, and the fact that the area can be used as natural floodplain and should not be developed were taken into account. The total area of six sites shown in the figure is 2,680,000 m^2, which provides a capacity of about 15,000,000 m^3.

If it is considered difficult to secure these disposal sites, which are the first preference candidates, we further propose No. 7 to 10 as second candidates (Figure 4.4.3). These candidate areas will pose somewhat more difficulties than the first preference candidate due to the longer hauling distances, slightly higher natural environmental sensitivity, and more expensive drainage measures due to reclamation into the valley.



Source: Project Team

Figure 4.4.2 Potential Disposal Sites upstream of the Davao River (First Preference Candidate)



Source: Project Team

Figure 4.4.3 Potential Disposal Sites upstream of the Davao River (Second Candidate)

Although the above four options have been discussed, from the viewpoint of certainty, the use of the six new disposal sites (plus additional four sites will also be considered) indicated in Option 4 is the basic approach, and if the timing of construction allows for effective use of excavated earth in the future, such as in the development of residential land in Option 2, then such soil transportation plan will be conducted.

(3) Labor, Equipment and Material for Construction

1) Labor

All labor can be procured in Davao City and surrounding cities.

2) Equipment

Most of the equipment can be procured in Davao City, surrounding cities, and in the Philippines. As for dredgers and dredging machines, it is possible to obtain them from Japan or third countries from the viewpoint of construction efficiency.

3) Material

Most of the materials such as revetment can be procured in Davao City, surrounding cities, and in the Philippines. However, materials that are not manufactured in the Philippines, such as through-slap gates made of steel or duplex stainless steel, hat-type steel sheet piles, etc., which may be possible by utilizing foreign technology, shall be obtained from Japan or a third country.

(4) Construction Method

1) Dredging

a) General

The dredging area is 23 km from the mouth of the river. The dredging will be performed at each cross-section of the river to excavate a section higher than the design riverbed to provide the required cross-section. The dredging quantities calculated from the cross-sections every 500 m is about 1.27 million m^3. There are six bridges in the construction area, and dredging will not be conducted for 100m upstream and downstream of the bridges for safety reasons.

b) Dredging Method

The dredging will be estimated to taken up to 7 years. The amount of dredging is approximately 1,270,000 m^3, which means that approximately 200,000 m^3 will be dredged per year. The construction period is 251 days, which means that more than 800m^3/day will be dredged. In this project, underwater dredging will be the main type of work. Underwater dredging may be performed by either a pump dredger (Cutter Suction Dredger), grab dredger, or backhoe dredger.

Considering conditions such as water depth, daily construction volume, and physical properties of the sediment to be dredged, pump dredging is applied to the section of silty and sandy soil up to 10 km from the river mouth, and backhoe dredging, which is considered to be versatile and easy to obtain equipment, is applied to the section upstream of that where gravel is mixed, as a recommended proposal. The dredged material is dried in a temporary storage area, loaded onto dump trucks, transported to a designated soil disposal sites, and spread out (or compacted, depending on the location) for fill and reclamation. Table 4.4.4 shows the dredging quantities by dredging method.

Table 4.4.4 Quantities by Dredging Method

Item	Unit	Dredging (Using Cutter Suction Dredger)	Dredging (Using Backhoe on Barge)
Scope		River Mouth ～ 10.0km	10.0 ～ 23.0km
Sub-Total	(m^3)	647,000	702,000
Deduction (Bridge Area)	(m^3)	63,000	16,000
Dredging Total Quantity	(m^3)	584,000	686,000
		1,270,000	
Loading, Transportation	(m^3)	890,000	
Embankment (at Disposal area)	(m^3)	890,000	

Source: Project Team

Since the dredging method will actually be adopted by the contractor's specialty, other methods such as Grab Dredging and Sand Pump Dredging (Submerged Dredging Pump) that can dredge gravel are also likely to be used. Ejector pump, a Japanese technology, may also be applied.

Maintenance dredging is planned after the F/S project is implemented.

In discussions with DPWH BOE and RO XI, backhoe dredging is recommended because of the difficulty of flood countermeasures for pump dredging, and the purchase of backhoe deck barges and dump trucks are being considered. Although backhoe dredging is more expensive due to its lower construction efficiency, it can be adopted as a reliable method. On the other hand, if other construction methods, such as dredgers owned by the contractor, can be used at a lower cost, then the adoption of these methods should be actively considered.

2) Cut-off Works

a) General

The Cut-off is a project for the meandering sections of the river, and the targeted section is from 6+500 to 12+700. The construction quantities for the shortcut sections are also shown in Table 4.4.5.

Table 4.4.5 Quantity of Cut-off

Item			Total
1	Channel Excavation (Excavation-Loading-Transportation)	m3	1,010,100
2	Embankment (for Dike)	m3	9,000
3	Embankment (at Disposal area)	m3	1,001,100
4	Concrete Revetment (t=30cm)	m3	14,287
5	Gabion (t=50cm) - Foot Protection	m3	6,684
6	Concrete Block - Slope Toe Protection	m3	2,001
7	RC Wall (Reinforced concrete)	m3	7,514
8	RC Wall back-filling (crushed stone)	m3	4,704
9	RC Wall base (crushed stone)	m3	729
10	Steel Sheet Piles , Furnished	m	8,125
11	Steel Sheet Piles, for temporary works, without materials	m	8,125

Source: Project Team

b) Construction Flow Chart

In the area where the Cut-off is to be implemented, the roads will be divided by the river, so that bridges will be constructed. To ensure economical way, construction should be performed prior to the diversion.

Construction of the Cut-off section will be done from the downstream side. The channel widening and Cut-off will be done by excavation followed by installing revetment. During the construction, the procedure should be carried out to prevent water from entering the construction area, and excavation should be conducted in the driest condition possible. Since excavation is to be carried out in dry conditions, temporary closure using steel sheet piles, etc., should be implemented as necessary to complete the excavation of the portion necessary to construct the revetment. The sediment remaining on the riverbed will be dredged underwater after the temporary closure is removed. After excavation of the revetment area is completed, revetment mats and concrete revetment will be constructed.

c) Installation of Bridges

Bridge erection is initially carried out in dry conditions. After excavation and substructure construction (pile work, footings, and pier concrete), shoring is installed and concrete is taken place for the girders.

3) Retarding Pond

a) General

Construction of Retarding Pond is planned at three locations, 29.0 km (RP-8, Right bank), 27.2 km (RP-9, Left bank), and 23.8 km (RP-11, Left bank) from the river mouth, with a total area of 200 ha and a total excavation volume of 12.7 million m^3. Table 4.4.6 shows the quantity of construction for each location.

Table 4.4.6 Quantity of Retarding Pond

Item			RP08	RP09	RP11	Total
1	Channel Excavation (Excavation-Loading-Transportation)	m3	5,893,700	1,931,500	4,345,700	12,171,000
2	Embankment (for Dike)	m3	31,100	38,200	11,900	81,000
3	Embankment (at Disposal area)	m3	5,862,613	1,893,240	4,333,752	12,090,000
4	Concrete Revetment (Reinforced Concrete t=50cm)	m3	38,001	0	0	38,001
5	Gabion (t=50cm)	m3	54,641	83,944	131,256	269,841
6	RC wall for heightening the crest (from 25.30 to 27.50)	m3	2,516	0	0	2,516
7	Steel Sheet Pile - riverside (SP-III)	m	47,000	0	0	47,000
8	Steel Sheet Pile - pond side (SP-II)	m	176,250	22,563	69,850	268,663
9	Foot Protection (Local Boulders - max size)	m3	21,150	0	0	21,150
10	Impermeable Liner	m2	55,600	85,629	155,922	297,151
11	Installing Drainage Gate	m2	16	16	16	48

Source: Project Team

b) Construction Flow Chart

Because of the large amount of excavation in the Retarding Pond, it is recommended to construct at least RP08 and RP11 of which excavation volume are large at the same time. The excavation should be carried out from the river side. Temporary cofferdam shall be taken place with steel sheet piles, etc., if necessary. Then, revetment blocks and revetment concrete are installed at the bottom of the slope, and after the excavation on the floodplain side is completed, the impermeable sheets are set over the slope and the gabion revetment is implemented on it.

(5) Efficiency of Construction Equipment

Table 4.4.7 shows the equipment combinations and work efficiencies for the main types of work for the projects covered by F/S.

Table 4.4.7 Work Efficiency of Equipment

Work Item	Equipment	Productivity			Remarks
		per hr	per day		
Excavation	Bulldozer (140 HT)	50	350	m3	
Loading	Backhoe (0.8 m3)	71	500	m3	
Transportation	Dump Truck (12Yd3)	9 ～ 5.2	63 ～ 36	m3	10km～20km
Spreading	Motorized Road Grader, 140hp	50	350	m3	
	Bulldozer (140 HT)				
Embankment	Vibratory 10mt SD100DC	50	350	m3	
Dredging-soils (using Backhoe on Barge)	Backhoe (0.8m3～)	16 ～ -	112 ～ 630	m3	Dredging
	Deck Barge (600mt DWT～)				
	Scow, 10 m3～				
	Tugboat, 500hp～				
	Payloader (1.5m3)- at Temporary yard				
	Crawler Crane (36-40m)190hp with Bucket				Unloading from
Dredging-soils (using Cutter Suction Dredger, 8"ϕ)	Dredger, 8"ϕ, 225hp～, 1.5km	88 ～ 300	616 ～ 2,100	m3	Dredging
	Motorized Banca, 20 hp				
	Payloader (1.5m3)				at Temporary Yard
Steel Sheet Piles (Slope Protection)	Crawler Crane (36-40mt)	10	70	m	
	Vibro Hammer (201 hp)				

Source: Project Team

(6) Packaging of Contract

International or domestic bidding shall be applied for construction contractor procurement. The contracted construction areas have been compiled into the following three packages, taking into consideration the construction cost, layout of construction structures, and traffic condition.

	Project size (Construction cost, Philippine peso)	Anticipated bids
Package 1: Dredging	1.1 Billion	Local Competitive Bidding
Package 2: Cut-off	1.7 Billion	International Competitive Bidding
Package 3: Retarding Pond	12 Billion	International Competitive Bidding

(7) Proposed Construction Schedule

Construction schedule is shown in Table 4.4.8.

Table 4.4.8 Construction Schedule

Unit		Unit	Quantity	Workable days pre Year	Year	Progress per Day	Year									
							1	2	3	4	5	6	7	8	9	10
1 Dredging																
1-2	Preparation, (Land acquisition, Compensation)	LS	1		3											
1-3	Construction															
1-3-0	Tendering, etc.	LS	1		1											
1-3-1	Dredging-soils (using Backhoe on Barge)	m3	686,000	251	6	448										
1-3-2	Dredging-soils (using Pump Dredger)	m3	584,000	251	4	600										
1-3-3	Channel Excavation (Loading soils from Temporary yard)	m3	890,000	243	4	890										
1-3-4	Embankment (at Embankment area, Disposal area)	m3	890,000	243	4	890										
1-4	Design, Construction Management	LS	1													
2 Cut-off																
2-2	Preparation, (Land acquisition, Compensation)	LS	1		1											
2-3	Construction															
2-3-0	Tendering, etc.	LS	1		1											
2-3-1	Channel Excavation (Excavation-Loading-Transportation)	m3	1,010,100	243	2	2,078										
2-3-2	Embankment (for Dike)	m3	9,000	243	2	19										
2-3-3	Embankment (at Disposal area)	m3	1,001,100	251	2	1,994										
2-3-4	Concrete Revetment (t=30cm)	m3	14,287	251	1	114										
2-3-5	Gabion (t=50cm) - Foot Protection	m3	6,684	251	0	266										
2-3-6	Concrete Block - Slope Toe Protection	m3	2,001	251	0	40										
2-3-7	RC Wall (Reinforced concrete)	m2	7,514	251	1	37										
2-3-8	RC Wall back-filling (crushed stone)	m3	4,704	251	0	40										
2-3-9	RC Wall base (crushed stone)	m2	729	251	0											
2-3-10	Steel Sheet Piles , Furnished	m2	8,125	251	0	62										
2-3-11	Steel Sheet Piles, for temporary works, without materials	m3	8,125	251	0											
2-3-12	Bridges	LS	1	251	1											
2-4	Design, Construction Management	LS	1		0											
3 Retarding Pond																
3-2	Preparation, (Land acquisition, Compensation)	LS	1		1											
3-3	Construction															
3-3-0	Tendering, etc.	LS	1		1											
3-3-1	Channel Excavation (Excavation-Loading-Transportation)	m3	12,171,000	243	7	7,155										
3-3-2	Embankment (for Dike)	m3	12,090,000	243	7	7,108										
3-3-3	Embankment (at Disposal area)	m3	54,491	251	3	72										
3-3-4	Concrete Revetment (Reinforced Concrete t=50cm)	m3	236,285	251	3	314										
3-3-5	Gabion (t=50cm)	m3	9,506	251	1	38										
3-3-6	RC wall for heightening the crest (from 25.30 to 27.50)	m2	60,000	251	5	48										
3-3-7	Sheet Pile (Slope Protection), Type-3	m2	268,663	251	5	214										
3-3-8	Sheet Pile (Slope Protection), Type-2	m3	9,506	251	3	28										
3-3-9	Foot Protection (Local Boulders - max size)	m3	21,150	251	3	324										
3-3-10	Impermeable Liner	m2	243,790	251	3	324										
3-3-11	Installing Drainage Gate	LS	1	251	1	0										
3-4	Design, Construction Management	LS	1		0											

Source: Project Team

4.4.3 Cost Estimate

(1) Conditions and Assumptions for Cost Estimate

1) Components of Project Cost

The construction cost was estimated using the construction unit cost method, referring to the Manual for Design and Estimation of Preparatory Studies for Cooperation, Trial Version (JICA, March 2009). The main cost items of the project cost consist of Project Management Cost, Preparation Cost, Construction & Procurement Cost, Consulting Service Cost, Contingency Cost, Technical Training Cost, Operation and Maintenance Cost. Unit rate was basically referenced to DPWH data.

2) Date of Implementation of Cost Estimation

The date for cost estimation shall be as of June 1, 2022. DPWH data for 2021 was used as the main base unit price for the cost estimation.

3) Currency Conversion

For currency conversion, the base foreign exchange rate (U.S. dollar) shall be 126 Japanese yen for every 1 U.S. dollar of the U.S. currency, as the figure to be applied during June 2022, as announced by the Bank of Japan. The arbitrage foreign exchange rate (for Philippine peso) shall be US$0.0192 per Philippine peso as the market rate of the relevant currency against the U.S. currency during April 2022, as arbitrated by the reference foreign exchange rate. Based on the above, 1 Philippine peso = (126 x 0.0192=) 2.419 yen.

4) Currency

Local and foreign currencies will be used in this project, but the evaluation will be made in terms of local currency. The distinction between local and foreign currencies will generally be as follows

a) Local currency
- Labor cost, Part of material cost, Part of equipment cost, Taxes

b) Foreign currency
- Cost of materials requiring high quality comparable to foreign products
- Cost of equipment requiring high quality comparable to foreign products

The allocation between local and foreign currencies was set with reference to other JICA projects in the Philippines. Table 4.4.9 shows the ratio adopted for this project with reference to the currency ratios of other projects.

Table 4.4.9 Currency Allocation and Ratio Adopted

Item		Agno	Iloilo	Laoag	Piatubo Bamban Abacan	West Pinatubo	Cavite Lowland	Kagayan	Davao	
									LC Portion	FC Portion
Labor		0	0	0	0	0	0	0	100	0
Equipment		100	70	70	70	70	70	70	30	70
Material										
	Fuel	50	-	-	-	-	-	-	-	-
	Fuel and Lubricant	-	80	70	80	70	70	70	30	70
	Wood/Stone/Sand	-	10	-	-	-	10	0	100	0
	Crushed/Uncrushed Stone material	-	-	40	40	40	-	40	60	40
	Lumber	-	-	40	40	40	-	40	60	40
	Cement	65	70	70	70	70	70	70	30	70
	Re-bar	65	90	80	80	80	90	90	10	90
	Structural Steel	100	90	90	90	-	90	90	10	90
	Chemical Product	-	90	-	-	-	90	90	10	90
	Bituminous Material	-	-	-	60	-	-	90	10	90
	Others	0	-	-	-	50	-	0	100	0

Source: Project Team

5) References

The following guidelines and criteria were used in the estimation process.

- Manual for Design and Estimation of Preparatory Studies for Cooperation, Trial Version (JICA, March 2009)
- DPWH, Flood Control and Drainage Construction Cost Estimation Manual (2017)
- DPWH, Standard Labor Rates for DPWH Regional/District Engineering Office (December 31, 2021)
- DPWH, Construction Material Price Data (DPWH, 4 Quarter, 2021)
- DPWH, List of Equipment Adopted in the Standard Dupa for Road, Bridge and Building (Low & High Rise) Construction Cost Estimation Manuals with Make, Model, Capacity and Operated Rental Rate per Hour Based on the Prevailing Acel Equipment Guidebook, Edition 26 (October 20, 2021)
- Ministry of Land, Infrastructure, Transport and Tourism, Estimation Standard for Civil Engineering Works 2022
- Japan Institute of Country-ology and Engineering, (JICE), River Earthworks Manual

(2) Project Management Cost

As in the Master Plan, the project management cost was set at 3.5% of the total amount of Construction & Procurement Cost, Consulting Service cost, and Contingency Cost.

(3) Preparation Cost

1) General

Preparation Cost consist of Site Acquisition Cost, Compensation Cost, removal, and Environmental Impact Assessment (EIA) Cost.

2) Site Acquisition Cost

Land acquisition costs were calculated using the unit cost of land established for each land category. The unit price for agricultural land was set at 60 PhP/m^2 (30 PhP/m^2 for Retarding Pond and Disposal Site), while the unit price for commercial, planned development, and residential areas was set at 12,180 PhP/m^2 , 6,860 PhP/m^2 , and 2,150 PhP/m^2 , respectively.

3) Compensation Cost

The cost was assumed to be the cost required to construct a new building at the relocation site that is equivalent to the site area of the building existing in the area required for the implementation of the measures. In this case, the cost was set at PhP130,000 per building unit.

4) Removal Cost

As with the Master Plan, 20% of the cost of the building relocation was set as the Removal Cost.

5) Environmental Impact Assessment (EIA) Cost

It was assumed to be included in the Common Temporary Cost of Construction and Procurement cost.

(4) Construction and Procurement Cost

1) General

Construction and Procurement Costs consist of Construction Cost, consisting of Civil and Building Construction Cost, and Equipment Procurement Costs. The main component of this project is the Civil Construction Cost. The Civil Construction Cost consists of the sum of Direct Construction Cost and Indirect Construction Cost (Common Temporary Cost and Site Management Cost), plus General and Administrative Cost.

2) Direct Cost

In this Project, labor, equipment, rental, and material costs were accumulated based on DPWH's "Flood Control and Drainage Construction Cost Estimation Manual (2017)," which describes standard construction cost estimates. Rental and material costs were accumulated. Modifications were made to the application as necessary depending on the scope of work.

a) Labor Cost

Labor rates were taken from the DPWH memorandum, "Standard Labor Rates for DPWH Regional/District Engineering Office (December 31, 2021)."

b) Material Cost

Material costs are surveyed by DPWH and updated quarterly. Here, the figures from "Construction Material Price Data (DPWH, 4 Quarter, 2021)" were used as the material unit cost table. For the gate for drainage of the recreational area, a unit cost of 8 million yen/m^2 (3.31Mil. pesos/m^2) per area of gate to be installed was used as the unit construction cost, including equipment costs, with reference to in Japan.

c) Equipment Cost

Hourly equipment rental costs are compiled by the Association of Carriers and Construction Equipment Lessors (ACEL) in a guidebook, and DPWH project costs are organized in the form of DUPAs based on that guidebook. The DPWH memorandum, List of Equipment Adopted in the Standard Dupa for Road, Bridge and Building (Low & High Rise) Construction Cost Estimation Manuals with Make, Model, Capacity and Operated Rental Rate per Hour Based on the Prevailing Acel Equipment Guidebook, Edition 26 (DPWH, October 20, 2021) is used for the equipment cost.

d) Other Cost

Work items that would be listed as necessary for the detailed design stage were included as other cost. These costs were set at 10% for Dredging and Cut-off areas, and 5% for Retarding Pond areas with high construction volumes.

3) Indirect Cost

Indirect Construction Cost consists of Common Temporary Construction Cost and Site Management Cost.

a) Common Temporary Facility Cost

Common Temporary Facility Cost is commonly required for each construction project to indirectly construct the object.

Common Temporary Facility Cost = Direct Construction Cost x Common Temporary Construction Cost rate + Accumulated amount

In this Project, the rate portion of common temporary facilities cost was assumed to be 4% of the Direct Construction Cost. In addition, the accumulated amount was adopted as 2% of the Direct Construction Cost.

b) Site Management Cost

Site Management Cost is calculated by multiplying the net construction cost, which is the total of Direct Construction Cost and Common Temporary Construction Cost, by the site management cost rate.

Site Management Cost = Net Construction Cost (Direct Construction Cost + Common Temporary Facility Cost) x site management cost ratio

In this Project, the site management cost rate is calculated as 15%, which is multiplied by the Net Construction Cost.

4) General Management Cost

General Management Cost is calculated by multiplying the Construction (Prime) Cost, which is the sum of Direct Construction Cost and Indirect Construction Cost (Common Temporary Facility Cost and General Management Cost), by the general management ratio.

General Management Cost = Construction (Prime) Cost (Direct Construction Cost + Indirect Construction Cost (Common Temporary Facility Cost + Site Management Cost)) x general management rate

In this Project, General Management Cost is calculated as 10% of the Construction (Prime) Cost.

(5) Consultant Service Cost

1) General

The Consultant Service Cost consists of the Detailed Design Cost and Construction Management Cost.

2) Detailed Design Cost

The Detailed Design Cost was set at 10% of the Construction and Procurement cost.

3) Construction Management Cost

The Construction Management Cost was set at 8% of the Construction and Procurement Cost.

(6) Contingency Cost

1) General

The cost is composed of Price Contingency Cost and Physical Contingency Cost.

2) Price Contingency

It was assumed at 16.6% for the sum of construction and procurement costs and design and supervision costs. The price increase in foreign currency was assumed to be 3.0% on the sum of construction, procurement, and design and supervision costs.

3) Physical Contingency

The Physical Contingency Cost is set at 5% (10% x 50%) of the total Construction and Procurement Costs and Consulting Service Cost.

(7) Technical Cost

It was decided not to take this into account for structures subject to F/S.

4.4.4 Operation and Maintenance Cost

The cost of maintenance dredging per year, which consists of the construction and procurement costs and design supervision costs, and 0.5% of the Construction and Procurement Costs for the Cut-off Works and Retarding Ponds are considered as the annual required Operation and Maintenance Cost. Since Operation and Maintenance Cost is required after the construction period, no costs are incurred during construction.

4.4.5 Project Cost

(1) Project Cost estimated based on Methodology, Conditions and Assumptions set in the Previous Sections of 4.4.3 and 4.4.4

The estimated project costs are shown in Table 4.4.10. Project costs were calculated using the method described above, and the total project cost for the project as an F/S target is shown at the bottom of the table. Maintenance and management costs are the costs required annually after the construction work is completed.

Table 4.4.10 Project Cost for F/S Project

Item			LC	FC	Total	Description
			(Unit: Million Philippines Pesos)			
1 Project Management Cost			282	418	700	3.5% of the amount of Construction & Procurement Cost, Consulting Service Cost and Contingency Cost.
		Subtotal	282	418	700	
2 Preparation Cost			0	0	0	
2-1	Land Acquisition Cost		889	0	889	Same as Master Plan
2-2	Compensation Cost		8	0	8	Relocating buildings located on the site to implement the measures.
2-3	Removal Cost		2	0	2	20% of the cost required for building transfer
2-4	Environmental Impact Assessment Cost		0	0	0	Included in Common Temporary Facility Cost
		Subtotal	899	0	899	
3 Construction & Procurement Cost			5,619	9,359	14,978	See Construction & Procurement Cost
		Dredging	419	698		7.5%
		Cut-off	639	1,064		11.4%
		Retarding Pond	4,561	7,597		81.2%
		Subtotal	5,619	9,359	14,978	
4 Consultant Service Cost						
4-1	Consultant Service Costfor Civil Work					
	4-1-1	Detail Design Cost	562	936	1,498	10 % of Construction & Procurement Cost
	4-1-2	Construction Management Cost	449	749	1,198	8 % of Construction & Procurement Cost
4-2	Consultant Service Cost for Building		0	0	0	
4-3	Consultant Service Cost for Equipment		0	0	0	
		Subtotal	1,011	1,685	2,696	
5 Contingency Cost			0	0	0	
5-1	Price Contingency		1,104	335	1,439	The price increase cost was assumed to be 16.6% and 3.0% of the total construction and procurement cost and design and supervision cost, respectively, in domestic and foreign currency (compounded over 6 years, respectively, as an average).
5-2	Physical Contingency		332	552	884	5% of the total Construction & Procurement and Consultant Service Cost.
		Subtotal	1,435	888	2,323	
6 Technical Training Cost			0	0	0	
		Subtotal	0	0	0	
7 Operation and Maintenance Cost			0	0	0	
		(1) Dredging (Implementation)	61	122	183	Construction & Procurement Cost for Maintenance Dredging
		(2) Dredging (Consultation)	11	22	33	Consultant Service Cost for Maintenance Dredging
		(3) Cut-off & Retarding Pond	26	43	69	Operation and Maintenance Cost for Cut-off and Retarding Pond
		Subtotal	98	187	285	
Total (Excluding OM Cost)			9,246	12,349	21,595	

Source: Project Team

Based on the results of the study on the priority projects for the measures of riverine flood of Davao River in the F/S stage, the project cost was reviewed only for the M/P of the measures of riverine flood of Davao River. The reviewed project cost is shown in Table 4.4.11.

Table 4.4.11 Construction Cost for M/P Project

Item			LC	FC	Total	Description
			(Unit: Million Philippines Pesos)			
1 Project Management Cost			788	1,166	1,954	3.5% of the amount of Construction & Procurement Cost, Consulting Service Cost and Contingency Cost.
		Subtotal	788	1,166	1,954	
2 Preparation Cost			0	0	0	
2-1	Land Acquisition Cost		1,821	0	1,821	Same as Master Plan
2-2	Compensation Cost		609	0	609	Relocating buildings located on the site to implement the measures.
2-3	Removal Cost		122	0	122	20% of the cost required for building transfer
2-4	Environmental Impact Assessment Cost		0	0	0	Included in Common Temporary Facility Cost
		Subtotal	2,552	0	2,552	
3 Construction & Procurement Cost						See Construction & Procurement Cost
	FS	Dredging	419	698	1,118	
	FS	Cut-off	639	1,064	1,703	
	FS	Retarding Pond	4,561	7,597	12,157	
	MP	River Widening	749	1,248	1,997	
	MP	Retarding Pond	9,323	15,528	24,851	
		Subtotal	15,690	26,135	41,826	
4 Consultant Service Cost						
4-1	Consultant Service Costfor Civil Work					
	4-1-1	Detail Design Cost	1,569	2,614	4,183	10 % of Construction & Procurement Cost
	4-1-2	Construction Management Cost	1,255	2,091	3,346	8 % of Construction & Procurement Cost
4-2	Consultant Service Cost for Building		0	0	0	
4-3	Consultant Service Cost for Equipment		0	0	0	
		Subtotal	2,824	4,704	7,529	
5 Contingency Cost			0	0	0	
5-1	Price Contingency		3,083	937	4,019	The price increase cost was assumed to be 16.6% and 3.0% of the total construction and procurement cost and design and supervision cost, respectively, in domestic and foreign currency (compounded over 6 years, respectively, as an average).
5-2	Physical Contingency		926	1,542	2,468	5% of the total Construction & Procurement and Consultant Service Cost.
		Subtotal	4,008	2,479	6,487	
6 Technical Training Cost			0	0	0	
		Subtotal	0	0	0	
7 Operation and Maintenance Cost			0	0	0	
		(1) Dredging (Implementation)	61	122	183	Construction & Procurement Cost for Maintenance Dredging
		(2) Dredging (Consultation)	11	22	33	Consultant Service Cost for Maintenance Dredging
		(3) Cut-off & Retarding Pond	28	47	75	Operation and Maintenance Cost for Cut-off and Retarding Pond
		Subtotal	100	191	291	
Total (Excluding OM Cost)			25,864	34,484	60,348	

Source: Project Team

(2) Project Cost applying land acquisition cost and compensation cost calculated in the RAP study as well as land unit price applied in the RAP study

For the F/S target project, the project cost was estimated in the above (1) under the conditions specified in Section 4.4.3. On the other hand, in this Project, land acquisition cost and compensation cost were calculated in the RAP study (see Section 4.6.3). Although the land acquisition cost and compensation cost should be studied and examined in detail at the detailed design stage, as reference value for future implementation, the preparation cost was calculated applying the land acquisition cost and compensation cost calculated in the RAP study as well as land unit price applied in the RAP study, and then the project cost was estimated. Table 4.4.12 shows the estimated project cost.

