REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

DATA COLLECTION SURVEY ON PARAÑAQUE SPILLWAY IN METRO MANILA IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

VOLUME 1: MAIN REPORT

MAY 2018

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CTI ENGINEERING INTERNATIONAL CO., LTD.
NIPPON KOEI CO., LTD.
CTI ENGINEERING CO., LTD.

GE
JR
18-086

REPUBLIC OF THE PHILIPPINES

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

DATA COLLECTION SURVEY ON PARAÑAQUE SPILLWAY IN METRO MANILA IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

VOLUME 1: MAIN REPORT

MAY 2018

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CTI ENGINEERING INTERNATIONAL CO., LTD.
NIPPON KOEI CO., LTD.
CTI ENGINEERING CO., LTD.

COMPOSITION OF FINAL REPORT

Volume 1 ： Main Report

Volume 2 ： Appendix

Exchange Rate
1 US$ = 50.84PHP = 110.96 JPY
1 PHP = 2.183 JPY
October 2017

SUMMARY

1. Outline of Survey

1.1 Background

For over 40 years since the 1970's, Japan had provided a wide range of support for Philippine infrastructure projects, including the preparation of flood control plans which targeted mainly the major rivers in Metro Manila, the implementation of ODA loan projects, and technical assistance to the central government agencies. Regarding river floods, after the Mangahan Floodway was completed in 1988, JICA had implemented the "Study on Flood Control and Drainage Projects in Metro Manila" (1988 to 1991), and the "Pasig-Marikina River Channel Improvement Project" (the Project) was selected as a highly urgent project to implement flood management measures in the Pasig-Marikina River. Through the feasibility study (F/S) and the former international cooperation bank's Special Assistance for Project Formation (SAPROF), JICA had decided to have the Project implemented in four (4) phases. Only recently, the construction works for Phase III (L/A signed in 2011) was completed.

As measures against flood that cause inland inundation and lake-water level rise in the West Mangahan district areas in Metro Manila and those around the Laguna de Bay (Basin Area is 2,920 km^2 and lake surface area is 900 km^2), JICA had provided support for the detailed design work of facilities in the East and West Mangahan district areas through the ODA loan project called the "North Laguna Lakeshore Urgent Flood Control and Drainage Project (L/A signed in 1989)" and also provided support for the construction of lakeshore dikes and drainage facilities as well as the installation of drain gates in the West Mangahan District through the ODA loan project known as the "Metro Manila Flood Control Project – West of Mangahan Floodway (1997~2007)".

However, the daily rainfall of 453 mm recorded during Typhoon Ondoy in September 2009 had caused massive flood damage in areas along the Marikina River and the Laguna de Bay Lakeshore, as well as in Metro Manila. In the West Mangahan District which is located in the Laguna de Bay Lakeshore where measures were implemented in the project of "Metro Manila Flood Control Project – West of Mangahan Floodway", about 80% of the low-lying residential areas was inundated for 1 to 3 weeks due to the overbank flow of Marikina River, inland inundation, and the water level rise of Laguna de Bay. Along the Laguna de Bay Lakeshore, low-lying areas with no flood management measure spread widely and these areas had experienced inundation for more than one month brought by Typhoon Ondoy. Despite the vulnerable situation, the provision of flood control measures in the Laguna de Bay lakeshore areas has lag behind compared to the center of Metro Manila, so that flood management measures are urgent matters to be addressed.

The Department of Public Works and Highways (DPWH), Government of the Republic of the Philippines, has a plan to implement the "Laguna Lakeshore Expressway Dike Project (LLEDP)", as a Public-Private Partnership (PPP) project, to reclaim the west bank area of Laguna de Bay, construct roads, and implement urban development. Measures against flood in the Laguna de Bay lakeshore areas are required and several flood management measures are being considered including the construction of lakeshore dike, drainage channel and drainage facilities, to drain excess lake-water from the Laguna de Bay to the Manila Bay through Parañaque City, as well as the construction of a floodway (hereinafter referred to as the "Parañaque Spillway") to control the water level of Laguna de Bay.

Since the acquisition of land for the Parañaque Spillway would be difficult in Parañaque City where urbanization is in progress, an underground channel of about 9.2 km is being considered instead of the open-cut type. To examine the feasibility of the Parañaque Spillway, the DPWH had requested the support of JICA for the implementation of this Data Collection Survey.

1.2 Objectives

The objectives of the data collection survey are to analyze the condition in the Laguna de Bay basin including the Pasig-Marikina River basin in a unified manner in line with the existing flood management projects and plans, to prepare the comprehensive flood management plan for the entire Laguna de Bay lakeshore area, and to conduct a Preliminary Feasibility Study (Pre-F/S) on the Parañaque Spillway as a part of the comprehensive flood management plan and data collection and confirmation of information for the examination of feasibility of the Project under JICA's ODA loan assistance, as well as the direction of the Data Collection Survey.

1.3 Schedule of the Data Collection Survey

The survey was started with the domestic preparation work in Japan in July 2017 and all tasks were completed in May 2018.

2. Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area

The flood damage in the Laguna de Bay Lakeshore areas is caused by the long-term high water level of the lake. Based on the flood damage data, the mechanism and characteristics of flood occurrence, causes and situation of flood damage incidents are summarized in Table 2.1.

Table 2.1 Hydraulic Situation and Flood Damage Situation in Laguna de Bay

Items	Descriptions
Fluctuation and characteristics of lake water level	✓ Abrupt increase in water level is caused by the rainfall to the lake surface due to typhoon and tropical cyclones, and inflow from rivers and drainage channels including the Mangahan Floodway. ✓ Reduction in water level is caused by the outflow form Napindan Channel and the Mangahan Floodway and evaporation. ✓ The high water level lasts for a long period due to the limited drainage capacity.
High water level continues for a long period	✓ Outflow capacities from Napindan Channel and the Mangahan Floodway area insufficient.
Frequency of flood damage occurrence	✓ More than EL 12m, which is the level affecting the living infrastructure, occurs more than 47 times in 71 years (occurrence is once in 1.5 years)
Geographical range of flood damage	✓ Except the mountainous area and the 10 km section of "Metro Manila Flood Control Project - West of Mangahan F1oodway", the land of most of Laguna de Bay shore area is utilized and the damaged area is expanded in almost all lake shore areas.
Inundation depth and duration of Inundation	✓ Based on the historical maximum water level (approximately EL 14m), the inundation depth reached about maximum 2 m at the residential areas located at EL 12m, and it reached about 1.5 m at the residential areas located at EL 12.5 m. ✓ During the flood caused by Typhoon Ondoy, the water level of EL 12.5 m or more continued about 130 days, whereas the water level of 13 m or more continued about 60 days.

Since the flood of Laguna de Bay extends throughout the entire lower area of lake shore, it is recommended that the comprehensive flood management plan of the entire lakeshore area is considered as the flood measures of Laguna de Bay. The study focused on the water level rising of Laguna de Bay, inland inundation and river flooding in Laguna de Bay basin and proposed the comprehensive flood management plan for Laguna de Bay lakeshore area as shown in Figure 2.1.

Comprehensive Flood Management Plan in the Laguna de Bay Lakeshore Areas(Draft)

Control in Water Level Rising (Structural Measures)
- ✓ Construction of the Parañaque Spillway
- ✓ Re-evaluation and enhancement of drainage capacity: Napindan Channel ＋ Mangahan Floodway

Mitigate Inundation Damage (Structural Measures)
- ✓ Construction of lakeshore diking system
- ✓ Inflow river channel improvement at Laguna de Bay lakeshore area

Non-Structural Measures
- ✓ Lake Management for the Laguna de Bay
- ✓ Land use control
- ✓ Establishment of Flood warning system
- ✓ Preparation of Flood Hazard Map

Figure 2.1 Three Key Elements of Laguna de Bay Comprehensive Flood Management Measures

2.1 Hydrologic and Hydraulic Analyses

1) Setting of Design Scale

The design scale was set by comprehensively evaluating the importance of the target basin, the actual condition of past flood damages, the existing plans in the vicinity, and the design scale specified in the DPWH Design Guidelines, Criteria and Standards (DGCS) of 2015.

Table 2.2 Design Scale

Classification	Evaluation Index	Design Scale	
Flood caused by water level rise of Laguna de Bay	**Water Level**	100-year	
Laguna de Bay Lakeshore Area (21 river basins), Las Piñas and Parañaque District	**Rainfall**	[Rivers] A=40km^2 or more: 50-year A=less than 40km^2 10km^2 or more: 25-year A=less than 10km^2: 15-year	[Drainage Canal] Drainage Canal: 15-year

Based on the water level data (from 1946 to 2016), the statistical analysis on water level in Laguna de Bay was conducted (refer to Table 2.3). The 100-year probability water level in Laguna de Bay is 14.3 m. The recorded maximum water level (14.03 m, 1972) is the water level equivalent to a 50-year probability. In addition, the maximum water level during Typhoon Ondoy in 2009 was 13.85m which is equivalent to a 40-year probability.

Table 2.3 Probability Water Level at Laguna de Bay

Return Period (year)	Water Level (m)
2	12.3
5	12.9
10	13.2
30	13.7
50	14.0
100	14.3
200	14.7

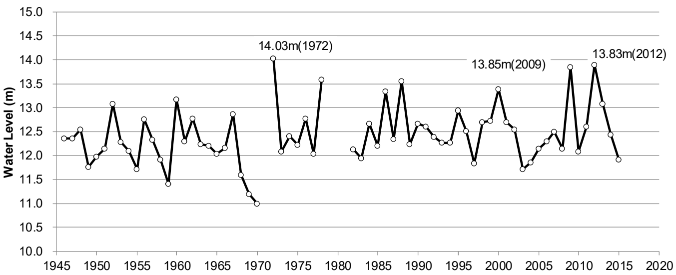


Figure 2.2 Long-Term Changes of the Maximum Water Level of Laguna de Bay (1946 to 2016)

2) Design Water Level Waveform

Since the water level in Laguna de Bay was applied for the flood caused by water level rise of the lake, the design water level waveform was studied. The design target water level waveform was prepared based on the water level waveforms in 2009 and 2012. The safety side was examined by evaluating the effectiveness of lake-water level reduction by the Parañaque Spillway with the waveform causing large damages (the waveform producing less effect of lake level reduction by the Parañaque Spillway).

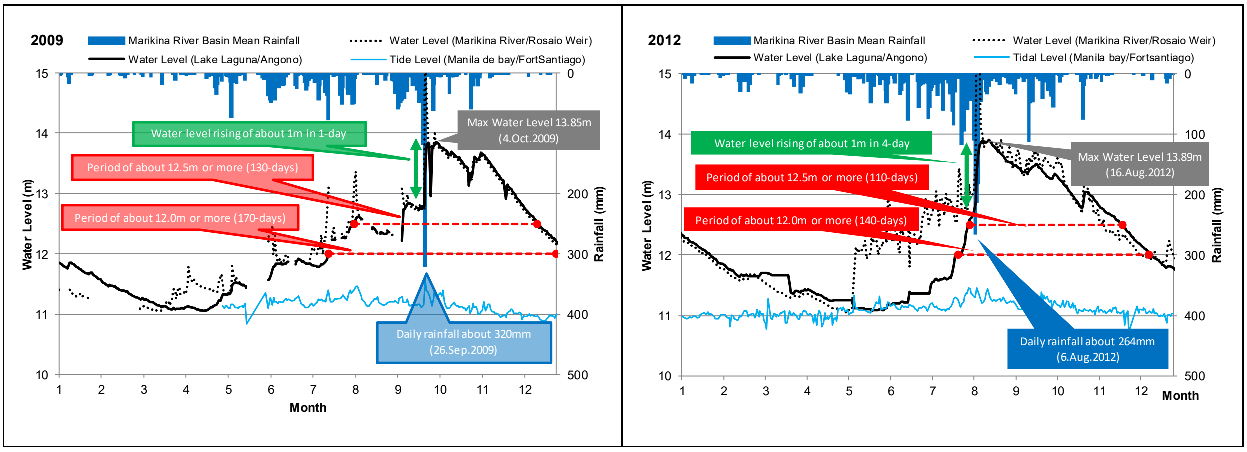


Figure 2.3 Laguna de Bay Water Level Fluctuation in 2009 and 2012

3) Water Level Fluctuation Analysis of Laguna de Bay (Long-Term Evaluation)

The Water Level Variation Analysis Model (Fluctuation Analysis Model) consists of three hydrological and hydraulic models, namely; the Runoff Model; the River Channel Network Model (Flood Tracking Model); and the Laguna de Bay Inundation Model as shown in Figure 2.4. The result of the water level fluctuation analysis of Laguna de Bay (long term evaluation) is shown in Figure 2.5.

<u>The main inflow and outflow affecting the water level fluctuation of Laguna de Bay</u>

- Inflow from the Laguna de Bay Basin (surrounding basins)
- Inflow from the Marikina River Basin to the Mangahan Floodway
- Outflow from Laguna de Bay to Mangahan Floodway to the Marikina River
- Direct rainfall to and evapotranspiration from the Laguna de Bay lake surface
- Inflow and outflow from Laguna de Bay to the Napindan Channel to the Pasig River

1. Runoff Analysis (NAM Module)

↓

2. River Channel Tracking Model (MIKE11)

↓

3. Laguna de Bay Water Level Fluctuation Model (MIKE11)

↓

4. Laguna de Bay Inundation Model

Procedure of Developing the Hydrological and Hydraulic Analysis Model

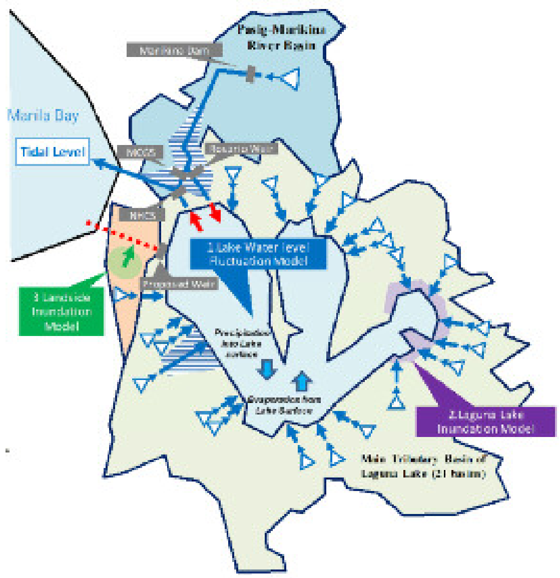


Figure 2.4 Conceptual Diagram of Hydrological and Hydraulic Analysis Model

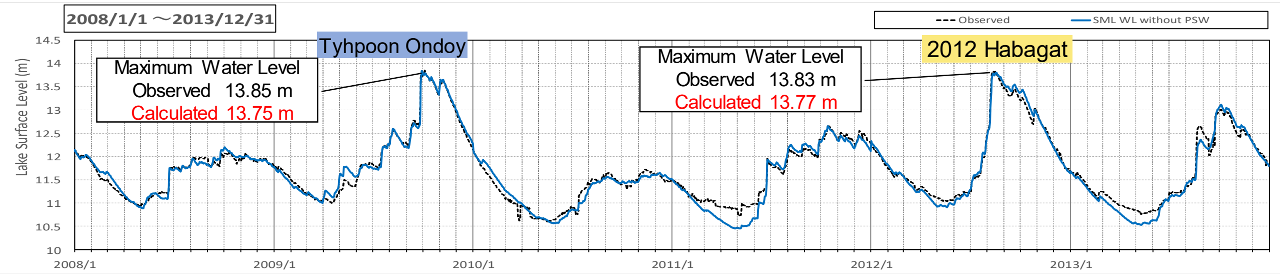


Figure 2.5 Result of the Water Level Fluctuation Analysis of Laguna de Bay (Long-Term Evaluation, Without Parañaque Spillway)

2.2 Structural Measures

The structural measures aim to reduce the inundation damage at the Laguna de Bay lakeshore area and to control the rise of lake-water level. These measures consist of the construction of the Parañaque Spillway, the heightening of parapet wall along the Napindan Channel, and the construction of a lakeshore dike system including pumping station, bridge and river dike.

1) Parañaque Spillway

Commercial facilities and houses are densely located on the alternative routes of the Parañaque Spillway so that the open channel which would require a lot of resettlement is not feasible. Hence, the siphon type of spillway with depth of more than 50 m, which does not require land acquisition except for the vertical shaft construction areas, is proposed. Based on the results of the study, it is concluded that the natural gravity flow without pumping could be applied.

The design discharge of the Parañaque Spillway is 200 m^3/s, which is the same as the river planning discharge. Although there is no particular restriction on the location of intake facility, the "Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA)" needs to be considered when the location of drainage facility is selected. As a result, the river connection method to the Parañaque River System or the Zapote River is proposed. Proposed alternatives of alignment of the spillway are as shown in Figure 2.6. Considering that there are possibilities of adoption in all cases except Outlet 2 and Outlet 3 in the present design stage, Route D is selected for further design due to the smallest impact on LPPCHEA and the smallest range of improvement of rivers. The specifications of the spillway along the Route D are as summarized in Table 2.4.

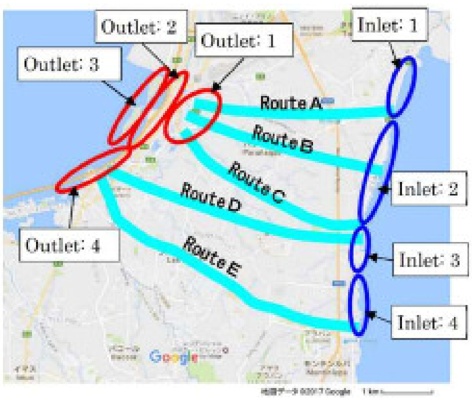


Figure 2.6 Comparison of Route Plans of Facility Location

Table 2.4 Specifications of Parañaque Spillway (Route D: Preliminary Design Stage)

Item	Route D
Design discharge (= River planning discharge)	200 m^3/s
Design water level	14.0 m
Operation start water level	12.0 m
Type of flow control at intake	Inflow Gate Control
Increase ratio	Approximately 10 %
Inner maintenance road	5 m
Longitudinal slope	1/1,500 (order slope)
Length of tunnel Tunnel inner diameter	10.0 km 12 m
Intake facility (vertical shaft) Diameter Depth	31.6 m 75.1 m～81.1 m
Outlet facility (vertical shaft) Diameter Depth	31.6 m 77.3 m～83.3 m

The result of the study on the Laguna de Bay lake water level lowering effect with design discharge of 200 m^3/s and the operation starting water level of EL 12.0 m was summarized as follows.

- ✓ Peak water level lowered by 0.55 m in 2009, and by 0.24 m in 12-year average.
- ✓ The period that the water level was over EL 12.5 m in was shortened from 110 days to 46 days in 2009, from 108 days to 63 days in 2012, and from 62 days to 15 days in 2013.
- ✓ The discharge to the Parañaque Spillway was conducted 9 times for 12 years.

