Chapter 4. Study on Draft Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area

Studied in the Parañaque Survey 2018 in connection with the Draft Flood Management Plan for Laguna de Bay Lakeshore Area, were: (1) the water level rise control (structural measures), (2) the flood damage reduction (structural measures); and (3) the non-structural measures. Based on the Draft Plan formulated in the Parañaque Survey 2018, this follow-up study re-examined the optimum facility scale such as the selected Parañaque spillway, lakeshore dike, drainage pumping station, etc.

4.1 Outline of Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area Formulated in 2018

The results of the Parañaque Survey 2018 are summarized in Subsections 4.1.1 to 4.1.4 below. It should be noted that the Draft Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area does not consider climate change.

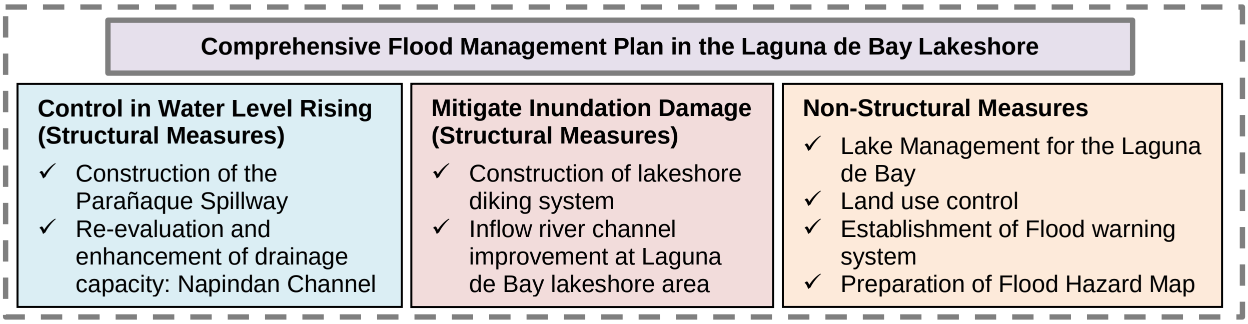
4.1.1 Flood Damage Situation in Laguna de Bay and the Flood Management Plan

Flood damage in 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 as summarized in Table 4.1.1.

Table 4.1.1 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, tropical cyclone, and inflow from rivers and drainage channels including the Manggahan Floodway. ✓ Reduction in water level is caused by the outflow from Napindan Channel and the Manggahan 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 capacity of Napindan Channel and Manggahan Floodway are insufficient.
Frequency of flood damage occurrence	✓ More than EL 12m, the level affecting the living infrastructure, occurred 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 Manggahan F1oodway,” land in most of Laguna de Bay shore area is utilized and the damaged area expands to almost all the lakeshore areas.
Inundation depth and duration of Inundation	✓ Based on the historical maximum water level (approximately EL 14m), the inundation depth reached a maximum of about 2 m at residential areas located at EL 12m, and reached about 1.5 m at the residential areas located at EL 12.5m. ✓ During the flood caused by Typhoon Ondoy, the water level of EL 12.5m or more continued for about 130 days; whereas, the water level of 13m or more continued for about 60 days.

Since the flood of Laguna de Bay extends throughout the entire lower lakeshore area, it is recommended that the comprehensive flood management plan of the entire lakeshore area is considered as the flood measures for 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 4.1.1.



Source：Parañaque Survey, 2018

Figure 4.1.1 Three Key Elements of Laguna de Bay Comprehensive Flood Management Measures

4.1.2 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 4.1.2 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 4.1.3). The 100-year probability water level in Laguna de Bay is 14.3m. The recorded maximum water level (14.03m, 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 4.1.3 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

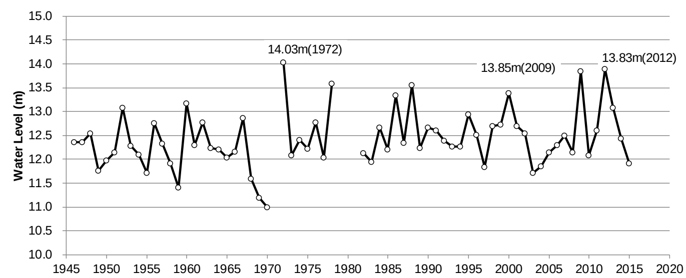
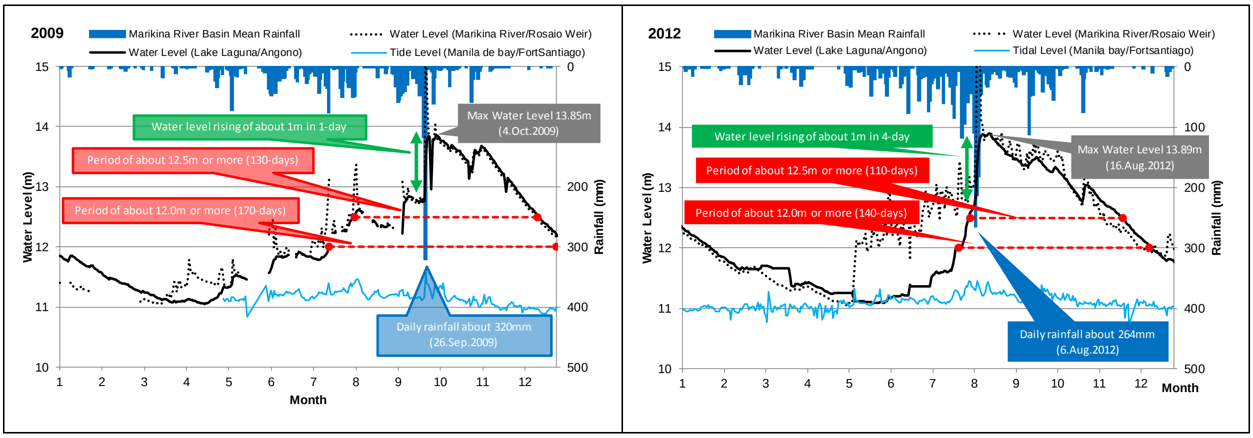


Figure 4.1.2 Long-Term Changes of the Maximum Water Level of Laguna de Bay (1946 to 2016)

Source：Parañaque Survey, 2018

(1) 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).



Source：Parañaque Survey, 2018

Figure 4.1.3 Laguna de Bay Water Level Fluctuation in 2009 and 2012

(2) Water Level Fluctuation Analysis of Laguna de Bay (LongTerm 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 4.1.4. The result of the water level fluctuation analysis of Laguna de Bay (long term evaluation) is shown in Figure 4.1.5.

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

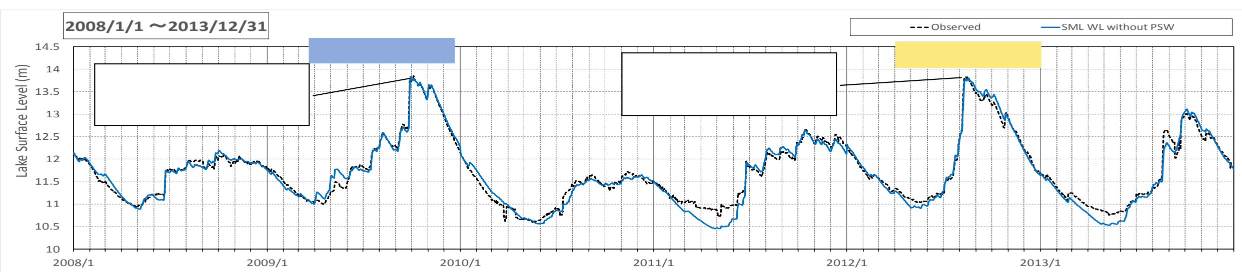
- Inflow from the Laguna de Bay Basin (surrounding basins)
- Inflow from the Marikina River Basin to the Manggahan Floodway
- Outflow from Laguna de Bay to Manggahan Floodway to the Marikina River
- Direct rainfall to and evapotranspiration from the Laguna de Bay lake surface
- Inflow and outflow from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

Source：Parañaque Survey, 2018

Figure 4.1.4 Conceptual Diagram of Hydrological and Hydraulic Analysis Model



Source：Parañaque Survey, 2018

Figure 4.1.5 Result of the Water Level Fluctuation Analysis of Laguna de Bay (Long-Term Evaluation, Without Parañaque Spillway)

4.1.3 Structural Measures

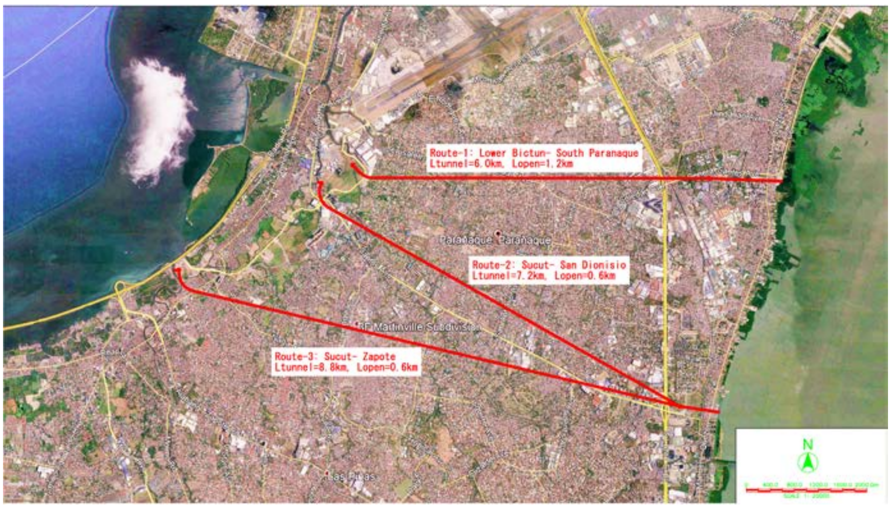
The structural measures aim to reduce the inundation damage at the Laguna de Bay lakeshore area and to control the rise of lake-water level. These measures consist of the construction of the Parañaque Spillway, the heightening of parapet wall along the Napindan Channel, and the construction of a lakeshore 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 will 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 can 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 4.1.6. The specifications of the spillway along Route D are as summarized in Table 4.1.4.



Source：Parañaque Survey, 2018

Figure 4.1.6 Proposed Alternatives of Alignment of Parañaque Spillway

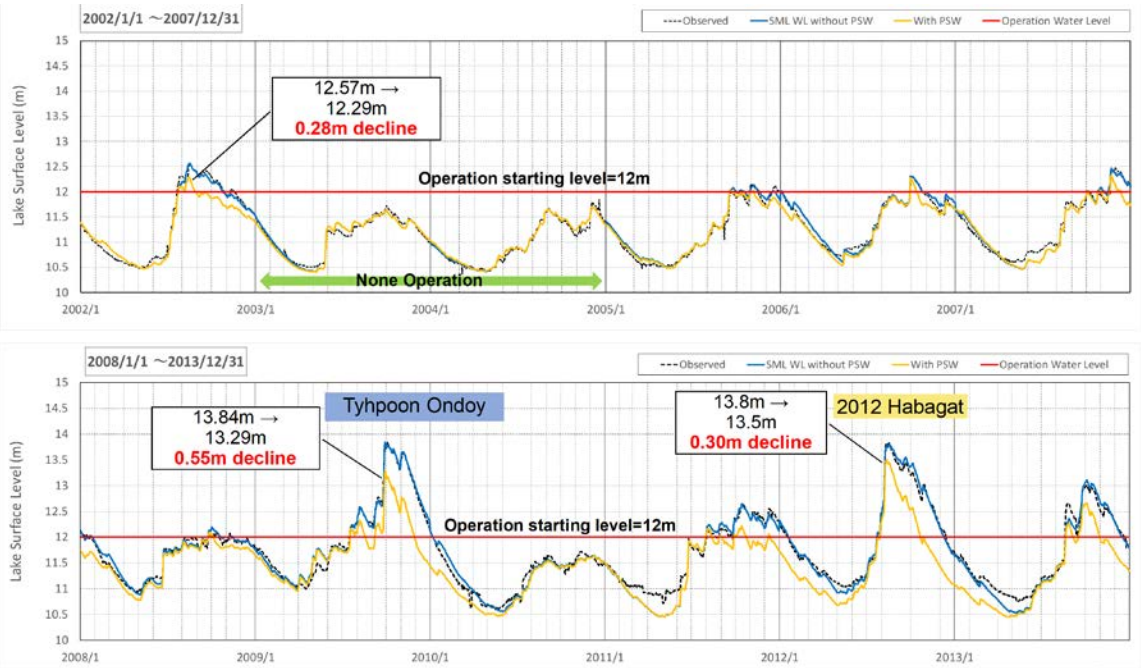
Table 4.1.4 Main Features of Parañaque Spillway Alternatives

Item	Route 1	Route 2	Route 3
Route	Lower Bicutan to South Parañaque River	Sucat to South Parañaque Rive	Sucat to Zapote River
Type of Spillway	Underground River, Pressure Pipe System		
Design Discharge (Max. Discharge)	200 m^3/s		
Laguna de Bay Design Flood Level	14.0m		
Operation Starting Water Level	12.0m		
Inlet Structure	With Control Gate		
Increased Ratio of Tunnel Cross Section	Approx. 10%		
Width of Inner Maintenance Road	5m		
Length of Intake Open Channel	1.2km	0.6km	0.6km
Length of Tunnel	6.0km	7.2km	8.8km
Inner Diameter of Tunnel	12m		
Diameter of Inlet Vertical Shaft	31.6m		
Diameter of Outlet Vertical Shaft	31.6m		

Source：Parañaque Survey, 2018

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



Source：Parañaque Survey, 2018

Figure 4.1.7 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 as shown in Table 4.1.5, and the water level fluctuation analysis with 100-year probability is as shown in Figure 4.1.8.

Table 4.1.5 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

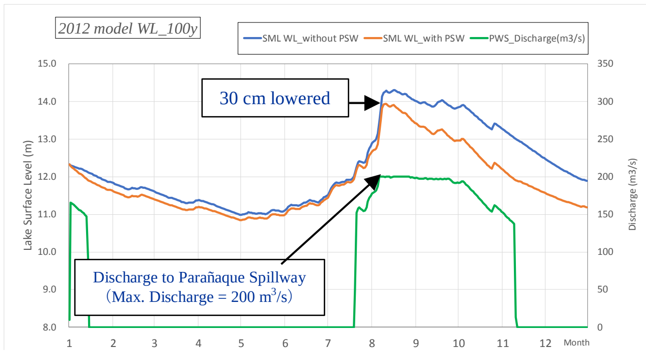


Figure 4.1.8 100-year Probability, Analysis Results of Water Level Fluctuation with Parañaque Spillway

Source：Parañaque Survey, 2018

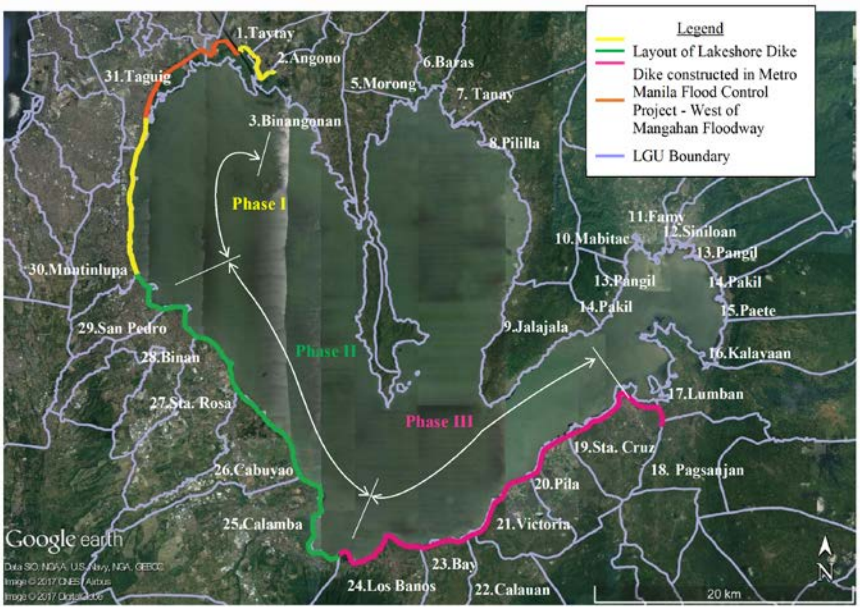
(2) Lakeshore Diking System

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. This system is designed to 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 locations at EL 12.0 m to EL 12.5 m are mostly chosen. The design lake water level is set at the 100-year probable water level (EL 14.0 m), and the lakeshore area is prioritized based on the land use and beneficial population and land area.

The lakeshore diking system will be constructed referring to the priorities, and the total length of the system is proposed to be approx. 83 km. Non-structural measures are proposed at the residual areas which has less assets, resulting in the low economical effect of 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



Source：Parañaque Survey, 2018

Figure 4.1.9 Layout Plan of the Lakeshore Dike (Priority Area)

(3) Parapet Wall Heightening at Napindan Channel

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 freeboard (0.3 m), the parapet wall is to be heightened by 0.2 m at almost the entire extent of the Napindan Channel (6.8 km).

4.1.4 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 the 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 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

Land use management measures proposed for the low-lying areas with high flood risk along the Laguna de Bay Lakeshore are:

- ✓ 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.

4.2 Re-study on Parañaque Spillway

4.2.1 Revised Operation Level of Parañaque Spillway

(1) Operation Level of Parañaque Spillway

In the Parañaque Survey 2018, the operation level of Parañaque Spillway was set at 12.0 m (full-year), and the effect of reducing the water level of Laguna de Bay was examined. To understand the impact on the lake water level by reviewing/revising the operation start water level of Parañaque spillway, the calculation conditions are the same as in the Parañaque Survey 2018: no climate change, tunnel inner diameter: 12 m, maximum discharge: 200 m^3/s.

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

＜Operation Level of Parañaque Spillway＞

- ・January～May（Non-flooding Period）：non operation
- ・June～July(water level raising Period）：11.5m
- ・August～December（water level lowering Period）：12.0m

In March 2019, a serious water shortage occurred in Metro Manila. To avoid the influence on the intake of the water treatment plant facilities using the Laguna de Bay as a water source in the dry season, the Parañaque Spillway is not operated during the non-flood season (January-May).

In addition, there are existing water purification facilities of Maynilad and Manila Water, using Laguna de Bay as the water source (see Subsection 2.2.2, Water Utilization Project). Based on the discussions with Maynilad and Manila Water regarding the water level in Laguna de Bay where water level affects the intake of water at the water supply facilities, there is no event that water intake was not possible due to the low water level in Laguna de Bay, and the impact oin Laguna is only the effect of water quality (salinity) on the intake.

(2) Impact on the Water Level of Laguna de Bay by Changing Operation Lake Level

- In the Parañaque Survey 2018, the operating level of the Parañaque Spillway was examined at EL 12.0m (all year), and as a result, the 100-year probable lake water level will decrease from 14.3m (no climate change) to 14.0m (0.3m).
- On the other hand, in this study, the operation start water level is set to 11.5 m from June to July and 12.0 m from August to December with the aim of lowering the water level before the flood season as mentioned above, The 100-year probable lake water level decreased from 14.3m (no climate change) to 13.8m (0.5m).

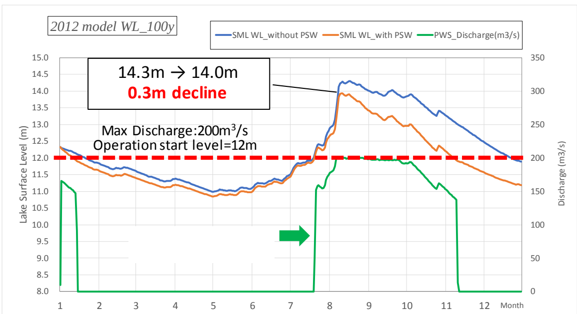
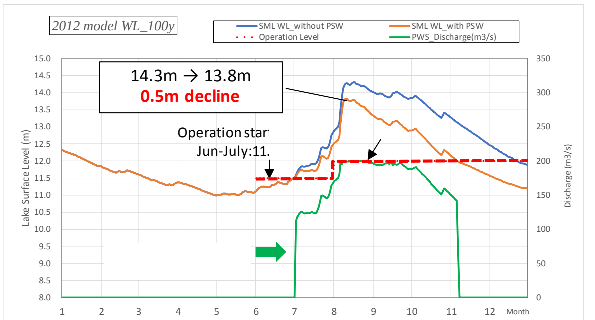
Result of 2018 Survey 100-year No Climate Change Operation Level：12.0m（fully year）	Result of this Study 100-year No Climate Change Operation Level：Jun-Jul：11.5m, Aug-Dec：12.0m
	

Figure 4.2.1 Analysis Results of Water Level Fluctuation 100-year Return Period (2018 Survey and this Study)

The review on the operation start water level confirmed that the 100-year probability (no climate change) lake water level decreased from 14.3 m to 13.8 m. Therefore, as described above, the operation start water level rise (June to July) changed to 11.5m, water level drop period (August to December), 12.0m, and non-flood period (January to May) no operation.

In order to understand the long-term impact on the water level of Laguna de Bay, changes in the water level of Laguna de Bay between 2002 and 2013 (12 years) with and without the Parañaque spillway are as shown in Figure 4.2.2 and Table 4.2.1.

Table 4.2.1 Long-Term Prediction Results from 2002 to 2013 (Operation Level, in June to July: 11.5m; Aug-Dec: 12m; Tunnel Diameter=12m, No Climate Change)

	Maximum Water level				days of more than 12.5m		
	Observed	SML					
		WL without PSW ①	With PSW ②	①－②	WL without PSW ③	With PSW ④	days (③-④)
2002	12.55	12.57	12.29	0.28	8	0	8
2003	11.72	11.64	11.64	0.00	0	0	0
2004	11.85	11.69	11.69	0.00	0	0	0
2005	12.15	12.12	12.03	0.10	0	0	0
2006	12.30	12.30	12.27	0.03	0	0	0
2007	12.49	12.47	12.33	0.14	0	0	0
2008	12.14	12.19	12.10	0.10	0	0	0
2009	13.85	13.84	13.29	0.55	110	46	64
2010	12.12	12.12	11.64	0.48	0	0	0
2011	12.65	12.65	12.22	0.43	17	0	17
2012	13.83	13.80	13.50	0.30	108	63	45
2013	13.01	13.11	12.66	0.45	62	15	47
Min	**11.72**	**11.64**	**11.64**	**0.00**	**0**	**0**	**0**
Ave	**12.56**	**12.54**	**12.31**	**0.24**	**25**	**10**	**15**
Max	**13.85**	**13.84**	**13.50**	**0.55**	**110**	**63**	**64**

- In Typhoon Ondoy (2009), the lake water level was 13.84m (calculated water level; no Parañaque Spillway), but when the Parañaque Spillway was operated, the water level decreased to 13.29m (0.55m reduction). Also, the number of inundation days of 12.5m or more decreased from 110 days to 46 days (reduced by 64 days), and the inundation days shortened by about 2 months.
- In 2012 Habagat, the water level of 13.80m decreased to 13.50m (0.3m reduction) with the operation of Parañaque Spillway. The number of inundation days over 12.5m shortened from 108 days to 63 days and 45 days.
- In 2013, 13.11m decreased to 12.66m, and inundation days shortened from 62 days to 15 days.

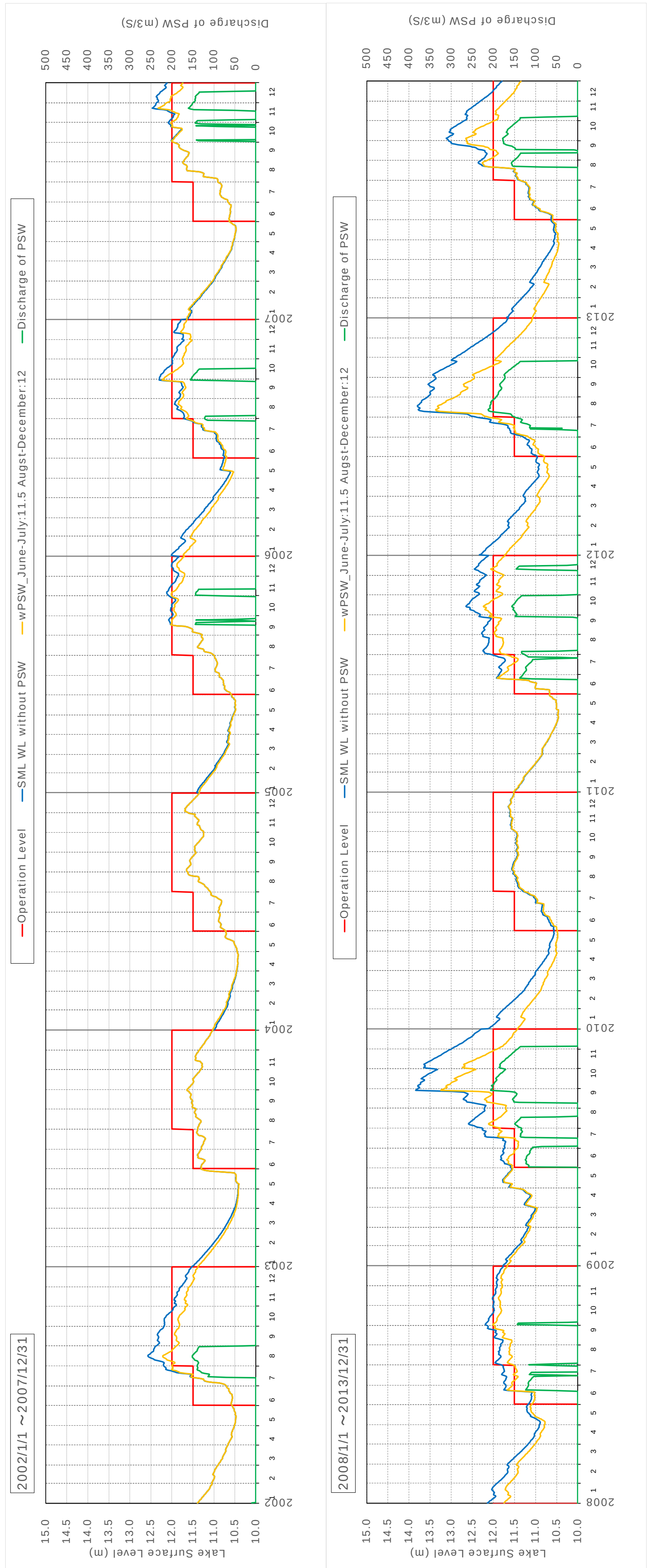


Figure 4.2.2 Long-term prediction Result from 2002 to 2013
operation level Jun-Juy:11.5m Aug-Dec:12m, Tunnel Diameter=12m, No Climate Change

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

(1) Policy of Re-study

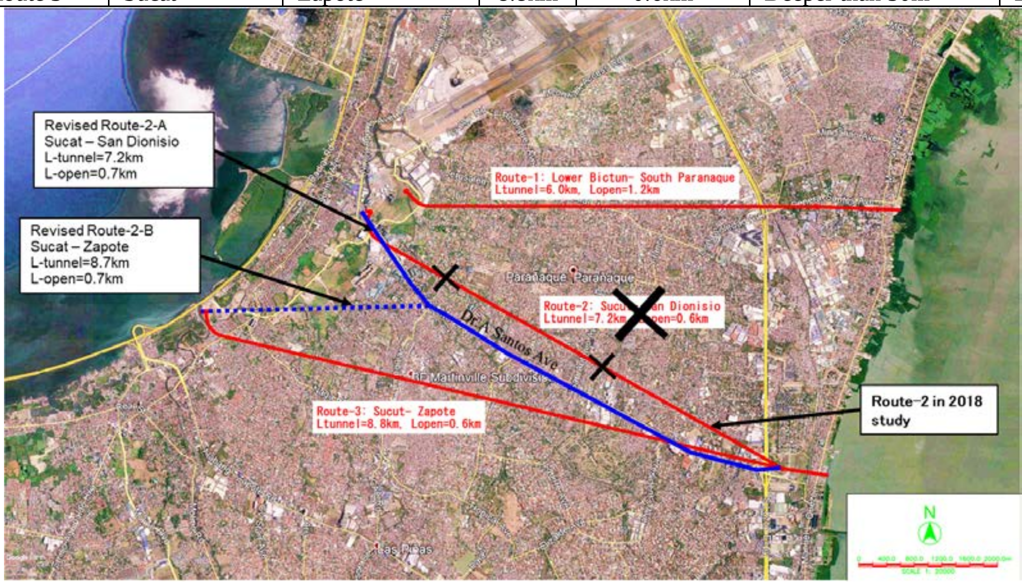
In this study, with the aim of cost reduction, a route plan for Parañaque spillway was set based on the following policy. The revised Parañaque spillway route (draft) is shown in Figure 4.2.3.