Table 4.4.12 Project Cost for F/S Project (when RAP Study Results are applied)

Item			LC	FC	Total	Description
			(Unit: Million Philippines Pesos)			
1 Project Management Cost			282	418	700	3.5% of the amount of Construction & Procurement Cost, Consulting Service Cost and Contingency Cost.
		Subtotal	282	418	700	
2 Preparation Cost						
		Subtotal	21,026	0	21,026	
3 Construction & Procurement Cost			5,619	9,359	14,978	See Construction & Procurement Cost
		Dredging	419	698		7.5%
		Cut-off	639	1,064		11.4%
		Retarding Pond	4,561	7,597		81.2%
		Subtotal	5,619	9,359	14,978	
4 Consultant Service Cost						
	4-1	Consultant Service Costfor Civil Work				
	4-1-1	Detail Design Cost	562	936	1,498	10 % of Construction & Procurement Cost
	4-1-2	Construction Management Cost	449	749	1,198	8 % of Construction & Procurement Cost
	4-2	Consultant Service Cost for Building	0	0	0	
	4-3	Consultant Service Cost for Equipment	0	0	0	
		Subtotal	1,011	1,685	2,696	
5 Contingency Cost			0	0	0	
	5-1	Price Contingency	1,104	335	1,439	The price increase cost was assumed to be 16.6% and 3.0% of the total construction and procurement cost and design and supervision cost, respectively, in domestic and foreign currency (compounded over 6 years, respectively, as an average).
	5-2	Physical Contingency	332	552	884	5% of the total Construction & Procurement and Consultant Service Cost.
		Subtotal	1,435	888	2,323	
6 Technical Training Cost			0	0	0	
		Subtotal	0	0	0	
7 Operation and Maintenance Cost			0	0	0	
		(1) Dredging (Implementation)	61	122	183	Construction & Procurement Cost for Maintenance Dredging
		(2) Dredging (Consultation)	11	22	33	Consultant Service Cost for Maintenance Dredging
		(3) Cut-off & Retarding Pond	26	43	69	Operation and Maintenance Cost for Cut-off and Retarding Pond
		Subtotal	98	187	285	
Total (Excluding OM Cost)			29,373	12,349	41,722	

Source: Project Team

In this Project, two types of project costs were calculated as mentioned above and the economic evaluation was also conducted for two types of project costs (see Section 4.5.4). In the next stage following this Project, it is necessary to carry out necessary surveys, examinations, and discussions for determining the land unit price to be applied, reflect it in the project cost, and improve the accuracy of the project cost.

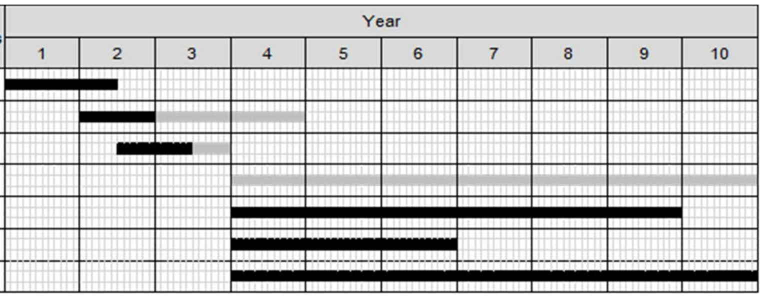
4.4.6 Implementation Schedule

The project implementation schedule is shown in Table 4.4.13.

After the detailed design, bidding for construction work will begin in the second year, with a target completion date of all the construction works of 10th year. Resettlement and land acquisition are planned to be started in the second year, in conjunction with the detailed design and construction work.

Table 4.4.13 Schedule of the F/S Project

Item		Months
1	Detailed Design	18
2	Land Acquisition	36
3	PQ and Tendering	12
4	Construction Works	84
4-1	Contract Package No.1 Dredging	72
4-2	Contract Package No.2 Cut-off	48
4-3	Contract Package No.3 Retarding Pond	84



Source: Project Team

4.5 Study for Project Evaluation

4.5.1 Project Implementation Schedule

From the first year, the detailed design of each project will be carried out. After the detailed design, PQ and tendering of construction work will be conducted and the construction work is planned to be completed in tenth year. The relocation and land acquisition are anticipated to be started in the second year of the detailed design and will be completed in the fourth year when the construction work will be commenced.

4.5.2 Consulting Engineering Services

It is anticipated that DPWH will implement the project, but by contracting consultants to prepare the documents related to detailed design, pre-qualification requirements (PQ) and tender. In addition, the consultants will assist in bidding and contracting during the pre-construction stage and in supervising the construction work. The duration of engineering services for the detailed design is anticipated to be 18 months, and the duration for the consulting services related to the construction supervision is planned to be 84 months (or 7 years excluding construction defects period).

4.5.3 Project Benefit

(1) Introduction

In this study, among the effects of flood control project, the benefits are estimated by calculating the “expected annual average damage reduction”. The expected reduction of annual flood damage cost is computed by comparing the damage cost when the project is implemented “With-case” and when the project is not implemented “Without-Case (or present situation)” per flood intensity.

(2) Economic Benefit

Assets targeted in this study are “Residential land and buildings”, “Commercial land and buildings”, “Industrial land and buildings”, “Agricultural land and buildings” and “Mixed used land and buildings”.

The evaluation of the Feasibility Study (F/S) and Pre-Feasibility Study (Pre-F/S) for Davao River is more detailed than the evaluation of the Master Plan Study which covers the entire City. Concretely, in the F/S and Pre-F/S, the value set per mesh is set more precisely by reflecting the building value per size, statistical data such as annual income per type of business and other factors.

(3) Benefit Computation

The methodology and damage rate used to compute damage cost refer to the “Manual on Economic Study of Flood Control Projects” published by the Ministry of Land, Infrastructure, Transport and Tourism of Japan in April 2005. Regarding the damage to infrastructures, the damage cost to infrastructures is calculated by multiplying the amount of damage to general assets by 0.3. Regarding the indirect damage, the indirect damage cost is calculated by multiplying the amount of direct damage by 0.3.

Table 4.5.1 shows the damage cost if no project is implemented (without case) and Table 4.5.2 the damage cost if F/S projects are implemented (with case).

Table 4.5.1 Damage Cost if "No project is implemented (without case)"

		W=1/2	W=1/3	W=1/5	W=1/10	W=1/25	W=1/50	W=1/100
Direct Damage		**5.596**	**6.995**	**12.435**	**21.308**	**33.405**	**42.548**	**50.989**
	Agriculture	0.842	1.053	1.914	3.370	5.398	6.232	6.789
	Commerce	0.119	0.148	0.192	0.503	1.158	1.755	2.378
	Industry	0.128	0.160	0.495	1.019	1.831	2.500	3.159
	Institution	0.598	0.747	1.257	1.928	2.935	3.824	4.717
	Residences	2.580	3.225	5.629	9.464	14.243	18.134	21.493
	Mix Use Facilities	0.038	0.047	0.078	0.107	0.131	0.285	0.686
	Infrastructure	1.291	1.614	2.870	4.917	7.709	9.819	11.767
Indirect Damage		**1.679**	**2.098**	**3.730**	**6.392**	**10.022**	**12.765**	**15.297**
Total Damage		**7.275**	**9.093**	**16.165**	**27.700**	**43.427**	**55.313**	**66.285**

Source: Project Team

Table 4.5.2 Damage Cost if "Projects are implemented (with case)"

		W=1/2	W=1/3	W=1/5	W=1/10	W=1/25	W=1/50	W=1/100
Direct Damage		1.192	1.231	1.470	2.512	16.294	26.166	35.051
	Agriculture	0.075	0.086	0.113	0.350	2.484	4.273	5.393
	Commerce	0.067	0.068	0.072	0.080	0.413	0.827	1.437
	Industry	0.001	0.003	0.007	0.048	0.795	1.335	1.910
	Institution	0.030	0.031	0.043	0.332	1.585	2.453	3.325
	Residences	0.740	0.753	0.891	1.113	7.236	11.207	14.847
	Mix Use Facilities	0.002	0.004	0.006	0.008	0.022	0.033	0.050
	Infrastructure	0.275	0.284	0.339	0.580	3.760	6.038	8.089
Indirect Damage		**0.358**	**0.369**	**0.441**	**0.754**	**4.888**	**7.850**	**10.515**
Total Damage		**1.550**	**1.600**	**1.911**	**3.265**	**21.183**	**34.016**	**45.566**

Source: Project Team

(4) Expected Annual Average Damage Reduction

Based on the results of the Flood Simulation of Davao River, the expected annual average damage reduction is computed as shown in Table 4.5.3.

Table 4.5.3 Expected Annual Average Damage Reduction if F/S Projects are Implemented

	Annual average exceedance probability	Amount of Damage (Billion PhP)			Average Damage per reach	Probabilities per reach	Annual Average Damage Reduction	Aggregated annual average damage = Expected
		Without Project (1)	With Project (2)	Damage Reduction (1)-(2)				
W=1/1	1.000	0.000	0.000	0.000				
W=1/2	0.500	7.275	1.550	5.725	2.862	0.500	1.431	1.431
W=1/3	0.333	9.093	1.600	7.494	6.609	0.167	1.102	2.533
W=1/5	0.200	16.165	1.911	14.254	10.874	0.133	1.450	3.983
W=1/10	0.100	27.700	3.265	24.435	19.345	0.100	1.934	5.917
W=1/25	0.040	43.427	21.183	22.244	23.340	0.060	1.400	7.317
W=1/50	0.020	55.313	34.016	21.297	21.771	0.020	0.435	7.753
W=1/100	0.010	66.285	45.566	20.719	21.008	0.010	0.210	7.963

Source: Project Team

4.5.4 Economic Evaluation

(1) Preconditions for Economic Evaluation

The parameters of the "Preparatory Survey for Flood Risk Management Project for Cagayan de Oro River" were refereed to set the ratio to convert financial cost into economic cost. Regarding the Social Discount Rate (SDR), the Investment Coordination Committee (ICC) led by the NEDA Board has updated the rate from 15% to 10%. In this study, both cases (SDR=10% and 15%) were considered as part of the sensitivity analysis. Regarding the Operations and Maintenance (OM) cost, the cost for maintenance dredging was added to the usual OM cost (0.5% of the construction cost).

(2) Economic Cost

Table 4.5.4 shows the economic cost converted from the financial cost and Table 4.5.5 the investment schedule in economic cost.

Table 4.5.4 Financial Cost and Economic Cost

Financial Cost

	LC	FC	Total (Billion PhP)
1 Project Management	0.282	0.418	0.700
2 Preparation, Resettlement	0.899	0.000	0.899
3 Constrution & Procurement	5.619	9.359	14.978
Dredging	0.419	0.698	1.118
Cut-off	0.639	1.064	1.703
Retarding Pond	4.561	7.597	12.157
4 Consulting Service	1.011	1.685	2.696
5 Contingency	1.435	0.888	2.323
Price Contingency	1.104	0.335	1.439
Physical Contingency	0.332	0.552	0.884
6 Technical Training Cost	0.000	0.000	0.000
TOTAL	**9.246**	**12.349**	**21.595**

Economic Cost

	LC	FC	Total (Billion PhP)
1 Project Management	0.274	0.418	0.691
2 Preparation, Resettlement	0.512	0.000	0.512
3 Constrution & Procurement	4.439	9.359	13.798
Dredging	0.331	0.698	1.030
Cut-off	0.505	1.064	1.568
Retarding Pond	3.603	7.597	11.200
4 Consulting Service	1.204	1.685	2.888
5 Contingency	1.466	0.888	2.353
Price Contingency	1.127	0.335	1.463
Physical Contingency	0.338	0.552	0.891
6 Technical Training Cost	0.000	0.000	0.000
TOTAL	**7.894**	**12.349**	**20.243**

Source: Project Team

Table 4.5.5 Investment Schedule (Economic Cost)

	PM Project Management	PR Preparation, Resettlement	CP Constrution & Procurement	CS Consulting Service	Cont Contingency	TTC Technical Training Cost	Economic Investment per Year (in Billion PhP)	Percentage (Yearly / Total Investment)
Year 1	0.069	0.171	0.000	0.289	0.235	0.000	0.764	3.77%
Year 2	0.069	0.171	0.000	0.289	0.235	0.000	0.764	3.77%
Year 3	0.069	0.171	0.000	0.289	0.235	0.000	0.764	3.77%
Year 4	0.069	0.000	2.294	0.289	0.235	0.000	2.888	14.27%
Year 5	0.069	0.000	2.294	0.289	0.235	0.000	2.888	14.27%
Year 6	0.069	0.000	2.294	0.289	0.235	0.000	2.888	14.27%
Year 7	0.069	0.000	1.772	0.289	0.235	0.000	2.365	11.68%
Year 8	0.069	0.000	1.772	0.289	0.235	0.000	2.365	11.68%
Year 9	0.069	0.000	1.772	0.289	0.235	0.000	2.365	11.68%
Year 10	0.069	0.000	1.600	0.289	0.235	0.000	2.193	10.83%
Total	**0.691**	**0.512**	**13.798**	**2.888**	**2.353**	**0.000**	**20.243**	**100.00%**

Source: Project Team

(3) Results of Economic Evaluation

Economic evaluation for priority projects in the proposed F/S for Davao River was carried out.

When the SDR is 10%, the Economic Internal Rate of Return (EIRR) is 15.32 %, Economic Net Present Values (ENPV) is PhP 9.99 Billion and Cost-Benefit Ratio (CBR) is 1.895.

When the SDR is 15%, ENPV is PhP 0.30 Billion and CBR is 1.110.

Therefore, the priority projects in the proposed F/S is evaluated as economically adequate in both cases.

For reference, when the SDR is 20%, EIRR remains unchanged at 15.32 %, ENPV is PhP -2.60 Billion and CBR is 0.709.

(4) Sensitivity Analysis

To check the economic adequacy in case of project cost increase and benefit decrease, a sensitivity analysis was conducted. In all cases, the economic internal rate of return (EIRR) exceeds the current social discount rate of 10%. Therefore, it can be concluded that the project can be evaluated as adequate from the viewpoint of investment efficiency.

Table 4.5.6 Results of Sensitivity Analysis

		EIRR (%)
Case 0	Base Case	15.32
Case 1	Project Cost: increase of 10%	14.41
Case 2	Project Cost: increase of 20%	13.61
Case 3	Benefit: Decrease of 10%	14.27
Case 4	Benefit: Decrease of 20%	13.15
Case 5	Project Cost: increase of 10% and Benefit: Decrease of 10%	13.40
Case 6	Project Cost: increase of 20% and Benefit: Decrease of 20%	11.59

Source: Project Team

For reference, the break-even point analysis shows the EIRR of 10.0% when project cost increases by 85.5% under the condition that there is no change in benefit as well as when benefit decreases by 44.2% under the condition that there is no change in project cost.

(5) Economic Evaluation for the Project Cost applying Results of RAP Study

An economic evaluation is carried out on the project cost estimated by applying the RAP study results, which was estimated as the reference value in Section 4.4.5(2).

When the SDR is 10%, the Economic Internal Rate of Return (EIRR) is 10.15 %, Economic Net Present Values (ENPV) is PhP 0.49 Billion and Cost-Benefit Ratio (CBR) is 1.260. Therefore, it is evaluated as economically adequate.

For reference, when the SDR is 15%, EIRR remains unchanged at 10.15 %, ENPV is PhP -8.43 Billion and CBR is 0.687. When the SDR is 20%, EIRR remains unchanged at 10.15 %, ENPV is PhP -10.66 Billion and CBR is 0.441.

In addition, for reference, the break-even point analysis shows the EIRR of 10.0% when project cost increases by 2.3% under the condition that there is no change in benefit as well as when benefit decreases by 2.2% under the condition that there is no change in project cost.

4.5.5 Revision of the Davao River Master Plan (M/P)

As explained in the Section 4.5.2 (1), to conduct the economic evaluation of the Feasibility Study (F/S) and Pre-Feasibility Study (Pre-F/S) for Davao River, the value set per mesh to compute benefit was reset in a more precise way. Concretely, unlike the M/P which covers the entire city, the value set per mesh in the areas surrounding Davao River, is reflecting the building value per size, statistical data such as annual income per type of business and other factors.

In this section, the economic evaluation of Davao River Master Plan is revised by using the same mesh value as the F/S and Pre F/S and revised project cost.

(1) Revised Expected Annual Average Damage Reduction

The target flood-scale of Davao M/P is 100-year flood. Therefore, if the proposed projects are implemented (With-Case) the damage are expected to be null, and the expected annual average damage reduction is calculated as bellow.

Table 4.5.7 Expected Annual Average Damage Reduction if M/P Projects are Implemented

	Annual average exceedance probability	Amount of Damage (Billion PhP)			Average Damage per reach	Probabilities per reach	Annual Average Damage Reduction	Aggregated annual average damage = Expected annual average damage reduction
		Without Project (1)	With Project (2)	Damage Reduction (1)-(2)				
W=1/1	1.000	0.000	0.000	0.000				
W=1/2	0.500	7.275	0.000	7.275	3.637	0.500	1.819	1.819
W=1/3	0.333	9.093	0.000	9.093	8.184	0.167	1.364	3.183
W=1/5	0.200	16.165	0.000	16.165	12.629	0.133	1.684	4.867
W=1/10	0.100	27.700	0.000	27.700	21.933	0.100	2.193	7.060
W=1/25	0.040	43.427	0.000	43.427	35.564	0.060	2.134	9.194
W=1/50	0.020	55.313	0.000	55.313	49.370	0.020	0.987	10.181
W=1/100	0.010	66.285	0.000	66.285	60.799	0.010	0.608	10.789

Source: Project Team

(2) Revised economic cost

Table 4.5.8 shows the revised economic cost converted from the financial cost.

Table 4.5.8 Financial Cost and Economic Cost

Financial Cost

	LC	FC	Total (Billion PhP)
1 Project Management	0.788	1.166	1.954
2 Preparation, Resettlement	2.552	0.000	2.552
3 Constrution & Procurement	15.690	26.135	41.826
Dredging	0.419	0.698	1.118
Cut-off	0.639	1.064	1.703
Retarding Pond	4.561	7.597	12.157
Widening	0.749	1.248	1.997
Retarding Pond (4)	9.323	15.528	24.851
4 Consulting Service	2.824	4.704	7.529
5 Contingency	4.008	2.479	6.487
Price Contingency	3.083	0.937	4.019
Physical Contingency	0.926	1.542	2.468
6 Technical Training Cost	0.000	0.000	0.000
TOTAL	25.864	34.484	60.348

Economic Cost

	LC	FC	Total (Billion PhP)
1 Project Management	0.765	1.166	1.931
2 Preparation, Resettlement	1.455	0.000	1.455
3 Constrution & Procurement	12.395	26.135	38.531
Dredging	0.331	0.698	1.030
Cut-off	0.505	1.064	1.568
Retarding Pond	3.603	7.597	11.200
Widening	0.592	1.248	1.840
Retarding Pond (4)	7.365	15.528	22.893
4 Consulting Service	3.361	4.704	8.065
5 Contingency	4.093	2.479	6.571
Price Contingency	3.147	0.937	4.084
Physical Contingency	0.945	1.542	2.487
6 Technical Training Cost	0.000	0.000	0.000
TOTAL	22.068	34.484	56.553

Source: Project Team

(3) Revised Economic Evaluation

The revised cost and benefits cash flow of the proposed M/P for Davao River was calculated.

When the SDR is 10%, the Economic Internal Rate of Return (EIRR) is 15.37 %, Economic Net Present Values (ENPV) is PhP 12.98 Billion and Cost-Benefit Ratio (CBR) is 1.728.

When the SDR is 15%, ENPV is PhP 0.41 Billion and CBR is 1.087.

Therefore, the proposed is evaluated as economically adequate in both cases.

For reference, when the SDR is 20%, EIRR remains unchanged at 15.37 %, ENPV is PhP -2.82 Billion and CBR is 0.728.

(4) Sensitivity Analysis

To check the economic adequacy in case of project cost increase and benefit decrease, a sensitivity analysis was conducted. In all cases, the economic internal rate of return (EIRR) exceeds the current social discount rate of 10%. Therefore, it can be concluded that the project can be evaluated as adequate from the viewpoint of investment efficiency.

Table 4.5.9 Results of Sensitivity Analysis

		EIRR (%)
Case 0	Base Case	15.37
Case 1	Project Cost: increase of 10%	14.33
Case 2	Project Cost: increase of 20%	13.41
Case 3	Benefit: Decrease of 10%	14.64
Case 4	Benefit: Decrease of 20%	13.83
Case 5	Project Cost: increase of 10% and Benefit: Decrease of 10%	13.60
Case 6	Project Cost: increase of 20% and Benefit: Decrease of 20%	11.87

Source: Project Team

For reference, the break-even point analysis shows the EIRR of 10.0% when project cost increases by 70.7% under the condition that there is no change in benefit as well as when benefit decreases by 54.9% under the condition that there is no change in project cost.

4.5.6 Environmental Evaluation

(1) Compliance of Environmental Compliance Certificate

Environmental and social consideration study was. Though the Project is recognized as an environmental enhancement project; the EMB decided to categorized Category-B from the viewpoint of the scale of retarding ponds. So the EMB Region XI Office (EMB-XI) has been taken over. A Project Description Sheet (PDS) was submitted to the EMB-XI for commencement of the EIS study in August 2021. The draft EIS report was submitted in April 2022 for their review. The EIS was approved by the EMB Region-XI; and ECC license was issued at August 15, 2022.

(2) Scoping

Scoping was undertaken in the environmental and social consideration study.

(3) Environmental Evaluation

The details of environmental evaluation was conducted in each item and environmental management and monitoring plan (EMP/ EMoP) were prepared.

4.5.7 Socio-economic Evaluation

(1) Principle

The Priority project aims to reduce flood risk along the Davao River; so as to mitigate damage to socio-economic value in Davao City through evaluation of damage by Davao River flood in 2013, Cyclone Vinta in 2017, etc.

(2) Estimated Level of Resettlement by the Priority Project

Total number of households to be relocated is estimated 100HHs or less.

(3) Preventive Relocation by the Priority Projects

The most of the households to be relocated have resided near the Davao River where it is high risk area and not suitable for dwellings. Therefore resettlement under the Priority project must encourage preventive relocation to protect their life and assets.

(4) Socio-economic Aspects on the Preventive Relocation

1) Protection of the Human Life

The preventive relocation by the Priority projects could encourage mitigation of damage to human life by relocation to out of high flood risk area.

2) Protection of the Assets

The preventive relocation by the Priority projects could encourage mitigation of damage to private assets and public infrastructures so as to enhance sustainable socio-economic activities.

(5) Social Evaluation

For above reasons, resettlement to be proposed is not only to secure necessary space for the project site but also to mitigate flood risk; and then project design was formulated with minimizing scale of resettlement, consensus with project affected households.

4.5.8 Technical Evaluation

As a result of a detailed examination on the construction plan for the priority projects, the technical feasibility, safety, reliability and appropriateness of the proposed structures were confirmed.

4.5.9 Overall Evaluation of the Project

Table 4.5.10 summarizes the comprehensive evaluation results of the F/S projects. The feasibility of each project was confirmed from the points of view of economic feasibility, socio-economic suitability, and environmental and technical safety and soundness.