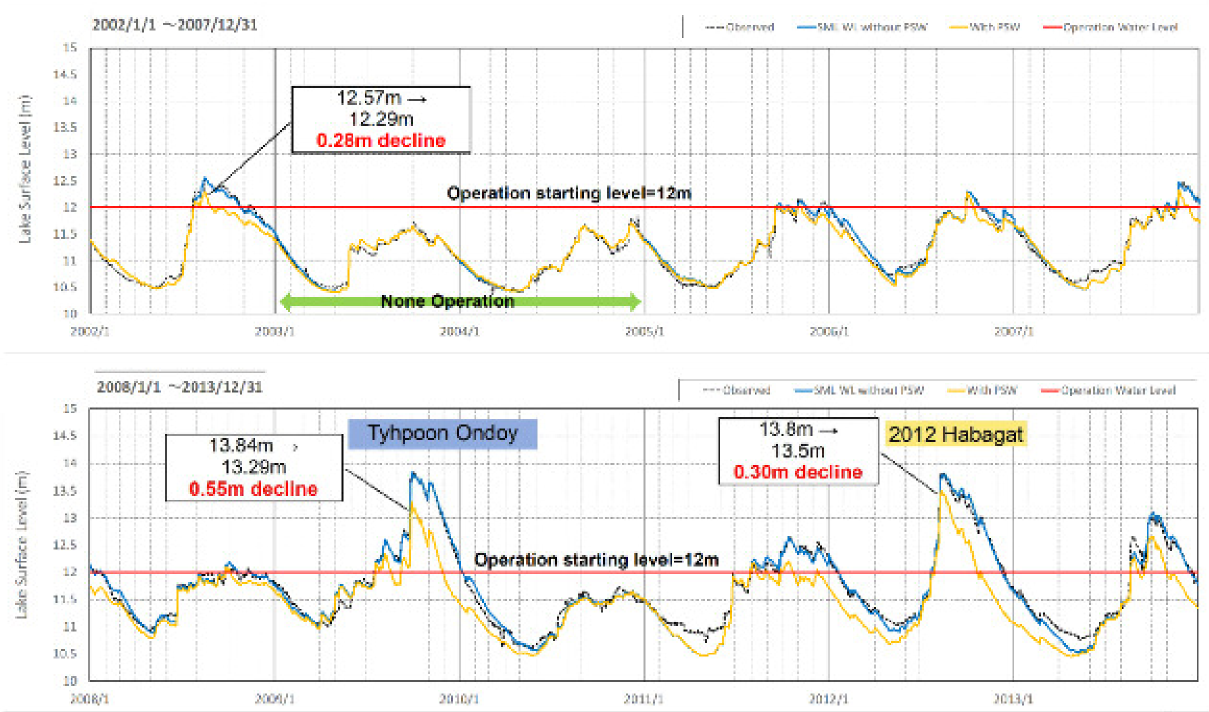


Figure 2.7 Long-term Prediction Calculation Results from 2002 to 2012 with Operation Starting level of EL 12.0m

The effectiveness of the Parañaque Spillway by probability scale was also analyzed. As the result, the maximum water level of Laguna de Bay by probability scale is shown in Table 2.5 and the water level fluctuation analysis with 100-year probability is shown in Figure 2.8.

Table 2.5 Outline of the Maximum Water Level of Laguna de Bay by Probability Scale

Probability	Parañaque Spillway		Lake Water Level Decline (m)
	Without	With	
200	14.7	14.3	0.4
100	**14.3**	**13.9**	**0.4**
50	14.0	13.7	0.3
30	13.7	13.4	0.3
10	13.2	13.0	0.2
5	12.9	12.8	0.1
2	12.3	12.3	0.0

Note: Operation Start Water Level: 12.0m

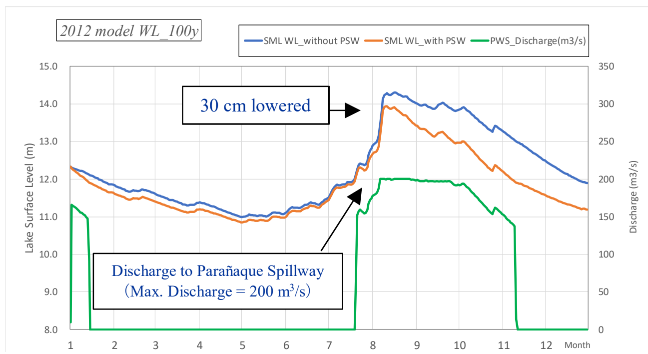


Figure 2.8 100-year Probability, Analysis Results of Water Level Fluctuation with Parañaque Spillway

2) Lakeshore Diking System

The construction of lakeshore diking system at the priority area of the Laguna de Bay lakeshore is proposed. The lakeshore diking system consists of lakeshore dike, drainage channel, pumping station, community road and bridge, and this system would minimize the damage caused by lake water rise up to the design lake water level. The construction site is selected by referring to the ground surface elevation, so that the locations at EL. 12.0 m to EL. 12.5 m are mostly chosen. The design lake-water level was set at the 100-year probable water level (EL. 14.0 m) and the lakeshore area was prioritized based on the land use and beneficial population and land area. The lakeshore diking system would be constructed referring the priorities and the total length of the system was proposed to be approx. 83 km. Non-structural measures were proposed at the residual areas which had less assets and resulting in low economical effect of the construction.

Item	Phase I (10 years)	Phase II (10 years)	Phase III (10 years)
Target Area	The 1st priority area	The 2nd and 3rd priority area	The 4th and 5th priority area
Lakeshore Dike Length	17 km	33 km	33 km

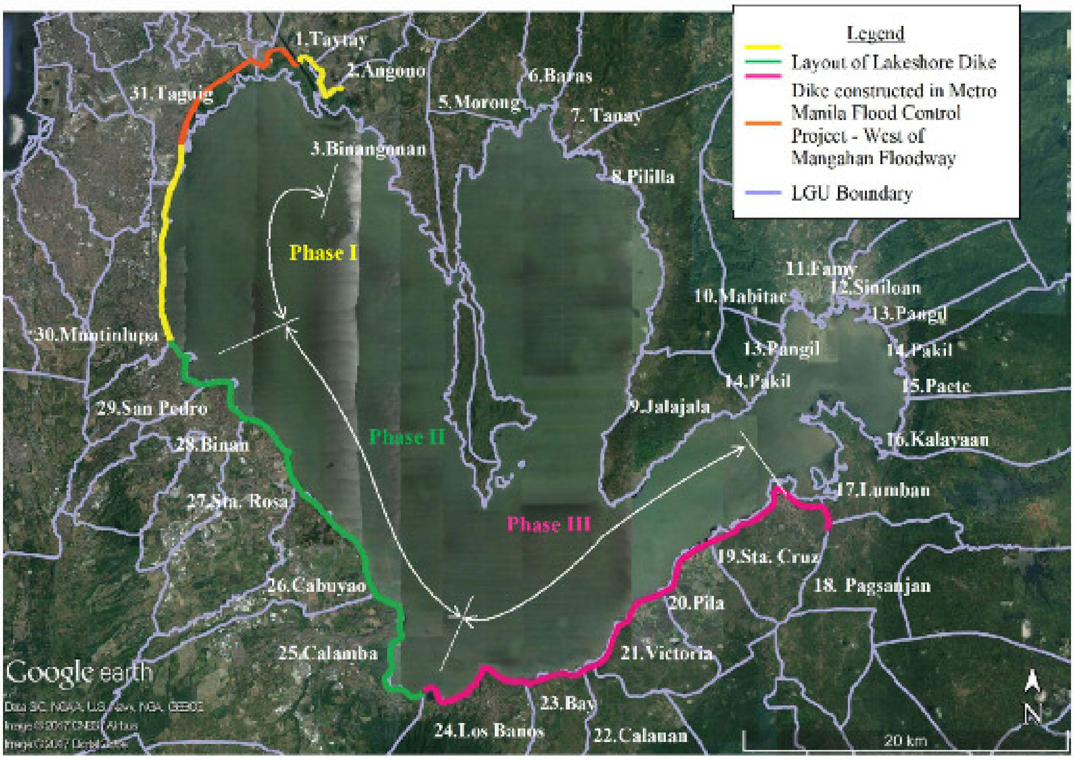


Figure 2.9 Layout Plan of the Lakeshore Dike (Priority Area)

3) Parapet Wall Heightening at Napindan Channel

The high water level of the Napindan Channel is 13.8 m and the crown level of the parapet wall along the channel is 14.1 m, while the design lake-water level of the Laguna de Bay is 14.0 m. Therefore, considering the high water level (14.0 m) and free board (0.3 m), the parapet wall is to be heightened by 0.2 m at almost the entire extent (6.8 km) of the Napindan Channel.

2.3 Non-Structural Measures

Non-structural measures are expected to show the flood reduction effect at less cost and time. In the Study, the following components are proposed.

1) Lake Management for the Laguna de Bay

Based on RA No. 4850, the water body and land below El. 12.50 m (bottom and lakeshore) are considered as the lake under the management of the LLDA. In the Study, it is proposed that EL. 12.50 m plus wave run-up height and some allowance at the lakeshore area is the elevation of lakeshore bank. It is also proposed that easement zones which should be set away from the bank elevation by 3 m for urban areas and by 20 m for agricultural areas are to be under the management of LLDA.

2) Improvement of Disaster Risk Management System for the Laguna de Bay Basin

To attain DRRM in the Laguna de Bay area, it is necessary to implement the Disaster Risk Reduction Management (DRRM) based on horizontal and vertical coordination and cooperation among the many LGUs and the related agencies.

- Coordination, cooperation and monitoring by NDRRMC of the whole DRRM in the Laguna de Bay Area; and
- Implementation of DRRM based on the DRRM Master Plan for the whole Laguna de Bay Area.

3) Land Use Management for the Laguna de Bay Basin

The land use management measures proposed for the low-lying areas with high flood risk along the Laguna de Bay Lakeshore Area.

- Resettlement of inhabitants from flood risk areas;
- Control of number of houses in flood risk areas; and
- Installation of evacuation places and evacuation buildings (shelters) at low-lying areas.

4) Flood Warning System for the Laguna de Bay Basin

To monitor the quality of lake-water and the water level of the Laguna de Bay, and for the issuance of warning signals, the following components of the flood forecasting and warning system are proposed:

- Strengthening of rainfall and water level observation systems for the flood forecasting and warning system in the Laguna Lake Basin;
- Installation of rainfall and water level observation facilities and conduct of observation by all of the LGUs around the Laguna de Bay; and
- Water level observation of the Parañaque Spillway and warning of inhabitants on the water through the Spillway.

5) Preparation of Flood Hazard Map

Flood hazard maps should be prepared showing inundation and evacuation information such as evacuation route and high-risk areas along the evacuation route for the smooth conduct of evacuation. Flood risk reduction is expected with the preparation and publication of these maps.

2.4 Preliminary Cost Estimate

1) Condition of Project Cost Estimate

Due to the lack of the experience of large tunneling construction works in the Philippines, the preliminary project cost was estimated compiling the tunneling construction examples in Japan and some other countries and interviewing with contractors and other companies specializing tunneling works.

Table 2.6 Conditions of Project Cost Estimate

Items	Conditions
Base Year of Cost Estimate	October 2017
Exchange Rates	1USD=110.96JPY; 1USD=50.84PHP, 1PHP=2.183JPY
Engineering Cost	10% of Construction Cost
Price Escalation	Price Escalation regarding Construction Cost, Engineering Cost F/C: 0.8%; L/C: 1.8%
Contingencies	10% of total amount of construction cost, engineering cost and price escalation
Land Acquisition/ Compensation	Detailed calculation for land acquisition and compensation for building removal (Inclusive of price escalation 1.8% for LC and also contingency 10%)
Project Administration Cost for Project Implementation Body	2% of total amount of construction cost, engineering cost and cost for land acquisition and compensation
VAT	12.0%

2) Project Cost Estimate

The following four (4) options, consisting of two routes (Route A and Route D) and two construction methods (shield tunneling method and NATM), of the Parañaque Spillway are considered in the the project cost estimate :

Option 1: Parañaque Spillway (Route A, Shield Tunneling Method), Lakeshore Diking Systems, Expansion of EFCOS

Option 2: Parañaque Spillway (Route A, NATM), Lakeshore Diking Systems, Expansion of EFCOS

Option 3: Parañaque Spillway (Route D, Shield Tunneling Method), Lakeshore Diking Systems, Expansion of EFCOS

Option 4: Parañaque Spillway (Route D, NATM), Lakeshore Diking Systems, Expansion of EFCOS

Table 2.7 Project Cost for Comprehensive Flood Management Plan in Laguna de Bay

Cost Items	Work Items	Option 1 (million PHP)	Option 2 (million PHP)	Option 3 (million PHP)	Option 4 (million PHP)
Construction Cost	Parañaque Spillway	45,876	36,148	49,121	37,653
	Lakeshore Diking Systems	42,073	42,073	42,073	42,073
	Expansion of EFCOS	114	114	114	114
	Sub-Total	88,063	78,335	91,308	79,840
Engineering Cost		8,806	7,833	9,131	7,984
Price Escalation		11,732	10,611	12,140	10,826
Contingencies		20,449	19,944	20,964	20,435
Land Acquisition, Compensation		8,786	8,786	8,786	8,786
Administration Cost		2,757	2,510	2,847	2,557
VAT		16,540	15,061	17,080	15,345
Total (million PHP)		157,133	143,082	162,255	145,773

Table 2.8 Operation and Maintenance Cost for Comprehensive Flood Management Plan in Laguna de Bay

Project Component	Items	O&M Cost (million PHP)
Parañaque Spillway	Operation cost of drainage pump, maintenance cost of hydro-mechanical facilities, maintenance cost of underground tunnels	200.2～265.1
	Sediment removal and cleaning of spillway tunnel	10.5～13.2
	Sub-Total	210.7～278.3
Lakeshore Diking System	O&M of Civil Works	155.3
	O&M of Electrical and Mechanical Equipment	110.2
	Sub-Total	265.4
Expansion of EFCOS	O&M of Electrical and Mechanical Equipment	1.1

2.5 Economic Analysis

EIRR was calculated for the comprehensive flood management plan of the Laguna de Bay Lakeshore Area. The results of economic analysis are as shown in Table 2.9.

Table 2.9 Economic Analysis for Comprehensive Flood Management Plan of Laguna de Bay Lakeshore Area.

Item	Economic Cost (million PHP)	EIRR	B/C	NPV (million PHP)
Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area (Parañaque Spillway) + (Lakeshore Diking System) + (Non-Structural Measures)	110,306～127,279	8.8% ~ 10.7%	0.86 ~ 1.08	-6,232 ~ 2,820

3. Pre-Feasibility Study on the Parañaque Spillway

Pre-Feasibility Study of the Parañaque Spillway, which was selected as the priority project in the comprehensive flood management plan for the entire Laguna de Bay lakeshore area, was conducted.

3.1 Structural Features of the Parañaque Spillway

In addition to the above-mentioned LPPCHEA, the conditions which might affect the Parañaque Spillway are the active faults (Valley Fault System) at the intake area. If the tunnel is designed to cross the Valley Fault System, the maintenance of the tunnel will be very difficult. Hence, it is proposed that an open channel crossing the Valley Fault System and connecting the Laguna de Bay with the intake facility is to be designed on the west side of the Valley Fault System.

As the result of the Study, it is concluded that Route 1, which will connect the Lower Bicutan and South Parañaque rivers, and Route 3 which will connect the Sucat and Zapote rivers, are feasible. Route 1 and Route 3, which are based on Route A and Route D studied in the comprehensive flood management plan, are examined in detail at the pre-F/S level. These routes are as outlined in Table 3.1 and Figure 3.1.

Table 3.1 Specifications of Parañaque Spillway

Item		Route 1	Route 3
Design discharge (= River planning discharge)		200 m^3/s	
Tunnel	Length Diameter	6.0 km 12 m	8.8 km 12 m
Open Channel	Length Diameter	1.2 km 46 m	0.6 km 46 m
Intake Facility (Vertical Shaft)	Diameter Depth	31.6 m 75.1 m～81.1 m	
Outlet Facility (Vertical Shaft)	Diameter Depth	31.6 m 77.3 m～83.3 m	

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

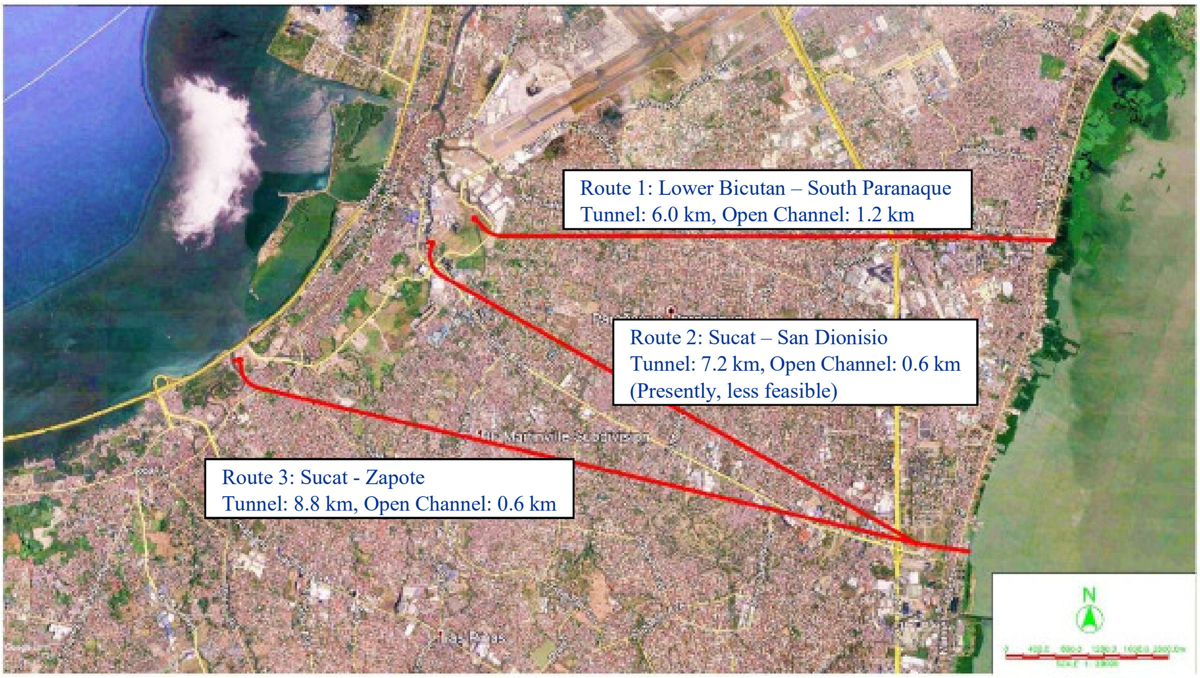


Figure 3.1 Alignment Plan of Parañaque Spillway (Pre-F/S)

3.2 Construction Method

1) Conditions

Construction methods were studied for the Route 1 and the Route 3 under the conditions summarized in Table 3.2.

Table 3.2 Conditions of Study for Route 1 and Route 3

Item	Condition
Soil	The results of survey conducted at 6 different locations show that there is a tuff layer at 50m in depth where the tunnel is planned. Further and more surveys are necessary for evaluation, but this study assumes that overburden of the tuff layer is sufficient for the tunnel throughout the whole route.
Underground Water Level	The results of the survey show that GL is -3m to -5m. Taking the safe side, this study adopts the GL.
Tunnel Inner Space	Diameter of inner space for circular cross-section is 12m (Approx. 113m^2)
Tunnel Length	Route 1: 6.0km; Route 3: 8.8km
Tunnel Overburden	There is no limitation against overburden under the road area, but 50m or more of overburden should be secured without concerning surface rights, so that the route between Laguna de Bay and Manila Bay can be planned freely.

2) Construction Method

The Shield Tunnelling Method and the NATM, which are non-open cut methods, were studied as the tunnelling method on the ground. Since there was not enough information about soil condition at the excavated area and underground water flow, the shield tunnelling method which could be applied to both weak soil and hard rock is selected as the basic method. NATM is also worth to be proposed with geological survey and the applicable construction period in the future study. Construction methods for vertical shafts with diameter of 30 m and depth of 70 m or deeper are the RC Diaphragm Wall Method and the Open-Caisson Method. In this Study, the Open-Caisson Method is selected.

