DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
REPUBLIC OF THE PHILIPPINES

REPUBLIC OF THE PHILIPPINES
FOLLOW-UP STUDY
ON PARAÑAQUE SPILLWAY PROJECT

FINAL REPORT

VOLUME 1: MAIN REPORT

OCTOBER 2020

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LOCATION MAP-1

LOCATION MAP-2

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ASEAN	Association of South – East Asian Nations
ASTI	Advanced Science and Technology
BOC	Bureau of Construction
BOD	Bureau of Design
BRS	Bureau of Research and Standards
CIDA	Canadian International Development Agency
CLB	Calamba-Los Baños
CLUP	Comprehensive Land Use Plan
CTIE	CTI Engineering Co., Ltd.
CTII	CTI Engineering International Co., Ltd.
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DILG	Department of the Interior and Local Government
DOF	Department of Finance
DOST	Department of Science and Technology
DPWH	Department of Public Works and Highways
EFCOS	Effective Flood Control Operation System
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMB	Environmental Management Bureau
ESSD	Environmental and Social Safeguards Division
FCMC	Flood Control Management Cluster
FCSEC	Flood Control and Sabo Engineering Center
FRIMP	Flood Risk Management Project
GIS	Geographic Information System
ICC	Investment Coordination Committee
ICHARM	International Centre for Water Hazard and Risk Management
IC/R	Inception Report
IPCC	Intergovernmental Panel on Climate Change
ISF	Informal Settler Families
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
IT/R	Interim Report
JV	Joint Venture
LGU	Local Government Unit
LLDA	Laguna Lake Development Authority
LLEDP	Laguna Lakeshore Expressway Dike Project
LPPCHEA	Las Piñas-Parañaque Critical Habitat and Ecotourism Area
MCGS	Marikina Control Gate Structure
MMDA	Metro Manila Development Authority
MSL	Mean Sea Level
MWSS	Metropolitan Waterworks and Sewerage System
NAMRIA	National Mapping and Resources Information Authority
NBCP	National Building Code of the Philippines
NCR	National Capital Region
NDRRMC	National Disaster Risk Reduction Management Council
NEDA	National Economic Development Authority
NHA	National Housing Authority
NHCS	Napindan Hydraulic Control Structure
NK	Nippon Koei Co., Ltd.
NSCP	National Structural Code of the Philippines
NWRB	National Water Resource Board
ODA	Official Development Assistance
PAGASA	Philippines Atmospheric Geophysical & Astronomical Services Administration
PEISS	Philippines Environmental Impact Statement System

PPP	Public-Private-Partnership
PRBFFWC	Pampanga River Basin Flood Forecasting and Warning Center
PSA	Philippine Statistic Authority
SC	Steering Committee
STEP	Special Terms for Economic Partnership
TOR	Terms of Reference
TWG	Technical Working Group
UNDP	United Nations Development Program
UP	University of Philippines
UPMO	Unified Project Management Office
USAID	United States Agency for International Development
WB	World Bank

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FOLLOW-UP STUDY
ON PARAÑAQUE SPILLWAY PROJECT

Final Report
Volume 1: Main Report

TABLE OF CONTENTS

Appendix Table of Contents

LIST OF TABLES

LIST OF FIGURES

SUMMARY

1. Outline of Survey

1.1 Background

The Philippines is one of the countries that are most vulnerable to natural disasters in the world. The Metropolitan Manila Area, (also known as Metro Manila or the National Capital Region), which includes the City of Manila, the political, economic and cultural center of the Philippines, is located in a lakeshore lowland area susceptible to typhoons/storms and floods, so that the economic and social activities are seriously affected. The Philippine government has been continuously addressing this problem through the development and implementation of flood control projects for more than 50 years, but there is not yet enough capacity to respond to flood events in the region.

For over 40 years since the 1970's, Japan has been providing and implementing wide ranging support and technical assistance as well as ODA loan projects to the Philippines, including the preparation of flood control plans, targeting mainly Metro Manila and the major rivers. Regarding river floods, after the completion of the Manggahan Floodway in 1988, JICA implemented the "Study on Flood Control and Drainage Project in Metro Manila" from 1988 to 1991, and the "Pasig Marikina River Channel Improvement Project" was selected as a highly urgent project for flood management of the Pasig Marikina River. Through the feasibility study (F/S) and JICA's Special Assistance for Project Formation (SAPROF), the project was decided to be implemented in four phases, namely; Phase I, Phase II, Phase III and Phase IV. Currently, additional works in Phase III (Supplemental Agreement No. 6) and the permanent works of Phase IV (L/A signed in 2018) are in progress.

In addition, as measures against floods causing inland inundation and lake water level rise in the western Manggahan District and the area surrounding the Laguna de Bay (Basin Area: 2,920 km^2; Lake Surface Area: 900 km^2), JICA had provided support on the detailed design work for the Eastern and Western Manggahan districts through the ODA loan project entitled "North Laguna Lakeshore Urgent Flood Control and Drainage Project (L/A signed in 1989)" and also supported the construction of lakeshore dikes, the construction of drainage facilities and the installation of drain gates in the western Manggahan District through the ODA loan project known as "Metro Manila Flood Control Project – West of Manggahan Floodway (1997~2007)."

However, Typhoon Ondoy, in September 2009, had brought an unprecedented daily rainfall recorded at 453 mm which caused massive flood damage in areas along the Marikina River and the surrounding Laguna de Bay lakeshore areas in Metro Manila. The Laguna de Bay lakeshore area where low lying areas without flood management measures are widespread had experienced inundation for more than one month. Flood control measures in the Laguna de Bay lakeshore areas had lagged behind those implemented in the center of Manila and hence flood management measures in the whole Metro Manila are urgent matters to be addressed.

Furthermore, as a countermeasure for flooding in the Laguna de Bay lakeshore areas, in addition to the construction of lakeshore dikes, drainage channels and pumping stations, the construction of a spillway (hereinafter referred to as the "Parañaque Spillway") for draining lake water from Laguna de Bay through Parañaque City to the Manila Bay to control the water level of Laguna de Bay is under consideration. Since it is difficult to acquire land in Parañaque City which is an urbanized area, underground channeling is being considered instead of the open cut method.

In view of the necessity of flood countermeasures for the Laguna de Bay lakeshore areas, JICA conducted the "Data Collection Survey on Parañaque Spillway in Metro Manila (hereinafter referred to as Parañaque Survey 2018)" from 2017 to 2018. In this project, additional studies on the integrated flood control plan for the Pasig Marikina River basin and the Laguna de Bay basin were conducted, including the effects of the Parañaque Spillway, based on the previous survey results, as well as the collection and confirmation of information to evaluate the feasibility of JICA's ODA loan projects and the direction of the Preparatory Survey.

1.2 Objectives

The objectives of this project are to analyze the situation in the Laguna de Bay basin, including the Pasig Marikina River basin, in a unified manner and in coordination with the existing flood control projects and plans, to prepare the comprehensive flood management plan of the entire Laguna de Bay Lakeshore Area, and to conduct collection and confirmation of information to examine the feasibility of JICA's ODA loan assistance project and the direction of the preparatory survey.

1.3 Schedule of the Study

The study was started with the domestic preparation work in Japan in November 2019 and all tasks were completed in October 2020.

2. Main Issues studied in This Report

Main issues studied in this report are summarized below:

2.1 Formulation of Flood Management Plan Considering Climate Change

In this study, a flood control plan was prepared in consideration of climate change based on Volume 3, Water Engineering Project of the DPWH guidelines, the "Design Guidelines, Criteria & Standards, 2015 DPWH" (hereinafter, DGCS).

> **Climate Change**
> Climate change should be considered as a part of the design and scoping for the project. This is outlined in Section 7.

Source: Design Guidelines, Criteria & Standards, 2015 DPWH; Volume3 Water Engineering Project

2.2 Operation Level of Parañaque Spillway

In the Parañaque Survey 2018, the operation level of Parañaque Spillway was set at 12.0 m (full year), and the effect of reducing the water level of Laguna de Bay was examined. In this study, the initial operation level of Parañaque Spillway is revised to lower the lake level of Laguna de Bay before the flood season and to increase the storage capacity during flood. In addition, the starting operation level of the four (4) drainage stations installed at West Manggahan Lakeshore dike is 11.5 m.

2.3 Design Flood Level of Laguna de Bay

Regarding the Design Flood Level (DFL) of 100-year probability at Laguna de Bay, the upper limit of DFL is set based on (1) consistency with existing projects and (2) safety level (risk at flood), and then (3) project cost. The DFL of Laguna de Bay will be set based on a total of three evaluation indices.

≪Three (3) Evaluation Indices in the Setting of Laguna de Bay DFL≫

Evaluation Index	Evaluation Perspective	Settings
Evaluation index (1)	Consistency with previous project and plan	Setting upper limit of DFL by evaluation index (1) and (2)
Evaluation index (2)	Safety level (risk at flood)	
Evaluation index (3)	Project cost	Setting DFL by evaluation index (3)

2.4 Re-study on Alignment of Alternative Routes of Parañaque Spillway

In this study, with the aim of cost reduction, a route plan for Parañaque spillway was set based on the following policy. In the Parañaque Survey 2018, two types of tunnel construction methods were examined on the tunnel part (shield construction method and NATM) based on the "shielding method", which enables the construction of tunnels. Regarding NATM, the possibility of adoption shall be examined based on future geological surveys.

- In the past, the Parañaque Spillway was considered several times but has not been realized. The main reason for this was that, aside from project funds, social impacts such as relocation and land acquisition were very large.
- In the 2018 survey, from the viewpoint of minimizing the social impact, it spillway was examined as the "underground waterway", applying the provision "Private land rights do not occur below 50m underground" defined in the recently enacted Philippine law.
- In this follow-up study, from the viewpoint of reducing project cost, the 2018 study was reviewed and the route of Parañaque Spillway was revised to shorten the height of vertical shaft considering that the construction of shafts (inlet and outlet) comprise a large part of construction cost and construction period.
- This proposed route can omit the construction of the shaft at the inlet of the spillway, reduce the cost and the construction period, can construct most of the tunnels on national land (under Dr. A. Santos Avenue), and also reduce the social impact.

2.5 Effect of Flood Control on Parañaque Spillway

In the Paranaque 2018 Survey, the benefits of mitigating inundation damage due to the Parañaque Spillway were examined for only the Laguna lakeshore area. In this study, the flood control and project effects of the Parañaque Spillway on the Pasig-Marikina River basin were also examined more accurately, based on the situations described below.

＜Background and purpose of considering the benefits to the Pasig-Marikina River basin＞

- In 1975, the Manggahan Floodway and the Parañaque Spillway were designed as a pair of facilities to divert floods from the Marikina River to Laguna de Bay in order to mitigate flood damage in Metro Manila.
- Manggahan Floodway was constructed in 1988, but due to issues such as land acquisition and house relocation, the Parañaque Spillway was not implemented up to this date. The operation of the Manggahan Floodway will raise the water level at the lakeshore area.
- As for the flood control measures for the Pasig Marikina River, the project effect as originally planned will be realized by the joint operation of the improved Pasig Marikina River, the Manggahan Floodway and the Parañaque Spillway. The project effects of the Parañaque Spillway are expected to be: (i) the mitigation of flood damage to the lakeshore area due to drainage inflow; and (ii) the mitigation of flood damage at the Pasig-Marikina River Basin.
- Currently, the inflow from Manggahan Floodway is treated in the same way as the given natural conditions. There is no record about project effect (ii), and the project effect of the Parañaque Spillway is underestimated.
- On the other hand, the benefit of reducing inundation damage due to flood inflow from Manggahan Floodway may duplicate the benefit of reducing inundation in the Pasig-Marikina River Basin. The benefits of reducing flood damage in the lakeshore area are not considered.
- In this study, project effects (i) and (ii) were examined as an integrated flood control plan for Laguna de Bay Basin and Pasig-Marikina River Basin connected by the Manggahan Floodway.

3. Update of Draft Comprehensive Flood Management Plan for Laguna de Bay

3.1 Goals and Safety Level of Flood Control

Considering the development status of the Laguna de Bay lakeshore area, historical flood damage, impact of climate change, etc., the inundation damage caused by 1/100 probability flood after climate change, etc., should be prevented and reduced by gradually constructing the Parañaque Spillway and the lakeshore diking system in 30 years.

3.2 Design Flood Level (DFL)

The Design Flood Level (DFL) of Laguna de Bay is set at 13.8m.

3.3 Comprehensive Flood Management Plan

1) Structural Measures (Water Level Rise Suppression and Flood Damage Reduction)

- Construction of Parañaque Spillway: (Underground Channel, Diameter: 13m) Inner diameter should be closely inspected in about 0.1 m in the next F/S stage.

- Lakeshore Diking System: (Total length: 82.75km, including drainage channels, drainage stations, back levee, bridges, etc.).

2) Non-Structural Measures

- Stricter development regulations within lake management boundaries (EL 12.5m or less)
- Promotion of land use regulations and ensuring the safety of residents in flood-prone areas (including resettlement)
- Hazard map creation, evacuation plan, disaster prevention awareness-raising activities for residents, local disaster prevention plan
- Construction of flood forecasting and warning system

3.4 Outline of Parañaque Spillway

1) Scale of Structures

Commercial facilities and houses are dense on the assumed route of the Parañaque Spillway, and if the open channel type is adopted, many residents will be relocated, making commercialization difficult. To minimize the social impact, the drainage channel shall be the Underground Pressure Tunnel type.

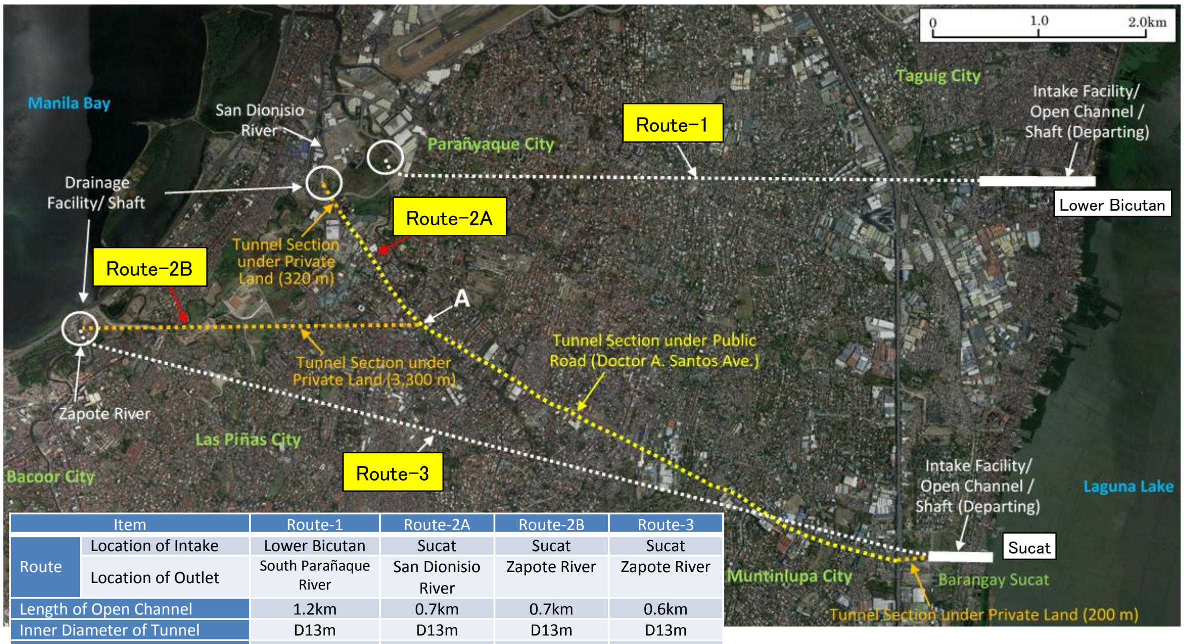
In case of climate change, Parañaque Spillway will require a channel inner diameter of 13m and a maximum discharge rate of 240 m^3/s to reduce the highest water level of Laguna de Bay of 14.5m during a 1/100 probability flood to 13.8m (DFL).

2) Operation Level of Parañaque Spillway

- January～May（Non-flooding Period） : non-operation
- June～July(Water Level Raising Period） : 11.5m
- August～December（Water Level Lowering Period） : 12.0m

3) Alignment Plan

The Parañaque spillway route (underground channel) shall be studied based on the following four (4) alternatives.



Item		Route-1	Route-2A	Route-2B	Route-3
Route	Location of Intake	Lower Bicutan	Sucat	Sucat	Sucat
	Location of Outlet	South Parañaque River	San Dionisio River	Zapote River	Zapote River
Length of Open Channel		1.2km	0.7km	0.7km	0.6km
Inner Diameter of Tunnel		D13m	D13m	D13m	D13m
Length of Tunnel		6.0km	7.2km	8.7km	8.8km
Depth of Tunnel from Surface		> 50m	< 30m	< 30m	> 50m
Height of Intake Vertical Shaft		75m	-	-	75m
Height of Outlet Vertical Shaft		75m	32m	32m	75m
Length of River Improvement		4.0km	8.0km	1.0km	1.0km

Source: JICA Study Team

Figure 3.1 Four Alternatives of Parañaque Spillway Route

3.5 Outline of Lakeshore Diking System

1) Design

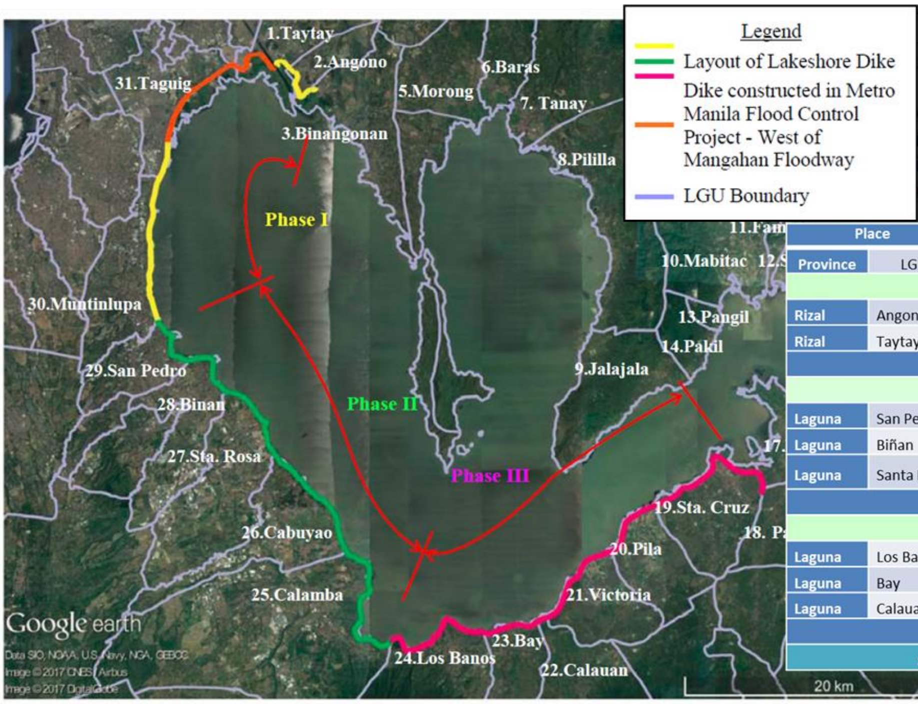
To construct a lakeshore diking system in the priority area along the lakeshore area to prevent inundation. Lakeshore diking system consists of lakeshore dike, drainage canals, pumping stations, community roads, bridges, etc., and resolves flood damage caused by rising water levels in Laguna de Bay.

- Lakeshore dike elevation will be 15.0m, considering 1.2m free board add to 13.8m (DFL).
- Lakeshore dike will be constructed on lakeshores of Laguna Lake elevation of 12 m to 12.5 m.
- Prioritize the location of lakeshore diking systems based on land use, beneficiary population, beneficiary area, etc. in the shore area, and arrange lakeshore diking from areas with higher priority.
- The length of the planned lakeshore dike will be about 83 km compared to about 220 km around the lake shore, and non-structural measures (warning systems, etc.) will be used for areas where there are few assets and the economic effect is low for arranging lakeshore diking system.

2) Implementation Phase of Lakeshore Diking System (Approx. 83km divided into Three Phases)

Lakeshore Diking System shall be implemented in 82.75 km from Angono to Santa Cruz in three phases:

- Phase I : Angono to Muntinlupa, 17.02 km in length
- Phase II : San Pedro to Calamba, 32.83 km in length
- Phase III : Los Baños to Santa Cruz, 32.90 km in length



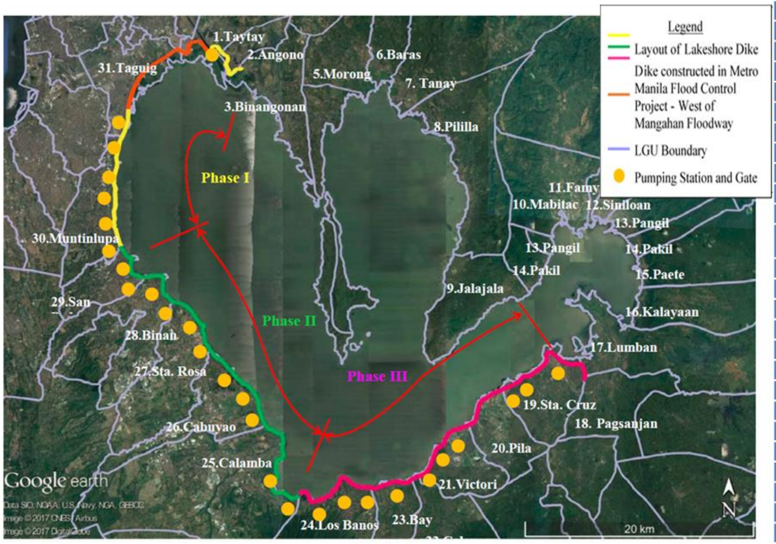
Place		Dike Length (m)	Place		Dike Length (m)
Province	LGU		Province	LGU	
Phase I					
Rizal	Angono	3,310	NCR	Taguig	2,490
Rizal	Taytay	1,350	NCR	Muntinlupa	9,870
Sub-total of Phase I					17,020
Phase II					
Laguna	San Pedro	4,080	Laguna	Cabuyao	8,390
Laguna	Biñan	4,660	Laguna	Calamba	9,920
Laguna	Santa Rosa	5,780			
Sub-total of Phase II					32,830
Phase III					
Laguna	Los Baños	8,240	Laguna	Victoria	6,470
Laguna	Bay	3,780	Laguna	Pila	4,750
Laguna	Calauan	840	Laguna	Santa Cruz	8,820
Sub-total of Phase III					32,900
Sub-total of Priority Area					82,750

Source: JICA Study Team

Figure 3.2 Layout of Lakeshore Diking System （Phase I, II, III）

3) Implementation Phase of Drainage Stations (28 Stations divided into Three Phases)

Drainage pumping stations for draining inland water shall be implemented in three (3) phases as part of the 82.75 km Lakeshore Diking System planned from Angono to Santa Cruz.