Table 4.5.10 Comprehensive Evaluation Results of the F/S for the Davao River

Project / Evaluation axis	Entire F/S	*Projects composing the F/S (Recommended projects based on the comparison of alternatives)*			
		Riverbed Dredging	***Retarding Ponds***	***Cut-Off Works (Northern Section)***	***Cut-Off Works (Southern Section)***
		Alternative 3: Preservation of the 200 meters in the upstream and downstream of each bridge, and bridge protection measures for Davao Bridge	***Alternative 1: With spillway***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***
a. Flood Protection Level (Expected damage reduction)	Target Flood: 10-year return period flood	*Reduction of 97% of the inundated area caused by a 10-year return period flood. The flow velocity increase in the upstream and downstream of the bridges is expected to not exceed 116% of the actual velocity.*	*Until 2032: 5 to 10-year return period flood; Until 2045: 25 year-return period flood; With the implementation of M/P:100-year flood*	*Target Flood capacity: 1,700 cubic meters per second (Corresponding to the 100-year return period flood targeted by the Master Plan)*	
b. Economic Effectiveness	Total cost: PhP 21.59 Billion EIRR:15.32% NPV:10.00 B/C:1.896 *SDR=10%	*Direct Construction Cost: PhP 0.36 Billion*	*Direct Construction Cost: PhP 7.09 Billion*	*Direct Construction Cost: PhP 0.49 Billion (Including the construction cost of a new bridge with a length of 110 meters) Cost for households relocation and land acquisition: PhP 0.45 Billion*	*Direct Construction Cost: PhP 0.34 Billion (Including the construction cost of a new bridge with a length of 110 meters) Cost for households relocation and land acquisition: PhP 0.11 Billion*
c. Feasibility in regards with social and legal restrictions	Including the proposed dump site, the project will not be located in the natural conservation area. The public consultation meetings with stakeholders will be required.	*The proposed locations for the project implementation and dump sites are not included in the natural conservation area.*			*Kagan Community is located within the area where the project is planned to be implemented and will need to be relocated. Therefore the continuation of information sharing on the project and dialogue with the Community will be needed.*

Project / Evaluation axis	Entire F/S	Projects composing the F/S (Recommended projects based on the comparison of alternatives)			
		Riverbed Dredging	***Retarding Ponds***	***Cut-Off Works (Northern Section)***	***Cut-Off Works (Southern Section)***
		Alternative 3: Preservation of the 200 meters in the upstream and downstream of each bridge, and bridge protection measures for Davao Bridge	***Alternative 1: With spillway***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***
d. Feasibility from the technical viewpoint to construct countermeasures:	Phased construction is possible.	*Phased construction is possible.*	*Phased construction is possible.*	*Phased construction is possible.*	
e. Sustainability	Sustainable. However, maintenance dredging is required.	*Sustainable.*	*Sustainable.*	*Sustainable. In addition, the volume of maintenance dredging to ensure the expected flood capacity (by avoiding the raise of riverbed) is estimated to be minimal.*	
f. Flexibility	Future revision is possible.	—	*After the construction of the structure, overflow from the surrounding dike can be avoided by the effect of the spillway, during floods exceeding the design flood scale.*	*The proposed landfill and maintenance of the new river channel is appropriate.* *However, the landfill of the actual river channel will require the installation of new drainage facilities to drain a maximum of 1.4 square kilometers in the actual meandering area (due to the changes in the drainage network).* *The revision of the cross section (such as increase of the flood capacity) will be relatively easy if the needs occur in the future.*	*The proposed landfill and maintenance of the new river channel is appropriate.* *However, the landfill of the actual river channel will require the installation of new drainage facilities to drain a maximum of 2.6 square kilometers in the actual meandering area (due to the changes in the drainage network).* *The revision of the cross section (such as increase of the flood capacity) will be relatively easy if the needs occur in the future.*
g. Social and natural environment impacts	Households relocated: 104 Relocation and land acquisition will be needed especially in the areas affected by the construction of the cut-off works.	*Households relocated: 0*	*Households relocated: 1* *The volume of excavation is lesser than the case without spillway.*	*Households relocated: 0* *The needed land acquisition will be large but the current river channel will not need any maintenance.*	*Households relocated: 103* *The needed land acquisition will be large but the current river channel will not need any maintenance.*

Evaluation axis / Project	Entire F/S	Projects composing the F/S (Recommended projects based on the comparison of alternatives)			
		Riverbed Dredging	***Retarding Ponds***	***Cut-Off Works (Northern Section)***	***Cut-Off Works (Southern Section)***
		Alternative 3: Preservation of the 200 meters in the upstream and downstream of each bridge, and bridge protection measures for Davao Bridge	***Alternative 1: With spillway***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***
	The inhabit of Designated Endangered Species (animals and plants) was not confirmed in the target area. However, to minimize the impact to the natural environment during the project implementation, water and air pollution measures will be promoted. After the completion of the F/S, the retarding ponds may be used as new places for nature restoration.			*The area where the cut-off works is planned is actually designated as "open-space" in the Comprehensive Land Use Plan (CLUP). Such lands are expected to provide recreational functions in the future. Therefore, the construction of easy slope (low-gradient river slope) is expected to ensure the accessibility to river.*	*The area where the cut-off works is planned is actually designated as "open-space" in the Comprehensive Land Use Plan (CLUP). Such lands are expected to provide recreational functions in the future. Therefore, the construction of easy slope (low-gradient river slope) is expected to ensure the accessibility to river.*
Others		–	–		*With the landfill of the existing river channel, the bridge actually under construction (DPWH-RO11) may become unnecessary.*
Evaluation Result	The Projects composing the F/S are appropriate from the viewpoint of economic efficiency, technical feasibility, sustainability and flexibility. On the other hand, the project may generate social impacts such as the relocation of the Kagan Community. Regarding this point, the impacts can be reduced by				

Project / Evaluation axis	Entire F/S	***Projects composing the F/S (Recommended projects based on the comparison of alternatives)***			
		Riverbed Dredging	***Retarding Ponds***	***Cut-Off Works (Northern Section)***	***Cut-Off Works (Southern Section)***
		Alternative 3: Preservation of the 200 meters in the upstream and downstream of each bridge, and bridge protection measures for Davao Bridge	***Alternative 1: With spillway***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***	***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW, without any expectation to the actual flood capacity of the channel***
	sharing the information on the project and continuing the dialogue with the Community. In addition, regarding the impacts on the natural environment (such as noise, water quality, etc.) during the construction, they can be reduced by devising construction methods. Therefore, it was evaluated that the project as a whole is appropriate.				

Source: Project Team

4.6 Environmental and Social Considerations

4.6.1 Categorization

Category "A" under the JICA-GL

Reason: The project site would cause adverse impacts which are described in the Guidelines for Environmental and Social Considerations (April 2010).

4.6.2 Environmental Impact

(1) Outline of the Project

The project outline, which environmental and social considerations study was undertaken for, is described in Table 4.6.1.

Table 4.6.1 Outline of the Project

Components	Location	Description
A. Riverbed dredging	Up to Approx. 23km upstream from the river mouth	Dredging volume: approx. 2 million m^3
B. Cut-off works (COW)	Approx. 7.13km from the river mouth	Total of approx. 700m with 110m width
C. Retarding ponds (RPs)	From the river mouth: RP11 : approx. 24km RP09 : approx. 27km RP08 : approx. 29km	Area Capacity RP11 : 0.67km^2, 4.5MCM RP09 : 0.37km^2, 2.2MCM RP08 : 0.75km^2, 4.7MCM

Source: Project Team

(2) Environmental Baseline

Environmental baseline was surveyed in [stage 1: Basic study] and [stage 2: Master Plan]. The results are described in the section [2.1 - 2.4]. The results found in the EIS study was described in the section [4.6.2(6): Results of Environmental and Social Considerations Study].

(3) Philippine Legal Framework Related to Environment and Organizations

Legal Framework and Gap Analysis between Philippines and JICA Guideline are described in the section [3.13.2: Environmental Legal Framework in Philippines] and [3.13.3: Gap Analysis between JICA Guideline and Philippine System] respectively.

(4) Alternative Analysis

Analysis on "Zero-option including without projects" was described in the section [3.15 Master Plan Evaluation]; while alternative analysis of 3 components examined in the F/S is in the section [4.1.5: Preliminary Design of Structure Measures of the Priority Project Targeted for Feasibility Study for Riverine Flood in Davao River].

(5) Scoping and TOR of Environmental and Social Consideration Study

An environmental and social consideration study (EIS study, RAP study was separately taken) was designed based on the scoping in M/P stage and the Philippine EIS system. The following table is described TOR.

Table 4.6.2 TOR of the EIS Study

Items	Survey Methods	Evaluation Method
Air quality	(1) Data collection and analysis from EMB, etc. (2) Air quality measurement at 3 locations CO, NO2, SO2, PM10, PM2.5 with 24 hours sampling	Compliance with the Philippine standard, examination of possible impact by the Project.
Water quality	(1) Data collection and analysis from EMB, etc. (2) Water quality measurement at 4 locations pH, TSS, Phosphorus, BOD, oil & grease, EC/ chloride, coliform, heavy metals (Cd, As, Pb, Cr) and mercury (3) Direct observation on the inflow of wastewater	Compliance with the Philippine standard, examination of possible impact by the Project. Forecast of turbid water spread.
Waste	(1) Data collection (2) Examination of possible disposal site (3) Direct observation on the illegal dumping to the river	Volume of dredging/ excavated soil Examination of possible reuse
River sediment	(1) Data collection and analysis (2) Soil quality measurement at 4 locations Items: Heavy metals (Cd, As, Pb, Cr), mercury, sulfide	Compliance with standards, pollution source
Noise/ vibration	(1) Data collection and analysis (2) Noise measurement at 3 location (2 locations for vibration)	Compliance with standards, pollution source
Subsidence	Data collection and analysis	Geological condition, examination of construction methodology
Odor	N/A	N/A
Protected Area	N/A	N/A
Ecosystem	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) observation (4) Sampling, trap	Inventory, impact evaluation
Hydrology	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) Geological/ topographical survey (separately conducted)	Impact evaluation
Geology/ Topography		
Resettlement	RAP Study (see details section [4.6.3 Land Acquisition and Resettlement])	
Poor, vulnerable	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) Public consultation	Socio economic profile of PAPs
Indigenous Peoples	N/A	N/A
Local economies	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) Public consultation	Community perception, examination on possible interruption
Utilization of land and local resources		
Water usage	N/A	N/A
Existing social infrastructures and services	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) Public consultation (4) Site observation (5) Traffic survey (traffic volume, hearing)	Community perception, examination on possible interruption
Local economies	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) Public consultation (4) Site observation	Community perception, examination on possible interruption

Items	Survey Methods	Evaluation Method
Community severance	(1) Data collection and analysis (2) Public consultation	Community perception, examination on possible interruption
Local conflicts of interest		
Cultural heritage	N/A	N/A
Landscape	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) Public consultation (4) Site observation	Community perception, examination on possible interruption
Gender	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc. (3) Public consultation	Community perception, examination on possible interruption
Children's rights		
Infectious diseases	(1) Data collection and analysis (2) Hearing with relevant organizations, communities, etc.	Community perception, examination on possible interruption
Labor conditions		
Accidents		
Global warming	N/A	N/A

Source: Project Team

(6) Results of Environmental and Social Consideration Study

1) Urban Environment, Pollution

Air Quality

Air quality measurement with five (5) items indicated in Table 4.6.2. The measurement was conducted at 3 locations for continuous 24 hours. As the result, all the data met the Philippine ambient air quality standards.

It can be said that air quality condition in the Project area is relatively good. The major pollution source would be operation of construction equipment; significant impact is not expected.

Water Quality

Water quality measurement with items indicated in Table 4.6.2 was undertaken at 4 locations.

BOD showed higher value in Bucana, near river mouth; but it met standard level. In general, the higher BOD value shows the downer stream nearer river mouth. Therefore it was ordinal condition.

Concentration of chloride in Bucana was over two (2) times higher than water quality standard. It was caused by salt water coming from the sea; that to say, natural situation.

All results of DO and fecal coliform passed the standard level. Occasionally the measurement by the EMB showed extreme contamination of fecal coliform, higher than tens of thousands of standard level; main pollution source must be from domestic water discharge.

Range of concentration of phosphate was between 0.6 - 0.9mg/L; these value were 20 – 30 times higher than standard limit. In general, pollution source of phosphorus is chemical fertilizer, detergent, e.g.; however it is not sure how much those pollution sources raise concentration in that time.

TSS level at All locations exceeded the standard level. Even in Mandug, out of urbanization area, TSS showed high value; therefore source of soil would be naturally inflowed from the land, not by human activities.

Concentrations of heavy metals and oil and greases at all locations were passed the standard levels.

Possible raise of concentration by the Project will be caused from the construction activities for example, spillage from fuel oils, waste, and TSS by dredging/ excavated soil.

River Sediment Condition

Sediment condition survey was conducted at the same locations as water quality measurement. Since the Philippine has not declared sediment/ soil standards; Canadian standard and guideline of NOAA were referred.

Concentration of As at the all locations passed both standard values. CD passed NOAA guideline; however slightly exceeded Canadian standard.

Concentration of Cr passed at three (3) locations except Mandug compared with NOAA guideline; all locations, while, exceeded Canadian standard. Major pollution sources of Cr are Nickel mining, chemical industries; but there are no such mining area or factories observed.

Pb met the Canadian standard (most relaxed level); but exceeded NOAA guideline (most stringent level).

Concentration of Hg was below detected level; it concluded that mercury pollution by gold mining was not observed.

It is recommended to prior monitor possible contamination of toxic in the dredged/ excavated soil; on the other hand it will be challenge how soil standards set for evaluation.

Noise and Vibration

Noise/ vibration measurement was taken at the same locations as air quality measurement.

As the result of the measurement, noise level at the N-3 in evening time exceeded the noise limitation over 8dB; however it could not be significant level. Major noise source were animal calls, construction noise, community sound, etc.; those are ordinal sources.

It is predicted that major source of noise by the Project is construction works; ordinal countermeasures, for instance maintenance of equipment, prohibit of night time work, prior notice of construction schedule to the communities, could be affordable.

Waste

Waste management is mainly undertaken by The City Environment and Natural Resources Office (CENRO); while policy making is controlled by The Davao City Solid Waste Management Board which is a direct office under the Mayor.

Most of the waste from Davao city is disposed at New Carmen sanitary waste dumping site located in Tugbok approximately 15km far from the downtown of the Davao City. It has been operated since 2010; service capacity will last in 8 – 10 years after.

2) Natural Environment

Geography, Topography

Because the location of retarding ponds and cut-off work are on the low and plain land; impacts to geographic and topographic conditions must not be significant. Erosion risk in the area will be low from the soil erosion map by NAMRIA.

Level of high turbid (TSS) water is forecasted possibly generated by the dredging work based on 2D HEC-RAS model. Level of high turbid water depends on scale of dredging work and river condition; the biggest impact case was simulated.

The highest concentration was shown 280m downstream; the High turbid water disappeared at the point of 0+018 station. No significant species, such as endangered aquatic biota observed at the Davao River mouth; and commercial fishing and recreation purposes are minor. And water quality monitoring by the EMB occasionally record over 500mg/L of high TSS which might be caused by natural resources. It could be concluded that significant impact by the high TSS water is not be expected; however it is possible to need control of generation of turbid water just in case.

Ecosystem

No designated area of protected area, primary forest etc. are observed. Dominant landuse at the retarding ponds area is agriculture in particular banana plantation. The area of cut-off work has been under urbanization, and occupied by banana plantation on the low are.

Investigation of the terrestrial flora and fauna was conducted at the six (6) locations (three (3) locations for fauna survey), which consists of 4 locations for retarding ponds area and 2 locations for cut-off area.

Flora

Most of the land for the retarding ponds is occupied by agricultural purposes; banana cassava, durian mango, coconut, cacao coffee, etc. have been planted. Few endemic species were found. The land for the cut-off works is used as tourist zone (Crocodile Park) and banana plantation. Few green area or open space have been observed along the Davao River downer stream from this area.

The most observed flora was moracea with 73 species, and then euphorbiaceae and fabaceae with 13 species and 11 species respectively. Others were ferns, palms, etc. observed; total of 168 species of flora were observed.

16 species of the above are endemic flora.

Total of 91 species of flora have been registered as Philippine rare flora according to DAO No. 2017-11: "The National List of Threatened Philippine Plants and their Categories'. Seven (7) species of them were observed in the Project area. The most of those flora are planted by the communities; wild ones were not found.

Animal

Five (5) species of fruit bats and one (1) species of muridae were observed. One (1) fruit bat of them, Eonycteris robusta, is registered as NT (near threatened) in IUCN category. The animals were the most abundant in RP-11, counted for 44 individuals. The bats were also found in the cut-off works area, counted for 14 individuals.

13 families , 18 species and total of 235 individuals of birds were observed in the Project area. The birds were also the most abundant in RP-11, half of individuals were observed.

The most observed birds were artamidae which occupied 20% of individuals. The Philippine Eagle, National bird of the Philippines was not obserbed in the project area.

As the other fauna, three (3) species of amphibia were observed; one of them, Giant Philippine Frog, is categorized as NT in IUCN category.

Survey on aquatic biota (macroinvertebrate, plankton) was undertaken at the same location of those on water quality measurement. Because of rain a day before of the survey, only five (5) species of macroinvertebrate were confirmed. Number of species of plankton which were confirmed was 13 species consist of bacillariophyta, cyanophyta; however number of cells was relatively low.

Major fish to be observed in the Davao River is eel (Anguilla sp), carp, (Cyprinus sp.), tilapia (Oreochromis sp.), freshwater shrimp (Macrobrachium sp.), etc. The fish designated in the IUCN is silver perch (VU), Asian eel (NT) and Tilapia, well known as one of the farmed fish, (LC).

A few species of endemic and/or endangered fauna/ flora were confirmed; however, it could be said that ecosystem in the Project area is ordinary and popular which observed in/ around Davao City. Wise use of retarding ponds for restoration of ecosystem is recommendable. No coral reef is confirmed in the river mouth.

3) Social Environment

Population

Total of 13 barangay are located in the Project area; four (4) barangay (New Valencia, Callawa, Mandug and New Carmen) are in the area of retarding ponds; and two (2) barangay (Ma-a and 19-B) are located in the area of cut-off works.

Average of population density of the four (4) barangays at the retarding ponds area and two (2) barangay at the cut-off works area are 5 pax/ha and 67 pax/ha respectively. Population density of the barangay in the downstream of the area of riverbed dredging is over 200 pax/ha.

Landuse

Retarding ponds area is located in the rural area; over 60% of the land is used as agriculture purposes. On the other hand, two (2) barangay which face to cut-off works area are occupied 60 % of green area (most of the green area is western part of barangay and located far from the Project area. Next residential zone and commercial zone occupy 13% and 12% of the land respectively.

Socio Economic Condition of the Project Affected Households (Interview Survey)

Interview survey was conducted with target of direct PAHs (with in approx. 1km from the Project site) and indirect PAHs in order to identify socio economic profile of the PAHs. Numbers of interviewees were 140 HHs for direct PAPs, 175 HHs for indirect PAHs, and then total of 315 HHs. 65% of responds was by women.

<u>Home Place</u>

Half of PAPs have been born and grown up in the same place. 80% of PAPs come from South Davao Province. Average of duration of residing is around 25 years. In addition, approximately 17% of PAHs is single household; those are younger generation and recently migrated.

Ethnic profile shows around 65% of PAPs are Davaoeño, and next Boholano occupies approx. 6%. Ten (10) PAHs expressed their ethnicity as IPs; they are Kagan community who have resided south part of cut-off works area; their religious status is Muslim. 72% of PAPs interviewed are Roman Catholic.

Average number of family member is around 5 persons/HH; it was slightly bigger size than the data based on the census, approx. 3 persons/HH.

<u>Income Source</u>

The biggest share was small shops such as vendors which occupies 23% of total PAPs; then private employees share 12% next.

70% of agricultural workers are employees; the landowners are residing in other places. Scale of agricultural land is less than 2ha; it occupies approx. 78% of farmers. And approx. 35% of farmers has the land less than 1h. Major production is banana, and coconuts in the retarding pond area. Income of approx. 30% of farmers is less than PHP 5,000 per month. It was observed to plant mango in the downstream area; those are not commercial level; consumed by local residences.

Income of the half of PAHs in the cut-off work and drainage (downstream) area and over 70% of that in the retarding area is less than PHP 10,000 per month; it is poor level. On the other hand, some PAHs in the downstream area have higher income level over PHP 40,000 per month.

<u>Houses</u>

Approx. 80% of PAHs interviewed own their houses and rest is renting. Approx. 38% of houses have been built less than 10 years, while approx. 25% is over 30 years.

Major materials of houses are corrugated-iron (for roof, almost all) and cement (for wall, 48%). Near 100% of PAHs have sceptic tank. 60% of PAHs use piped water; the service has been increasing year by year. Around half of PAHs use wood or charcoal in the kitchen; this situation was found higher in rural area. Electricity service totally covers all the area.

Education, etc.

In general, Philippine families give high attention to children's education; only less than 2% of PAPs have not been given basic education due to financial problem. 55% of PAPs have been educated high school education; while less than20% of them have been got university/ college education.

Health services are sufficiently provided; while 30% of patients use self-treatment or traditional doctors; this situation is popular in rural area.

51% of PAHs use City waste collection network; on the other hand, 7% of garbage in the rural area is treated by each household mostly by incineration. Recycle of compositing shares around 5%.

Information, Communication

Major sources of information are through TV, mobile phone, LGUs sharing 27%, 22% and 20% respectively. Around 40% of communities are involved in social groups; the most involved are women group and senior group with 34% and 30% respectively.

Local Issues

They have highlighted the following local issues;

- Floods (30)
- Landslide (13%)
- Employment (12%) and
- Education

Perception on the Project

Over half of PAPs had known about flood control plan by the DPWH. Mostly they were informed through barangay.

All PAPs generally have agreed with the Project. They have expected reduction of flood (68%), reduction of landslide (18%) and increase of job chance (13%).

On the other hand, Half of PAPs in the cut-off work area expressed negative concerns about resettlement. They expressed demands to the LGUs for "sufficient compensation and support" and "Provision of relocation sit" those shared 98% of demands.

4) Indigenous People

The Project site is located out of the ancestral domains. On the other hand, it was found the Kagan who is the one of the Muslim groupa residing in the Davao city. Originally, they had resided in mountainous area or costal area (Toril, e.g.); some of them had been transferring into the City area, for example Barangay Ma-a, Magsaysay etc.

In general term of "Kagan" is the one of the sub-groups of the "Kalagan"; while Davao City has declared in the ordinance that they are "Kagan" not "Kalagan" in order to set them apart from other Kalagan group. NCIP took a field-based investigation (FBI) with consultation as a Pre-FPIC (Pre- free prior and informed consent); and it was resulted that they are not IPs who have an ancestral domains land and been isolated from the ordinal Philippine tradition, custom, political/ legal system. Upon this decision, Certificate of Non-Overlap (CNO) will be issued; and an IPAP will not be required. However, it is fact that Kagan in Ma-a is relatively poor and categorized as ISFs, and they have strong community relation; special considerations, therefore, to keep the quality of their life are recommendable.

5) Gender Mainstreaming

Government of the Philippines, Davao City and DPWH have tackled on the improvement of Gender mainstreaming. Based on the actions by the DPWH, Davao City and other related organizations through interview surveys and discussions, and through stakeholder meetings, the expected contributions and points of concern from this project was summarized. Considering the summarized results, suggestions to pay attention to gender, handicapped, etc. was prepared.

(7) Environmental Evaluation

The results of environmental evaluation was consolidated by items for each project.

(8) Proposed Environmental Managements and Cost

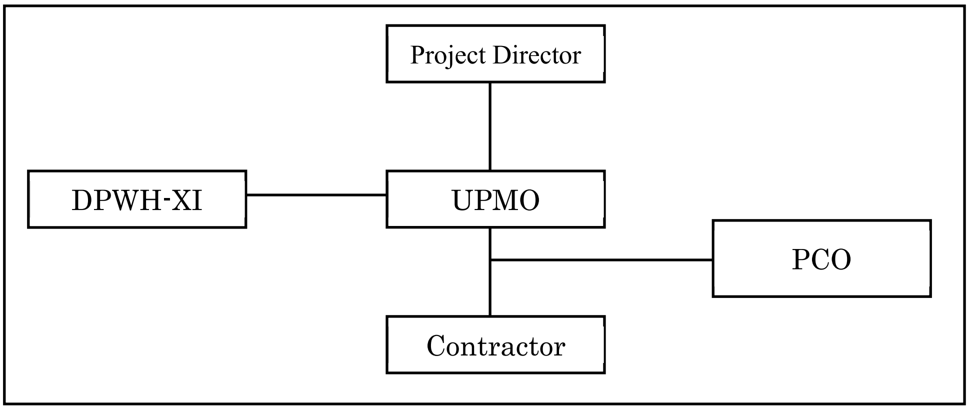
Proposed environmental managements for each component are summarized by items. Mitigation cost will be generally a part of a contractor's construction cost; thus, it would be estimated in each implementation plan. As of now, it is estimated approximately PHP 160 million including wastewater treatment facility, operation cost of base camp, etc.

(9) Monitoring Plan

An environmental monitoring plan including monitoring methods, frequency, implementer and supervisor was examined by items.

(10) Organization

The project proponent is DPWH-UPMO; DPWH-XI will cooperate. A pollution control officer PCO) shall be assigned based on EMB guideline, DAO 30-03. A contractor, in general, dispatches the PCO; his/her responsibility is direct reporting to the project proponent. Figure 4.6.1.



Source: Project Team

Figure 4.6.1 Project Implementation Organization

(11) Public Consultation Meetings

1) IEC Campaign

Public consultation meetings (hereinafter called "PCM") were undertaken based on the EIS guideline.

First IEC (Information, Education, and Communication) campaign was conducted with IEC material (explain project summary with Visaya language); The Study team visited with courtesy to the each barangay to request cooperation on the EIS study; in addition interview survey with communities.

Candidate participants on the PCM were selected based on the results of interview survey, discussion with the EMB-XI. IEC Campaign was undertaken in 29th to 30th September, 2019 in the each barangay office.

2) Public Consultation Meetings

The PCMs were undertaken two (2) times at the beginning of the Study and at the reporting. Because COVID-19 pandemic, the PCMs were taken by hybrid, face-to-face and webinar. The meeting venue for the face-to-face was set at Mandug considered with internet condition.

Summary of the PCMs is indicated in Table 4.6.3.

Table 4.6.3 Summary of PCMs1

Date		Venue	Participants	Topics
1	7th December, 2021	Barangay Mandug office with webinar	Barangay leaders/ representatives, LGU commissioners, communities, landowners, social groups, CPDO, DENR, etc. total of 101 attendances	Purposes of the PCM Summary of EIS system Project summary Discussion Conclusion, further schedule, etc.
2	28th June, 2022	Barangay Mandug office with webinar	Barangay leaders/ representatives, LGU commissioners, communities, landowners, social groups, CPDO, DENR, etc. total of 76 attendances	Purposes of the PCM Project summary Results of the EIS Study Discussion Conclusion, further schedule, etc.

Source: Project Team

4.6.3 Land Acquisition and Resettlement

(1) Necessity of Land Acquisition and Resettlement

The RAP Study prepares the draft of the relocation plan to ensure that the affected households and Informal Settler Families (ISFs) residing inside the Right of Way to-be-acquired lands needed in the implementation of the Priority Projects, are appropriately relocated and their rights justly protected.

The RAP Study covers the draft plan preparation in two of three project components of the Project; namely, the component on Retarding Ponds 8, 9 and 11, and the component on the Cut Off Works. The component on Dredging is excluded from the RAP Study because there are no lands to be affected in this component.

(2) Legal and Institutional Framework

The RAP must be prepared based on, and hence is inevitably closely linked with, relevant policies, laws, regulations, guidelines and other binding documents and commitments in and of the Philippines. In general, the RAP has been prepared with reference to:

- Relevant laws, regulations, guidelines and so on of the Government of the Republic of the Philippines (GOP)
- JICA Guidelines for Environmental and Social Considerations (April 2010)
- World Bank Operational Policies, OP 4.01 (January 1999) and Involuntary Resettlement Policy, OP 4.12 (December 2001)

(3) Scale of Land acquisition and Resettlement

There is a total of about 212.48 hectares of affected lands for acquisition and an estimated of 104 affected Informal Settler Family (ISF) in the project areas, specifically in RP 11 and Brgy. Ma-a. It is expected both physical and economic impacts for families necessary to be relocate.

(4) Compensation Policy, Package and Procedure

(a) Eligibility for Compensation and Other Entitlement

Resettlement entitlement and compensation policies cover the (1) loss of land; (2) loss of use of land; (3) loss of houses and structures; and (4) loss of income and livelihood. The project's compensation policy and package were developed in consultation with the UPMO and ESSD and other concerned government entities such as DPWH-XI ROW Acquisition & Legal Division, and CPDO of Davao City. The views of other stakeholders and PAPs through both on-line and face-to-face consultations are also reflected in the development of the policy and packages. The compensation policy and packages are based on and guided by Republic Act (RA) 10752 and in accordance with the JICA Guidelines for Environmental and Social Considerations (2010).

(b) Cut-off dates

The determination of Project-Affected Persons (PAPs) and affected improvements shall be based on the cut-off date (COD).

The Cut-Off Dates (COD) in Barangay Mandug is October 14, 2021; COD for Ma-a is July 7, 2022 and Barangay 19-B is October 20, 2021. There are no PAPs (ISFs) in New Valencia and Callawa.

(c) Entitlement Matrix

Entitlement Matrix of this project that is mentioned about type of loss and eligibilities for compensation has been prepared.

(5) Grievance Redressing Mechanism

Grievance Redressing Mechanism is described the members and powers of the organization responsible for handling complaints and problems as well as the methods of grievance procedures during land acquisition and resettlement, and operation stage. The proponents (DPWH-UPMO) is responsible to address grievance related to the environmental issues.

(6) Implementation System

The UPMO -FCMC, the project proponent, carries overall responsibility for the project. The managerial and supervisory body of DPWH is its UPMO-FCMC. Under the UPMO-FCMC lies the ROW Task Force and the Technical Working Group (TWG) that are mandated to implement the RAP. At the local level, a Right-Of-Way/Resettlement Implementation Committee (RIC) will be set up in Davao City to assist DPWH in implementing the RAP before start project.