3.3 Preliminary Cost Estimate

1) Conditions of Project Cost Estimate

The Project Cost of the Parañaque Spillway was preliminary estimated under the following conditions for the four options:

- The detailed design and procurement of Consultant will proceed concurrently after obtaining the ICC, signing of the Exchange of Notes (E/N) and Loan Agreement (L/A), while procurement of the Contractor is scheduled in 2021.
- Construction Project: Parañaque Spillway

  Option 1 : Route 1, Shield Tunnelling Method: January 2022 to February 2030
  Option 2 : Route 1, NATM: January 2022 to January 2031
  Option 3 : Route 3, Shield Tunnelling Method: January 2022 to August 2030
  Option 4 : Route 3, NATM: January 2022 to June 2032

The project cost shown here is re-examined at the Pre-F / S level, which is different from the values in Table 2.7 and Table 2.8.

2) Project Cost Estimate (Pre-F/S)

The preliminary cost estimate results for each case are as shown in Table 3.3. It should be noted that river improvement plans are required for rivers such as the South Parañaque and Zapote rivers where the outlet of the Parañaque Spillway is to be connected. The costs and benefits need to be separately studied.

Table 3.3 Project Cost (Pre-F/S)

Cost Items	Work Items	Option 1 (million Pesos)	Option 2 (million Pesos)	Option 3 (million Pesos)	Option 4 (million Pesos)
Construction Cost (Route 1, Shield Tunnelling Method)	Tunnel	17,879	11,707	24,258	16,839
	Vertical Shafts	11,940	9,899	11,940	9,899
	Open Channel	4,544	4,544	3,412	3,412
	River Improvement	2,382	2,382	596	596
	Surplus Soil Disposal	1,828	1,828	1,937	1,937
	Sub-Total	38,573	30,360	42,143	32,683
Engineering Cost		3,857	3,036	4,214	3,268
Price Escalation		4,022	3,645	4,359	4,218
Contingencies		4,645	3,704	5,090	4,017
Land Acquisition and Compensation Costs		1,352	1,352	1,316	1,316
Project Administration Cost		1,049	842	1,146	910
VAT		6,294	5,052	6,876	5,460
Total (million Pesos)		59,792	47,991	65,324	51,873

Table 3.4 Operation and Maintenance Cost (Pre-F/S)

Item	Cost Items	O&M Cost (PHP million) Route 1	O&M Cost (PHP million) Route 3	Reference
Parañaque Spillway	Operation cost of drainage pump	1.3	1.6	
	Maintenance cost of hydro-mechanical facilities	17.9	17.9	1.0% of Mechanical Cost
	Maintenance cost of underground tunnels	142.9	201.8	0.5% of Civil Works Cost
	Sediment removal and cleaning of spillway tunnel	13.6	16.6	
	Sub-Total	175.7	237.9	

3.4 Project Evaluation

1) Economic Analysis

Since the benefit of increase of land prices and re-use of surplus soil have wide range of assumptions, it is calculated here as a reference value. Main quantified benefits are as summarized below:

Benefit (1) Reduced economic damage induced by inundation
Benefit (2) Increase of land price (Reference Value)
Benefit (3) Re-use of surplus soil (Reference Value)

In the Study, the following three cases were studied:

Case 1 Only Benefit (1)
Case 2: Benefit (1) and Benefit (2)
Case 3: All Benefits [Benefits (1), (2) and (3)]

Table 3.5 Results of Economic Analysis (Pre-F/S)

Benefit Case	Cost Option	EIRR	B/C	NPV (million PHP)
Case 1	Option 1 (Route 1, Shield)	9.1%	0.87	-3,181
	Option 2 (Route 1, NATM)	10.4%	1.06	1,109
	Option 3 (Route 3, Shield)	8.3%	0.76	-6,279
	Option 4 (Route 3, NATM)	9.6%	0.95	-1,062
Case 2 (Reference Value)	Option 1 (Route 1, Shield)	10.1%	1.02	420
	Option 2 (Route 1, NATM)	11.5%	1.23	4,383
	Option 3 (Route 3, Shield)	9.2%	0.89	-3,005
	Option 4 (Route 3, NATM)	10.6%	1.10	1,914
Case 3 (Reference Value)	Option 1 (Route 1, Shield)	10.7%	1.11	2,511
	Option 2 (Route 1, NATM)	12.3%	1.38	6,474
	Option 3 (Route 3, Shield)	9.7%	0.96	-914
	Option 4 (Route 3, NATM)	11.4%	1.22	4,005

Considering the other qualitative benefits where the impact on society was not quantified in economic value, the project is thought to be at the economically viable level in all options.

2) Economic Analysis of the Project with Pasig-Marikina Flood Mitigation Project

During flood of Pasig - Marikina River Basin, a flood flow of up to 2,400 m^3/s flows into Laguna de Bay through Mangahan Floodway. Peak discharge of Pasig - Marikina River is reduced by this diversion through Mangahan Floodway. It is the most important measure of the Pasig - Marikina River flood mitigation plan. Meanwhile, lakeshore area of Laguna de Bay is inundated due to flood flow from Marikina River. The flood management plan of lakeshore area of Laguna de Bay consisting of Parañaque Spillway should be dealt with Pasig - Marikina River flood mitigation project.

The cost and benefit of the river improvement project given in "The Preparatory Survey for Pasig Marikina River Channel Improvement Project (Phase III), October 2011" and the assumed cost and benefit of the on-going Marikina Dam and Retarding Basin projects, as well as the cost and benefit of the Parañaque Spillway estimated in the survey, were used. The results of analysis are as shown in Table 3.6.

Table 3.6 Results of Economic Analysis of Pasig-Marikina Flood Mitigation Project and Comprehensive Flood Management Project of Laguna Lakeshore Area

Combination of Project	EIRR	B/C	NPV (million PHP)
1. Pasig-Marikina River Improvement Project, Phase II, III and IV	28.6%	4.5	27,391
2. Pasig-Marikina River Improvement Project, Phase II, III and IV + Parañaque Spillway	26.8%	3.1	27,708
3. Pasig-Marikina River Improvement Project, Phase II, III and IV + Marikina Dam and Retarding Basin + Parañaque Spillway	26.1%	2.8	28,285

3) Environmental and Social Considerations

The projects would cause various types of environmental and social impacts. It is anticipated that the construction of project facilities on the ground surface including intake facility, open channel, drainage facility, etc., would require land acquisition and the resettlement of 300 households at the maximum, although construction of the underground spillway proposed at the depth of more than 50 m from the ground surface does not require any land acquisition and compensation in accordance with the legislation of the Philippines (RA No. 10752). Generation of solid waste is estimated to be enormous, consisting of debris of demolished structures and facilities for the construction of project facilities. The volume of excavated materials from tunneling works for underground spillway is estimated at 2 million cubic meters at the maximum. It is, therefore, indispensable to pay attention to these potential impacts, and to provide the necessary mitigation measures through the formulation of an Environmental Management Plan (EMP).

4. Conclusion and Recommendation

4.1 Conclusion

In this study, the comprehensive flood management plan of Laguna de Bay Lakeshore Area including Pasig Marikina River Basin was compiled and the Pre-F/S of the Parañaque Spillway, which was approved as a priority project by the 4th Steering Committee Meeting held on 23 January 2018, has been executed. In this survey, there were two routes for the Parañaque Spillway and two types of tunnel construction methods for the underground spillway (Shield Tunnelling Method and NATM). Those routes and construction methods were mixed and EIRRs were calculated.

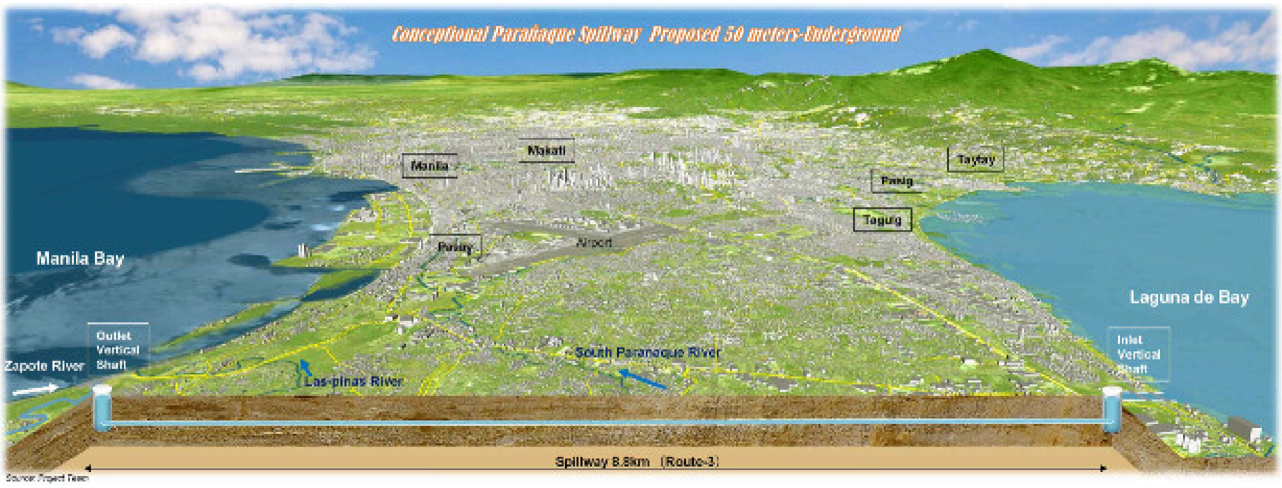


Figure 4.1 3-Dimensional Image of Parañaque Spillway

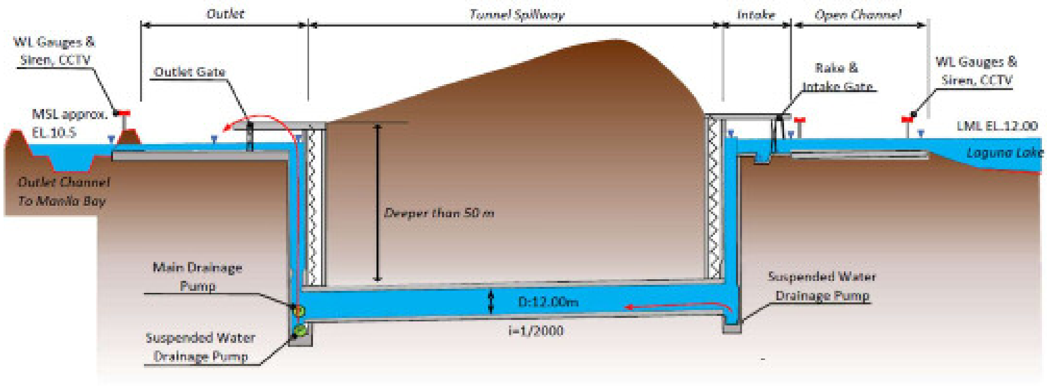


Figure 4.2 Schematic View of Parañaque Spillway

The results of the Pre-F/S show that EIRR is more than 10% for Parañaque Spillway alone, and EIRR is more than 20% if combined with flood mitigation project of Pasig-Marikina River Basin. The results suggest that the Parañaque Spillway project is feasible.

4.2 Recommendation

This project was conducted in a short and limited time (approximately in 9 months, from August 2017 to April 2018) to formulate the comprehensive flood management plan and implement Pre-F/S of the Parañaque Spillway. Therefore, although the Parañaque Spillway project was concluded as feasible in Pre-F/S, the F/S is urgently needed based on the additional investigation shown in below.

＜Contents to be included in the F/S ＞

1. Topographic survey
2. Sounding survey (Laguna de Bay)
3. Longitudinal and cross-sectional river survey and evaluation on the effect to the downstream rivers
4. Borehole drilling survey
5. Hydraulic model experiment
6. Diffusion analysis of discharge from the Parañaque Spillway
7. Environment Impact Assessment (EIA) and Preparation of the Resettlement Action Plan (RAP)

At the Laguna de Bay lakeshore area, there are many low land areas evenly spread around the lake. Those areas are suffered from the inundation lasting for more than one month. Despite the urbanization of the lakeshore area, the provision of flood management measures in the Laguna de Bay lakeshore areas has lag behind compared to the center of Metro Manila, so that catastrophic flooding disaster may strike there. Therefore, it is recommended to the Philippine Government to conduct the F/S on the Parañaque Spillway and to take an immediate action for the implementation of the Parañaque Spillway project which contributes to the mitigation of the flood damage in the entire Laguna de Bay lakeshore area.

LOCATION MAP

DATA COLLECTION SURVEY
ON PARAÑAQUE SPILLWAY
IN METRO MANILA
IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

VOLUME 1: MAIN REPORT

TABLE OF CONTENTS

LIST OF TABLES

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

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

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 Express Way 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
PHIVOLCS	Philippine Institute of Volcanology and Seismology
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

CHAPTER 1. PROJECT OUTLINE

1.1 Background

The Philippines is one of the countries where the most natural disaster occurs in the world. The Metro Manila is political, economic and cultural center of the Philippines, but the area is located in the lakeshore lowland area where is susceptible to typhoons/storms and floods, and the economic and social activities in the area have been seriously affected by floods. The Philippine government has been continuously addressing this problem for over 50 years through the development and implementation of the flood control; however, the Metro Manila has not yet had enough capacity to respond flood events.

In the Philippines Mid-Term Development Plan (2017-2022), the Philippine government has stated that continuation of the initiative to reduce flood risks, specifically, conducting to update the design and maintenance standards of the flood control facilities, to develop the river information data base and update the baseline data for the flood plain designation, to update and develop the flood control plan and drainage plan for the major 18 river basins and other important river basins, improve the coordination capacity of river management.

For over 40 years since 1970s, Japan has provided wide-ranging supports, including the preparation of flood control plans targeting mainly the Metro Manila and major rivers, and the implementation of the ODA loan projects, and the technical assistance to the central government agencies. Regarding river floods, after the Mangahan Floodway was completed in 1988, JICA has implemented “Study on Flood Control and Drainage Project in Metro Manila” from 1988 to 1991, and selected “Pasig-Marikina River Channel Improvement Project” as a project with high urgency for the flood management measure of the Pasig-Marikina Rivers. Through feasibility study (F/S) and former international cooperation bank’s Special Assistance for Project Formation (SAPROF), JICA declared a policy to implement the project in four phases. Currently, the permanent works of Phase III (L/A signed in 2011) is in progress.

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

In addition, as measures against floods which are causing by the inland inundation and lake water level rise in the western Mangahan District located in the Metro Manila area and its surrounding area of Laguna de Bay (Basin area is 2,920 km^2 and lake surface area is 900 km^2), JICA has supported the detailed design work of the Eastern and Western Mangahan Districts through the ODA loan project “North Laguna Lakeshore Urgent Flood Control and Drainage Project (L/A signed in 1989)” and also supported the construction of lakeshore dikes, construction of drainage facilities and installation of drain gates in the western Mangahan District through the ODA loan project "Metro Manila Flood Control Project – West of Mangahan Floodway (1997~2007)".

However, Typhoon Ondoy, hit in September 2009, recorded the daily rainfall of 453 mm which caused massive flood damage in the area along the Marikina River and around the Laguna de Bay Lakeshore areas as well as the Metro Manila. In the West Mangahan District located in the Laguna de Bay Lakeshore areas where measures were implemented in the project of "Metro Manila Flood Control Project – West of Mangahan Floodway", about 80% of low-lying residential area inundated over 1 to 3 weeks due to the influence of flooding caused by the overflowing from the Marikina River, inland inundation and the water level rise of Laguna de Bay. In the Laguna de Bay Lakeshore areas, low-lying areas without the flood management measures are wide spread and the area has experienced inundation damages for more than one month. The flood control measures in the Laguna de Bay Lakeshore areas is behind as compared to the one implemented in the center of Manila, and the flood management measures are urgent matters to be addressed.

Moreover, the Department of Public Works and Highways (DPWH) in the Philippines plans "Laguna Lakeshore Express Way Dike Project (LLEDP)" as a PPP project to reclaim the area located in the west bank of Laguna de Bay, construct roads and implement urban development. For the implementation of this project, measures against floods in the Laguna de Lake lakeshore area are required. As the flood management measures of the Laguna de Bay Lakeshore areas, several measures are considered including to construct lakeshore dikes, drainage channel and drainage facilities, as well as to drain the lake water from Laguna de Bay to Manila Bay through the Parañaque City and to construct the floodway (hereinafter referred to as "Parañaque Spillway") in order to control the water level of Laguna de Bay. Since it is difficult to acquire the land of the Parañaque City where urbanization is in progress, the underground channel with the length of about 9.2 km is considered instead of the open-cut type. To examine the feasibility of the Parañaque Spillway, DPWH requested JICA to support them with the survey implementation.

1.2 Objectives

The objectives of this project are to analyze Laguna de Bay basin including the Pasig-Marikina River basin in a unedified manner while aligning with the existing flood control projects and plans, to prepare the comprehensive flood control plan of the entire Laguna de Bay Lakeshore areas and conduct the Pre-F/S of the Parañaque Spillway as part of the comprehensive flood control plan, to conduct collection and confirmation of information to examine the feasibility of the JICA's ODA loan assistance project and the direction of the preparatory survey.

1.3 Project Description

Outline of the Survey is described as follows.

(1) Study Area

The entire Laguna de Bay Lakeshore areas in the Philippines (Metro Manila area and surrounding area)

(2) Counterpart Agency

- Department of Public Works and Highways (DPWH)

(3) Related Government Offices and Authorities

- Lake Laguna Development Authority (LLDA)
- Metro Manila Development Authority (MMDA)
- National Economic and Development Authority (NEDA)
- Department of Interior and Local Government (DILG)
- Department of Environment and Natural Resources (DENR)
- Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA)
- Philippine Institute of Volcanology and Seismology (PHIVOLCS)
- Local Government Unit (LGU)

(4) JICA's Major Assistances related to this Project

(a) Development Study

- Study on Flood Control and Drainage Project in Metro Manila (1991)

(b) ODA Loan

- Metro Manila Flood Control and Drainage Project (1973~)
- Metro Manila Flood Control Project - West of Mangahan 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 ~ Present)

(c) 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)

1.4 Schedule of This Survey

The schedule of the Survey is shown in Table 1.4.1.