In the Parañaque Survey 2018, two types of tunnel construction methods were examined on the tunnel part (shield construction method and NATM) based on the "shielding method", which enables the construction of tunnels. Regarding NATM, the possibility of adoption shall be examined based on future geological surveys.

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

Table 4.2.2 Re-study on Alignment of Parañaque Spillway Alternatives

Route	Location Inlet	Location Outlet	Tunnel Length	Open Channel Length	Tunnel Depth	Description
Route 1	Lower Bicutan	South Parañaque	6.0km	1.2km	Deeper than 50m	2018 Survey
Route 2-A	Sucat	San Dionisio	7.2km	0.7km	Deeper than 15～30m	This Study
Route 2-B	Sucat	Zapote	8.7km	0.7km	Deeper than 15～30m	This study
Route 3	Sucat	Zapote	8.8km	0.6km	Deeper than 50m	2018 Survey



Source：Parañaque Survey, 2018

Figure 4.2.3 Alternative Routes of Parañaque Spillway

(2) Review on Route 1 and Route 3 of Parañaque Spillway

1) Alignment Plan of Spillway

The alignments of Route 1 and Route 3 in the "Parañaque Study 2018" are as shown in Figure 4.2.3 and Table 4.2.3.

Table 4.2.3 Alignment Plans of Route 1 and Route 3 of Parañaque Spillway (Parañaque Study 2018)

Route Name	Route-1 (Lower Bicutan to South Parañaque River)	Route-3 (Sucat to Zapote River)
Summary of Spillway Alignment	Basically, straight line between Lower Bicutan and South Parañaque River to minimize the water head loss. (However, the alignment bends upstream of the Outlet Shaft due to the adjustment of inflow angle.)	Basically, straight line between Sucat and Zapote River to minimize water head loss. (However, the alignment bends upstream of the Outlet Shaft due to the adjustment of inflow angle.)
Spillway Length (Measured by Google Earth)	Lower Bicutan - South Parañaque River Spillway : 6.0 km Open Channel : 1.2 km	Sucat - Zapote River - Spillway : 8.8 km Open Channel : 0.6 km

Source：Parañaque Survey, 2018

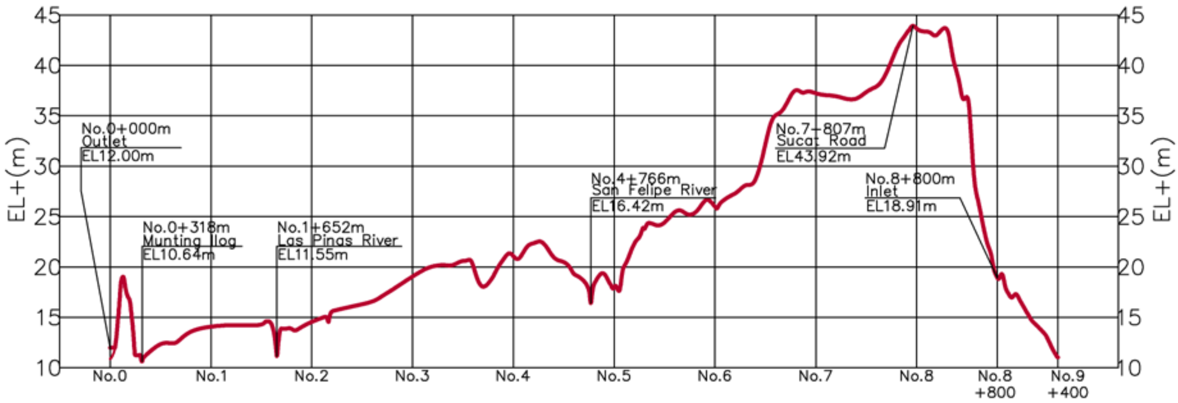
2) Cross Section Plan (Inner Section Plan)

According to the "Parañaque Study 2018", the inner diameter is 12 m and the width of the inner maintenance road is 5 m

3) Longitudinal Plan of Tunnel

According to Section 4.3 of Parañaque Survey 2018, the slope of the Basic Longitudinal Plan is "1/1,500" and the direction is "Order Slope" (Inlet to Outlet).

According to Section 11 of the IRR of RA 10752, the depth of the longitudinal plan of Shield Tunnel Method should be more than 50 m to minimize the land acquisition area based on the GIS Data obtained from NAMRIA. The existing ground and the critical point of the longitudinal plan based on GIS Data is as shown in Figure 4.2.4.



Source：Parañaque Survey, 2018

Figure 4.2.4 Existing Ground Level and Critical Points based on GIS Data (Route 3)

According to Figure 4.2.4, the ground level and longitudinal plan of each critical point of the Shield Tunneling Method are as shown in Table 4.2.4.

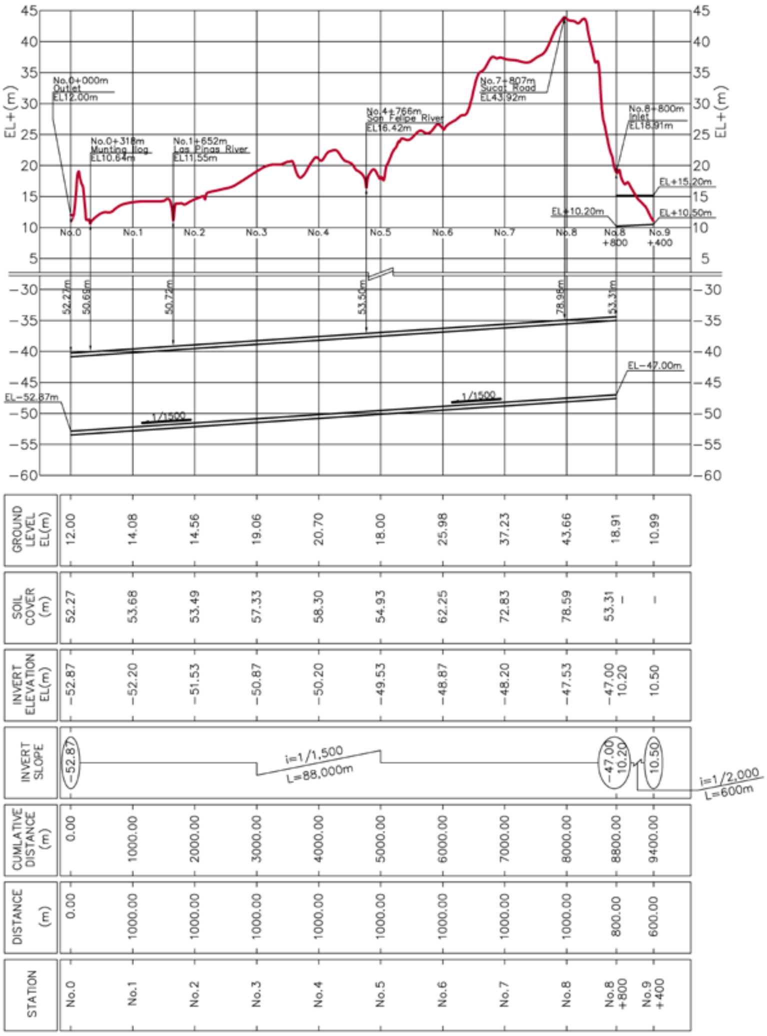
Table 4.2.4 Longitudinal Plan and Critical Points of Shield Tunneling Method (Route 3)

Station	Cumulative Distance (m)	Place	Ground Level EL(m)	Invert Elevation EL(m)	Slope	Soil Cover (m)	Note
No. 0+000	0	Outlet Shaft	+12.00	-52.87	1/1,500	52.27	Complemented Ground
No. 0+318	318	Munting Ilog	+10.64	-52.65		50.69	Critical Point
No. 1+652	1,652	Las Piñas River	+11.55	-51.77		50.72	
No. 4+766	4,766	San Felipe River	+16.42	-49.68		53.50	
No. 7+807	7,807	The Highest Point	+43.92	-47.66		78.98	
No. 8+800	8,800	Inlet Shaft	+18.91	-47.00		53.31	
		Downstream of Open Channel		+10.20	1/2,000	—	Open Channel Section
No. 9+400	9,400	Upstream of Open Channel	+10.99	+10.50		—	

Source：Parañaque Survey, 2018

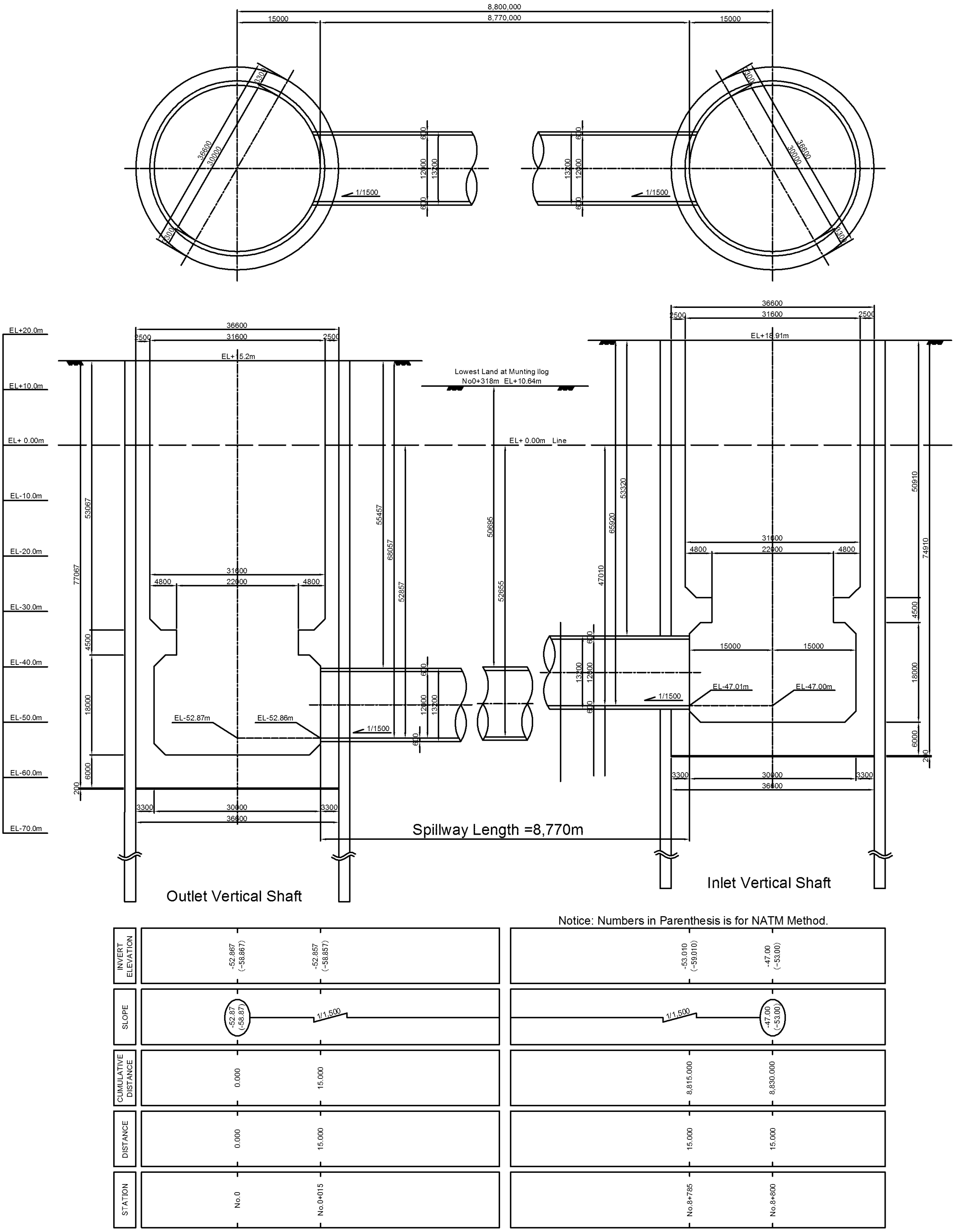
4) Longitudinal Plan of Tunnel

In accordance with the Parañaque Survey 2018, outline drawings of main facilities, such as Longitudinal Profile of Parañaque Spillway, Plan Drawing of Vertical Shafts for Inlet and Outlet, Plan Drawing of the Intake Facility (Inlet), Cross Section Drawing of the Intake Facility, Plan Drawing of Drainage Facility and Cross Section Drawing of Drainage Facility (Outlet), are as shown in Figure 4.2.5 to Figure 4.2.10, respectively.



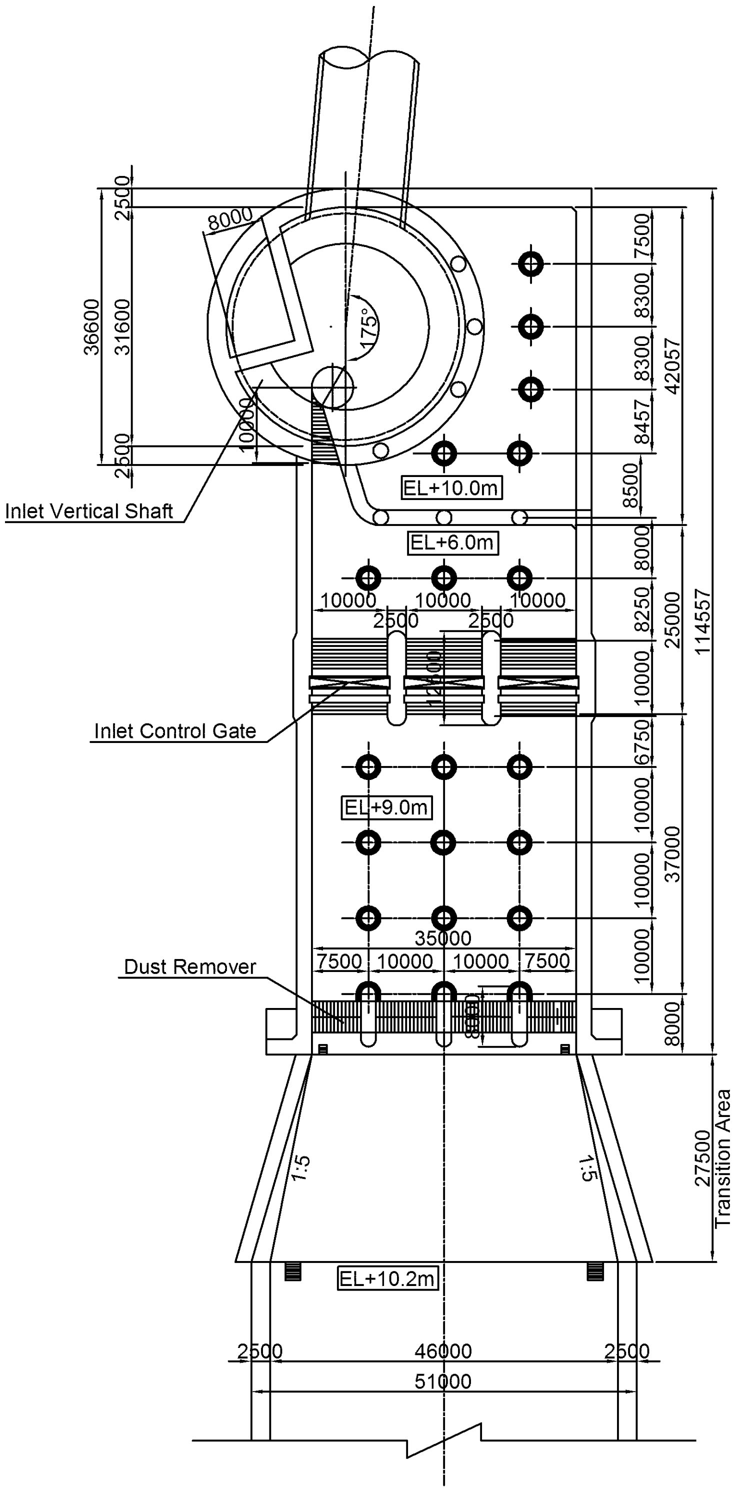
Source: Parañaque Survey, 2018

Figure 4.2.5 Longitudinal Profile of Parañaque Spillway (Route 3)



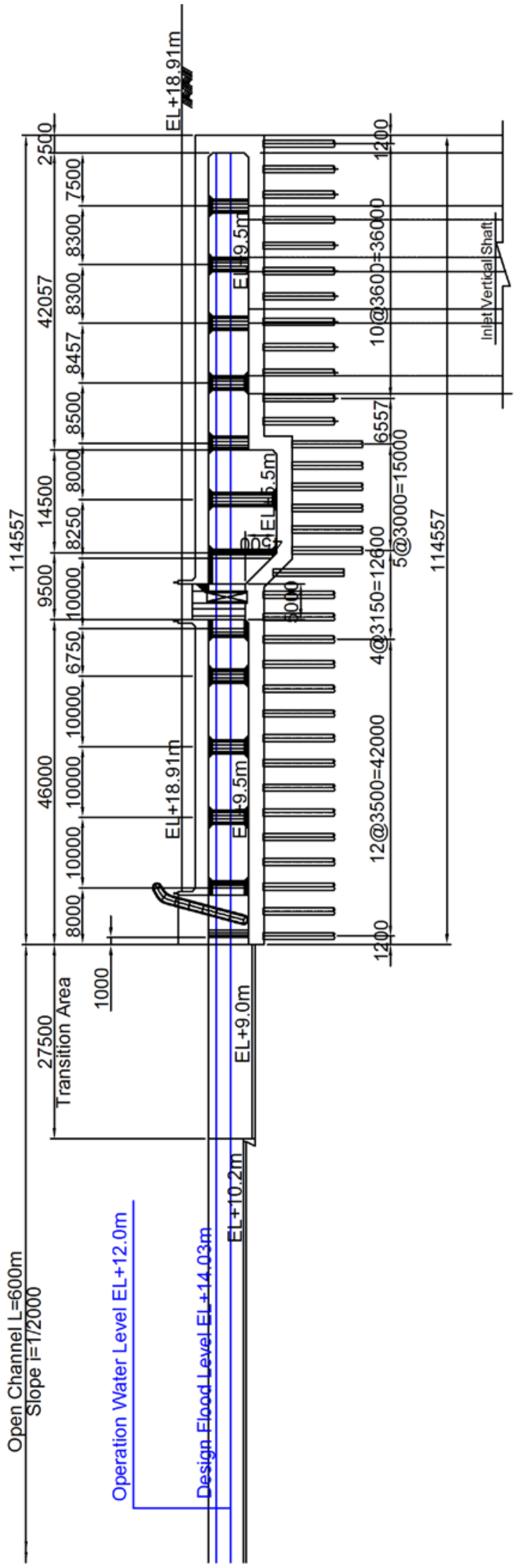
Source: Parañaque Survey, 2018

Figure 4.2.6 Plan Drawing of Vertical Shafts for Inlet and Outlet



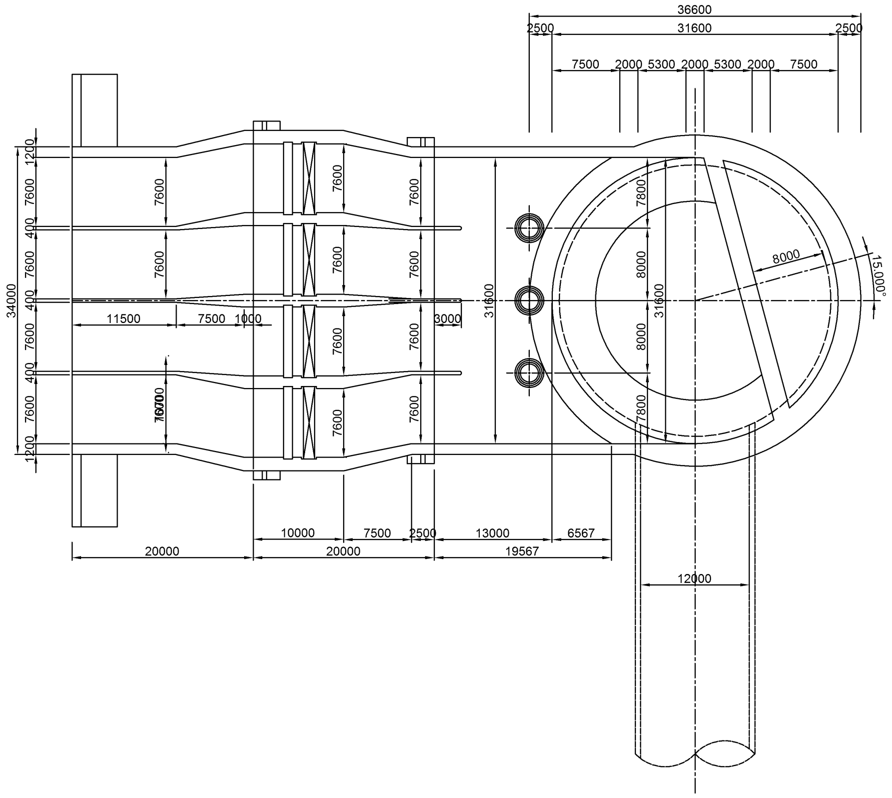
Source: Parañaque Survey, 2018

Figure 4.2.7 Plan Drawing of Intake Facility



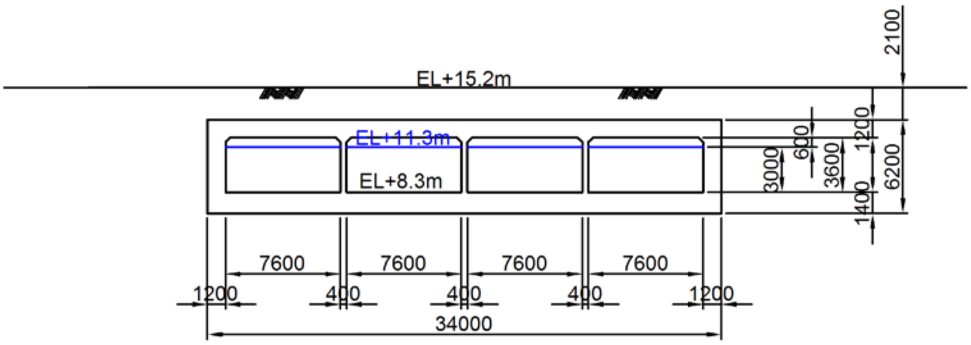
Source: Parañaque Survey, 2018

Figure 4.2.8 Cross Section Drawing of Intake Facility



Source: Parañaque Survey, 2018

Figure 4.2.9 Plan Drawing of Drainage Facility



Source: Parañaque Survey, 2018

Figure 4.2.10 Cross Section Drawing of Drainage Facility

(3) Review on Route 2 of Parañaque Spillway

1) Re-study Policy

The ground in Manila is highly self-sustaining and has a strong tuff layer near the ground surface, and the route has a similar tendency. In the previous survey, it was confirmed that the construction efficiency and excavation efficiency of the shaft was extremely low due to the high strength of the ground, and the construction cost and the construction period were greatly increased. Therefore, to be examined in this re-study is the reduction of construction cost and construction period by reducing the shaft size.

In previous studies, in order to shorten the length of the tunnel, it was planned to construct a tunnel deeper than 50m below the ground cover that does not have ground rights so that it can pass as a route under private land. By restudying the route, the overburden was reduced and the depth of the shaft was reduced.

2) Alignment Plan of Spillway

Alignments of Route 2-A and Route 2-B are shown in Figure 4.2.11 and Figure 4.2.12.