Drainage Stations (Phase I, II, III)

No	River Basin			Retarding Pond			Capacity of Pomp (m³/s)
				Area (ha)	Depth (m)	Capacity (m³)	
1	SB-23	Muntinlupa	SB23-RB1	0.9	2.0	17,000	5.0
2			SB23-RB2	1.2	2.0	23,000	7.0
3			SB23-RB3	1.4	2.0	27,000	9.0
4			SB23-RB4	0.5	2.0	10,000	3.0
5			SB23-RB5	0.2	2.0	4,900	2.0
6	SB-22	San Pedoro	SB22-RB1	0.5	2.0	9,000	2.0
7			SB22-RB2	1.7	2.0	34,000	7.0
8			SB22-RB3	1.2	2.0	23,500	5.0
9	SB-21	Binan	SB21-RB1	6.4	2.0	128,200	27.0
10			SB21-RB2	1.3	2.0	25,000	5.0
11	SB-20	Sta. Rosa	SB20-RB1	0.8	2.0	16,000	4.0
12			SB20-RB2	2.9	2.0	58,000	14.0
13			SB20-RB3	0.9	2.0	18,000	4.0
14			SB20-RB4	7.5	2.0	149,000	36.0
15	SB-19	San Cristobal	SB19-RB1	5.7	2.0	113,000	27.0
16	SB-18	San Juan	SB18-RB1	2.9	2.0	57,000	15.0
17	SB-17	Los Banos	SB17-RB1	1.6	2.0	32,800	13.0
18			SB17-RB2	1.0	2.0	20,200	8.0
19			SB17-RB3	2.9	2.0	58,100	23.0
20			SB17-RB4	0.3	2.0	5,800	2.0
21	SB-16	Calauan	SB16-RB1	0.4	2.0	7,000	2.0
22			SB16-RB2	0.3	2.0	5,800	2.0
23	SB-15	Pila	SB15-RB1	0.8	2.0	16,900	4.0
24			SB15-RB2	4.4	2.0	87,900	23.0
25			SB15-RB3	7.1	2.0	141,300	37.0
26	SB-14	Sta. Cruz	SB14-RB1	5.9	2.0	118,000	26.0
27			SB14-RB2	0.7	2.0	14,000	3.0
28	SB-02	Taytay	SB02-RB1	1.0	2.0	20,000	6.0
Total				62.0		1,240,400	321.0

Source: JICA Study Team

Figure 3.3 Layout of Drainage Stations (Phase I, II, III)

3.6 Non-Structural Measures

As a countermeasure until the Parañaque Spillway and Lakeshore Diking System are completed, non structural measures (warning system, etc.) shall be promoted in areas where there are few assets and the economic effect is low for arranging the Lakeshore Diking System.

Table 3.1 Proposed Non-Structural Measures for Flood Mitigation of Lowland Area

Proposed Non-Structural Measure	Description
Strict Implementation of Land Use Management Regulation in Lake Public Area below El. 12.5m	Existing reclamation activity, houses, factories, stockyards should strictly be regulated and controlled. Lake boundary at El. 12.5m should be clearly determined.
Evacuation/Resettlement from Flood Dangerous Area	Promotion of resettlement from flood dangerous areas below El. 12.5m to safety areas.
Improvement of the Disaster Risk Management System, Preparation of Hazard Maps and Education and Information Campaign for Inhabitants	Some LGUs along the lakeshore area have prepared the DRRMP. However, DRRMP for the entire Laguna Lake is not prepared yet. It is needed. Assistance in preparation of Hazard maps along the lakeshore and inflow rivers. Using Hazard maps, education for inhabitants through LGUs.
Proposed Flood Forecasting and Warning System for the Laguna de Bay Basin	Flood forecasting and warning for flash floods of inflow rivers and lake floods should be established. Warning system for inhabitants along the Parañaque Spillway should be established for proper operation.

Source: JICA Study Team

3.7 Project Implementation Plan (Long Term Plan for 30 years and Priority Implementation of Parañaque Spillway)

The Parañaque Spillway is expected to be completed in about 5 to 9 years (depending on route), and flood mitigation effect is expected over the entire Laguna Lakeshore Area soon after completion. On the other hand, the Lakeshore Diking System requires a lot of resettlement and land acquisition, and it is expected to have an impact on fishery, historically. It will also take a long time to complete (20-30 years). Therefore, the Parañaque Spillway should be given first priority as a flood management plan, and its early implementation is desirable, to complete construction in about 5 to 9 years, and then steadily implement the Lakeshore Diking System over a long period (about 30 years) considering the reduction of water level effect of the Parañaque Spillway.

Table 3.2 Project Implementation Plan

No	Component	30-year Project Implementation (2021-2050)		
		10 years (2021-2030)	Next 10 years (2031-2040)	Final 10 years (2041-2050)
I	Structural Measures			
	1) Parañaque Spillway (Priority Project)			
	2) Lakeshore Diking System*			
	Phase I (17.02km)			
	Phase II (32.83km)			
	Phase III (32.90km)			
II	Non-Structural Measures			
	1) Strict Implementation of Land Use Management Regulation			
	2) Evacuation/Resettlement from Flood Dangerous Area			
	3) Improvement of the Disaster Risk Management System			
	4) Proposed Flood Forecasting and Warning System			

Source: JICA Study Team

3.8 Project Cost and Evaluation of Draft Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area

The project cost, compensation and economic evaluation are as shown in the table below.

Table 3.3 Project Cost and Detail Compensation of Draft Comprehensive Flood Management Plan (with Climate Change、PSW D=13m、Shield)

Parañaque Spillway (PSW) + Lakeshore Dike System (LDS)	Cost (million PHP)								
	Construction		Design and Supervision	Price Escalation	Physical Contingency	Compensation	Administration	Vat	Total
	PSW	LDS							
PSW (Route-1) + LDS	46,203	44,945	9,115	34,286	13,455	15,293	3,266	19,596	186,158
PSW (Route-2A) + LDS	41,888	44,945	8,683	32,318	12,783	16,028	3,133	18,797	178,576
PSW (Route-2B) + LDS	41,263	44,945	8,621	32,159	12,699	16,428	3,122	18,734	177,971
PSW (Route-3) + LDS	50,736	44,945	9,568	35,486	14,074	15,941	3,415	20,490	194,654

Table 3.4 Compensation Cost under the Draft Comprehensive Flood Management Plan (with Climate Change、PSW D=13m、Shield)

Parañaque Spillway (PSW) + Lakeshore Dike System (LDS)	Parañaque Spillway				Lakeshore Diking System			
	Compensation Cost (million PHP)	Land Acquisition (ha)	House Evacuation (house)	Affected People (person)	Compensation Cost (million PHP)	Land Acquisition (ha)	House Evacuation (house)	Affected People (person)
PSW (Route-1) + LDS	2,147	12.8	340	1,390	13,146	1,284.9	2,913	11,524
PSW (Route-2A) + LDS	2,882	7.7	360	1,470				
PSW (Route-2B) + LDS	3,283	12.9	360	1,470				
PSW (Route-3) + LDS	2,795	6.8	360	1,470				

Table 3.5 Evaluation of Draft Comprehensive Flood Management Plan (with Climate Change, PSW: D=13m, Shield)

Parañaque Spillway (PSW) + Lakeshore Dike System (LDS)	Annual Benefit (million PHP)	NPV of B (million PHP)	NPV of C (million PHP)	EIRR	NPV (million PHP)	B/C
PSW (Route-1) + LDS	22,475	80,132	41,043	16.3%	39,088	1.95
PSW (Route-2A) + LDS	21,279	95,871	42,474	19.6%	53,397	2.26
PSW (Route-2B) + LDS	21,181	95,459	42,427	19.7%	53,032	2.25
PSW (Route-3) + LDS	23,751	84,165	44,060	16.2%	40,105	1.91

3.9 Project Cost and Evaluation for Parañaque Spillway (Priority Project)

The project cost, compensation and economic evaluation are as shown in the table below.

Table 3.6 Project Cost of Parañaque Spillway (with Climate Change, PSW: D=13m, Shield)

Parañaque Spillway (PSW)	Cost (million PHP)							
	Construction	Design and Supervision	Price Escalation	Physical Contingency	Compensation	Administration	Vat	Total
PSW (Route-1)	46,203	4,620	7,797	5,862	2,147	1,333	7,996	75,959
PSW (Route-2A)	41,888	4,189	5,830	5,191	2,882	1,200	7,197	68,376
PSW (Route-2B)	41,263	4,126	5,671	5,106	3,283	1,189	7,134	67,771
PSW (Route-3)	50,736	5,074	8,997	6,481	2,795	1,482	8,890	84,454

Table 3.7 Compensation of Parañaque Spillway (with Climate Change, PSW: D=13m, Shield)

Parañaque Spillway (PSW)	Parañaque Spillway				
	Compensation Cost (million PHP)	Land Acquisition (ha)	House Evacuation (house)	Affected People (person)	Construction Period (month)
PSW (Route-1)	2,147	12.8	340	1,390	98
PSW (Route-2A)	2,882	7.7	360	1,470	60
PSW (Route-2B)	3,283	12.9	360	1,470	64
PSW (Route-3)	2,795	6.8	360	1,470	105

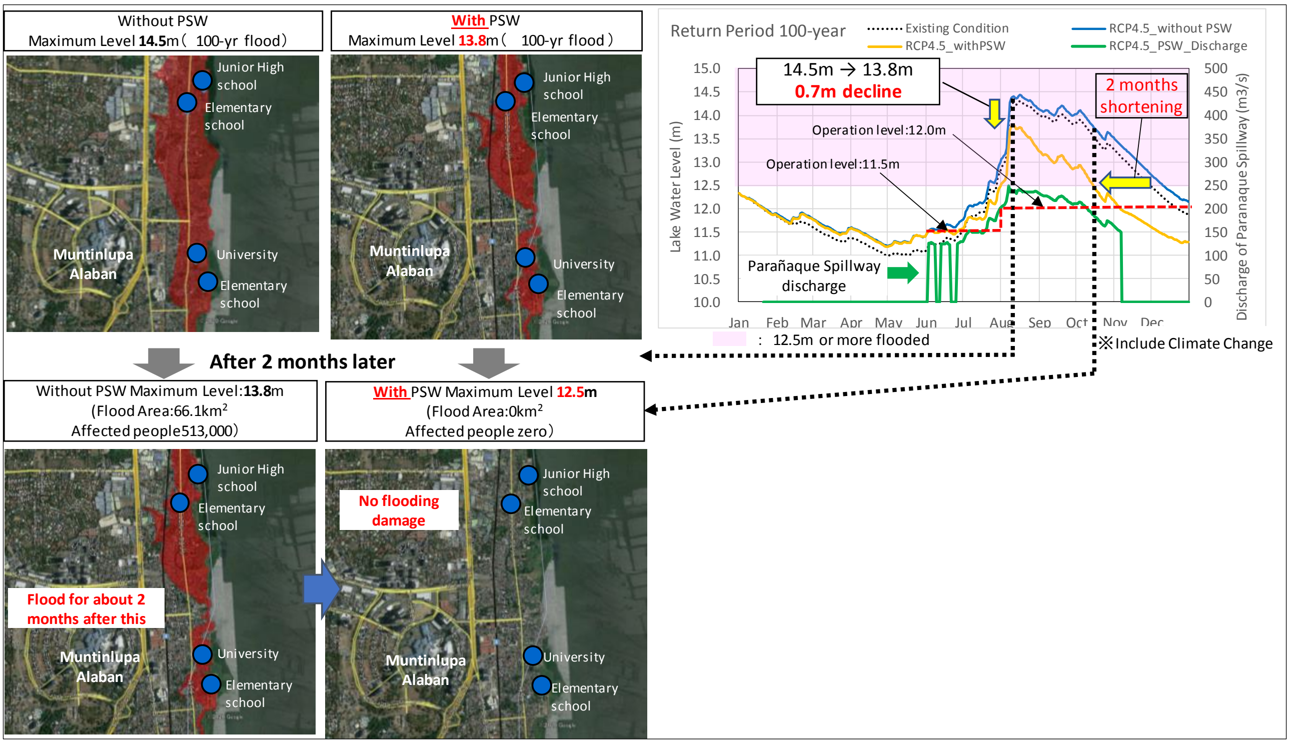
Table 3.8 Evaluation of Parañaque Spillway (with Climate Change, PSW: D=13m, Shield)

Parañaque Spillway (PSW)	Annual Benefit (million PHP)	NPV of B (million PHP)	NPV of C (million PHP)	EIRR	B/C
PSW (Route-1)	19,676	69,586	26,013	18.9%	2.68
PSW (Route-2A)	18,480	86,201	27,444	23.1%	3.14
PSW (Route-2B)	18,382	85,790	27,397	23.1%	3.13
PSW (Route-3)	20,952	73,619	29,030	18.6%	2.54

3.10 Effect of Parañaque Spillway in 100-Year Probability of Water Level

The 100-year probable water level will be reduced from 14.5 m to DFL 13.8 m by the development of Parañaque Spillway. From this, the inundation area above 12.5 m is reduced by 32.5 km^2 from 98.6 km^2 without the Parañaque Spillway to 66.1 km^2. The inundation period is shortened by 2.3 months from 4.8 months to 2.5 months, and the inundation damage population is reduced by 340,000 people from 853,000 to 513,000. Economic and social damages are greatly reduced.

The figure below shows the inundation area before and after the 100-year probability of Parañaque Spillway in the Alabang district of Muntinlupa City. Schools are scattered along the coast of Laguna de Bay, and if there is no Parañaque Spillway, inundation will continue for about 4 months or longer.



Source: JICA Study Team

Figure 3.4 Image of Mitigating Inundation Damage by Effect of Parañaque Spillway

Table 3.9 Effect of Parañaque Spillway against Probable Flood

Index	100-year Probability		10-year Probability		5-year Probability	
	Base Year (2020)	Target Value* (2032)	Base Year (2020)	Target Value* (2032)	Base Year (2020)	Target Value* (2032)
Maximum Lake Water Level (m)	14.5	13.8	13.4	13.0	13.1	12.8
Inundation Area (km^2)	98.6	66.1	45.6	24.6	29.3	14.5
Inundation Period (month)	4.8	2.5	3.1	0.8	2.4	0.6
Inundation Damage Population (person)	853,000	513,000	339,000	160,000	206,000	89,000

Source: JICA Study Team

* The target value is due to the effect of Parañaque Spillway.

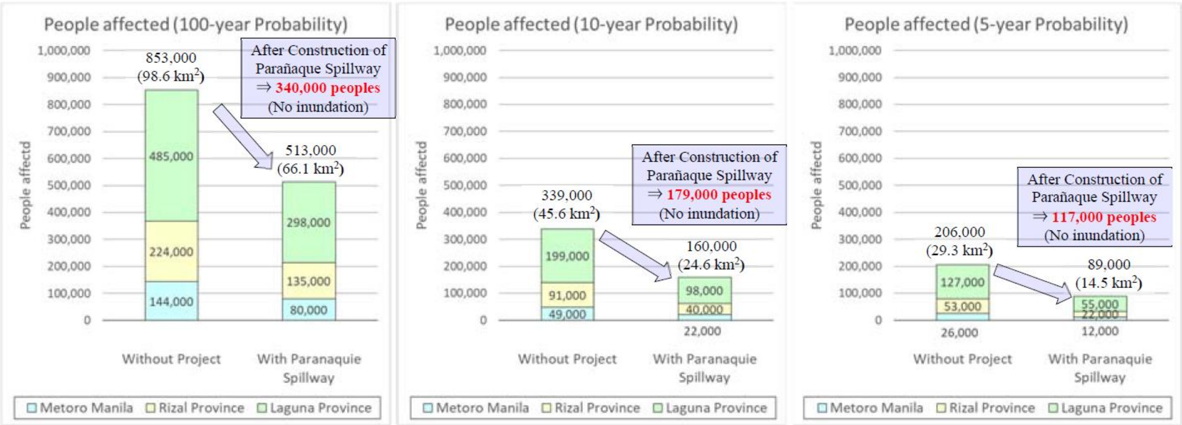


Figure 3.5 Reducing Inundation Population by Effect of Parañaque Spillway

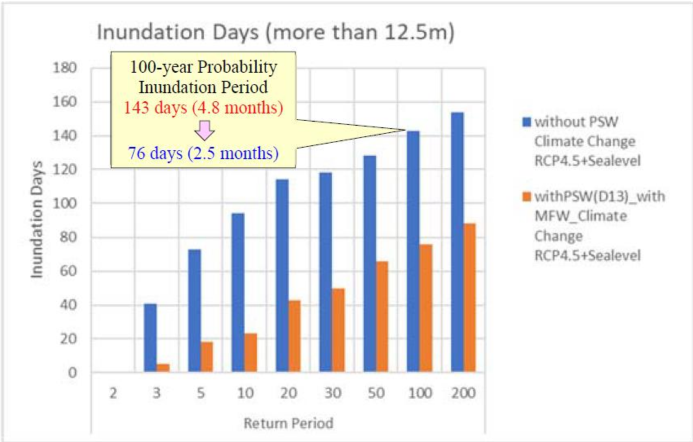


Figure 3.6 Reducing Inundation Period by Effect of Parañaque Spillway

4. Recommendation

4.1 Recommendation

In 1975, both the Manggahan Floodway and the Parañaque Spillway, which have the function of diverting the flood flow of Marikina River to Laguna de Bay and the function of releasing the flood flow of Marikina River stored in Laguna de Bay to Manila Bay, respectively, were proposed as a pair of facilities to mitigate flood inundation damage in Metro Manila. The Manggahan Floodway was constructed in 1988 to reduce flood damage in Metro Manila, but the Parañaque Spillway has yet to be not installed due to issues such as land acquisition and house evacuation. As a result, operations of the Manggahan Floodway raise the Laguna lake water level.

As for the flood management of the Pasig-Marikina River, the Pasig-Marikina River improvement works, the Manggahan Floodway and the Parañaque Spillway shall be operated jointly to produce the integrated project effect as originally planned. The project effect of Parañaque Spillway consists of (1) the effect of releasing the inflow from the Laguna de Bay basin to Manila Bay and reducing the inundation damage along the Laguna de Bay lakeshore area, and (2) the effect of reducing the inundation damage along the Pasig Marikina River. At present, the inflow from the Manggahan Floodway is treated in the same way as the given natural conditions, the project effect (2) is not considered for evaluating the Parañaque Spillway, and the project effect of Parañaque Spillway is underestimated.

In this study, project effects (1) and (2) were examined and the project effect of Parañaque Spillway was evaluated more accurately as the integrated flood management plan for the Laguna de Bay lakeshore area and Pasig Marikina River basin connected by Manggahan Floodway. As a result, the EIRR of Parañaque Spillway was as high as 18.6% to 23.1%, indicating that the Parañaque Spillway project is feasible.

Lowlands spread all over the Laguna de Bay lakeshore area, and not enough flood management projects have been implemented. In the past, long-term flood damage has occurred. Flood management in Laguna de Bay lakeshore area is far behind that in Metro Manila, and urbanization of the lakeshore area is progressing, which may cause serious flood damage in the future.

In order to implement the Parañaque Spillway which is expected to have a flood risk mitigation effect along the entire lakeshore area, it is recommended that DPWH take prompt action on the following matters:

1) To obtain approval from the Philippine government and NEDA of the “Draft Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area” as a Master Plan; and
2) To carry out a Feasibility Study (F/S) on the Parañaque Spillway, which is a priority project in the Master Plan in which feasibility was shown in this study.

4.2 Contents to be studied in the F/S on Parañaque Spillway

The contents to be included in the F/S are summarized under the following items.

(1) Topographic Survey for Structural Design
(2) Sounding Survey (Laguna de Bay) for Structural Design of Intake and Open Channel
(3) Longitudinal and Cross-Sectional River Survey and Evaluation of Effect to Downstream River
(4) Borehole Drilling Survey along the Route of Parañaque Spillway
(5) Hydraulic Model Experiment for confirming the hydraulic specifications of structures
(6) Diffusion Analysis of Discharge from Parañaque Spillway to examine the effect on LPPCHEA
(7) Operation and Maintenance Plan for Underground Channel, which is the first attempt in the Philippines
(8) Operation Plan of Rosario Weir considering the water level of Laguna de Bay.
(9) Environment Impact Assessment (EIA) and Preparation of the Resettlement Action Plan (RAP)

Chapter 1. Project Description

1.1 Background

The Philippines is one of the countries that are most vulnerable to natural disasters in the world. The Metropolitan Manila Area (also known as Metro Manila or the National Capital Region), which includes the City of Manila, the political, economic and cultural center of the Philippines, is located in a lakeshore lowland area susceptible to typhoons/storms and floods, so that the economic and social activities are seriously affected. The Philippine government has been continuously addressing this problem through the development and implementation of flood control projects for more than 50 years, but there is not yet enough capacity to respond to flood events in the region.

The Philippine government states in its Mid-Term Development Plan (2017-2022) that, to improve the coordination capacity for river management, needed are the continuous initiative to reduce flood risk, updating of design and maintenance standards for flood control facilities, the development of river information database and updating of baseline data for flood plain designation, and the updating and development of flood control and drainage plans for the 18 major river basins.