Table 1.4.1 Schedule of the Survey

Work Items \ Period	2017 Jul	Aug	Sep	Oct	Nov	Dec	2018 Jan	Feb	Mar	Apr	May	Jun
【A】 Domestic Preparation Works and Consultation of IC/R with JICA												
【A-1】 Domestic Preparation Works and Consultation of IC/R with JICA	□	■										
【B】 Comprehensive Flood Management Plan of Laguna de Bay Lakeshores Area												
【B-2】 Collection and Consolidation of Basic Data		■	■									
【B-3】 Collection of Past Flood Damage and Information		■	■									
【B-4】 Evaluation of the Existing Flood Control Plan and Activities		■	■									
【B-5】 Rainfall Analysis												
1) Collection of Material and Study on Preconditions of the Analysis		■										
2) Hydrological Probability Analysis		■										
【B-6】 Set of Target Return Period and Target Rainfall												
1) Set of Target Return Period		■										
2) Set of Target Rainfall		■										
3) Comparison with Other Flood Management Projects on the Targett Return Period		■										
4) Climate Change Analysis		■										
【B-7】 Set of Target Sea Level of Manila Bay		■										
【B-8】 Runoff Analysis and Inundation Analysis of Entire Laguna Lake Basin Including Pasig-Marikina River Basin with Analysis of Lake Water												
1) Construction of Hydraulic Model for Entire Laguna Lake Basin Including Pasig-Marikina River Basin		■	■									
2) Validation of the Hydraulic Model with Existing Flood Record			■									
3) Hydraulic and Inundation Analysis with Target Rainfall			■									
4) Comprehension of the Tendency and Causes of Water Level Rising and Drawdown with Paranaque Spillway at Laguna de Bay			■	■								
【B-9】 Proposal of Design Criteria		■	■									
【B-10】 Proposal of Evaluation Criteria For Comprehensive Flood Management Plan of Laguna de Bay Lakeshores Area			■	■								
【B-11】 Preliminary Survey of Non-Structural Measures			■	■								
【B-12】 Proposal of Full Menu of Comprehensive Flood Management Plan of Laguna de Bay Lakeshores Area (Primary Step)			■	■								
【B-13】 Preliminary Environmental and Social Analysis and Examination			■	■								
【B-14】 Proposal of the Appropriate Project Evaluation Methods				■	■							
【B-15】 Formulation of Comprehensive Flood Management Plan of Laguna De Bay Lakeshores Area (Secondary Step)				■	■							
【B-16】 Selection of Priority Projects					■							
【B-17】 Proposal of Implementation Framework and Operation and Maintenance Framework of Priority Projects				■	■							
【B-18】 Preparation and Submission of IT/R and Discussions with Related Officers				■	■	■						
【C】 Pre-Feasibility Study of Paranaque Spillway												
【C-19】 Basic Design of Major Structure Works and Design Standard Including Examination of the Possibility of Utilizing Japanese Technologies						■	■	■				
【C-20】 Procurement and Construction Plan								■				
【C-21】 Operation and Maintenance Cost								■				
【C-22】 Environment and Social Consideration								■	■			
【C-23】 Rough Project Cost Estimation and EIRR								■	■			
【C-24】 Overall Project Schedule of the Paranaque Spillway								■	■			
【C-25】 Verification of the Effectiveness of the Paranaque Spillway Project									■			
【C-26】 Confirmation of the Burden by the Philippines side									■			
【C-27】 Preparation and Submission of DF/R and Discussion with Related Officers							■	■	■			
【C-28】 Preparation and Submission of F/R									■	■	■	
Discussion and Submission of the Report												
Report		Δ IC/R					Δ IT/R		Δ DF/R		Δ F/R	

CHAPTER 2. GENERAL CONDITIONS OF TARGET AREAS

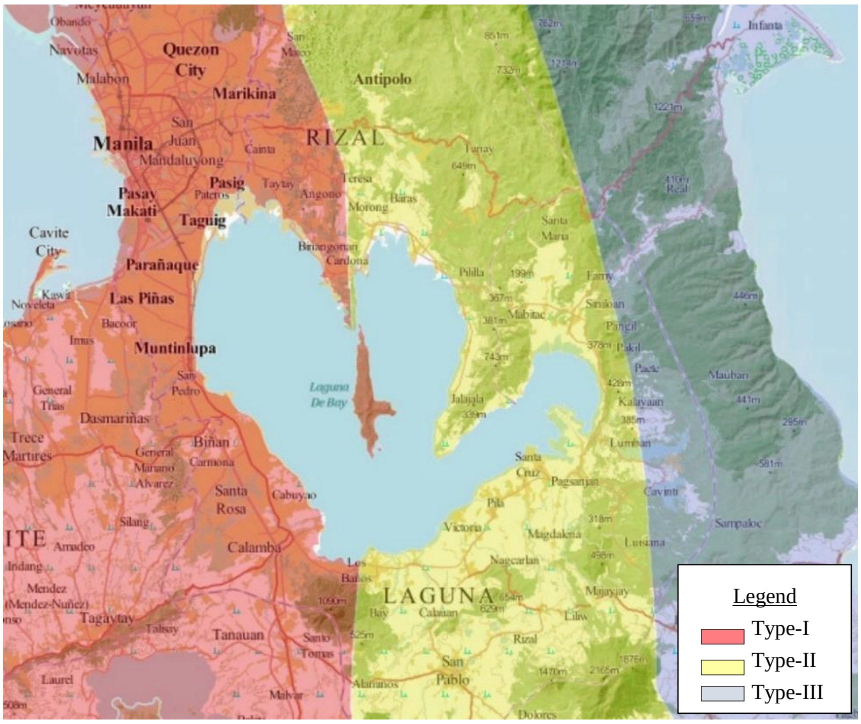
2.1 General Conditions

2.1.1 Natural Condition

(1) Climate

Climate in the survey area is affected by several climate phenomena such as monsoon, trade winds[1] and typhoons and is especially characterized by the typical dry season (November to April) and the rainy season (May to October) in the west of Laguna de Bay. Annual rainfall in the survey area varies from about 1,700 mm to about 3,000 mm, depending on the area. In the past, there are also years in which annual rainfall exceeds 5,000 mm in the Pakil Observatory (in Laguna Province).

PAGASA divides the entire Philippines into four climate types, and the survey area belongs to three climate types (see Figure 2.1.1). Type I, which encompasses Metro Manila and the west side of Laguna de Bay, is characterized by the typical dry season (November to April) and the rainy season (May to October) as mentioned above, with concentrated precipitation from June to September. The eastern half of Laguna de Bay belongs to Type II and there is no conspicuous dry season; rainfall decreases from March to May, and it tends to rain from December to February. Finally, on the Pacific side of Laguna de Bay, Type III climate can be seen. There is no distinct rainy season in this area, and the dry season can only be seen for about 1 to 3 months.



Source: Designed with http://www.geoportal.gov.ph/viewer/

Figure 2.1.1 Climate Categories by PAGASA

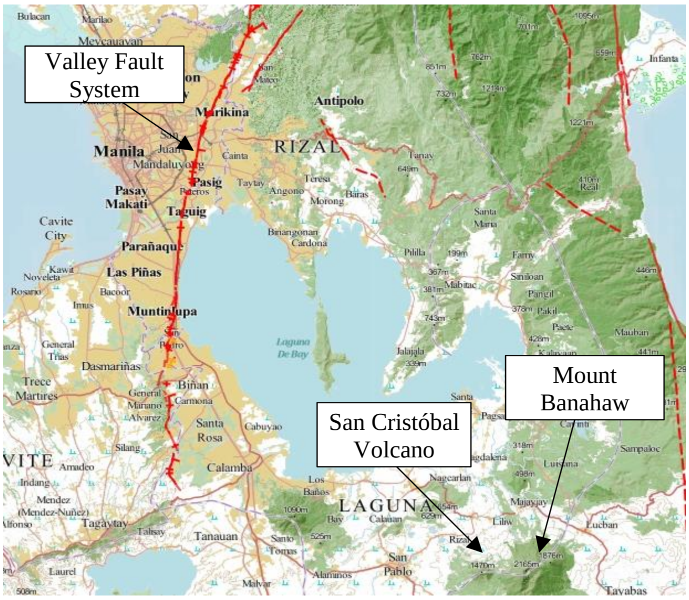
[1] The trade winds are the prevailing pattern of easterly surface winds found in the tropics.

According to the meteorological observation data around the survey area, the monthly average temperature varies from 24°C in December and January to 30°C in August and September, and from 26.5°C to 28°C in annual average. In addition, humidity changes with rainfall trend in the survey area: relative humidity rises during the rainy season from May to October and the highest value is recorded from July to August, when the southwestern monsoon is dominant at the west side of Laguna de Bay. In addition, relative humidity decreases during the dry season from November to April, when the influence of the northeast monsoon and the trade winds are strong, and the lowest value is generally recorded between March to April. Tropical cyclones cause the flooding that occurs most influentially in the survey area. Many tropical cyclones occur from June to October. There are 20 annual cyclones in the Philippines, and 16 of these cyclones pass through Central Luzon where the survey area is located. Due to strong winds and torrential rains, tremendous damage to human life and properties has occurred. According to PAGASA, the tropical cyclone is classified with maximum wind speed of 35 to 64 km per hour, tropical storm of 65 to 118 km per hour and typhoon of 119 km per hour or more.

In recent years, several typhoons and southeast monsoons caused water level rise in Laguna de Bay resulting in large flood damage. Among them, the major ones are Typhoon Edeng (International Name: Susan) and Typhoon Gloring (International Name: Rita) which was appeared at the same time with Typhoon Eden in July 1972, Typhoon Kading (International Name: Rita) in October 1978, Typhoon Unsang (International Name: Ruby) in October 1988, Typhoon Ondoy (International Name: Ketsana) and Typhoon Pepeng (International Name: Parma) in September 2009, and the tropical southwest monsoon in August 2012. Typhoon Ondoy and Typhoon Pepeng in 2009 caused the most severe floods and damage.

(2) Topography and Geology

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 900 km^2, 1.3 times as large as Lake Biwa, which is the largest lake in Japan. From the northwest to the west of the Survey area, flatlands spread, becoming commercial and residential densely populated areas. The southeastern part is a flat land mainly used for agriculture. Mountainous regions are seen from the



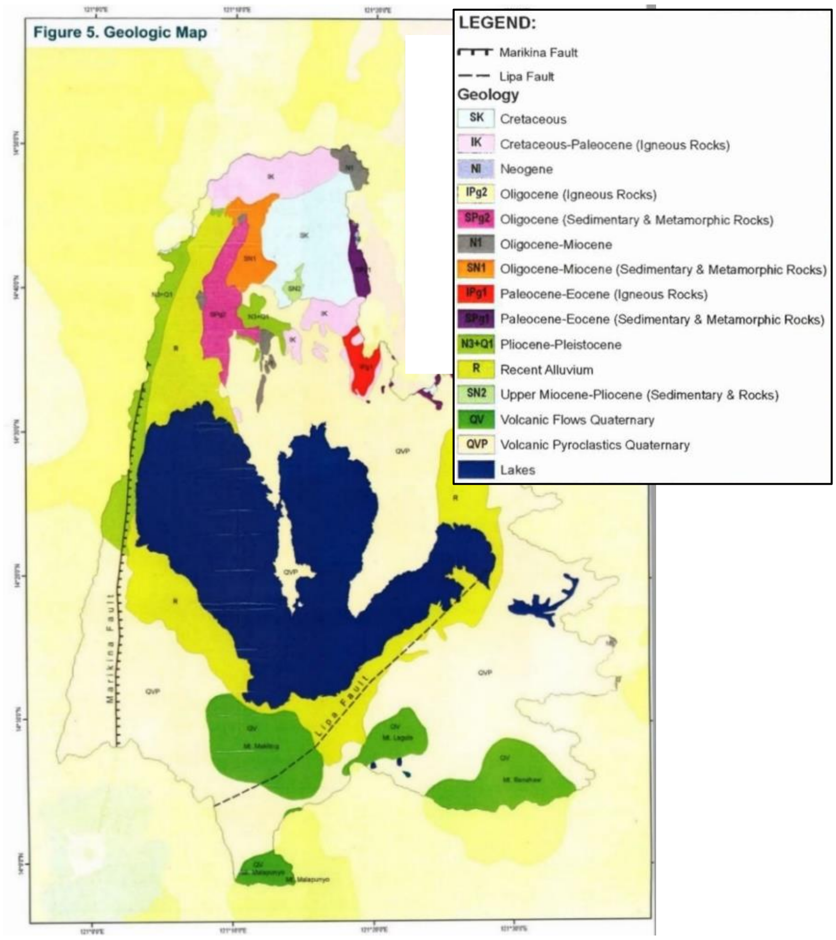
Source: Fault Finder, PHIVOLCS

Figure 2.1.2 Topographic Map of the Survey Area

northeast to the north and in the south. Among these mountains there are active volcanoes such as Mount Banahaw (2,169 m) and potentially active volcanoes such as Mount San Cristobal (1,470 m). 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.

According to the geological map (see Figure 2.1.3) published in the "Hydrologic Atlas of Laguna de Bay, 2012", the geology of the survey 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 2.1.3 Geology in the Survey Area

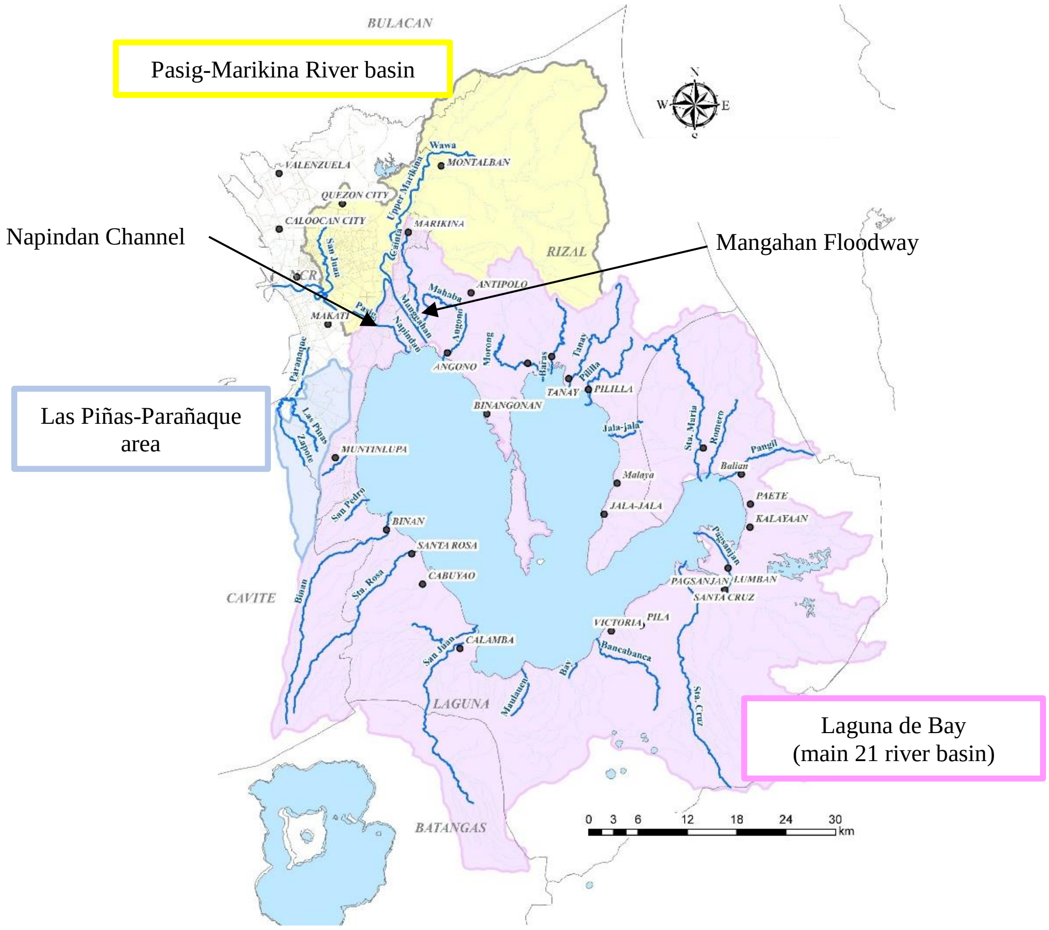
In addition, according to the "Geology of the Philippines, Second Edition", the hilly land between Laguna de Bay and Manila Bay, which is also a candidate site for the Parañaque Spillway route is regarded as Guadalupe Formation of Pleistocene. It is inferred that so-called soft rocks consisting of volcanic 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: JICA Survey Team

Figure 2.1.4 Rock Exposure (along Gen. Santos Street at the south of Taguig City)

(3) River System

The river system in the survey area consists of the three systems: the Laguna de Bay basin consisting of the main 21 rivers flowing directly into Laguna de Bay; the Pasig-Marikina River basin connected to Laguna de Bay by the Mangahan floodway and Napindan channel; and the water systems of Las Piñas Parañaque area flowing down to Manila Bay. The location and catchment area of each water system are shown in Figure 2.1.5 and Table 2.1.1. Details of each river systems are described in Chapter 3.



Source: JICA Survey Team

Figure 2.1.5 River System at Survey Area

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
Las Piñas-Parañaque Area	74

Source: JICA Survey Team

2.1.2 Economy

(1) Local Government and Population

According to the Census in 2015, the total population of the Philippines is 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). The population of each region in 2015 are 12,877 thousand and 14,415 thousand which is 12.8% and 14.3% of 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 2.1.2 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%

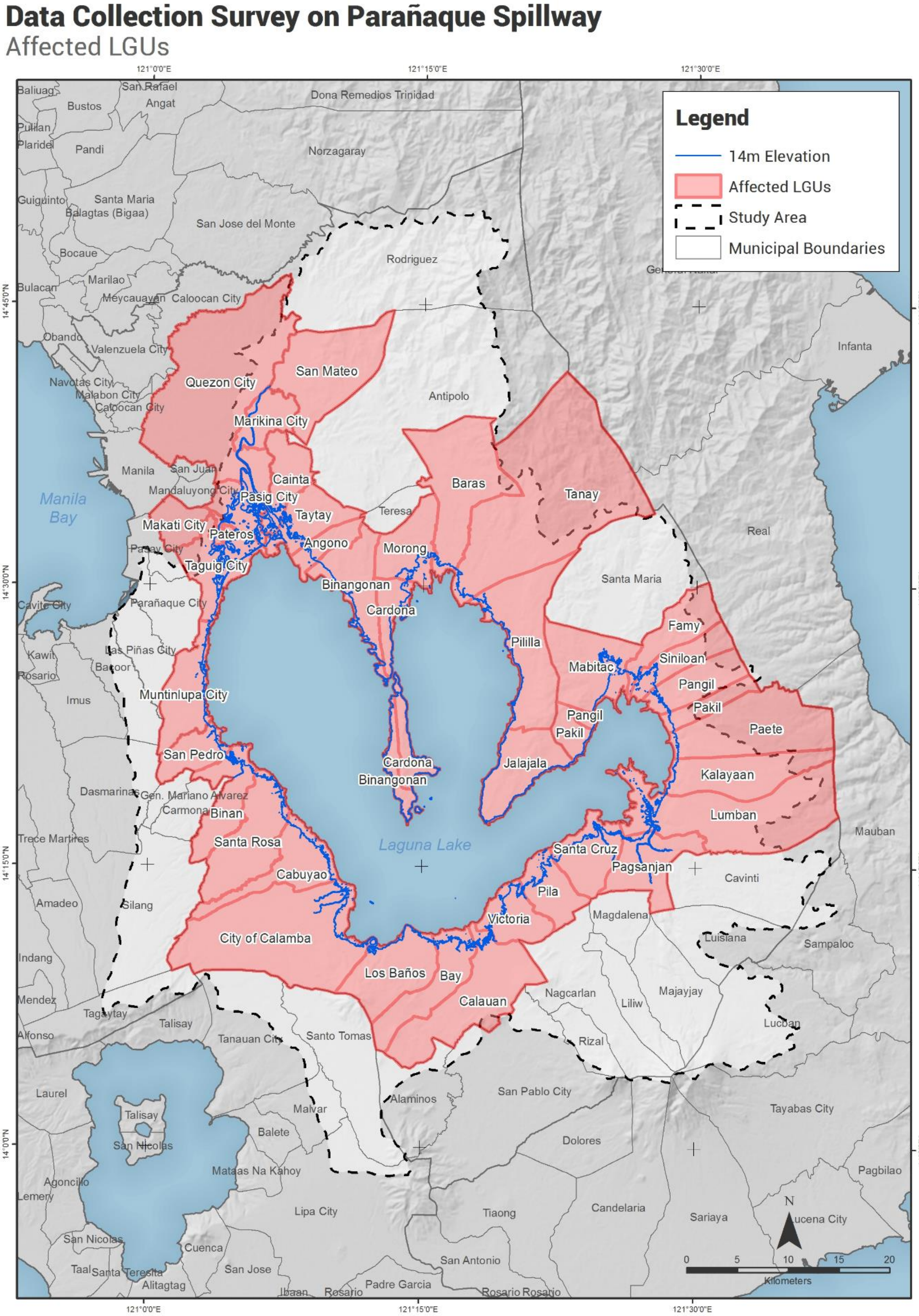
Source: NSO, 2015 census

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 2.1.3 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; JICA Survey Team



Source: NAMRIA

Figure 2.1.6 Location Map of Cities and Municipalities in the Study Area

(2) Economy and Industry

Economy in the Philippines is developed satisfactorily, and the total GDP achieved PHP 14,481 billion in 2016. Annual increase rate of GDP was ensured high at 5.4% in 2014 and 8.7% in 2015. Shares of the regional GDP in NCR and Region IV-A are 38.1% and 14.8% respectively. GDP amount of two regions take majority of the national GDP, and it clearly shows the importance of the 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 take higher share in NCR. In Region IV-A, industrial sectors of manufacturing, real estate, trade, transportation and communication have higher share. In both regions, share of the primary sector (agriculture, forestry, mining, etc.) is low as less than 5% of total regional GDP.