Table 4.2.5 Alignment Plans of Route 2-A and Route 2-B of Parañaque Spillway

Route Name	Route 2-A (Sucat to San Dionisio River)	Route 2-B (Sucat to Zapote River)
Summary of Spillway Alignment	A tunnel is planned under Dr. A. Santos Avenue that connects Laguna de Bay and Manila Bay efficiently from the Sucat inlet shaft, and is a straight line that connects to the outlet shaft of San Dionisio River.	A tunnel is planned under Dr. A. Santos Avenue that connects Laguna de Bay and Manila Bay efficiently from the Sucat inlet shaft, and is a straight line that connects to the outlet shaft of Zapote River.
Spillway Length (Measured by Google Earth)	Sucat - South Parañaque River Spillway : 7.2 km Open Channel : 0.7 km	Sucat - Zapote River - Spillway : 8.7 km Open Channel : 0.7 km

Source：Parañaque Survey 2018

i. Route 2-A (Sucat-San Dionisio Route)

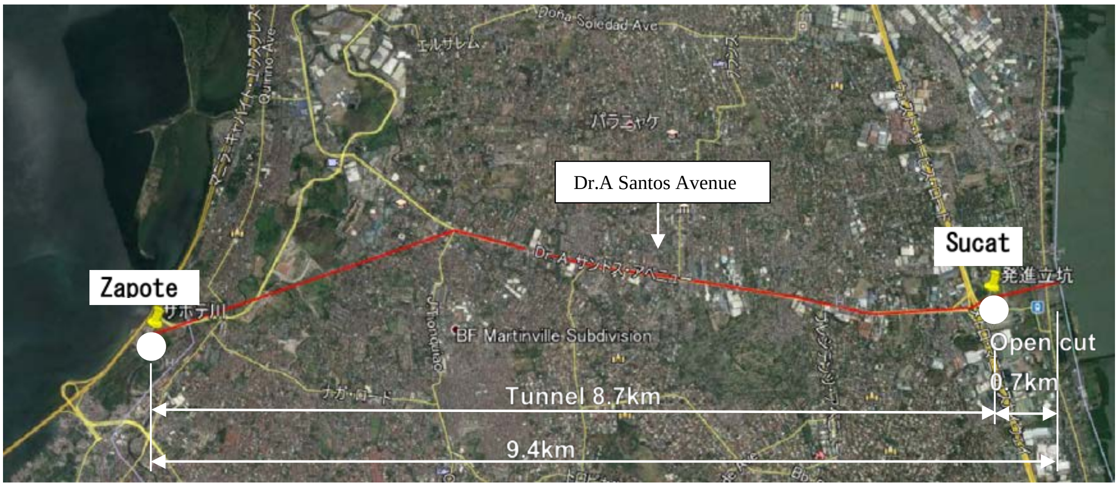
It was decided to place the tunnel under the existing Dr. A. Santos Avenue that connects Laguna Lake and Manila Bay since it provides the optimal route and road width. The starting part of the shield will use the site that is currently a vacant lot in Sucat, and approximately 700 m from Laguna Lake to the tunnel will be an open channel as planned in the previous fiscal year. The arriving part is a vacant lot along the San Dionisio River where the tunnel length can be minimized. As a result, the shield tunnel length is approximately 7.2 km.

Source：JICA Study Team

Figure 4.2.11 Layout Plan of Route 2-A（Proposed Route to San Dionisio River）

ii. Route 2 (Sucat-San Dionisio Route)

The destination is Zapote instead of San Dionisio. The starting section is the same route up to 5.4 km, but then passes straight underground towards Zapote through private properties. The private properties where the tunnel passes 50 m underground will receive compensation for ground rights.

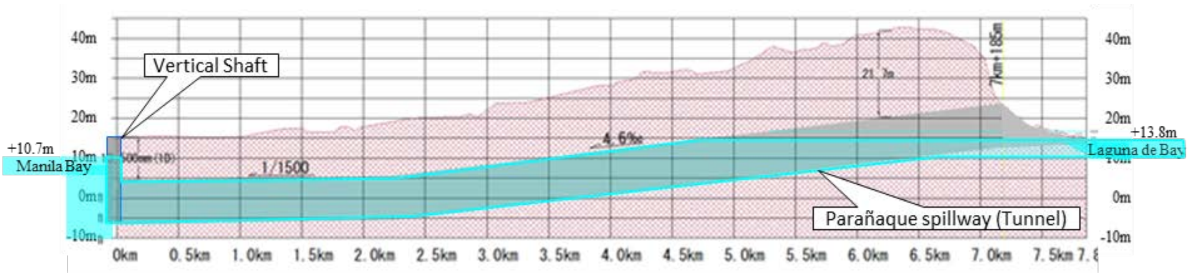


Source：JICA Study Team

Figure 4.2.12　Layout Plan of Route 2-B（Proposed Route to Zapote River）

3) Longitudinal Plan of Tunnel

The ground at Sucat site which is assumed to be the launching point of the shield, has a steep slope from Lake Laguna toward the west. The launching section shall start on the ground slope without a shaft. The reaching part shall be a vertical alignment that secures at least 1D (D is the outside diameter of the tunnel) overburden, and the excavation depth shall be reduced significantly from 82m to 32m. The tunnel plan is shown below. The "Zapote arrival route plan" is almost the same, and is omitted.



Source：JICA Study Team

Figure 4.2.13　Image of Longitudinal Profile（Route 2-A and Route 2-B）

(4) Comparison of Three Alternatives of Parañaque Spillway Alignment

The specifications of spillway routes examined in the Parañaque Survey 2018 and this study are summarized in Table 4.2.6. The construction process is shown in Figure 4.2.14 to Figure 4.2.17.

As summarized in Table 4.2.6, Route 2-B is currently the most prominent of the four alternative routes of the Parañaque Spillway.

Table 4.2.6 Comparison of Alignment Plans of Parañaque Spillway

Route Name	Route 1 (Lower Bicutan to South Parañaque River)	Route 2-A (Sucat to San Dionisio River)	Route 2-B (Sucat to Zapote River)	Route 3 (Sucat to Zapote River)
Summary of Spillway Alignment	Basically, straight line between Lower Bicutan and South Parañaque River to minimize the water head loss. (However, the alignment bends upstream of the Outlet Shaft due to the adjustment of inflow angle.)	A tunnel is planned under Dr. A. Santos Avenue that connects Laguna de Bay and Manila Bay efficiently from the Sucat inlet shaft, and is a straight line that connects to the outlet shaft of San Dionisio River.	A tunnel is planned under Dr. A. Santos Avenue that connects Laguna de Bay and Manila Bay efficiently from the Sucat inlet shaft, and is a straight line that connects to the outlet shaft of Zapote River.	Basically, straight line between Sucat and Zapote River to minimize water head loss. (However, the alignment bends upstream of the Outlet Shaft due to the adjustment of inflow angle.)
Spillway Length (Measured by Google Earth)	Lower Bicutan - South Parañaque River Spillway : 6.0 km Open Channel: 1.2 km	Sucat - South Parañaque River Spillway : 7.2 km Open Channel: 0.7 km	Sucat - Zapote River - Spillway : 8.7km Open Channel: 0.7km	Sucat - Zapote River- Spillway : 8.8 km Open Channel: 0.6 km
Vertical Shaft	Inlet Shaft : 75m height Outlet Shaft : 75m height	Inlet Shaft : - Outlet Shaft : 32m height	Inlet Shaft : - Outlet Shaft : 32m height	Inlet Shaft : 75m height Outlet Shaft : 75m height
Depth of Underground Tunnel	Deeper than 50m	Deeper than 15～30m, Mainly under Dr. A. Santos Avenue	Deeper than 15～30m, Mainly under Dr. A. Santos Avenue	Deeper than 50m
Site of Intake Facility	It is necessary to relocate large-scale facilities, such as Polytechnic University of Philippines. Δ	Mainly unused ground is widely spaced but adjacent to church. O		
Site of Drainage Facility	There is sufficient open space between upstream and downstream which are the Carlos P. Garcia Avenue Exits. ◎	An open area exists between the Parañaque Police Centre and the Premier Medical Centre. ◎	There is substantial open space at the right bank side for the viaduct bridge with a few houses avoided. ◎	
River Improvement	Widely required river improvement area due to the narrow existing channel. In addition, it may be necessary to improve the other rivers in the river system. Δ	River improvement in the upper and lower sections of the outlet facility is required. In addition, it may be necessary to improve other rivers in the river network system. Δ	Required river improvement area is smaller among two rivers because of the wide river channel near the river mouth. ◎	
Construction	No problem ◎	Since it is close to the hospital, it is important to take measures against vibration and noise during construction. Δ	No problem ◎	
Construction Period	98 months (refer to Figure 4.2.14)	60 months (refer to Figure 4.2.13) Significantly shortened construction period by eliminating the inlet vertical shaft and starting from the ground.	64 months (refer to Figure 4.2.14) Significantly shortened construction period by eliminating the inlet vertical shaft and starting from the	105 months (refer to Figure 4.2.17)

Route Name	Route 1 (Lower Bicutan to South Parañaque River)	Route 2-A (Sucat to San Dionisio River)	Route 2-B (Sucat to Zapote River)	Route 3 (Sucat to Zapote River)
	O	◎	ground. ◎	Δ
Operation & Maintenance	No problem ◎			
Social Environment	The length of 1200m of Open Channel is longer than Sucat and the land acquisition area is also wider. O	Most of the tunnel section is under the road and no compensation is required. Smaller than land acquisition of Route-1 for open channel section. O	60% of the tunnel section is under the road and no compensation is required. The remaining 40% is private underground, and compensation costs (30% of acquisition costs) are required. Smaller than land acquisition of Route-1 for open channel section. O	It is necessary to make resettlement of Laguna de Bay lakeshore area. O
Natural Environment	No problem due to open green area but precious species survey is necessary. O	No problem due to developed land ◎		
Influence to LPPCHEA	Relatively larger influence than Zapote River Case. The final decision should be considered with the result of the diffusion analysis of drainage water. Δ		Relatively smaller influence than Parañaque River Case. The final decision should be considered with the result of the diffusion analysis of drainage water. O	
Effect of Subway & Railway	No problem O		The same as left at the Open Channel area and the necessity of negotiation of the Drainage Facility site. Δ	
Cost	Cheaper than the Route 3 because of shorter of tunnel length. However, the cost for resettlement and land acquisition might be higher than it. O	This is a plan with excellent economic efficiency because it is a plan to eliminate the inlet shaft and smaller outlet shaft. ◎		More expensive plan than Route 2. Δ
Evaluation	High possibility due to economy because of the shorter tunnel length but the feasibility of river improvement and the influence to LPPCHEA still remain as problems.	This is the plan with the shortest construction period and the lower construction cost. If the river can be rehabilitated and the impact on LPPCHEA is small, it may be adopted.	The construction period is shorter and the construction cost is the lowest. This is the most promising route with little impact on drainage rivers and LPPCHEA.	More realistic plan despite of the relatively expensive cost due to longer tunnel length because the river improvement area is small and the less influence to LPPCHEA.
	O	O	◎	O

Legend: ◎ Excellent; ○ Good; △ Not Good/Some Problem; × Difficult/Impossible
Source: Originally "Parañaque Survey 2018" and partially modified by JICA Study Team

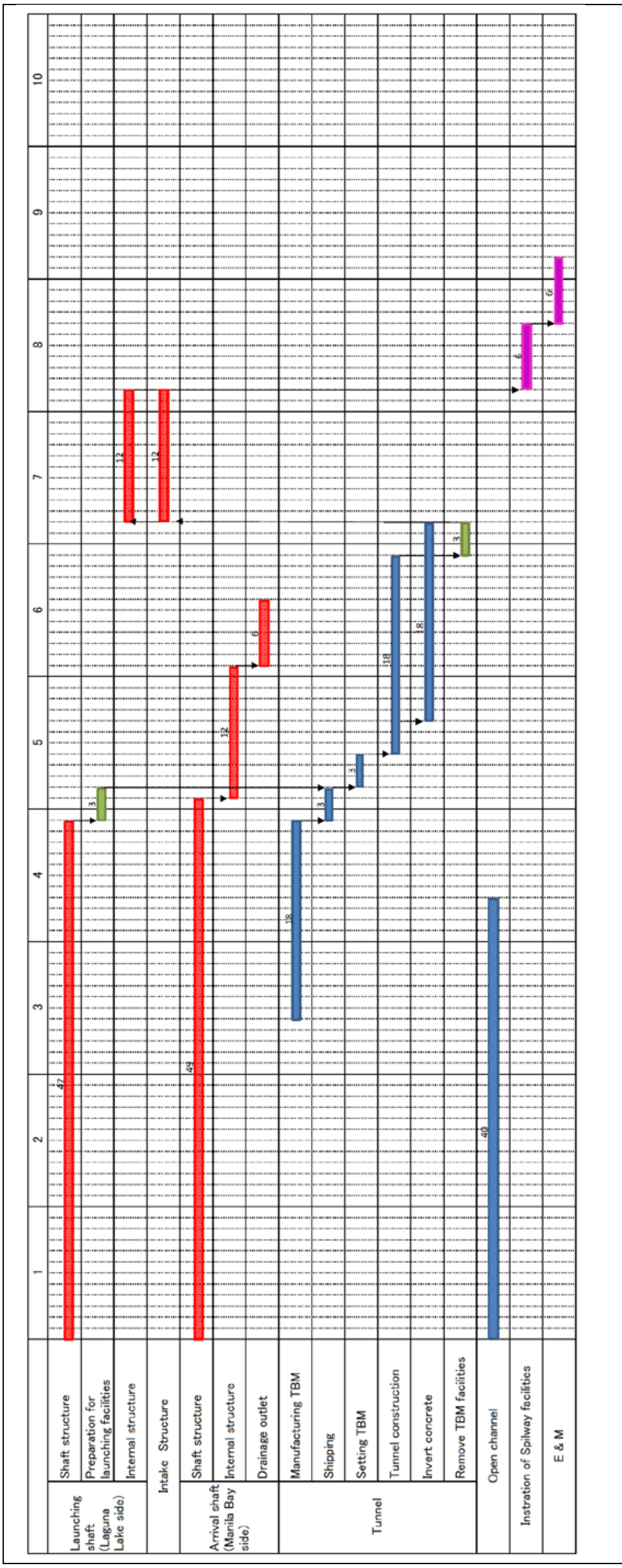
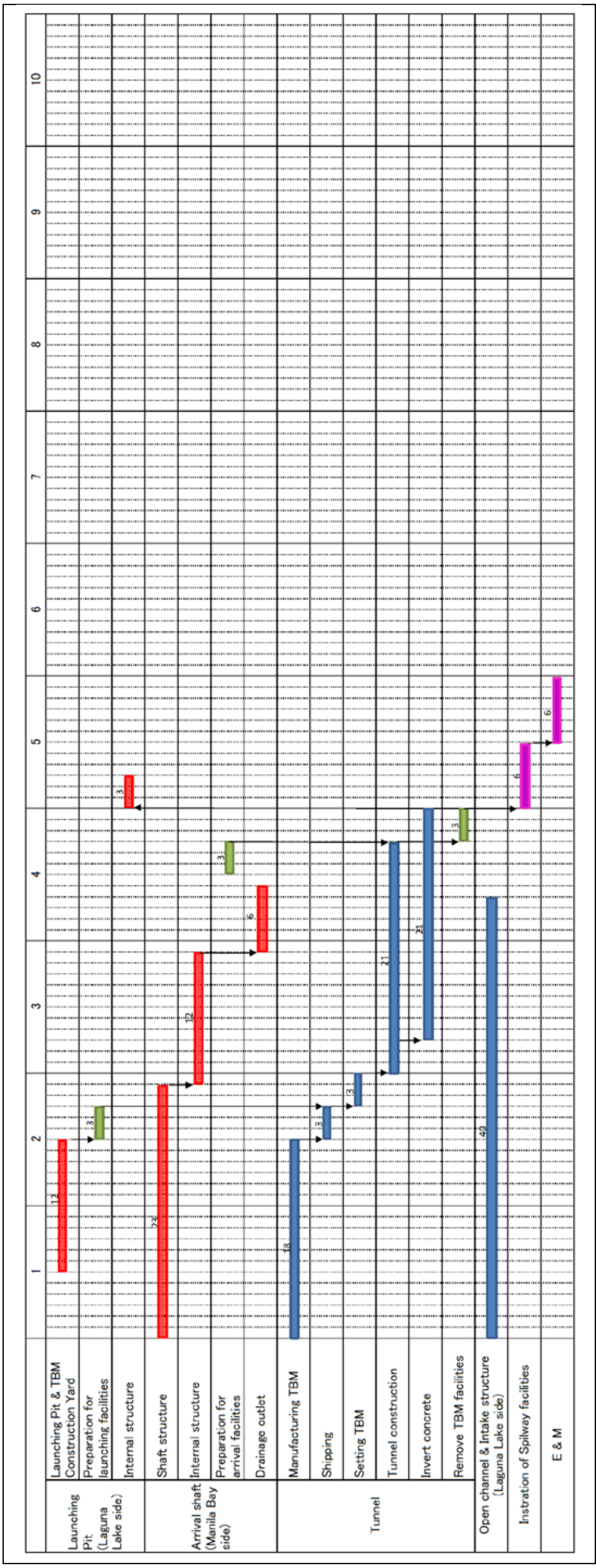
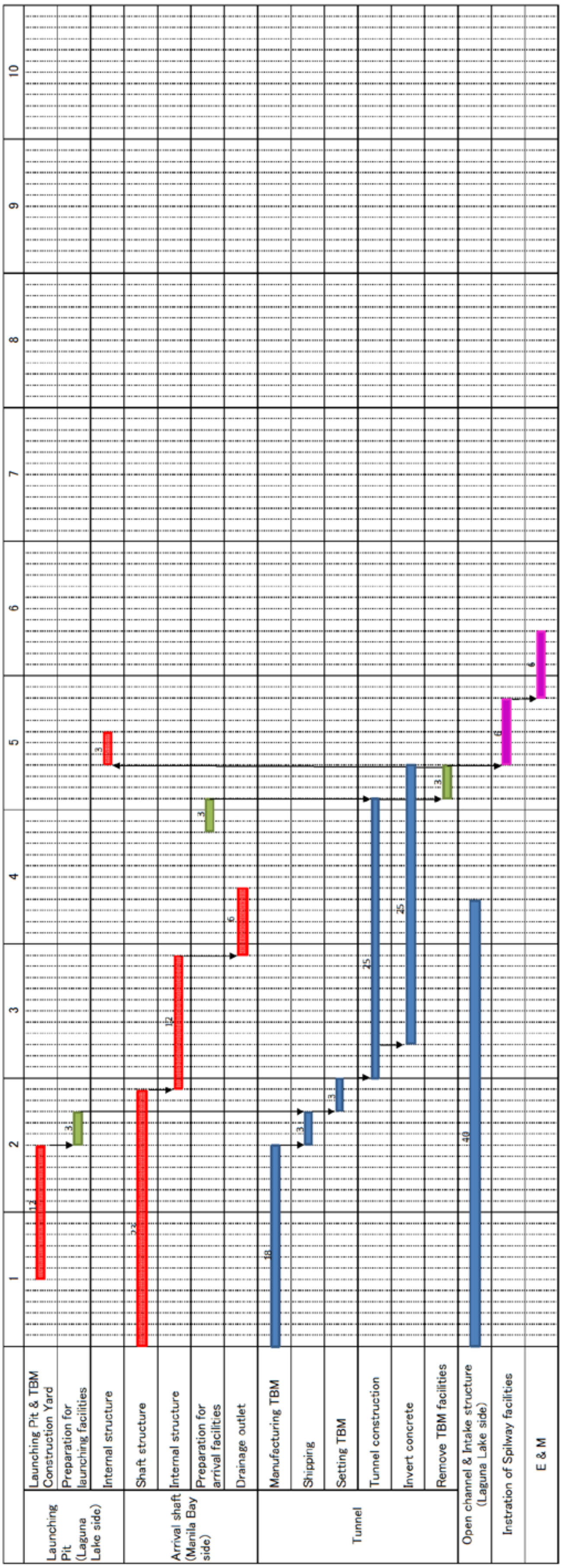


Figure 4.2.14 Outline of Construction Schedule (Route 1, Shield)



Source: JICA Survey Team

Figure 4.2.15 Outline of Construction Schedule（Route 2-A, Shield)



Source JICA Survey Team

Figure 4.2.16 Outline of Construction Schedule -A, Shield

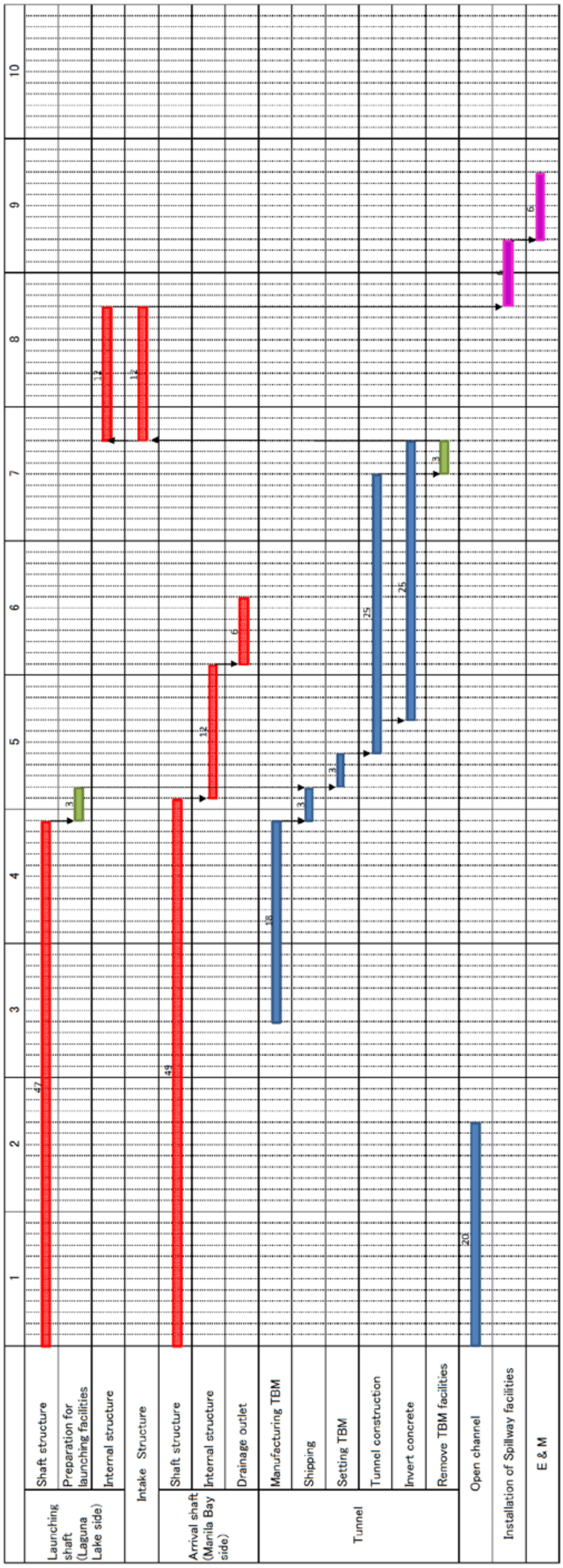


Figure 4.2.17 Outline of Construction Schedule -A, Shield

Source JICA Survey Team

4.3 Formulation of Flood Management Plan Considering Climate Change

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

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

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

4.3.1 Climate Change Evaluation in Rainfall

In this study, the latest PAGASA climate change model (2018 version) was confirmed in consultation with PAGASA and DPWH. Currently, PAGASA is forecasting future weather based on the RCP scenario (Representative Concentration Pathways, IPCC Fifth Report).

Table 4.3.1 IPCC Fifth Assessment RCP Scenario

(Those in red frame is the scenario predicted by PAGASA)

RCP:Representative Concentration Pathways	Type of Scenario
RCP2.6	Low stabilization scenario Lowest emission scenario developed with the goal of keeping future temperature rise below 2 ° C
RCP4.5* Scenario used for the study	Medium stabilization scenario
RCP6.0	High-level stabilization scenario
RCP8.5	High-level reference scenario Scenario equivalent to the maximum greenhouse gas emissions in 2100

PAGASA predicts future weather based on two scenarios, RCP4.5 and RCP8.5. Using the forecast results for each province described in the report "Observed Climate Trends and Projected Climate Change in the Philippines, 2018" obtained from PAGASA, the impact on the Laguna Lake water level in consideration of climate change was examined. As a result of discussions with PAGASA and DPWH, the scenario for future prediction adopted RCP4.5, which is also used as a basic scenario in PAGASA, for future sea level rise of 20 cm.

The predicted future rainfall (Table 4.3.2) based on the RCP4.5 scenario increases by about 48% from December to February and about 23% from March to May, while it increases from June to August in the rainy season. Is expected to increase by 2.1% and from September to November it will increase by about 8%. Table 4.3.3 shows the increase / decrease rate of 3-month rainfall calculated from the area-weighted average of the target area of this project (Laguna de Bay Basin) based on the 3-month rainfall prediction results based on the RCP4.5 scenario.

The predicted future rainfall in the area covered by this work will increase by about 50% from December to February and increase by about 25% from March to May, while it will decrease by 0.9% from June to August in the rainy season, and expected to increase by about 8% from September to November.