For over 40 years since the 1970's, Japan has been providing and implementing wide-ranging support and technical assistance as well as ODA loan projects to the Philippines, including the preparation of flood control plans, targeting mainly Metro Manila and the major rivers. Regarding river floods, after the completion of the Manggahan Floodway in 1988, JICA implemented the "Study on Flood Control and Drainage Project in Metro Manila" from 1988 to 1991, and the "Pasig-Marikina River Channel Improvement Project" was selected as a highly urgent project for flood management of the Pasig-Marikina River. Through the feasibility study (F/S) and JICA's Special Assistance for Project Formation (SAPROF), the project was decided to be implemented in four phases, namely; Phase I, Phase II, Phase III and Phase IV. Currently, additional works in Phase III (Supplemental Agreement No. 6) and the permanent works of Phase IV (L/A signed in 2018) are in progress.

Regarding measures against drainage and inland inundation, JICA has been supporting the implementation of river dredging and the construction/installation of pumping facilities, water-gates, drainage channels and others through various projects, including the ODA loan project called "Metro Manila Flood Control and Drainage Project" in 1973, the grant aid project named as "Project for Retrieval of Flood Prone Areas in Metro Manila (Phases I and II)" from 1989 to 1994, and the ODA loan project called "The KAMANAVA Area Flood Control and Drainage System Improvement Project" from 2000 to 2008.

In addition, as measures against floods causing inland inundation and lake water level rise in the western Manggahan District and the area surrounding the Laguna de Bay (Basin Area: 2,920 km^2; Lake Surface Area: 900 km^2), JICA had provided support on the detailed design work for the Eastern and Western Manggahan districts through the ODA loan project entitled "North Laguna Lakeshore Urgent Flood Control and Drainage Project (L/A signed in 1989)" and also supported the construction of lakeshore dikes, the construction of drainage facilities and the installation of drain-gates in the western Manggahan District through the ODA loan project known as “Metro Manila Flood Control Project – West of Manggahan Floodway (1997~2007).”

However, Typhoon Ondoy, in September 2009, had brought an unprecedented daily rainfall recorded at 453 mm which caused massive flood damage in areas along the Marikina River and the surrounding Laguna de Bay lakeshore areas in Metro Manila. The Laguna de Bay lakeshore area where low-lying areas without flood management measures are widespread had experienced inundation for more than one month. Flood control measures in the Laguna de Bay lakeshore areas had lagged behind those implemented in the center of Manila and hence flood management measures in the whole Metro Manila are urgent matters to be addressed.

Furthermore, as a countermeasure for flooding in the Laguna de Bay lakeshore areas, in addition to the construction of lakeshore dikes, drainage channels and pumping stations, the construction of a spillway (hereinafter referred to as the “Parañaque Spillway”) for draining lake water from Laguna de Bay through Parañaque City to the Manila Bay to control the water level of Laguna de Bay is under consideration. Since it is difficult to acquire land in Parañaque City which is an urbanized area, underground channeling is being considered instead of the open-cut method.

In view of the necessity of flood countermeasures for the Laguna de Bay lakeshore areas, JICA conducted the “Data Collection Survey on Parañaque Spillway in Metro Manila (hereinafter referred to as Parañaque Survey 2018)” from 2017 to 2018. In this project, additional studies on the integrated flood control plan for the Pasig-Marikina River basin and the Laguna de Bay basin were conducted, including the effects of the Parañaque Spillway, based on the previous survey results, as well as the collection and confirmation of information to evaluate the feasibility of JICA’s ODA loan projects and the direction of the Preparatory Survey.

1.2 Objective

The objectives of this project are to analyze the situation in the Laguna de Bay basin, including the Pasig-Marikina River basin, in a unified manner and in coordination with the existing flood control projects and plans, to prepare the comprehensive flood management plan of the entire Laguna de Bay Lakeshore Area, and to conduct collection and confirmation of information to examine the feasibility of JICA’s ODA loan assistance project and the direction of the preparatory survey.

1.3 Project Description

(1) Study Area

The Study Area involves the entire Laguna de Bay Lakeshore Area (Metro Manila Area and Surrounding Areas).

(2) Related Government Offices and Authorities

・Department of Public Works and Highways (DPWH)

・Lake Laguna Development Authority (LLDA)

・Metro Manila Development Authority (MMDA)

(3) JICA's Major Assistance related to theProject

① Development Study

- Study on Flood Control and Drainage Project in Metro Manila (1990)

② ODA Loan

- Metro Manila Flood Control and Drainage Project (1973~)
- Metro Manila Flood Control Project - West of Manggahan Floodway (1997 ~ 2007)
- Pasig-Marikina River Channel Improvement Project (Phase I) (1999 ~ 2000)
- Pasig-Marikina River Channel Improvement Project (Phase II) (2006 ~ 2013)
- Pasig-Marikina River Channel Improvement Project (Phase III) (2012 ~ 2018)
- Pasig-Marikina River Channel Improvement Project (Phase IV) (2019 ~)

③ Basic Information Collection and Confirmation Study

- Data Collection Survey on Drainage System in Metro Manila (2013)
- Data Collection Survey on Flood Management Plan in Metro Manila (2014)
- Data Collection Survey on Parañaque Spillway in Metro Manila (2018)

1.4 Schedule

To show the progress of the work, the following reports are to be prepared and submitted to the agencies concerned:

- Inception Report: November 2019
- Draft Final Report: April 2020
- Final Report: June 2020

The work plan is as shown in the following table.

Table 1.4.1 Work Plan for Follow-up Study on Parañaque Spillway Project

No.	Work Items \ Period	FY 2019 Oct	FY 2019 Nov	FY 2019 Dec	FY 2020 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
【1】	Domestic Preparation Works and Consultation of IC/R with JICA		□■											
【2】	Confirmation and arrangement of existing plans and studies on flood control, water utilization, land use, environmental management / basin conservation, climate change		■□											
【3】	Confirmation of inflow from Manggahan floodway into Laguna Lake, resulting rise in Laguna Lake level, inundation area		■□											
【4】	Consideration and proposal of a method for organizing and examining the coast of Laguna Lake and flood control in the Pasig-Marikina river basin as the flood control effect of the Paranaque spillway		■□											
【5】	Collection of information on people using Laguna Lake		■□											
【6】	Creating an interim report (IT / R)			□■										
【7】	Confirmation of optimal facility scale combination by sensitivity analysis			□	□									
【8】	Reorganization of basic design plan and trial calculation of maintenance costs				□■	■								
【9】	Examination of the components of the implementation procedure				□■	■								
【10】	Reorganization of project economic effects (EIRR,B/C)				■	■								
【11】	Outline of climate change adaptation measures					■								
【12】	Rearrangement of non-structural measures				■	■								
【13】	Rearrangement of flood control plan in Laguna Lake basin					■□	□							
【14】	Examination of operation rules for Paranaque spillway					■□	□							
【15】	Organizing the position of the Paranaque floodrway development project on sustainable development and conservation of Laguna Lake					■□	□							
【16】	Examination and proposal of the presentation method of the project effect of Paranaque spillway					■□	□							
【17】	Creation, explanation and discussion of DF/R					■□	□	□	□					
【18】	Pereparation, Submission of F/R								□	□	□	□		
【19】	Topographic Survey										■	■	■	
	Discussion and Submission of the Report													
	Report		Δ IC/R	Δ IT/R					Δ DF/R			Δ F/R (Main Report)		Δ F/R (Survey Report)

【Legend】 In the Philippines : ■ Domestic Works : □ Reporting : Δ

IC/R : Inception Report, IT/R : Interim Report, DF/R : Draft Final Report, F/R : Final Report

Chapter 2. Conditions of the Study Area

2.1 Condition of the Study Area

2.1.1 Natural Condition

(1) Laguna de Bay Lakeshore Areas

The Laguna de Bay Lakeshore Area spans over three (3) provinces [National Capital Region (NCR): two (2) cities; Rizal Province: nine (9) towns; and Laguna Province; five (5) cities and thirteen (13) towns). The densely populated Manila Metropolitan Area or the NCR, with the current population of around 24 million, is in the northeastern part (see Figure 2.1.1).

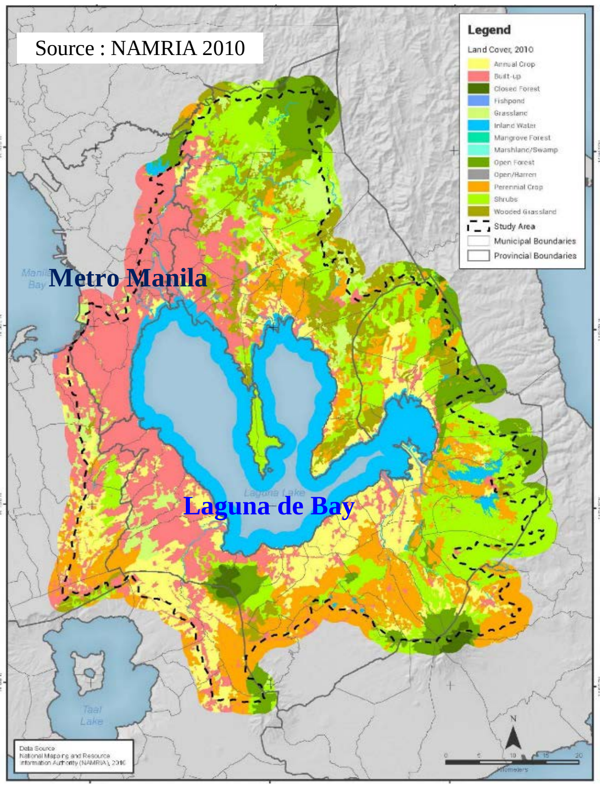


Figure 2.1.1 Land Use around Laguna de Bay (The red part is a densely populated area)

Laguna de Bay is under the jurisdiction of the LLDA which was established in 1969. The LLDA is one of the agencies affiliated to the Ministry of Environment and Natural Resources (DENR), and it is responsible for the conservation, development and sustainability of Laguna de Bay and the 21 major tributaries. According to Presidential Decree No. 813, Series of 1975, the area of Laguna de Bay below 12.5m above sea level is defined as public land.

The lakeshore length of Laguna de Bay is 220km and its surface area is 900km^2, which is about 1.3 times the surface area of Lake Biwa, the largest lake in Japan. The Laguna de Bay basin area is about 3,820km^2, including the Marikina River Basin (about 540km^2), which connects through the Manggahan Floodway.

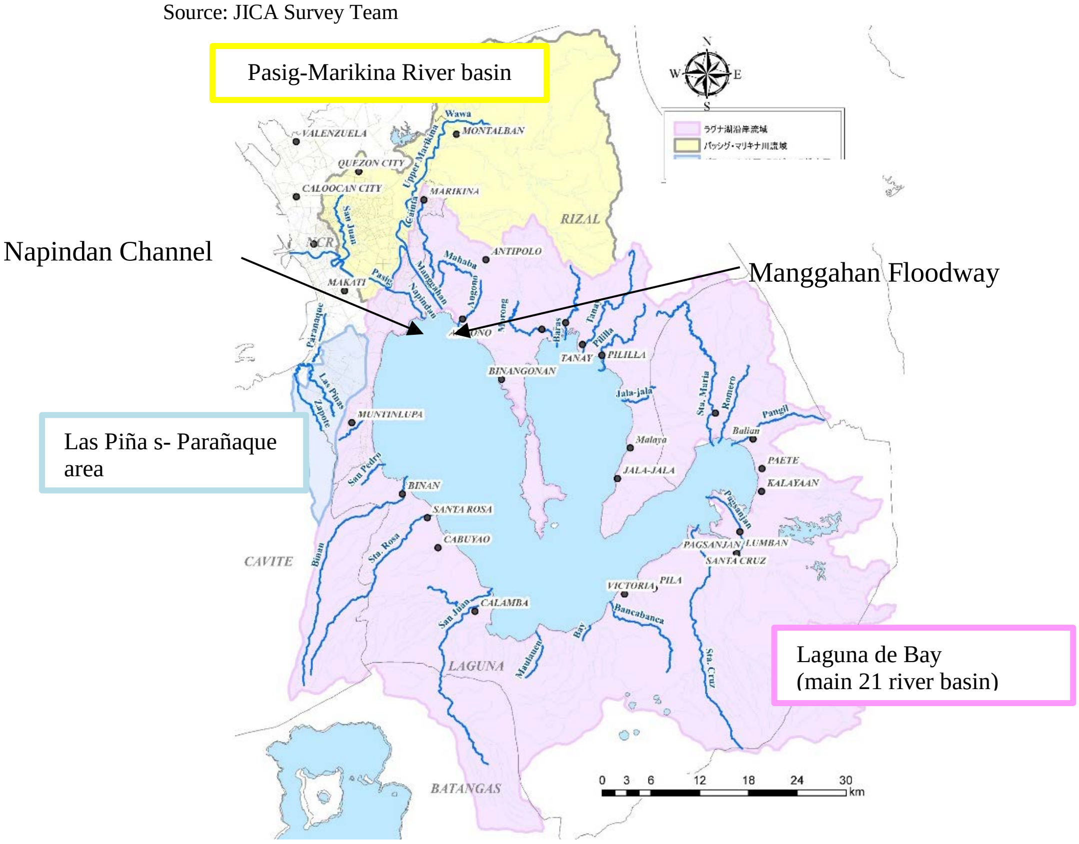
There are 21 main rivers flowing into Laguna de Bay. The water level of Laguna de Bay is lowest in April to May at the end of the dry season, and highest in September and January of the second half of the rainy season. It is therefore necessary to formulate a flood control plan, considering the balance between flood control capacity and the water use capacity, and according to the seasonal fluctuation of the lake's water level.

Table 2.1.1 Catchment Area of Basins in Survey Area

Basin Name	Catchment Area (km^2)
Laguna de Bay Basin	**3,280**
Laguna de Bay Surface	900
Other River basins	2,380
Pasig-Marikina River Basin	**640**
Marikina River Basin	538

Pasig River basin	102

Source: JICA Survey Team



Source: JICA Survey Team

Figure 2.1.2 River System at Survey Area

Prior to 1988, the Marikina River flood flow did not directly flow into Laguna de Bay, but flowed down Pasig-Marikina River, causing great flood damage in Metro Manila area (lower Pasig River). In 1988, Manggahan Floodway was completed as a flood control measure in Manila Metropolitan Area where population and assets are concentrated, and by temporarily storing flood of the Marikina River in Laguna de Bay, flood damage in Pasig Marikina River basin was much mitigated.

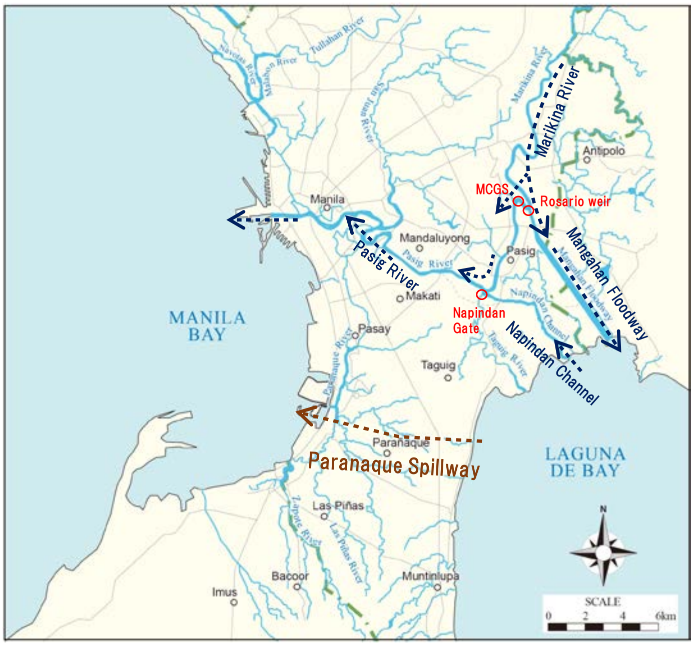
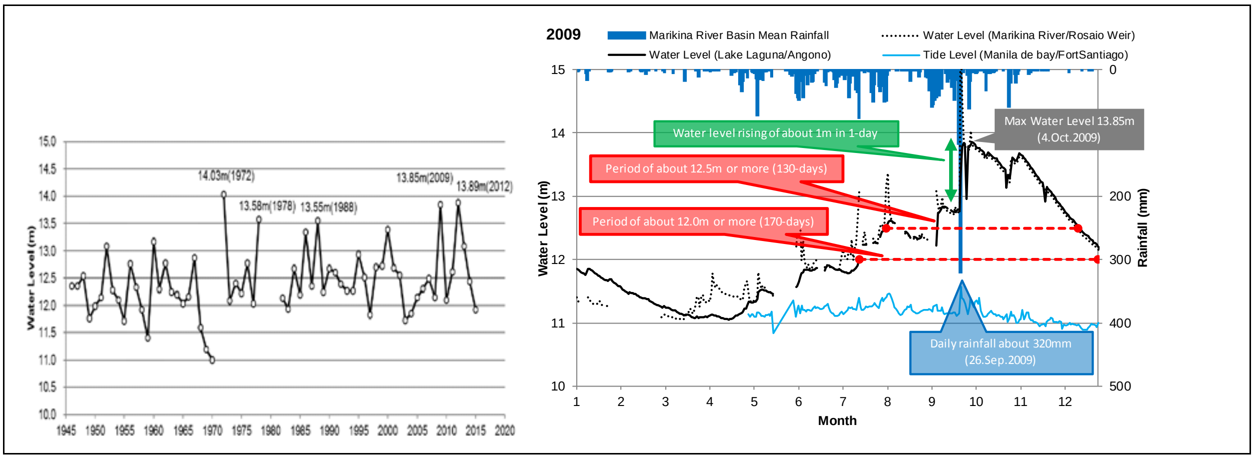


Figure 2.1.3 Hydraulic System of Laguna de Bay, Manggahan Floodway and Napindan Channel

(2) Historical Flood Events in Laguna de Bay

The average annual minimum lake level is 10.6m, the average annual average level is 11.3m, and the average annual maximum water level is 12.4m. Laguna de Bay is a sizeable lake that can store floodwaters, but the main runoff river is only Napindan Channel. Therefore, once water levels rise, the high water level stays for a long time. To make it worst, the flood characteristics of Laguna de Bay is that floods cause inundation damage over a wide area. The maximum water level of 13.85m due to Typhoon Ondoy in 2009 took about three (3) months to subside to 12.5m.



Source: Parañaque Survey, 2018

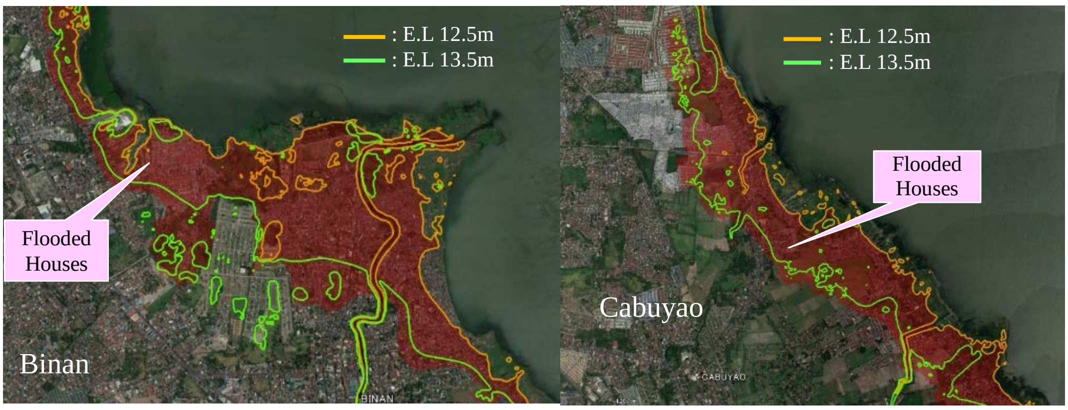
Figure 2.1.4 Maximum Lake Water Level and Lake Water Level Fluctuation in 2009

Table 2.1.2 Annual Minimum, Average and Maximum Lake Water Level (1946-2019)

Year	Annual Minimum Surface Level m	Annual Average Surface Level m	Annual Maximam Surface Level m
1946	10.62	11.38	12.36
1947	10.60	11.32	12.36
1948	10.66	11.5	12.54
1949	10.50	11.07	11.76
1950	10.63	11.27	11.98
1951	10.66	11.28	12.15
1952	10.57	11.64	13.08
1953	10.74	11.51	12.28
1954	10.64	11.19	12.10
1955	10.50	10.97	11.71
1956	10.74	11.46	12.76
1957	10.69	11.32	12.33
1958	10.43	11.1	11.92
1959	10.35	10.83	11.41
1960	10.62	11.65	13.17
1961	10.50	11.33	12.29
1962	10.66	11.41	12.77
1963	10.54	11.14	12.24
1964	10.37	11.22	12.20
1965	10.68	11.22	12.04
1966	10.56	11.15	12.16
1967	10.66	11.45	12.87
1968	10.31	10.85	11.59
1969	10.17	10.64	11.19
1970	10.32	10.58	11.00
1971	No data	No data	No data
1972	10.60	11.88	14.03
1973	10.58	11.15	12.08
1974	10.77	11.45	12.40
1975	10.62	11.07	12.22
1976	10.59	11.57	12.77
1977	10.40	11.06	12.03
1978	10.30	11.36	13.58
1979	No data	No data	No data
1980	No data	No data	No data
1981	No data	No data	No data
1982	10.45	11.19	12.13

Year	Annual Minimum Surface Level m	Annual Average Surface Level m	Annual Maximam Surface Level m
1983	10.32	11.02	11.94
1984	10.32	11.13	12.67
1985	10.32	11.23	12.20
1986	10.39	11.54	13.34
1987	10.19	10.98	12.35
1988	10.52	11.43	13.55
1989	10.76	11.43	12.24
1990	10.41	11.34	12.67
1991	10.50	11.36	12.60
1992	10.46	11.24	12.39
1993	10.41	11.08	12.27
1994	10.77	11.47	12.27
1995	10.46	11.42	12.94
1996	10.84	11.46	12.52
1997	10.45	11.07	11.83
1998	10.44	11.07	12.70
1999	11.04	11.87	12.72
2000	10.95	11.9	13.39
2001	10.89	11.59	12.69
2002	10.48	11.39	12.55
2003	10.50	11.12	11.72
2004	10.36	10.98	11.85
2005	10.48	11.17	12.15
2006	10.70	11.45	12.30
2007	10.59	11.33	12.49
2008	10.93	11.65	12.14
2009	11.00	12.09	13.85
2010	10.60	11.26	12.12
2011	10.72	11.66	12.65
2012	11.04	12.05	13.83
2013	10.75	11.63	13.01
2014	10.56	11.29	12.26
2015	10.50	11.08	11.83
2016	10.48	11.14	11.89
2017	10.73	11.47	12.26
2018	10.73	11.57	12.65
2019	10.68	11.27	11.94
Min	**10.17**	**10.58**	**11.00**
Ave	**10.58**	**11.32**	**12.40**
Max	**11.04**	**12.09**	**14.03**

Laguna de Bay lakeshore areas generally have an altitude of 12.0m, and areas above 12.5m have many dwellings and social infrastructure. Figure 2.1.5 shows the flooding of many houses during the 2009 Typhoon Ondoy.