Table 2.1.4 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

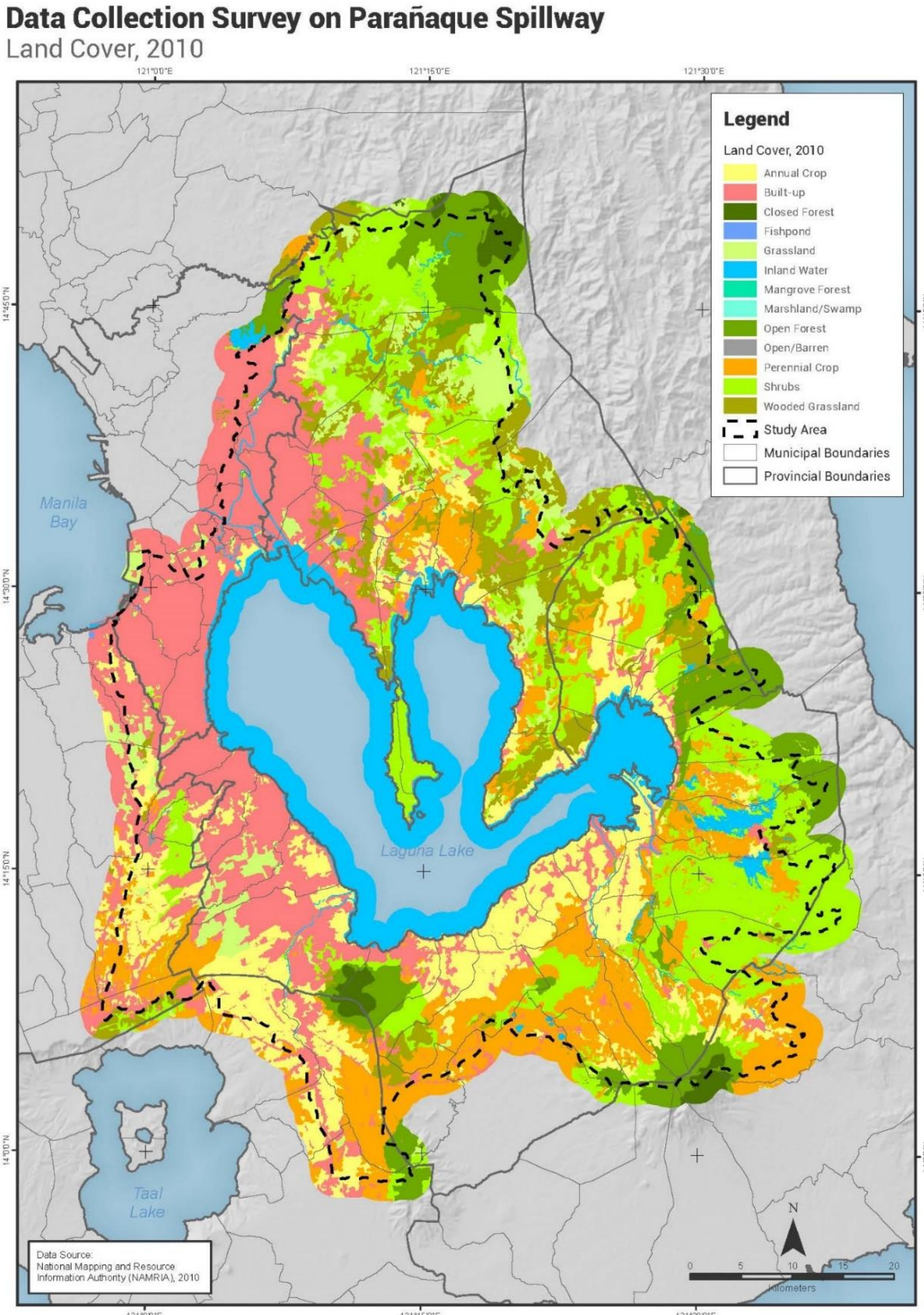
Source: Gross Regional Domestic Product 2014-2016 (as of May 2017), NSO

(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 as follows.

As seen on the land use map, the northwest area of Laguna de Bay, where Metro Manila is located, is mainly covered by a Built-Up area. The 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 area. In Region IV-A, annual crop and perennial crop area takes a majority of the land. Land area of shrubs, open forest and built-up area are also shown in this table.



Source: Land Use Map, NAMRIA, 2010

Figure 2.1.7 Land Use Map of the Study Area

Table 2.1.5 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

Source: NAMRIA, 2010, analyzed by JICA Survey Team, unit: m^2

(4) Outline of Land Use in Lakeshore Area

The coastal area of Laguna de Bay, which extends about 220 km, is used for residential areas, industrial and commercial areas, and agricultural lands. The current land use is classified into two areas, the eastern area of the lake is used for agriculture whereas the western part is used for residential areas and commercial - industrial areas. An overview of the land use situation of the Laguna de Bay lakeshore area is shown in Table 2.1.6.

The residential areas are located on the ground above EL.12.0 m, especially many residential areas are located above EL.12.5 m. The center of LGUs in the eastern part of the lake coast, where many farmlands, is located in a relatively high elevation area.

Table 2.1.6 Outline of Land Use in Lakeshore Area

No.	Region	Applicable LGU	Land Use Situation
1	Northern Lake Shore	Taguig City Taytay, Angono	Residential areas and commercial/industrial areas are spreading from the area in Metro Manila (Taguig) or the surrounding area of Metro Manila. On the coast in Taguig City and Taytay Town, there is a lake shore dyke (the length of about 10km) as the Laguna de Bay flood control measure.
2	Eastern Lake Shore	Binagonan, Cardona, Morong, Baras, Tanay, Pililla, Jalajala, Mabitac, Famy, Siniloan, Pangil, Pakil, Paete, Kalayaan, Lumban, Sta. Cruz, Pila, Victoria, Calauan	On the eastern lake shore, mountainous regions and narrow/wide flat lands are mixed. In Tanay Town, Baras Town and Morong Town located in the northern part of the eastern region, three major rivers are flowing into the lake and the wide flat land is used for paddy fields. In Cardona Town and Binagonan Town located in the northwest side of the eastern region, the mountains are approaching to the lake shore. In addition, in Jalajala Town and Pililla Town located in the eastern center region, the mountains are approaching to the lake shore. In the northeastern part of the eastern region, three major rivers are flowing into the lake and paddy fields are located. In the east side of the eastern region, the mountains are approaching, and the narrow lake shore is utilized for residential areas and farmland. The south side of the eastern region, there are two major rivers and the wide flat lands are irrigated for paddy fields. Sta. Cruz Town, the capital city of Laguna State, with a population of 200,000 is located.

No.	Region	Applicable LGU	Land Use Situation
3	Southern Lake Shore	Bay, Los Banos, Calamba City	A volcano of 1,090m is located on the south side, and the mountains are approaching the lake, and the shore areas are narrow. There are residential areas. There are many inflow rivers.
4	Western Lake Shore	Taguig City, Muntinlupa City, San Pedro City, Binan City, Sta. Rosa City, Cabuyao City	It is located in Metro Manila (Taguig and Muntinlupa) or the surrounding area, where highly developed as residential areas, and commercial/industrial areas.

2.2 Laguna de Bay Basin and History of Flood Control Measure

2.2.1 Laguna de Bay Basin

(1) Outline of Laguna de Bay Basin

Laguna de Bay is under jurisdiction by LLDA established in 1969. For the land along Laguna de Bay, Presidential Decree No. 813 (1975) stipulates the elevation of 12.5 m or less as a public land. The coastal area of Laguna de Bay extends about 220 km and the lake area is about 900 km^2. The catchment area is about 3,820 km^2 including the Marikina River Basin (about 540 km^2) is connected by the Mangahan Floodway. More than 100 rivers and drainage canals are flowing into Laguna de Bay.

On the other hand, the natural exit from Laguna de Bay to Manila Bay is only the Napindan River-the Pasig River located on the north bank of the lake. There are 21 river basins as shown in Figure 2.2.1. The features of each major river are summarized in Table 2.2.1.

Table 2.2.1 21 Development Status of 21 River Basins

No.	River Name	Basin Area (km^2)	Major Town along Rivers	Basin Development Status
1	Angono	86.6	Angono	Almost entire basin has been developed. The mountainous area is undeveloped.
2	Morong	95.9	Morong	The Basin is well developed such as cultivated land, residential land, etc.
3	Baras	21.7	Baras	The plain lands in the basin are cultivated land and residential land, etc. and the mountainous area is undeveloped.
4	Tanay	52.2	Tanay	
5	Pililla	40.4	Pililla	
6	Jalajala	70.6	Jalajala	
7	Sta. Maria	202.2	Mabitac, Santa Maria	
8	Siniloan	71.7	Siniloan	
9	Pangil	50.1	Pangil	
10	Caliraya	128.8	—	Catchment areas of Caliraya and Lumot Reservoirs
11	Pagsanjan	301.2	Lumban, Pagsanjan	In the plain lands and the middle river section in the basin, the cultivated lands and residential areas are extended. The upper river section is the mountainous area.
12	Sta. Cruz	146.7	Sta. Cruz City	
13	Pila	89.3	Pila	
14	Calauan	154.5	Bay	
15	Los Banos	102.1	Los Banos	
16	San Juan	191.7	Calamba City	In the plain lands and the middle river section in the basin, the cultivated lands and residential areas are extended. The upper river section is the mountainous area.
17	San Cristobal	140.6	Calamba City	
18	Sta. Rosa	119.8	Sta. Rosa City, Cabuyao City	
19	Binan	84.8	Binan City	
20	San Pedro	46.0	San Pedro City, Muntinlupa City	
21	Muntinlupa	44.1	Muntinlupa City	Residential area, etc. is extended in the entire basin.

Figure 2.2.1 21 River Basins of Laguna de Bay

(2) Hydrological Condition of Laguna de Bay

Due to the inflow from the rivers during the rainy season, precipitation to the lake surface, and evaporation during the dry season, the lake level of Laguna de Bay shows the seasonal fluctuation throughout the year. Generally, the lowest water level is reached from April to May at the end of the dry season, and the maximum water level is reached from September to January of the following year at the latter half of the rainy season. The average minimum water level of the lake is EL 10.8 m, and the average maximum water level is EL 12.4 m. The average minimum water level is almost equal to the average sea level of Manila Bay (about EL 10.5 m). When the tide level is high, the salt water flows up to the lake through the Pasig River – the Napindan River. This backflow continues until the lake water level becomes higher than the sea level.

In the rainy season, the lake water level increases when the inflow amount from the surrounding area and the precipitation to the lake surface exceeds the outflow amount and evaporation from the Napindan River which flow capacity is limited. The flow capacity of the Napindan River is too small to drain rapidly the high-water in Laguna de Bay. The flow capacity of the Napindan River changes according to the water level at the confluence of the Pasig -Marikina -Napindan Rivers, the tide level of Manila Bay and the water level of Laguna de Bay. In the past study, the flow capacity of the Napindan River is estimated to be about 500m^3/s[2] at the maximum.

In Laguna de Bay, brackish water fishery is popular by utilizing the saltwater intrusion phenomenon. In addition, although the amount of the water use is not so large, the lake water is utilized for irrigation water, living water, industrial water, water transportation and recreation. On the other hand, the deterioration of water quality due to the inflow of the domestic drainage is a serious problem.

Moreover, Laguna de Bay is utilized for the flood control measure of the central Metro Manila. It has a temporary storage function by diverting some of the massive flood water from the Marikina River flowing to the Pasig River which flows through the central Metro Manila to Laguna de Bay through the Mangahan Floodway which was completed in 1988. At this time, the Napindan Adjustment Gate located at the confluence of the Napindan River, the Marikina River and the Pasig River is closed. After the flood event in the Marikina - Pasig Rivers, the high water of Laguna de Bay flows down to Pasig River through Napindan channel and the Mangahan Floodway and then flows to Manila Bay (refer to Figure 2.2.2).

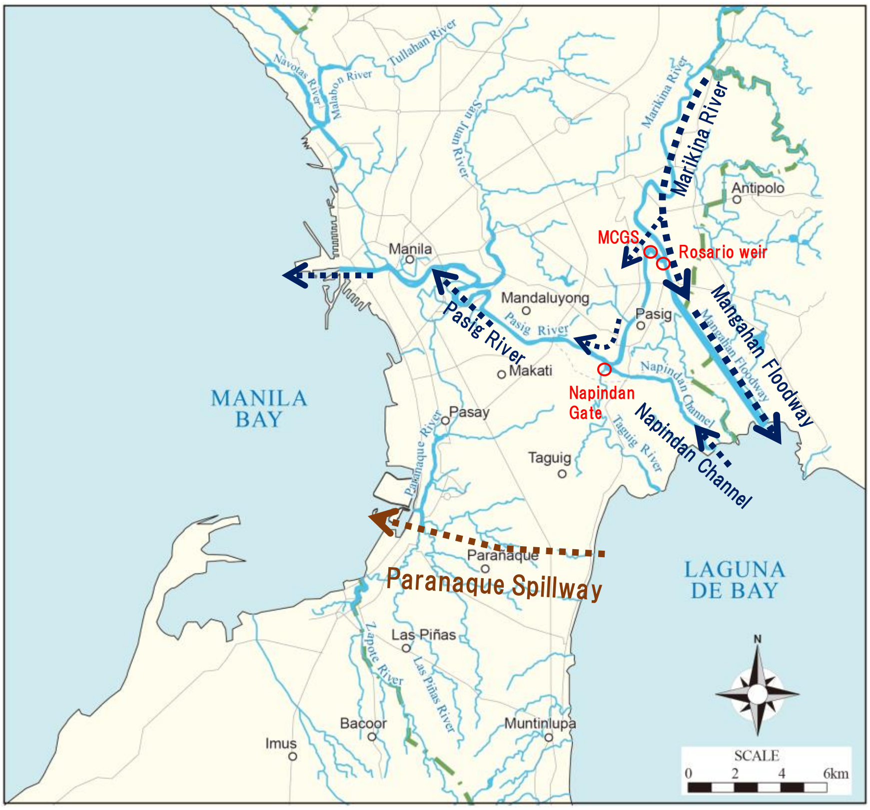


Figure 2.2.2 Hydraulic System of Laguna de Bay, Mangahan Floodway, Napindan Channel

2 Detailed Engineering Design of the North Laguna Lakeshore Urgent Flood Control and Drainage Project,1992

2.2.2 Past Flood and History of Flood Control Measures

(1) Historical Flood Events in Laguna de Bay

In the Laguna de Bay Lakeshore area, the inhabited area is seen at EL 12m and many residents and infrastructures are seen at EL 12.5 m. According to the 71-year records between 1946 to 2016, the peak water level exceeded EL 12m is 47 times, whereas 23 times over EL 12.5m, 10 times over EL 13.0m, 5 times over EL 13.5m, only once over EL 14m. The water level when the media such as newspaper start reporting the flood damage is EL 12.5m or more which occurs once every three years.

Although Laguna de Bay is a large lake where it can store the flood water, the only main river outflowing to the lake is Napindan Channel. Therefore, it is the characteristic of the area that once the water level rises, the high water level continues for a long period, and the extended area is damaged by inundation.

Two typhoons in 2009 (Typhoon Ondoy and Typhoon Pepeng) caused the peak water level of 13.85 m and it took 73 days for the peak level to drop to 12.78 m which was the water level before the water level rise, while the water level was 12.5 m and more for about 108 days.

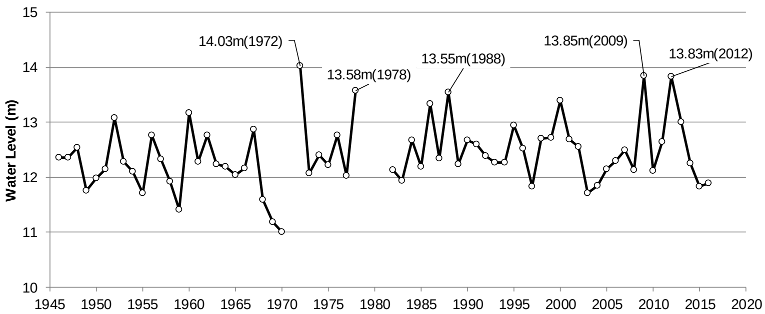


Figure 2.2.3 Annual Maximum Water Level in Laguna de Bay

Table 2.2.2 Major Flood Events in Laguna de Bay

No.	Year	Highest Water Level	Water Level (m) and Period of Days			Maximum 2-day Rainfall in Laguna Lake Basin	First date of the Maximum 2-day Rainfall	Water Level (m)	
			H>12.5	H>13.0	H>13.5			Before the Storm	After the Storm
1	1972	14.03	87	66	39	N/A	N/A	N/A	N/A
2	2009	13.85	108	65	38	286	9/25	12.73	13.77
3	2012	13.83	114	75	27	?	?	?	?
4	1978	13.58	60	42	8	221	10/8	12.46	12.40
5	1988	13.55	48	24	4	189	10/24	12.02	12.97

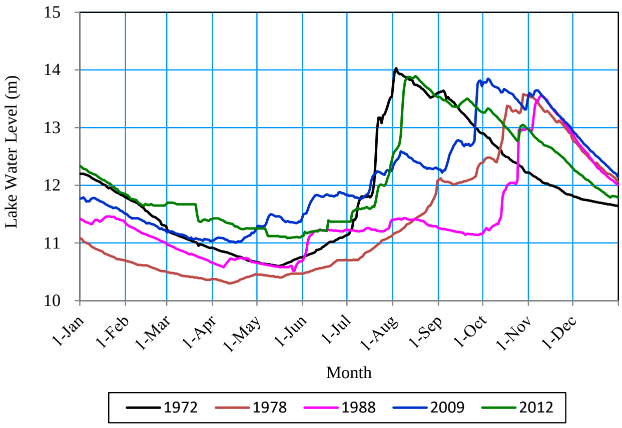


Figure 2.2.4 Water Level of Laguna de Bay in 1972, 1978, 1988, 2009 2012

(2) History of Flood Management in Laguna de Bay

As shown in Table 2.2.3, the necessity of the measures against floods in the Laguna de Bay Lakeshore areas has been recognized since 1970's.

Table 2.2.3 History of Flood Management in Laguna de Bay

First Half of 1970's	The Comprehensive Flood Management Plan for Manila Metro Area and the Laguna de Bay Lakeshore areas was planned (The plan included construction of the Mangahan Floodway and Marikina Control Gate Structure (MCGS) to divert the large volume of flood water from the Marikina River to Laguna de Bay, construction of the Napindan Hydraulic Control Gate, and construction of the Parañaque Spillway and improvement of the Pasig-Marikina Rivers to reduce the high water level of Laguna de Bay).
1983	Completion of Napindan Hydraulic Control Structure (Supported by ADB)
1988	Completion of the Mangahan Floodway (Floodway length: approximately 9km, supported by Japan) Other measures were not implemented due to the problems such as funds, land and housing relocation, etc.
1990	Study on Flood Control and Drainage Project in Metro Manila (JICA) After the above project, "Pasig-Marikina River Channel Improvement Project" and F/S of "North Laguna Lakeshore Urgent Flood Control and Drainage Project" have been implemented.
2007	Completion of the Metro Manila Flood Control Project – West of Mangahan Floodway (Construction of facilities including lakeshore dikes (approximately 10km), drainage facilities at 4 locations, and bridges at 2 locations.)
2012	Master Plan for Flood Management in Metro Manila and Surrounding Areas (Funded by World Bank). Proposed heightening the west dike of Laguna de Bay, heightening the lakeshore urban areas, improvement of the inflow river channels, the East Mangahan Floodway, the West Mangahan drainage improvement and land use control.