Table 4.3.2 The Result of 3-month Rain Change Rate by RCP4.5

Month	Present Condition 1971-2000					Future 2036-2065 (RCP4.5)									
	Rainfall (mm)					Rate of Rainfall change (%)						Rainfall (mm)			
	Cavite	Laguna	Quezon	Rizal	NCR	Cavite	Laguna	Quezon	Rizal	NCR	Average	Cavite	Laguna	Quezon	Rizal
12~2	124.9	629.2	827.7	262.4	107.5	55.7	43.9	31.6	51.5	55.5	47.64	194.5	905.2	397.4	397.4
3~5	242.8	386.8	382.7	241.5	198.5	17.9	24.8	18.9	25.6	25.7	22.58	286.2	482.6	303.4	303.4
6~8	985.7	845	670	1001.3	1170.2	9.4	-2.1	5.3	-1.7	-0.4	2.1	1,078.6	827.3	983.9	983.9
9~11	579	1065.5	1229.3	821.8	758.7	6.7	5.7	7.6	12.7	7.7	8.08	618.0	1,127.0	926.5	926.5

Table 4.3.3 Area Weight Average of Relevant Province (Forecast for 2036 to 2065：RCP4.5)

Area (km^2)	Cavite	Laguna	Quezon	Rizal	NCR
Province Area km^2=	1,257.6	1,803.0	8,322.1	1,260.7	593.9
Target area inProvince km^2=	192.8	1,416.2	73.5	949.5	232.6

Month	Future 2036-2065 (RCP4.5)					
	Rate of Rainfall change (%)_Weighted average					
	Cavite	Laguna	Quezon	Rizal	NCR	Total
12~2	3.7	21.7	0.8	17.1	4.5	47.8
3~5	1.2	12.3	0.5	8.5	2.1	24.5
6~8	0.6	-1.0	0.1	-0.6	-0.0	-0.9
9~11	0.5	2.8	0.2	4.2	0.6	8.3 ←Rainy Season
Average	1.5	8.9	0.4	7.3	1.8	19.9

Table 4.3.4 Climate Change Forecast Results (PAGASA, 2018)

Relevant Provinces for this study

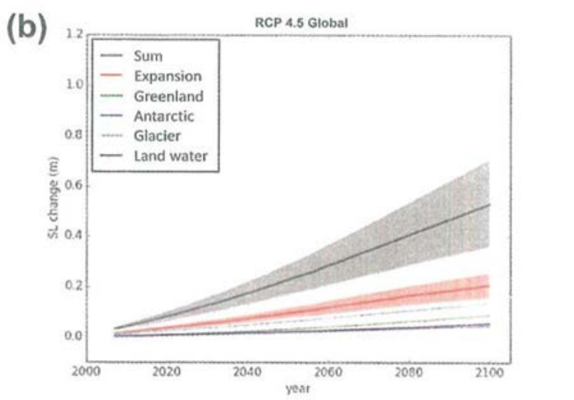
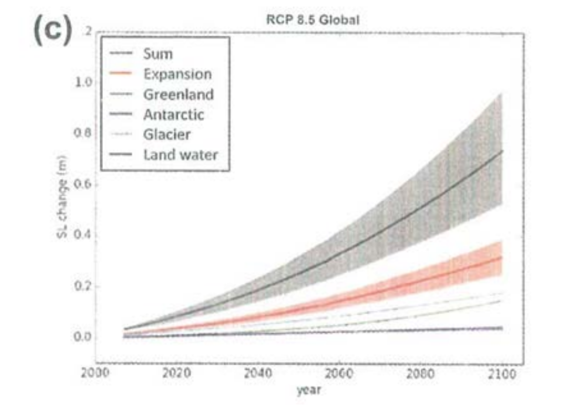
[redacted]

Region	Province	Observed (1971-2000) DJF	MAM	JJA	SON	Scenario	Range*	Projected (2036-2065) DJF (Dec-Jan-Feb) Percent change	Projected value	MAM (Mar-Apr-May) Percent change	Projected value	JJA (Jun-Jul-Aug) Percent change	Projected value	SON (Sep-Oct-Nov) Percent change	Projected value
Region 4-A	Batangas	231.0	280.4	856.5	746.4	Moderate Emission (RCP4.5)	Lower Bound	7.5	248.2	-0.1	280.1	-27.7	619.4	-11.4	661.6
							Median	14.9	265.5	1.7	285.1	-15.2	726.1	-3.6	719.7
							Upper Bound	56.1	360.7	15.8	324.8	1.0	865.1	8.2	807.2
						High Emission (RCP8.5)	Lower Bound	1.4	234.2	-11.4	248.3	-23.5	655.6	-9.7	673.7
							Median	8.1	249.8	0.5	281.8	-8.9	779.9	0.4	749.5
							Upper Bound	37.7	318.2	25.1	350.7	10.2	944.0	10.0	821.2
	Cavite	124.9	242.8	985.7	579.0	Moderate Emission (RCP4.5)	Lower Bound	8.6	135.6	0.6	244.3	-26.7	722.4	-7.7	534.3
							Median	12.5	140.5	6.9	259.6	-18.0	808.1	-4.1	555.4
							Upper Bound	55.7	194.5	17.9	286.2	9.4	1,078.6	6.7	618.0
						High Emission (RCP8.5)	Lower Bound	7.8	134.7	-11.0	216.1	-22.8	760.8	-4.3	553.9
							Median	12.8	140.9	3.7	251.8	-10.4	883.2	0.9	584.2
							Upper Bound	35.9	169.7	33.1	323.1	11.7	1,100.6	10.3	638.9
	Laguna	629.2	386.8	845.0	1,066.5	Moderate Emission (RCP4.5)	Lower Bound	4.2	655.9	-2.1	378.5	-22.7	653.4	-9.0	970.3
							Median	10.2	693.2	12.6	435.4	-14.3	724.0	-5.8	1,004.7
							Upper Bound	43.9	905.2	24.8	482.6	-2.1	827.3	5.7	1,127.0
						High Emission (RCP8.5)	Lower Bound	2.3	643.7	-14.4	331.0	-20.9	668.8	-10.8	951.0
							Median	13.8	716.3	-0.1	386.3	-11.0	752.0	1.4	1,081.1
							Upper Bound	32.9	836.4	28.3	496.2	7.5	908.8	10.5	1,178.9
	Quezon	827.7	382.7	670.0	1,229.3	Moderate Emission (RCP4.5)	Lower Bound	4.7	866.2	6.2	406.4	-22.0	522.4	-9.3	1,115.0
							Median	8.4	897.2	9.3	418.4	-17.2	554.9	1.6	1,249.0
							Upper Bound	31.6	1,089.2	18.9	455.1	5.3	705.8	7.6	1,322.5
						High Emission (RCP8.5)	Lower Bound	-0.8	820.8	-4.5	365.6	-16.9	557.0	-7.0	1,143.2
							Median	13.9	942.6	7.3	410.6	-6.3	627.8	2.5	1,260.3
							Upper Bound	32.4	1,095.7	19.6	457.9	5.6	707.8	14.0	1,400.9
	Rizal	262.4	241.5	1,001.3	821.8	Moderate Emission (RCP4.5)	Lower Bound	0.0	262.4	-2.8	234.8	-27.3	728.0	-14.9	699.5
							Median	7.8	282.8	12.9	272.7	-20.0	800.7	-9.5	743.7
							Upper Bound	51.5	397.4	25.6	303.4	-1.7	983.9	12.7	926.5
						High Emission (RCP8.5)	Lower Bound	3.6	271.8	-14.2	207.2	-25.4	747.4	-13.2	713.6
							Median	15.0	301.7	-1.1	238.8	-11.6	885.5	0.9	829.6
							Upper Bound	52.2	399.4	17.1	282.7	11.7	1,118.9	19.6	983.1
Region 4-B	Occidental Mindoro	159.5	265.9	1,091.2	762.6	Moderate Emission (RCP4.5)	Lower Bound	-1.7	156.8	-5.0	252.6	-25.1	817.5	-19.5	613.8
							Median	13.2	180.6	2.6	272.8	-20.6	866.8	-3.0	740.0
							Upper Bound	52.3	242.9	12.7	299.6	3.6	1,130.2	4.2	794.3
						High Emission (RCP8.5)	Lower Bound	-1.4	157.3	-18.3	217.2	-28.1	784.2	-18.1	624.9
							Median	9.5	174.6	-3.3	257.2	-13.0	949.8	-3.6	735.1
							Upper Bound	25.9	200.7	23.3	327.9	11.6	1,217.6	7.9	822.5
	Oriental Mindoro	260.3	269.3	894.3	791.2	Moderate Emission (RCP4.5)	Lower Bound	0.0	260.2	3.6	279.1	-24.9	671.2	-17.3	654.6
							Median	10.8	288.5	5.6	284.3	-18.8	726.2	-7.7	729.9
							Upper Bound	31.9	343.3	12.3	302.5	-0.4	890.8	5.2	832.3
						High Emission (RCP8.5)	Lower Bound	-2.7	253.3	-9.5	243.7	-27.2	650.7	-13.9	681.2
							Median	13.9	296.6	5.7	284.6	-12.9	778.9	-6.8	737.5
							Upper Bound	27.9	332.8	9.2	294.1	9.5	979.6	4.9	829.8
	Palawan	101.8	189.3	781.7	640.6	Moderate Emission (RCP4.5)	Lower Bound	-9.9	91.8	-10.6	169.2	-25.7	581.1	-14.3	548.7
							Median	0.0	101.8	-7.4	175.3	-12.0	688.2	-8.1	588.9
							Upper Bound	26.8	129.1	10.3	208.9	1.0	789.3	10.2	705.7
						High Emission (RCP8.5)	Lower Bound	-17.8	83.6	-16.2	158.6	-25.0	586.2	-22.5	496.5
							Median	4.3	106.2	-3.6	182.4	-5.6	737.8	-6.2	601.0
							Upper Bound	14.2	116.3	9.2	206.7	12.9	882.5	11.1	711.5
	Romblon	357.0	224.0	653.0	778.0	Moderate Emission (RCP4.5)	Lower Bound	1.7	363.2	-5.2	212.3	-26.0	483.2	-13.3	674.8
							Median	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
							Upper Bound	37.1	489.6	31.7	295.0	4.3	681.2	13.6	883.6
						High Emission (RCP8.5)	Lower Bound	-3.6	344.0	-15.8	188.5	-35.3	422.3	-25.6	578.5
							Median	10.8	395.5	6.4	238.4	-6.6	609.6	-4.6	742.3
							Upper Bound	26.0	449.7	23.7	277.1	15.1	751.5	20.5	937.4
NCR	Metro Manila	107.5	198.5	1,170.2	758.7	Moderate Emission (RCP4.5)	Lower Bound	-0.1	107.3	0.7	199.8	-21.3	920.8	-10.8	676.4
							Median	17.7	126.5	6.9	212.2	-10.1	1,051.6	-6.0	713.5
							Upper Bound	55.5	167.1	25.7	246.9	-0.4	1,165.2	7.7	817.2
						High Emission (RCP8.5)	Lower Bound	2.7	110.4	-7.2	184.2	-17.0	970.9	-8.0	698.1
							Median	27.8	137.4	4.8	208.1	-6.1	1,098.5	3.9	788.3
							Upper Bound	53.4	164.9	19.8	237.9	7.7	1,260.5	19.9	909.4
Region 5	Albay	739.8	386.9	705.8	941.3	Moderate Emission (RCP4.5)	Lower Bound	-3.5	713.9	-2.4	377.6	-25.5	525.6	-12.1	827.2
							Median	13.5	839.4	2.8	397.9	-12.8	615.7	-2.6	916.6
							Upper Bound	38.7	1,026.3	20.1	464.6	-2.5	688.1	8.7	1,023.3
							Lower Bound	-4.8	704.6	-0.2	386.1	-25.2	527.9	-11.0	837.9

Source: PAGASA (Observed Climate Trends and Projected Climate Change in the Philippines, 2018)

4.3.2 Climate Change Evaluation in Sea Level Rise

Based on RCP 4.5 scenarios (Representative Concentration Pathways, IPCC Fifth Report) of PAGASA, sea level rise is set at 20 cm.

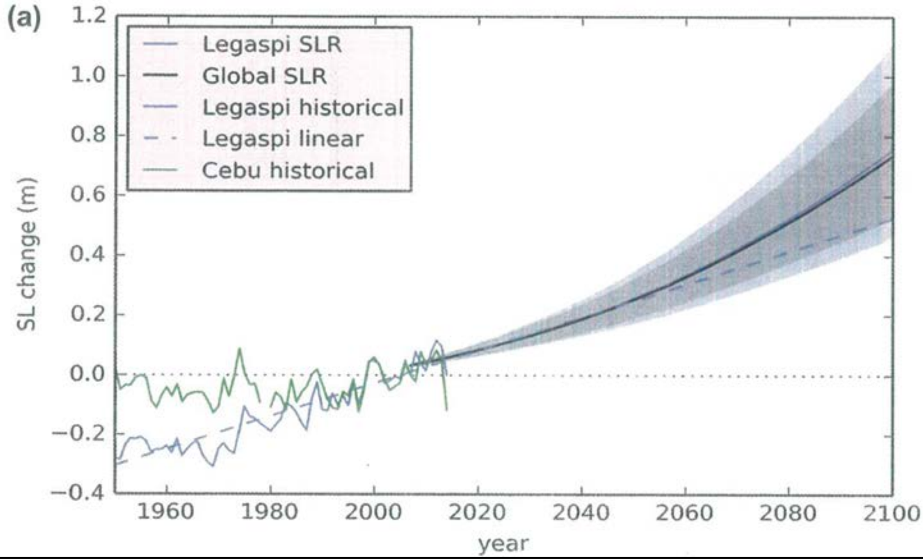
RCP4.5	RCP8.5
	

Source: PAGASA (Observed Climate Trends and Projected Climate Change in the Philippines,2018)

Figure 4.3.1 Sea Level Rise Based on RCP Scenario

Projected changes in sea level

As shown in Figure 11, sea level rise in the Philippines will continue to be slightly larger than the global average[9]. In both the moderate (RCP4.5) and high (RCP8.5) emission scenarios, the increase is expected to be almost the same by the mid-21st century. The trend for RCP4.5 will continue to be linear up to the end of the 21st century, while the trend for RCP8.5 will follow a rather exponential increase - leading to a sea level rise by approximately 20 cm (Fig. 11b and 11c). The projected increase in sea level might worsen storm surge hazards particularly on coastal communities, which requires climate change adaptation action plans.



Source: PAGASA (Observed Climate Trends and Projected Climate Change in the Philippines,2018)

Figure 4.3.2 Sea Level Rise Forecast by PAGASA

4.3.3 Impact of Climate Change on Laguna de Bay Water Level

The effect on Laguna de Bay water level was examined by using the 3-month rainfall increase/decrease rate calculated in Subsection 4.3.1 and the future average basin rainfall in lakeshore area in consideration of climate change. The water level of Laguna de Bay with and without 100-year probability scale is as shown in Figure 4.3.3 and described as follows:

- ➢ The water level of 100-year probability without climate change is 14.3 m, but the water level of 100-year probability with climate change will be 14.5 m, or an increase of 20 cm.
- ➢ The predicted future rainfall from December to February will increase by about 50% and from March to May by about 25%, which will increase the water level of Laguna Lake during the non-flood season (January to May).

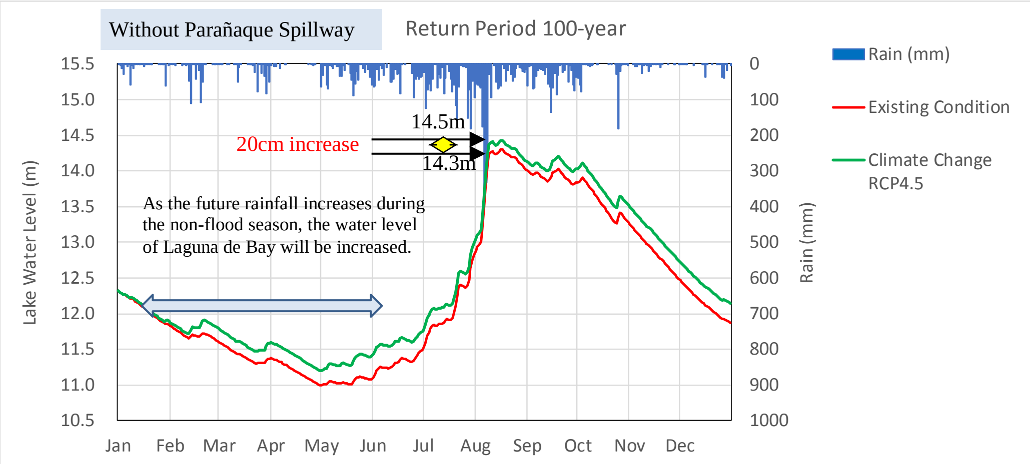
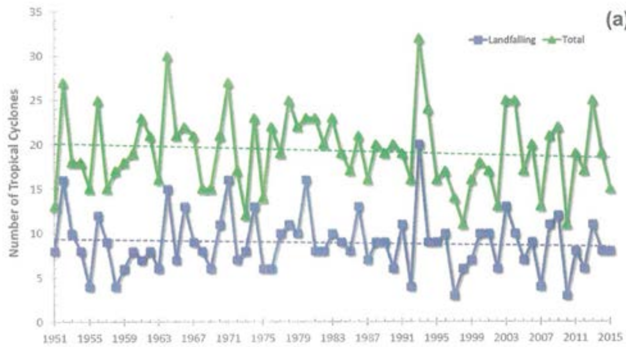


Figure 4.3.3 100-year Probability of Laguna de Bay Water Level (Comparison between Without Climate Change and With Climate Change)

4.3.4 Impact Analysis of Climate Change

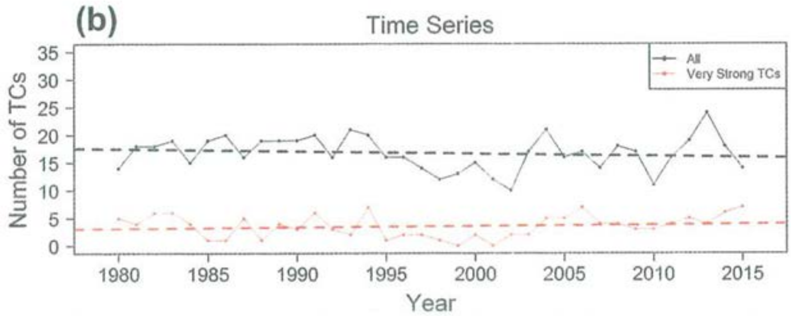
In the impact analysis, the impact of climate change on cyclones and typhoons was grasped. In the "Observed Climate Trends and Projected Climate Change in the Philippines,2018" by PAGASA, the actual number of typhoons and cyclones and landings from 1951 to 2015 having the maximum wind speed of 170 KPH (kilometer per hour) are as shown in Figure 4.3.4, while. Figure 4.3.5 shows the number of tropical cyclones that exceeded the maximum. These figures indicate the following:

- ➢ The number of typhoons and cyclones and the number of landings is decreasing.
- ➢ Tropical cyclones with the maximum wind speed of 170 KPH tend to increase slightly since 1980.



Source: Observed Climate Trends and Projected Climate Change in the Philippines, 2018

Figure 4.3.4 Number of Tropical Cyclones and Number of Landings (1951-2015)



Source: Observed Climate Trends and Projected Climate Change in the Philippines, 2018

Figure 4.3.5 Tropical Lows that Exceed the Maximum Wind Speed of 170 KPH (1951-2015)

PAGASA has been investigating the future impact on tropical cyclones using five Regional Climate Model Simulations in collaboration with the UK Met Office. According to the study, the frequency of tropical cyclones in the future (2036 to 2065) is predicted to be lower in three of the five models, and two of the five models are expected to be comparable to the current situation.

	Climate Model Simulations				
	1	2	3	4	5
Change in tropical cyclone frequency	↓	↓	—	—	↓
Change in tropical cyclone intensity	—	↑	↑	↑	↑

Note: Black arrows indicate significant changes, gray arrows indicate minor changes, and dashes indicate no changes.
Source: Observed Climate Trends and Projected Climate Change in the Philippines, 2018

Figure 4.3.6 Frequency and Intensity of Tropical Cyclones in the Future

From the results of the PAGASA study, it is predicted that the frequency of tropical cyclones will be at the same level as the current situation or is decreasing, so it is considered that changes in tropical cyclones due to climate change will have little effect on the water level of Laguna de Bay.

4.4 Examination of Facility scale by Sensitivity Analysis

The optimum size of lakeshore dike height and Paranaque Spillway was investigated by modifying the DFL of Laguna de Bay.

4.4.1 Design Flood Level of Laguna de Bay

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

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

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

(1) Existing Projects in the Lakeshore Area [Evaluation Index (1)]

The "Metro Manila West Manggahan Flood Control Project (ODA Loan Project)" (hereinafter referred to as "West Manggahan Project") was implemented in the West Mangahan District from 1997 to 2007, and a lakeshore dike was constructed 10 km from the west side of the Manggahan Floodway to Lower Bicutan.

In the Detailed Design of West Manggahan, the probable lake water level was estimated based on the observed lake water level from 1949 to 1989. The lake water level of 40-year probability was 14.0m based on the observed data, but, if (i) dredging of Pasig River and (ii) Dredging of Napindan Channel are executed, the lake water level of 40-year probability will decrease from 14.0m to 13.8m. Therefore, the DFL of Laguna de Bay was set at 13.8m.

* At this moment , dredging of Pasig River was carried out by a Belgian company for the Belgian trader as a grant project, and only part of the section was implemented by the PRRP (Pasig River Rehabilitation Project (DENR is the main agency). Dredging of Napindan Channel was not carried out.

DFL and Lakeshore Dike Height in West Manggahan project

- DFL was set at 13.8m (40-year probability equivalent water level)
- The height of lakeshore dike was planned at 15.0m.
- The height of parapet wall was planned at 14.1m, including 0.3m for freeboard.

Figure 4.4.1 West Manggahan Lakeshore Dike

The lakeshore dike in West Manggahan District has already been installed at DFL 13.8m, and if the Laguna de Bay DFL is set to 13.8m or more in this study, the West Manggahan Lakeshore Dike will be an existing unqualified/rehabilitated section, which has a large social impact.

(2) Previous Flooding Damage [Evaluation Index (2)]

The highest inundation levels experienced by residents during Typhoon Ondoy and Pepeng in 2009 and Habagat in 2012 were 13.85m and 13.83m. It is therefore desirable to set the DFL so that the risk of inundation damage does not exceed these achievements. In Parañaque Survey 2018, inundation area and affected people were calculated for each elevation (Table 2.1.2). Based on the calculation results, the number of affected people and inundated area were approximately 540,000 people and 69 km^2 of flooding area.

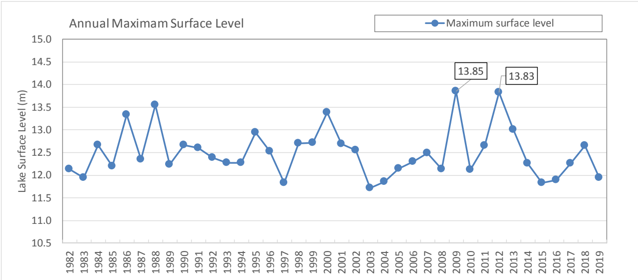
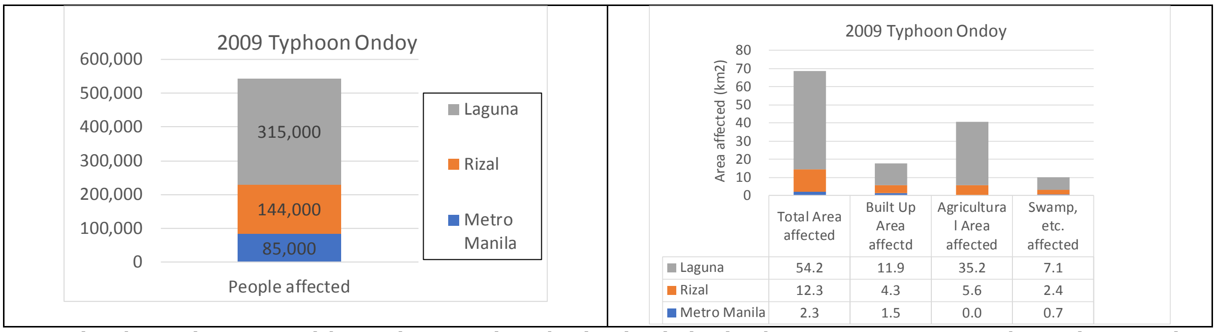


Figure 4.4.2 Maximum Lake Water Level from 1982 to 2019



* Based on the inundation area and the inundation population by altitude calculated in the Parañaque Survey 2018, the inundation population and inundation area at the highest water level of 13.85m during the typhoon were calculated.

Figure 4.4.3 Assumed Flooded Population and Flooded Area during Typhoon Ondoy in 2009

(3) Setting of Upper Limit of DFL and Facilities Scale

As shown in the Evaluation Indices of DFL setting described in 4.4, Evaluation Index (1), Consistency with existing projects (4.4.1) and Evaluation Index (2), past inundation damage status summarized in 4.4.2, from the viewpoint of safety, the upper limit of **DFL in Laguna de Bay is 13.8 m**.

The Laguna de Bay water level fluctuation sensitivity analysis was performed when the inner diameter of Parañaque Spillway was changed from D=11.0m to D=15.0m at 1m intervals. The effect on lake water level due to the difference in tunnel inner diameter is summarized in Table 4.4.1. When the tunnel inner diameter is D=11m and D=12m, the lake water level with a probability scale of 100-year is 13.8m or more, which is the upper limit of DFL; therefore, the tunnel inner diameter of the Parañaque spillway should be D=13m or more.

The largest shield construction in Japan, which is a mud pressure shield machine with an outer diameter of 16.1 m and an inner diameter of 14.5 m, is the main tunnel construction in the Tokyo Section of the Tokyo Outer Ring Road. Therefore, in this study, the maximum tunnel inner diameter was set to 15 m.