Source：Created based on Google Earth

Figure 2.1.5 Inundation Area of Typhoon Ondoy in 2009 (Maximum Water Level: EL. 13.85m)

In the previous Parañaque Survey (2018), the approximate flooded area and flooded population at every 0.5m elevation with the lowest elevation of flood damage as 12.5m have been calculated as shown in

Table 2.1.2. For example, when the maximum flood level was 14.0m, 74.8km^2 was inundated, and the flooded population was estimated to be 506,000[1].

Table 2.1.3 Flooded Area and Flooded Population in Lakeshore Area by Water Level

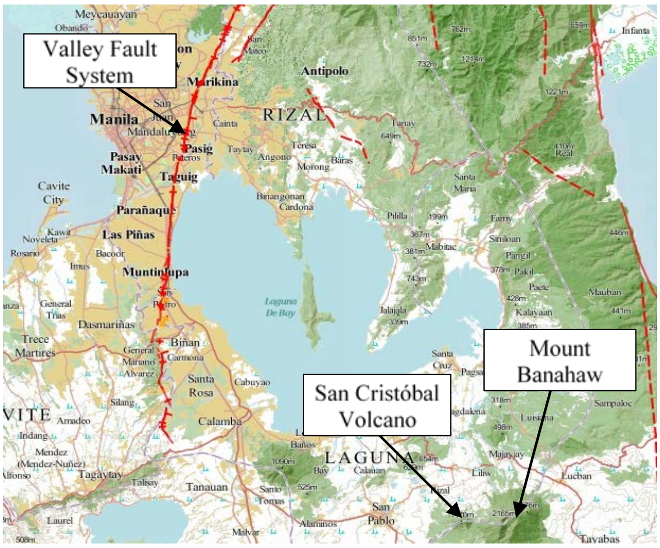
Lake Water Level (m)	Flooded Area (km^2)	Assumed Flooded Population (person)
12.5	0	0
13.0	23.8	131,000
13.5	48.8	305,000
14.0	74.8	506,000
14.5	100.1	701,000

Source：Parañaque Survey, 2018

(3) Topography and Geology of Laguna de Bay

Luzon Island where the Survey area is located is found between the Manila Trench and the Philippine Trench, which is also found between the Eurasian Plate and the Philippine Sea Plate. The Survey area is in the southern part of Luzon Island, the southern part of Metro Manila, and has Laguna de Bay with its area of about 900km^2, 1.3 times as large as Lake Biwa, the largest lake in Japan. From northwest to west of the survey area, flatlands spread, becoming commercial and residential densely populated areas. The southeastern part is flat land mainly used for agriculture.

Mountainous regions are seen from northeast to north and in the south. Among these mountains there are active volcanoes such as Mount Banahaw (2,169m) and potentially active volcanoes such as Mount San Cristobal (1,470m). Many other inactive and dead volcanoes are concentrated especially in the southern part of Laguna de Bay. In the survey area, active fault groups called Valley Fault System running north and south in the western part of Laguna de Bay can be seen, and a height difference of a couple ten meters was confirmed in the terrain around the active fault group. Altitude steeply decreases toward Laguna de Bay.

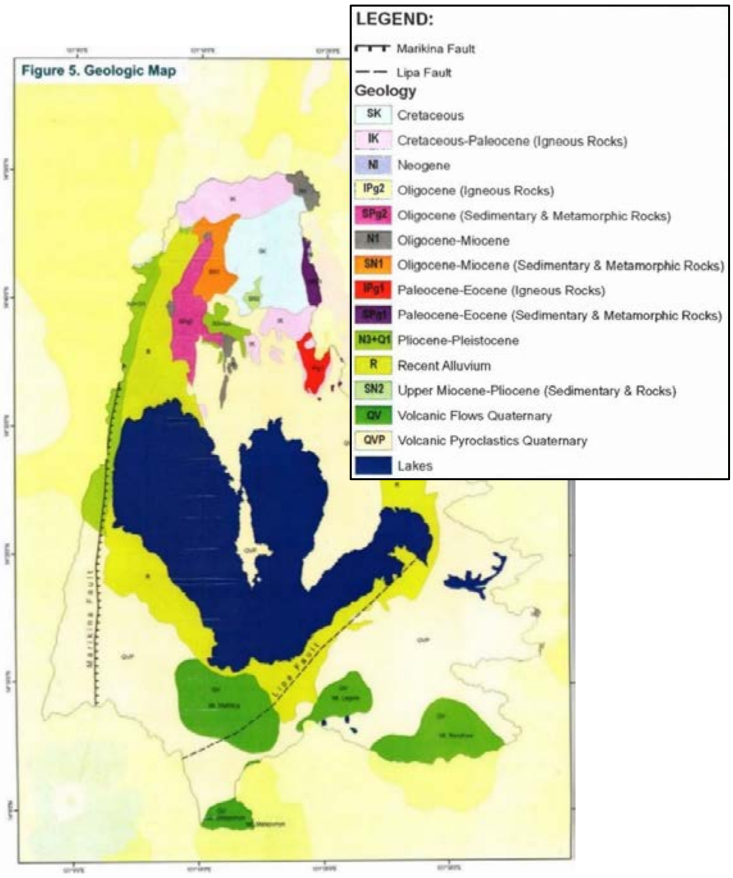


Source: Fault Finder, PHIVOLCS

Figure 2.1.6 Topographic Map of the Survey Area

[1] Inundation population is calculated as the population living at land heights of 12.5m to 14.5m above sea level where there is a possibility of flood damage according to GIS data analysis. The population data used for the GIS analysis are calculated assuming that population of each barangay in the 2015 Census (PSA) live in uniform density in the Built-Up area of each barangay. Built-up area was created by image analysis of Landsat 8 Satellite Image.

According to the geological map (see Figure 2.1.7) published in the "Hydrologic Atlas of Laguna de Bay, 2012", geology of the area is based on the Neogene and Quaternary Pliocene deposits and the Quaternary volcanic streams and volcanic debris deposits by volcanoes lining at the south of Laguna de Bay.



Source: Hydrologic Atlas of Laguna de Bay 2012

Figure 2.1.7 Geology around Laguna de Bay

In addition, according to "Geology of the Philippines, Second Edition", the hilly land between Laguna de Bay and Manila Bay, which is also a candidate site for the Parañaque Spillway route, is regarded as Guadalupe Formation of Pleistocene. It is inferred that the so-called soft rocks consisting of volcanic clastic rocks (tuff, volcanic gravel tuff, tuff brittle conglomerate, volcanic ash silt rock, etc.) are spreading. In the survey area, houses are densely built and there are few exposures of the rock, but some are exposed by the cuts along the road.

Source：Parañaque Survey, 2018

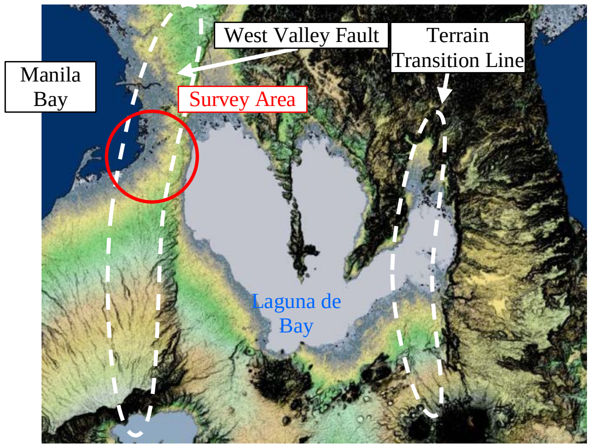
Figure 2.1.8 Rock Exposure (along Gen. Santos Street South of Taguig City)

(4) Topography and Geology of Parañaque Spillway

The survey area is at the hilly land, approximately 10km interval in-between Manila Bay and Laguna de Bay at the southern part of Metro Manila as shown in Figure 2.1.9. The topography around the survey area, taken by the Shuttle Radar Topography Mission (SRTM) and published by the National Aeronautics and Space Administration (NASA), shows the terrain transition line in the North-Northeast-South direction as shown in Figure 2.1.10. This line is called “West Valley Fault” in the “Valley Fault System.” Although another terrain transition line can be seen on the east edge of Laguna de Bay, it has not been confirmed as a part of the fault.

Source: JICA Study Team

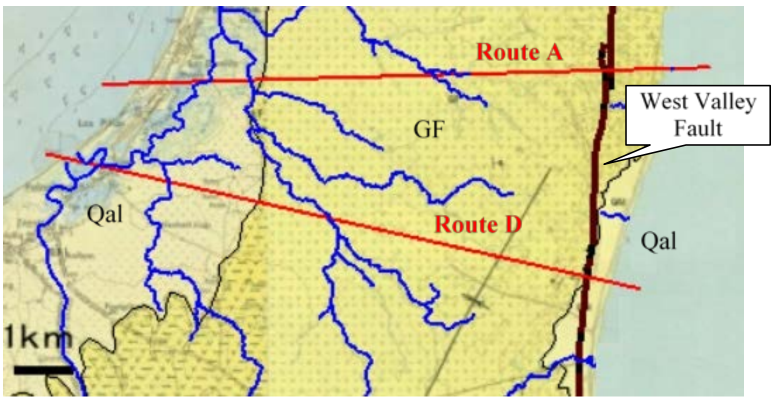
Figure 2.1.9 Location of the Survey Area



Source: SRTM, Visualized by JICA Study Team

Figure 2.1.10 Topography around the Survey Area

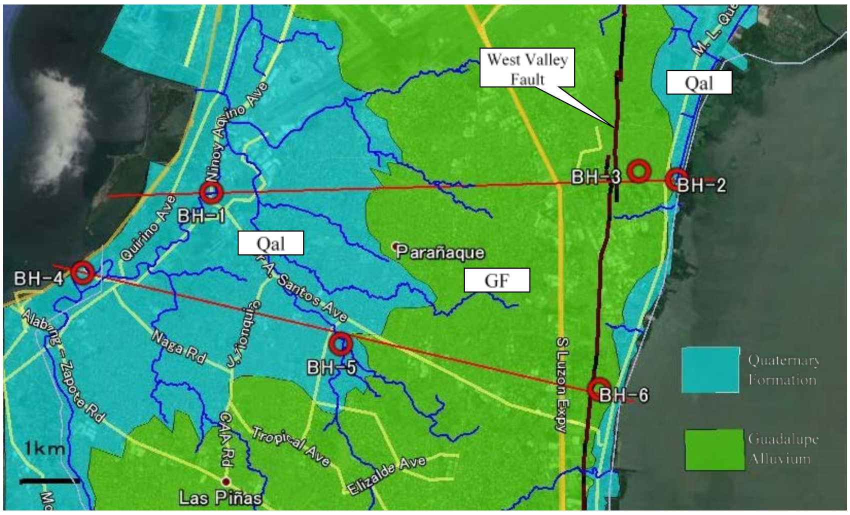
The geological map created by the Geological Survey Division of the Philippine Bureau of Mines and Geo-Sciences is shown in Figure 2.1.11. According to this map, basement rock in this hilly land is the Pleistocene Guadalupe Formation (GF), mainly composed of volcanic clastic rocks (tuff, lapilli tuff, tuff gravel rock, volcanic ash, silt, etc.), the so-called “soft rocks”. In the lowlands on the western side of the hill and the lowlands along the Laguna de Bay lakeshore area, Holocene Quaternary Alluvium (Qal), unconsolidated deposits such as clay, silt, sand and gravel, cover the basement soft rocks.



Source: Geology of the Philippines, Philippine Bureau Of Mines and Geo-Sciences Geological Survey Division

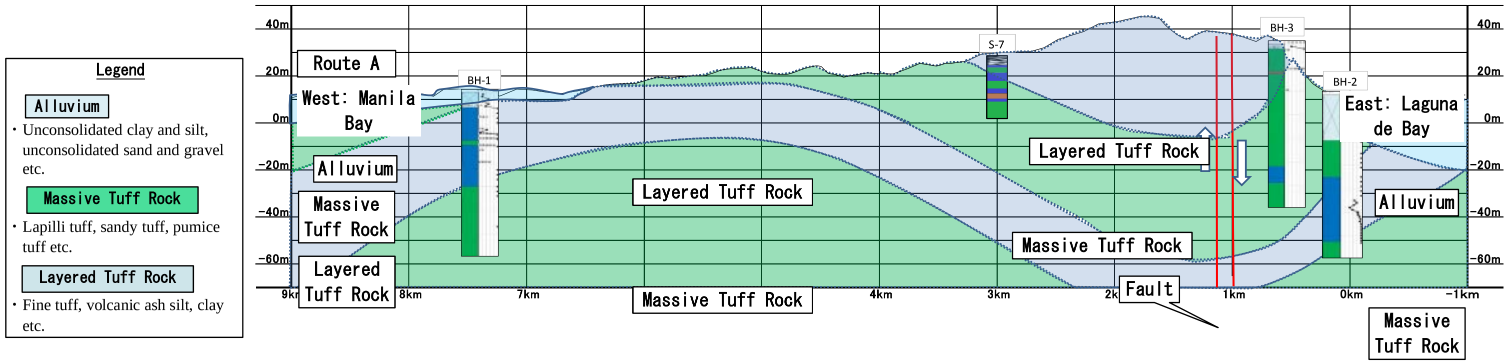
Figure 2.1.11 Geological Map around the Survey Area

In the Parañaque Survey of 2018, based on the geological map shown in Figure 2.1.11, another geological map and longitudinal section newly created and shown as Figure 2.1.12 and Figure 2.1.13 reflect the information obtained by several site investigations, boring test results and SRTM elevation data, which were executed in 2017 and 2018.

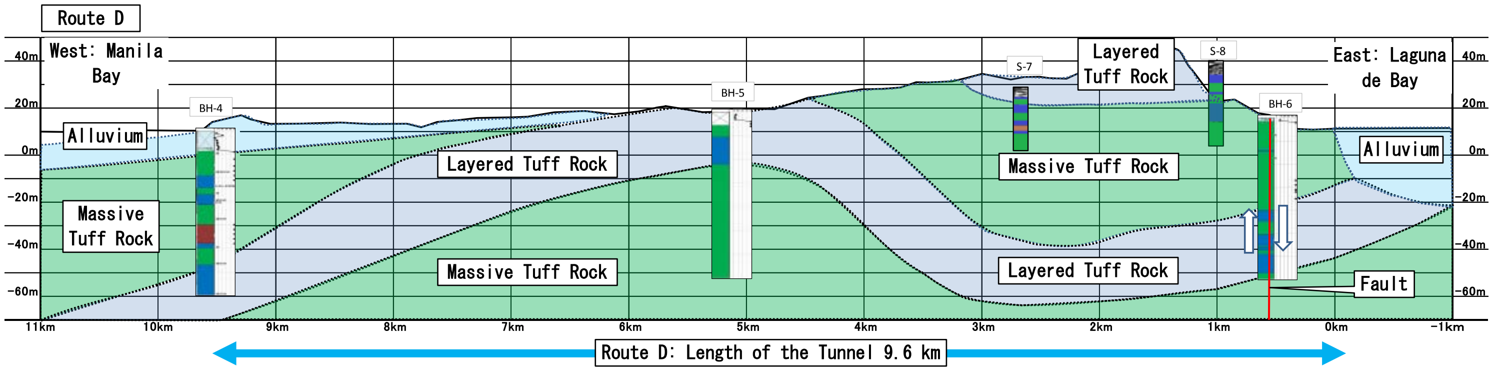


Source：Parañaque Survey, 2018

Figure 2.1.12　Revised Geological Map around the Survey Area



· Alluvium deposits are distributed in the lowland on the western side (Manila Bay side) and east side (Laguna de Bay), and volcanic clastic rocks are distributed in the central hilly land.
· Basement rocks are volcanic clastic rocks (Pleistocene) called Guadalupe Formation (tuff, lapilli tuff, tuff breccia, volcanic ash silt rocks, etc.) and have layered planes within 5 to 6 degrees .
· There are few cracks in the rocks, and the permeability is considered to be small. In addition, the uniaxial compressive strength of the basement rock is about 24.2 Mpa on average.
· The alluvium consists of unconsolidated sand and clay, N value is about 10 to 30, basement rocks excluding weathered part of 1 to 3 m surface layer, N value is more than 50. On the Laguna de Bay Lakeshore area, about 19 m of sand and silt layer with an N value of 10 to 30 has been confirmed.
· From the assumed start point of the Parañaque Spillway, two faults are assumed to be located around 1.0 to 1.1 km, and the altitude of the fault location is around 28 m.



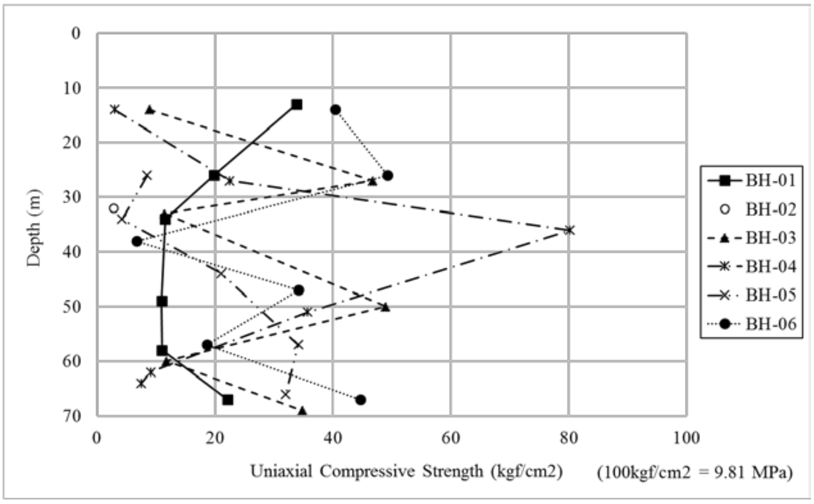
Note:
These drawing are stretched 20 times in lateral direction. Actual strata should be almost horizontally distributed.

· Alluvium deposits are distributed in the lowland on the western side (Manila Bay side) and east side (Laguna de Bay), and volcanic clastic rocks are distributed in the central hilly land.
· Basement rocks are volcanic clastic rocks (Pleistocene) called Guadalupe Formation (tuff, lapilli tuff, tuff breccia, volcanic ash silt rocks, etc.) and have layered planes within 5 to 6 degrees .
· There are few cracks in the rocks, and the permeability is considered to be small. In addition, the uniaxial compressive strength of the basement rock is about 24.2 Mpa on average.
· The alluvium consists of unconsolidated sand and clay, N value is about 10 to 30, basement rocks excluding weathered part of 1 to 3 m surface layer, N value is more than 50. On the Laguna de Bay Lakeshore area, about 19 m of sand and silt layer with an N value of 10 to 30 has been confirmed.
· From the assumed start point of the Parañaque Spillway, single fault is assumed to be located around 0.5 km to 0.6 km, and the altitude of the fault location is around 10 m.

Source: Parañaque Survey, 2018

Figure 7.1.14 Geological Longitudinal Section along Route A and D

Figure 2.1.15 shows the relation between uniaxial compressive strength of the Guadalupe Formation, which was executed in Parañaque Survey, 2018, as well as the depth from the ground surface at each borehole. This figure indicates that most of the uniaxial compressive strength are under 50 kgf/cm^2 (4.91 Mpa). Compared with Figure 2.1.16, the Guadalupe Formation is relatively soft in the soft rock classification.



Source: Parañaque Survey, 2018

Figure 2.1.15 Uniaxial Compressive Strength of Rock Specimen

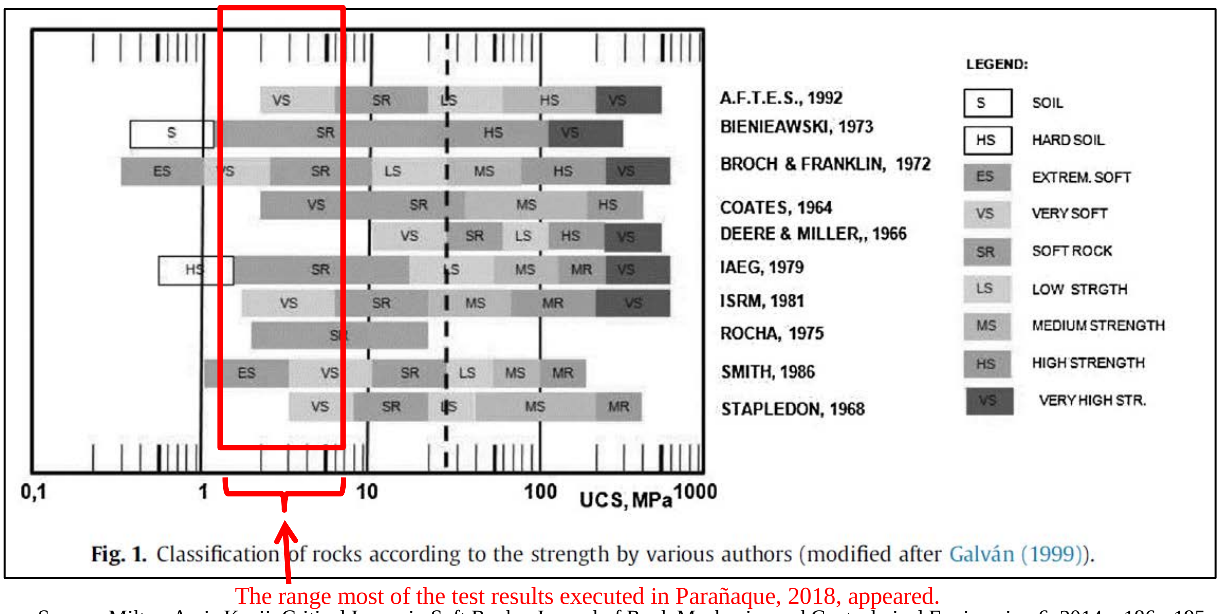


Fig. 1. Classification of rocks according to the strength by various authors (modified after Galván (1999)).