2.2.3 Past Flood Damage and Information

Table 2.2.4 summarizes the weather conditions such as typhoons which caused the water surface of Laguna de Bay to rise and the situation of the damages in the Philippines.

Table 2.2.4 Summary of Climate and Damages in Major Floods

Year	Water Level at Laguna de Bay (m)	Summary of Climate and Damages
1972	14.03	- Typhoon Gloring, which recorded a maximum wind speed of 75 m/s and a minimum atmospheric pressure of 911 hPa, brought a very heavy rain to the whole of Luzon, along with typhoon Eden and the tropical southwest monsoon stagnating in the northern part of the South China Sea. The total damage amount in the Philippines was more than 150 million USD and 214 people lost their lives. [1]
1978	13.58	- Typhoon Kading, which recorded the maximum wind speed of 80 m/s and the lowest air pressure of 878 hPa, traversed Central Luzon over 12 hours. [1] - More than 200 people died all over the Philippines. [2]
1988	13.55	- Typhoon Usang and Typhoon Yoning, which emerged continuously in the Philippine Sea, recorded the maximum wind speed of 64 m/s and the lowest pressure of 916 hPa, respectively, crossing the central part of the Philippines. - More than 300 people were killed by Typhoon Usang throughout the Philippines and more than 470,000 people lost their residences. - Due to Typhoon Yoning, 104 people lost their lives, 95 people were missing, more than 600,000 people lost their residences, causing serious damage to the crops.[1]
2009	13.85	- The tropical southwest monsoon stimulated by Typhoon Pepeng and Typhoon Ondoy brought floods in a wide area around Laguna de Bay. - Damages caused by Typhoon Ondoy were as follows.[3] · The affected population was about 1 million households and about 5 million people. · Number of casualties was 464, the number of injured people was 529, 37 people missing · The damage amount was about 11 billion pesos. - Damages caused by Typhoon Pepeng were as follows. [3] · The population affected was about 1 million households, and about 4.5 million people. · Number of casualties was 465 people, the number of injured people 207, 47 people missing · The damage amount was about 27.3 billion pesos

<table>
<tr><th>Year</th><th>Water Level at Laguna de Bay (m)</th><th>Summary of Climate and Damages</th></tr>
<tr><td>2012</td><td>13.83</td><td>- The tropical southwest monsoon stimulated by Typhoon Jose and Typhoon Haikui brought floods around Laguna de Bay
- Damages in municipalities and cities around Laguna de Bay were as follows:4)
<table>
<tr><th>Provinces</th><th>Affected Population</th><th>Casualty</th><th>Totally-Damaged House</th><th>Damage Amount (million pesos)</th><th>Inundated Municipality/City</th></tr>
<tr><td>Metro Manila</td><td>106,912</td><td>1</td><td>0</td><td>412</td><td>3</td></tr>
<tr><td>Laguna</td><td>363,000</td><td>2</td><td>94</td><td>0.22</td><td>15</td></tr>
<tr><td>Rizal</td><td>155,361</td><td>0</td><td>2,469</td><td>153</td><td>7</td></tr>
</table>
Note: Each damage amount is shown for the entire province, not only for the Laguna de Bay surrounding municipalities/cities.</td></tr>
</table>

Source: 1) Annual Typhoon Report, US NAVY、2) Youngstown Daily Vindicator, 3) Final Report on Tropical Storm “ONDOY”{Ketsana} and Typhoon “PEPENG”{Parma}, NDRRMC Effects of Southwest Monsoon Enhanced by Typhoon Haikui、NDCC, 4) Sitrep No. 20 Effects of Southwest Monsoon Enhanced by Typhoon Haikui、NDRRMC

“The Post Disaster Needs Assessment (PDNA) Study” in January 2010 compiled by the World Bank and the "Manila Metropolitan Area Flood Control Plan Information Collection and Confirmation Survey” in 2014 by JICA explain the flood damage caused by Typhoon Ondoy in 2009. The former summarized the damage nationwide and the latter mainly focused on the damage to the Metro Manila area. The damage situation in the Laguna Lakeshore area can be known from Sitrep No. 27 (as of October 13, 2009) and No. 32 (as of October 16, 2009) of the National Disaster Coordinating Council (NDCC).

According to the PDNA of the World Bank, direct damage was 68.2 billion pesos (148.8 billion yen) as shown in Table 2.2.5 and 27.9 billion pesos (609 billion yen) in Metro Manila (NCR) as shown in Table 2.2.6. Table 2.2.7 shows that the damage amount in the Laguna de Bay basin reached approximately 1.1 billion pesos (2.4 billion yen) as of October 13, 2009.

Table 2.2.5 Summary of Damages Caused by Typhoon Ondoy (Whole Affected Area)

Sector	Damage and Losses (Million Pesos)					
	Damage	Losses	Total	Public	Private	Total
Productive Sectors	**26,214.3**	**125,100.7**	**151,315.0**	**4,010.7**	**147,304.3**	**151,315.0**
Agriculture	3,765.0	36,152.0	39,917.0	4,010.7	35,906.3	39,917.0
Industry	9,832.0	9,122.8	18,954.8	-	18,954.8	18,954.8
Commerce	12,041.3	77,288.6	89,329.9	-	89,329.9	89,329.9
Tourism	576.0	2,537.3	3,113.3	-		3,113.3
Social Sectors	**33,207.3**	**9,986.9**	**43,194.2**	**8,812.2**	**34,382.0**	**43,194.2**
Housing	25,453.8	8,872.1	34,325.9	4,203.1	30,122.8	34,325.9
Education	2,515.7	229.5	2,745.2	2,149.3	595.9	2,745.2
Cultural Heritage	279.8	25.6	305.4	305.4	-	305.4
Health	4,958.0	859.7	5,817.7	2,154.4	3,663.3	5,817.7
Infrastructure	**8,512.6**	**2,641.8**	**11,154.4**	**7,807.6**	**3,346.7**	**11,154.3**
Electricity	713.1	878.5	1,591.6	-	1,591.6	1,591.6
Water and Sanitation	372.5	768.6	1,141.1	497.3	643.8	1,141.1
Flood Control, Drainage and Dam Management	716.9	-	716.9	716.9	-	716.9
Transport	6,517.1	994.7	7,511.8	6,593.4	918.3	7,511.7
Telecommunication	193.0	-	193.0	-	193.0	193.0
Cross-Sectoral	**294.2**	**41.0**	**335.2**	**335.2**	**0.0**	**335.2**
Local Government	294.2	41.0	335.2	335.2	-	335.2
Social Protection	-	-	0.0	-	-	0.0
Financial Sector	-	-	0.0	-	-	0.0
Disaster Risk Reduction and Management	-	-	0.0	-	-	0.0
Total	**68,228.4**	**137,770.4**	**205,998.8**	**20,965.7**	**185,033.0**	**205,998.7**

Source: Post-Disaster Needs Assessment (WB, 2009)

Table 2.2.6 Summary of Damages Caused by Typhoon Ondoy (NCR)

Sector	Damage (Mil. Pesos)	Losses (Mil. Pesos)	Total (Mil. Pesos)
Productive Sectors	**17,329**	**19,900**	**37,230**
Agriculture	-	-	-
Industry (Manufacturing)	9,035	6,449	15,485
Commerce (Wholesale and Retail Trade)	7,786	12,256	20,042
Tourism	509	1,195	1,703
Social Sectors	**9,957**	**2,283**	**12,240**
Housing	6,530	2,276	8,806
Education	423	1	424
Cultural Heritage	62	6	67
Health	2,943	0	2,943
Infrastructure	**608**	**352**	**969**
Cross-Sectoral	**-**	**-**	**-**
Total	**27,894**	**22,535**	**50,438**

Source: Post-Disaster Needs Assessment (WB, 2009)

Table 2.2.7 Summary of Damages Caused by Typhoon Ondoy (Survey Area)

Municipality/City	Affected Population[1)]	Casualty[2)]	Totally-Damaged House [1)]	Partially-Damaged House [1)]	Damage on Infrastructure[2)] (Peso)	Damage on Agriculture[2)] (Peso)	Total Damage[2)] (Peso)
NCR	**476,960**	**64**	**0**	**0**	**92,858,280**	**0**	**92,858,280**
Las Piñas	26,330				7,850,000		7,850,000
Marikina	78,775	61			5,850,000		5,850,000
Muntinlupa	87,815	3			12,810,000		12,810,000
Parañaque	2,250				18,900,000		18,900,000
Pasig	152,160				37,308,780		37,308,780
Taguig	129,630				10,139,500		10,139,500
LAGUNA	**828,902**	**13**	**2,898**	**2,022**	**0**	**449,570,570**	**449,570,570**
Bay	22,605		1	130			
Biñan	198,700		302	442			
Cabuyao	99,140						
Calamba	59,052	1	847	510			
Famy	14,415	7	55	96			
Kalayaan	3,918						
Los Baños	29,730		324	249			
Lumban	5,146		46	84			
Mabitac	15,830	1	59	98			
Pangil	5,945		16	23			
Paete	4,320		2	2			
Pakil	10,578		5	98			
Pila	9,657						
San Pabro	0						
San Pedro	153,536	1	12	16			
Santa Cruz	102,590	1					
Santa Rosa	77,052	2	1,120	54			
Siniloan	9,045		109	220			
Victoria	7,643						
RIZAL	**481,865**	**56**	**5,987**	**10,001**	**383,860,000**	**196,292,893**	**580,152,893**
Angono	52,375	10					
Baras	28,440		93	117			
Binangonan	66,896		562	380			
Cardona	33,825		524	181			
Jalajala	4,999		4,139	8,155			
Morong	2,630	3					
Pililla	34,000		0	300			
Tanay	35,610	43	610	804			
Taytay	223,090		59	64			
Total	1,787,727	133	8,885	12,023	476,718,280	645,863,463	1,122,581,743

Source: 1) Sitrep No. 32 on Tropical Storm "Ondoy" {KETSANA} and Typhoon "PEPENG" {Parma} Oct 16, 2009、2) Sitrep No. 27 on Tropical Storm "Ondoy" {KETSANA} and Typhoon "PEPENG" {Parma} Oct 13, 2009

Since Laguna de Bay has a nearly trapezoidal shape and the capacity of the Napindan River (the outflow river) is limited it has the characteristics of long flood duration. This indicated that the flooding of Laguna de Bay has reached the same ground elevation as the flood level.

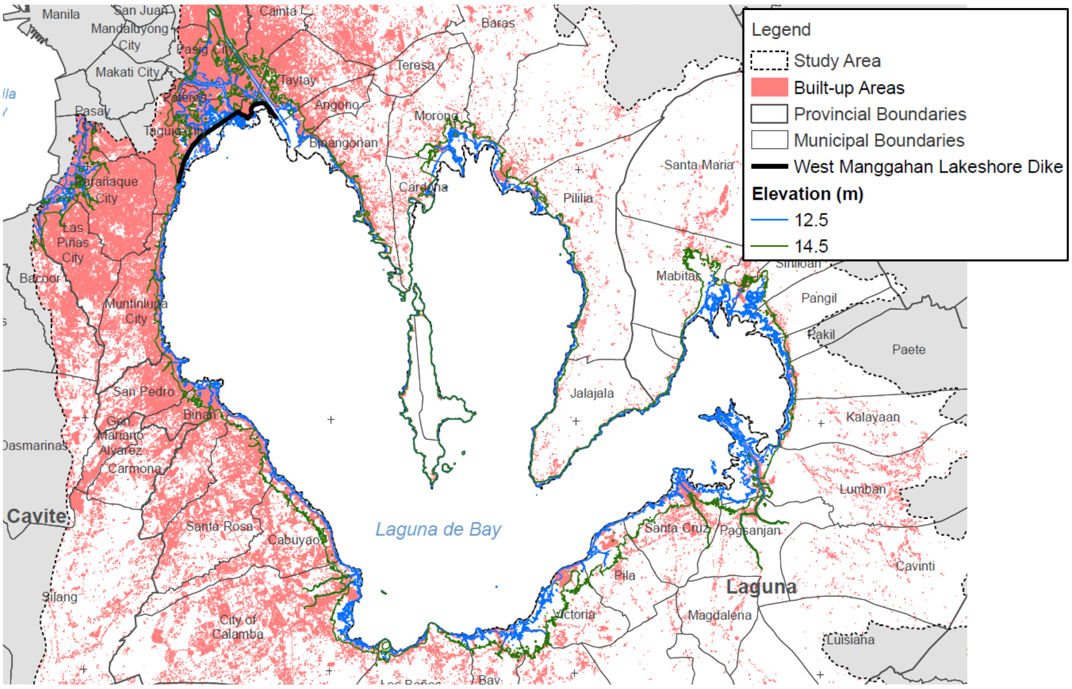
In the Laguna de Bay Coastal Area, the residential area appears from EL. 12.0 m and many residents and infrastructures are seen above EL. 12.5 m. When EL. 12.0 m is considered as the lowest elevation when flood damage starts occurring, Table 2.2.8 shows the calculation results of the approximate inundation area for every 0.5 m elevation based on DEM.

Table 2.2.8 Inundation Area and Number of affected People for every 0.5 m Elevation

Water Level (m)	Inundation Area*1 (km^2)	Number of affected People*2 (person)
12.0	0.0	0
12.5	20.8	48,000
13.0	44.6	179,000
13.5	69.6	353,000
14.0	95.6	554,000
14.5	120.9	749,000

*1 : estimated by JICA Survey Team based on DEM Data (NAMRIA).
*2 : estimated by JICA Survey Team based on Built-up Area in LANDSAT 2016 and Census 2015.

For example, when the highest water level reaches 13.0 m, it is assumed that 44.6 km^2 of the residential area is flooded and the inundated population is 179 thousand from the water level 12.0 m.



Source: JICA Survey Team

Figure 2.2.5 Laguna de Bay Lakeshore Area and Assumed Flood Area (12.5 m, 14.5 m Contour Line)

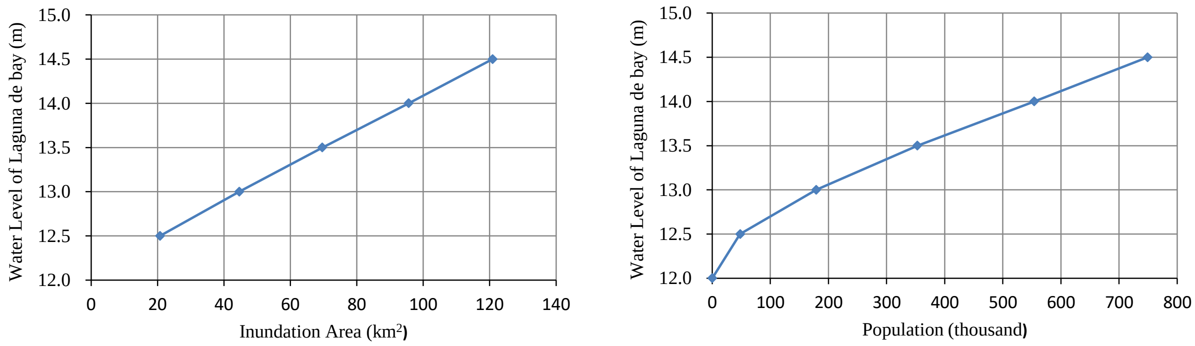


Figure 2.2.6 Assumed Flood Area and Population of Laguna de Bay Lakeshore Area

2.3 Evaluation of the Existing Flood Control Measure Project

In the Laguna de Bay Basin including the Pasig - Marikina River Basin, following projects on large scale structural measures/ non-structural measures have been implemented. The followings except for (2) donored by ADB, were completed by the Japanese ODA.

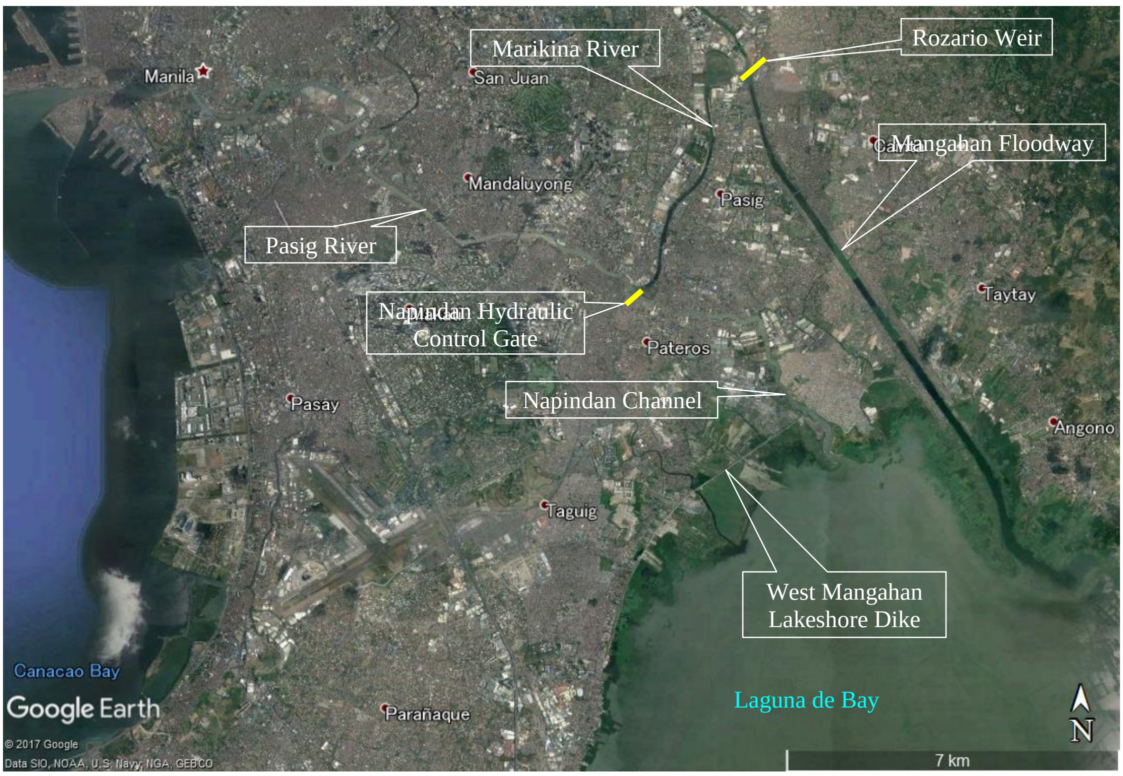
(1) Construction Works of Mangahan Floodway

(2) Construction Works of Napindan Hydraulic Control Gate

(3) Pasig- Marikina River Channel Improvement Project (I, II, III)

(4) Metro Manila Flood Control Project – West of Mangahan Floodway Project

(5) Effective Flood Control Operation System (EFCOS) for Metro Manila Project



Source: Google Earth, Digital Globe, JICA Survey Team

Figure 2.3.1 Location of Existing Flood Control Measure Project

There are also non-structural countermeasures implemented under the support of other donors and the Philippine Government's own initiatives.

(6) KOICA Project

(7) Resilience Project (UNDP and Canadian International Development Agency: CIDA)

(8) Ready Project (Hazard Mapping and Assessment for Effective Community-based Disaster Risk Management, United Nations Development Program: UNDP and Australian Agency for International Development: AusAID)

(9) Project NOAH (Nationwide Operational Assessment of Hazards)

Among these projects, the projects which have been implemented or underway are selected and a survey was conducted on their project descriptions, status of project effectiveness and operation-maintenance status. The results are shown in Table 2.3.1.