Table 4.4.1 Lake Water Level due to Difference in Tunnel Inner Diameter

Case	Existing	PSW_D11	PSW_D12	PSW_D13	PSW_D14	PSW_D15
Climate Change	✔	✔	✔	✔	✔	✔
Parañaque Spillway	—	✔	✔	✔	✔	✔
Tunnel inner diameter	—	D=11m	D=12m	D=13m	D=14m	D=15m
100	14.5	14.0 (13.98)	13.9 (13.89)	13.8 (13.79)	13.8 (13.73)	13.8 (13.72)
50	14.2	13.8 (13.74)	13.7 (13.65)	13.6 (13.56)	13.6 (13.51)	13.5 (13.50)
30	13.9	13.5 (13.49)	13.4 (13.40)	13.4 (13.33)	13.3 (13.28)	13.3 (13.28)
20	13.8	13.4 (13.40)	13.4 (13.32)	13.3 (13.25)	13.2 (13.20)	13.2 (13.20)
10	13.4	13.1 (13.06)	13.0 (13.00)	13.0 (12.95)	13.0 (12.92)	13.0 (12.92)
5	13.1	13.0 (12.89)	12.9 (12.82)	12.8 (12.79)	12.8 (12.77)	12.8 (12.77)
3	12.8	12.6 (12.60)	12.6 (12.58)	12.6 (12.56)	12.6 (12.55)	12.5 (12.50)
2	12.5	12.4 (12.37)	12.4 (12.35)	12.4 (12.35)	12.4 (12.34)	12.4 (12.33)

*Figures in parentheses indicate calculated values. The numerical value set in the plan should be on the safe side and rounded up to the first decimal place.

(4) Project Cost [Evaluation Index (3)]

The project cost was compared for the inner diameters D13m to D15m of the Parañaque spillway tunnel with a lake water level of 13.8m or less.

In the Parañaque Survey 2018, two types of tunnel construction methods (shield method, NATM) as the construction method of the tunnel part were examined. In this study, the "shield method", which allows safe and reliable construction of tunnels regardless of the presence of spring water from soft ground to hard ground, was considered as the basis. Based on the results of the geological survey to be carried out in the future, NATM will continued to be examined whether or not to adopt it

Structural measures in the Comprehensive Flood Management Plan for Laguna de Bay Basin (draft) are: (1) Construction of Parañaque Spillway; (2) Lakeshore diking system (composed of backwater levee, pumping station, bridge); and (3) EFCOS expansion for non-structural measures. Therefore, the main project costs of (1) to (3) will be organized.

- The main project cost for the inner diameter of the Parañaque spillway is about 46 billion pesos (about 98 billion yen) when the tunnel inner diameter is 13 m, about 52 billion pesos (about 110 billion yen) when the inner diameter is 14 m, and about 58 billion pesos (about 1230 million) when the inner diameter is 15 m. 100 million yen). Expanding the tunnel inner diameter by 1 m will increase the main project cost by about 12 billion yen.
- Since the lake water level with a 100-year probability at D13m, D14m, and D15m is 13.8m, only the main project cost of the Parañaque spillway varies depending on the inner diameter of the tunnel, and the project cost of the lakeshore diking system is the same regardless of the inner diameter of the tunnel.
- Even if the tunnel inner diameter is expanded from 13 m to 15 m, the lake water level with a probability of 100 years does not change to 13.8m. The peak of the lake water level is in August, and even if the inner diameter of the tunnel is expanded, the lake water level during the rising water level will only drop by a few centimeter. Therefore, the Laguna Lake water level rises by as much as 1 m in about a week, so the effect of reducing the Laguna Lake water level by the tunnel inner diameter is small.

- The capacity of Laguna de Bay when the water level is raised by 1 m is 900 MCM, while the capacity of Parañaque Spillway, D:13m, with the maximum discharge of 240 m^3/s is about 20 MCM when operated for one day. Therefore, it will take 45 days to drain the capacity of 900 MCM.

Table 4.4.2 Construction Cost due to Difference in Tunnel Inner Diameter (Route 1, Shield Method)

Tunnel Inner Diameter	100-year Probable Lake Level	Construction Cost (PHP 1,000,000)			
		Parañaque Spillway	Lakeshore Diking System	Expansion EFCOS	Total
13m	13.8m	46,203	44,822	123	91,149
14m	13.8m	51,798	44,822	123	96,743
15m	13.8m	57,859	44,822	123	102,804

(5) DFL Lower Limit Value Analysis by Sensitivity Analysis

Installing Parañaque Spillway with an inner diameter of 13m will reduce the lake water level with a probability of 100 years from 14.5m to 13.8m. To reduce the DFL to 13.8 m or less, it is necessary to add more tunnels. Examined in this re-study was the case of DFL near 13.5m and 12.5m.

Table 4.4.3 Result of Economic Evaluation by DFL including Climate Change (Route 1, Tunnel Inner Diameter=13m, Shield Method)

Case	DFL (Simulated Value)	Parañaque Spillway			Lakeshore Diking System Project Cost (PHP Billion)	Total Project Cost (PHP Billion)	Annual Benefit (PHP Billion)		B/C	EIRR
		Spillway Number	Inner Diameter (m)	Project Cost (PHP Billion)			Lakeshore Area	Pasig-Marikina RB[1)]		
1	13.8(13.79)	1	13	76.0	110.0	186.0	7.3	15.2	1.95	16.3%
2	13.3	2	13	152.0	94.2	246.2	7.5	15.2	1.65	15.1%
3	12.5	5	13	380.0	0.0	380.0	7.8	15.2	1.31	13.4%

1) When considering multiple Parañaque spillways, the annual benefit of the Pasig-Marikina River basin should only be included in the first spillway.

- When two 13m inner diameters are installed, the DFL of Laguna de Bay is 13.3m, B/C is 1.65, and EIRR is 15.1%.
- To lower the DFL to 12.5m, it is necessary to install 5 discharge channels with inner diameters of 13m. This is because the inflow is 1,720 MCM for 13 days from the end of July to August in the 100-year probability flood. To maintain the water level at 11.5m at the start of operation and keep the water level rise to 1m during the lake period (maximum water level is 12.5m), it is thus necessary to discharge approximately half of the 1,720 MCM inflow from the Parañaque Spillway. Therefore, 5 spillways with inner diameter of 13m will be required. However, B/C will be low at 1.31 and EIRR will also be low at 13.4%.

(6) Setting of the DFL of Laguna de Bay

Based on the comprehensive evaluation, the overall project cost of the Parañaque Spillway and the lakeshore system will be the minimum, the inner diameter of the Parañaque spillway is 13 m which maximizes the EIRR and B/C, and the **DFL of Laguna Lake is 13.8 m**.

4.4.2 Sensitivity Analysis Based on Route

The following table shows the results of cost-benefit analysis based on the Parañaque spillway route plan mentioned before. The sensitivity analysis for each route was conducted with the tunnel inner diameter of 13m, which gives the highest economic value.

- Route 2-B, which was reviewed in this study, passes under Dr. A. Santos Avenue and drains to the Zapote River has the highest EIRR (19.7%).
- The EIRR of Route 1, which is the same route as the 2018 survey, was 8.8% in the 2018 survey. However, due to the flood damage reduction effect of Parañaque Spillway in the Pasig-Marikina River basin, the water level reduction due to the revised operation level of Parañaque Spillway and the additional benefit items considering the flood characteristics of Laguna de Bay (long-term flooding), the result of economic evaluation was estimated to be 16.3% for Route 1 and from 10.7% to 16.2% for Route 3.

Table 4.4.4 Results of Economic Evaluation Based on the Proposed Route
Climate change consideration (Tunnel Inner Diameter=13m, Shield Method)

Route※1	Project Cost (million PHP)	Benefit of NPV (million PHP)			Cost of NPV (million PHP)	EIRR	B/C
		Pasig-Marikina RB	Lakeshore Area※2	Total			
Route 1	186,158	47,935	32,196	80,132	41,043	16.3%	1.95
Route2-A	178,576	58,774	37,097	95,871	42,474	19.6%	2.26
Route2-B	177,971	58,363	37,097	95,459	42,427	19.7%	2.25
Route 3	194,654	51,968	32,196	84,165	44,060	16.2%	1.91

※1：Details of route need to be examined by F / S
※2：Includes additional benefit items (reduction of households, suspension of business, reduction of fishery damage due to inundation).

4.4.3 Selection of Optimal Facility Scale of Parañaque Spillway

In this study, based on the DGCS of DPWH and considering the flood control plan against climate change, the tunnel inner diameter of the Parañaque Spillway was set at D13m, which can reduce the lake water level with a probability scale of 100 years to 13.8m of DFL.

For the Parañaque spillway route (4 routes in total), the optimum route will be selected in consideration of the results of topographical and geological surveys, underground buried substance surveys, etc., which are planned for future F/S.

Table 4.4.5 Optimal Facility Scale of Parañaque Spillway

Items	Setting Value
DFL of Laguna de Bay	13.8m
Parañaque Spillway Tunnel Inner Diameter	13.0m
Parañaque Spillway Maximum Discharge	240m^3/s
Route of Parañaque Spillway	Select the optimum route for F/S in the future

4.5 Effect of Parañaque Spillway

Considering the increase of rainfall and sea level rise due to climate change based on future RCP4.5 scenario, the impact of climate change on the lake water level and the effect of Parañaque Spillway were examined. The analysis results of 100-year probable water level fluctuation are as shown in

Table 4.5.1 and Figure 4.5.1, and the water level of Laguna de Bay by each probability is shown in Table 4.5.2.

- Although there is no climate change and no Parañaque Spillway (No. 1), the lake level of 100-year probability is 14.3m, but due to climate change, the lake level without Parañaque Spillway (No. 2) is 14.5m. Due to the effects of climate change, the water level of Laguna de Bay will also rise by 20 cm.
- Due to climate change and the Parañaque Spillway (D13m) (No. 3), the water level in June will increase due to the increase of rainfall during the non-flood season, the water level rise to over 11.5m, the Parañaque Spillway can be operated from early June.
- If climate change is taken into consideration, 100-year probability water level will decrease to 13.8m with tunnel inner diameter of 13m (No. 3).
- The number of inundation days (the number of days of EL 12.5m or more) without the Parañaque Spillway is 142 days (about 5 months) in a 100-year probability, but with the Parañaque Spillway (D=13.0m), the number of inundation days will be 75 days (about 2.5 months) and the inundation period will be shortened by 2.5 months.

Table 4.5.1 Results of 100-Year Probable Water Level Fluctuation Analysis

No.	Climate Change		Parañaque Spillway			Water Level of 100-Year Probability
	Yes	No	Yes	nNo	Tunnel Inner Diameter	
1		✔		✔	-	14.3 m
2	✔			✔	-	14.5 m
3	✔		✔		13.0 m	13.8 m

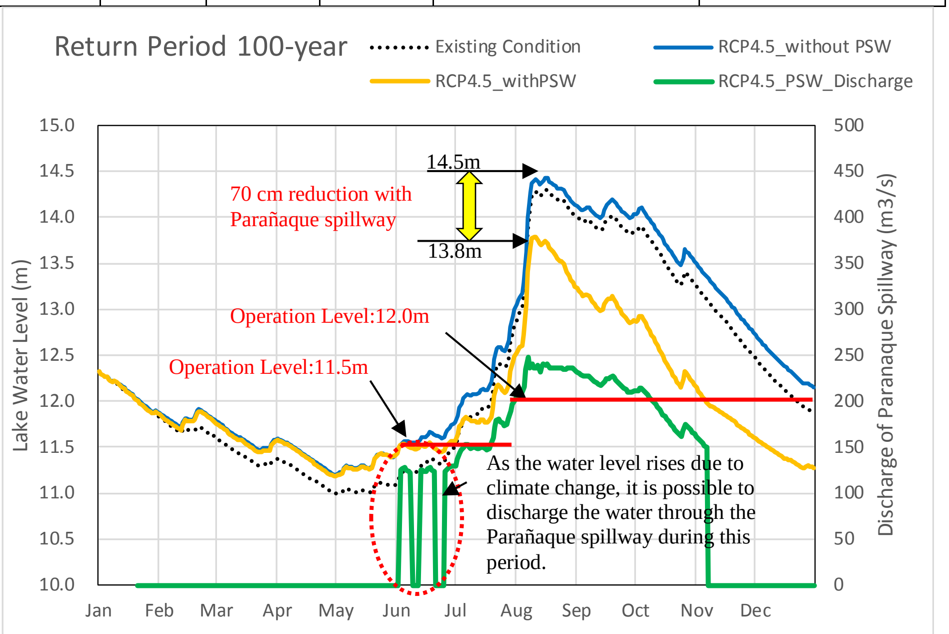


Figure 4.5.1 Result of Water Level Fluctuation Analysis, 100-Year (D=13m)

Table 4.5.2 Probable Water Level Include Climate Change, D=13m

Return period	Existing Condition	Without project	With PSW
200	14.7	14.9	14.1
100	**14.3**	**14.5**	**13.8**
50	14.0	14.2	13.6
30	13.7	13.9	13.3
20	13.6	13.8	13.2
10	13.2	13.4	12.9
5	12.9	13.1	12.8
3	12.6	12.8	12.6
2	12.3	12.5	12.3

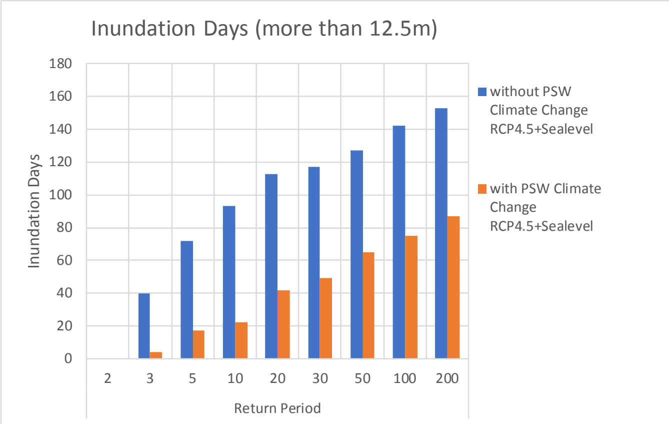


Figure 4.5.2 Change of Inundation Days with and without Parañaque Spillway

Table 4.5.3 Number of Days of Inundation with or without the Parañaque Spillway (EL 12.5m and above are considered inundated)

○**without** Parañaque Spillway with Climate Change

without PSW Climate Change RCP4.5+Sealevel unit:days

WL	Return Period								
	2	3	5	10	20	30	50	100	200
>12.5	0	40	72	93	113	117	127	142	153
>13.0	0	0	5	61	83	89	99	112	123
>13.5	0	0	0	0	29	49	69	85	98
>14.0	0	0	0	0	0	0	17	58	71
>14.5	0	0	0	0	0	0	0	0	31
>15.0	0	0	0	0	0	0	0	0	0
Inundation days	**0**	**40**	**72**	**93**	**113**	**117**	**127**	**142**	**153**

○**with** Parañaque Spillway (D13m) with Climate Change

with PSW Climate Change RCP4.5+Sealevel unit:days

WL	Return Period								
	2	3	5	10	20	30	50	100	200
>12.5	0	4	17	22	42	49	65	75	87
>13.0	0	0	0	0	14	18	25	45	65
>13.5	0	0	0	0	0	0	4	17	27
>14.0	0	0	0	0	0	0	0	0	9
>14.5	0	0	0	0	0	0	0	0	0
>15.0	0	0	0	0	0	0	0	0	0
Inundation days	**0**	**4**	**17**	**22**	**42**	**49**	**65**	**75**	**87**

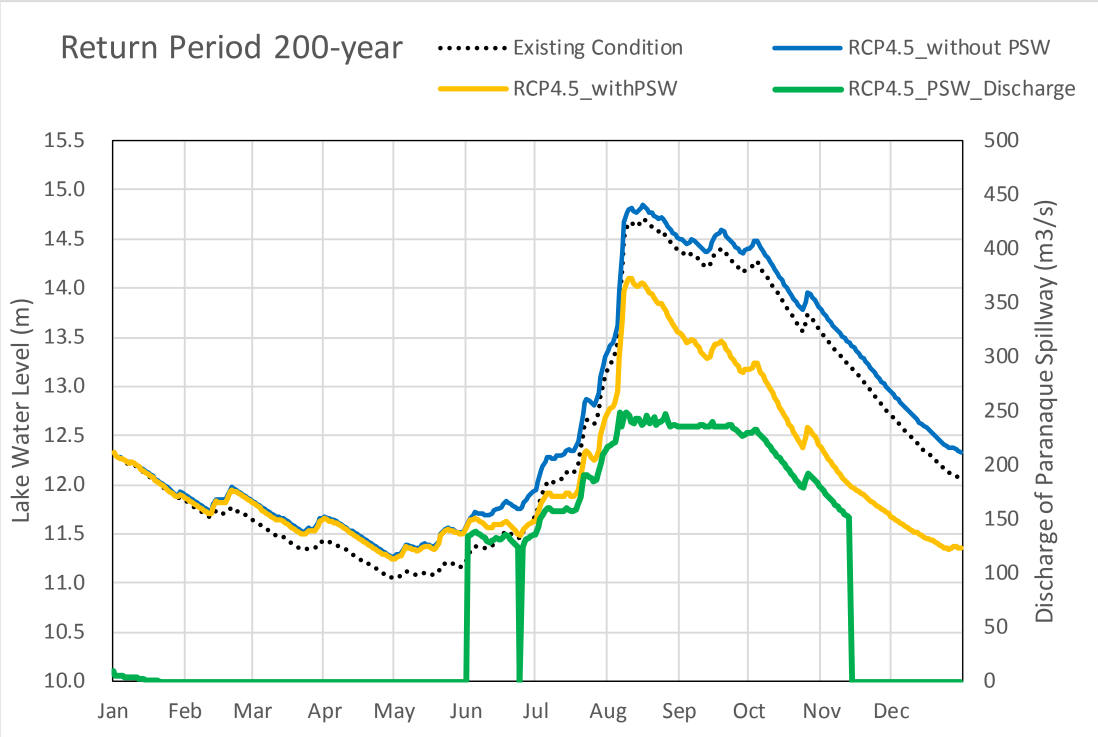


Figure 4.5.3 (1) Result of Water Level Fluctuation Analysis 200-year (D=13m)

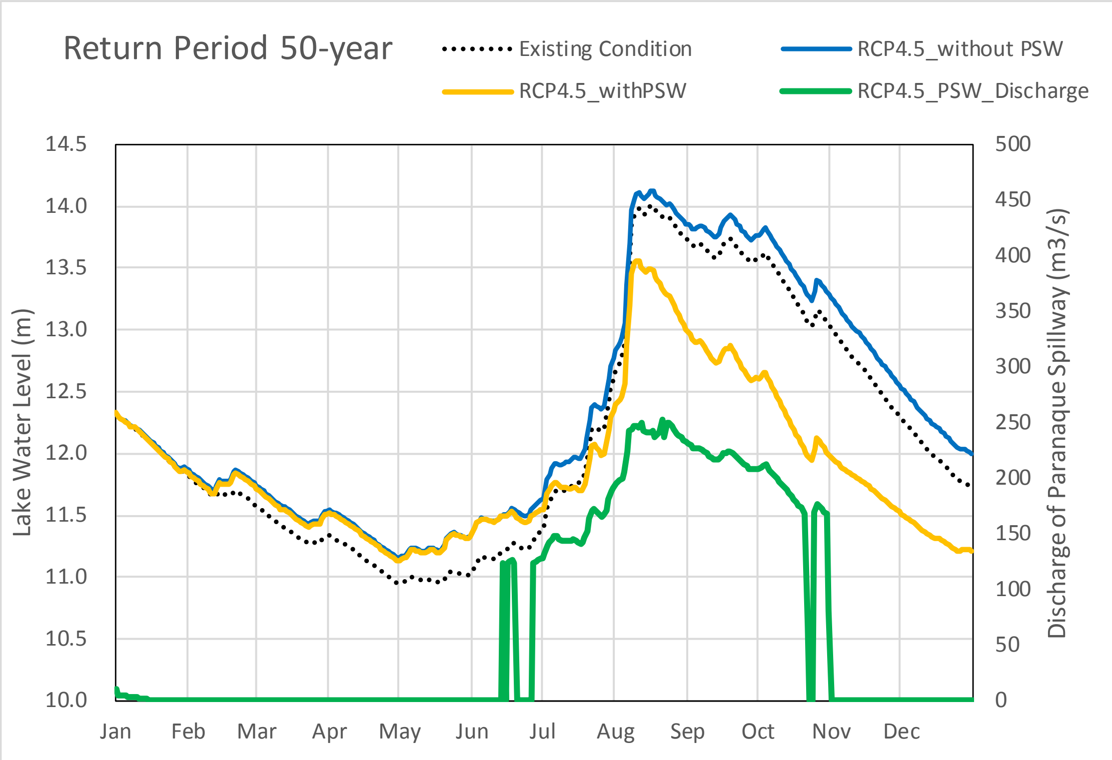


Figure 4.5.3 (2) Result of Water Level Fluctuation Analysis 50-year (D=13m)

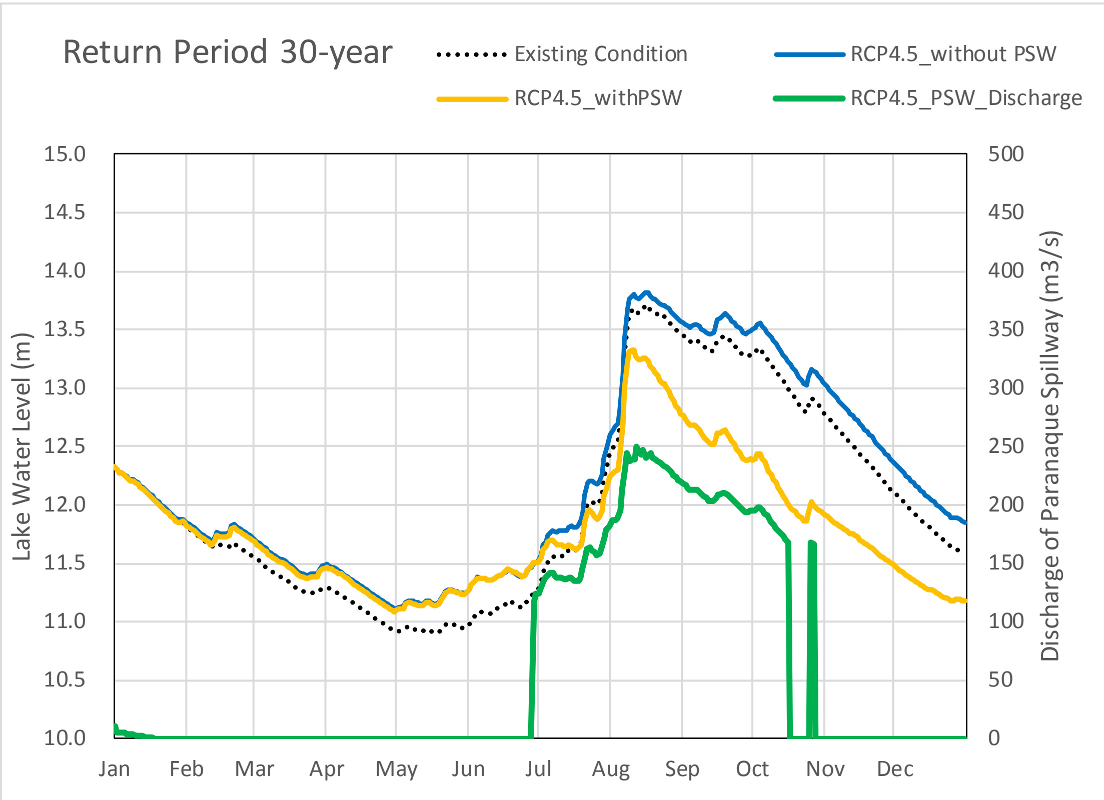


Figure 4.5.3 (3) Result of Water Level Fluctuation Analysis 30-year (D=13m)

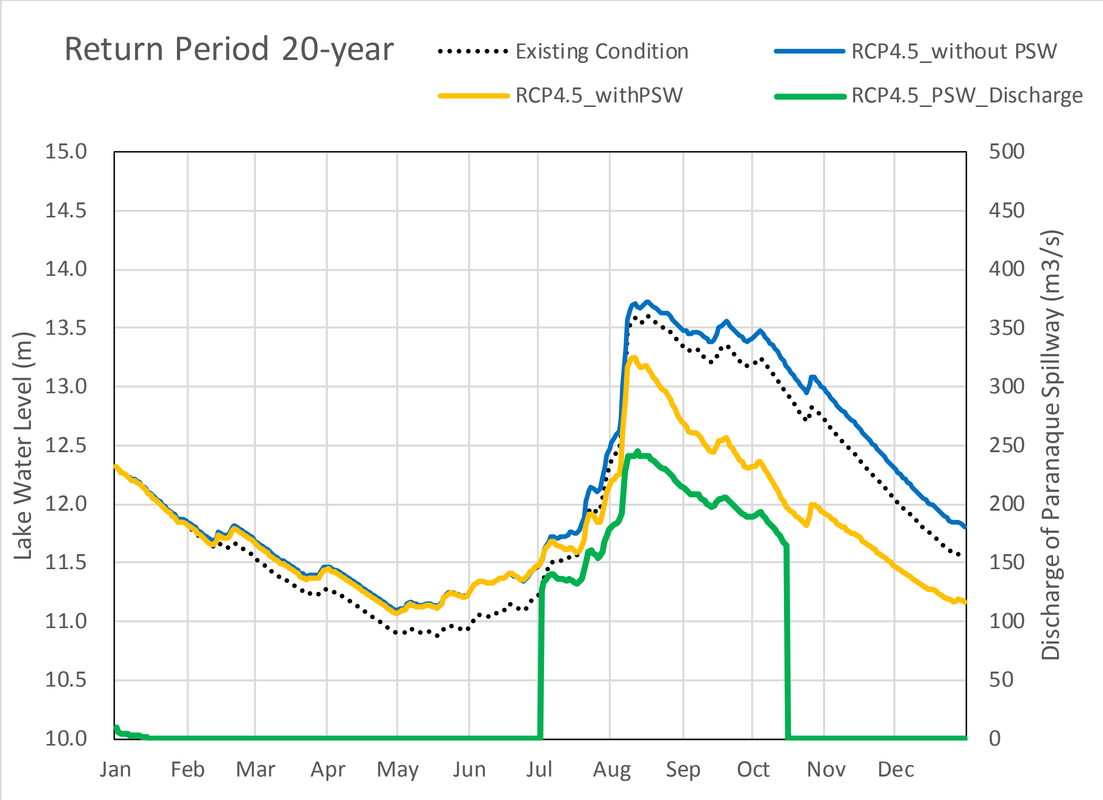


Figure 4.5.3 (4) Result of Water Level Fluctuation Analysis 20-year (D=13m)