Source: Milton Assis Kanji, Critical Issues in Soft Rocks, Journal of Rock Mechanics and Geotechnical Engineering 6, 2014, p186-p195
Parañaque Survey, 2018

Figure 2.1.16 Comparison between Test Results and Classifications of Rock

2.1.2 Economy

(1) Local Government and Population

According to the Census in 2015, the total population of the Philippines was 109.8 million. The country comprises 14 legislative regions, and the study area is covered by two regions, namely, NCR (National Capital Region) and Region IV-A (CALABARZON). Population of each region in 2015 were 12,877 thousand and 14,415 thousand which are 12.8% and 14.3% of the whole country, and the annual increase rates are 1.58% and 2.58% from 2010 to 2015, respectively. There are five provinces under Region IV-A. The table below shows the population and number of local governments per region and province.

Table 2.1.4 Population in the Study Area

Regions	Provinces	No. of Cities/Municipalities (as of March 2015)	Population		Increase Rate (2010-15)
			2010	2015	
Whole Country	81 provinces	144 cities 1,490 municipalities	92,337,852	100,981,837	1.72%
NCR		16 cities, 1 mun.	11,855,975	12,877,253	1.58%
IV-A	Total	18 cities, 124 mun.	12,609,803	14,414,774	2.58%
	Laguna	6 cities, 24 mun.	2,669,847	3,035,081	2.47%
	Cavite	6 cities, 17 mun.	3,090,691	3,678,301	3.37%
	Quezon	2 cities, 39 mun.	1,987,030	2,122,830	1.33%
	Rizal	1 city, 13 mun.	2,484,840	2,884,277	2.88%
	Batangas	3 cities, 31 mun.	2,377,395	2,694,335	2.41%

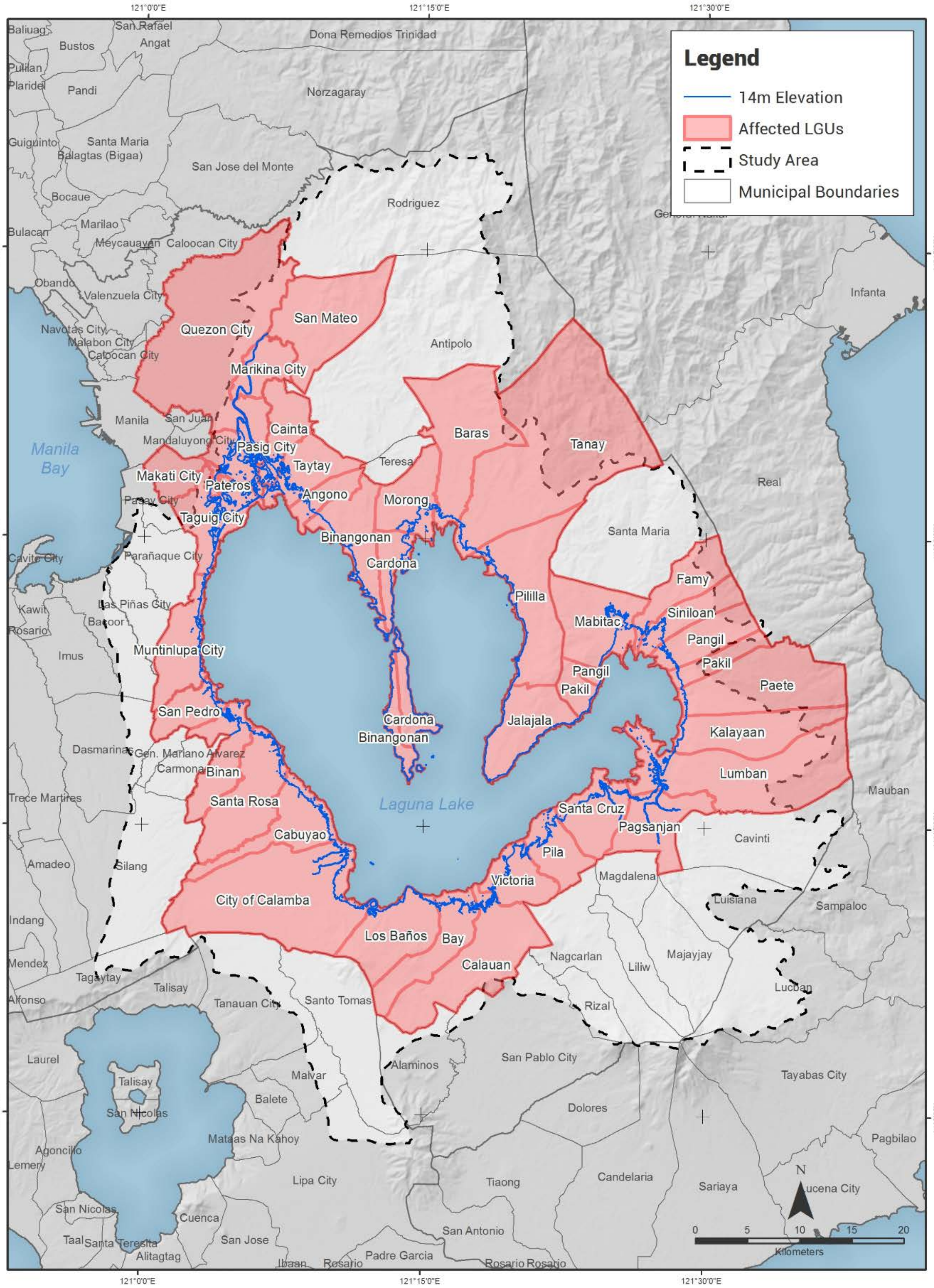
Source: NSO, 2015 Census

In the Philippines, there are cities and municipalities regulated under the regional level. In the study area, there are 75 local governments in total. Among them, 35 local governments could be affected by inundation around Laguna de Bay (shown in the map next page). Population in the study area takes 17.7% and flood-prone area takes 6.8% of the total population.

Table 2.1.5 List of LGUs in the Study Area and Population

Regions	Provinces	Population in 2015	Study Area		Affected Area	
			No. of Cities/ Municipalities	Population	No. of Cities/ Municipalities	Population
NCR	-	12,877,253	10	7,769,261	3	1,401,742
IV-A	Laguna	3,035,081	30	3,035,081	17	1,964,505
	Cavite	3,678,301	7	2,235,379	5	1,479,627
	Quezon	2,122,830	7	496,445	0	0
	Rizal	2,884,277	14	2,884,227	6	1,128,842
	Batangas	2,694,335	7	1,472,605	4	921,551
Total		27,292,077	75	17,892,997	35	6,896,267

Source: NSO 2015 Census; Parañaque Survey, 2018



Source: NAMRIA, Parañaque Survey, 2018

Figure 2.1.17 Location Map of Cities and Municipalities in the Study Area

(2) Economy and Industry

Economy in the Philippines had developed satisfactorily, and the total GDP achieved PHP 14,481 billion in 2016. Annual increase rate of GDP was high at 5.4% in 2014 and 8.7% in 2015. Shares of the regional GDP in NCR and Region IV-A were 38.1% and 14.8%, respectively. GDP amount of two regions take majority of the national GDP, and this clearly shows the importance of economic activities in the study area.

According to the GDP census data in 2016, in terms of economic value, industrial sectors of manufacturing, trade, real estate, financing, construction took higher share in NCR. In Region IV-A, industrial sectors of manufacturing, real estate, trade, transportation and communication have higher shares. In both regions, share of the primary sector (agriculture, forestry, mining, etc.) was low as less than 5% of total regional GDP.

Table 2.1.6 Outlook of Economy (2016)

Items	Whole Country	NCR	Region IV-A
GDP (billion PHP)	14,481	5,522	2,144
- Increase rate of GDP 2014-15	5.4%	8.0%	2.4%
- Increase rate of GDP 2015-16	8.7%	9.5%	4.1%
GDP per capita (PHP)	140,259	431,783	148,917
GDP per Industrial Sector	14,481	5,522	2,144
(1) Agriculture, hunting, forestry and fishing	1,398	11	125
(2) Mining and quarrying	114	0	3
(3) Manufacturing	2,845	592	1,035
(4) Construction	1,050	177	130
(5) Electricity, gas and water supply	456	157	69
(6) Transportation, storage & communication	913	264	120
(7) Trade and repair of motor vehicles, motorcycles, personal and household goods	2,643	1,657	192
(8) Financial intermediation	1,165	604	102
(9) Real estate, renting & business activities	1,899	1,107	235
(10) Public administration & defense, compulsory social security	576	294	30
(11) Other services	1,423	657	103

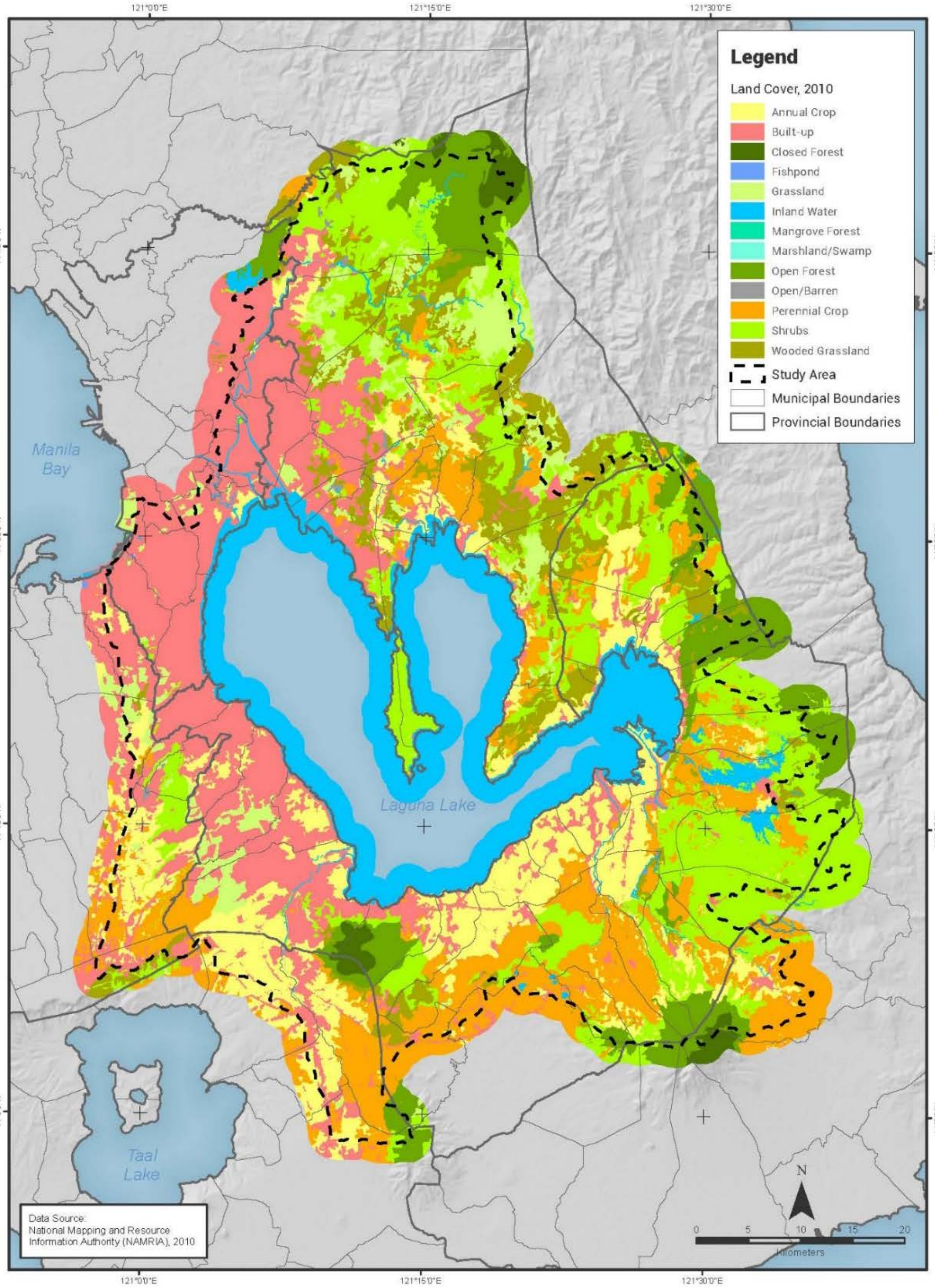
Source: Gross Regional Domestic Product 2014-2016 (as of May 2017), NSO, Parañaque Survey, 2018

(3) Land Use

The Land Use Map of the Study Area provided by NAMRIA and the table showing the share of each land category are described as follows.

As seen in the land use map, the northwest area of Laguna de Bay where Metro Manila is located, is mainly a built-up area. This built-up area continues to the southwest side of the lake where inhabitants can commute to Metro Manila. The southeast area is composed of agricultural field of annual crops, perennial crops and shrub area. The north-east area of the lake is Grassland and Open Forest.

Land use area per province in the study area is summarized in the following table. A majority of Metro Manila, approximately 90% of the total area, is covered with built-up areas. In Region IV-A, the annual crop and perennial crop areas take a majority of the land. Land areas of shrubs, open forests and built-up areas are also shown in this table.



Source: Land Use Map, NAMRIA, 2010, Parañaque Survey, 2018

Figure 2.1.18 Land Use Map of the Study Area

Table 2.1.7 Land Use Condition in Study Area (2010)

Land Cover Type	Metro Manila	Batangas	Cavite	Laguna	Quezon	Rizal	Total
1) Built-up	208,635,461	32,063,983	68,484,981	259,668,004	2,983,026	173,167,970	745,003,426
2) Annual Crop	7,730,373	67,515,047	51,963,492	306,637,878	14,102,125	78,733,758	526,682,672
3) Perennial Crop	0	44,173,245	27,858,018	263,565,445	24,002,894	80,635,871	440,235,473
4) Wooded Grassland	1,754,509	3,266,348	4,496,157	82,227,621	26,170	175,922,009	267,692,813
5) Grassland	7,230,073	819,989	14,325,362	40,195,148	0	111,908,565	174,479,137
6) Shrubs	3,150,810	927,753	21,647,240	320,340,657	17,959,511	261,434,094	625,460,064
7) Open Forest	1,274,982	10,166,823	0	91,053,004	10,872,400	61,952,045	175,319,255
8) Closed Forest	0	4,475,887	0	11,096,868	3,278,711	8,280,365	27,131,831
9) Open/Barren	50,512	0	1,165,114	430,097	0	5,423,320	7,069,044
10) Mangrove Forest	45,982	0	5,943	0	0	0	51,925
11) Marshland/ Swamp	43,497	0	0	0	0	0	43,497
12) Fishpond	196,740	0	7,489	505,823	0	245,181	955,232
13) Inland Water	3,202,584	169,370	40,429	27,692,478	225,982	6,045,442	37,376,285
Total	233,315,524	163,578,445	189,994,226	1,403,413,024	73,450,818	963,748,618	3,027,500,655

Unit: m^2
Source: NAMRIA, 2010, analyzed by Parañaque Survey, 2018

2.2 Confirmation of Existing Plans and Studies

Existing plans and studies on transportation/traffic, water use, flood control, land use/environmental management/climate change have been confirmed.

2.2.1 Transportation Project

(1) Laguna Lake Expressway Dike Project (Cancelled)

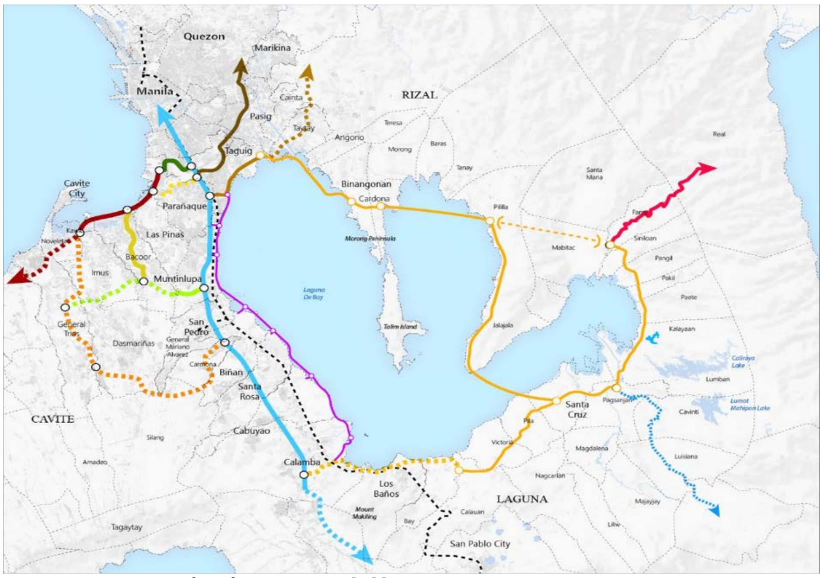
The Laguna Lakeshore Expressway Dike Project (LLEDP), which DPWH has planned as a PPP project, contains two components, namely; lakeshore dike construction and urban development project from Bicutan, Taguig City in Metro Manila area to Los Baños in Laguna Province, with the stretch of 47 km on Laguna de Bay. The executing agency is DPWH. The Feasibility Study of the project took place in 2012. A 100-year probability lake water level at EL. 14.0m was set as the design high water level with a freeboard of 1.0 m.

Bidding was held in the beginning of 2017 as a PPP project, but the selection of a contractor was unsuccessful and the project was cancelled.

(2) Laguna Lakeshore Road Network Project (LLRN Project)

The DPWH is promoting the Laguna Lakeshore Road Network Project (LLRN Project) as a project to replace the aforementioned LLEDP. This project aims to reduce transport restrictions on existing roads, promote further economic development in the region and neighboring states, and achieve the development goals of the region.

The project is divided into Phase 1 and Phase 2, and at present (as of December 2019), the Phase 1 Feasibility Study (F/S) is underway. The layout plan of the LLRN Master Plan is shown in Figure 2.2.1 and the project outline of LLRN Phase 1 is shown in Table 2.2.1.



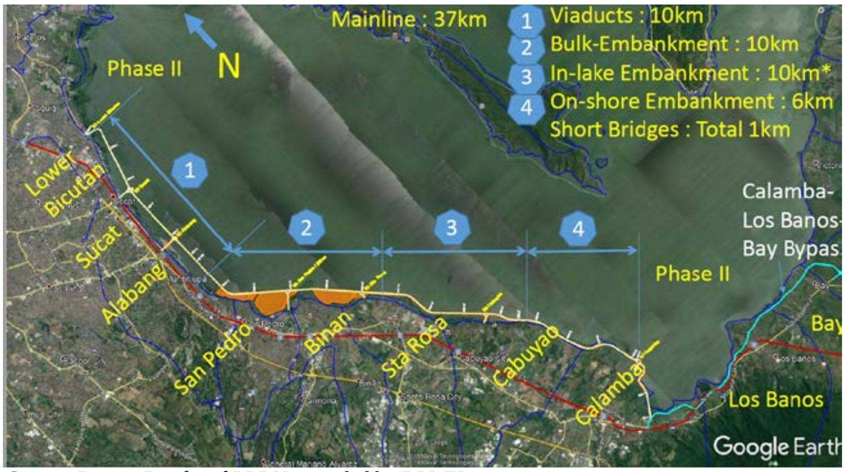
Source: Project Briefer of LLRN provided by DPWH

Figure 2.2.1 LLRN Master Plan (Phase 1 and Phase 2)

Table 2.2.1 Project Outline of LLRN Phase 1

Item	Project Outline
Project Location	Western coast of Laguna de Bay From Lower Bicutan/Taguig in Metro Manila to Calamba in Laguna Province (see Figure 2.2.2)
Length	Length: 37km Section 1 (10km): Viaduct Section 1 (10km): Bulk Embankment Section 1 (10km): In-Lake Embankment Section 1 (6km): On-shore Embankment (1km): Short Bridges
Project Cost	PHP 146.25 Billion
Funding Source	ADB Technical Assistance Loan No. 3589 PH
Consultant	Ove Arup and Partner Hong Kong Ltd. With Sub-consultant DCCD and Ecosyscorp
Completion of F/S	April 2020

Source: Project Briefe of LLRN provided by DPWH



Source: Project Briefer of LLRN provided by DPWH

Figure 2.2.2 Layout Plan of LLRN Phase 1

In the elevated section of Section 1 (Viaduct), the elevation below the girder is 16.5m, the elevation above the road is 19.0m to 19.8m, and the elevation above the embankment is approximately 16.0m. As for Section 2, it is planned to reclaim the area between the lakeside road and the coast of Laguna de Bay. However, this landfill project will be implemented by the LGUs.

The intake facility of the Parañaque Spillway is located in the elevated section of Section 1 and, basically, has no significant impact on the ADB road project. However, since the connecting road structure from land is close, it may be necessary to adjust the layout of the intake facility structure including the open channel.

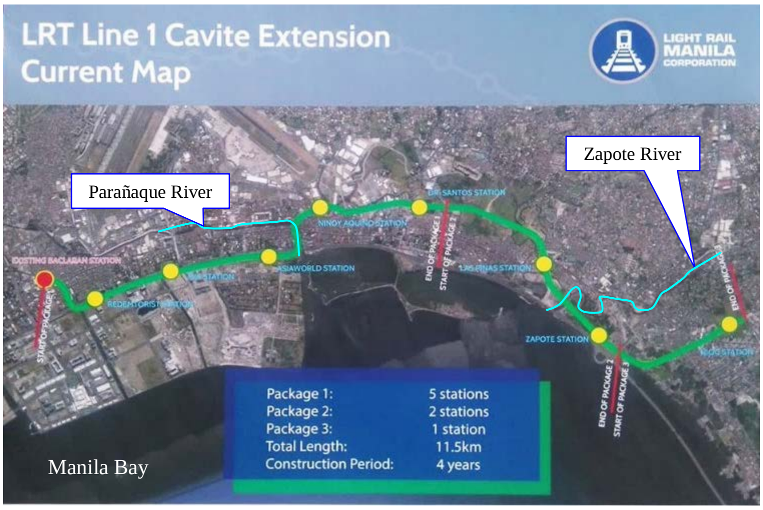
In the inflow river section along the coast of Laguna de Bay in the embankment section from Section 2 to Section 4, bridges will be installed so that the inflow river and Laguna de Bay are not divided. The road embankment does not have a levee function (water stop function), and no consideration is given to drainage pump stations for the purpose of removing internal water.