(7) Implementation Schedule

Main step to implement RAP consists of the following 10 items and RAP will be carried out continuously from the RAP survey until final evaluation in 1-2 years after completion of the project.

1. Review and Update of RAP	6. Grievance Redress System
2. Arrangements for Implementation of RAP	7. Monitoring of RAP Implementation
3. Compensation and Other Assistance	8. RAP for RP11
4. Relocation of PAPs	9. RAP for XX ISFs in COW area
5. Information Dissemination and Consultation	10. Synchronization of Implementation

(8) Cost and Budget

The total cost for implementation of land acquisition and resettlement is estimated to be approximately **PhP 12,193,895,404.89** as shown in Table 4.6.4.

Table 4.6.4 Cost for Resettlement and Assistance to Vulnerable Group

No.	Items	Amount (PhP)	Remarks
1	Compensation Cost for Land	10,064,247,200.00	
2	Compensation Cost for Trees and Crops	33,613,265.00	
3	Compensation for HH Dwelling Units	40,740,899.00	
4	Compensation for Other Structures	21,525,000.00	
5	Compensation for DLPC Electric Posts	660,000.00	
5	Compensation for Transmission Tower	80,840,148.05	
6	Cost for Development of Resettlement Site in Mandug	250,678.67	
7	Cost for Development of Resettlement Site in Maa-Phase 1	191,809,998.70	
8	Cost for Development of Resettlement Site in Maa-Phase 2	140,595,119.18	
9	Cost for Resettlement and Assistance to Vulnerable Groups	4,105,000.00	
10	Cost for Monitoring	25,000,000.00	
	SUB-TOTAL	**10,603,387,308.60**	
11	Administrative & Contingency	1,590,508,096.29	15 %
	TOTAL	**12,193,895,404.89**	

Source: Project Team

(9) Monitoring System and Monitoring Form

ESSD will conduct the evaluation and in-house monitoring of RAP. The UPMO-FCMC of DPWH will commission an external monitoring agent (EMA) to undertake independent monitoring and evaluation. Monitoring will be carried out monthly/quarterly until end of RAP implementation, every 6/12 months until one year after completion of construction, and one and two years after completion of the project.

(10) Public Consultations

Public consultations are crucial for any proposed projects as these provide venues for disclosure and generate feedback relevant for consideration of project designs and other components.

Three layers of consultations were done for project dissemination and feedback. Each layer focused on specific stakeholders:

1) Coordination and Consultation Meetings with BLGUs, MLGUs, CSOs, and Line Agencies
2) First Round Public Consultation Meetings (PCMs) with PAPs (including ISFs)
3) Second Round Consultation Meetings (PCMs) with PAPs (including ISFs)

4.7 Project Implementation

4.7.1 Project Organization

(1) Organizational Framework for Structural Measures

In order to facilitate smooth implementation of projects covered in the feasibility study, the following organizational framework is recommended to be considered:

1) During Detailed Engineering Design and Construction

The Flood Control Management Cluster-Unified Project Management Office (FCMC-UPMO) of DPWH is expected to assume a major role and shall take the lead in the overall implementation of the projects. They will be administratively and technically supported by the DPWH Regional Office and the Davao City District Engineering Offices (DC DEO).

In order to facilitate an effective and efficient project implementation, a Davao River Project Management Office (DRPMO) will be established. The DRPMO is an adhoc office with a specialized organizational structure created to handle the overall responsibility, supervision and management of the project during detailed engineering design and during construction period. The DRPMO is expected to be under the supervision of the Office of Undersecretary for Regional Affairs-Unified Project Management Office.

2) During Operation and Maintenance

The Davao City District Engineering Office (DC DEO) is proposed to be the primary body responsible in the operation and maintenance of retarding ponds, cut-off works and dredging in Davao River with the technical support from the FCMC-UPMO.

Moreover, in order to facilitate continuity and sustainability of the technology acquired during the detailed engineering design and during construction period, it is proposed that the Davao River Management Office (DRPMO) which was established during the detailed engineering design and during construction period shall be institutionalized and a Davao River Operation & Maintenance Unit (DROMU) shall be created as a permanent unit which is responsible for the implementation of operation and maintenance of flood control works in the Lower Davao River under the Maintenance Section of Davao City DEO.

(2) Organizational Framework for Non-Structural Measures

1) During Detailed Engineering Design and Construction

In addition of responsible organization for each activity, during the detailed engineering design and construction period, the proposed Davao River Project Management Office (DRPMO) is expected to lead in carrying out the abovementioned activities in partnership with other key agencies including, but not limited to the Local Government Unit of Davao City, line government agencies, non-government organizations and the project affected communities.

2) During Operation and Maintenance

During operation and maintenance, non-structural measure activities are expected to continue. Consultations and information dissemination as well as awareness campaign on significant concerns as to the overall operation and management of the facilities shall also be conducted periodically. In this manner, relevant stakeholders are adequately informed about operation and maintenance works of the facilities and such a scheme needs to be constructed centering on DPWH.

4.7.2 Procurement Method

The construction work for this project includes large-scale earthwork and dredging work to be performed within a limited period of time, as well as embankments that require meticulous quality control. Therefore, based on the circumstances, the project will be implemented through international or domestic bidding. The contract packages will be divided into the following three packages to provide opportunities for participation to Philippine domestic contractors.

Package 1: Dredging
Package 2: Cut-off
Package 3: Retarding Pond

For detailed design and construction supervision, consulting services will be provided by a coordinated group of international and domestic engineering consultancy firms.

4.7.3 Implementation Schedule

The construction work will be divided into three packages. The implementation schedule is shown in Table 4.7.1.

Table 4.7.1 Schedule of the F/S Project

Item		Months	Year									
			1	2	3	4	5	6	7	8	9	10
1	Detailed Design	18										
2	Land Acquisition	36										
3	PQ and Tendering	12										
4	Construction Works	84										
4-1	Contract Package No.1 Dredging	72										
4-2	Contract Package No.2 Cut-off	48										
4-3	Contract Package No.3 Retarding Pond	84										

Source: Project Team

4.7.4 Funding / Finance

The total funds required to implement the project amount to 9,246 million (Local Currency Portion, pesos equivalent), and 12,349 million (Foreign Currency Portion, pesos equivalent). The total amount is 21,595 million (pesos equivalent).

4.7.5 Consulting Services

DPWH will implement the project, but a consultant will be hired to prepare the detailed design, pre-qualification (PQ), and bid documents. The consultant will also assist and support the bidding and contracting process in the pre-construction phase and supervise the construction.

(1) Consulting Service

1) Prepare detailed design, construction cost estimates, pre-qualification (PQ) and bid documents

2) PQ and bidding process assistance for selecting construction contractors, and construction supervision

(2) Duration of the Consulting Service

Engineering services (detailed design) shall be for a period of 18 months. Consulting services (construction supervision) shall be provided for 84 months (7 years, not including the construction defect period).

4.7.6 Effect of the Project and Performance Indicator

The project performance indicators to conduct the ex-post evaluation to be conducted three years or more after the F/S completion are considered and proposed.

(1) Project Performance Indicator: Operation Indicator

Water level observation is actually conducted at Waan Bridge (Tigatto Station), which is the control point of the Davao River. The monitoring of the annual maximal water or during flood event (and conversion from water level to discharge) in this station enables the evaluation of the effects (or water level decrease) due to the river channel improvement and construction of retarding ponds. In addition, through the monitoring of water level, the appropriateness and continuity of operation and maintenance (including periodic maintenance dredging) can be checked.

Regarding the three retarding ponds, non-structural measures including the installation of water level gauges are proposed. The monitoring of the water level at the retarding ponds sites enables the evaluation of the operation and maintenance of these large-scale facilities by checking the water inflow condition, duration and frequency of operation during floods.

Therefore, annual maximal water level at Waan Bridge and at the retarding ponds sites is recommended to be used as operation indicator.

(2) Project Performance Indicator: Effect Indicator

With the implementation of the F/S, damage caused by Davao River during a 10-year return period flood will almost be eliminated in the urban areas of the City. As one methodology to measure the project effect, the comparison between the targeted value of inundated area with the project implementation and the simulated value of flood area under actual situation is proposed.

Concretely, as effect indicator, the floods records on inundated areas, location of inundated areas and inundation cause (river overflow or rainwater/inland inundation) during real flood events is proposed.

4.8 Recommendation

Based on the overall results and outputs of the study, the recommendations related to the priority projects targeted in the F/S are described below.

(1) Early implementation of priority projects

Floods with inundation damage are occurring frequently in the target area, such as the flood in November 2021 (estimated to be about 5-10 year scale flood from the inundation situation). Priority projects are expected to have early effects, therefore, those early implementation is desirable to contribute to the reduction of flood damage.

(2) Effective use of excavated soil during construction and soil by maintenance dredging after construction

A large amount of excavation and dredging soil will be generated in any of the projects targeted in this F/S. In addition, even after the construction is completed and the facility is completed, soil will be generated due to the removal of sediment after flooding or regular maintenance dredging. This treatment of soil is a major issue for the projects.

On the other hand, commercial extracted sand and gravel business has been actively carried out along the Davao River. Also, at the stakeholder meetings held during the project, residents requested the use of this excavated soil, as well as a large-scale filling has been carried out in the development of residential areas along the Davao River. Based on these circumstances, it is highly possible that these generated soils will be used effectively.

It is essential to confirm the soil contamination before using it, but it is desirable to cooperate with the surrounding residents, organizations, and Davao City to make effective use of the generated soils.

(3) Detailed examination of the disposal site and implementation of environmental survey

Regarding the large amount of excavation and dredging soil generated during the implementation of this F/S projects, candidate sites for disposal sites were proposed in this Project, but no concrete decision has been reached.

In this Project, a series of discussions have been carried out so far like 1) explanation to DPWH and Davao City about the assumed amount of excavation and dredging soil and necessity of the disposal sites, 2) explanation and discussion on options for disposal sites and utilization of the soils, 3) investigation and discussion on the availability of candidate landfill sites along the coast, and 4) discussion on the availability of candidate sites for new disposal sites proposed by Project Team. Through these discussions, DPWH and Davao City fully understand the importance of securing disposal sites for the realization of the projects.

However, since the implementation of the project and its timing have not been concretely decided at this time, further detailed examination for disposal sites, such as possibility of utilization for other public projects and consultation with private companies and local residents regarding the use of the soil.

As for future prospects, it is conceivable that the treatment and reuse plan for the large amount of the soil and the selection and securing of the disposal sites will be the conditions for project implementation. Therefore, in the next phase, which is expected to be conducted toward the implementation of the projects, it is necessary to carry out detailed examination and coordination regarding the treatment and reuse plan for the excavation and dredging soil and the selection and securing of the disposal sites.

In addition to above, the followings shall be paid attentions in the environmental and social considerations:

- It is possible to select a possible disposal site in the middle – upper stream of the Davao River. In this case, candidate site shall be selected to avoid from not only naturally sensitive area but also ancestral domains lands.
- Involuntary resettlement shall be avoided as much as possible. If it is difficult to avoid it; sufficient compensation and social support shall be given to the PAPs.
- It is recommended to effectively reuse excavated/ dredged soil to reduce the necessary size of disposal site. And provision of soil to the sand mining operators, who will be stopped operation during construction phase, must be one of the mitigation measures to recover their income, etc.
- Continual public consultation for above considerations and implementation of environmental/ RAP study must be effective tools to encourage communication with the stakeholders and consensus building.

(4) Establishment and maintenance of operation and maintenance framework including procurement of necessary equipment

Appropriate maintenance is essential to maintain the effectiveness of measures and facilities. It is expected that the operation and maintenance framework proposed in this Project will be established, and that the framework will function and be maintained appropriately, such as securing equipment and budget for maintenance dredging.

(5) Implementation of hydraulic model test for retarding ponds

Various specifications of the retarding ponds (overflow dike height, overflow dike width, etc.) were set in this F/S, but these are determined based on the results of simulations by an analytical hydraulic model constructed using topographic data available in this Project.

Since it is difficult to completely reproduce a complicated flow in the simulation using the hydraulic model, it is crucial before implementing the projects that detailed topographic surveys such as river longitudinal and cross sectional surveys in the section of installation of retarding ponds including upstream and downstream of the retarding ponds, and ground height survey around retarding ponds as well as necessary surveys like riverbed material survey and geotechnical investigation will be conducted, and a hydraulic model test will be carried out by modeling topography, rivers and facilities using the survey results in the next phase such as detailed engineering design stage, in order to revise and finalize various specifications of the retarding ponds.

(6) Upgrading of height of overflow dike of retarding ponds

In the construction stage of F/S projects, the overflow dikes in the retarding ponds will be constructed at the height set based on the flow capacity (about 800 m^3/s) of the lower Davao River after the dredging project, which is one of the priority projects.

After the implementation of the river widening works, which is a mid/long-term measures, the overflow dikes need to be upgraded, that is, height of overflow dikes needs to be raised based on the enhancement of the downstream flow capacity (planned at 1700 m^3/s) to exert an appropriate effect in the event of large-scale floods.

It should be noted that the maintenance (upgrading) will be carried out in stages according to the development status of the river channel of lower Davao River.

(7) Utilization of retarding ponds in normal times

The retarding ponds are inundated/submerged for a few days during and after floods, but it is not inundated in normal times and can be used in various ways. The total area of the three retarding ponds of priority projects, is about 1.5 km^2 in terms of the area of the bottom of the retarding ponds.

It is desirable to make effective use of the retarding ponds in normal times such as sports facilities, natural parks, renting out for small-scale agricultural areas and so on, in collaboration with local residents and related organizations, taking account of the conditions of inundating/submerging in the event of floods.

(8) Handling of the present river after implementation of the cut-off works

Rainwater drainage from areas along the Davao river flows into the Davao River not only during floods but also during normal times. If the present river channel (meandering part) will be reclaimed after the cut-off works project, it is necessary to plan and install facilities (drainage channels connecting to the Davao river, regulating reservoirs, etc.), which properly treat the rainwater drainage flowing into the present river channel from the surrounding area during normal and flood times.

(9) Coordination with other projects (Davao Expressway) closely related to the F/S projects

In the Davao River, there are many on-going and planned road projects such as the bypass road currently being implemented and the Davao Expressway where F/S completed, even in the target area of the F/S projects. Of these, the alignment of the Davao Expressway is planned to cross the Davao River multiple times.

Since most of the sections of the Expressway are elevated except for some sections, there is no problem in relation to the HWL during floods, but in the cut-off works planning section targeted for this F/S, the planned alignment of the Expressway intersects the cut-off works section on the south side. It is necessary to coordinate/adjust the alignment of the road or the position and type of the piers.

Davao Expressway is under the jurisdiction of DPWH UPMO RMC. Appropriate coordination must be made within DPWH UPMO to implement the projects.

(10) Enhancement of disaster management activities by utilizing flood hazard map and IEC materials referencing Japanese actual examples

In Davao City, although flood hazard maps were prepared, several organizations create the maps with different methods and accuracy, and, there is no sufficient explanation from preparing agency when distributing the map. Therefore, the maps are not linked to effective disaster management activities.

In this Project, the first draft of IEC materials was created to improve residents' awareness of flood risks, and it was proposed that they will be distributed and utilized at the training institute to be established in Davao, although actual way of utilizing them would be discussed and determined by DPWH and Davao CDRRMO.

In Japan, various ideas have been devised regarding the utilization and publicity of hazard maps and IEC materials, like 1) explanation of how to use the hazard maps and meaning of items written on the maps at various city events, 2) creating hazard maps focusing on the living area of residents through discussion on information necessary for evacuation with residents and local government officials, 3) holding on-site lectures and study sessions for residents by local government officials and river administrators, 4) conducting evacuation drills using the hazard maps, 5) using the maps and materials for disaster management education at schools, 6) introducing the maps and materials in the mass media (radio), 7) publicizing the maps and materials through public relations magazines, and 8) displaying information on the hazard map, such as water levels in the event of a disaster, on utility poles and billboards throughout the town to raise awareness among local residents.

Referencing these actual examples in Japan, it is expected that hazard maps and IEC materials prepared in this Project will be appropriately updated and utilized paying attention to the following points of 1) when distributing materials, to explain carefully the contents of the materials and how to use them, and 2) to provide a wide range of opportunities for distributing and introducing the materials.

Chapter 5 Pre-Feasibility Study for Future Priority Project

5.1 Future Priority Project and Preliminary Design of Structural Measures Targeted for Pre-Feasibility Study for Riverine Flood in Davao River

5.1.1 Future Priority Project of Structural Measures Targeted for Pre-Feasibility Study for Riverine Flood in Davao River

(1) Overview of Priority Project (Structural Measure) Target for Pre-Feasibility Study

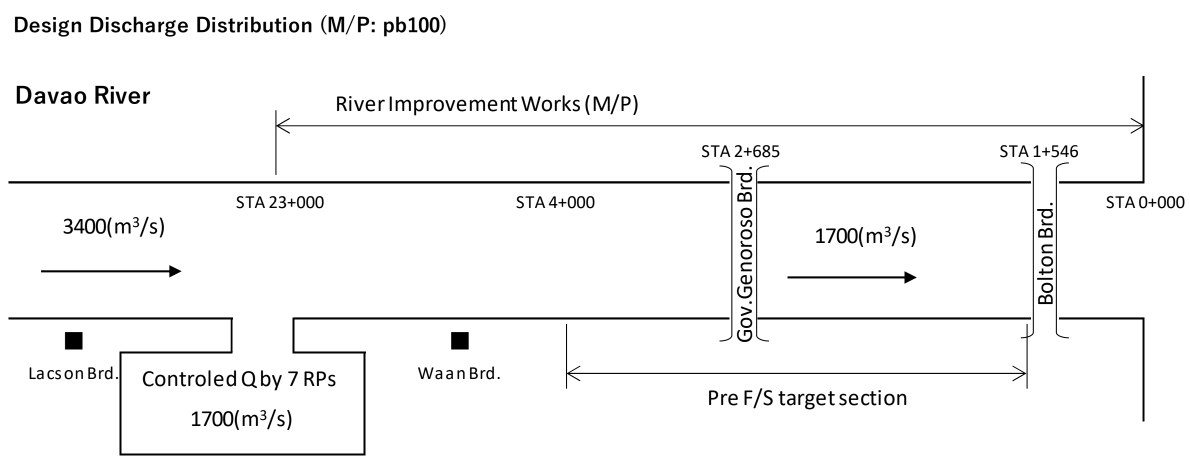
The priority project targeted for Pre-F/S will be undertaken after completion of the priority projects targeted for F/S described in Chapter 4, therefore, the project is based on the premise that flood control safety level of 10 year scale flood or less is already secured.

In this Pre-F/S, the downstream section with 2.5km distance from the Bolton bridge to Sta. 4+000 was selected as a pilot section for the river widening works, which is one of the mid-long term measures for the Davao River, and the study at pre F/S level was conducted for the pilot section. The purpose of the study is to grasp in advance the issues that will arise when implementing future widening works and to consider countermeasures against the issues, and then, to contribute to the smooth implementation of future project.

Table 5.1.1 Priority Project Targeted for Pre-Feasibility Study and Structural Measures in M/P

Item	Target Portion	Remarks
River Improvement	Riverbed Dredging Works STA 0+500 – STA 23+000 (L=18.0km)	Priority Project for F/S
	Cut-off Works STA 6+500 – STA 12+700 (L=1.3 ㎞)	Priority Project for F/S
	River widening Works STA 0+500 – STA 23+000 (L=18.0km) (Target Area of Riverine Flood Control)	Priority Project for Pre-F/S at the portion of STA 1+561 – STA 4+000 (L≒2.4km)
Retarding Ponds	7 retarding ponds installation at upper portion of the Davao River	Priority Project for F/S at the portion of RP 08, RP 09, and RP 11

Source: Project Team

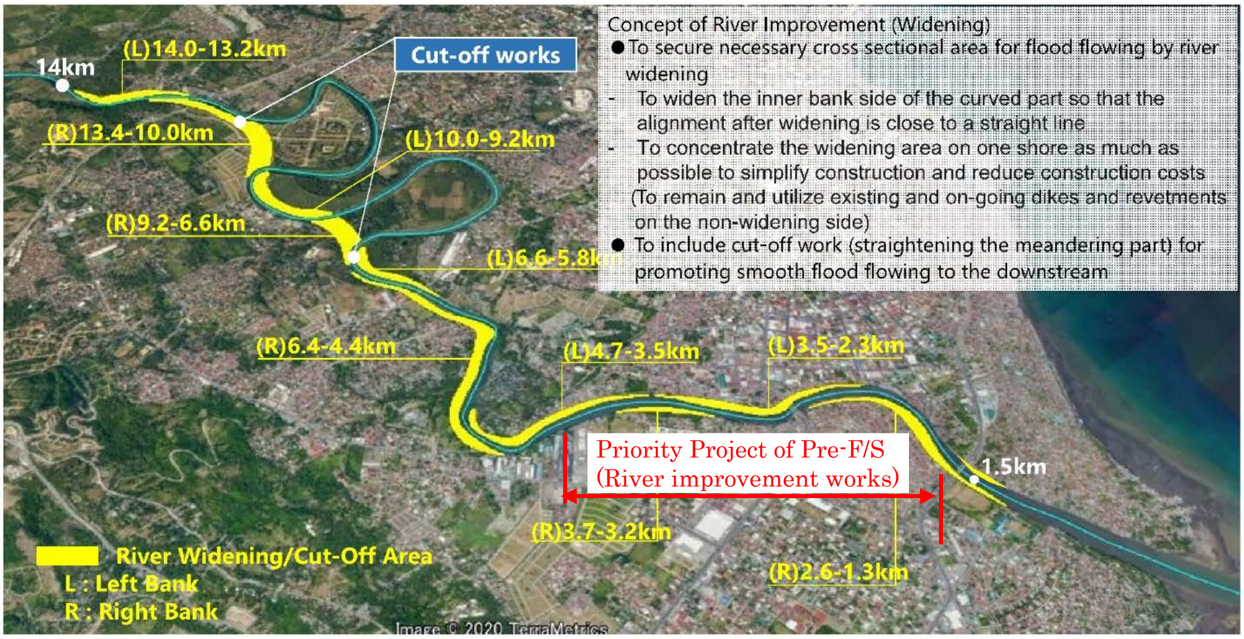


Source: Project Team

Figure 5.1.1 Design Flood Discharge Distribution of Davao River (100-yr scale floods)

(2) Target Area of Priority Project (Structural Measure) Target for Pre-Feasibility Study

As shown in Figure 5.1.2, the target area of the priority project for Pre-F/S is the reach from immediately upstream of the Bolton Bridge (STA 1+561) to STA 4+000 since the downstream of the Bolton Bridge has been undertaken the river improvement works by DEO and RO in addition to that reach has sufficient flow capacity against the design flood discharge of 1,700 m^3/s.



Source: Project Team

Figure 5.1.2 Conceptual Drawing of Priority Project for Pre-F/S

5.1.2 Additional Topographic and River Surveys for Structure Measures of the Future Priority Project Targeted for Pre-Feasibility Study for Riverine Flood in Davao River

For the facilities (river widening) subject to PRE-F/S of the Davao River, topographical surveys and river surveys were conducted on the Downstream of the Davao River. The survey works was subcontracted to a local survey firm and carried out during the period from April 2021 to August 2021. The work items and quantity are as Table 5.1.2.

Table 5.1.2 Work Item and Work Quantity (Additional Topographic and River Survey)

Work Item	Quantity
1. River and Topographic Survey of PRE-F/S Targeted Structure (Downstream of the Davao River)	
1.1 River Longitudinal Survey (Station No. 0+500 – 4+000)	3.5km
1.2 River Cross Sectional (C/S)Survey (Interval of C/S：100m pitch, Width：200m)	36 sections
1.3 Ortho-photo Mapping by UAV(including GCP survey:10points)	70 ha

Source: Project Team

5.1.3 Geotechnical Investigation for Structure Measures of the Future Priority Project Targeted for Pre-Feasibility Study for Riverine Flood in Davao River

A geological investigation (BH-9: 1 site) was carried out in the central part of the river channel widening section for the preliminary design of the pre-F/S priority project (structural measures).

The main purpose of the geological investigation was to confirm the stratigraphy of the underlying ground for the study of the revetment at the channel widening section, in particular to confirm the presence or absence of the soft ground. As the elevation of the existing borehole was unknown, we made sure to take the elevation of those new boreholes. The location map and coordinates of the geotechnical survey locations are shown below.

Source: Project Team

Figure 5.1.3 Geotechnical survey location maps for priority projects for F/S (BH-09)

Table 5.1.3 List of Geotechnical survey location for priority projects for F/S (BH-09)

No.	Coordinate Location		Description with type of structure assumed
	N	E	
BH-9	7° 4'8.12"N	125°35'49.24"E	Channel Widening (revetment / embankment)

Source: Project Team

(1) Geotechnical Investigation on River Widening Section

In the channel widening section, BH-11 was drilled near the middle of the section. The foundation soil consists of alternating layers of sand and clay with a thickness of 2-5 m. For the clayey layer, the average N-value is more than 10 at depths of 1.5-4.5 m and more than 20 at deeper depths, indicating that there was no soft ground at investigated location.

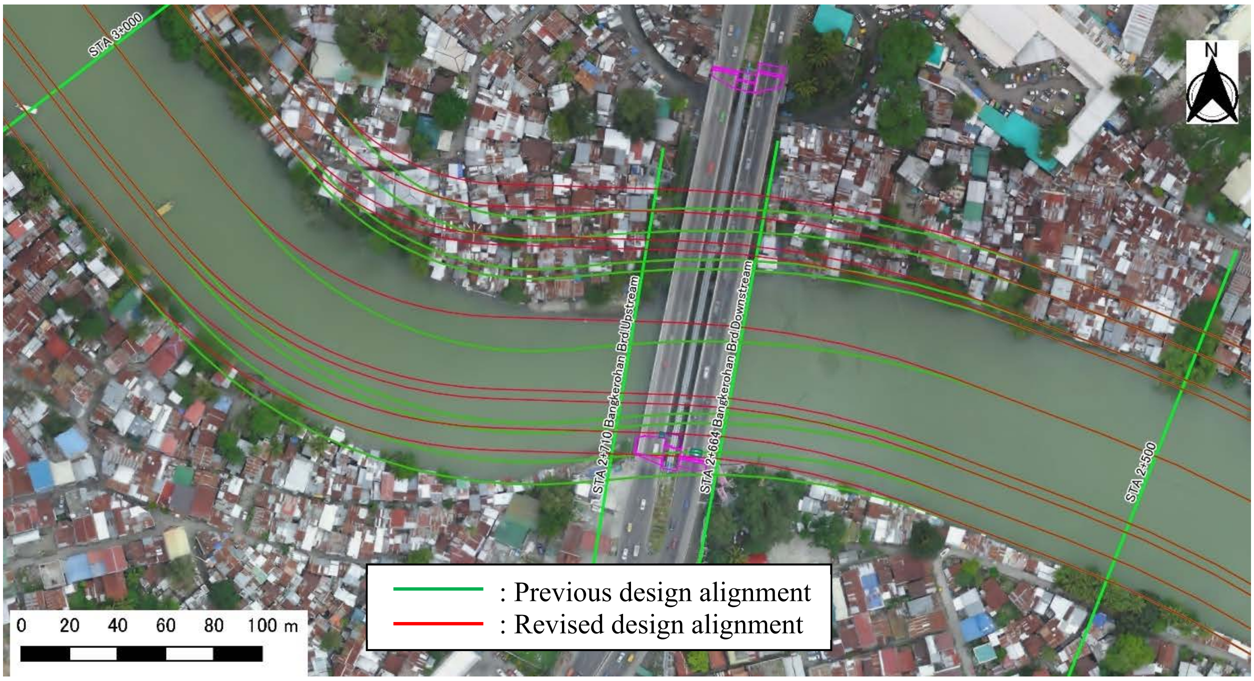
5.1.4 Hydraulic Study and Setting of Design Conditions for Future Priority Project of Structural Measures Targeted for Pre-Feasibility Study

(1) Design River Shape

The design river shape is considered based on the river shape that is considered corresponding to the design flood scale (100-yr scale flood) in Chapter 4 Feasibility Study.