Table 2.3.1 Constructed Structural Countermeasures

No.	Project	Project Descriptions	Status of Project Effectiveness	Operation Maintenance Status
1	Mangahan Floodway Project	F/S was implemented in 1975, and the diversion of flood water in the Marikina River in 1988 was the first operation. Until then, the flood water in the Marikina River had flowed out to Manila Bay through the Pasig River which flows through the centre of Metro Manila. Since the flow capacity of the Pasig River is limited, it was necessary to divert some of the flood water from the Marikina River to Laguna de Bay through the Mangahan Floodway in order to prevent the central part of Metro Manila from flooding by the overflow of the Pasig River. The design discharge of floodway is 2400m^3/s and the length is 9km. At the Rosario Weir installed at the end of the floodway channel, the gate operation is conducted for diversion of the flood water from the Marikina River to Laguna de Bay (Gate width 18.75m x height 3.0m x 8 gates, foundation height EL.10.5m)	After completion, the overflow from the Pasig River has not occurred, and it is considered that the effect is great. However, with respect to the design discharge of 2900 m^3/s in the Marikina River, the Rosario Weir is not sufficient in order to adequately divert water. Therefore, the construction of the Marikina Weir is planned.	Operation and maintenance is conducted by MMDA. There are many illegal residents in the floodway channel which is an operational problem.
2	Napindan Hydraulic Control Gate Project	It is completed in 1983 with ADB's financial support with the aim of improving water quality, water resource development and the flood control of Laguna de Bay. Water gate width 15m x height 9m x 4 gates. Ship operation lock gate (width18m x height 9.0m), Foundation height EL.6.0m	Regarding the operation of the gate, since the fishermen are opposed to close the gate at all the time as it influences on the brackish water fishery of Laguna de Bay, the gate is kept open except the time of the operation for flood control.	MMDA is implementing together with the Mangahan Floodway and Rosario Weir Flood Gate
3	Pasig- Marikina River Channel Improvement Project (I, II, III)	F/S was implemented in the JICA Study "Metro Manila Flood Control Plan" in 1990. The channel improvement for about 30 km is underway in Phase IV. Phase I is the detailed design, and Phase II and II are the construction works which have been completed (target is the lower section of the Pasig - Marikina River for about 22 km). In the future, improvement of the middle section of the Marikina River including the	It is expected prevent the overflow damages by safely draining the design scale 30-year probability flood of the Pasig -Marikina River. When the Marikina Dam project which is currently under planning is completed, Metro Manila will be prevented from flooding of the 100-year probability scale.	It is agreed to transfer the maintenance work from DPWH to MMDA after the project completion.

No.	Project	Project Descriptions	Status of Project Effectiveness	Operation Maintenance Status
		construction of the Marikina Weir (8.0 km and the design discharge of 2,900m^3/s) is scheduled as Phase IV. The improvement work of the upper section of the Marikina River (5.8km, the design discharge of 2,900m^3/s) is being implemented by DPWH with the Philippine Government fund.		
4	Metro Manila Flood Control Project – West of Mangahan Floodway Project	F/S was implemented in the JICA Study "Metro Manila Flood Control Plan" in 1990. It consists of the lake shore dyke system (construction of the lake shore dyke of about 10 km, four drainage stations and one bridge) and the flood prevention wall (5.2 km) along the Napindan Channel which is the outflow river. The lake shore dyke has a community road (two lanes). It was completed in 2007.	It prevents the area about 39 km^2 in the Taguig City of lowland, Pasig City and Pateros town located in the Laguna de Bay coast from flooding of Laguna de Bay. The design target flood is the past maximum water level of EL.14.03m in 1972. Beneficiaries are about 600,000 people After the completion, the effectiveness was demonstrated during the flood events at Laguna de Bay in 2009 and 2012. At the time of the flood events caused by Typhoon Ondoy and Typhoon Pepeng in 2009, although the protected area was inundated by the overflow from the Marikina River, the flooded water was removed by the graet performance of the drainage plant (Other areas in the lake coastal areas without measures have inundated for several months).	Operation and maintenance management work has been transferred from DPW to MMDA

Table 2.3.2 Implemented Non-Structural Countermeasures

No.	Project	Project Descriptions	Status of Project Effectiveness	Operation Maintenance Status
1	Effective Flood Control Operation System Project (EFCOS)	EFCOS was established in 1993 for proper operation of Mangahan Floodway and for conducting warning to the inhabitants along the Floodway. EFCOS owns radio telemetric rain gauges and water level gauges in the Pasig-Marikina River Basin, radio telemetric water level gauge in the northern part of the Laguna de Bay, and warning posts along the Floodway. Observed data are also sent to PAGASA and utilized for flood forecasting and warning.	Observed data by EFCOS are utilized for operation of Rosario Weir of the Mangahan Floodway. Warning to the inhabitants along the Floodway is also conducted properly.	DPWH managed EFCOS in the beginning. Then, EFCOS was transferred to MMDA. In 2001 and 2016, rehabilitations of the equipment were conducted by JICA Grant Aid Projects.
2	KOICA Project	From 2010 to 2012, radio and SMS telemetric rain gauges and water level gauges as well as warning posts were installed in the Pasig-Marikina River Basin by KOICA. The observation system belongs to PAGASA and is utilized for flood forecasting and warning system.	KOICA data is utilized for flood forecasting and warning by PAGASA together with the data of EFCOS. As the water level observation of KOICA is done by ultrasonic water level gauge from the air.	KOICA system is maintained by PAGASA. Lacking observed data can be seen sometimes among the data of KOICA.
3	Resilience Project	The objective of the Resilience Project is to strengthen DRR capacity LGUs by the assistance from UNDP and CIDA. The Project included development and implementation of flood forecasting and warning system in the Pasig-Marikina River Basin and the Malabon-Tullahan River Basin by installing GSM telemetric rain gauges and water level gauges. The Project was conducted from 2010 to 2013.	Necessary to collect information. (The Project does not have direct relation with the Laguna River Basin.)	Necessary to collect information. (The Project does not have direct relation with the Laguna River Basin.)

No.	Project	Project Descriptions	Status of Project Effectiveness	Operation Maintenance Status
4	Ready Project	Objective of the Ready Project is to strengthen institutional capacity of OCD-NDRRMC through assistance by UNDP and AusAID. The Project includes installation of SMS telemetric rain gauges and water level gauges in the tributary river basin called the Tanay River Basin and the surrounding areas in the north-eastern part of the Laguna River Basin. Observed data of the observation stations are sent to the Flood Forecasting and Warning Center of PAGASA.	The Project is utilized for flood forecasting and warning in the Tanay River Basin and the surrounding areas.	Due to robbery and trouble of rain gauges, some parts of the observation stations are not functioning now.
5	Project NOAH (Nationwide Operational Assessment of Hazards)	The Project aims to strengthen Response and Prevention & Mitigation against climate change related disasters. By DOST-ASTI, DOST-PAGASA and PHIVOLCS under assistance by UP, the Project includes installation of hydro-meteorological observation systems with target year of 2013 in the 18 major river basins and disaster assessment through preparing more accurate flood hazard maps and others.	Hydro-meteorological observation systems have been installed by the Project to the LGUs of the Laguna River Basin.	Management including maintenance of the hydro-meteorological observation systems installed by the Project is to be conducted by the LGUs.

In addition, projects currently being implemented or under planning include the following.

(1) The Pasig-Marikina River Channel Improvement Project (V) (Under implementation by DPWH's budget)

(2) Detailed Design of the Marikina Dam (Under implementation at the World Bank funding by DPWH to flood control of the Marikina River)

(3) The Pasig - Marikina River Channel Improvement Project (IV) (DPWH is planning to construct. It is expected to prevent the flood damages caused by overflowing from the eastern bank of the middle section of the Marikina River into the Cainta River Basin.)

(4) The construction plan of the regulating area located in the upper section of the Marikina River (in order to control the flood in the Marikina River, DPWH is selecting the consultant for the investigation and planning).

(5) The Eastern Mangahan District Flood Control Plan (DPWH plans to commercialize the flood control measures in the eastern area of the Mangahan Floodway which is facing Laguna de Bay).

2.4 Utilization of Local Water Resources

2.4.1 Utilization of Local Water Resources in Laguna Lake

Laguna Lake provides local people with various forms of benefits. The lake is utilized for inland fishery (fishing and aquaculture), and lake water is used for irrigation, hydropower generation, industrial (cooling) and transportation.

(1) Fishery

(a) Fishery Output

Fishery in Laguna Lake is divided into fishing (open lake fishery) and aquaculture. Output of open lake fishery has been increasing in recent years: it has 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)

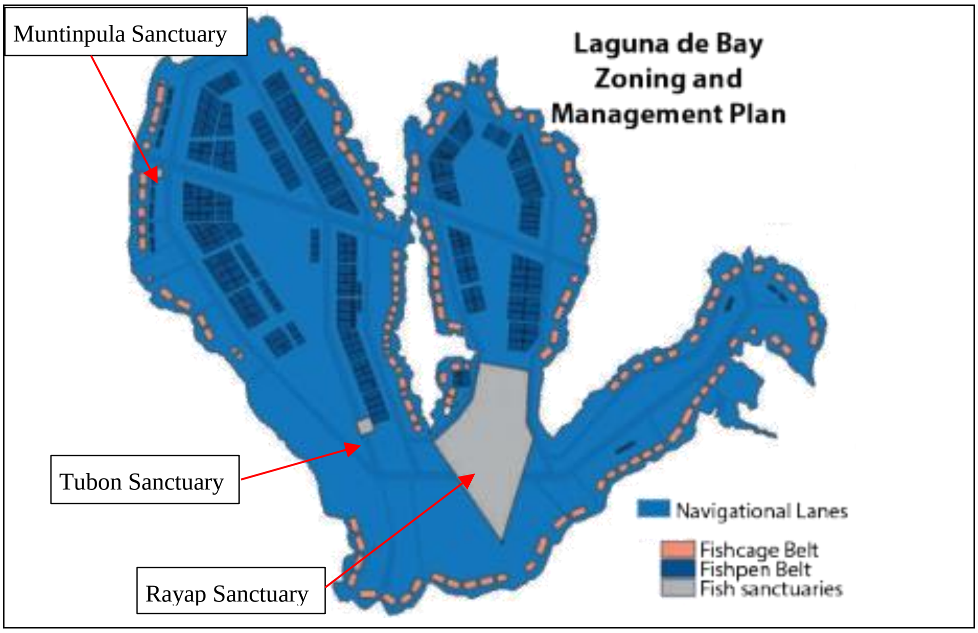
On the other hand, aquaculture in Laguna Lake is carried out in the forms of fish pen and fish cage. Fish pen is an artificial enclosure made up of bamboo poles constructed within a body of water for culturing fish. Fish cage is an enclosure which is either stationary or floating made up of nets or screens. The area of fish pen and fish cage was 12,0643ha as of 2015, accounts for approx. 13% of lake water (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 (Bangus), Tilapia and Carp.

(b) Zoning and Management Plan (ZOMAP)

Fish pen was introduced in Laguna Lake in 1973 and has rapidly proliferated because of its high productivity. Consequently, too many fish pens and fish cages have scattered, which resulted in diminishing productivity. It has also caused conflicts between marginalized fisher folks and fish pen operators.

Under such circumstances, these socio-economic and environmental problems in Laguna Lake prompted LLDA to formulate and approve the Zoning and Management Plan (ZOMAP) on January 1996. Through the ZOMAP, lake resources are equitably delineated and allocated to various users for aquaculture operations, navigation, and open fishing. Figure 2.4.1 shows the ZOMAP in 1999, which shows that fish cages are distributed along the lake shore and fish pens inside. It is shown in the figure that fish pens are located only in West Bay and Central Bay but very few in East Bay.

The ZOMAP is currently being reviewed and will be revised in January 2018 according to LLDA. It is because of over usage beyond the lake’s carrying capacity under the current ZOMAP. After the ZOMAP is revised, the total area of fish pen and fish cage will be approx. 9,000ha according to an official of LLDA. (Sited from website of LLDA so far)



Source: Website of LLDA

Figure 2.4.1 Zoning and Management Plan (ZOMAP) of Laguna Lake (1999)

(c) Fish Sanctuary

Fish sanctuaries are established in Laguna Lake aiming at the protection of fish resources in the lake. There are three fish sanctuaries in the lake stipulated in LLDA Board Resolution No. 136 (2000) as shown in Figure 2.4.1. Details of the sanctuaries are shown in Table 2.4.1.

Table 2.4.1 Fish Sanctuaries in Laguna Lake

No.	Name	Location	Area (ha)
1	Rayap Sanctuary	Central Bay	5,000
2	Tabon Sanctuary	West Bay	126.27
3	Muntinlupa Sanctuary	West bay	30.12

Source: LLDA Board Resolution No. 136 (2000)

In addition to these fish sanctuaries, protected area and Yankaw fish garden sanctuary are established off-shore in South Bay of Laguna Lake based on Calamba City Ordinance No. 495 (Figure 2.4.2).

Source: EIS for Laguna Lakeshore Expressway Dike Project (LLEDP), 2014

Figure 2.4.2 Fish Sanctuary Established by Calamba City

(2) Water Use for Irrigation, Domestic, Industrial and Hydropower Generation

Lake water in Laguna Lake is used with the issuance of Water Permits in the survey area as shown in Table 2.4.2. Water Permits are exclusively managed and issued by the National Water Resources Board (NWRB). Forty (40) Water Permits have been issued for usage of lake water, consisting of 37 for irrigation, and three others (domestic water supply, industrial water and hydropower). Intake points of each Water Permit are distributed, namely; two in Metro Manila Area (one for domestic water supply and another one for irrigation), three in Laguna Province (two for irrigation and one for hydropower generation), and 35 in Rizal Province (34 for irrigation and one for industrial water).

Table 2.4.2 Water Permits for Taking Water of Laguna Lake

Location		No. of Water Permits Issued for Water Intake from Laguna Lake	Purpose			
Province	City / Municipality	Laguna Lake	Irrigation	Domestic water supply	Industrial water	Hydropower generation
Metro Manila	Muntinlupa	2	1	1		
Laguna	Kalayaan	1				1
	Pangil	2	2			
Rizal	Jala-jala	8	8			
	Pililla	3	2		1	
	Baras	3	3			
	Morong	5	5			
	Cardona	2	2			
	Biñangonan	8	8			
	Angono	1	1			
	Taytay	5	5			
Total		40	37	1	1	1

Source: National Water Resources Board (NWRB)

(3) Inland Water Transport

Since time immemorial, Laguna Lake has served its purpose for water-based transport. More than 5,000 motorized and non-motorized watercrafts operate as a means of transportation for lakeshore communities. In addition, there are 23 barges plying the lake to transport an average of 75,640 barrels of oil and oil products to various supply depots daily. (Laguna de Bay Master Plan, 2016)

LLDA issued Board Resolution (BR) No. 66 / 1998 for the purpose of mitigating water traffic in the lake, by which waterways of ferries were established. Waterways are classified into the following three, and are added to the existing waterway for oil transportation routes (round trip between Pasig River and Sucat, Muntinlupa (Metro Manila), Malaya, Pililla (Rizal)).

a. an express lane of 500 meters wide going to Los Baños, Laguna, and then to Pangasinan, Laguna;
b. secondary lanes of 400 meters wide to provide access to other municipalities around the lake, including Talim Island;
c. tertiary routes of 200 meters wide leading to the landing areas in strategic municipalities.

In this connection, there are many mooring facilities, regardless of public or private, along the lakeshore and are utilized for fishing, transport and harvesting of kangkong, etc. These activities and facilities might be affected by the Project.

2.4.2 Groundwater Use

Water use including groundwater use is managed by the National Water Resources Board (NWRB) in a centralized manner. NWRB issues water permits for groundwater use imposing a fee to users. In this regard, Water permits are issued for groundwater use from deep wells based on probationary results and issued to shallow well users only for registration purposes. According to NWRB, no new water permit is issued at present in accordance with NWRB Resolution No.001-0904 and No. 020-1209 in Metro Manila, including Muntinpula, Parañaque and Las Piñas, aiming to prevent over-pumping of groundwater and saline water intrusion.

Table 2.4.3 shows the number of water permits issued in the survey area. In areas of the four cities where Parañaque Spillway is proposed, 210 existing water permits for groundwater use have been issued in Parañaque, followed by 152 in Muntinlupa, 98 in Las Piñas and 63 in Taguig. In the area of Laguna Province, LGUs located in west shore of the lake from San Pedro to Calamba, Water Permits are issued with the number from 85 to 155 for groundwater use. However, the number of Water Permits issued in the area from Los Baños eastward is less than 30. In Rizal Province, the number of water permits is less than 40.

Most of the water permits were issued for deep well use, including water intake from rivers and Laguna Lake.. There are two cases of water permits for water intake from Laguna Lake in Muntinlupa. Other cases are located in Rizal Province at the north side of the lake. (Refer to previous section regarding water intake cases from Laguna Lake.)

Table 2.4.3 Water Permits Issued in the Survey Area

Location		No. of Water Permits Issued	No. of WPs (cancelled)	No. of WPs (existing)	Groundwater		Surface Water		
Province	City / Municipality				Deepwell	Others	River	Laguna Lake	Others
Metro Manila	Parañaque	248	35	213	207	3	3	0	0
	Las Piñas	108	9	99	98	0	1	0	0
	Taguig	67	1	66	63	0	3	0	0
	Muntinlupa	164	10	154	152	0	0	2	0
Laguna	San Pedro	93	1	92	91	1	0	0	0
	Biñan	91	4	87	83	2	2	0	0
	Santa Rosa	136	0	136	132	1	3	0	0
	Cabuyao	96	1	95	91	4	0	0	0
	Calamba	167	3	164	155	5	3	0	1
	Los Baños	11	0	11	9	0	1	0	1
	Bay	11	0	11	7	0	3	0	1
	Calauan	31	0	31	7	19	3	0	2
	Victoria	2	1	1	0	0	1	0	0
	Pila	10	0	10	7	1	2	0	0
	Santa Cruz	14	0	14	13	0	1	0	0
	Pagsanjan	12	0	12	7	3	2	0	0
	Lumban	9	0	9	2	0	7	0	0
	Kalayaan	3	0	3	2	0	0	1	0
	Paete	5	0	5	1	0	4	0	0
	Pakil	14	0	14	0	11	3	0	0
	Pangil	12	0	12	4	1	5	2	0
	Siniloan	4	0	4	0	0	4	0	0
	Famy	2	0	2	0	0	2	0	0
	Mabitac	2	0	2	0	1	1	0	0
Rizal	Jala-jala	17	0	17	1	1	7	8	0
	Pililla	21	0	21	8	1	8	3	1
	Tanay	44	1	43	17	15	10	0	1
	Baras	24	0	24	19	0	2	3	0
	Morong	31	0	31	13	1	10	5	2
	Cardona	6	0	6	4	0	0	2	0
	Biñangonan	45	0	45	33	1	2	8	1
	Angono	16	1	15	12	0	2	1	0
	Taytay	51	3	48	38	2	2	5	1

Source: National Water Resources Board (NWRB), 2017

2.5 Relevant Development Plans and Projects

Related development plans and projects around Laguna de Bay are as described below.

- Laguna Lakeshore Expressway Dike Project
- LRT-1 Cavite Extension Project
- Construction of water supply facilities in Muntinlupa City by Maynilad
- North-South Railway Project (South Line)
- Mega Manila Subway Project
- Manila-Quezon Expressway Project
- Infrastructure Preparation and Innovation Facility
- Power generation project by CBK Power Company

2.5.1 Relevant Development Plans

(1) Laguna Lakeshore Expressway Dike Project

The Laguna Lakeshore Expressway Dike Project (LLEDP) which DPWH is planning as a PPP project contains two components, 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 the Laguna de Bay. The executing agency is DPWH. The Feasibility Study of the project took place in 2012. 100-year probability lake water level at EL. 14.2 m was set as the design high water level with a freeboard of 1.0 m and the crest elevation of EL. 15.2 m. The expressway is planned to be constructed on the dike whose material is made of sediments in Laguna de Bay. In Metro Manila area, an urban development area (max. 700 ha) is planned to be constructed. The outline of the LLEDP is shown in Table 2.5.1 and Figure 2.5.1.