Therefore, it is necessary to construct the lakeshore dike in the flood management plan for the Laguna de Bay lakeshore area on the land side of the road embankment or to improve the road embankment to have a water-stop function. In addition, there is a plan to add a levee function to this road embankment at the time of design and use it as part of the lake levee in the future, but for that purpose, it is necessary to implement an F/S on lakeshore dike based on the road embankment design.

(3) LRT-1 Cavite Extension Project

The Light Rail Transit Line-1 (LRT-1) started its operation in 1984 and it was the first LRT route in Manila taking the basic role of commuting people to and from their sources of livelihood. The "Philippine Development Plan of 2011-2016" published in May 2011 states that it is necessary to take advantage of the funds and human resources from the private sector as the driving force of development promotion in the Philippines for the expansion of routes, rationalization of the organization, and operation and maintenance.

Based on the above background, the LRT-1 Cavite Extension Project (LRT-1 Cavite Extension), as a PPP project, started to take advantage of private funds and know-how to extend the LTR-1 line in the southern part of Metro Manila and to improve the traffic situation. At the same time, the operation and maintenance of LTR-1 line was entrusted to the private sector, aiming to improve the level of efficiency and service. The location of the project is shown in Figure 2.2.3 and the project outline is given in Table 2.2.1.



Source: LRMC, Parañaque Survey, 2018

Figure 2.2.3 Location Map of LRT-1 Cavite Extension Project

Table 2.2.2 Outline of LRT-1 Cavite Extension Project

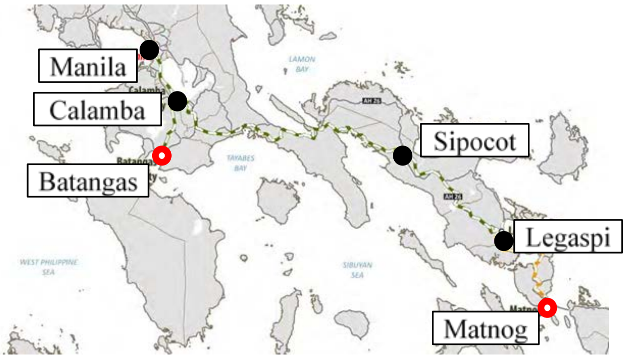
Item	Contents
Budget	64.9 Billion pesos
Construction Period	4 years
Operation Start	2021
Target Route Length	11.5 km (from Baclaran to Bacoor, 10.5 km, elevated)
Other Construction/Procurement Target	New station building (8 stations), Rolling Stock (from Japan), expansion of existing depot, new depot
Effect	Increase in the daily transport of people from 500,000 to 800,000; shortening of travel time

Source: Information from LRMC, Parañaque Survey, 2018

A drainage facility for the Parañaque Spillway is expected to be built in the vicinity of the LRT-1 line. Since the LRT-1 line is planned to be elevated, there is basically no problem at the intersection of the spillway and the LRT-1 line. However, attention should be paid on the relation between the position of the station building and the spillway.

(4) North-South Railway Project (South Line)

The Philippine National Railways (Philippine National Railways: PNR) had owned the main truck route with an extension of 797 km that runs from La Union Province to Bicol in the north-south direction. Due to insufficient maintenance, natural disasters and illegal settlers, its function has been greatly impaired. In 2007 and 2009, land acquisition based on the ROW, replacement of iron bridge and the railway track rehabilitation of station buildings were carried out and in 2011, the Bicol express re-started its operation. However, due to the lack of maintenance, long-distance transport is presently not performed between Sipocot in Bicol and Calamba west of Laguna Province.



Source: "North-South Railway Project South Line" ADB, DBP

Figure 2.2.4 Layout Plan of South Line, N-S Railway Project

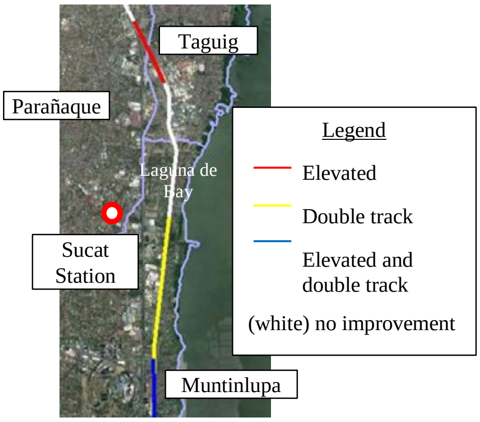
Based on the above background, this project as a PPP project aims: (1) to improve the existing route from Manila to Legaspi, extend the route from Calamba to Batangas and extend from Legaspi to Matnog, and manage long-distance passenger transport along the route; and (2) to provide a reliable commuter route service from Manila to Calamba. Table 2.2.2 gives the project outline.

Table 2.2.3 Outline of North-South Railway Project (South Line)

item	Contents
Budget	1,452 billion pesos (excluding land acquisition costs)
Construction Pperiod	4 years
Operation Start	2022 (2022 (However, F/S will be reviewed in the ADB project as mentioned in Clause (7))
Target Route Length	653 km (improvement of existing routes: 478 km; extension of the route: 175 km)
Construction and Procurement Target	Railway track renovation (replacement, double tracking, elevation) new station buildings, rolling stock, signaling systems, automatic ticket gate, depot, other equipment
Effect	Daily commuter transport volume: in 2020, 316,000 trips, in 2030, 485,000 trips

Source: Information from DOTC, Parañaque Survey, 2018

The improvement plan of the existing route is shown in Figure 2.2.3. Since the track is several hundred meters away from the lakeshore of Laguna de Bay, there is no direct impact on the lakeshore dike. If attention is paid to the construction method such as construction road path, there is also no significant difficulty on the construction work. On the other hand, Parañaque Spillway will cross the track. Hence, if the structure for the spillway is designed at the surface of the ground or close, some consideration for the structure and discussion with related organizations is required in the further study.



Source: information from DOTr, compiled by JICA Survey Team

Figure 2.2.5 Improvement Plan of South Line (Partial)

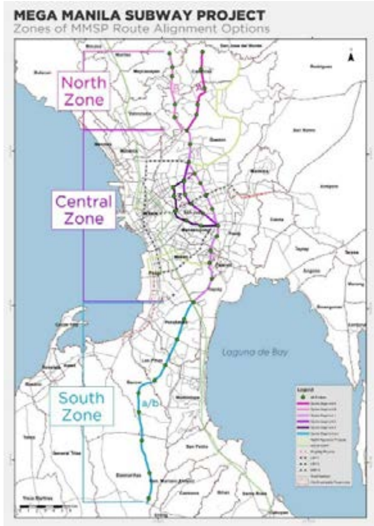
(5) Mega Manila Subway Project

In the "Philippine Development Plan of 2011-2016" published in May 2011, it was proposed as a priority issue to accelerate the infrastructure development of the transport sector. In response, the "Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Areas (Region III and Region IV-A)" was carried out with JICA assistance (2013). In the roadmap, with the "North-South Commuter Rail Project (Malolos-Tutuban)", which is with the expectation of Japan Yen Loan, the subway project in the north and south direction was proposed. The project aims at responding to the increasing demand for transportation and alleviating traffic congestion in Metro Manila, and thus contributing to sustainable economic growth of the country. This will be done by establishing the urban railway system including the subway in Metro Manila connecting Caloocan or Meycauayan, Bulacan in the north of Manila and Dasmariñas in Cavite.

In relation to this project, an information collection survey was carried out in 2015 by JICA. In the survey, urban railway with the approximate length of 60 km was divided into three zones, the North Zone (2 options), the Central Zone (3 options) and the South Zone (2 options), and were examined in the total of 12 options. The survey results are summarized in Table 2.2.3. It should be noted that, according to interviews with DOTr, no further study was carried out after this survey.

The zone of the railway track related to the Parañaque Spillway is the south one. In the South Zone, there were two options considered, both for the whole stretch; one is elevated, and the other is underground. In the case of elevated structure, the spillway can be the underground structure. Even if the railway track becomes the underground structure, since the elevation of the track is planned to be EL. 5 m, the deeper spillway will not be affected. Only if the spillway lay on the ground or close, some consideration for the structure and discussion with related organizations is required in the further study.

Table 2.2.4 Information on Mega Manila Subway Project

Item	Contents	Location
Budget	3,570 billion - 4,410 billion pesos	
Construction Period	About 5 years (carried out in two phases)	
Construction Target	Elevated structure, elevated station, underground structure, underground station, depot, railway track, rolling stock, signal system, etc.	
Effect	EIRR: 16.6% to 17.6% Demand Forecast: 400,000 to 500,000 people in 2025; 2 to 2.4 million people in 2045	

Source: Information Collection Survey for Mega Manila Subway Project

2.2.2 Water Use Project

(1) Waterworks (Maynilad)

Maynilad Water Services, Inc. (Maynilad) is another concessionaire of the Metropolitan Waterworks and Sewerage System (MWSS), and it is responsible for water and sewerage services in 17 cities and municipalities in the western part of Metro Manila.

Muntinlupa City, located in the western part of Laguna de Bay, has a population of about 500,000 and huge commercial areas such as Alabang and Sucat. The development of residential areas (subdivisions) has been progressing in the suburbs, but the supply of clean water has not caught up, especially in areas at high altitudes. Therefore, safe supply of clean water is an urgent issue. Based on this situation, the Putatan No. 2 Water Purification Plant Construction Project was implemented for the purpose of safe and stable supply of clean water in Muntinlupa City and the surrounding areas. The project outline is as given in Table 2.2.4.

Table 2.2.5 Outline of Putatan No. 2 Water Treatment Plant Project

Item	Putatan No. 2 WaterTreatment Plant Project
Budget	PHP 6.75 Billion
Operation Start Time	April 2019
Location of Water Intake	In the dry season, the water quality of Laguna de Bay (increased salinity) deteriorates and water intake is restricted.
Water Supply for Tap Water	300 MLD (approx. 3.5 m^3/s) including the No. 1 water treatment plant
Location of Facility	Barangay Putatan, Muntinlupa
Effect	Stable water supply to 1.2 million Maynilad users in Muntinlupa, Las Pinas and Cavite, water supply at 110 kPa

Source: JICA Study Team based on Maynilad’s information

Source: https://www.acciona.com.au/projects/water/drinking-water-treatment-plants/putatan-water-treatment-plant-2/

Figure 2.2.6 Putatan No. 2 Water Treatment Plant Project

The Putatan No. 2 Water Treatment Plant draws water from Laguna de Bay, and the minimum intake elevation is about 10.5m. The intake of water is restricted because it flows into Laguna de Bay and, along its way, the water quality deteriorates (salt content increases).

Maynilad is also planning a new water treatment plant at Poblacion, Muntinlupa. The project outline is as given in Table 2.2.5.

Table 2.2.6 Outline of Muntinlupa Poblacion Water Treatment Plant Project

Item	Muntinlupa Poblacion Water Treatment Plant Project
Budget	Unknown
Operation Start Time	Construction start: 2020, Operation start: around 2022
Location of Water Intake	In the dry season, the water quality of Laguna de Bay (increased salinity) deteriorates and water intake is restricted.
Water Supply for Tap Water	Water intake: 150 MLD (approx. 1.7 m^3/s)
Location of Facility	Poblacion, Muntinlupa
Effect	Stable water supply to densely populated area such as Las Pinas and Cavite

Source: JICA Study Team based on Maynilad's information

Source: Google Earth, JICA Study Team based on Maynilad information

Figure 2.2.7 Location of Maynilad New Water Treatment Plant Near Laguna de Bay

(2) Waterworks (Manila Water)

Manila Water Company, Inc. (Manila Water) is another concessionaire of Metropolitan Waterworks and Sewerage System (MWSS), and it is responsible for water and sewerage services for cities and municipalities in the eastern Manila area.

Manila Water has a project using water from Laguna de Bay as a new water source in order to break the constitution of raw water from the Angat Dam Reservoir. Table 2.2.6 outlines the Cardona Water Treatment Plant (WTP) that started operation in March 2019.

Table 2.2.7 Outline of Cardona Water Treatment Plant Project

Item	Cardona Water Treatment Plant Project
Budget	PHP 13.5 Billion
Operation Start Time	Start of Operation: March 2019
Location of Water Intake	In the dry season, the water quality of Laguna de Bay (increased salinity) deteriorates and water intake is restricted.
Water Supply for Tap Water	100 MLD (approx. 1.2 m^3/s) Water intake: 140 MLD (approx. 1.6 m^3/s)
Location of Facility	Cardona, Rizal
Effect	Stable water supply to densely populated area such as Angono, Pasig

Source: JICA Study Team based on Manila Water information

The Cardona Water Treatment Plant is located in the center, north of Laguna de Bay, but seawater flows into Laguna de Bay through the Napindan Channel down to the south, and then flows north into the center. For this reason, the Cardona site is also affected by saltwater. Water quality (salt content) is important, and if the salt concentration is low, water can be taken even if the water level is low.

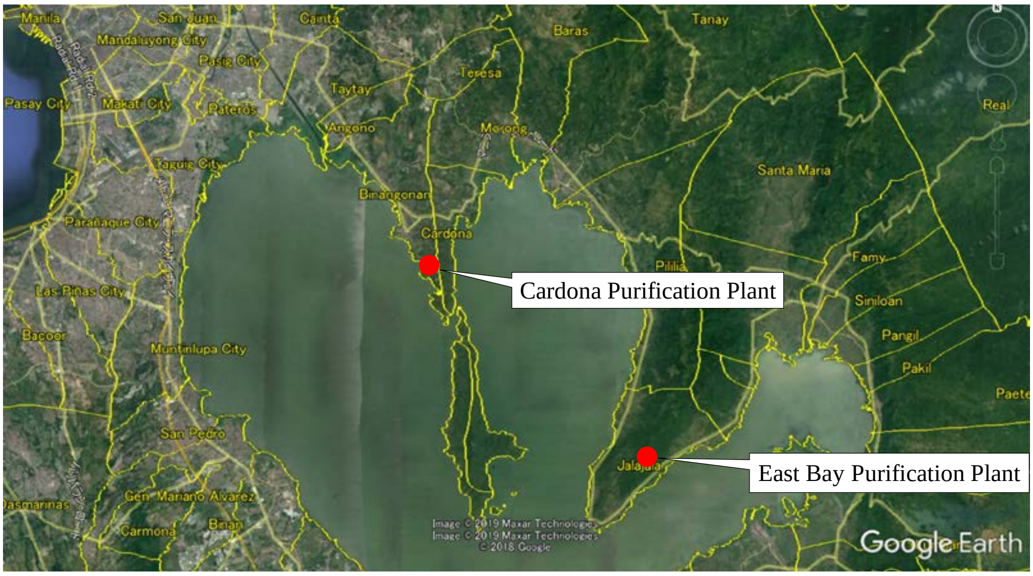
Manila Water is also planning to install a new water treatment plant in East Bay (Jalajala). The project outline is as given in Table 2.2.7.

Table 2.2.8 Outline of East Bay (Jalajala) Water Treatment Plant Project

Item	East Bay (Jalajala) Water Treatment Plant Project
Budget	PHP 13.5 Billion
Operation Start Time	Start of Operation: 2022
Location of Water Intake	It is away from the Napindan Channel. There will be no water intake limitation from the salinity viewpoint.
Water Supply for Tap Water	250 MLD (approx. 2.9 m^3/s) Water intake: 350 MLD (approx. 4.1 m^3/s)
Location of Facility	Jalajala
Effect	Stable water supply to densely populated area such as Las Pinas, Cavite

Source: JICA Study Team based on Manila Water information

The East Bay Water Treatment Plant is located away from the Napindan Channel and there is no restriction on water intake due from the salinity viewpoint. Therefore, even if the water level of Laguna de Bay is low, water intake is not affected.

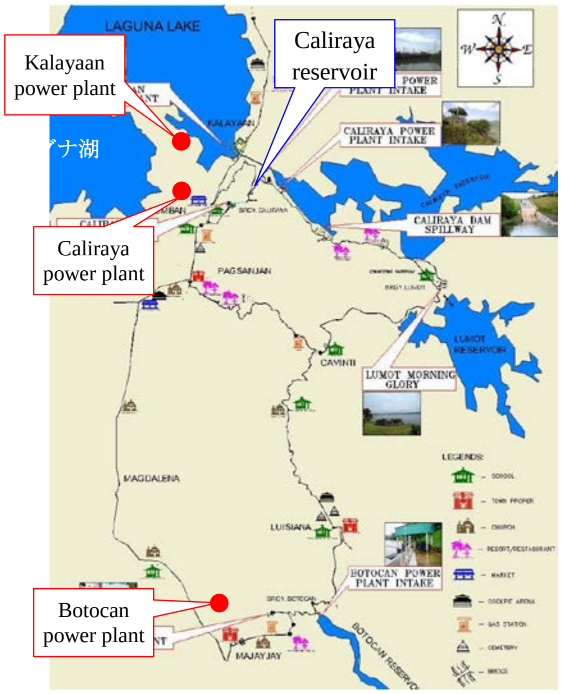


Source: Google Earth, JICA Study Team organizes Manila Water information

Figure 2.2.8 Location of Manila Water New Purification Plant around Laguna de Bay

(3) Power Generation Project by CBK Power Company

Since the inauguration of National Power Corporation(NPC) in 1936 and until the 1980's, all power generation and distribution were owned by NPC. Movement of privatization in the power sector was driven by Republic Act No. 9136, generally referred to as "Electric Power Industry Reform Act of 2001", came into force in June 2001. In the same year, the right to construct new facilities and the maintenance of the Caliraya (C), Botocan (B) and Kalayaan (K) power plants located in the east of Laguna de Bay were also passed to CBK Power Company Limited (CBKPCL) from the NPC in the three power plants in Kalayaan (K). Further, in 2005, Japanese companies acquired CBKPCL.



Source: CBKPCL brochure

Figure 2.2.9 CBK Power Plant Location Map

This project is for the supply of electric power to the Luzon area including Metro Manila. Among these three power plants, the Kalayaan Power Plant generates electricity by storing the river water at Caliraya Reservoir (upper reservoir) and pumping up water from Laguna de Bay (lower reservoir) at night. Table 2.2.8 shows the Kalayaan Power Plant specifications and features.

Table 2.2.9 Specification and Features of Kalayaan Power Plant

Item	Contents
Facility	Penstock (2 in number, dia: 5.5m to 6m, usually single operation), generators (total output of 685MW, 4 in number, usually two in operation), small hydroelectric power system (for blackout, 1 unit, 1 MW), diesel power generator (for blackout, 1 unit, 1 MW)
Characteristics	- CBKPCL has maintenance and operation rights of power generation facilities. Water rights of the Caliraya Reservoir is owned by PNR. - Full water level of the Caliraya Reservoir is 288.0m (above sea level), highest water level at Laguna de Bay is designed at EL. 13.72m and the lowest at EL. 10.12 m for the power plant. Design power generation water head is at 286.5m to 289.5m. - 60m^3/s of water is consumed by a generator. - River water is not sufficient for power generation, pumping up from Laguna de Bay to Caliraya Reservoir which is the upper reservoir (effective storage amount 22 million m^3) is carried out nightly. - Since 1995, sedimentation level measurements have been carried out in Laguna de Bay once in every few years (at the area of about 1.5km from the shore). There is no major change in the last 10 years.

Source: CBKPCL brochures, etc.

In Kalayaan Power Plant, design highest water level at Laguna de Bay is set at EL. 13.72m and the lowest at EL. 10.12m. Hence, there is no problem if the lake water level proposed by the JICA flood management plan is higher than EL. 10.12m. On the other hand, if the Laguna de Bay water level drops, the power generation head increases so that it becomes somewhat advantageous for power generation.

Since the maximum operating water level of Laguna de Bay of the Kalayaan Power Plant is 13.72m, if the lake water level exceeds 13.72m, the operation of the power plant will only be stopped for a short period of time and this will have no major impact on the operation of the power plant. In 2009, when Typhoon Ondoy caused flood damage in the lakeshore area (highest lake water level 13.85m), the Kalayaan Power Plant was not damaged.

(4) Open Lake Fishery and Aquaculture

Fishery in Laguna de Bay is divided into fishing (open lake fishery) and aquaculture. Output of open lake fishery has been increasing in recent years: it increased from 81 billion tons in 2008 to 90 billion tons in 2013. Open lake fishery is carried out by 20,326 fisher folks living in 18 municipalities in Laguna Province, 9 municipalities in Rizal Province and 2 cities in NCR. It is an important livelihood of local people and contributes to the local economy a lot. (Laguna Lake Master Plan, 2016)

On the other hand, aquaculture in Laguna de Bay is carried out in the forms of fish pen and fish cage. Fish pen is an artificial enclosure made up of bamboo poles constructed within a body of water for culturing fish. Fish cage is an enclosure which is either stationary or floating made up of nets or screens. The area of fish pen and fish cage was 12,0643ha as of 2015, accounts for approx. 13% of lake water surface (900km^2), composed of 10,386.86ha (86.1%) of fish pen and 1,677.77ha (13.9%) of fish cage. Gross output of the two was 149,271MT in 2008 and 155,518MT in 2013, accounting for slight increase. Main cultured fish species include Milkfish (Bañgus), Tilapia and Carp.

According to the "Laguna de Bay Basin Master Plan: 2016 and Beyond", total fisheries production of Laguna de Bay had fluctuated, but the decline in 2009, 2010, 2011 and 2012, was attributed to losses due to typhoon, especially Laguna Province.