1) Plan View Designing

The design river alignment has been set in Chapter 4 Feasibility Study with respect to the existing channel alignment, while considering the number of houses to be relocated due to river widening work, effective use of existing revetments, construction period and cost, and with widening by single-bank side construction in mind. The location of abutments of Gov. Generoso Bridges (STA 2+664 (downstream side) and STA 2+710 (upstream side)) were identified in conjunction with additional surveying in Pre-F/S. As a result, it was found that the design river channel conflicts with the right bank abutment and that the left bank abutment is located far from the current left bank. Therefore, the design river alignment was adjusted so that the design river channel would fit within the width of the existing bridge.

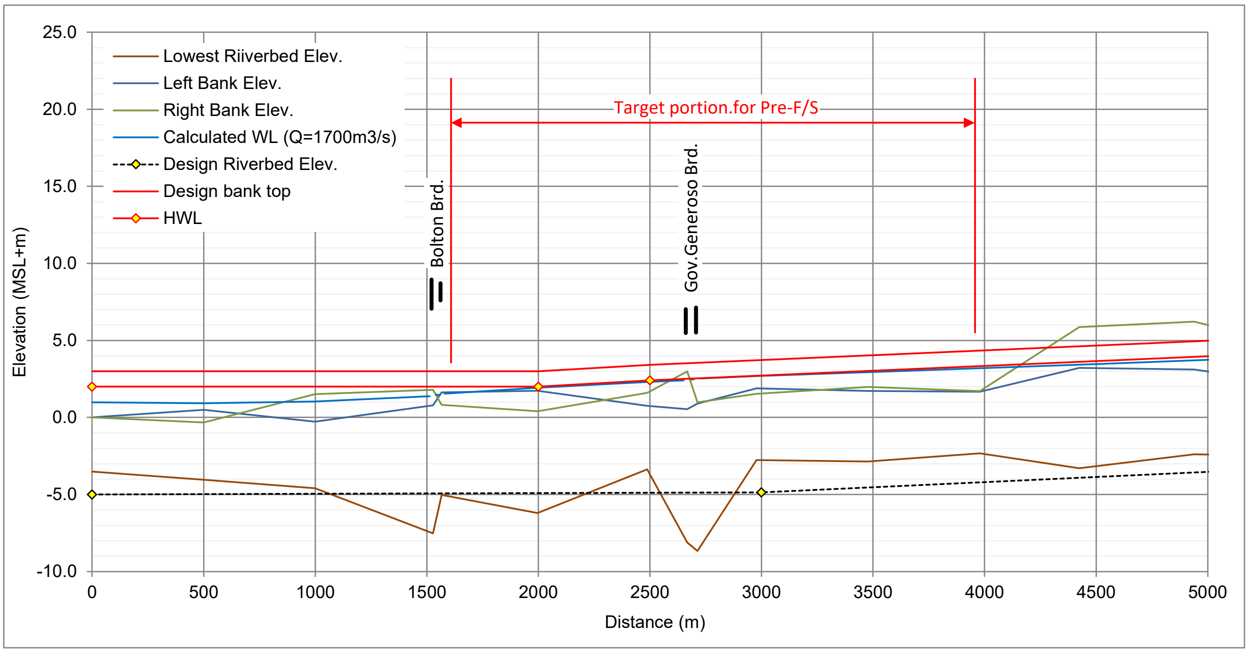


Source: Project Team

Figure 5.1.4 Design River Alignment Portion Arranged in Pre-F/S

2) Longitudinal Profile Designing

The design riverbed elevation and gradient have been set as generally the same as the existing river channel in Chapter 4 Feasibility Study, with no large-scale alteration of the riverbed gradient or excavation of the riverbed, in order to ensure stable riverbed elevation and biological habitat. Figure 5.1.5 shows the design longitudinal profile of target reach for Pre-F/S. Here, a storm surge protection levee (MSL+3.00m) will be constructed up to STA 2+000.

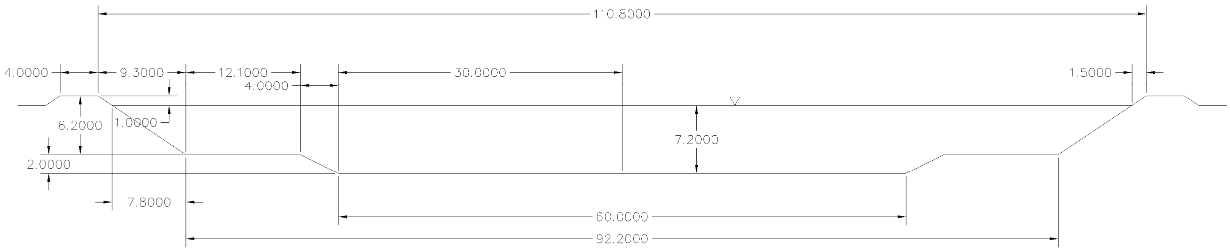


Source: Project Team

Figure 5.1.5 Design River Profile of Target Reach for Pre-F/S

3) Typical Design Cross-section

The typical design cross-sectional has been set by no-uniform flow calculations as a cross-section that can flow the design flood discharge based on the design longitudinal profile in Chapter 4 Feasibility Study. Since the target reach for Pre-F/S includes a portion subject to the backwater effect of the tide level, the water level with design flood discharge is calculated by non-uniform flow calculation for the river channel to which the typical cross-section shown in Figure 5.1.6 is applied, and the validity of the design high water level would be confirmed.

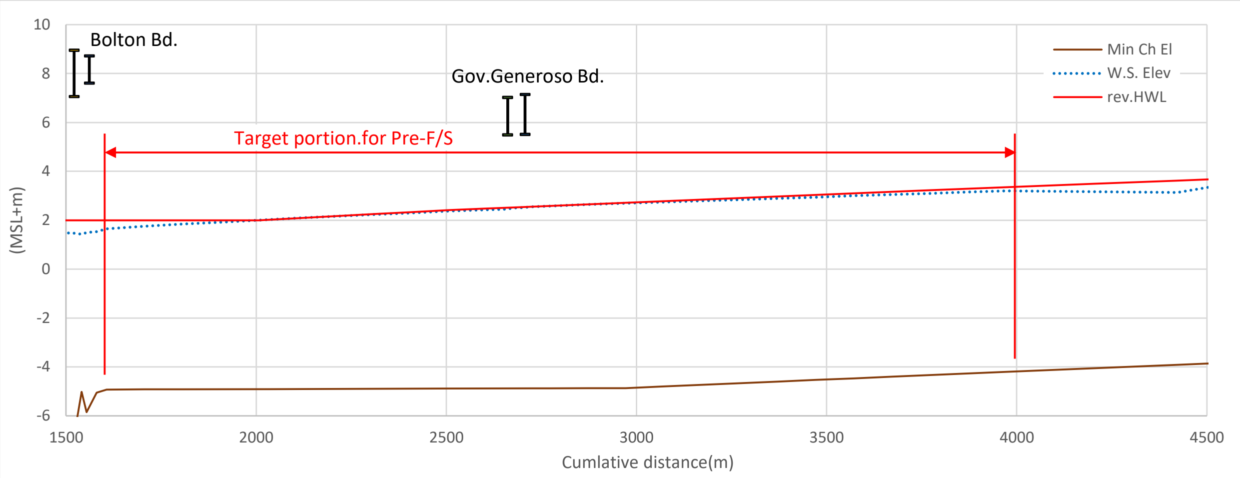


Source: Project Team

Figure 5.1.6 Typical Design Cross-section of Target Reach for Pre-F/S

(2) River Widening

The water level at the condition of design flood discharge of 1,700m3/s was calculated using 1D non-uniform flow calculations for the design rive shape set in the section above. For the downstream end boundary condition, the mean high tide level (MHHW) (MSL+0.981m) was applied, taking into account that the project for Pre-F/S is a middle to long-term project in the M/P, and that future increases of tide level due to climate change. As a result of the calculations, as shown in Figure 5.1.7, the water level at the condition of design flood discharge was less than HWL in the target reach for Pre-F/S, and it was confirmed that the design river shape considered in the previous section has no hydraulic problems.



Source: Project Team

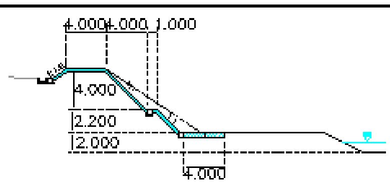
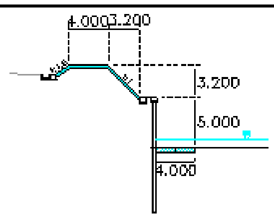
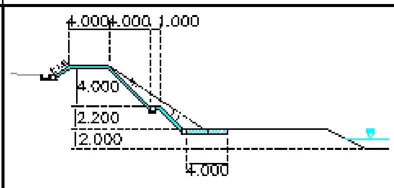
Figure 5.1.7 River Water Level Profile with Design River Shape of Target Reach for Pre-F/S

5.1.5 Comparison of Alternatives for Future Priority Project of Structural Measures Targeted for Pre-Feasibility Study

(1) River Widening

Regarding the river widening, land acquisition is the key to smooth implementation of the project. Therefore, the width of the channel is preferable to be smaller, but on the other hand, in order to secure the enough channel capacity to be safely flowing the design flood discharge, sheet pile revetments, etc., which may result in increased construction costs, need to be installed. Consequently, the required right-of-way (ROW) and cross-sectional structure are selected as items for setting alternatives for comparison. The alternatives are shown in Table 5.1.4. Regarding the handling of the 30-meter Easement, discussions were held with related agencies including C/P such as DPWH UPMO and Davao City, and it was concluded that "Development of the 30-meter Easement is still in the concept stage and there are no concrete plans at this time, so the project should be considered within the design river channel width and ROW". For reference, however, a proposal to secure the 30m Easement from the design riverbank is also shown in Table 5.1.4.

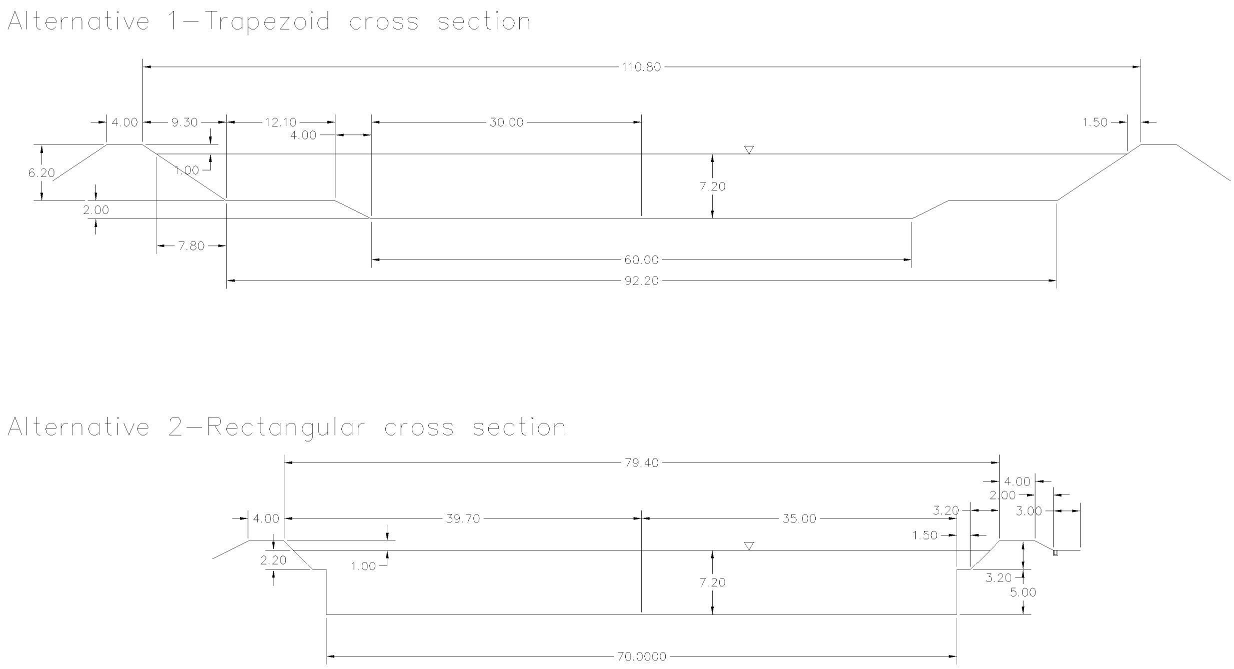
Table 5.1.4 Alternatives of River Widening

Alterna-tives	Alt.1	Alt.2	Reference
Contents	- Inverted trapezoidal double cross-section - Channel width: 111m+ROW	- Rectangular cross-section with straight wall - Channel width: 80m+ROW	- Inverted trapezoidal double cross-section - Channel width: 111m+30m Easement
Revetment structure			

Source: Project Team

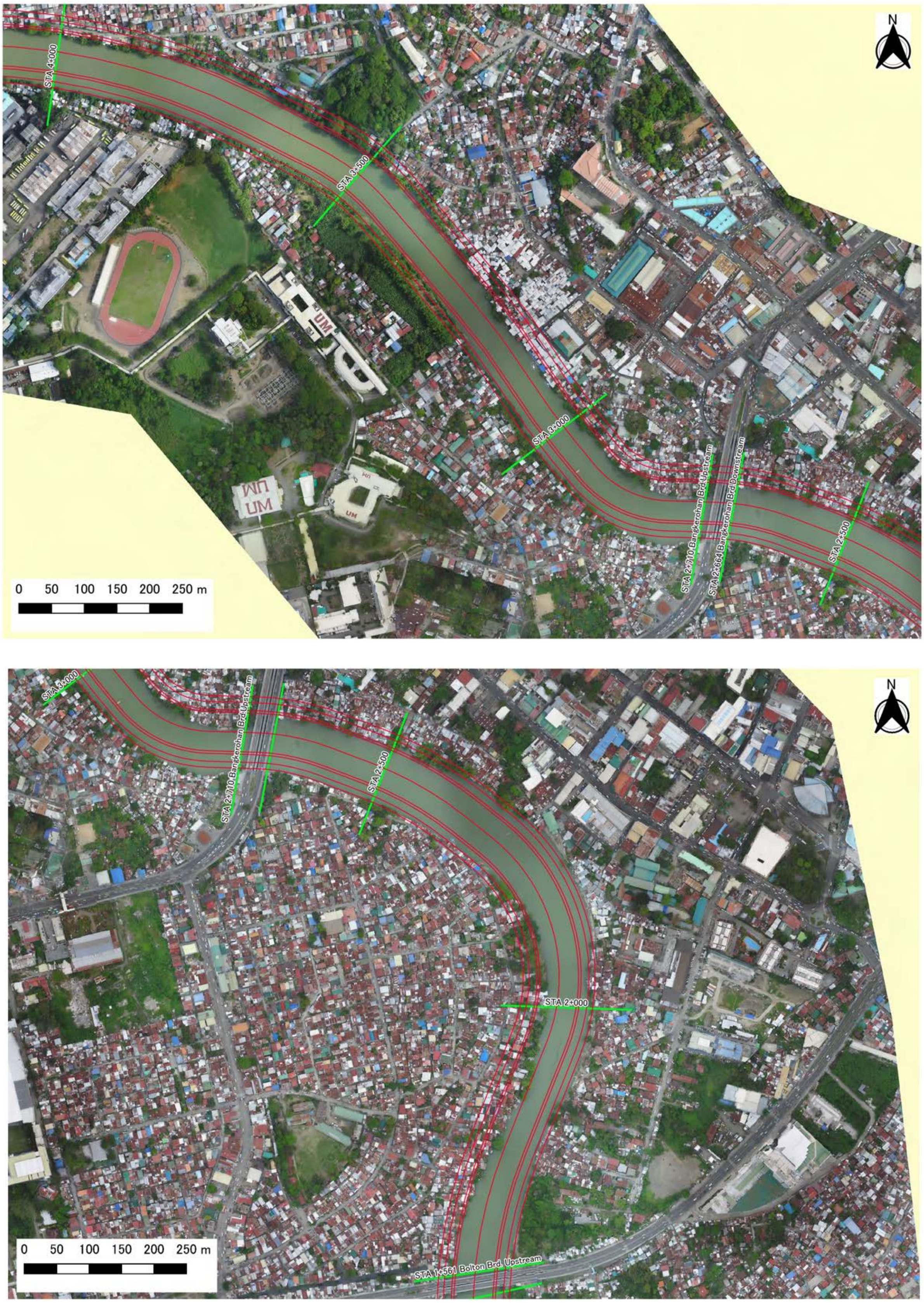
The revetment structure of Alt.1 is a concrete revetment with a slope of 1:1.0 with a catwalk, based on the typical cross-section shown in Section (1), to ensure the stability of the slope, and to prevent bank erosion with the flow velocity under the condition of design flood discharge. Alt.2 is a rectangular cross-section with sheet pile revetment to minimize the required width of the designed river channel. In order to ensure the structural stability of the revetment, a sheet pile revetment height from the riverbed would be less than 5m, and a 1:1.0 concrete revetment is applied for the portion beyond 5m. As a result, the typical design cross-section width for Alt.2 is approximately 80m. As described in (2), the target reach for Pre-F/S shall be considered to the backwater effect of the tide level, so it is confirmed that the water level calculated by the non-uniform flow calculation is less than HWL for Alt.2 as well.

For the design alignment of Alt.1, the design channel alignment studied in F/S is applied, while for Alt.2, the design channel alignment is adjusted to reduce the number of affected houses as the width of the design channel is reduced. The design plan drawings for each alternative are shown in Figure 5.1.9 and Figure 5.1.10, respectively.



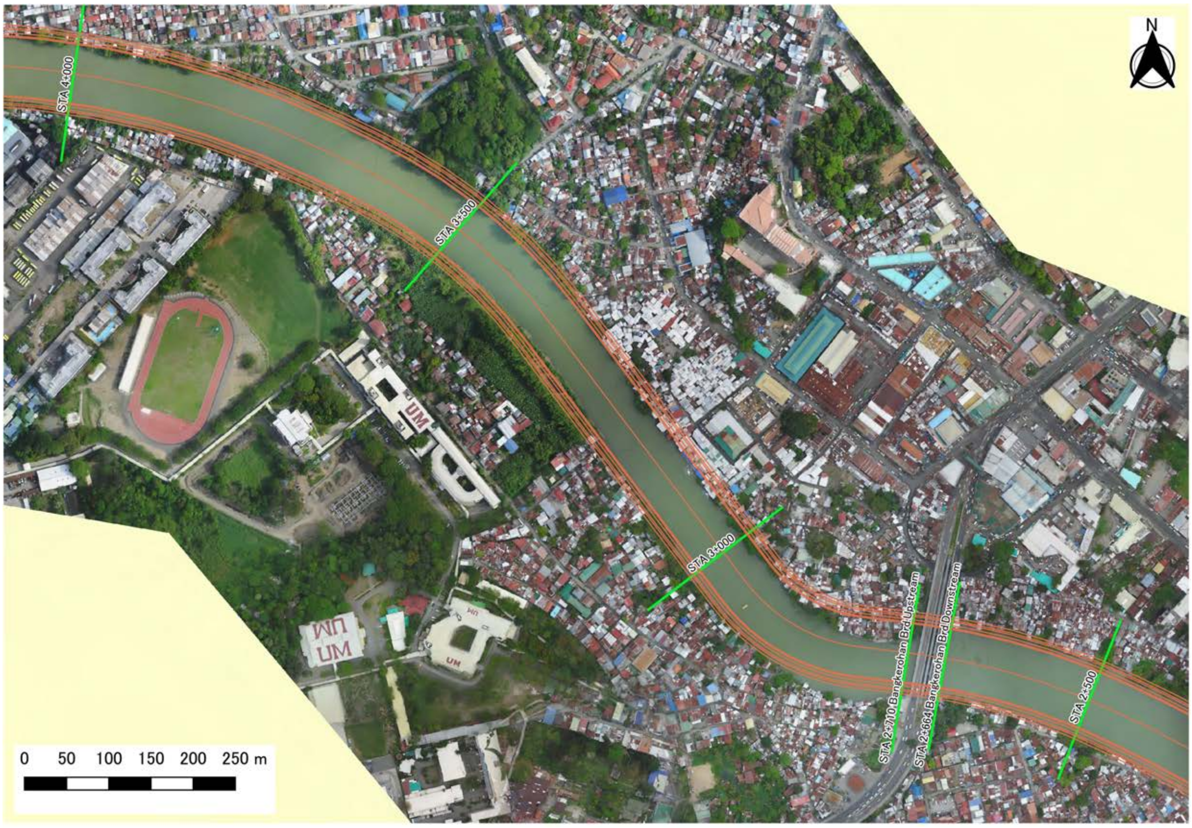
Source: Project Team

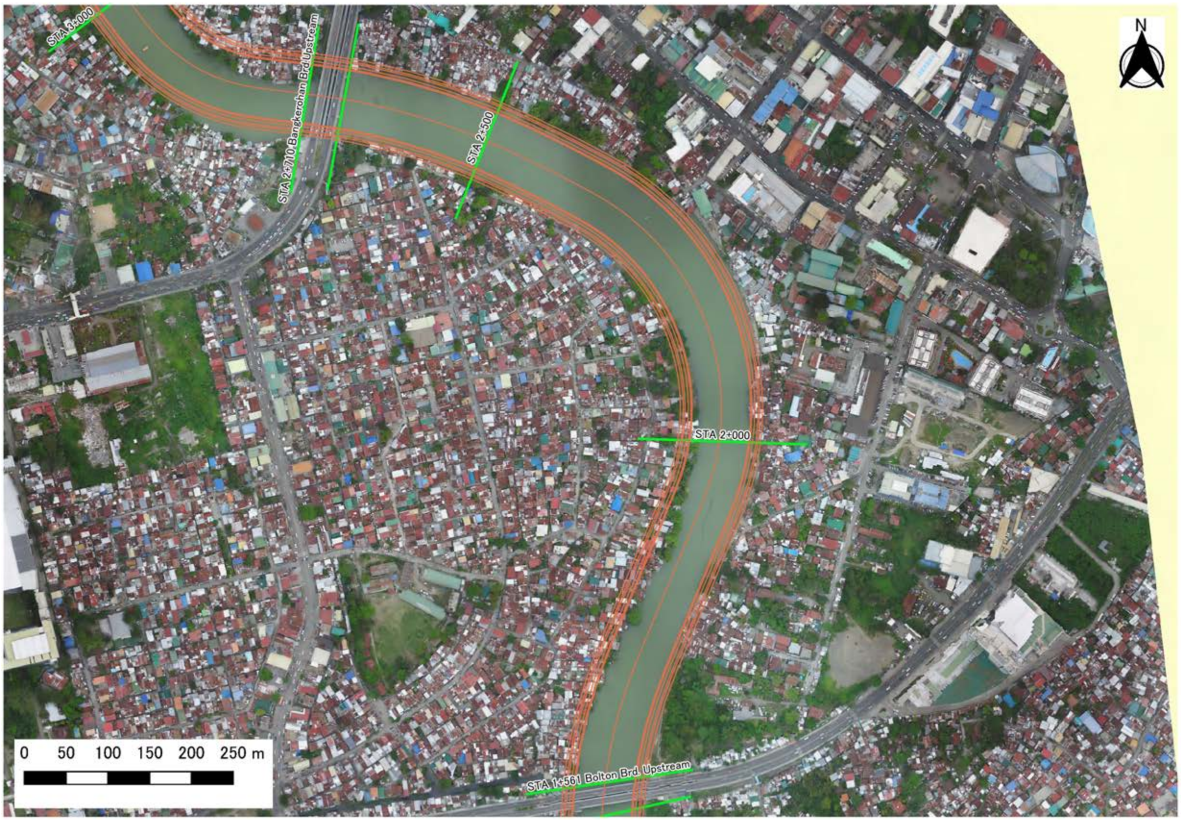
Figure 5.1.8 Typical Cross-section of Alternatives of River Widening



Source: Project Team

Figure 5.1.9 Design Alignment of Alternatives of River Widening (Alt.1)





Source: Project Team

Figure 5.1.10 Design Alignment of Alternatives of River Widening (Alt.2)

The result of comparison of river widening alternatives is shown in Table 5.1.5.