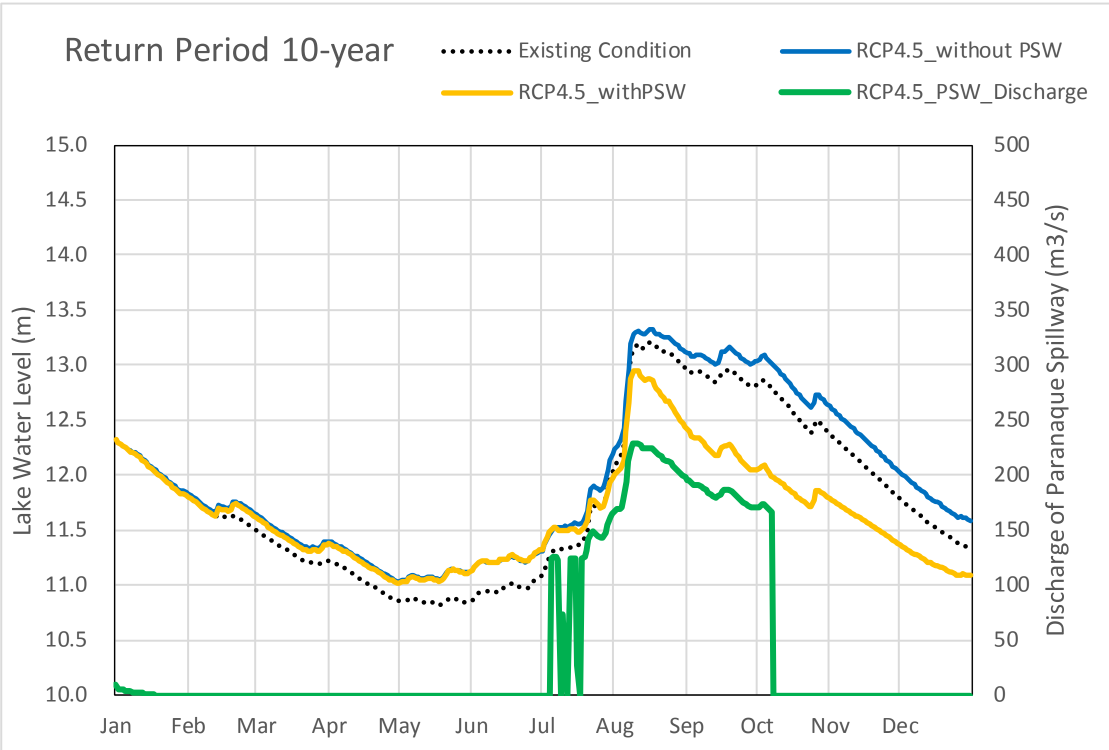


Figure 4.5.3 (5) Result of Water Level Fluctuation Analysis 10-year (D=13m)

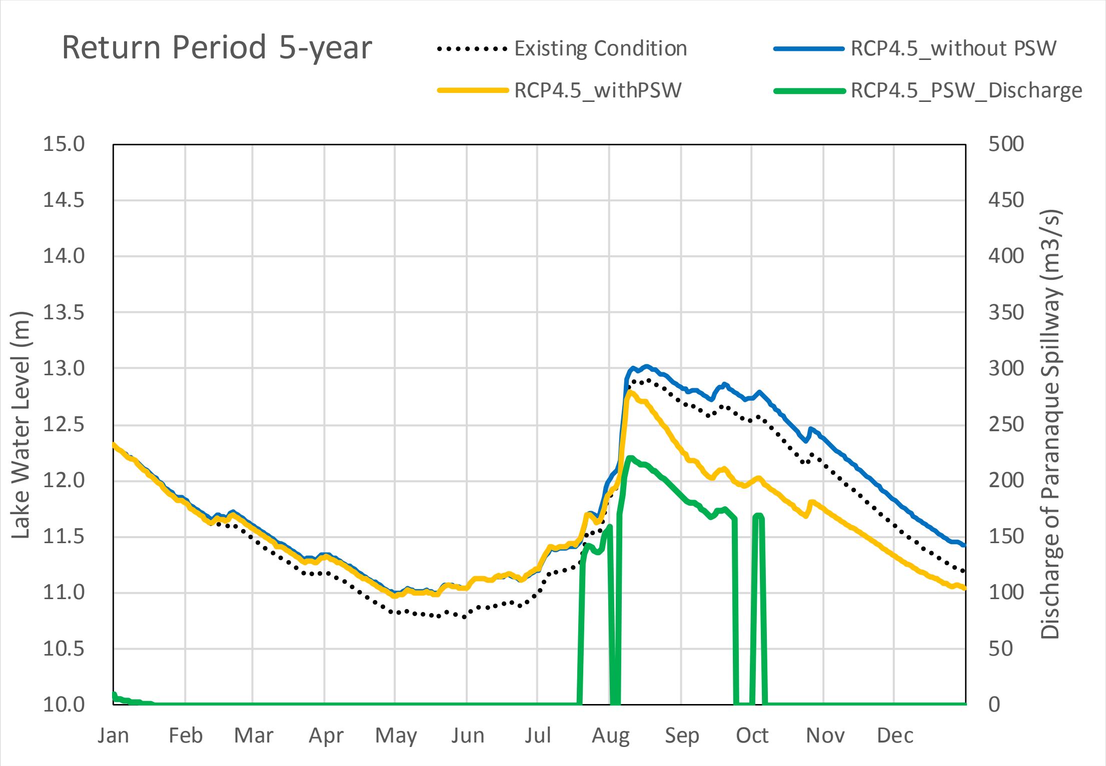


Figure 4.5.3 (6) Result of Water Level Fluctuation Analysis 5-year (D=13m)

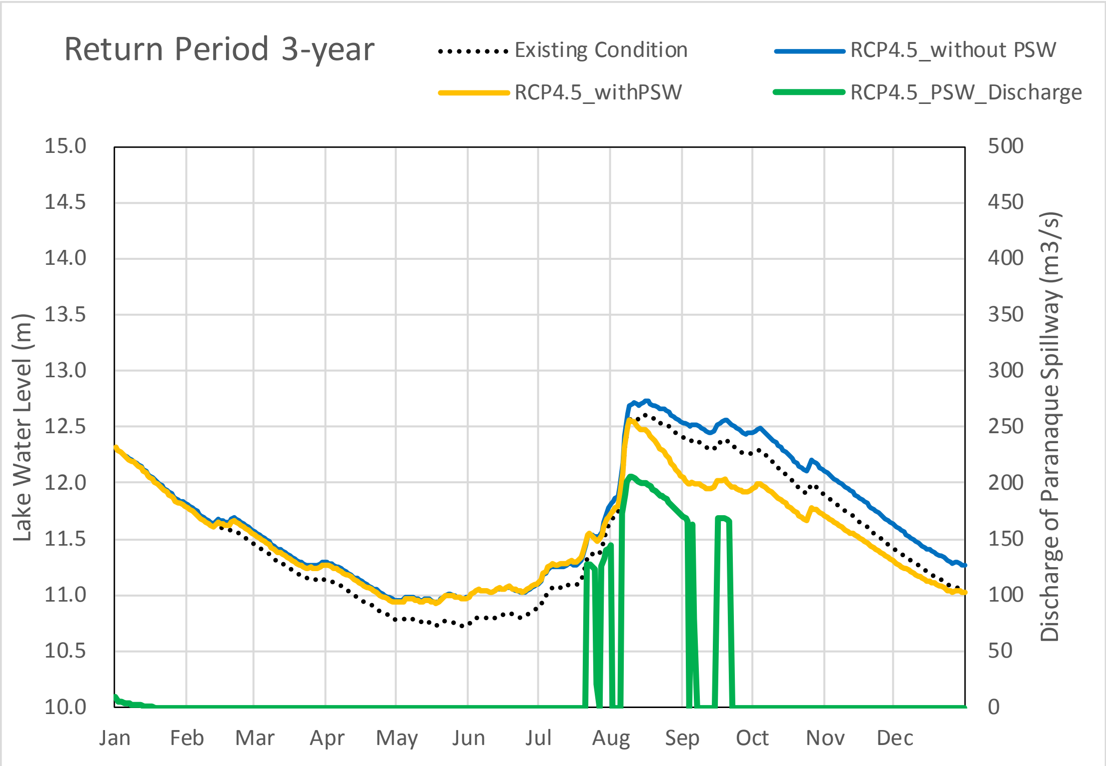


Figure 4.5.3 (7) Result of Water Level Fluctuation Analysis 3-year (D=13m)

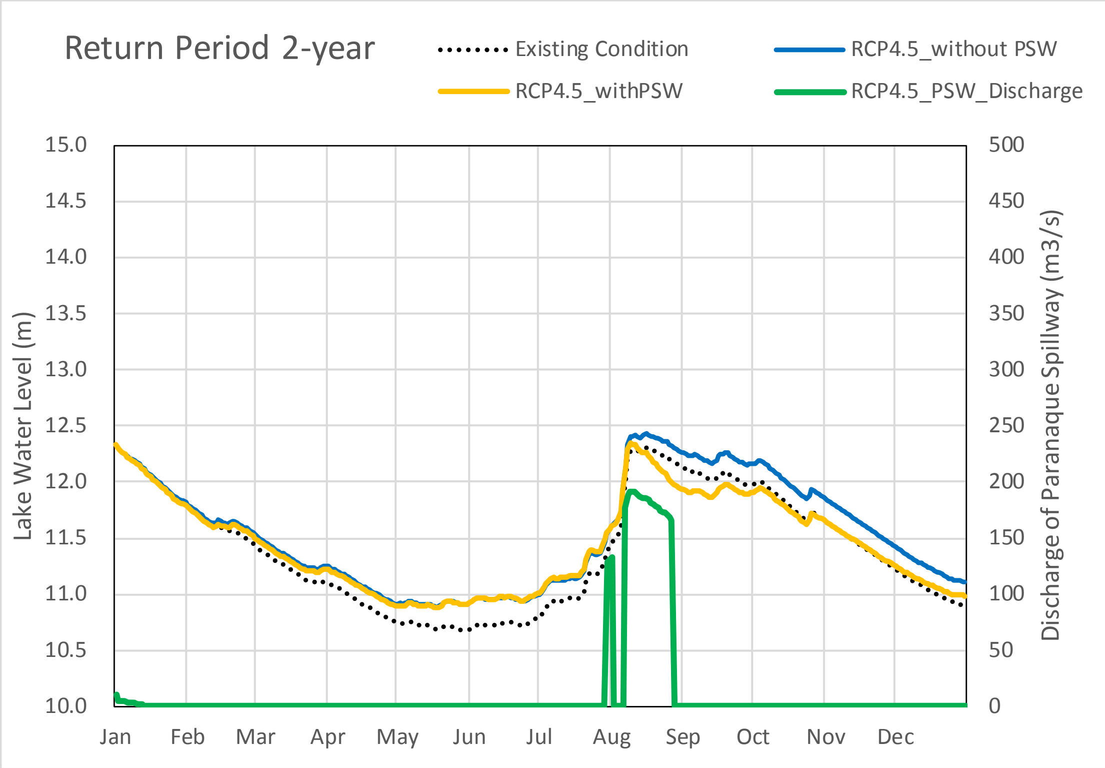


Figure 4.5.3 (8) Result of Water Level Fluctuation Analysis 2-year (D=13m)

4.6 Flow Capacity of Parañaque Spillway considering Tidal Level Fluctuation in Manila Bay

The discharge from Parañaque Spillway is controlled by the water level difference between Laguna de Bay and Manila Bay. In the above analysis, the boundary condition of water level in Manila Bay is set to MSL (Mean Sea Level), but in this section, the discharge from Parañaque Spillway is confirmed in consideration of the actual tidal level fluctuation (hourly data).

4.6.1 Calculation Formula of Discharge

The water level conditions and setting conditions used for discharge calculation using MS as the boundary condition of water level in Manila Bay are shown below.

Water Level of Laguna de Bay	: Design Flood Level (DFL): EL+13.8m
Water Level of Manila bay	: MSL + Level rise 0.2m = EL+10.47m + 0.2m = EL+10.7m
Length of Spillway	: L = 10km (Depending on the route, the longest was assumed)

Generally, the head loss to be considered is the overflow weir of an inflow facility, the dust remover (screen), the inflow of the vertical shaft, the friction loss of the discharge channel, the linear curve loss, the outflow of the vertical shaft, and the widening loss of the discharge channel. However, in this study, the discharge was calculated considering the friction of discharge channel, loss of inflow and outflow, and loss of dust remover (screen) as the main loss head. (More detailed examination should be made during the F/S.)

Based on Japan's "Ministry of Land, Infrastructure, Transport and Tourism Technical Criteria for River Works: Practical Guide for Planning (1997)", the cross section of the spillway was considered as "The increase ratio of approximately 10%".

1. Cross Section

For open channel tunnel, air pressure becomes lower if either obstruction of discharge capacity or fast flow is caused by garbage, driftwood or sediment. Therefore, enough air area of cross section, such as more than approximately 15%, is necessarily required in general.

If the existing river channel is ignored for some reason or another, the tunnel cross section shall be decided to take into an account the future safety. The design discharge to decide the cross section is to be in accordance with "Design Chapter 1, Section 10".

On the other hand, for pressure pipe type tunnel, the cross section shall be decided in consideration of the discharge capacity, entrained air volume, possibility of negative pressure, water stop performance, surging phenomena, lining design and so on. Invert will be installed for operation and maintenance depending on the necessity. The increase ratio of pressure pipe type is mainly adopted as approximately 10%. In addition, it is necessary to construct countermeasures, such as shape examination of inlet and intake and air duct of tunnel to minimize the entrained air volume.

Source：Japan's Ministry of Land, Infrastructure, Transport and Tourism Technical Criteria for River Works: Practical Guide for Planning (1997)

The discharge calculation formula and loss calculation formula based on Bernoulli's theorem are as follows:

$V = (2gH / (f_f (L / D) + fe + fo + fs))^{0.5}$

$Q = V A$

$H = (f_f (L / D) + fe + fo + fs) V^2/2g$

Pipe Flow Velocity V	: (m)
Up-downstream Water Level Difference H	: 13.8m – 10.7m = 3.1m
Tunnel Length L	: 10,000m
Tunnel Inner diameter D	: 12.255m (D = 13m, Considering maintenance road)
Cross Sectional Area A	: $A = \pi D^2/4$ (m^2)
Friction Loss f_f	: $f_f = 124.5 n^2 / D^{1/3}$ (Friction Loss Head $hf = f_f (L / D) V^2/2g$)
Inflow Loss fe	: fe = 0.5 (Inflow Friction Loss $he = fe V^2/2g$)
Out Flow Loss fo	: fo = 1.0 (Outflow Friction Loss $ho = fo V^2/2g$)
Screen Loss fs	: $fs = 0.1 \times 2g/V^2$ (Screen Loss hs = 0.1)
Tunnel Roughness Coefficient	: 0.015

In the case where water level of Laguna de Bay is 13.8m, water level of Manila Bay is 10.7m, Spillway Length is 10,000m, and Spillway Diameter is 13.0m, the flow capacity of Parañaque Spillway was calculated as 268 m^3/s (flow velocity: 2.27m/s) as shown in Table 4.6.1.

Since the above-mentioned “The increase ratio approximately 10%” is applied to this calculation, the actual flow capacity is estimated to be about 307 m^3/s (flow velocity: 2.34 m/s). (See Table 4.6.2).

Table 4.6.1 Flow Capacity of the Parañaque Spillway
(Without “the increase ratio of approximately 10%” of Cross-Section Area)

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	10% Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
13.00	132.732	5.00	22.620	1.680	117.947	12.255	117.947	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Screen Loss hs (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m3/s)
2.270	2.606	0.131	0.263	0.100	3.100	0.000	OK	267.8

Source : Parañaque Survey, 2018

Table 4.6.2 Flow Capacity of the Parañaque Spillway
(With “the increase ratio of approximately 10%” of Cross Section Area)

Diameter (m)	Area (m2)	Invert (m)	Angle (Degree)	Invert Area (m2)	Reduction Area (m2)	Conversion Diameter (m)	Conversion Area (m2)	Roughness Coefficient	Inlet fe	Outlet fo
13.00	132.732	5.00	22.620	1.680	131.052	12.917	131.052	0.015	0.50	1.00

Velocity *1 v (m/s)	Friction Loss hf (m)	Entarance Loss he (m)	Outflow Loss ho (m)	Other Loss h' (m)	Total Loss ht (m)	Loss Difference dh (m)	Check <0.01	Calculated Discharge (m3/s)
2.340	2.581	0.140	0.279	0.100	3.100	0.000	OK	306.7

Source : Parañaque Survey, 2018

4.6.2 Effect of Tide Level on Discharge

(1) Variation of Discharge due to Fluctuation of Manila Bay Water Level (Laguna de Bay Water Level: 11.5m)

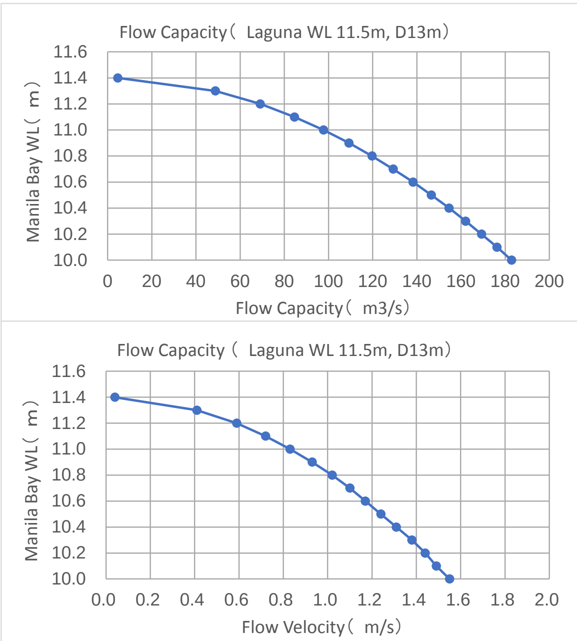
Table 4.6.3 and Figure 4.6.1 show the variation of discharge of Parañaque Spillway in case the water level in Manila Bay fluctuates under the condition that the Laguna lake water level is constant at 11.5m (Start water level of Parañaque Spillway).

As shown in Table 4.6.3, if the Manila Bay water level rises by 0.5 m above the MSL, the discharge will be approximately 53% (69.1/129.3), and if the Manila Bay water level falls by 0.5 m below the MSL, the discharge will be approximately 131% (169.3/129.3).

Table 4.6.3 Flow Velocity and Flow Capacity of Parañaque Spillway (Laguna de Bay Water Level: 11.5m, Spillway Diameter: 13m)

Water Level of Manila Bay (m)	Water Level of Laguna de Bay (m)	Flow Velocity (m/s)	Flow Capacity (m^3/s)
11.4	11.5	0.04	4.6
11.3		0.4	48.8
11.2		0.6	69.1
11.1		0.7	84.6
11.0		0.8	97.8
10.9		0.9	109.3
10.8		1.0	119.7
10.7		1.1	129.3
10.6		1.2	138.3
10.5		1.2	146.6
10.4		1.3	154.6
10.3		1.4	162.1
10.2		1.4	169.3
10.1		1.5	176.3
10.0		1.6	182.9

Source：JICA Survey Team



Source：JICA Survey Team

Figure 4.6.1 Flow Velocity and Flow Capacity of Parañaque Spillway (Laguna de Bay Water Level: 11.5m, Spillway Diameter: 13m)

(2) Variation of Discharge due to Fluctuation of Manila Bay Water Level (Lagna de Bay Water Level 13.8m)

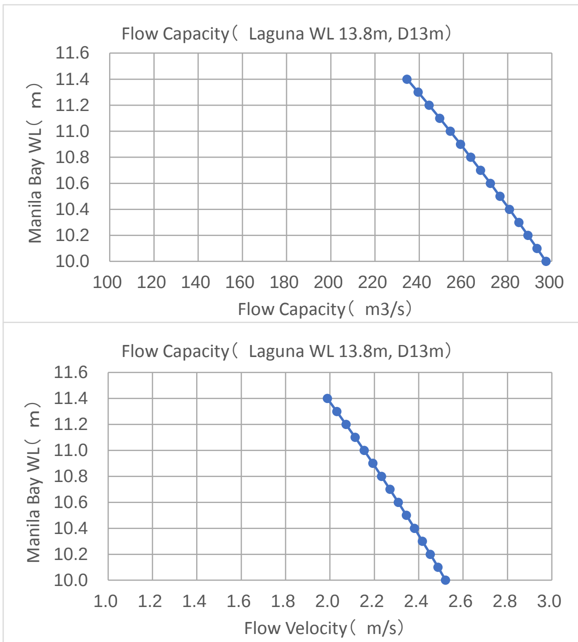
Table 4.6.4 and Figure 4.6.2 show the variation of discharge of the Parañaque Spillway in case the water level in Manila Bay fluctuates under the condition that the Laguna de Bay water level is constant at 13.8m (Design Flood Level).

As shown in Table 4.6.4, if the Manila Bay water level rises by 0.5 m above the MSL, the discharge will be approximately 91% (244.4/267.8), and if the Manila Bay water level falls by 0.5 m below the MSL, the discharge will be approximately 108% (289.2/267.8).

Table 4.6.4 Flow Velocity and Flow Capacity of Parañaque Spillway
(Laguna de Bay Water Level: 13.8m, Spillway Diameter: 13m)

Water Level of Manila Bay (m)	Water Level of Laguna de Bay (m)	Flow Velocity (m/s)	Flow capacity (m^3/s)
11.4		2.0	234.5
11.3		2.0	239.5
11.2		2.1	244.4
11.1		2.1	249.3
11.0		2.2	254.0
10.9		2.2	258.7
10.8		2.2	263.3
10.7	13.8	2.3	267.8
10.6		2.3	272.2
10.5		2.3	276.5
10.4		2.4	280.8
10.3		2.4	285.1
10.2		2.5	289.2
10.1		2.5	293.3
10.0		2.5	297.3

Source：JICA Survey Team



Source：JICA Survey Team

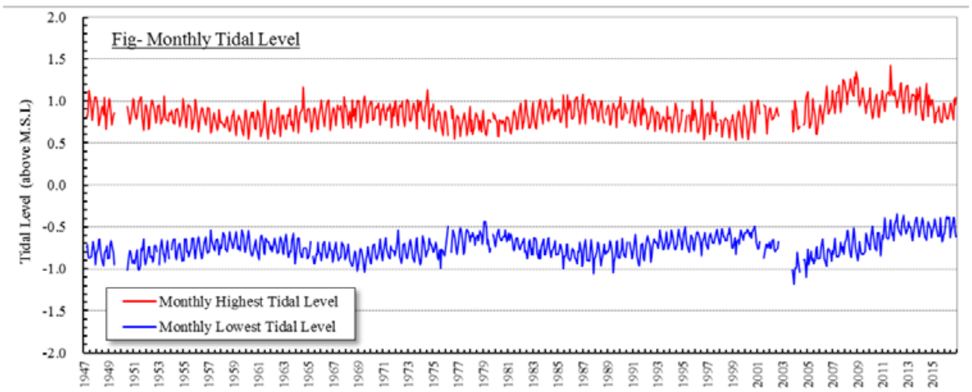
Figure 4.6.2 Flow Velocity and Flow Capacity of Parañaque Spillway
(Laguna de Bay Water Level: 13.8m, Spillway Diameter: 13m)

(3) Study of the Spillway Discharge with Observed Tidal Level

The flow capacity of Parañaque Spillway considering tide fluctuation was calculated using the observed tide levels (hourly data, 1995-2015) of Manila South Harbor collected from the National Geographic Resources and Information Agency (NAMRIA). In particular, the study was conducted focusing on July and August when the tide level reached 11.5 m (water level at which the operation started).

The monthly maximum and minimum tide levels of the collected observed tide level data are shown in Figure 4.6.3. Data for 2003 and 2004 are almost missing, and after the restart of the observation after 2005, compared to previous data, (1) the tide level increased over the entire period, (2) the monthly maximum/minimum tide level was unbalanced, etc. The reference tide level may not be correct.

This is also mentioned in PAGASA's latest climate change model report (Observed Climate Trends and Projected Climate Change in the Philippines, 2018), which may be the effect of land subsidence. However, the tide level data collected were used without correction because the above evidence is not clear.



Source：Parañaque survey 2018

Figure 4.6.3 Monthly Maximum and Minimum Tide Level (Manila South Harbor)

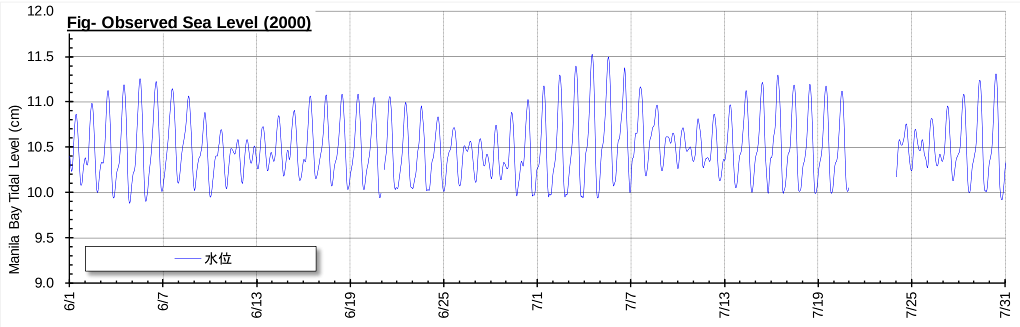
Table 4.6.5 shows the average tide level and average discharge from June to July when the water level of Laguna de Bay was 11.5 m and the Manila Bay tide level was the observed tide level (hourly data) from June to July. Figure 4.6.4 is an example of hourly observed tide level (June to July 2000).