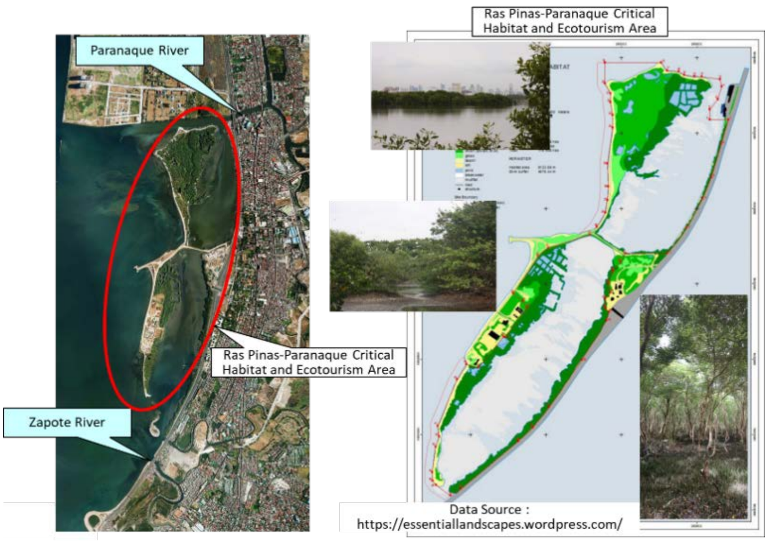
2.2.3 Environmental Issues

(1) Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA)

The Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA) was established as the Philippine's first critical habitat through Executive Order No. 1412, series of 2007. "Critical habitat" is defined in Republic Act No. 9147 as "areas where threatened species are found". The law protects it "from any form of exploitation or destruction which may be detrimental to the survival of the threatened species dependent therein".

LPPCHEA is located on the southern portion of Metro Manila and is part of Manila Bay. It is bounded by Pasay City on the northeast; by Bacoor, Cavite on the southwest. It covers approximately 175 ha and consists of two islands, Free Island and Long Island.

LPPCHEA is known for hosting a diverse variety of wild birds. At present, there are 82 wild bird species found, 47 of which are migratory, and some endemic spices are found (Philippine Duck, Chinese Egret). In addition, it has a mangrove forest known as the thickest and most diverse among the remaining mangrove areas in Manila Bay.



Source: Parañaque Survey, 2018

Figure 2.2.10 Las Piñas-Parañaque Critical Habitat and Ecotourism Area（LPPCHEA）

Among the plant species in the LPPCHEA, mangroves are particularly important to preserve the natural environment of LPPCHEA. Mangroves comprise 36 ha of LPPCHEA, which is about 18% of the island. LPPCHEA's mangrove forest is known as the thickest and most diverse among the remaining mangrove areas in Manila Bay. In the past, a lot of mangrove areas existed in Manila Bay, but they were lost with the development of the country. LPPCHEA has been drawing attention as the last remaining thick and diverse mangrove area.

LPPCHEA has 114 hectares of mudflat which serve as feeding grounds for shore birds. In the mudflats macro-invertebrates and fish species live. Macro-invertebrates include polychaetes represented by mud worms, crustaceans and mollusks. Mollusks are the most abundant, and they include 23 species of bivalves and 14 species of gastropods. Owning to the 114 hectares of mudflats that are abundant in bird food, mollusks and other bottom dwelling and small aquatic animals, LPPCHEA is a good habitat for avian species. In addition, a lot of migratory birds visit LPPCHEA as an overwintering site from August to April and the number of birds reaches 5,000. Based on the survey by DENR in 2004 to 2008, 44 species of birds roosted in LPPCHEA.

The increase of freshwater entering near LPPCHEA due to the Parañaque Spillway is favorable for mangroves because they can save energy to remove salt from saltwater. Moreover, if the salinity decreases temporarily due to freshwater inflow, there will be no room for other plant species to intrude, because salt will be unlimitedly provided from the ocean, and the salinity will recover after the drainage from Parañaque Spillway.

Based on the above, it is necessary to thoroughly discuss and study the circumstances with DENR, which manages LPPCHEA, during the Feasibility Study.

2.2.4 Reclamation Plan

(1) Reclamation Plan around LPPCHEA

The Philippine Reclamation Authority (PRA) is a government organization for implementing reclamation plans for the entire Manila Bay, and is promoting them around LPPCHEA. The description of the PRA homepage is given below.

<u>Las Piñas-Parañaque Coastal Bay Project</u> The Las Piñas-Parañaque Coastal Bay Project involves the reclamation of shallow portions of Manila Bay in the southwest of Manila. Las Piñas City has 431.71 hectares under its jurisdiction while Parañaque City has 203.43 hectares. This 635.14-hectare project is intended to be a government center, residential, industrial, educational, and commercial zone. It is bounded by Asia World Properties in the North, and the Municipality of Bacoor, Cavite in the South.

Opposition movements are actively being carried out on this reclamation plan from the viewpoint of environmental protection, and the reclamation implementation was suspended. However, this plan is still alive and it is necessary to consider this in the implementation of the Parañaque Spillway Project.

Figure 2.2.11 Reclamation Plan around LPPCHEA by PRA (image)

Chapter 3. Examination of Integrated Flood Control Plan for Laguna de Bay Basin Including Pasig-Marikina River Basin

3.1 History of Flood Control Planning in Laguna de Bay Basin

Laguna de Bay is the source of water for irrigation, fishery, aquaculture, industrial water, potable water, power generation, and recreation. It also serves as the outflow destination of rivers in lakeshore river basins, the domestic drainage destination of lakeside residents, industrial drainage destination (water sink), route for water transportation, and so on.

In the 1960's, Manggahan Floodway and Parañaque Spillway were planned as a set in the Marcos's Flood-Control Program for Metro Manila as a flood control measure in the Manila Metropolitan Area, and the comprehensive flood control plan for the Laguna de Bay basin were examined including the Pasig-Marikina River Basin.

The need for flood control in coastal areas due to the high water level of Laguna de Bay has long been recognized, and in 1975, feasibility studies for the Parañaque Spillway and of the Manggahan Floodway were conducted at the same time (Table 3.1.1). However, due to the high project cost and the great social impact of construction, implementation of the projects was postponed.

In the 1990 Manila Flood Control Plan Study regarding the future flood control measures and inland water removal measures in and around Metro Manila (hereinafter, the "JICA1990M/P"), a future comprehensive flood control framework plan and a master plan with 2020 as the target year was formulated. Since the Parañaque Spillway required a huge construction costs and it was difficult to complete the project by 2020, it was not the master plan but a framework plan of comprehensive flood control measures for Metro Manila in the future consisting of a lakeshore dike in the coastal area of Laguna de Bay in Eastern Manggahan and Western Manggahan was considered as the master plan for mitigating inundation damage caused by the rise of lake water level.

From 1997 to 2007, the "Metro Manila Flood Control Project - West of Manggahan Floodway" was implemented. A 10km lakeshore dike and four (4) drainage pump stations were constructed, but the shoreline in Eastern Manggahan that was proposed in the 1990JICAM/P had not been implemented at that stage.

Local residents and local governments have expressed great dissatisfaction on the lack of drastic flood countermeasures in the Laguna Lake coastal area. In particular, since the construction of Manggahan Floodway in 1988, dissatisfaction at the coastal area of Laguna Lake was large and widespread.

In recent years, significant progress has been made in the coastal area of Laguna de Bay (increased flood damage potential), civil engineering construction has advanced, financial conditions has improved, etc. In order to move to the next stage, which is a framework plan for comprehensive flood control measures, the "Data Collection Survey for Parañaque Spillway in Metro Manila" (hereinafter, Parañaque Survey 2018) was conducted by JICA in 2018.

"The Comprehensive Flood Management Plan in the Laguna de Bay Lakeshore Areas (Draft)" was proposed in the Parañaque Survey 2018 as below:

i. Control in Water Level Rising: Parañaque Spillway, enhancement of drainage capacity of Manggahan Floodway

ii. Mitigate Inundation Damage: Lakeshore Diking System (include back levee, pumping station, etc.)

iii. Non-structural Measures

A Pre-F/S survey was conducted on the Parañaque Spillway, which has a shorter construction period than lakeshore diking system and also a water level suppression effect over the entire Laguna de Bay Basin. The Comprehensive Flood Management Plan in the Laguna de Bay Lakeshore Areas (Draft) formulated in the Parañaque Survey 2018 needs to be implemented with the approval of the Philippine government and NEDA.

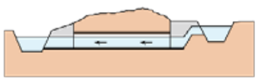
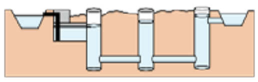
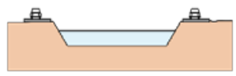
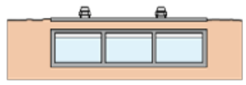
Table 3.1.1 History of Flood Control Plan in Laguna de Bay Basin

Year	Study Result
1960s	In the Marcos's Flood-Control Program for Metro Manila, Manggahan Floodway and the Parañaque Spillway were planned as a set as a flood control measure for Metro Manila.
1975	An overall flood control plan was formulated for Metro Manila and Laguna de Bay lakeshore area (Construct (1) Manggahan Floodway and (2) Marikina Control Gate Structure (MCGS), to divert floods of Marikina River to Laguna de Bay, (3) Napindan Hydraulic Control Gates, (4) Parañaque Spillway, to reduce high lake level, and (5) river improvement of Pasig-Marikina River. As for the F/S for Parañaque Spillway, DMJM (American) was the consultant In the Parañaque Spillway F/S (USAID), it was concluded that the US consultant (DMJM) has the potential to realize it *1 (Maximum planned discharge: 350 m^3/s, Total length: 8.3 km, Natural flow open channel system and Tunnel channel construction). *1 The tunnel proposal was considered as an option to minimize the social impact, but it was rejected because the project cost was huge.
1977	DPWH reviewed the Parañaque Spillway F/S results and decided to postpone construction (Reason: Social impacts such as relocation and land acquisition are large, and project costs are high)
1983	Completion of Napindan Hydraulic Control Gates (supported by ADB)
1988	Completion of Manggahan Floodway (supported by Japan), Greatly contributed to mitigating flood damage in Metro Manila
1990	A framework plan and a master plan were considered in the Manila Flood Control Plan Study (JICA). Since the Parañaque Spillway has a large project cost, it was proposed as part of a framework plan that requires construction of a spillway in the future *2. (Draft system for open drainage with a bottom width of 60 m) In the Master Plan, lakeshore dike in the eastern and western parts of Manggahan were proposed as a measure to mitigate inundation damage due to the rise in water level of Laguna de Bay. *2: It was suggested that early implementation of a flood countermeasure survey covering the entire Laguna de Bay Basin including the Parañaque Spillway is desired.
1991	An emergency flood control project for the northern coast of Laguna de Bay was implemented with a Japanese ODA loan, and it supported the detailed design of lakeshore dike in the eastern and western areas of Manggahan.
2007	"Metro Manila Flood Control Project - West of Manggahan Floodway" was executed; constructed a 10km lakeshore dike, four (4) pumping stations, sluice gate.
2012	In the 'Master Plan for Flood Management in Metro Manila and Surrounding Areas (World Bank), Parañaque Spillway was considered (extension 8.9km, open channel system partly 3.3km tunnel with diameter 15m, planned flow 270m^3/s). Low Possibility based on economic evaluation, not included in master plan. As a flood countermeasure for Laguna de Bay lakeshore basin, land-raising was proposed instead of lakeshore dike.
2018	According to the "Data Collection Survey on Parañaque Spillway in Metro Manila (JICA)", (1) Parañaque Spillway as a measure for suppressing water level rise, (2) Lakeshore diking system as a measure for mitigating flood damage, (3) Non-Structural measures were proposed as a Comprehensive Flood Control Plan. Since the construction period is shorter than that of lakeshore diking system and the water level control effect is over the entire Laguna de Bay lakeshore area, as a priority project, the Pre-Feasibility Study (3 routes, deep underground river, 12 m diameter tunnel) of the Parañaque Spillway was extended. The planned discharge was 6 to 9km and the planned discharge was

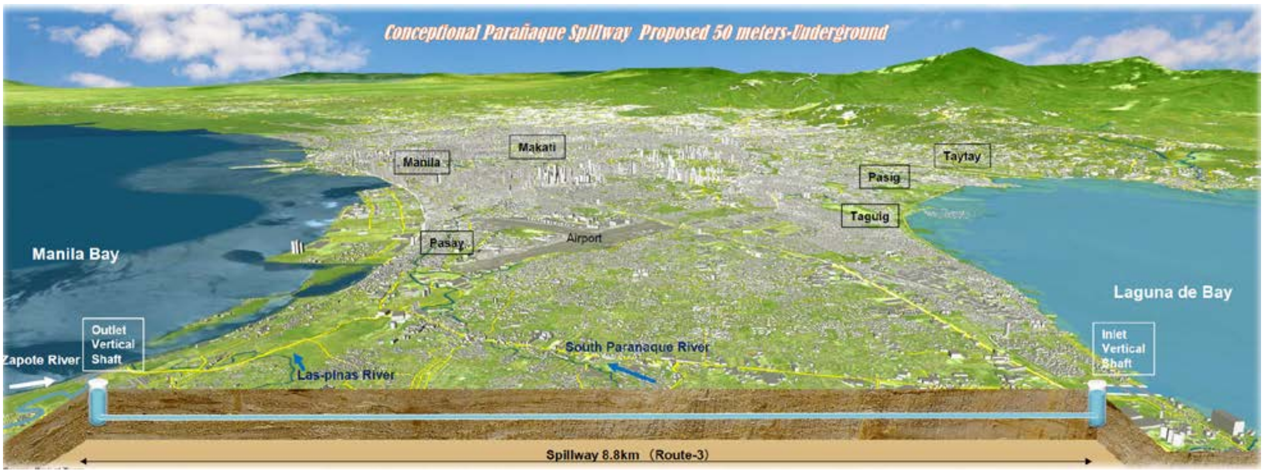
Year	Study Result
	200 m^3/s).

In the Parañaque Survey 2018, the plan study was not realized until now due to the background and reasons such as social impacts, relocation of the project, land acquisition, compensation for right holders of lake water, replacement of existing social infrastructure facilities, etc. As a plan to minimize the above, a comparative study of various plans and systems (Table 3.1.2) was conducted, and the "underground river plan (pressure piping system)" was adopted.

Table 3.1.2 Comparison of Hydraulic Condition of Parañaque Spillway in Parañaque Survey 2018

Case	Underground River Systems		Open Channel Systems	
	Case-1: Gravity Flow Open Channel System	Case-2: Pressure Pipe System	Case-3: Open Channel System	Case-4: Open Channel Tunnel System
Outline Figure				
Summary	Existing River/Spillway flows into the tunnel under the road/hill. It is the most common system for River Tunnels and the most desirable for Underground Rivers.	The discharge water flows through the pressure pile and is drained by syphon. Pumping is necessary for some hydraulic conditions.	This is the original plan of open channel. Construction Cost is cheap, but land acquisition and RAP have problems.	To utilize the upper portion of channel, the tunnel system is adopted. Generally, the space is used as road or park.
Evaluation	Gravity Flow Open Channel System is impossible because of not enough earth covering required for tunneling.	Possible case because of the relatively small area of land acquisition and small number of RAP.	Land acquisition and RAP are very difficult. In addition, the cost is not so cheap taking into account land & compensation cost.	The same as Case-3. In addition, construction cost and O&M are expensive so no reason for adoption.
	X: Impossible	O : Adopted	△ : Some Problems	X: Difficult

* Philippine RA 10752 (2016) and its IRR stipulates that there is no section right to the ground if it is deeper than 50m.
Source: Parañaque Survey 2018



Source; Parañaque Survey 2018

Figure 3.1.1 3-Dimensional Image of Parañaque Spillway

On the other hand, Philippine NGOs and civil society (POs) have taken a great deal of attention in modifying Laguna de Bay. Laguna de Bay nature conservation and development related to lakes from the perspective of protecting the livelihoods of fishermen, farmers and urban poor who have been living on Laguna de Bay for a long time have sometimes been carried out against the plan and business.

Examples of alteration of Laguna de Bay and reaction of NGOs include preventing the intrusion of seawater into Manila Bay at the most downstream end of the Napindan River, which is the only outflow river of Laguna Lake (the confluence of the Pasig-Marikina River), and there is the Napindan Hydraulic Control Gates (NHCS) construction for desalination of the lake (1983). Since it was said that the operation of opening and closing the sluice gate had a large effect on the catch of Laguna de Bay, strong opposition to the operation of the sluice gate (particularly closing the gate) occurred. The NHCS is not currently opened or closed.

Furthermore, the Manggahan Floodway was completed in 1988, and part of the flood that occurred in the Marikina River basin that year was released to Laguna de Bay through the Manggahan Floodway. This operation also caused rejection from the already flooded Laguna lakeshore community and municipalities. Lakeshore residents realized that the Manggahan Floodway, an artificial waterway, is further exacerbating floods in the lakeshore area.

In the 1990s to 2000s, the detailed design and construction of the Laguna Lake flood control project (Metro Manila West Manggahan Flood Control Project) targeting the northern coast of Laguna de Bay was also considered to be part of the Laguna Lake desalination project. Dialogue meetings were frequently held due to active opposition movements by NGOs and POs. The construction was temporarily stopped, and it took more than 10 years to complete the project with a length of about 10 km along the lakeshore dike.

Recently, an automobile traversing the 47km Laguna Lakeshore Expressway Dike, which is the DPWH-PPP project plan where F/S was carried out in 2012 (Laguna Lakeshore Expressway Dike Project, from Lower Bicutan District of Taguig City in the western part of Laguna coast to Los Baños City dedicated roads and levees) faced opposition movements by NGOs. In the end, the 2016 bid ended unsuccessfully with no bidders. NGOs believed that it was the result of opposition. The NGOs have pointed out that the campaign against development and alteration is due to the nature conservation of Laguna de Bay, adverse effects on fishermen, urban poor, local communities, and reduction of lakeshore area.

In the Parañaque Survey 2018, a proposal for the construction of a lakeshore diking system was proposed and considered as one of the options for flood protection on the lakeshore area. It was expected that this will take a lot of time to be completed in the face of popular opposition movements.

3.2 Integrated Flood Control Plan

3.2.1 Study on Flood Control and Drainage Project in Metro Manila in 1990, JICA

The Parañaque Spillway was considered as a framework plan of comprehensive flood control measures for Metro Manila in the 1990 Manila Flood Control Plan Study (hereinafter, 1990JICAM/P Study). The framework plan covers the entire metropolitan area of Manila and areas, including Cainta and Taytay outside the metropolitan area. The outline of each plan of the 1990JICAM/P Study is given in Table 3.2.1.

The Parañaque Spillway was proposed as part of the framework plan, but the master plan is feasible for investment only by 2020 and the formulated plan is assumed to be completed by 2020. Therefore, it was judged that it would be difficult to complete the Parañaque Spillway by 2020, because it requires a huge construction cost and it was not included in the master plan.

At present, the target year of the Master Plan is 2020, it is necessary to proceed with the Framework Plan, which is the next stage of the Master Plan, according the urbanization of Metro Manila, and the lakeshore area is progressing rapidly (increased flood damage potential).

Table 3.2.1 Outline of Each Plan in the 1990 M/P

Plan	Target Year	Target Area	Design Scale
Framework Plan (including Parañaque Spillway)	Far future * * The project completion time is not set.	The whole area of Metro Manila and areas including Cainta and Taytay	Flood Control: 100-year Drainage: 10-year
Master Plan	Estimate the amount of investment that can be invested by 2020 and formulate a feasible plan	The whole area of Metro Manila and areas including Cainta and Taytay	Based on the planned size of the framework plan, but the planned size was set according to the river and drainage area because the financial scale is one standard.
Priority Project	Formulate a detailed plan with 2020 as the target year for completion	Areas selected as priority projects	Same as the Master Plan

3.2.2 Eighteen Major Basins in the Philippines

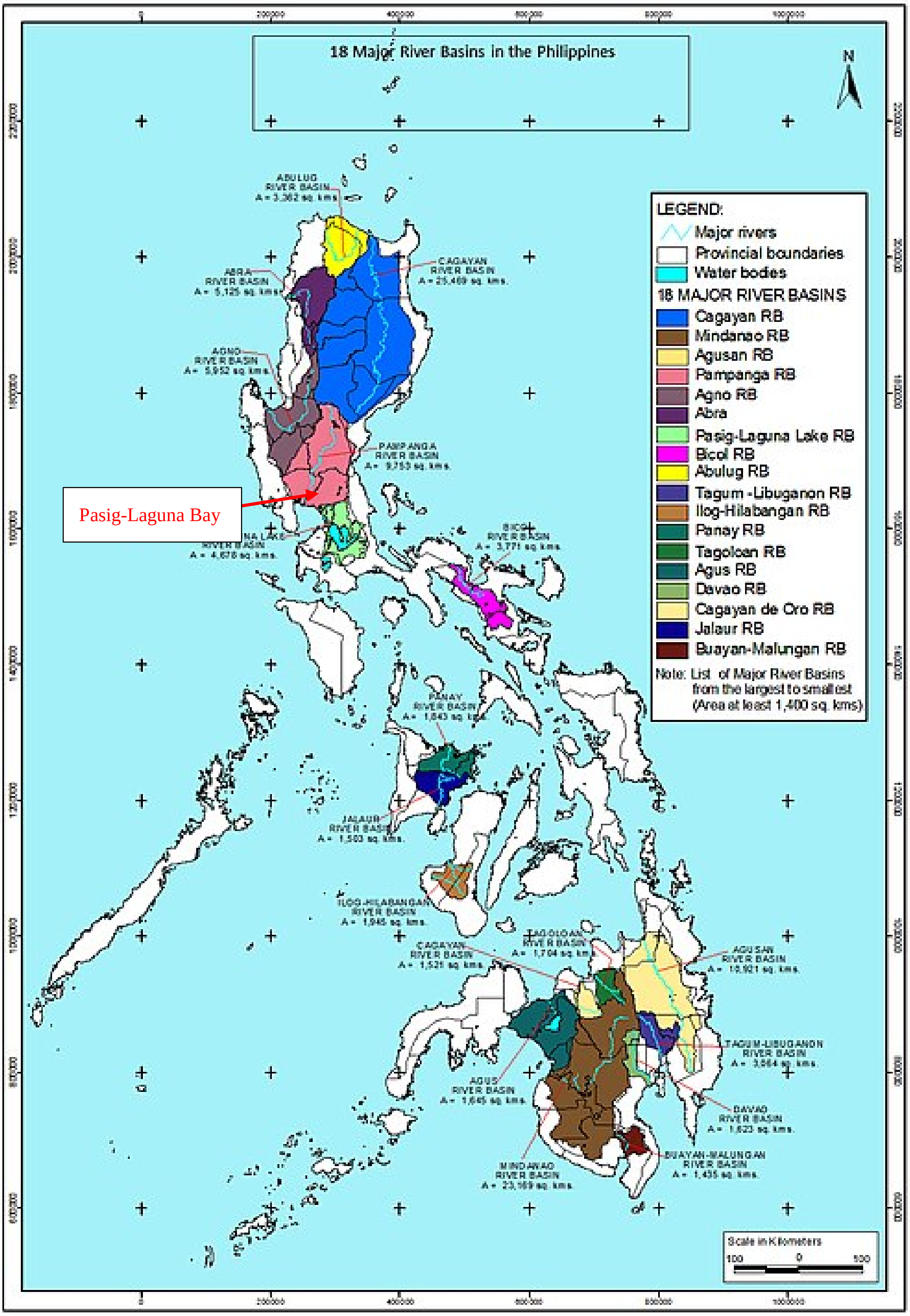
The Philippine government has designated eighteen (18) basins of major rivers as the main basins, and preferentially formulates flood control plans from river basins that have large populations and cities that are the centers of economic activity. The location map of the 18 main watersheds is shown in Figure 3.2.1 and the outline of watersheds is shown in Table 3.2.2.