Table 5.1.5 Comparison of Alternatives for River Widening

Alternatives	Alt.1: Inverted trapezoidal double cross-section (channel width: 111m+ROW)	Alt.2: Rectangular cross-section with straight wall (channel width: 80m+ROW)	Reference: Inverted trapezoidal double cross-section (channel width: 111m+30m Easement)
A. Flood protection level (expected damage reduction)	Flow capacity 1700m^3/s (Design flood discharge in M/P (100-yr scale floods)		
B. Economic effectiveness	Direct cost for works: 0.50 Billion PhP Land acquisition/compensation cost: 0.35 Billion PhP Total: 0.85 Billion PhP	Direct cost for works: 1.40 Billion PhP Land acquisition/compensation cost: 0.14 Billion PhP Total: 1.54 Billion PhP	Direct cost for works: 0.50 Billion PhP Land acquisition/compensation cost: 0.73 Billion PhP Total: 1.23 Billion PhP
C. Feasibility from in regards with social restriction	Affected houses: 1,150 (incl. 990 IFS)	Affected houses: 480 (incl. 440 IFS)	Affected houses: 2,240 (incl. 1,850 IFS)
D. Feasibility from the technical viewpoint to construct countermeasures	Phased construction is available.	Phased construction is available.	Phased construction is available.
E. Sustainability	- Maintenance dredging volume is minimum	- Maintenance dredging volume increase twice of Alt.1 - Difficulty and cost for rehabilitation/repairing would be higher since structure of straight wall portion will be sheet pile	- Maintenance dredging volume is minimum
F. Flexibility	- It is relatively easy to deal with the need to revise the cross-section (increase the flow area) in the future.	- The straight wall portion will be a sheet pile structure, and it is difficult to respond to the need to revise the cross-section (increase the flow area) in the future.	- It is relatively easy to deal with the need to revise the cross-section (increase the flow area) in the future.
G. Social and natural environment impact	- Compared to Alt.2, the land acquisition area would be larger. Impact to the local society (variation of land use, reconstruct of existing infrastructures, especially road) would be occur. - Compared to Alt.2, access to the river is easier and more hydrophilic.	- Compared to Alt.1, the scale of land acquisition and impact to local society would be mitigated. - Compromising access to the river and the landscape due to the high straight wall.	- The scale of land acquisition and impact to local society is maximum. - Compared to Alt.2, access to the river is easier and more hydrophilic.
	- There is a possibility of air and water pollution due to construction, whereas it can be reduced by general measures. - Project site is an urban area with almost no forests or green areas. Vulnerable ecosystems are not assumed, whereas general measures for conservation of urban ecosystems (control of generation and diffusion of turbid water, green areas in river channels, design considering natural riverbeds, etc.) are recommended.		
Other	—	—	—
Evaluation Result	**The direct construction cost is 1/3 of Alt.2, the volume of maintenance dredging can be minimized, and there is greater future flexibility.** **The number of relocations is about twice that of Alt.2, but the consent of Davao City and**	**The number of relocations is less than half that of Option 2, but the direct construction cost is about three times that of Option 2.** **Although future flexibility is low and maintenance costs including maintenance**	

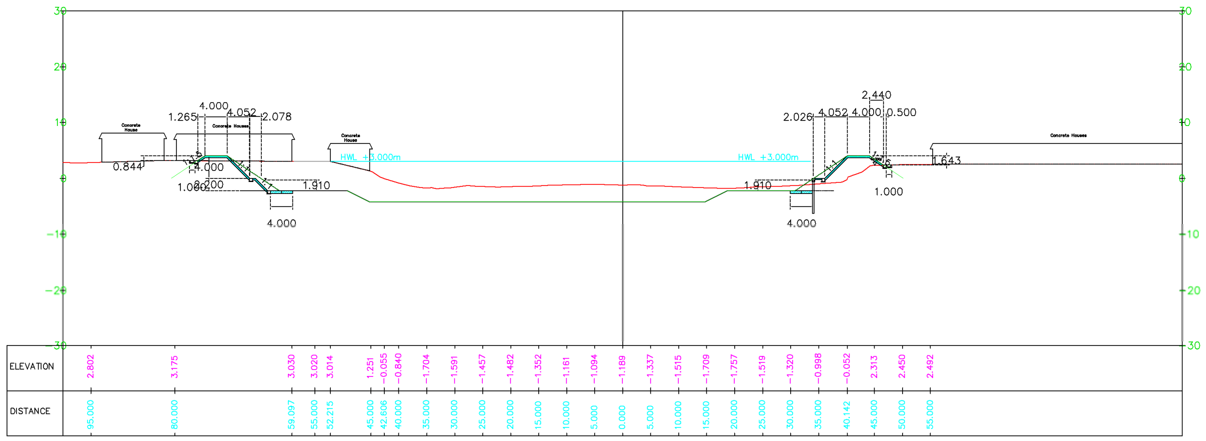
Alternatives	Alt.1: Inverted trapezoidal double cross-section (channel width: 111m+ROW)	Alt.2: Rectangular cross-section with straight wall (channel width: 80m+ROW)	Reference: Inverted trapezoidal double cross-section (channel width: 111m+30m Easement)
	DPWH, regarding the main river channel alignment and ROW, has been obtained. ◎ (Recommended)	dredging are expected to be high, it can be an alternative when land acquisition is extremely difficult. △	

Source: Project Team

5.1.6 Preliminary Design of Structure Measures of the Future Priority Project Targeted for Pre-Feasibility Study for Riverine Flood in Davao River

(1) Preliminary Design of Structural Measures (Pilot Section of River Widening Works)

The revetment structure was studied for the cross section of the river channel widening works. An example of a 4.0k cross-section is shown below as a standard cross-section including left and right banks. The planned crest height is 2.5m higher than the current ground level at most, while some sections have "excavate channel" where the crest height is lower than the existing ground.



Source: Project Team

Figure 5.1.11 River widening works: standard revetment section (4.0k)

Concrete revetment structure (without steel sheet piles) will be the standard structure, but depending on the relationship between the planned river cross-section and existing ground level/existing dike alignment and the planned cross-section, different types of structure are proposed, such as the installation of steel sheet piles as foundation or the use of the existing dike.

(2) Investigation of ROW and Affected Buildings for Pilot Section of River Widening Works

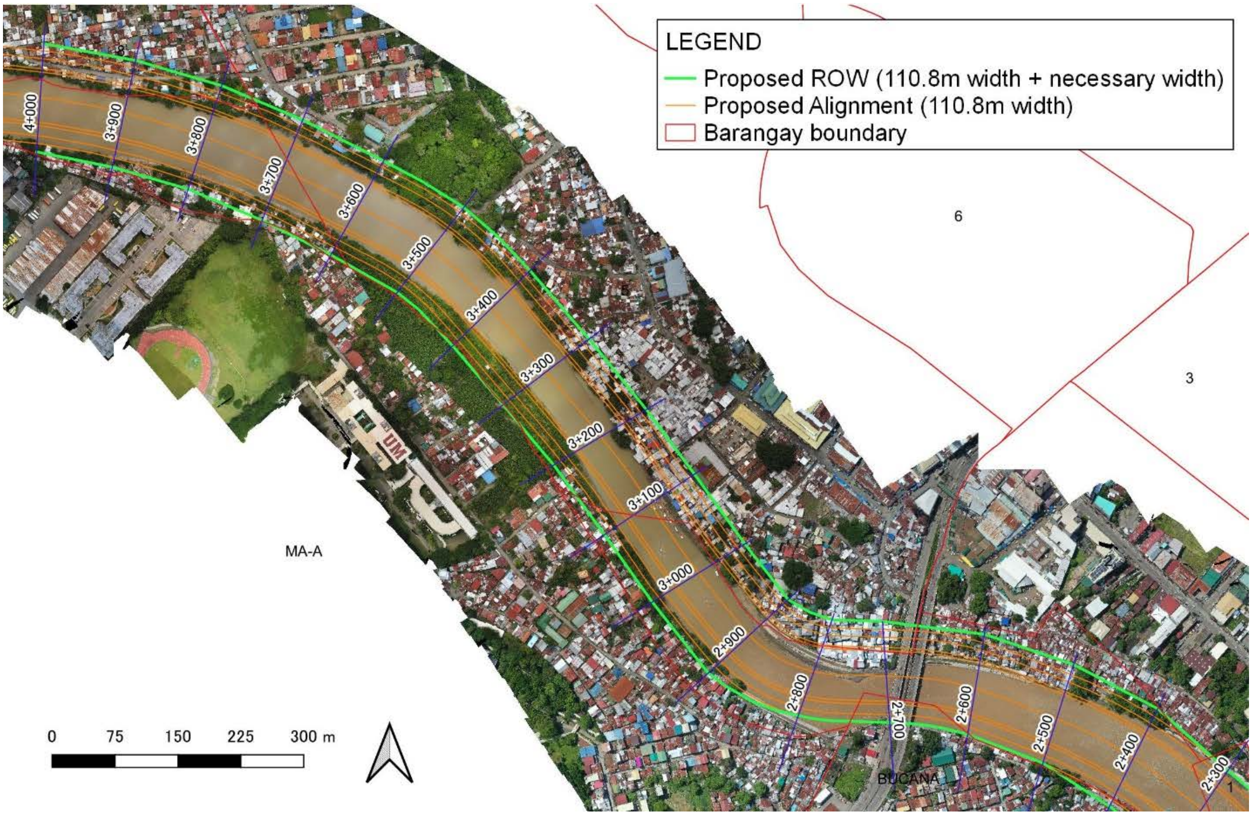
Right of way (ROW) for Pilot Section of River Widening Works was investigated. Necessary width that consists of crown width, slope, base concrete and width for construction was checked for each surveyed cross section with 100m interval in longitudinal direction. Then those checking points are connected to set ROW alignment as shown in Figure 5.1.12.

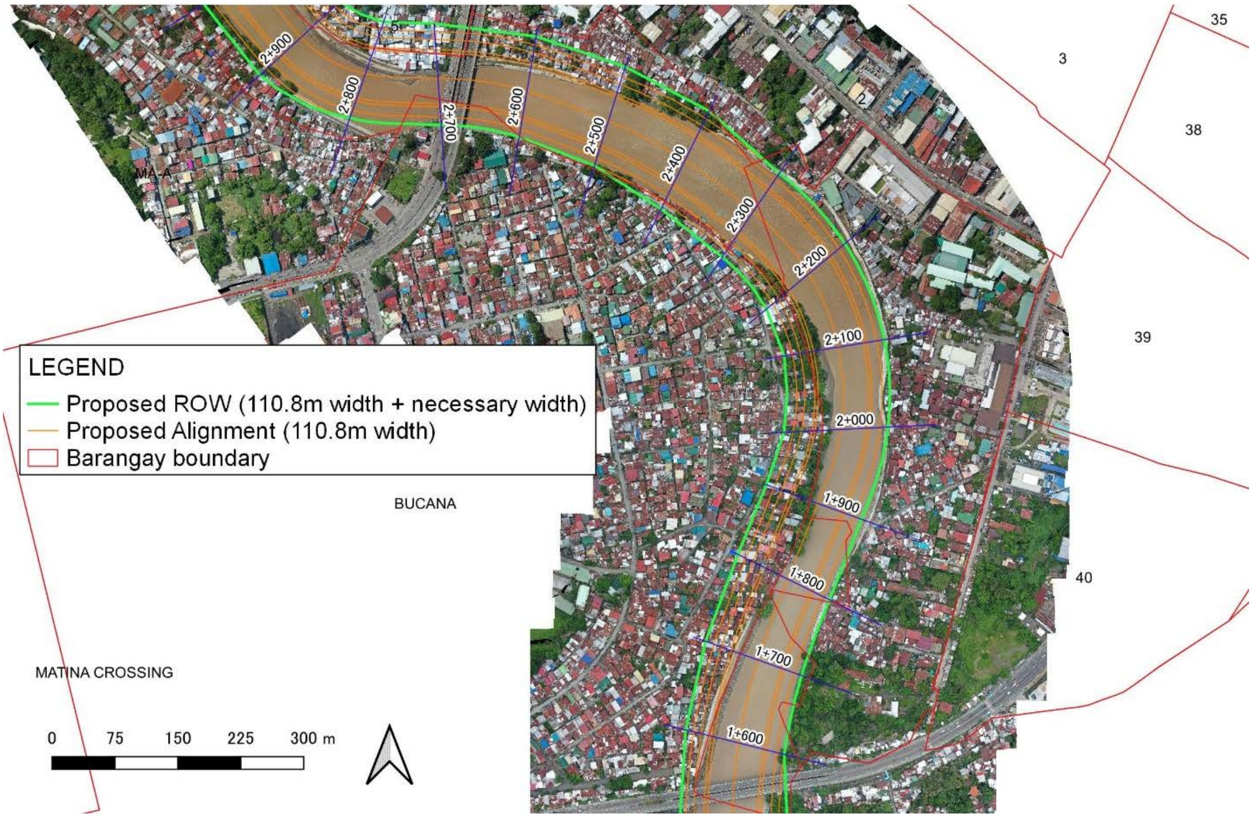
In addition, as a preliminary parcellary survey, tax maps and technical description were collected from CAO (City Assessor's Office) in Davao City and analyzed. Figure 5.1.13 shows digitized lot boundary around ROW in the pilot section with about 2.5 km from Bolton bridge to Station 4+000. Also, Figure 5.1.14 shows status of land in ROW such as with/without title or area included/not included in collected Tax Maps. From the analysis, it was found that:

- The Tax Map, currently available in the City, only covers partially the proposed ROW.

- In the ROW area where already populated by structures/improvement but without Tax Map may have titles and subdivided or still governmental lands. To confirm this, the collection of TCT and/or OCT as well as the technical description is necessary.

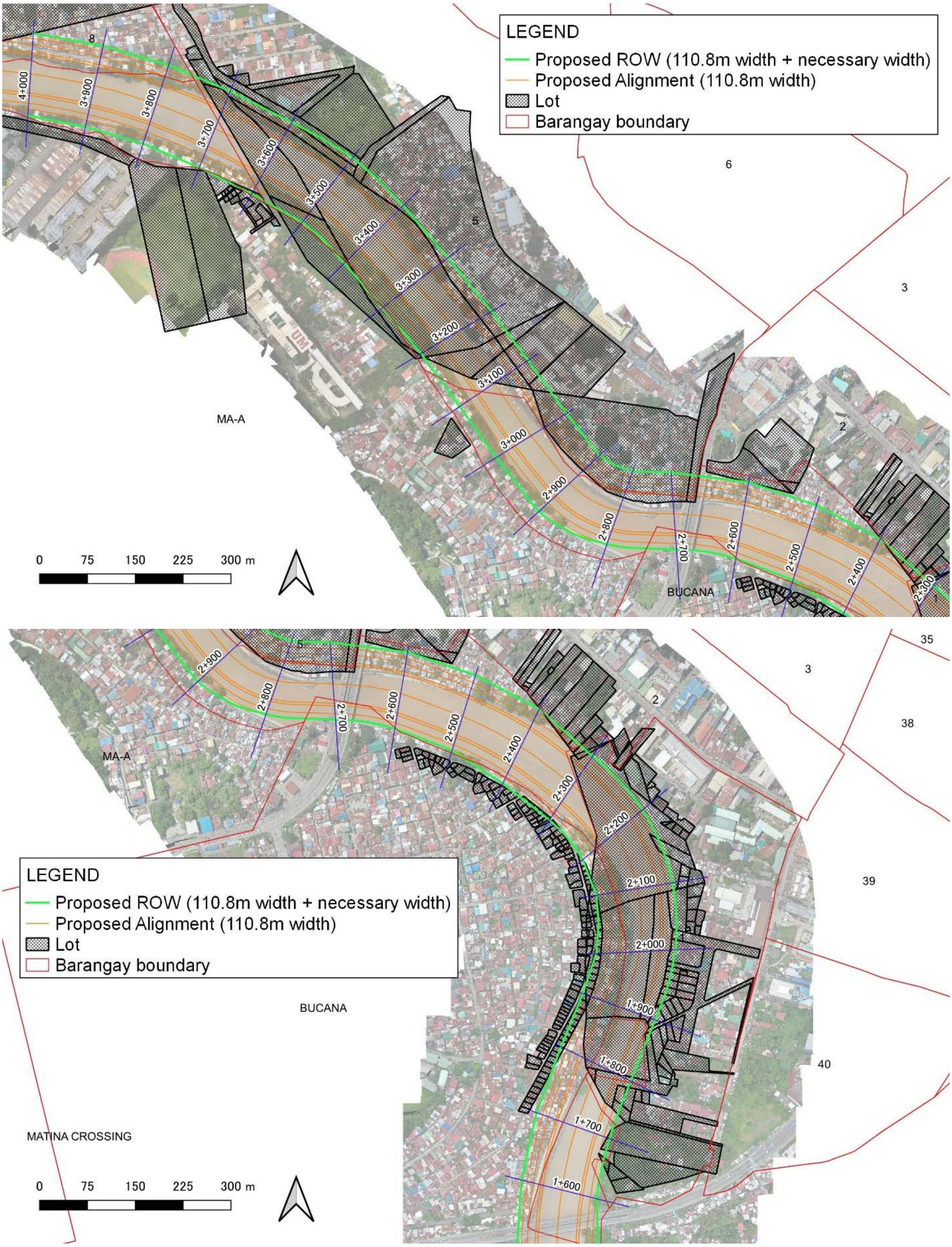
In the Detailed Design Stage, it is necessary that 1) to collect the approved land plans and technical description for the proposed ROW to confirm the latest status of the subdivision in each lot from DENR Region 11, 2) to collect TCT and/or OCT from Land Survey Department Region 11, 3) to collect Tax Declaration from City Assessor Office of Davao City, and then, 4) to prepare the Parcellary Survey Plan based on the above supporting documents, and 5) to validate the eligibility of each affected lot for the compensation by the government.





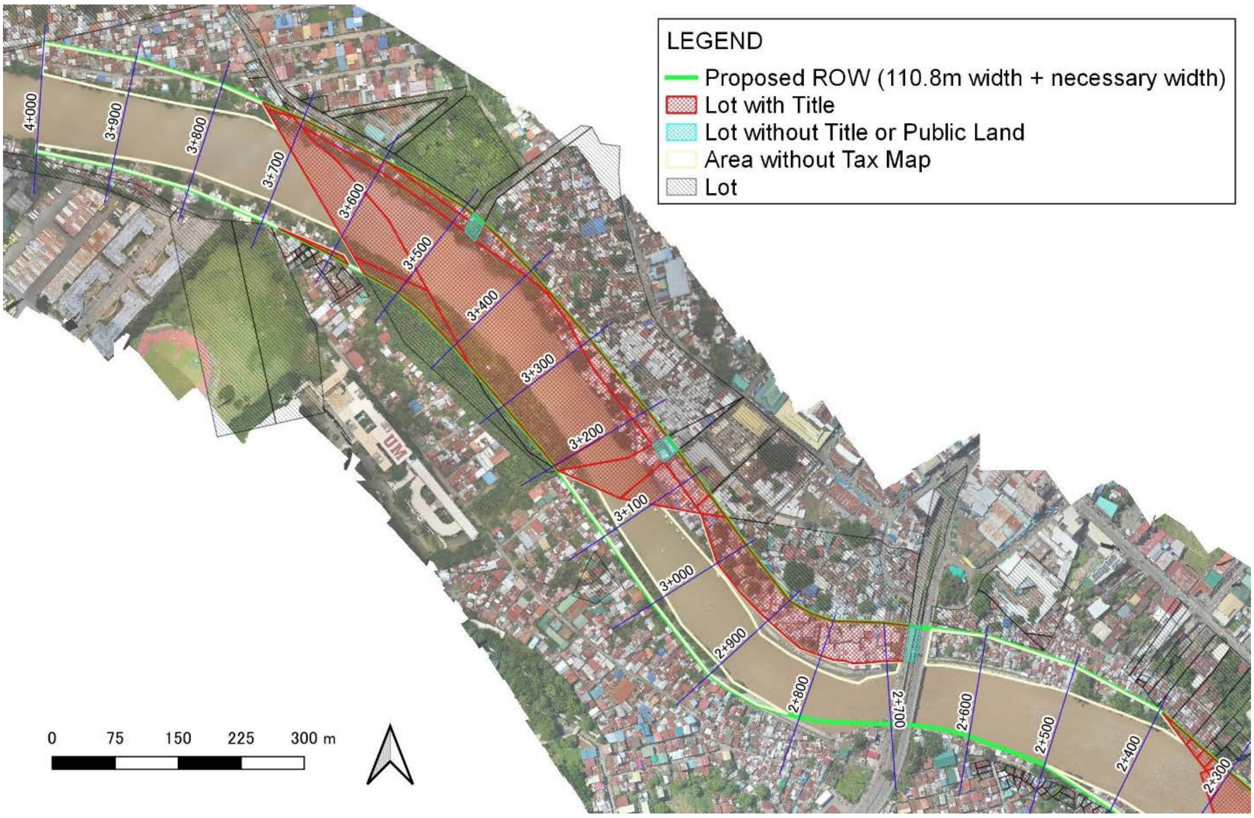
Source: Project Team

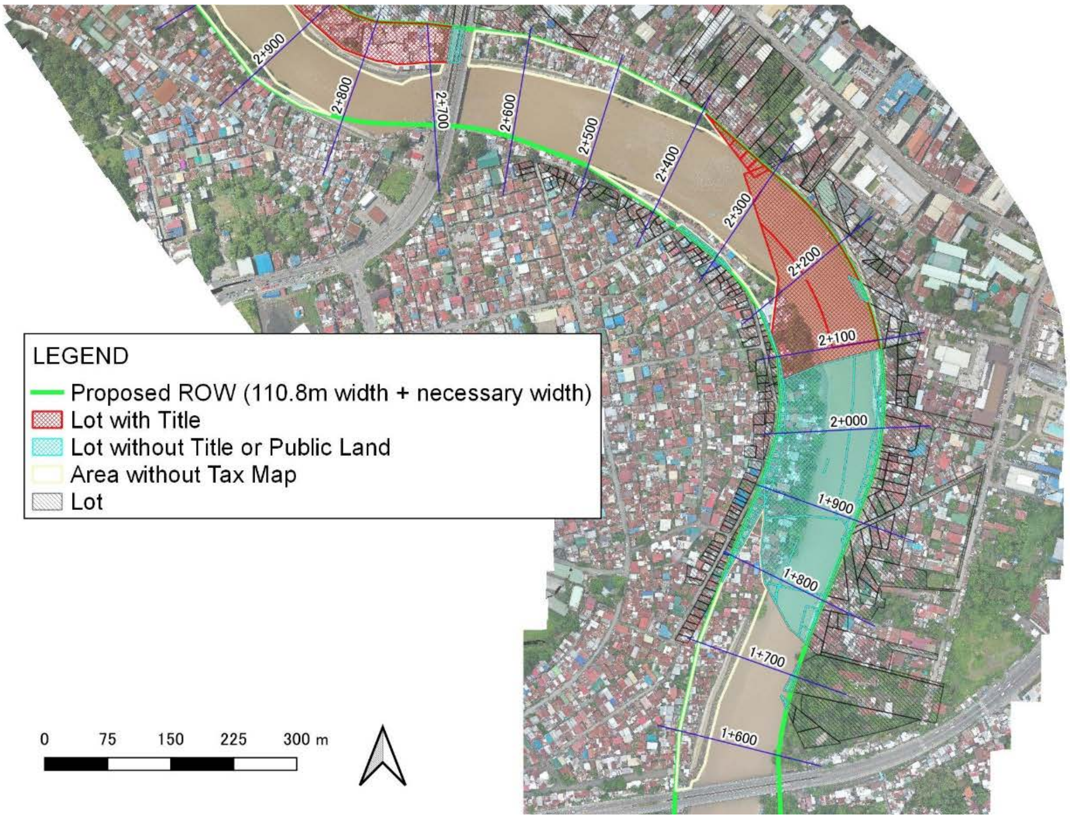
Figure 5.1.12 ROW for Pilot Section (from Bolton bridge to Station 4+000) of River Widening Works



Source: Project Team

Figure 5.1.13 Condition of Lot Boundary in and around ROW in Pilot Section from Bolton bridge to Station 4+000





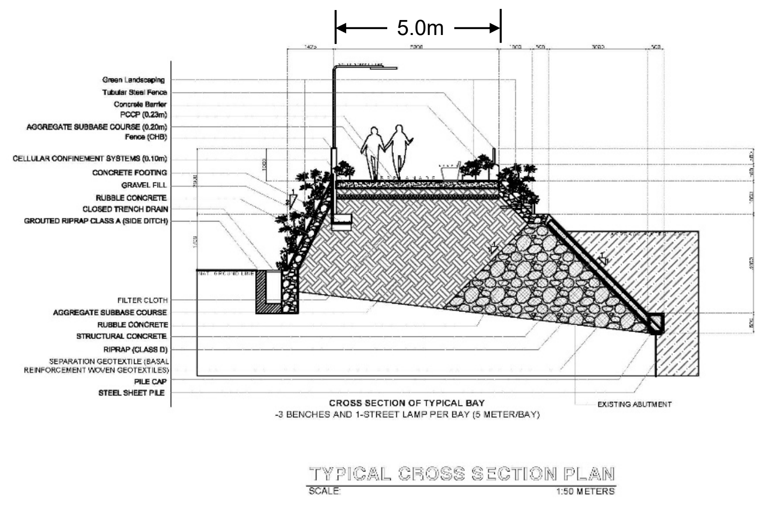
Source: Project Team

Figure 5.1.14 Status of Land in ROW (with/without Title or Area without Tax Map)

(3) Additional Examination on Cross-Sectional Structures

Additional examination is conducted on the cross-sectional structure of the river widening works.

Davao City is currently implementing a project to develop dike and revetments, as well as a promenade for the river mouth and downstream sections of the Davao River. Figure 5.1.15 shows the typical cross section plan of dike, revetment and promenade in the river mouth of the Davao River and an example of developed promenade.



Source: DPWH DCDEO Source: Project Team

Figure 5.1.15 Typical Cross Section Plan of Dike, Revetment and Promenade in the River Mouth of the Davao River (Left) and an Example of Developed Promenade (Right)

The structure of the river widening works for target section in this Pre-F/S has already been studied in the above (1), whereas it was examined that if the similar structure as the promenade currently developed in the Davao River is to be applied in the target section, whether the structure could be implemented within the ROW proposed in the above (2) or not.

As a result of the examination using two cross sections as examples, the required land width to incorporate the promenade will be 0.25m to 0.55m larger than the original design, but this can be adjusted from the 3m set as the construction width (reducing the width by 0.25m to 0.55m from the 3m width for construction), and it can be judged possible to incorporate a promenade within the ROW proposed in (2).

In addition, the project cost estimated in this Project (detailed in Section 5.2) does not include the cost of outdoor lights, fences, etc. for the promenade. These construction costs are roughly estimated at approximately 200 million pesos. If the promenade development will be judged to be applied and included in the project for the widening works in future, more detailed studies and cost calculations need to conducted in the next stage such as detailed design stage and it is necessary to include it in the project cost.

5.2 Construction Plan and Cost Estimate

5.2.1 General

This section describes the construction plan and cost estimation after clarifying the construction procedures. In the construction plan and cost estimation, the process and construction method should be studied in consideration of necessary construction conditions such as access to the construction site and the method of bringing in materials and equipment.

5.2.2 Construction Plan and Schedule

(1) Scope of Work

The major works of the Project are shown in Table 5.2.1, and the major construction quantities are shown in Table 5.2.2, respectively.

Table 5.2.1 Summary of the Project

Item	Descriptions
River Widening	Scope：1.5km～4.0km from River Mouth (Length =2.5 km)
	Width of the River：80m
	Excavation Volume：321,000m^3, (Open Cut：112,000m^3, Dredging：209,000m^3)

Source: Project Team

Table 5.2.2 Quantity of the Project

Item		Unit	Quantity
River Widening			
1-1	Channel Excavation (Excavation-Loading-Transportation)	m3	112,000
1-2	Dredging-soils (using Backhoe on Barge)	m3	209,000
1-3	Channel Excavation (Loading and Transportation)	m3	146,000
1-2	Embankment (for Dike)	m3	46,000
1-3	Embankment (at Disposal area)	m3	212,000
1-4	Concrete Revetment (Reinforced Concrete t=50cm)	m3	23,535
1-5	Gabion (t=50cm) - Foot Protection	m3	10,000
1-6	Concrete Block - Slope Toe Protection	m3	3,750
1-7	Steel Sheet Piles , Furnished	m	16,250
1-8	Steel Sheet Piles, for temporary works, without materials	m	16,250

Source: Project Team

(2) Basic Conditions of Construction Plan

The conditions related to construction planning are the same as those described in Section 4.4.

(3) Labor, Equipment and Material for Construction

Labor, equipment, and materials are available in Davao City and surrounding cities; same as described in Section 4.4.

(4) Construction Method

1) General

The channel widening is at 1.5 km to 4.0 km from the mouth of the river. The quantity of earthwork including dredging is shown in Table 5.2.3, respectively.

Table 5.2.3 Quantity of Earthwork Including Dredging

Station	Structures	Dredging Area from barge (m2)	Cut Area from ground (m2)	Dredging Volume (m3)	Cut Volume (m3)	Filling Area (m2)	Filling Volume (m3)
STA 1+561	Bolton Brd. U	0	0	0	0	0	0
STA 2+000		151	41	33,242	9,062	8	1,760
STA 2+500		44	7	48,964	12,037	7	3,827
STA 2+664	Gov.Generoso Brd. D	90	51	11,024	4,746	9	1,351
STA 2+710	Gov.Generoso Brd. U	150	103	5,520	3,547	8	398
STA 3+000		82	69	33,617	24,919	43	7,479
STA 3+500		82	39	40,921	26,861	12	13,988
STA 4+000		59	86	35,252	31,125	55	16,757
Total				209,000	112,000		46,000

Source: Project Team

2) Construction Flow Chart

Excavation is to be carried out in dry conditions, and if necessary, temporary closure using steel sheet piles, etc., is to be used to complete the excavation of the portion necessary to construct the revetment. The excavated sediment remaining on the river side will be dredged to excavate the river channel after the temporary sealing is removed. After excavation of the revetment area is completed, revetment mats and concrete revetment will be constructed.