Table 4.6.5 Average Tide Level and Average Discharge from June to July (Water Level of Laguna de Bay: 11.5m)

Year	Climate Change (Without Tide Level Rise)		Climate Change (With Tide Level Rise: 0.2m)	
	Average Tide Level (m)	Average Discharge (m^3/s)	Average Tide Level (m)	Average Discharge (m^3/s)
1995	10.272	162	10.472	146
1996	10.385	153	10.585	135
1997	10.333	158	10.533	141
1998	10.341	157	10.541	140
1999	10.473	146	10.673	127
2000	10.496	143	10.696	124
2001	10.524	141	10.724	122
2002	10.486	144	10.686	124
2003	Missing			
2004	Missing			

Year	Climate Change (Without Tide Level Rise)		Climate Change (With Tide Level Rise: 0.2m)	
	Average Tide Level (m)	Average Discharge (m^3/s)	Average Tide Level (m)	Average Discharge (m^3/s)
2005	10.462	146	10.662	127
2006	10.583	133	10.783	112
2007	10.464	144	10.664	124
2008	10.551	135	10.751	115
2009	10.713	121	10.913	99
2010	10.552	138	10.752	117
2011	10.558	137	10.758	115
2012	10.585	134	10.785	113
2013	10.572	137	10.772	116
2014	10.552	139	10.752	119
2015	10.582	135	10.782	113

Source：JICA study team



Source：JICA Study Team

Figure 4.6.4 Example of Hourly Observed Tide Level (June to July 2000)

The discharge of about 125 m^3/s from Parañaque Spillway in June and July, which is the analysis result of water level fluctuation with 100-year probability (Tide level rise of 0.2 m, Manila Bay water level fixed at MSL 10.7 m), was verified using observed hourly tide data.

As a result, the discharge of about 125 m^3/s was generally satisfied from 1995 to 2002 before the missing period. The discharge was 10% less from 2005 to 2015 because of the overall rise of observed tide.

4.7 Examination of Necessary Measures for Channels and Rivers at Outlet of Spillway

In this study, the influence of the discharge of Parañaque Spillway on the downstream rivers was examined for Route 1 (Drainage to South Parañaque River), Route 2-B and Route 3 (Drainage to Zapote River).

Since the discharge of Parañaque Spillway will affect the downstream rivers, it is necessary to consider the operation rules, etc., to temporarily stop the drainage after setting the optimum route in the F/S.

Figure 4.7.1 River Network System in Las-Piñas and Parañaque

< Effect to Downstream Rivers due of Discharge from Parañaque Spillway>

- Route 1 (Outlet to South Parañaque River)
  - ✓ When draining from Parañaque Spillway during a 2-year probability rainfall, the river water level rises by about 60 cm.
  - ✓ If there is rainfall with a probability of 10 years or more, the river water level will be 13. m or more (Laguna de Bay DFL or more), hence drainage from Parañaque Spillway will be temporarily difficult.

- Route 2-B and Route 3 (Outlet to Zapote River)
  - ✓ The drainage of Parañaque Spillway raises the water level by about 10 cm.

Table 4.7.1 Water Level Change at Drainage Candidate Sites on South Parañaque River Route 1

SP.1+800

Return Period	**without** Paranaque Spillway		**with** Paranaque Spillway				Laguna Lake water level
	WL	River Q	WL	River Q	Outlet Q* Max	Outlet Q* Min	
	(m)	(m3/S)	(m)	(m3/S)	(m3/S)	(m3/S)	(m)
100	15.0	364.8	-	-	-	-	13.8
50	14.7	315.3	-	-	-	-	13.8
25	14.3	268.5	-	-	-	-	13.8
15	14.1	235.7	-	-	-	-	13.8
10	13.9	210.6	-	-	-	-	13.8
5	13.5	168.3	13.8	170.0	116.6	28.2	13.8
2	12.9	110.9	13.5	113.2	117.0	41.9	13.8

Drainage difficulty

60cm increase

Table 4.7.2 Water Level Change at Drainage Candidate Sites on Zapote River Route 2-B and Rote 3

ZA.0+100

Return Period	**without** Paranaque Spillway		**with** Paranaque Spillway				Laguna Lake water level
	WL	River Q	WL	River Q	Outlet Q* Max	Outlet Q* Min	
	(m)	(m3/S)	(m)	(m3/S)	(m3/S)	(m3/S)	(m)
100	12.2	677.6	12.3	673.1	167.0	145.1	13.8
50	12.1	586.0	12.2	581.1	167.0	149.3	13.8
25	12.0	501.8	12.2	496.7	167.0	153.3	13.8
15	12.0	442.5	12.1	437.6	167.0	155.9	13.8
10	12.0	396.4	12.1	391.6	167.0	157.9	13.8
5	11.9	319.0	12.0	314.3	167.0	160.7	13.8
2	11.9	216.1	12.0	210.9	176.2	172.8	13.8

10cm

4.8 Review of Lakeshore Diking System

4.8.1 Study Conditions

(1) Composition of Lakeshore Diking System

The structure consisting of lakeshore dike, drainage channel, pumping station, community road and bridge is called as the lakeshore diking system.

When constructing a dike along the lakeshore, it is necessary to treat the inland water. In general, the dike is crossed by a pipe which connects the inland to Laguna de Bay. However, when the water level of Laguna de Bay rises higher than the ground at the dike, the gate is closed to block the inflow from Laguna de Bay. At that time, the inland water is drained by drainage facilities. For drainage treatment, it is necessary to install a drainage channel, culverts and pumping station. Since the maintenance cost of a drainage facility is high, consideration should be given to the addition of a reservoir, if the drainage facility is necessary,

A maintenance road is set at the crest of the dike, while a road for the community is located on the inland side of the lakeshore dike. At the river, a bridge connecting the community road is installed.

(2) Study on Priority Area

People live and have assets throughout the Laguna de Bay lakeshore area, about 220 km in length. However, some of the assets that may be damaged by flooding are different depending on the region. The lakeshore area varies with residential areas, areas where agricultural land is spreading, and areas where mountains are approaching. When planning the construction of only the lakeshore dike with the lakeshore stretch of about 200 km in total, the dike that can be constructed within the limited planning period is also limited. Therefore, the priority of dike construction is studied.

The method of selecting the priority area was examined separately for each of the 31 LGUs using the following indicators and taking into consideration the type of flooding and geographical classification:

- Topographical classification (Mountainous, Flats are wide to narrow)
- Land use (urban area and agricultural fishing village)
- Beneficiary population (flooded area between EL 12.5 m and EL 13.5 m)
- Beneficiary population (flooded area between EL 12.5 m and EL 14.3 m)
- Beneficiary area (flooded area between EL 12.5 m and EL 14.3 m)

The beneficiary population (calculated in two ways based on the elevations) and beneficiary areas are calculated in 1 km each of the dike length. The scoring of each LGU and index is shown in Table 4.8.1.

Table 4.8.1 Evaluation of Priority Area for the Lakeshore Diking System

No.	LGU	Length of Lakeshore Dike (km)	Topography	Land Use	Beneficiary EL 13.5 m or lower (persons/km)	Beneficiary EL 14.3 m or lower (persons/km)	Beneficial Area (km^2/km)	Total Score
I.	**Rizal**							
1	Taytay	1.35	wide plain	urban area	18,909 (3)	37,634 (3)	1.62 (2)	8
2	Angono	3.31	wide plain	urban area	4,512 (3)	7,804 (2)	0.28 (1)	6
3	Binangonan	19.11	mountainous	urban area	952 (1)	1,949 (0)	0.08 (0)	1
4	Cardona	13.11	mountainous	agriculture, fishery area	173 (0)	396 (0)	0.08 (0)	0
5	Morong	5.67	plain	agriculture, fishery area	639 (1)	1,372 (0)	0.42 (1)	2
6	Baras	3.29	plain	agriculture, fishery area	762 (1)	1,785 (0)	0.33 (1)	2
7	Tanay	4.53	plain	agriculture, fishery area	1,893 (2)	3,295 (1)	0.36 (1)	4
8	Pililla	17.32	plain, mountainous	agriculture, fishery area	142 (0)	450 (0)	0.12 (0)	0
9	Jalajala	23.31	mountainous	agriculture, fishery area	149 (0)	306 (0)	0.03 (0)	0
	Sub Total	91.00			896 (1)	1,786 (0)	0.15 (0)	1
II.	**Laguna**							
10	Mabitac	4.96	plain, mountainous	agriculture, fishery area	354 (0)	523 (0)	1.01 (1)	1
11	Famy	0.60	plain	agriculture, fishery area	967 (1)	2,702 (1)	2.05 (2)	4
12	Siniloan	1.59	plain	agriculture, fishery area	2,031 (2)	7,562 (2)	2.35 (2)	6
13	Pangil	4.26	plain	agriculture, fishery area	531 (1)	1,602 (0)	0.45 (1)	2
14	Pakil	6.30	narrow plain	agriculture, fishery area	136 (0)	302 (0)	0.11 (0)	0
15	Paete	2.73	narrow plain	agriculture, fishery area	767 (1)	1,050 (0)	0.27 (1)	2
16	Kalayaan	3.84	narrow plain	agriculture, fishery area	30 (0)	235 (0)	0.19 (0)	0
17	Lumban	8.90	plain	agriculture, fishery area	552 (1)	1,630 (0)	0.58 (1)	2
18	Pagsanjan	1.16	plain	urban area, agriculture, fishery area	593 (1)	1,505 (0)	0.91 (1)	2
19	Sta. Cruz	8.82	plain	urban area, provincial capital	2,614 (3)	4,174 (2)	0.78 (1)	6
20	Pila	4.75	plain	urban area, agriculture, fishery area	1,190 (2)	3,143 (1)	1.24 (1)	4
21	Victoria	6.47	plain	urban area, agriculture, fishery area	1,355 (2)	2,110 (1)	0.94 (1)	4
22	Calauan	0.84	plain	urban area, agriculture, fishery area	102 (0)	583 (0)	2.80 (2)	2

No.	LGU	Length of Lakeshore Dike (km)	Topography	Land Use	Beneficiary EL 13.5 m or lower (persons/km)	Beneficiary EL 14.3 m or lower (persons/km)	Beneficial Area (km^2/km)	Total Score
23	Bay	3.78	plain	urban area	1,931 (2)	3,426 (1)	0.90 (1)	4
24	Los Banos	8.24	plain		858 (1)	1,468 (0)	0.13 (0)	1
25	Calamba	9.92	plain		1,513 (2)	4,276 (2)	0.49 (1)	5
26	Cabuyao	8.39	plain		3,477 (3)	5,871 (2)	0.51 (1)	6
27	Sta. Rosa	5.78	plain		2,570 (3)	7,692 (2)	0.35 (1)	6
28	Binan	4.66	plain		10,286 (3)	16,267 (3)	0.53 (1)	7
29	San Pedro	4.08	plain		4,960 (2)	10,984 (3)	0.33 (1)	7
	Sub Total	100.07			1,955 (2)	3,924 (1)	0.61 (1)	4
III. Metro Manila								
30	Muntinlupa	9.87	narrow plain	urban area	2,388 (2)	6,015 (2)	0.24 (1)	5
31	Taguig	2.49	narrow plain		2,013 (2)	3,586 (1)	0.12 (0)	3
	Sub Total	12.36			2,312 (2)	5,526 (2)	0.21 (1)	5
Grand Total		203.43			1,503 (2)	3,065 (1)	0.38 (1)	4

*: The number in the parentheses are the scores.
3 points for 2,500 or more beneficiary population, 2 points for 1,000 or more and 1 point for 500 or more (beneficiary EL 13.5 m or lower),
3 points for 10,000 or more, 2 points for 4,000 or more and 1 point for 2,000 or more (beneficiary EL 14.3 m or lower),
3 points for 3.0 km^2/km or more beneficial area, 2 points for 2.0 km^2/km or more and 1 point for 1.0 km^2/km or more
Source: Parañaque Survey, 2018

Based on the above evaluation, priority areas were ranked as follows:

a) Taytay City (No. 1) and Angono (No. 2) which are located at the east side of Mangahan Floodway in Rizal Province next to Metro Manila has a well-urbanized plain area with a large damage amount. In addition, Taguig City (No. 31) and Muntinlupa City (No. 30) are also well-urbanized and have a large number of houses which makes the damage amount high. These are located at the south end of the lakeshore dike constructed in the “Metro Manila Flood Control Project - West of Mangahan” and new lakeshore dikes are to be constructed from the dike. Hence, these 4 LGUs are considered to be “the first priority area”.

b) San Pedro (No. 28), Biñan (No. 28), and Santa Rosa (No. 27) which are located near Metro Manila, are ranked as the highest in the evaluation table. They are highly urbanized, the lakeshore area is also heavily populated, and the damage amount is large, so it makes them the “the second priority area”.

c) Cabuyao (No. 25) and Calamba (No. 26) in the western part of the lakeshore near Metro Manila in Laguna Province where urbanization is progressing, show large damage amounts with high scores. In addition, the demand for community roads constituting part of the lakeshore diking system is also high so that they are in “the third priority area”.

d) As the capital of Laguna Province, the town of Sta. Cruz (No. 19), where residential, commercial and industrial areas have developed and urban areas are spreading, are designated as “the fourth priority area”.

e) LGUs (Pila, Victoria, Calauan, Bay and Los Baños, from No. 20 to No.24) between "d)" and "e)" are in “the fifth priority area”

f) Although Tanay (No. 7), Famy (No. 11) and Siniloan (No. 12) are basically the LGUs with agricultural and fishery lands, but these have a large inundation area. Hence, they are selected as the “6th priority area”.

(3) Study on the cCombination of Lakeshore Diking System and Non-Structural Measures

As a plan to prevent inundation damage on the lakeshore area, the concept of arrangement of the lakeshore diking system and warning system is as follows:

i. The 100-year probability of water level (EL.14.30 m) of Laguna de Bay is targeted.
ii. It is impossible to place a lakeshore dike for the entire lakeshore area within the project period (assumed to be 30 years). For this reason, implementation schedule should be considered with priority ranking.
iii. There are some places with few assets where the economic effect of the lakeshore dike is small. Measures at such areas are handled with an alarm system.
iv. For example, when the plan period of 30 years is divided into 10 years at a single phase, consider the construction work volume of the lakeshore diking system from the high priority area and make the following implementation plan.

Table 4.8.2 Implementation Schedule of the Lakeshore Diking System

Item	Phase I (initial 10 years)	Phase II (middle 10 years)	Phase III (final 10 years)
Target Area	The 1st priority area (Taytay, Angono, Taguig and Muntinlupa)	The 2nd priority area (San Pedro, Binan, Santa Rosa) The 3rd priority area (Cabuyao, Calamba)	The 4th priority area (Sta. Cruz) The 5th priority area (Pila, Victoria, Calauan, Bay, Los Banos)
Lakeshore Dike Length (Total: 83km)	17 km*	33 km	33 km

* The length of 17 km does not include the existing dike portion constructed for "Metro Manila Flood Control Project - West of Mangahan Floodway"

Source: Parañaque Survey, 2018

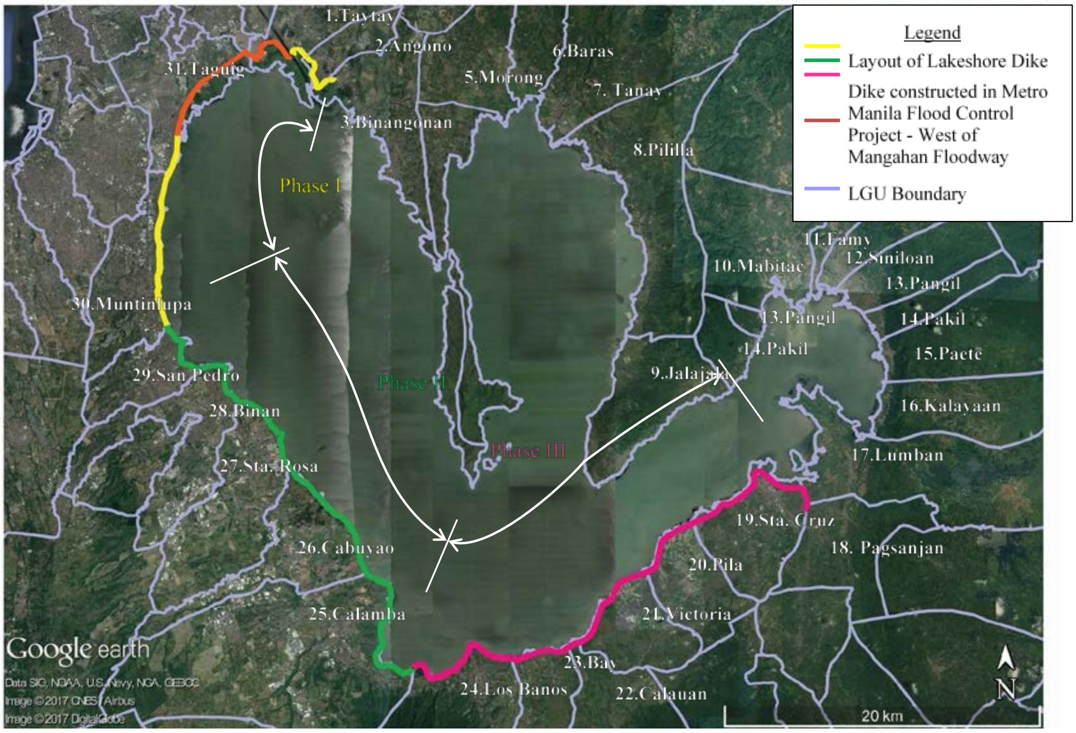
Table 4.8.3 Priority Area of Lakeshore Diking System

No.	LGU	Length of Lakeshore Dike (km)	Topography	Land Use	Beneficiary EL 13.5 m or lower (persons/km)	Beneficiary EL 14.3 m or lower (persons/km)	Beneficial Area (km^2/km)	Total Score
I. First Priority Area								
2	Angono	3.31	wide plain	urban area	4,512 (3)	7,804 (2)	0.28 (1)	6
1	Taytay	1.35	wide plain		18,909 (3)	37,634 (3)	1.62 (2)	8
31	Taguig	2.49	narrow plain		2,013 (2)	3,586 (1)	0.12 (0)	3
30	Muntinlupa	9.87	narrow plain		2,388 (2)	6,015 (2)	0.24 (1)	5
	Sub-Total	17.02			4,057 (3)	8,516 (2)	0.34 (1)	6
II. Second and Third Priority Areas								
29	San Pedro	4.08	plain	urban area	4,960 (3)	10,984 (3)	0.33 (1)	7
28	Binan	4.66	plain		10,286 (3)	16,267 (3)	0.53 (1)	7
27	Sta. Rosa	5.78	plain		2,570 (3)	7,692 (2)	0.35 (1)	6
26	Cabuyao	8.39	plain		3,477 (3)	5,871 (2)	0.51 (1)	6
25	Calamba	9.82	plain		1,513 (2)	4,276 (2)	0.49 (1)	5
	Sub Total	32.83			3,875 (3)	7,821 (2)	0.46 (1)	6
III. Fourth and Fifth Priority Areas								
24	Los Banos	8.24	plain	urban area	858 (1)	1,468 (0)	0.13 (0)	1
23	Bay	3.78	plain		1,931 (2)	3,426 (1)	0.90 (1)	4
22	Calauan	0.84	plain	urban area, agriculture, fishery area	102 (0)	583 (0)	2.80 (2)	2
21	Victoria	6.47	plain		1,355 (2)	2,110 (1)	0.94 (1)	4
20	Pila	4.75	plain		1,190 (2)	3,143 (1)	1.24 (1)	4
19	Sta. Cruz	8.82	plain	urban area, provincial capital	2,614 (3)	4,174 (2)	0.78 (1)	6
	Sub Total	32.90			1,578 (2)	2,764 (1)	0.78 (1)	4
Total of I. II & III		82.75			2,999 (3)	5,953 (2)	0.56 (1)	6

No.	LGU	Length of Lakeshore Dike (km)	Topography	Land Use	Beneficiary EL 13.5 m or lower (persons/km)	Beneficiary EL 14.3 m or lower (persons/km)	Beneficial Area (km^2/km)	Total Score
IV. Sixth and Seventh Priority Area								
18	Pagsanjan	1.16	plain	urban area, agriculture, fishery area	593 (1)	1,505 (0)	0.91 (1)	2
17	Lumban	8.90	plain		552 (1)	1,630 (0)	0.58 (1)	2
16	Kalayaan	3.84	narrow plain		30 (0)	235 (0)	0.19 (0)	0
15	Paete	2.73	narrow plain		767 (1)	1,050 (0)	0.27 (1)	2
14	Pakil	6.30	narrow plain		136 (0)	302 (0)	0.11 (0)	0
13	Pangil	4.26	plain		531 (1)	1,602 (0)	0.45 (1)	2
12	Siniloan	1.59	plain		2,031 (2)	7,562 (2)	2.35 (2)	6
11	Famy	0.60	plain		967 (1)	2,702 (1)	2.05 (2)	4
10	Mabitac	4.96	plain, mountainous	agriculture, fishery area	354 (0)	523 (0)	1.01 (1)	1
9	Jalajala	23.31	mountainous		149 (0)	306 (0)	0.03 (0)	0
8	Pililla	17.32	plain, mountainous		142 (0)	450 (0)	0.12 (0)	0
7	Tanay	4.53	plain		1,893 (2)	3,295 (1)	0.36 (1)	4
6	Baras	3.29	plain		762 (1)	1,785 (0)	0.33 (1)	2
5	Morong	5.67	plain		639 (1)	1,372 (0)	0.42 (1)	2
4	Cardona	13.11	mountainous		173 (0)	396 (0)	0.08 (0)	0
3	Binangonan	19.11	mountainous	urban area	952 (1)	1,949 (0)	0.08 (0)	1
	Sub Total	120.68			477 (0)	1,085 (0)	0.25 (1)	1
Grand Total		203.43			1,503 (2)	3,065 (1)	0.38 (1)	4

*: Numbers in the parentheses are the scores. Refer to Table 4.8.1 for the scoring criteria.

Source: Parañaque Survey, 2018



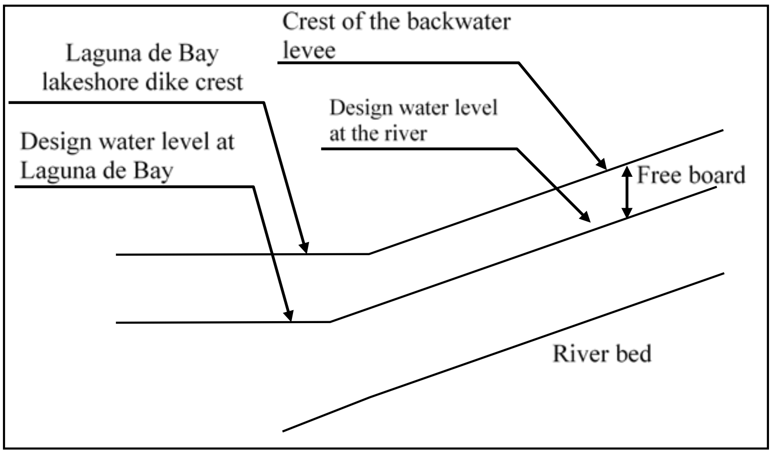
Source: Parañaque Survey, 2018

Figure 4.8.1 Layout Plan of the Lakeshore Dike (Priority Area)

(4) Design Criteria

1) Revetment Height

Revetment is proposed to have the design flood level heightened with a freeboard in compliance with the Japanese and Philippine national standards. The relation between the water level in Laguna de Bay and the surrounding dikes are as shown in Figure 4.8.2.



Source: Parañaque Survey, 2018

Figure 4.8.2 Relation Between Level and Revetment Height

2) Freeboard

With reference to the Laguna de Bay Lakeshore Dike installed in the "Metro Manila Flood Control Project - West of Manggahan Floodway" which has been used for 10 years as a flood countermeasure facility without any problem, the freeboard of the lakeshore dike is set at 1.2 m

The freeboard required for the river improvement is in accordance with the flow rate as shown in Table 4.8.4. However, as shown in Figure 4.8.2, in the backwater influence section due to the design water level of Laguna de Bay, a height corresponding to the crest height of the lakeshore dike is required.

Table 4.8.4 Design Flood Discharge and Freeboard

Design Discharge (m^3/s)	Freeboard (m)
Less than 200	0.6
200 - 500	0.8
500 - 2 ,000	1.0
2,000 - 5,000	1.2

Source: DPWH Standard Guideline 2015, Manual for Government Ordinance for Structural Standard for River Administration Facilities

3) Crest Width

The crest width of the lakeshore dike is set at 6.8 m, referring to the Laguna de Bay lakeshore dike constructed in the "Metro Manila Flood Control Project - West of Mangahan Floodway". For river improvement works, the freeboard stipulated in the Japanese and Philippine National standards as shown in Table 4.8.5 is adopted.

Table 4.8.5 Crest Width

Design Flood Discharge (m^3/s)	Crest Width (m)	Adopted Width (m)
Less than 500	3	3
Equal or above 500 and less than 2,000	4	5
Equal or above 2,000 and less than 5,000	5	

Source: DPWH Standard Guideline 2015, Manual for Government Ordinance for Structural Standard for River Administration Facilities

4) Slope

The slope of the lakeshore dike is the same as that of the Laguna de Bay lakeshore dike installed in the "Metro Manila Flood Control Project - West of Mangahan Floodway". Since river improvement by widening the river channel is considered not easy in a developed area, the slope is set at 1:0.5 to minimize the area for land acquisition. On the other hand, channel widening for river improvement in an undeveloped area such as agricultural lands is considered to be easier, so that 1:3.0 slope is adopted to make slope stability higher and slope protection works inexpensive. In addition, when the slope is 1:0.5 and the revetment height exceeds 5 m, a berm 3 m in width is set in the middle of revetment.