Table 2.5.1 Outline of the LLEDP

Item	Component	Structure	Quantity	Remarks
Component	Component 1 Expressway - Dike (2 x 3 Lanes)	Dike road	47 km	About 500m lakeside from the lakeshore from Taguig to Los Baños
		Interchange	8 places	
		Bridge	16 bridges	
		Pump station	16 locations	
		Crest elevation	15.2 m	100-year probability
	Component 2 Reclamation	Reclamation	700 ha	100ha / place x 7 places, width 450m
Construction cost	Component 1	(as shown above)	64.9 billion pesos	As of 2013
	Component 2	(as shown above)	57.9 billion pesos	As of 2013
Benefit	Flood Management		20.0 billion pesos	Preventing the damage for 800 thousand people
	Traffic		5.4 billion pesos	
	Reclamation		118.8 billion pesos	
	Total		144.2 billion pesos	

Source: Laguna Lakeshore Expressway - Dike Project (LLEDP), Public-Private-Partnership Project, Presentation to UK Transport Solutions, September 18, 2014, DPWH in cooperation with LLDA

Source: Laguna Lakeshore Expressway - Dike Project (LLEDP), Public - Private Partnership Project, Presentation to UK Transport Solutions, September 18, 2014, DPWH in cooperated with LLDA

Figure 2.5.1 Location and Layout Plan of LLEDP

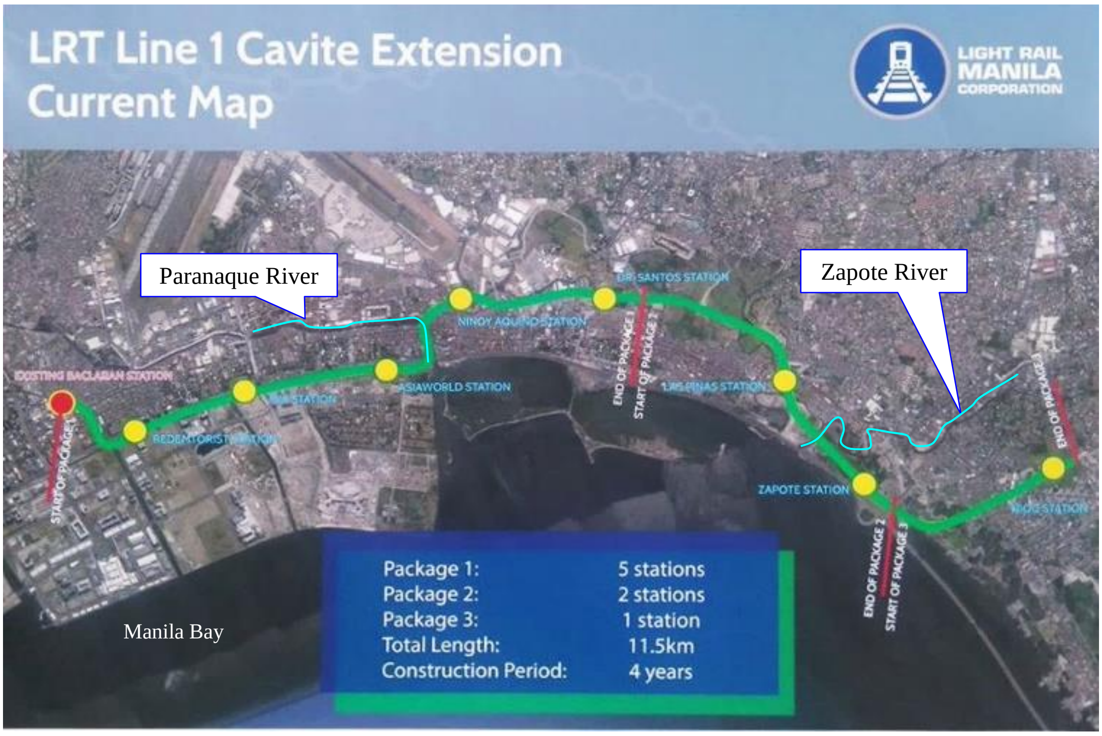
Tenders were invited in the early 2017 as a part of the PPP project, but the process was unsuccessful. Therefore, the DPWH reviewed the contents of the project and decided that the flood mitigation portion shall be carried out by DPWH.

(2) 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 the 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 it was entrusted to the private sector, aiming to improve the level of efficiency and service.

The location of the project is shown in Figure 2.5.2 and the project outline is given in Table 2.5.2.



Source: LRMC

Figure 2.5.2 Location Map of LRT-1 Cavite Extension Project

Table 2.5.2 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, summarized by JICA

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.

(3) Construction of Water Supply Facilities in Muntinlupa City by Maynilad

Muntinlupa City, which is located in the western part of the Laguna de Bay, have a population of about 500,000 and has huge commercial areas such as Alabang and Sucat. However, there are still some areas relying on deep wells for clean drinking water. In the suburbs, the development of subdivisions is progressing and, in particular, areas at high altitude lag behind the supply of clean water. Hence, supply of safe drinking water is a pressing issue.

Based on the above background, this project aims at providing a safe and stable water supply in Muntinlupa City. The outline of the project is summarized in Table 2.5.3.

Table 2.5.3 Outline of Construction of Water Supply Facilities in Muntinlupa City by Maynilad

Item	Victoria Homes pump station	Putatan water treatment plant 2
Budget	250 million pesos	6.75 billion pesos
Operation start	November 2017 (already started)	May 2018
Intake position	(Because it is a relay pumping station, no water intake is needed)	Laguna de Bay (EL. 10.5 m) It should be noted that the water intake is restricted during the dry season due to the bad quality of the lake water
Intake quantity	-	300 MLD (3.5 m^3/s) with plant 1
Construction target	Pumping station and adjustment reservoir	Water treatment facility Existing intake will be used.
Location	Barangay Tunasan, Muntinlupa	Barangay Putatan, Muntinlupa (adjacent to the Putatan water treatment plant 1)
Intake facility	-	Barangay Putatan, Muntinlupa City  Source: Google
Effect	• Water supply to Barangay Tunasan and Barangay Poblacion • Water supply to Victoria Homes Subdivision • Water supply at 110 kPa	• Stable water supply to 1.2 million users of Maynilad in Muntinlupa, Las Piñas and Cavite • Water supply at 110 kPa

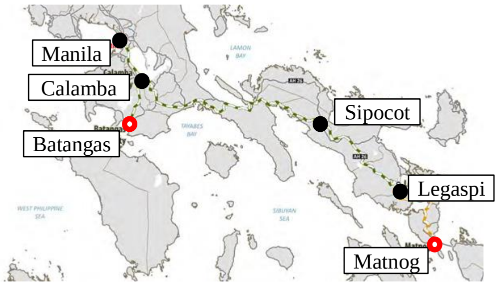
Source: information from Maynilad, summarized by JICA Survey Team

With respect to the Victoria Homes pumping stations, there is no influence of the pumping station construction and operation since it is constructed at inland area of Barangay Tunasan. On the other hand, Putatan Water Treatment Plant 2 has its water intake at Laguna de Bay. Although the lowest elevation of the water intake is EL10.5 m, water intake is restricted during the dry season due to the bad quality of the lake water. Further, since the intake path of Putatan Water Treatment Plants 1 and 2 and the lakeshore dike intersect, the layout plan and the structural design of the lakeshore dike at the intersection should be carried out carefully in the future study.

(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 the 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 in west of Laguna Province.

Based on the above background, this project as a PPP project aims to (1) 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 2.5.4 gives the project outline.



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

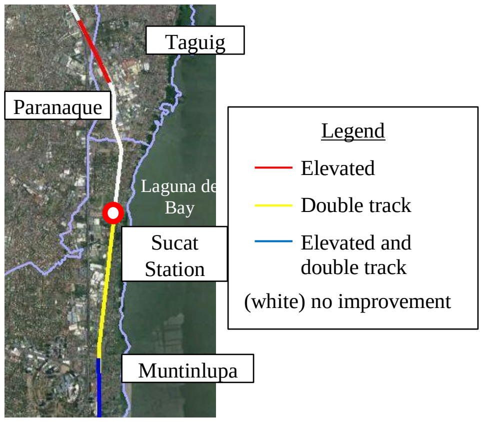
Figure 2.5.3 Layout Plan of South Line, N-S Railway Project

Table 2.5.4 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 the 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, summarized by JICA Survey Team

Improvement plan of the existing route is shown in Figure 2.5.4. 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 2.5.4 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 "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 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 north of Manila and

Dasmariñas in Cavite.

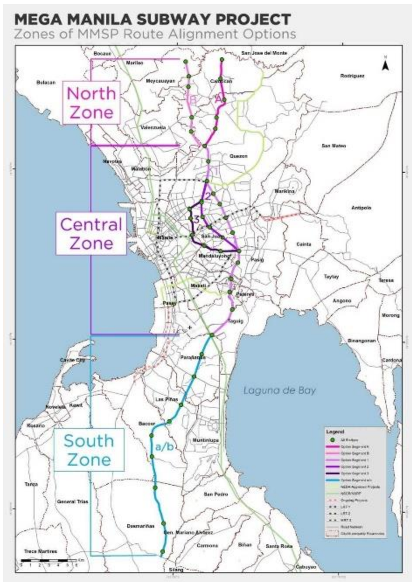
In relation to this project, information collection survey was carried out in 2015 by JICA. In the survey, urban railway with the approximate length of 60 km was divided into three zones which are the North Zone (2 options), the Central Zone (3 options) and the South Zone (2 options) and were examined in the total of 12 options. The survey results are summarized in Table 2.5.5. 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 2.5.5 Information Collection Survey Result on the Mega Manila Subway Project

Item	Contents
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 the Mega Manila subway project



Source: Information collection survey for the Mega Manila subway project

Figure 2.5.5 Zones for Mega Manila Subway Project Route

(6) Manila-Quezon Expressway Project

The Manila-Quezon Expressway Project is a 100-km long new Expressway project to provide fast, safe and comfortable transportation between Metro Manila and Lucena City. This project aims at the following issues.

- Reduce the travel time between Metro Manila and Lucena City to one and half hours from present three hours.
- Serves as the supply chain of various food products, goods from the South Tagalog and Bicol region and for access to regional/international airports.
- Contribute well-balanced development of the CALABARZON
- Attract new economic zones
- Alleviate the traffic congestion at SLEX

In 2010, the preliminary route selection was conducted and four route alternatives were proposed. Among the alternatives, the route B was selected and the pre-feasibility study was conducted. Then, in 2016, the project was financially updated and economically re-evaluated. Presently, the project has being proposed for the detailed feasibility study by the concessionaire, or Grand Metro-Manila Gateway Company, Inc. (GMMGCI) as a PPP project to DPWH.

Source: Feasibility Study on Manila-Quezon Expressway Project Final Report (August 2011 and August 2016)

Figure 2.5.6 Route Alternatives in the Preliminary Route Selection

Table 2.5.6 Features of the Manila-Quezon Expressway Project

<table>
<tr><th>Item</th><th>Contents</th></tr>
<tr><td>Budget</td><td>66.7 billion pesos</td></tr>
<tr><td>Construction period</td><td>5 years (divided into three segments; C5 to Pilillia (Segment 1, 33 km), Pililla to Pila (Segment 2, 29 km) and Pila to Candaelaria (Segment 3, 40.3 km)</td></tr>
<tr><td>Construction target</td><td>102 km road including embankment road, viaduct, bridge, interchange, rest area, service area and toll plaza
- Road Specification:
<table>
<tr><th>Item</th><th>Contents</th></tr>
<tr><td>No. of lanes</td><td>Case 1 and Case2: 3+3 Lanes, 2+2 Lanes
Case 3: 3+3 Lanes, 1+1 Lanes</td></tr>
<tr><td>Lane width</td><td>3.5 m</td></tr>
<tr><td>ROW width</td><td>60 m</td></tr>
<tr><td>Median width</td><td>1.5m (min)</td></tr>
<tr><td>Pavement Type</td><td>Asphalt concrete</td></tr>
</table></td></tr>
<tr><td>Effect</td><td>EIRR: 15.2 % to 16.5 %</td></tr>
</table>

Source: Feasibility Study on Manila-Quezon Expressway Project Final Report

In the study, the route B crosses Laguna de Bay and Mangahan Floodway. The six-lane expressway with 26 m width was proposed along or on the existing dike road along the Mangahan Floodway. Attention to sharing the information between the Manila-Quezon Expressway Project and the project shall be paid in aspect of the water flow not to be interfered by the expressway at Mangahan Floodway and of the lake water level proposed by the project to be reflected to the express way crossing Laguna de Bay.

(7) Infrastructure Preparation and Innovation Facility

In order to clarify the goals of infrastructure investment, the Philippine government requested ADB for financial assistance for the Infrastructure Preparation and Innovation Facility (IPIF), and in October 2017, ADB approved a $100 million loan for the project. IPIF consists of the three consultation services for the design of 1) roads and bridges, 2) flood protection and 3) rail, public transport, port and airport, and one for the improvement of project development management at DPWH, DOTr and the related organizations. DPWH had signed the contract in February 2018 with Ove Arup & Partners Hong Kong Ltd. (Arup) for the component of "1) road and bridge" and will do for the rest within a couple of months.

Table 2.5.7 shows the list of the projects in IPIF. Among these projects, the ones which may affect this project are "Laguna Lakeshore Road Network" in Output 1 and "PNR South Commuter" in Output 3. Although the details of the Laguna Lakeshore Road Network project are not disclosed yet, since these projects are still in the F/S or reviewing F/S stages, problems which may appear during these studies would be solved if DPWH and DOTr has discussions during these studies.

Table 2.5.7 List of the Projects in IPIF

Project name	Required Action	Estimated Investment Cost
Output 1) Roads and Bridges		
North Eastern Luzon Expressway	F/S for 10 km tunnel	PhP18.42 billion (~ US$372.17 million)
Nationwide Island Provinces Link Bridges for Sustained Economic Growth (Sorsogon–Samar)	F/S for 4 bridges (1.2 km + 7.0 km + 6.0 km + 4.0 km) between Sorsogon and Samar	PhP92.23 billion (~ US$1.84 billion)
Laguna Lakeshore Road Network	F/S	PhP50 billion (~ US$1 billion)
Panay–Guimaras–Negros Island Link (Long Span Bridge)	F/S	PhP 97.5 billion (~. US$1.95 billion)
Negros-Cebu Link Bridge	F/S for a long span bridge between Negros and Cebu	PhP27.589 billion (~ US$557.40 million)
Cebu–Bohol Link Bridge	F/S for a long span bridge between Cebu and Bohol	PhP122.748 billion (~ US$2.48 billion)
Samal Island–Davao City Connector Bridge	F/S for a 1 km bridge over the Pakiputan Strait between Samal and Davao City and approximately 3.4 km approach roads	PhP17.815 billion (~ US$359.94 million)
Output 2) Flood Protection		
Apayao-Abulug River Basin	Review of MP, and FS and DED of priority infrastructures for a drainage area of 3,372 sq.km and a river length of 175 km	PhP 4.869 Billion (~ US$97.4 million)
Abra River Basin	Review of MP, and FS and DED of priority infrastructures for a drainage area of 5,125 sq.km and a river length of 181 km	PhP4.861 Billion (~ US$97.4 million)
Jalaur River Basin	MP, FS and DED of priority infrastructures for a drainage area of 1,503 sq.km and a river length of 123 km	PhP5.292 Billion (~ US$105.8 million)
Buayan-Malungon River Basin	MP, FS and DED of priority infrastructures for a drainage area 1,435 sq.km and a river length of 64 km	PhP 858 Million (~ US$ 17.2 million)
Agus River Basin	MP, FS and DED of priority infrastructures for a drainage area of 1,645 sq.km and a river length of 36 km.	PhP1.109 Billion (~ US$ 22.2 million)
Tagum-Libuganon River Basin	Review of MP, and FS and DED of priority infrastructures for a drainage area of 3,064 sq.km and a river length of 89 km	PhP5.729 Billion (~ US$ 114.6 million)

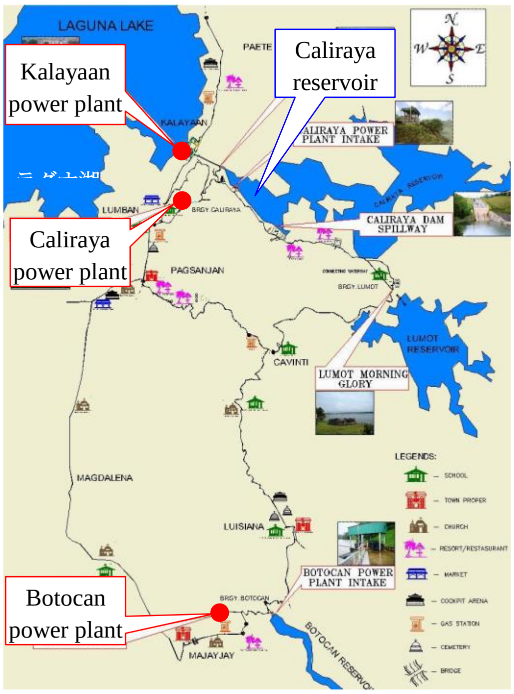
Project name	Required Action	Estimated Investment Cost
Output 3) Rail, Public Transport, Port and Airport		
PNR South Commuter	Review of FS, preparation of Design-Build BD, for the reconstruction of a 72-km st and ard gauge, dual-track, electrified railway between Manila and Los Banos, Laguna	PhP 133.7 billion (~ US$2.7 Billion)
PNR South Long Haul	Review of FS, preparation of Design-Build BD for a 581-km st and ard gauge, single-track, non-electrified railway between (a) Los Banos and Legazpi, Albay, (b) Calamba and Batangas, and (c) Legazpi and Matnog, Sorsogon	PhP 151 billion (~ US$ 3.0 Billion)
Mindanao Railway: Tagum-Davao City-Digos Segment	Review of MP, FS, preparation of Design-Build BD for a 102-km st and ard gauge, single-track, non-electrified railway between Tagum, Davao City, and Digos	PhP 36 billion (~ US$640 million)
M’lang Airport	Review of FS, and DED and BD for the optimum development of existing airport facilities	For Turbo Prop Operation – Php 1.50 Billion (~ US$30 million) For Jet Operation – Php 2.5 Billion (~ US$50 Million)
National Greenways and Non-Motorized Transport Development Project	Review of F/S, DED and BD to develop regulations for open space, pedestrian access, and non- motorized transport (NMT) infrastructure in Metro Manila, Metro Cebu, Metro Davao, and selected secondary cities.	PhP 10 Billion (~ US$200 million)
National Intelligent Transport Center	Nationwide Multi-modal ITS Master Plan; F/S and Design- Build BD for the NITC and its components.	PhP 19.3 Billion (~ US$ 386 Million)

Source: Project Administration Manual, Infrastructure Preparation and Innovation Facility (RRP PHI: 50288, October 2017)

2.5.2 Relevant Project

(1) 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 2.5.7 CBK Power Plant Location Map

This project is to supply electric power in Luzon area including Metro Manila. Among those 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 2.5.8 shows the Kalayaan Power Plant specifications and features.

Table 2.5.8 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 288.0 m (above sea level), highest water level at Laguna de Bay is designed at EL. 13.72 m and the lowest at EL. 10.12 m for the power plant. Design power generation water head is at 286.5 m 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.13.72 m and the lowest at EL. 10.12 m. Hence, there is no problem if the lake water level proposed by JICA flood management plan is higher than EL. 10.12 m. 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.