(5) Efficiency of Construction Equipment

Table 5.2.4 shows the equipment combinations and work efficiencies for the major types of work in the Pre-F/S covered projects.

Table 5.2.4 Equipment Combinations and Work Efficiencies for the Major Works

Work Item	Equipment	Productivity per hr	Productivity per day	Unit	Remarks
Excavation	Bulldozer (140 HT)	50	350	m3	
Loading	Backhoe (0.8 m3)	71	500	m3	
Transportation	Dump Truck (12Yd3)	9 ～ 5.2	63 ～ 36	m3	10km～20km
Spreading	Motorized Road Grader, 140hp	50	350	m3	
	Bulldozer (140 HT)				
Embankment	Vibratory 10mt SD100DC	50	350	m3	
Dredging-soils (using Backhoe on Barge)	Backhoe (0.8m3～)	16 ～ -	112 ～ 630	m3	Dredging
	Deck Barge (600mt DWT～)				
	Scow, 10 m3～				
	Tugboat, 500hp～				
	Payloader (1.5m3)- at Temporary yard				
	Crawler Crane (36-40m)190hp with Bucket				Unloading from
Steel Sheet Piles (Slope Protection)	Crawler Crane (36-40mt)	10	70	m	
	Vibro Hammer (201 hp)				

Source: Project Team

(6) Package of Contract

The construction contractor procurement shall be conducted through international or domestic tender. The contracted construction area shall be one package. It should be noted that the river widening project is expected to be an International Competitive Bidding process, considering the difficulty of construction and the scale of the work.

(7) Proposed Construction Schedule

Construction schedule is shown in Table 5.2.5.

Table 5.2.5 Construction Schedule

	Unit	Unit	Quantity	Workable days pre Year	Year	Progress per Day	Year 1	2	3	4	5	6	7	8	9	10
1	River Widening															
1-2	Preparation, Resettlement															
1-3	Construction															
1-3-0	Tendering, etc.	LS	1		1.0											
1-3-1	Channel Excavation (Excavation-Loading-Transportation)	m3	112,000	243	2.0	230										
1-3-2	Dredging-soils (using Backhoe on Barge)	m3	209,000	243	2.0	430										
1-3-3	Channel Excavation (Loading and Transportation)	m3	146,000	243	2.0	300										
1-3-4	Embankment (for Dike)	m3	46,000	251	2.0	92										
1-3-5	Embankment (at Disposal area)	m3	212,000	251	2.0	422										
1-3-6	Concrete Revetment (Reinforced Concrete t=50cm)	m3	23,535	251	2.0	47										
1-3-7	Gabion (t=50cm) - Foot Protection	m3	10,000	251	2.0	20										
1-3-7	Concrete Block - Slope Toe Protection	m3	3,750	251	2.0	7										
1-3-8	Steel Sheet Piles , Furnished	m	16,250	251	2.0	32										
1-3-9	Steel Sheet Piles, for temporary works, without materials	m	16,250	251	2.0	32										
1-4	Design, Construction Management	LS	1		2.0											

Source: Project Team

5.2.3 Cost Estimation

The project cost estimation method was the same as described in Section 4.4.3.

5.2.4 Project Cost

(1) Project Cost estimated based on the Methodology set in the Section 4.4.3

The estimated project costs are shown in Table 5.2.6.

Table 5.2.6 Project Cost for Pre-F/S Project

No.	Item	LC (Unit: Million Philippines Pesos)	FC	Total	Description
1	Project Management Cost	17	21	38	3.5% of the amount of Construction & Procurement Cost, Consulting Service Cost and Contingency Cost.
	Subtotal	17	21	38	
2	Preparation Cost	0	0	0	
2-1	Land Acquisition Cost	231	0	231	Same as Master Plan
2-2	Compensation Cost	167	0	167	Relocating buildings located on the site to implement the measures.
2-3	Removal Cost	33	0	33	20% of the cost required for building transfer
2-4	Environmental Impact Assessment Cost	0	0	0	Included in Common Temporary Facility Cost
	Subtotal	431	0	431	
3	Construction & Procurement Cost	344	474	818	See Construction & Procurement Cost
	Subtotal	344	474	818	
4	Consultant Service Cost	0	0	0	
4-1	Consultant Service Costfor Civil Work	0	0	0	
4-1-1	Detail Design Cost	34	47	82	10 % of Construction & Procurement Cost
4-1-2	Construction Management Cost	28	38	65	8 % of Construction & Procurement Cost
4-2	Consultant Service Cost for Building	0	0	0	
4-3	Consultant Service Cost for Equipment	0	0	0	
	Subtotal	62	85	147	
5	Contingency Cost	0	0	0	
5-1	Price Contingency	68	17	85	The price increase cost was assumed to be 16.6% and 3.0% of the total construction and procurement cost and design and supervision cost, respectively, in domestic and foreign currency (compounded over 6 years, respectively, as an average).
5-2	Physical Contingency	20	28	48	5% of the total Construction & Procurement and Consultant Service Cost.
	Subtotal	88	45	133	
6	Technical Training Cost	0	0	0	
	Subtotal	0	0	0	
7	Operation and Maintenance Cost	2	2	4	
	Subtotal	2	2	4	
	Total (Excluding OM Cost)	943	625	1,568	

Source: Project Team

(2) Project Cost applying another land unit price

For the Pre-F/S project, the project cost was estimated in the above (1) under the conditions specified in Section 4.4.3. On the other hand, there was a comment from the relevant division (DPWH ESSD) that it would be desirable to calculate the land acquisition cost in the project cost using another land unit price (current market value or double BIR Zonal Value). Although the land acquisition cost and compensation cost should be studied and examined in detail at the detailed design stage, as reference value for future implementation, the preparation cost was calculated applying the another land unit price (13,800Php/m^2, which is double of the zonal value (6,900Php/m^2) of the Pre-F/S target section in DO No. 032-2021 of Department of Finance), and then the project cost was estimated. Table 5.2.7 shows the estimated project cost.

Table 5.2.7 Project Cost for Pre-F/S Project (when another land unit price is applied)

No.			Item	LC	FC	Total	Description
				(Unit: Million Philippines Pesos)			
1	Project Management Cost			17	21	38	3.5% of the amount of Construction & Procurement Cost, Consulting Service Cost and Contingency Cost.
			Subtotal	17	21	38	
2	Preparation Cost			0	0	0	
	2-1	Land Acquisition Cost		1,482	0	1,482	Same as Master Plan
	2-2	Compensation Cost		167	0	167	Relocating buildings located on the site to implement the measures.
	2-3	Removal Cost		33	0	33	20% of the cost required for building transfer
	2-4	Environmental Impact Assessment Cost		0	0	0	Included in Common Temporary Facility Cost
			Subtotal	1,683	0	1,683	
3	Construction & Procurement Cost			344	474	818	See Construction & Procurement Cost
			Subtotal	344	474	818	
4	Consultant Service Cost			0	0	0	
	4-1	Consultant Service Costfor Civil Work		0	0	0	
		4-1-1	Detail Design Cost	34	47	82	10 % of Construction & Procurement Cost
		4-1-2	Construction Management Cost	28	38	65	8 % of Construction & Procurement Cost
	4-2	Consultant Service Cost for Building		0	0	0	
	4-3	Consultant Service Cost for Equipment		0	0	0	
			Subtotal	62	85	147	
5	Contingency Cost			0	0	0	
	5-1	Price Contingency		68	17	85	The price increase cost was assumed to be 16.6% and 3.0% of the total construction and procurement cost and design and supervision cost, respectively, in domestic and foreign currency (compounded over 6 years, respectively, as an average).
	5-2	Physical Contingency		20	28	48	5% of the total Construction & Procurement and Consultant Service Cost.
			Subtotal	88	45	133	
6	Technical Training Cost			0	0	0	
			Subtotal	0	0	0	
7	Operation and Maintenance Cost			2	2	4	
			Subtotal	2	2	4	
	Total (Excluding OM Cost)			2,194	625	2,819	

Source: Project Team

In this Project, two types of project costs were calculated as mentioned above and the economic evaluation was also conducted for two types of project costs (see Section 5.3.4). In the next stage following this Project, it is necessary to carry out necessary surveys, examinations, and discussions for determining the land unit price to be applied, reflect it in the project cost, and improve the accuracy of the project cost.

5.2.5 Project Implementation Schedule

The project implementation schedule is shown in Table 5.2.8.

After the detailed design, bidding for construction work will begin in the third year, with a target completion date of six years later. Resettlement and land acquisition are planned to be carried out in the second and third years, in conjunction with the detailed design and construction work.

Table 5.2.8 Project Implementation Schedule for Pre-F/S Project

	Item	Months	Year										
			0	1	2	3	4	5	6	7	8	9	10
1	Preparation, Loan Agreement etc.	6											
2	Procurement of Consultant (for D/D, C/S)	12											
3	Detailed Design	12											
4	Preparation of PQ and Tender Document	6											
5	PQ and Tendering	12											
6	Construction Works	36											
7-1	Contract Package No.1 River Widening	36											

Source: Project Team

5.3 Project Evaluation

5.3.1 Project Implementation Schedule

The implementation of the Pre-F/S will be carried out through international and local bidding in accordance with specific guidelines taking into account the scale of the project. The contract package was assumed to be included in one package for the river widening in order to provide opportunity to Philippines domestic contractor to participate.

5.3.2 Consulting Engineering Services

Consulting services for detailed design and construction supervision will be provided by a group of international and local engineering consultants.

5.3.3 Project Benefit

The project benefit of the pre-FS was computed by using the same methodology as the F/S described in Chapter 4.

(1) Benefit Computation

Table 5.3.1 shows the damage cost if no project is implemented (without case) and Table 5.3.2 the damage cost if pre-F/S projects are implemented (with case).

Table 5.3.1 Damage Cost if "No project is implemented (without case)"

		W=1/2	W=1/3	W=1/5	W=1/10	W=1/25	W=1/50	W=1/100
Direct Damage		**5.596**	**6.995**	**12.435**	**21.308**	**33.405**	**42.548**	**50.989**
	Agriculture	0.842	1.053	1.914	3.370	5.398	6.232	6.789
	Commerce	0.119	0.148	0.192	0.503	1.158	1.755	2.378
	Industry	0.128	0.160	0.495	1.019	1.831	2.500	3.159
	Institution	0.598	0.747	1.257	1.928	2.935	3.824	4.717
	Residences	2.580	3.225	5.629	9.464	14.243	18.134	21.493
	Mix Use Facilities	0.038	0.047	0.078	0.107	0.131	0.285	0.686
	Infrastructure	1.291	1.614	2.870	4.917	7.709	9.819	11.767
Indirect Damage		**1.679**	**2.098**	**3.730**	**6.392**	**10.022**	**12.765**	**15.297**
Total Damage		**7.275**	**9.093**	**16.165**	**27.700**	**43.427**	**55.313**	**66.285**

Source: Project Team

Table 5.3.2 Damage Cost if "Pre-F/S projects are implemented (with case)"

		W=1/2	W=1/3	W=1/5	W=1/10	W=1/25	W=1/50	W=1/100
Direct Damage		1.184	1.209	1.249	1.520	12.042	19.064	24.796
	Agriculture	0.074	0.083	0.100	0.279	2.415	4.222	5.344
	Commerce	0.052	0.053	0.054	0.055	0.223	0.349	0.435
	Industry	0.016	0.017	0.019	0.021	0.554	0.967	1.333
	Institution	0.019	0.020	0.021	0.022	0.369	0.696	1.076
	Residences	0.404	0.409	0.414	0.434	4.181	6.316	8.141
	Mix Use Facilities	0.345	0.348	0.353	0.358	1.521	2.114	2.745
	Infrastructure	0.273	0.279	0.288	0.351	2.779	4.399	5.722
Indirect Damage		**0.355**	**0.363**	**0.375**	**0.456**	**3.613**	**5.719**	**7.439**
Total Damage		**1.540**	**1.571**	**1.624**	**1.976**	**15.654**	**24.783**	**32.234**

Source: Project Team

(2) Expected annual average damage reduction

Based on the results of the Flood Simulation of Davao River, the expected annual average damage reduction is computed as shown in Table 5.3.3.

Table 5.3.3 Expected annual average damage reduction if F/S projects are implemented

	Annual average exceedance probability	Amount of Damage (Billion PhP)			Average Damage per reach	Probabilities per reach	Annual Average Damage Reduction	Aggregated annual average damage = Expected annual average damage reduction
		Without Project (1)	With Project (2)	Damage Reduction (1)-(2)				
W=1/1	1.000	0.000		0.000				
W=1/2	0.500	7.275	1.540	5.735	2.867	0.500	1.434	1.434
W=1/3	0.333	9.093	1.571	7.522	6.628	0.167	1.105	2.538
W=1/5	0.200	16.165	1.624	14.541	11.032	0.133	1.471	4.009
W=1/10	0.100	27.700	1.976	25.724	20.133	0.100	2.013	6.023
W=1/25	0.040	43.427	15.654	27.772	26.748	0.060	1.605	7.627
W=1/50	0.020	55.313	24.783	30.530	29.151	0.020	0.583	8.211
W=1/100	0.010	66.285	32.234	34.051	32.290	0.010	0.323	8.533

Source: Project Team

5.3.4 Economic Evaluation

(1) Economic Cost

Table 5.3.4 shows the economic cost converted from the financial cost and Table 5.3.5 the investment schedule in economic cost.

Table 5.3.4 Financial Cost and Economic Cost

Financial Cost

	LC	FC	Total (Billion PhP)
1 Project Management	0.300	0.439	0.738
2 Preparation, Resettlement	1.330	0.000	1.330
3 Constrution & Procurement	5.963	9.833	15.796
Dredging	0.419	0.698	1.118
Cut-off	0.639	1.064	1.703
Retarding Pond	4.561	7.597	12.157
Widening	0.344	0.474	0.818
4 Consulting Service	1.073	1.770	2.843
5 Contingency	1.523	0.933	2.456
6 Technical Training Cost	0.000	0.000	0.000
TOTAL	**10.189**	**12.974**	**23.163**

Economic Cost

	LC	FC	Total (Billion PhP)
1 Project Management	0.291	0.439	0.729
2 Preparation, Resettlement	0.758	0.000	0.758
3 Constrution & Procurement	4.711	9.833	14.543
Dredging	0.331	0.698	1.030
Cut-off	0.505	1.064	1.568
Retarding Pond	3.603	7.597	11.200
Widening	0.272	0.474	0.746
4 Consulting Service	1.277	1.770	3.047
5 Contingency	1.555	0.933	2.488
6 Technical Training Cost	0.000	0.000	0.000
TOTAL	**8.592**	**12.974**	**21.566**

Source: Project Team

Table 5.3.5 Investment schedule (Economic Cost)

	PM Project Management	PR Preparation, Resettlement	CP Constrution & Procurement	CS Consulting Service	Cont Contingency	TTC Technical Training Cost	Economic Investment per Year (in Billion PhP)	Percentage (Yearly / Total Investment)
Year 1	0.069	0.171	0.000	0.288	0.235	0	0.763	3.54%
Year 2	0.069	0.171	0.000	0.288	0.235	0	0.763	3.54%
Year 3	0.069	0.171	0.000	0.288	0.235	0	0.763	3.54%
Year 4	0.069	0.000	2.294	0.288	0.235	0	2.886	13.38%
Year 5	0.069	0.000	2.294	0.288	0.235	0	2.886	13.38%
Year 6	0.069	0.000	2.294	0.288	0.235	0	2.886	13.38%
Year 7	0.069	0.000	1.772	0.288	0.235	0	2.364	10.96%
Year 8	0.069	0.000	1.772	0.288	0.235	0	2.364	10.96%
Year 9	0.069	0.000	1.772	0.288	0.235	0	2.364	10.96%
Year 10	0.069	0.000	1.600	0.288	0.235	0	2.192	10.16%
Year 11	0.007	0.082	0.000	0.028	0.022	0	0.139	0.65%
Year 12	0.007	0.082	0.000	0.028	0.022	0	0.139	0.65%
Year 13	0.007	0.082	0.000	0.028	0.022	0	0.139	0.65%
Year 14	0.007	0.000	0.249	0.028	0.022	0	0.306	1.42%
Year 15	0.007	0.000	0.249	0.028	0.022	0	0.306	1.42%
Year 16	0.007	0.000	0.249	0.028	0.022	0	0.306	1.42%
Total	**0.729**	**0.758**	**14.543**	**3.047**	**2.488**	**0.000**	**21.566**	**100.00%**

Source: Project Team

(2) Results of Economic Evaluation

The cost and benefits cash flow of the proposed pre-F/S for Davao River was calculated.

When the SDR is 10%, the Economic Internal Rate of Return (EIRR) is 16.43 %, Economic Net Present Values (ENPV) is PhP 13.76 Billion and Cost-Benefit Ratio (CBR) is 2.175.

When the SDR is 15%, ENPV is PhP 1.52 Billion and CBR is 1.244.

Therefore, the proposed is evaluated as economically adequate in both cases.

For reference, when the SDR is 20%, EIRR remains unchanged at 16.43 %, ENPV is PhP -2.15 Billion and CBR is 0.779.

(3) Sensitivity Analysis

To check the economic adequacy in case of project cost increase and benefit decrease, a sensitivity analysis was conducted. In all cases, the economic internal rate of return (EIRR) exceeds the current social discount rate of 10%. Therefore, it can be concluded that the project can be evaluated as adequate from the viewpoint of investment efficiency.

Table 5.3.6 Results of Sensitivity Analysis

		EIRR (%)
Case 0	Base Case	16.43
Case 1	Project Cost: increase of 10%	15.53
Case 2	Project Cost: increase of 20%	14.72
Case 3	Benefit: Decrease of 10%	15.88
Case 4	Benefit: Decrease of 20%	15.28
Case 5	Project Cost: increase of 10% and Benefit: Decrease of 10%	14.97
Case 6	Project Cost: increase of 20% and Benefit: Decrease of 20%	13.56

Source: Project Team

For reference, the break-even point analysis shows the EIRR of 10.0% when project cost increases by 114.0% under the condition that there is no change in benefit as well as when benefit decreases by 76.0% under the condition that there is no change in project cost.

(4) Economic Evaluation for the Project Cost applying another land unit price

An economic evaluation is carried out on the project cost estimated by applying another land unit price, which was estimated as the reference value in Section 5.2.4(2). In this evaluation, the project cost of the premised F/S project is the project cost estimated by applying the RAP survey results (the project cost estimated in Section 4.4.5(2)).

When the SDR is 10%, the Economic Internal Rate of Return (EIRR) is 11.75 %, Economic Net Present Values (ENPV) is PhP 5.67 Billion and Cost-Benefit Ratio (CBR) is 1.496. Therefore, it is evaluated as economically adequate.

For reference, when the SDR is 15%, EIRR remains unchanged at 11.75 %, ENPV is PhP -5.49 Billion and CBR is 0.820. When the SDR is 20%, EIRR remains unchanged at 11.75 %, ENPV is PhP -8.38 Billion and CBR is 0.494.

In addition, for reference, the break-even point analysis shows the EIRR of 10.0% when project cost increases by 28.2% under the condition that there is no change in benefit as well as when benefit decreases by 31.3% under the condition that there is no change in project cost.

5.3.5 Environmental Evaluation

(1) Compliance of Environmental Compliance Certificate

The Pre-feasibility study does not aim to comply with ECC license. The river widening is possible to be designated as “environmental enhancement”; if so, the ECC will not be required. However since huge volume of excavated soil will be generated, and the project is located in the area where socially and economically important; environmental and social impact could be significant. Therefore careful examination and coordination with EMB are important in the next stage, F/S stage, e.g.

(2) Preliminary Scoping

Draft scoping is prepared based the results of the environmental and social consideration study; and then described in the section [5.4.1 Environmental Impact]. The TOR for further environmental study was drafted.

(3) Basic Policy on Environmental Mitigation

The following basic policies are made based on the results of basic study in the MP stage, EIS and RAP studies in the F/S stage and quick study written in the section [5.4 Environmental and Social Considerations].

- The project area is located along the Davao River downstream; naturally sensitive area (protected forest, mangrove, etc.) is not found. Stakeholder meetings resulted necessity of accessibility to the river and recreation use. Therefore, it is recommendable to introduce environmentally friendly structural design and construction method to improve quality of environment and recreation purposes.
- The project will lead huge scale of involuntary resettlement, interruption of local economy, community life, etc. Sufficient compensation and social support must be given to the PAPs.
- Mitigation of air/ water pollution shall be incorporated with construction method.
- Effective and continual public consultation with LGUs and communities must be given.

5.3.6 Socioeconomic Evaluation

(1) Estimated Level of Resettlement by the Project

Total number of households to be relocated by the project is estimated approximately 1,100 HHs or 3,300 persons. In addition considerable scale of infrastructures must be relocated or demolished.

(2) Preventive Relocation by the Priority Projects

The most of the households to be relocated have resided near the Davao River where it is high risk area and not suitable for dwellings. Therefore resettlement under the Priority project must encourage preventive relocation to protect their life and assets.

(3) Protection of the Human Life

The preventive relocation by the Priority projects could encourage mitigation of damage to human life by relocation to out of high flood risk area.

(4) Protection of the Assets

The preventive relocation by the Priority projects could encourage mitigation of damage to private assets and public infrastructures so as to enhance sustainable socio-economic activities.

(5) Social Evaluation

For above reasons, resettlement to be proposed is not only to secure necessary space for the project site but also to mitigate flood risk; and then project design was formulated with minimizing scale of resettlement, consensus with project affected households.

5.3.7 Technical Evaluation

As a result of a detailed examination on the construction plan for the priority project, the technical feasibility, safety, reliability and appropriateness of the proposed structure were confirmed.

5.3.8 Overall Evaluation of the Project

Table 5.3.7 summarizes the comprehensive evaluation results of the Pre-F/S project. The feasibility of the project was confirmed from the points of view of economic feasibility, socio-economic suitability, and environmental and technical safety and soundness. Since the Pre-F/S project assumes the implementation of the F/S projects, the overall evaluation of the Pre-F/S is combined with the evaluation results of the F/S consisting of river dredging, retarding ponds and cut-off channel.

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Table 5.3.7 Comprehensive Evaluation Results of the Pre-F/S for the Davao River

Project / Evaluation Axis	Pre-F/S including the three projects composing the F/S	*Pre-F/S: River widening Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW*	*Entire F/S (River dredging, retarding ponds, cut-off channel)*
a. Flood Protection Level (Expected damage reduction)	Target Flood: 25-year return period flood	*Target Flood capacity: 1,700 cubic meters per second (Corresponding to the 100-year return period flood targeted by the Master Plan)*	*Target Flood: 10-year return period flood*
b. Economic Effectiveness	Total cost: PhP 23.163 Billion EIRR:16.43% NPV:13.76 B/C:2.177 *SDR=10%	*Direct construction cost: PhP 0.50 Billion Cost for households relocation and land acquisition: PhP 0.35 Billion*	*Total cost: PhP 21.595 Billion EIRR:15.32% NPV:10.00 B/C:1.896 *SDR=10%*
c. Feasibility in regards with social and legal restrictions	Including the proposed dump site, the project will not be located in the natural conservation area. The coordination with concerned Communities will be required.	—	*The proposed locations for the project implementation and dump sites are not included in the natural conservation area. Kagan Community is located within the area where the project is planned to be implemented and will need to be relocated. Therefore the continuation of information sharing on the project and dialogue with the Community will be needed..*
d. Feasibility from the technical viewpoint to construct countermeasures:	Phased construction is possible.	*Phased construction is possible.*	*Phased construction is possible.*
e. Sustainability	Sustainable. However, maintenance dredging is required.	*Sustainable. In addition, the volume of maintenance dredging to ensure the expected flood capacity (by avoiding the raise of riverbed) is estimated to be minimal.*	*Sustainable. However, maintenance dredging is required.*
f. Flexibility	Future revision is possible.	*The revision of the cross section (such as increase of the flood capacity) will be relatively easy if the needs occur in the future.*	*Future revision is possible.*
g. Social and natural environment impacts	Households relocated:1,254	*Households relocated:1,150 (Including 990 informal households)*	*Households relocated: 104*

Evaluation Axis \ Project	**Pre-F/S including the three projects composing the F/S**	***Pre-F/S: River widening*** ***Alternative 1: compound inverted trapezoid cross section with a width of 111 meters in addition to the ROW***	***Entire F/S*** ***(River dredging, retarding ponds, cut-off channel)***
	Relocation and land acquisition will be needed especially in the areas affected by the construction of the cut-off channel and river widening. In addition, social impacts may occur. Even though some environmental impact may occur, the retarding ponds may be used as new places for nature restoration in the future.	*The amount of relocated households and land acquisition will be large. In addition, some changes in land use and impact to actual infrastructures such as road network is anticipated.*	*Relocation and land acquisition will be needed especially in the areas affected by the construction of the cut-off channel.* *The inhabit of Designated Endangered Species (animals and plants) was not confirmed in the target area. However, to minimize the impact to the natural environment during the project implementation, water and air pollution measures will be promoted.* *After the completion of the F/S, the retarding ponds may be used as new places for nature restoration.*
Evaluation Result	The Projects composing the F/S are appropriate from the viewpoint of economic efficiency, technical feasibility, sustainability and flexibility. On the other hand, the project may generate social impacts such as the relocation of the Kagan Community. Regarding this point, the impacts can be reduced by sharing the information on the project and continuing the dialogue with the Community. In addition, regarding the impacts on the natural environment (such as noise, water quality, etc.) during the construction, they can be reduced by devising construction methods. Therefore, it was evaluated that the project as a whole is appropriate.		

Source: Project Team

5.4 Environmental and Social Considerations

5.4.1 Categorization

Category "A" under the JICA-GL

Reason: The project site would cause adverse impacts which are described in the Guidelines for Environmental and Social Considerations (April 2010).

5.4.2 Environmental Impact Evaluation

Initial level of environmental impact evaluation was undertaken for the proposed project targeted for Pre-F/S. The alternative analysis was summarized in the section 5.1.5.

(1) Method

The evaluation was conducted based on the basic study [Chapter 2], environmental and social consideration study in the F/S [4.6 Environmental and Social Considerations], data collection and site reconnaissance; and then formulated scoping.

(2) Environmental Aspect

1) Summary

The project site is located urbanization area of the Davao City; little artificial forest exists. Aquatic biota figures ordinal aspect which is seen any place in the city area; less endangered, commercial fish are observed. Impact to ecosystem could be minor.

On the other hand, since urbanization has rapidly proceeded, and economic growth and population has increased; impact to socio economy in particular land procurement and resettlement must be significant. Many ISFs has resided along the Davao River (see section [5.4.3 Social Impact]); and their income level is lower; therefore, their relocation and income recover must be key factors to implement the project.

Currently DPWH-RO XI has taken action to construct a dyke; land clearance and demolition have been progressed.

2) Natural Environment

The Project site is located in the downstream of the Davao City in low and plain land; therefore, topographic limitation will be small. Erosion risk could be minor from the soil erosion map by NAMRIA.

3) Urban Environment

Air quality condition in the downstream area, in particular Brgy. Bucana, showed good condition to meet air quality standard according to the FS. Though noise level slightly exceed the noise standard; it could be acceptable level.

Water quality condition of Chloride, Inorganic phosphorus and TSS exceeded the limitation according to the results of FS. Increase of chloride was caused by sea water. High TSS level has been generally observed in the Davao River and the Matina/ Talomo River; the source of soil might be inflow from mountainous area. One of the source of phosphorus is chemical fertilizer; but it is not sure.