Table 3.2.2 Outline of Eighteen Major Basins

River Basin	Region	Catchment Area (km^2)
Cagayan	Region II	25,469
Mindanao	Region XI and XII	23,169
Agusan	Region XIII	10,921
Pampanga	Region III	9,759
Agno	Region III	5,952
Abra	Region I	5,125
Pasig-Laguna Bay※	**NCR and Region IV-A**	**4,678**
Bicol	Region V	3,771
Abulug	Region II	3,372
Tagum-Lubuganon	Region XI	3,064
Ilog-Hilabanga	Region VI and VII	1,945
Panay	Region VI	1,843
Tagoloan	Region X	1,704
Agus	Region XII and ARMM	1,645
Davao	Region XI	1,623
Cagayan	Region X	1,521
Jalaur	Region VI	1,503
Buayan-Malungun	Region XI	1,434

*Including Marikina River Basin

Therefore, the Laguna de Bay basin (including the Marikina River basin) is recognized as the "Pasig-Laguna Bay" Basin, one of the 18 major basins in the Philippines.



Source: NWRB

Figure 3.2.1 Location Map, Eighteen Major Basins in the Philippines

3.2.3 Integrated Flood Control Plan for Pasig-Marikina River Basin and Laguna de Bay Basin

The Manggahan Floodway was completed in 1988 as a part of the Pasig-Marikina River flood control. Laguna de Bay has the function of temporarily storing floodwaters in the Marikina River basin, as well as the water flowing from the Napindan Channel and the Manggahan Floodway into Manila Bay. (See Figure 3.2.2). The Parañaque Survey 2018 had examined the amount of water flowing into Laguna de Bay and the rise in water level during the 2009 Typhoon Ondoy as follows:

<< Analysis of Factors and Trends of Lake Water Level Rise>>

- Based on the calculation results in 2009, the factors causing the water level rise in Laguna de Bay were examined. The water level rise at the time of Typhoon Ondoy in 2009 is summarized below.

【 Breakdown of Inflow and Outflow of Laguna de Bay ※Total Amount of 25 to 28 September 2009】

Inflow from the Laguna de Bay Basin	V_{IN}	=736.0 MCM (**64.6%**)	Inflow from lakeshore area mostly influenced the lake level raising.
Inflow from the Mangahan Floodway	$V_{M,IN}$	=181.0 MCM (15.9%)	**Inflow V=1,139.8 MCM**
Inflow from the Napindan Channel	$V_{N,IN}$	= 11.8 MCM (1.0%)	
Rainfall to the Laguna de Bay Lake Surface	V_R	=211.0 MCM (18.5%)	
Evapotranspiration from the Laguna de Bay Lake Surface	V_{EVA}	= 4.7 MCM (7.0%)	**outflow V =66.9 MCM**
Outflow from the Napindan Channel	$V_{N,OUT}$	= 53.8 MCM (80.4%)	
Outflow from the Mangahan Floodway	$V_{M,OUT}$	= 8.4 MCM (12.6%)	

Inflow V

$\Delta V = V_{IN} + V_{M,IN} + V_{N,IN} + V_R - (V_{EVA} + V_{N,OUT} + V_{M,OUT})$

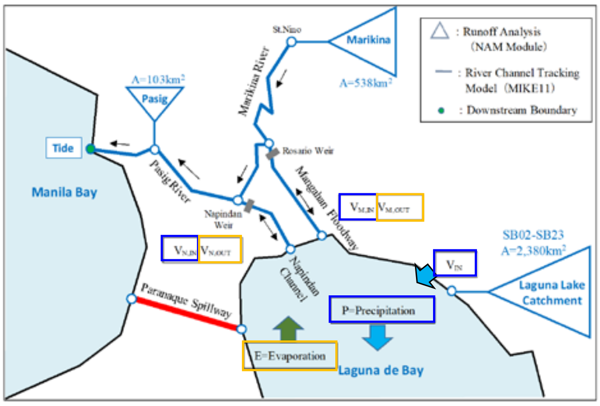
outflow V

= 1,139.8 – 66.9

= **1,072.6 MCM**

(1.11m water level up)

2009/9/25 WL=12.77m (Observed)
2009/9/28 WL=13.81m(Observed)
ΔL=1.04m



Source: Project Tam

Source: Parañaque Survey 2018

Figure 3.2.2 Hydraulic System of Laguna de Bay and Pasig-Marikina River in Typhoon Ondoy

According to this analysis, during Typhoon Ondoy, the flood inflow from the Marikina River basin through the Manggahan Floodway into Laguna de Bay was as large as 181 MCM (this amount is equivalent to about 4 times the currently planned Marikina Dam flood control capacity). The Manggahan Floodway is, therefore, contributing greatly to the reduction of inundation damage in the Metro Manila area of the Pasig Marikina River basin.

On the other hand, the inflow of 181 MCM into Laguna de Bay increased the lake water level by about 20cm and increased inundation damage in the Laguna de Bay lakeshore area (inundation area increased by about 10km2 and inundation population increased by about 80,000).

As mentioned in Subsection 3.2.2, in the Philippines, the Laguna de Bay basin is recognized as an integrated basin with the Pasig-Marikina River basin. Investigation of an "integrated flood control plan" that combines flood mitigation effects (positive effects) on the area and negative effects on the Laguna Lake coastal area to improve flood control safety in the Pasig-Marikina River basin and the entire Laguna Lake basin is thus important.

3.3 Flood Characteristics of Pasig-Marikina River and Laguna de Bay Basin

Inundation damage in the coastal area of Laguna de Bay is due to long-term (several months) high water levels that occur during the flood season. On the other hand, the inflow from the Mangahan Floodway is a short-term flood diversion (about 1-2 days) that occurs in the Pasig-Marikina River, and has different flood characteristics.

The Parañaque Spillway continuously drains water in order to control the rise in lake water level that occurs over a long period during the flood season, promote high water level reduction, and reduce the high water level period. The drainage scale of Parañaque Spillway is proposed by considering the effect (how much the Laguna lake water level can be suppressed or lowered) and project cost.

The lake water increase of Laguna de Bay is greatly affected by the inflow from the sorrounding area and the inflow from the Pasig-Marikina River basin. During Typhoon Ondoy in 2009, the inflow volume was about 16% of the total inflow of Laguna de Bay as calculated in the Parañaque Survey 2018. (See Figure 3.3.1).

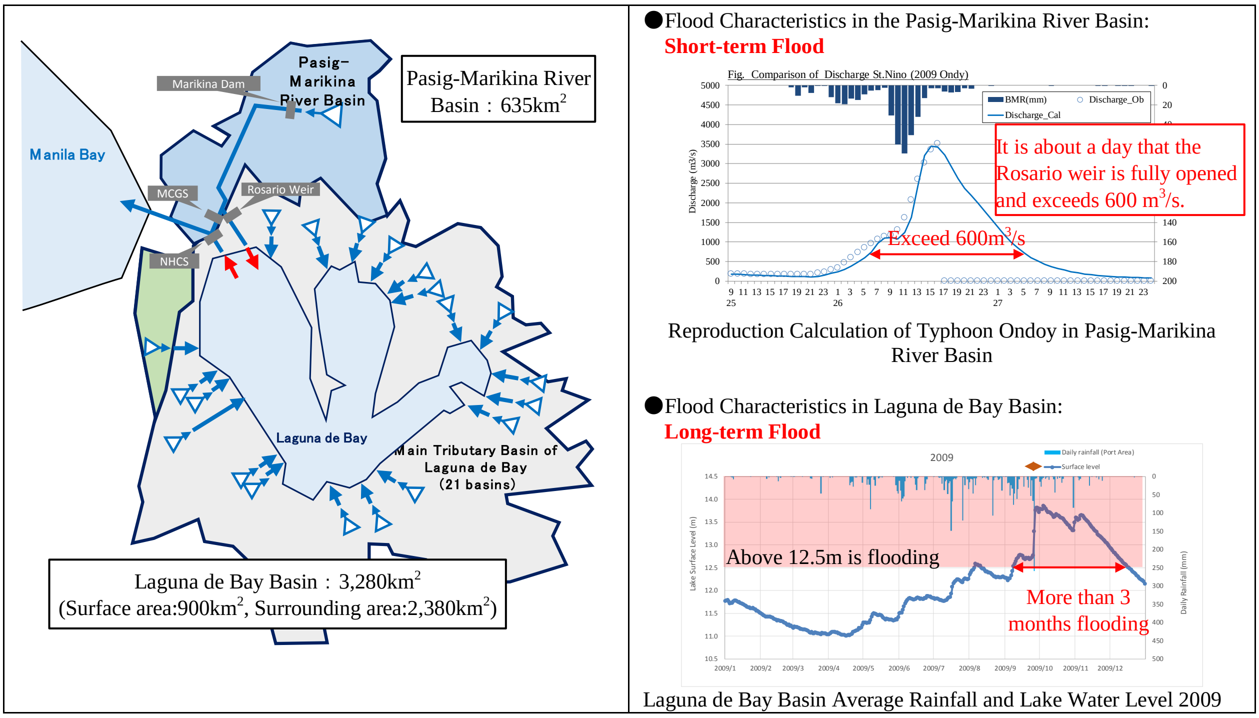


Figure 3.3.1 Pasig-Marikina River Basin and Laguna de Bay Basin (Right Figure), Inflow and Lake Water Level in 2009 Typhoon Ondoy (Left Figure)

3.4 Design Discharge of Manggahan Floodway

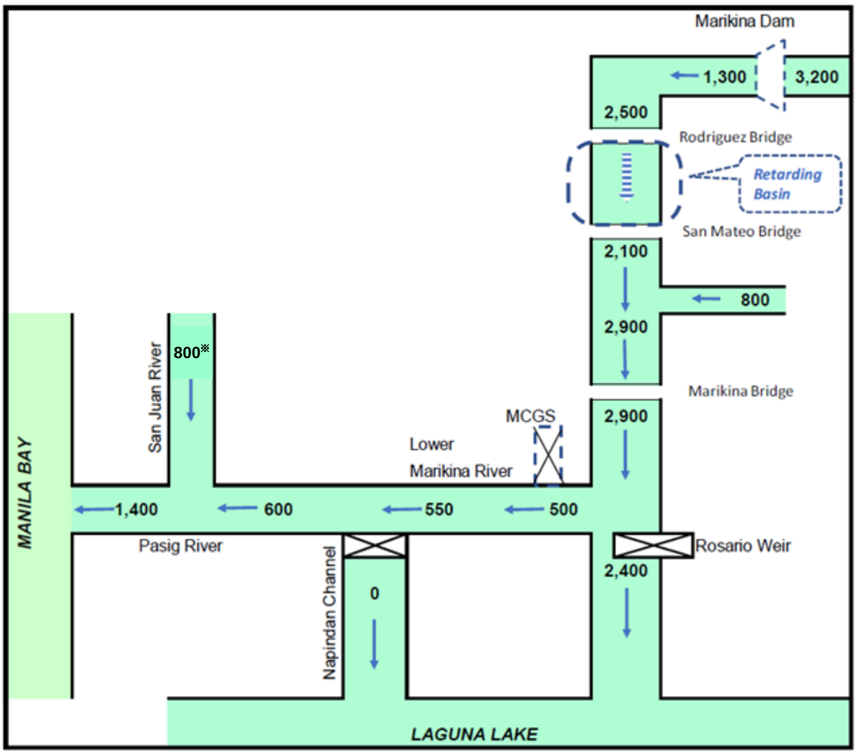
The design discharge of Mangahan Floodway is as follows, 1990 based on the Master Plan. The existing flood control plan for the Pasig-Marikina River basin is as summarized in Table 3.4.1.

- The design flood is at 100-year return period under the condition Marikina Dam is constructed and the design discharge at Sto. Niño is 2,990 m^3/s
- Under the conditions for constructing MCGS, the flow distribution will be 2,400 m^3/s for Manggahan Floodway and 500 m^3/s for downstream of Marikina River.

Table 3.4.1 Existing Flood Control Plan for Pasig-Marikina River Basin

Existing Flood Control Plan	Background and Purpose of the Survey
1952MP[1]	・ Conducted an investigation following the unprecedented Great Flood that occurred in November 1943. ・ Main purpose is to formulate MP for drainage measures in northern Manila and southern Manila ・ Considering and proposing flood control measures for the Pasig and Marikina rivers.
1975FS/DD	・ In response to the Great Flood that occurred in 1970, the FS and DD 2of the Manggahan Floodway, which was proposed in 1952 MP, and the FS of the Parañaque Floodway, which was planned for draining Laguna de Bay, were implemented.
JICA1990MP[3]	・ Technical cooperation was officially requested for the Manila Flood Countermeasures Plan Survey in November 1986 when President Aquino went to Japan, and the survey was conducted in response to this request. ・ Study FP, formulate the MP, implement the FS for priority areas.
2002DD[4]	・ In order to deal with frequent floods, DPWH decided to implement the PMRCIP project based on JICA1990MP / FS. ・ 2002DD is positioned as Phase I of PMRCIP. Detailed design of the overall plan, review of the JICA1990MP planned flood discharge, and setting of the planned flood discharge for the immediate maintenance are implemented.
JICA2011Preparatory Survey[5]	・ Due to the great damage caused by Typhoon Ondoy in September 2009, the early completion of PMRCIP was made an issue for funding. ・ In particular, the plan including the following contents focusing on the target section of Phase III has to be reviewed: Current river condition reflecting recent basin development, recent flood damage condition, and flood damage condition due to impact of future climate change.
WB2012MP[6]	・ Conducted a survey to show the roadmap for sustainable and effective flood risk management in Metro Manila and surrounding areas following the large-scale flood damage caused by Typhoon Ondoy. ・ One of the main purposes was to formulate a comprehensive flood control master plan.
JICA2014 Survey[7]	・ By reviewing past survey results (especially planned high water flow rate in WB2012MP) in consideration of climate change in the target area, the survey was conducted to prepare basic information that contributes to the formulation of a more detailed flood control plan. Implementation. ・ The purpose was to re-examine the technical validity of the structural countermeasures examined in WB2012MP.
2015IV&V8	・ It has been recognized that urgent implementation of the Phase IV section is necessary after the occurrence of the great flood damage caused by Typhoon Ondoy, and the FS of the Phase IV section and FS and DD of the Phase V section were implemented.
WB2018 UMD FS9	・ Marikina Dam FS and DD were required for completion of the entire PMRCIP. ・ Feasibility study and detailed design and preparation of bidding based on the feasibility study to determine the optimal upstream river structure (dam/reservoir) option to reduce the flow of Marikina River before floods flow into Metro Manila.
JICA2019IV DD	・ Detailed design (D/D) of Phase IV section construction (Mangahan Floodway diversion point to Marikina Bridge) of the Pasig-Marikina River Improvement Project of which total length is 30km.

1 Plan for the Drainage of Manila and Suburbs, Ministry of Public Works, Transportation and Communication (MPWTC),1952
2 The Manggahan Floodway - A feasibility study, February 1975
3 Study on Flood Control and Drainage Project in Metro Manila,JICA,1990
4 Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project, DPWH, March 2002
5 Pasig-Marikina River Channel Improvement Project (III),JICA, 2011
6 Master Plan for Flood Management in Metro Manila and Surrounding Areas, World Bank, 2012
7 Data Collection Survey on Flood Management Plan in Metro Manila, JICA, 2014
8 Supplemental Agreement No. 1 for the Consulting Engineering Services for Assistance to Procurement of Civil Works and Construction Supervision of the JICA-Assisted Pasig-Marikina River Channel Improvement Project, Phase II (PH-P252) Upper Marikina River Channel Improvement Works (PMRCIP Phase IV and V), DPWH, 2015
9 Consulting Service for the Feasibility Study and Preparation of Detailed Engineering Design of the Flood



※Flow rate assuming that the flow rate will be cut off at around 200m^3/s due to basin measures, etc.
Source：2019JICA Phase IV D/D

Figure 3.4.1 Allocation Plan of High Water Discharge (Draft) (Design Scale is 100-Year Return Period)

Marikina River, constructed at the flow rate of 2,900 m^3/s at Sto. Niño point, is equivalent to a 100-year probability flow rate when the flow regulation by the upstream Marikina Dam and the retarding basin is taken into consideration. If not taken into consideration, the design scale will be equivalent to a 30-year.

From the development of the Marikina River (completion of Phase IV) to the completion of the Marikina Dam and Retarding Basin, there will be from 20-year probability to 30-year probability of flood control in the Phase IV river improvement section during this period.

3.5 Relationship between Design Discharge of Manggahan Floodway and Design Discharge of Parañaque Spillway

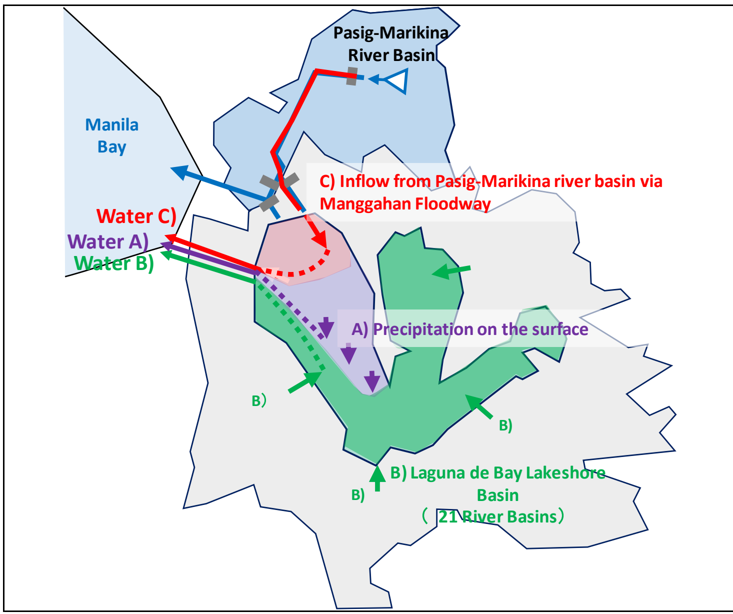
The discharge of 2,400 m^3/s from the Mangahan Floodway is the planned maximum discharge of short-term flood diversion in the Pasig-Marikina River. The total inflow from Manggahan Floodway at the time of this short-term flood is 180 million m^3 (increases the water level of Laguna de Bay by about 0.2m) over four (4) days, taking the case of Typhoon Ondoy as an example. The inflow will be almost the same as when the Parañaque Spillway (assuming a design discharge of 200 m^3/s) is in operation for 10 days (total drainage of about 180 million m^3 and Laguna lake water level of about 0.2 m decline).

In this way, the design discharge of Mangahan Floodway was set to reduce flood damage in Pasig-Marikina River basin. On the other hand, the design discharge of Parañaque Spillway was set by confirming the combination of optimal facility scales through the long-term inundation damage mitigation effect in the lakeshore area and sensitivity analysis result.

The relationship between the inflow from Manggahan Floodway and the discharge from the Parañaque Spillway during a 100-year probability flood is summarized below.

- ○ The inflow from the Manggahan floodway is 196 million m^3 for 10 days (the water level of Laguna de Bay has increased by about 0.2 m), and the peak discharge at that time is 2,400 m^3/s (design discharge of Manggahan Floodway).

- ○ In the Parañaque Spillway, water A), B), and C) are integrally drained to eliminate lake water rise due to inflow from Manggahan Floodway, and also to mitigate flood damage of lakeshore area due to inflow from surrounding area.



■Rainfall Runoff to Lakeshore basin

Water A) : Precipitation directly on the surface of Laguna de Bay

Water B) : Inflow from lakeshore area of Laguna de Bay (21 river basins)

■Flowing from Other Basins

Water C) : Water released from Pasig-Marikina river basin to Laguna de Bay via Manggahan floodway

Water C) through Manggahan Floodway can contribute to mitigate flood damage in Pasig-Marikina River Basin

Figure 3.5.1 Three Types of Lake Water Discharged from Parañaque Spillway

- ○ From the Laguna de Bay water level in 100-year probable flood (Table 3.5.1), the lake water level is 14.3 m when there is no Manggahan or Parañaque spillway (before 1986 condition).

- ○ With the Manggahan Floodway (current situation), the lake water level of 100-year probable flood is 14.5 m, and the 20 cm water level rises as the flood flow in the Pasig-Marikina River basin flows into Laguna de Bay through the Manggahan Floodway.

- ○ When the Parañaque Spillway is constructed, the lake water level of 100-year probable flood will be reduced from 14.5 m to 13.8 m, the rise in water level due to inflow from the Manggahan floodway will be resolved, and flood damage of lakeshore area due to inflow from surrounding area is mitigated.

Table 3.5.1 Laguna de Bay Water Level under 100-year Probable Flood

Case	Parañaque Spillway	Manggahan Floodway	100-Yr flood WL (m)
Initial			14.3
Current		✔	14.5 50cm decline 70cm decline
With project	✔	✔	13.8

【Calculation Condition】
Considering climate change (see Section 4.3 for detailed study on climate change), the inner diameter of the Parañaque Spillway was set to D = 13m.