4) Social Environment

The river widening project will occupy total of approximately 8.5ha of land, changing from land to water area. Nearly 90% of the land is residential zone; and roads occupy around 6 %. Occupation of the land by the project will lead loss and demolition of private/ public buildings, infrastructures; its impact must be significant.

Especially relocation of ISFs must be one of the most significant issue. Since river widening will continue in mid- and long-term stage; development of relocation site indicated in the section [3.17 Examination of Measures to Promote Implementation of Master Plan] is key factor to smoothly implement the project.

A church was confirmed in the project area, which is to be relocated.

(3) Scoping

Draft scoping made in the MP (in 2019) was updated based on the above survey.

(4) Study Items and Methodology for the Environmental and Social Considerations

Study Items and Methodology for the Environmental and Social Considerations (EIS Study) were examined by items.

5.4.3 Social Impact

Basically, the project site has been developed; approximately 90% of the land is used as residential zone. The site reconnaissance resulted that the project site is key area for residential and commercial activities, and many community roads have passed along or nearby the Davao River. From this results, it could be concluded that river widening could affect not only direct impact in terms of loss of land but also indirect impact to local economy and road network.

Davao City conducted a census survey in 1992 in order to identify volume of ISFs; and to examine possible compensation. Total volume of ISFs was estimated around 1,000 units according the IM4Davao Study (2017).

Even though the City declared not to compensate to the ISFs who migrated after 1992; in fact, Volume of ISFs along the Davao River has increased. The City undertook an interview survey to update condition of dwelling based on ICBMs (Intelligent Community Based Monitoring System). The survey estimated number of ISFs 1,117 HHs (3,334 persons). Number of buildings/ dwellings were also estimated by Orthophoto survey under FS; estimated number counted 1,080 units which is same label as the ICBMs.

Significant increase of volume of ISFs was not shown; one of the reason may be because construction of dyke by the DPWH-RO XI which has been implemented since 1019 has accelerated relocation of ISFs.

As for share of ISFs in the PAHs/ PAPs, the share occupies over 60% of resettlement volume; especially only 3HHs out of 462HHs are formally residing.

Regarding share of PAPs in ISFs, who have been residing less than 6 years, occupies approximately 22%; its share was more than triple of those in FSFs (share approx. 7%). Principally ISFs who has migrated after 1992 have no eligible for compensation; however careful consensus building and sufficient support for informal PAHs must be key challenge for smooth implementation of the Project.

5.4.4 Recommendation

The followings are recommendation form the environmental and social viewpoints in order to smoothly implement the river widening project:

1. Excavation work generates plenty volume of soil. It is recommended to encourage reuse of excavated soil for urban/ housing/ infrastructure development, land adjustment etc. aside from development of soil disposal areas.
2. Environmentally friendly flood control, such as slope and unpaved dyke, plantation on the embankment, etc. must be promoted to create new attractive water area.
3. Balance of safety and accessibility to riverbank for recreation purposes, improvement of landscape must be considered.

4. Over 1,000 HHs of ISFs will be relocated in this project; river widening will continue up to 14km from the river mouth; therefore, huge volume of resettlement will totally happen. Development of sufficient relocation site is key challenge; Relocation site development proposed in the section [3.17 Examination of Measures to Promote implementation of Master Plan] shall be progressed.
5. Davao City conducted a census survey when setting up the Easement in 1992 and issued a regulation that ISFs that entered before 1992 would be compensated, but households that entered after 1992 would not. However, the influx has continued since 1992, and by 2021 there is more than 1,000 households. Differences in compensation for resettled households may raise concerns about serious social unrest and resistance to the project. Social support measures for them are necessary for supporting relocation and recover of livelihoods after relocation. Considering the above, it is required to conduct the RAP study and fulfill it at the time of implementation.
6. Sine downstream of the Davao River is located in the area of important economy and transpiration network; construction plan and schedule shall pay special attention to avoid degradation of economy and disturbance of traffic.
7. Public consultation, consensus building and IEC activities shall be provided in order to avoid social conflict and fear.

5.5 Framework of Implementation of Widening Works

In this Pre-F/S, the downstream section with 2.5km distance from the Bolton bridge to Sta. 4+000 was selected as a pilot section for the river widening works, which is one of the mid-long term measures for the Davao River, and the study at pre F/S level was conducted for the pilot section. The purpose of the study is to grasp in advance the issues that will arise when implementing future widening works and to consider countermeasures against the issues, and then, to contribute to the smooth implementation of future project.

Below, the results of the pilot section study on the project organization, procurement method and so on are described. In this regard, however, when actually implementing the project of widening works, referring to the results of the examination for this pilot section, the F/S should be conducted for the entire section of the widening works (from river mouth to Sta. 14+000 (14km upstream from the river mouth)) and the plan for the entire section should be formulated.

(1) Project Organization

1) During Detailed Engineering Design and Construction

The Flood Control Management Cluster-Unified Project Management Office (FCMC-UPMO) of DPWH is expected to assume a major role and shall take the lead in the overall implementation of the projects. They will be administratively and technically supported by the DPWH Regional Office and the Davao City District Engineering Offices (DC DEO).

In order to facilitate an effective and efficient project implementation, it is recommended that a Davao River Project Management Office (DRPMO) will be established.

2) During Operation and Maintenance

The Davao City District Engineering Office (DC DEO) is proposed to be the primary body responsible in the operation and maintenance with the technical support from the FCMC-UPMO. It is also proposed that the Davao River Management Office (DRPMO) shall be institutionalized and a Davao River Operation & Maintenance Unit (DROMU) shall be created as a permanent unit which is responsible for the implementation of operation and maintenance of flood control works in the Lower Davao River under the Maintenance Section of Davao City DEO.

(2) Procurement Method

The construction of this project will be conducted through international or domestic bidding in accordance with the size of the project and other factors. The contract package will be one of the following packages to provide opportunities for participation to Philippine domestic contractors.

Package 1: River Channel Widening

Consulting services for detailed design and construction supervision will be provided by a coordinated group of international and domestic engineering consultancy firms.

(3) Implementation Schedule

Project Implementation schedule is shown in Table 5.5.1.

Table 5.5.1 Project Implementation Schedule for Pre-F/S Project

Item		Months	Year										
			0	1	2	3	4	5	6	7	8	9	10
1	Preparation, Loan Agreement etc.	6											
2	Procurement of Consultant (for D/D, C/S)	12											
3	Detailed Design	12											
4	Preparation of PQ and Tender Document	6											
5	PQ and Tendering	12											
6	Construction Works	36											
7-1	Contract Package No.1 River Widening	36											

Source: Project Team

(4) Funding / Finance

The total funds required to implement the project amount to 943 million (Local Currency Portion, pesos equivalent), and 625 million (Foreign Currency Portion, pesos equivalent). The total amount is 1,568 million (pesos equivalent).

(5) Consulting Services

DPWH will implement the project, but a consultant will be hired to prepare the detailed design, pre-qualification (PQ), and bid documents. The consultant will also assist and support the bidding and contracting process in the pre-construction phase and supervise the construction.

1) Consulting Service

i) Prepare detailed design, construction cost estimates, pre-qualification (PQ) and bid documents

ii) PQ and bidding process assistance for selecting construction contractors, and construction supervision

2) Duration of the Consulting Service

Engineering services (detailed design) shall be for a period of 12 months. Consulting services (construction supervision) shall be provided for 36 months (3 years, not including the construction defect period).

5.6 Recommendation

Based on the overall results and outputs of the study, the recommendations related to the project targeted in the Pre-F/S are described below.

(1) Implementation of F/S for entire section

As described in Section 5.5, in this Pre-F/S, only the downstream section with 2.5km distance from the Bolton bridge to Sta. 4+000 was examined as a pilot section for the river widening works. When actually implementing the project of widening works, referring to the results of the examination for this pilot section, the F/S should be conducted for the entire section of the widening works (from river mouth to Sta. 14+000 (14km upstream from the river mouth)) and the plan for the entire section should be formulated.

(2) Points for implementing widening works

Widening works project that improve the flow capacity of river channels should be implemented sequentially from the most downstream side of the project implementation section so as not to adversely affect the downstream side of the construction section. In case of the section targeted by this Pre-F/S, construction should be proceeded from the most downstream Bolton Bridge to the upstream in sequence. Therefore, the relocation needs to be implemented with priority from the downstream area.

In addition, the project is desirable to be carried out consistently with a unified concept. The project should be implemented by DPWH (DPMO), which is also the implementing body of the short-term measures targeted by F/S.

(3) Handling of 30m Easement

After discussions with the Davao city, it was decided to plan the project by setting a ROW within a range of approximately 10m from the riverbank (top of the slope of revetment in river side) as a necessary range for the widening works.

As a background, it has been confirmed with the Davao city that the development within 30m Easement along the riverbank (CLUP plans to develop 10m as a promenade and 20m outside as a road) is at the concept level at present and there is no concrete plan, hence, this Project can make a plan without consideration of 30m Easement.

On the other hand, it is considered that the Davao city will proceed with the development of the Easement range in the future, therefore, it is desirable that cooperation with the Davao city will continue in the future stages and the plan by the of Davao city will be incorporated into the flood control M/P as appropriate based on the progress of the plan.

(4) Promotion of Relocation

Looking at the 2.5km pilot section targeted by this Pre-F/S, about 1,100 buildings needs to be relocated. Prompt implementation of the relocation is essential for the implementation of the widening works. It is recommended to proceed with the development of the relocation site, which was considered as a measure to promote the implementation of M/P, and to lead to the smooth implementation of the widening works.

In addition, when land acquisition and resettlement will be extremely restrictive for the implementation of the project, the rectangular cross section shown in the comparison of alternatives as Alt.2 can be considered to be applied or partially applied to minimize the range of land acquisition and the number of resettlements.

Davao City has declared in the city ordinance that ISFs, who had migrated in the easement after 1992, are not eligible for compensation for resettlement. It is, however, recommended the DPWH to take actions (consensus building with the PAPs, social assistances, provision of relocation site, etc. proposed in the section 5.4.4).

＜Part　II : Capacity Enhancement＞

Chapter 1 Capacity Enhancement

1.1 Approach

1.1.1 Current Issues on Flood Control and Drainage

The following are issues in the field of flood control in the Philippines that the Project Team has identified as potential obstacles to the implementation of this Project.

1) Necessity of enhancement of DPWH's capacity to formulate plans
2) Insufficient coordination among relevant organizations concerning planning and implementation
3) Inadequate management of basic data necessary for the formulation and renewal of plans, and maintenance of project

1.1.2 Approach for Capacity Enhancement in the Project

Based on the current issues mentioned in 1.1.1, capacity enhancement program was planned as shown in Table 1.1.1 and activities in this Project were carried out with the following basic approaches on capacity enhancement in mind:

1) "Foster the capacity to formulate an integrated flood control M/P by personnel in DPWH by acquiring the knowledge and skills necessary for supervising subletting work"
2) "Strengthen the organization, in order to secure the sustainability of the measures by implementing the M/P formulated in this project and the selected priority projects and by properly operating and maintaining the projects".

Table 1.1.1 Methodology for Capacity Enhancement

Item / Target / Place	Method	Content
Capacity Enhancement on M/P formulation and management <u>Target</u> C/Ps of DPWH-FCMC, PS <u>Sub-target</u> Other C/Ps <u>Place</u> Manila	C/Ps meeting and technical training meeting	「**C/Ps meeting**」 It will be held regularly when the project team stays. Confirm and share the progress and issues of the project. Confirm and share the work situation of each project team member and C/Ps, and activity contents of the relevant period and future schedule. 「**Technical training meeting**」 It will be held together with the C/Ps meeting when the project team stays At the Stage 1, the C/Ps will deepen understanding by lectures, practical training, and discussions on the M/P process and important tasks (setting of river area, design level, etc.) in each stage. At the Stage 2, the C/Ps will obtain the information on planning situation from each member of the project team, and discuss key issues on the plan such as target design level setting, contents of structural measures and consensus building with stakeholders. At the Stage 3, the C/Ps will discuss challenges focusing on F/S of the Davao River, mainly on environmental impact assessment, resident resettlement action plan and maintenance and management system.
	M/P formulation on Matina River	In order to deeply understand the methodology for formulation of an integrated flood control master plan, it is regarded as quite effective to experience all the process of the formulation of the plan through actual activities to prepare the plan by themselves. Therefore, C/Ps themselves will formulate M/P for the Matina River which is one of three target basins during the period of Stage 2, utilizing their knowledge, experiences and learning through the contents of the technical training meeting at Stage 1 as well. The project team ensures the adequate support for this activity.
	On the Job Training (OJT)	As OJT, collection, arrangement and analysis of data and information will be conducted together with C/Ps.

Item / Target / Place	Method	Content
	Seminar	Approximately three seminars will be held (Manila and/or Davao) during the Project. The seminars will include the introduction of Japanese experience which may contribute to address the water-related disasters in the Philippines and the findings obtained through the project activities and discussion which is facilitated by C/Ps.
	C/Ps training in Japan	To promote further understanding of Japanese cases on flood control, advanced technologies and knowledge as well as those backgrounds, C/Ps training in Japan, in which C/Ps can directly observe and experience, will be conducted. The content of the training would emphasize the following points. • Examples of flood control projects in Japan (survey, planning, design, construction) and river management (maintenance and disaster response, etc.) • Disaster prevention and flood control projects in urban river basins and industrial clusters in Japan • Disaster prevention measures integrated with land use (urban planning, land use regulation, etc.) • Efforts to manage information on rivers
Strengthening of capacity on organization aspect for project implementation Target C/Ps and stakeholders Place Davao	Coordination meeting	The coordination meetings aim to widely recognize and share issues related to floods in the target areas among stakeholders, to facilitate understanding of M/P, smooth implementation of flood control measures and appropriate maintenance and management activities. The meeting will be held in Davao City, and coordinated by C/Ps of DPWH RO-XI and C/Ps of Davao City. Participants are stakeholders. Manila's C/Ps will also expect to participate for understanding the local conditions and the local awareness, related organizations and local residents so as to contribute to appropriate M/P formulation activities in Manila. The meetings will be held three times in Stage 1. The meetings are designed to link with the public consultation for SEA in Stage 2.
	OJT	The site survey in the target area will be conducted together with C/Ps and the project team members. In addition, the inventory of data collected during the survey will be conducted together with C/Ps, and database to organize the data will be prepared. Training on how to utilize the database will also be provided.
	Seminar	Same as mentioned above
	C/Ps training in Japan	Same as mentioned above

Source: Project Team

1.2 Activities

1.2.1 C/P Meeting and Technical Training Meeting

At all Stages of Stage 1, Stage 2 and Stage 3, the C/P meetings were always held simultaneously with the technical training meetings. Regarding the counterpart members targeted for C/P meetings and technical training meetings, DPWH was requested to select members from the beginning of the Project in November 2018, and 7 members of the DPWH HQ were notified in January 2019. After that, in March 2019, a total of 13 counterpart members including 2 additional members from the DPWH HQ and members from DPWH RO and DEO and Davao City were notified, and full-scale activities have started.

(1) Stage 1

The technical training meetings in Stage 1 were held twelve times in total at the same timing as the C/P meetings as mentioned above, and basically held in Manila except the field survey in the Matina River basin conducted in the Davao area as the 5th technical training meeting for two nights and three days, and the meetings held on April 30 and July 22, 2019 in Davao. At Stage 1, the technical training meetings aimed at deepening the understanding the process of M/P's formulation and important issues in formulation of M/P in the form of lectures from each expert and discussions.

(2) Stage 2

In Stage 2, technical training meetings were held eight times in total for sharing the status of M/P development and discussing major issues. In Stage 1, the concepts and methods of examining important issues on the planning process were learned through mainly by lectures. In Stage 2, the practical planning capacity for flood control was enhanced through discussing and examining specific issues in the target area as actual planning activities.

Technical training meetings were mainly held in Manila, but not only Manila C/Ps also Davao C/Ps frequently participated in the meetings and actively discussed each other. According to additional request from C/Ps, the meetings on April 30 and May 2, 2019 were held in order to introduce the drainage network simulation model in details. In addition to the C/P, the other DPWH RO and DEO officers attended the May 2 meeting in Davao. The participation rate of C/Ps in the meetings was generally high, although the participation from Davao City was limited. The meetings also became a place to share information about project activities with DPWH since one of DPWH UPMO-FCMC project manager and TWG member attended almost every meeting, also TWG chairperson and DPWH DEO director sometimes attended.

(3) Stage 3

In Stage 3, technical training meetings were held eleven times in total for sharing the status of F/S study and discussing major issues. The technical training meetings in Stage 3 were started from August 2021 as a monthly meeting that were held on the last Friday of every month in principle. The meetings were carried out by online meeting style since JICA Project Team could not enter the Philippines until March 2022 due to the influence of COVID-19. In the meetings, it was shared and discussed that the process for project implementation such as setting hydraulic conditions for structural design, preliminary design of structural measures, procurement/construction plan, environmental impact assessment and resettlement action plan as well as various issues and problems that occurred in the process. In Stage 3, capacity for the project implementation process was enhanced through activities to solve/try to solve problems in collaboration with C/P and JICA Project Team.

1.2.2 M/P Formulation on Matina River

Specific activities for this item were carried out in the Stage 2 of M/P formulation stage. In the Stage 1, as preparation activities, explanation and discussion on the M/P formulation process and important issues in the formulation process were conducted in the technical training meetings described in 1.2.1. Also, as an item of the technical training meetings, field surveys of the Matina River basin were carried out for two nights and three days in the 5th technical training meeting. Most of the C/Ps, except for a few, participated in the field survey from the upstream to the downstream of Matina River basin, and interviews with the residents were also carried out to deepen the local understanding. By conducting the field survey with all C/Ps, discussions can be held with a common specific image when considering M/P formulation in the Stage 2.

In Stage 2, specific activities were carried out to formulate the M/P for the Matina River. Specifically, first, the C/Ps learned the specific process through information sharing and discussion in the examination of the M/P on the Davao River, which was conducted mainly by the project team, then, the C/Ps tried to formulate the M/P for the Matina River with reference to the study process for the Davao River. As for hydrological analysis and runoff flood analysis on the Matina River, practical technical training was held in each of Manila and Davao to strengthen the capacity of the C/Ps. At the practical technical training held in Davao, the related officers other than the C/Ps also participated, indicating the high level of interest in this training.

Since the F/S study on the priority project(s) for the Davao river was conducted in Stage 3, the capacity building activities for the Matina river were completed in Stage 2.

1.2.3 Coordination Meeting

The coordination meetings were held with the following objectives:

- To widely recognize and share issues related to flood/drainage/tidal flood and coastal erosion in Davao among stakeholders, and
  to facilitate understanding of M/P and smooth implementation of flood control measures as well as appropriate maintenance and management activities of the measures.
- To utilize discussed results in the meeting for 1) understanding the actual conditions and the awareness of related organizations and residents, and 2) formulating appropriate Master plan.

For the meetings, target barangays were selected for each theme, and barangay captains from the selected barangays and relevant organizations were invited. The meetings were held in Davao City. Selection of barangays and related organizations and preparation and coordination of meetings were conducted cooperating with experts, DPWH HQ, DPWH RO and DEO and Davao City.

In the total of 3 coordinating meetings, 70 to 90% of the invited barangays positively participated. The participated representatives from each barangay were divided into several groups, then the current situation, problems and expected countermeasures on flooding were discussed within the group. Through presentation by each group representative, the participants were able to share their opinions on the flood situation and expected countermeasures in each area.

The coordination meetings are designed to link with public consultation at SEA, aiming to integrate flood control and environmental conservation. Public consultation meetings for SEA were held in July 2019 at the end of Stage 1 and in January 2020 in Stage 2. There was participation from the DPWH headquarters in all the three coordination meetings. Although some of the C/Ps in Manila had no chances to participate for the coordination meetings, most of the C/Ps in Manila could participate in the following public consultation meetings in Davao and they could grasp the conditions and the awareness of related organizations and residents in Davao. The outline of the public consultation meetings is as described in section 3.14 of Part I.

The coordination meetings as a part of capacity enhancement activities ended with the above-mentioned three meetings in Stage 1, whereas public consultation meetings were continuously held in the Stage 2 and 3, following the coordination meetings.

1.2.4 Seminar

The seminar was planned to be held about three times throughout the project period at the timing of the report compilation, but it was held only once due to the influence of COVID-19. The program of the seminar included and will include progress and results of the Project, introduction of technical cases in Japan contributing to the solution of flood issues in the Philippines, introduction of knowledge obtained through the Project activities by C/P, discussion and exchange of opinions.

The first seminar was held at the timing of the preparation of the progress. In the Q&A session after each presentation in the first seminar, active participation was seen including many questions on the content of the presentation regarding the details of rainwater storage facilities in Japan and related laws and regulations, how to manage waste as part of flood control, how to deal with climate change, the contents of inland flood control in this project, etc.

1.2.5 C/Ps Training in Japan

The training in Japan aims to promote understanding through direct inspections and experiences of actual situation and the background of flood control planning and measures in Japan that cannot be taught through the technical training meetings and OJT, and to utilize those acquired knowledge and experiences for project activities and future activities on flood control. In this Project, training in Japan is scheduled to be conducted twice. The first training conducted in 2019 focuses on planning on measures against riverine flood. The second training was planned to be carried out in 2020 focusing on design, construction and maintenance related to inland flood and coastal measures, but it was canceled due to the influence of COVID-19.

(1) Outcomes of Training

Through a series of lectures and site visits in Japan, the following items could be learned as effort of integrated flood control measure.

- River improvement measures such as retarding basin, underground diversion channel, and each river improvement
- Storage and infiltration measures in the basin such as regulating pond/reservoir, permeable pavement, and green space conservation
- Land use control in the basins such as development regulations in vulnerable areas, super levees

According to the comments from one of the trainees, he thought that there were limits to flood control in the Davao river basin, but his image of the countermeasure could be materialized through this training.

As for application of retarding basins and underground diversion channels to Davao, the trainees were able to deepen their understanding through question-and-answer sessions on how to pay attention to landowners.

After the training, the results of this training were shared with other C/Ps and DPWH officers who did not participate in the training, and discussions were held on how to utilize them for flood control in the Davao river basin, in the C/P meeting and technical training meeting held on June 14, 2019 and the DPWH-UPMO internal regular meeting held on July 15, 2019.

Regarding the three target rivers including the Davao River, 11 major issues described in Section 2.7.10 of Part I have been clarified. Among them, regarding (1) “Improvement of Present Situation of Implementation of Flood Control Measures with Different Design Levels”, implementation of countermeasures based on the “Fundamental river management policy” and “River improvement plan” in Japan, which was lectured in the training in Japan, will contribute. Also, as for (10) “Better Operation and Maintenance Activities”, although the second training in Japan, which was planned focusing on operation and maintenance as one of the main topics, could not be implemented due to the influence of COVID-19, even in the 1st training in Japan, it is considered that the understanding of the importance of operation and maintenance has progressed through 1) repetitive explanations that proper maintenance is essential for the planned and constructed facilities to continue to fulfill the prescribed function, and 2) seeing and hearing actual examples of maintenance activities such as inspection and cleaning after operation in retarding basins, underground diversion channel and so on.

It is expected that activities aimed at resolving the major issues will be implemented by utilizing what was learned in the training in Japan.

1.3 Outputs and Evaluation

In this Project, project activities have been done with the following basic approaches on capacity enhancement in mind:

1) "Foster the capacity to formulate an integrated flood control M/P by personnel in DPWH by acquiring the knowledge and skills necessary for supervising subletting work"
2) "Strengthen the organization, in order to secure the sustainability of the measures by implementing the M/P formulated in this project and the selected priority projects and by properly operating and maintaining the projects".

Concretely, as mentioned in Section 1.2, capacity enhancement activities have been carried out through C/P Meeting and Technical Training Meeting, seminar, C/Ps Training in Japan and coordination meetings as well as on-the-job training (OJT), such as discussing project issues with related parties including C/P, and conducting field surveys together to confirm local conditions and issues, especially during field activities in Davao.

In addition, there were various opportunities during Project to present/explain and discuss the content and activity status of the Project at many conferences and meetings, such as the Business Webinar by NEDA XI and Consulate General of Japan, IDC XI quarter regular meeting, public consultation meetings for environmental and social consideration and so on, C/P members often made presentations and responded to questions and answers at those meetings.

As for formulating M/P in Matina River, due to time constraints, while discussing the main issues with C/P, most of the plan was prepared by the project team, but as for the basic approach 1) "Foster the capacity to formulate an integrated flood control M/P", it can be evaluated to have been strengthened to a certain extent, mainly through thematic training and discussions at technical training meetings and discussions at OJT.

Regarding the basic approach of 2), proper understanding of the Project is indispensable for presentations and discussions at many official meetings, and appropriate understanding of the content of the measures, the necessity of the measures and their effects will lead to the operation and maintenance of the measures during and after the construction. In this respect, it can be evaluated that some results have been achieved in 2) as well.

On the other hand, it is considered that there is a limit to the capacity enhancement that can be done by development-study-type technical cooperation of which main purpose is to formulate M/P and conduct F/S, and implementation of a technical cooperation project whose main purpose is to strengthen the capacity is needed in order to further strengthen the capacity.

Chapter 2 Recommendation

Based on the activities related to capacity enhancement in this Project, the followings are recommended:

(1) Implement flexible activities according to the needs of the implementing agency and secure a scheme for that

In this project, while formulating M/P and implementing F/S, capacity enhancement activities were also carried out. C/P member of this Project actively participated in technical training meetings, field surveys, discussions and consultations on issues despite their own respective duties. On the other hand, it seems that there are large time constraints in their respective duties, and it may be difficult to carry out specific examination work related to this Project and to secure time for it. In addition, as a project team member (JICA team member), there was a time limit for preparing for training and preparing materials while conducting various studies and works related to the formulation of the plan.

In the future, when conducting a project aiming at practical and effective capacity enhancement while formulating M/P and implementing F/S, it is considered effective to formulate a project considering the following:

＜Project Team Side＞

- A generous project schedule

  To secure a project schedule and assignment period with sufficient time for collaborative work with C / P and capacity enhancement, in addition to time for each work of the part in charge related to M/P and F/S examination.

- Continued on-site stay

  Opportunities for jointly responding, discussing, examining issues that arise on the C/P side are extremely valuable and practical chances for capacity enhancement.
  In order to respond without missing such an opportunity, to secure a scheme that the team can stay in the site continuously and respond appropriately.

- Flexible team member composition

  Even if sufficient prior consultation is conducted, it may happen that it will be necessary to deal with new related fields after the start of a project, beyond the issues and needs that can be assumed at the time of project formation and start.
  To make a flexible member composition that can respond to unexpected issues, or secure a scheme that makes it easy to change or add members.

＜C/P Side＞

- Creating an environment where C/P can engage in collaborative work

  It is considered that there is a limit to capacity enhancement in the form of lectures and short-term intensive training, and responding to specific issues and long-term collaborative work are effective in strengthening practical capacity.
  To secure an environment where C / P can engage in collaborative work as much as possible.

(2) Implementation of technical cooperation projects of which main purpose is to enhance capacity

It is considered that there is a certain limit to the capacity enhancement that can be carried out by development-study-type technical cooperation of which main purpose is to formulate M/P and implement F/S. In order to effectively enhance capacity, it will be efficient to implement a collaborative technical cooperation project of which main purpose is capacity enhancement.

When implementing a project, it is desirable to consider training in a third country if there are successful examples from countries/regions with similar disaster scales, budgets, and organizational structures. As one of candidates for a third country training for a project targeting the Philippines, Indonesia can be considered because of d similarity as an island country and its organizational structure related to flood management activity.