4.8.2 Layout and Cross-Sectional Plan

(1) Layout Plan of the Lakeshore Dike

In proposing the layout plan of the lakeshore dike, the basic concept is summarized as follows:

(i) Since land at EL 12.5 m and lower is basically considered to be the area of Laguna de Bay, except the special land (Prior land) where land ownership was given to the old resident who had stayed there before the establishment of LLDA, it is considered that there is a little problem in land acquisition and that compensation cost is relatively low;

(ii) Residential areas and commercial areas can be seen from the vicinity at EL 12.0 m, and can be confirmed more from EL 12.5 m;

(iii) In the future, considering the case where a lakeshore dike is constructed around the entire Laguna de Bay, the area of Laguna de Bay will decrease as the dike position moves towards the lake side, causing the rise of the Laguna de Bay lake water level during flood. In addition, construction of the lakeshore dike at low elevation is less desirable as it may mislead the residents of the surrounding area to the boundary between the residential area and the lake;

(iv) Basically, EL 12.5 m has been set as the boundary of the lakeshore diking system. If developed areas such as residential and commercial areas are seen at that elevation, the lakeshore diking system should be placed at EL 12.0 m; and

(v) The elevation of the crest of the lakeshore dike constructed in the "Metro Manila Flood Control Project - West of Manggahan Floodway" is EL 15.0 m. If raising of the crest is within the freeboard required, a parapet shall be applied.

Table 4.8.6 Lakeshore Dike Length (with Laguna de Bay Water Level at EL 13.8 m)

Place		Dike Length (m)	Foundation Elevation (EL.m)	Place		Dike Length (m)	Foundation Elevation (EL.m)
Province	LGU			Province	LGU		
Phase I							
Rizal	Angono	3,310	12.0	NCR	Taguig	2,490	12.0
Rizal	Taytay	1,350	12.0	NCR	Muntinlupa	9,870	12.0
Sub-total of Phase I						17,020	
Phase II							
Laguna	San Pedro	4,080	12.0	Laguna	Cabuyao	8,390	12.0
Laguna	Biñan	4,660	12.0	Laguna	Calamba	9,920	12.5
Laguna	Santa Rosa	5,780	12.0				
Sub-total of Phase II						32,830	
Phase III							
Laguna	Los Baños	8,240	12.0	Laguna	Victoria	6,470	12.0
Laguna	Bay	3,780	12.0	Laguna	Pila	4,750	12.5
Laguna	Calauan	840	12.0	Laguna	Santa Cruz	8,820	12.5
Sub-total of Phase III						32,900	
Sub-Total of Priority Area						82,750	

Source: Parañaque Survey, 2018

(2) Cross Section of the Lakeshore Dike

The lakeshore dike is basically based on the lakeshore dike constructed in the "Metro Manila Flood Control Project - West of Manggahan Floodway" which has been well functioning as a flood control facility for ten years. However, structural changes are proposed in the following points.

(i) Asphalt Pavement of Community Road

The community road of the lakeshore dike previously constructed was not designed to have a lot of traffic by general vehicles and did not consider the benefits generated by traffic. However, since the proposed lakeshore dike passes through areas that have already been developed, or connects those areas, a large volume of general vehicles is expected. Therefore, a durable pavement structure is desirable for community roads, as a structure capable of withstanding heavy traffic. On the other hand, from the experience of the previously built lakeshore dike, pavement that can follow the deformation of the embankment shape is preferable, assuming inconsistent settlement of the embankment. Therefore, asphalt pavement is proposed.

(ii) Omission of Drainage Embankment

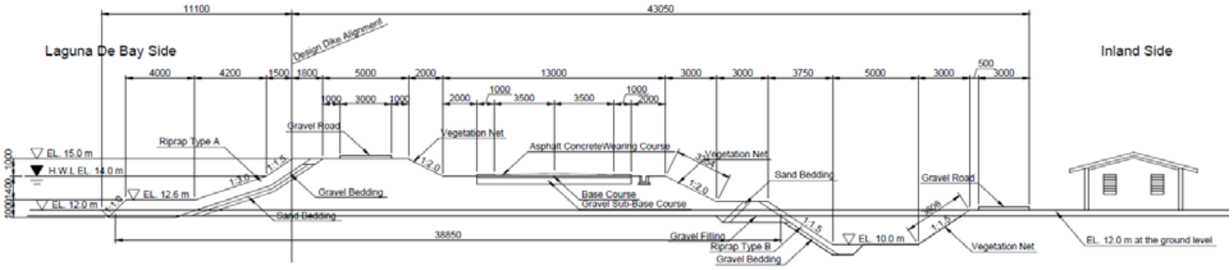
The previously constructed lakeshore diking system had its embankment designed along the drainage channel because the foundation ground was low. Since the foundation ground for the new drainage embankment is assumed at between EL 12.0 m and EL 12.5 m, embankment along the drainage channel is omitted.

(iii) Vegetation Net

In recent years, DPWH has been recommending a vegetation net using recycled materials instead of sodding. This vegetation net is also described in detail in the DPWH Standard Specifications for Highways Bridges and Airports, 2013, which is common in the Philippines. Therefore, this type of vegetation net is proposed instead of the sodding works.

(iv) Standard Cross Section

The standard cross section of lakeshore dike is shown in Figure 4.8.3.



Source: Parañaque Survey, 2018

Figure 4.8.3 Standard Cross Section of Lakeshore Diking System (Design High Water Level: 14.0 m)

(3) Pumping Station and Flood Gate

Pumping stations and floodgates are necessary to drain water from the inside of the bank surrounded by the lakeshore dike and the backwater levee described later. In the detailed design of the "Metro Manila Flood Control Project - West of Manggahan Floodway", pumping station has the target probability year of 5 years, and the depth of inundation is 0 m. For this proposed project, the contents of the detailed design are followed, and the drainage capacity required at the pumping stations is based on the water collection area ratio calculated.

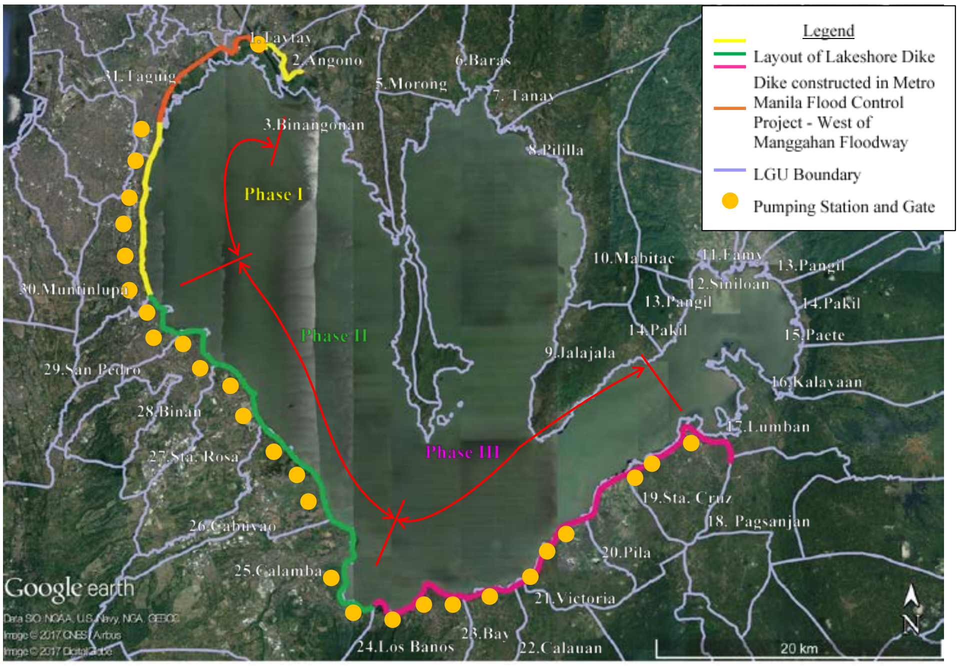
Table 4.8.7 and Table 4.8.8 describe the size of the pumping stations and floodgates.

Table 4.8.7 Pumping Station and Flood Gate Size (1/2)

No	Basin			Catchment Area (km^2)	Specific Discharge 5-yr Probability ($m^3/s/km^2$)	Peak Discharge 5-yr Probability (m^3/km^2)	Channel Storage (m^3/s)	Required Pump Capacity w/o Regulation Pond (m^3/s)
1	SB-23	Muntinlupa	SB23-RB1	1.7	8.4	14.3	7.1	7.1
2			SB23-RB2	2.3	8.4	19.3	9.7	9.7
3			SB23-RB3	2.7	8.4	22.7	11.3	11.3
4			SB23-RB4	1.0	8.4	8.4	4.2	4.2
5			SB23-RB5	0.5	8.4	4.1	2.1	2.1
6	SB-22	San Pedro	SB22-RB1	0.9	5.6	5.0	2.5	2.5
7			SB22-RB2	3.4	5.6	19.0	9.5	9.5
8			SB22-RB3	2.4	5.6	13.2	6.6	6.6
9	SB-21	Binan	SB21-RB1	12.8	5.7	73.1	36.5	36.5
10			SB21-RB2	2.5	5.7	14.3	7.1	7.1
11	SB-20	Sta. Rosa	SB20-RB1	1.6	6.4	10.2	5.1	5.1
12			SB20-RB2	5.8	6.4	37.1	18.6	18.6
13			SB20-RB3	1.8	6.4	11.5	5.8	5.8
14			SB20-RB4	14.9	6.4	95.4	47.7	47.7
15	SB-19	San Cristobal	SB19-RB1	11.3	6.4	72.3	36.2	36.2
16	SB-18	San Juan	SB18-RB1	5.7	6.9	39.3	19.7	19.7
17	SB-17	Los Banos	SB17-RB1	3.3	10.7	35.1	17.5	17.5
18			SB17-RB2	2.0	10.7	21.6	10.8	10.8
19			SB17-RB3	5.8	10.7	62.2	31.1	31.1
20			SB17-RB4	0.6	10.7	6.2	3.1	3.1
21	SB-16	Calauan	SB16-RB1	0.7	7.0	4.9	2.5	2.5
22			SB16-RB2	0.6	7.0	4.1	2.0	2.0
23	SB-15	Pila	SB15-RB1	1.7	6.9	11.7	5.8	5.8
24			SB15-RB2	8.8	6.9	60.7	30.3	30.3
25			SB15-RB3	14.1	6.9	97.5	48.7	48.7
26	SB-14	Sta. Cruz	SB14-RB1	11.8	5.8	68.4	34.2	34.2
27			SB14-RB2	1.4	5.8	8.1	4.1	4.1
28	SB-02	Taytay	SB02-RB1	2.0	8.6	17.2	8.6	8.6
Total				124.0	206.8	856.9	428.4	428.4

Table 4.8.8 Pumping Station and Flood Gate Size (2/2)

No	Basin			Regulation Pond			Required Pump Capacity w/ Regulation Pond (m^3/s)	Gate (W5m x H4m) (unit)
				Area (ha)	Depth (m)	Volume (m^3)		
1	SB-23	Muntinlupa	SB23-RB1	0.9	2.0	17,000	5.0	1
2			SB23-RB2	1.2	2.0	23,000	7.0	1
3			SB23-RB3	1.4	2.0	27,000	9.0	2
4			SB23-RB4	0.5	2.0	10,000	3.0	1
5			SB23-RB5	0.2	2.0	4,900	2.0	1
6	SB-22	San Pedoro	SB22-RB1	0.5	2.0	9,000	2.0	1
7			SB22-RB2	1.7	2.0	34,000	7.0	1
8			SB22-RB3	1.2	2.0	23,500	5.0	1
9	SB-21	Binan	SB21-RB1	6.4	2.0	128,200	27.0	4
10			SB21-RB2	1.3	2.0	25,000	5.0	1
11	SB-20	Sta. Rosa	SB20-RB1	0.8	2.0	16,000	4.0	1
12			SB20-RB2	2.9	2.0	58,000	14.0	2
13			SB20-RB3	0.9	2.0	18,000	4.0	1
14			SB20-RB4	7.5	2.0	149,000	36.0	5
15	SB-19	San Cristobal	SB19-RB1	5.7	2.0	113,000	27.0	4
16	SB-18	San Juan	SB18-RB1	2.9	2.0	57,000	15.0	2
17	SB-17	Los Banos	SB17-RB1	1.6	2.0	32,800	13.0	2
18			SB17-RB2	1.0	2.0	20,200	8.0	2
19			SB17-RB3	2.9	2.0	58,100	23.0	4
20			SB17-RB4	0.3	2.0	5,800	2.0	1
21	SB-16	Calauan	SB16-RB1	0.4	2.0	7,000	2.0	1
22			SB16-RB2	0.3	2.0	5,800	2.0	1
23	SB-15	Pila	SB15-RB1	0.8	2.0	16,900	4.0	1
24			SB15-RB2	4.4	2.0	87,900	23.0	4
25			SB15-RB3	7.1	2.0	141,300	37.0	5
26	SB-14	Sta. Cruz	SB14-RB1	5.9	2.0	118,000	26.0	4
27			SB14-RB2	0.7	2.0	14,000	3.0	1
28	SB-02	Taytay	SB02-RB1	1.0	2.0	20,000	6.0	1
Total				62.0		1,240,400	321.0	56



Source: Parañaque Survey, 2018

Figure 4.8.4 Location of Pumping Station and Gate along for the Lakeshore Diking System

4.9 Operation and Maintenance

DPWH oversees the planning, designing and construction of large-scale flood control projects in the Metro Manila area. The completed flood control facilities are later transferred to MMDA which also conducts the operation and maintenance.

The target area of this project covers the Metro Manila area under the jurisdiction of MMDA and the provinces of Laguna and Rizal outside of MMDA's jurisdiction. Therefore, the responsibility for operation and maintenance is shared among several organizations, which is not always effective. In addition, since the proposed measures are large-scale structures, it is but appropriate to establish the project implementation/operation and maintenance system by positioning DPWH at the center.

Based on the existing condition of organizations, institutions, and financial and human resources, an outline of the conceivable organization for the operation, maintenance and management of the comprehensive food control works in the Laguna de Bay area (Parañaque Spillway, Laguna Lakeshore Dike, pumping stations, river improvement works) is proposed as shown in Table 4.9.1.

Table 4.9.1 Proposed Organization for Project Implementation, Operation, Maintenance and Management of Flood Management for Laguna de Bay

Works	Outline	Implementation	Operation and Maintenance
Spillway	Underground tunnel spillway (L: approx. 10km, drainage pump facilities)	DPWH-UPMO	・ DPWH-UPMO/MMDA
Lake Dike	Crest EL.14.0m, total length 83km	DPWH-UPMO	・ MMDA-FCSMO (in Metro Manila) ・ DPWH-RO/DEOs or LGUs (other areas) ・ Land management for related structures by LLDA/LGUs
Pump Station	28 pump stations in low-lying lake dike areas	DPWH-UPMO	
River Improvement	Tributaries in construction areas of lake dike	DPWH-UPMO	

Source: Parañaque Survey, 2018

Since the proposed spillway is a large-scale underground tunnel facility, it will require an advanced intake/outlet operation and a large amount of budget for maintenance works (drainage and sediment removal from tunnel), it is but appropriate that the DPWH and MMDA will collaborate in the operation and maintenance of the spillway and facilities, utilizing the special operation and maintenance fund.

This is the first attempt in the Philippines to operate and maintain an underground discharge channel. In accordance with the proposed facility plan/design, MMDA carries out gate operation when starting/stopping the discharge channel, monitoring/recording during operation, and operating pump equipment during tunnel drainage. DPWH is in charge of setting detailed methods/procedures such as sediment removal, cleaning, and inspection, staffing, implementation, and large-scale repair. In addition, it is desirable to transfer the knowledge on management technology in Japan, which has many experiences in the operation and maintenance of underground discharge channels and underground storage facilities. It is necessary to continue to support Japanese engineers to prepare maintenance manuals and to support regular on-site maintenance work.

On the other hand, after construction of the proposed lake dike flood control facilities, pump stations and river improvement work in the surrounding area of Laguna de Bay, they will be handed over to the

DPWH regional offices concerned (NCR, Region IV-A and related district engineering offices), or to the MMDA in case the facilities are located within Metro Mania.

LGUs will generally conduct the monitoring and cleaning of smaller scale flood control facilities concerned. The roles and responsibilities on operation and maintenance works of the LGUs shall be identified through a Memorandum of Agreement (MOA) among all stakeholders.

4.10 Implementation Schedule and Preliminary Cost Estimate

4.10.1 Implementation Schedule

(1) Basic Policy

The Parañaque Spillway is expected to be completed in about 5 to 9 years (depending on the routes), and the flood mitigation effect over the entire Laguna Lakeshore area is expected as soon as possible. On the other hand, the Lakeshore Diking System requires a lot of resettlement and land acquisition, and it is expected to have an impact on fisheries, historically.

It will take a long time (20-30 years) to complete the works. Therefore, as a flood management plan (about 5 to 9 years of construction), it is appropriate to implement the Parañaque Spillway early as a priority, and steadily implement the Lakeshore Diking System over a long period of time (about 30 years), considering the reduction of water level effect of the Parañaque Spillway. The construction period of the Parañaque Spillway is 5 to 8.8 years, depending on the route.

The target period of completion is 30 years after the start of the project. The project will be implemented in three stages: 10 years (short term), 20 years (medium term), and 30 years (Long Term).

Table 4.10.1 Project Implementation Plan of Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area

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

* : Implementation of Lakeshore Diking System was assumed based on construction quantity and did not include the period for bidding, house evacuation and land acquisition.

Source: JICA Study Team

(2) Setting Conditions

It is assumed that the 30 years from 2021 to 2050 will be divided into short-term, medium-term, and long-term.

[Preparation]: July 2020-April 2021

- ✓ F/S (10 months), Loan preparation including ICC application from the latter half of F/S.

[Short-Term]: May 2021 to December 2030

- ✓ In parallel with consultant procurement for STEP-D/D (Parañaque Spillway), after obtaining the ICC, signing of the Exchange of Notes (E/N), and concluding the Loan Agreement (L/A) in June 2021.
- ✓ STEP-D/D (Parañaque Spillway) starts in July 2021.
- ✓ Procurement of contractors proceeds in parallel; Selection of contractor is completed in September 2023, and construction of Parañaque Spillway starts in October 2023 (fastest completion in September 2028 (for Route 2-B)).
- ✓ From July 2024 to June 2026, Detailed Design (D/D) for Phase I, Lakeshore Diking System, and Bidding for contractor selection.
- ✓ In July 2026, construction of Phase I Lakeshore Diking System (including drainage pump station, bridge, backwater Levee, etc.) starts.
- ✓ From January 2029 to December 2030, Detailed Design (D/D) for Phase II, Lakeshore Diking System, and Bidding for contractor selection.

[Medium-Term]: January 2031 to December 2040

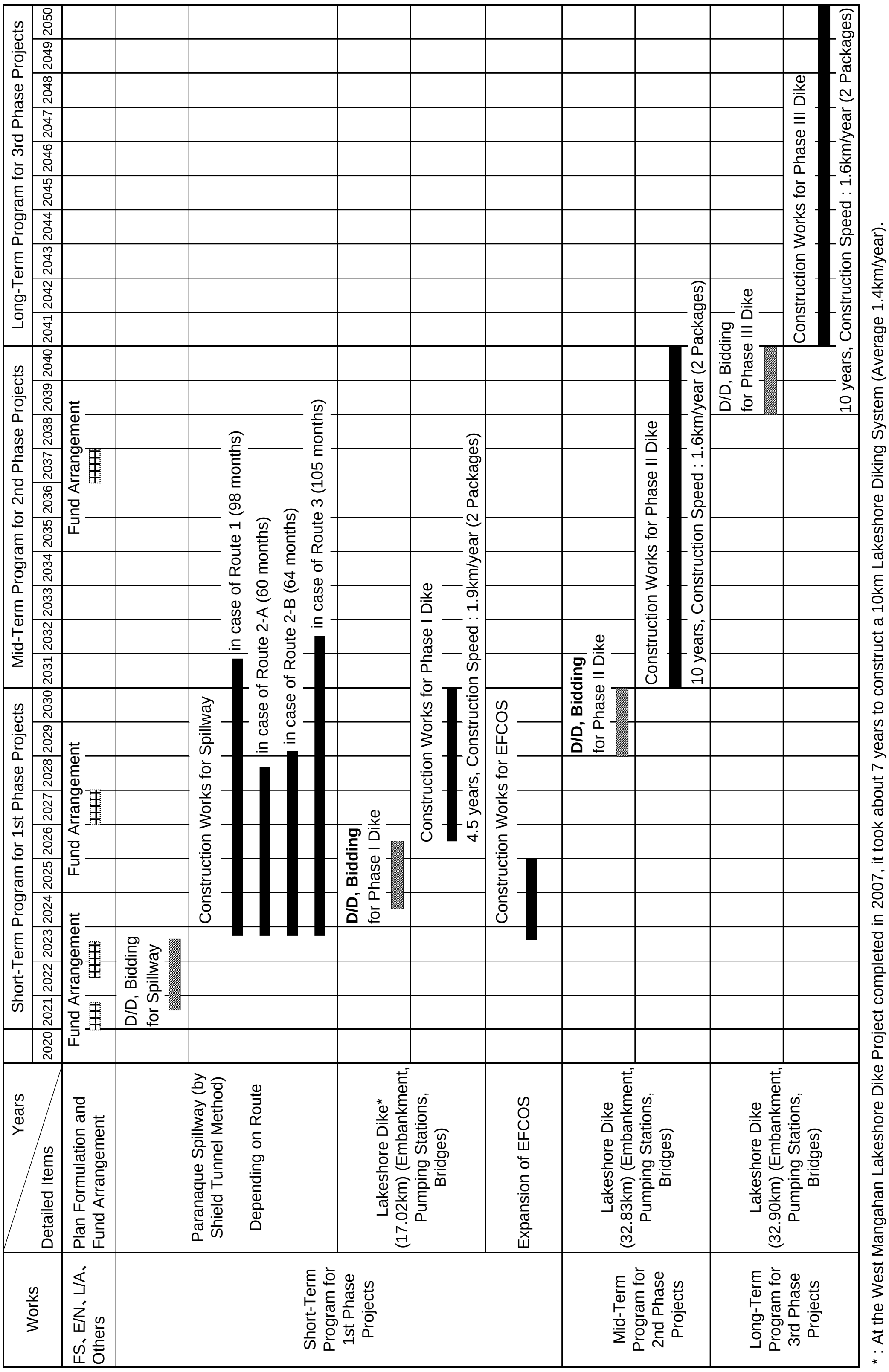
- ✓ In January 2031, construction of Phase II Lakeshore Diking System starts.
- ✓ From January 2039 to December 2040, Detailed Design (D/D) for Phase III Lakeshore Diking System, and Bidding for contractor selection.

[Long-Term]: January 2041 to December 2050

- ✓ In January 2041, construction of Phase III Lakeshore Diking System starts.

(3) Project Implementation Schedule

The project implementation schedule created under the above conditions is shown in Figure 4.10.1. For Parañaque Spillway, four routes are assumed.



Source : JICA Study Team

Figure 4.10.1 Details of Project Implementation Schedule of Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area

4.10.2 Preliminary Cost Estimate

(1) Project Cost Items

The project cost items are as follows:

- Construction Cost
- Engineering Cost (the cost for consulting services)
- Price Escalation
- Contingency

The following are non-eligible loan items:

- Land acquisition and compensation
- Project administration cost by project implementation body
- Tax (VAT)

(2) Policy on the Calculation of Construction Cost

The construction cost, which is based on the calculation of project cost, is roughly calculated under the policy stated in the following table.

Table 4.10.2 Policy on the Calculation of Construction Cost

Construction Project	Policy on Cost Estimate
Parañaque Spillway	There are no past experiences on big tunneling projects in the Philippines. Therefore, cost estimation will be done, assuming the implementation of tunneling project in Philippines in reference to the cost estimate in the "Data Collection Survey on Parañaque Spillway in Metro Manila in the Republic of the Philippines, May 2018", the examples in other countries including Japan, and the information obtained by hearing from Japanese Contractors and Specialist Contractors.
Lakeshore Diking Systems (Inclusive of Pumping Stations, Bridges, etc.)	Base unit costs are considered in reference to past projects such as the "Data Collection Survey on Parañaque Spillway in Metro Manila in the Republic of the Philippines, May 2018" and the "Metro Manila Flood Control Project – West of Manggahan Floodway" (Tender Year: 2000), and also adjusted by the price escalation up to base year of cost estimate, i.e., January 2020.
Expansion of EFCOS	Cost estimate for concerned project is based on the information by hearing from PAGASA under the "Data Collection Survey on Parañaque Spillway in Metro Manila in the Republic of the Philippines, May 2018". Therefore, the cost is adjusted by the price escalation up to base year of cost estimate, i.e., January 2020

Source: JICA Study Team

(3) Calculation Condition of Project Cost

The following conditions were applied to calculate Project Cost.

Table 4.10.3 Calculation Condition of Project Cost

Items	Conditions	Remarks
Base Year of Cost Estimate	January 2020	
Exchange Rate	1USD=18.67JPY; 1USD=51.03PHP	Refer to data on Exchange

Items	Conditions	Remarks
	1PHP=2.130JPY	Rates in IMF homepage (Average rate from November 2019 to January 2020)
Engineering Cost	10% of Construction Cost	
Price Escalation	Price Escalation regarding Construction Cost, Engineering Cost F/C: 0.9%、L/C: 2.7%	Refer to "World Economy Outlook" published in the IMF homepage
Contingency	10% of total amount for construction cost, engineering cost and price escalation	
Land Acquisition, Compensation	Detailed calculation for land acquisition and compensation for building removal (Inclusive of price escalation: 2.7% for LC and also contingency: 10%)	
Project Administration Cost for project implementation body	2% of total amount of construction cost, engineering cost and the cost for land acquisition and compensation	
VAT	12.0%	

Source: JICA Study Team

(4) Preliminary Cost Estimate

(i) Preliminary Cost Estimate

Project Costs based on the above policy and conditions are shown in Table 4.10.4 to Table 4.10.7. As stated in the planning condition of implementation schedules, the following four (4) options for Parañaque Spillway were applied for the construction cost which is the basis of project cost.

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

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

Option 3: Parañaque Spillway (Route 2B, Shield Tunneling Method), Lakeshore Diking Systems, Expansion of EFCOS

Option 4: Parañaque Spillway (Route 3, Shield Tunneling Method), Lakeshore Diking Systems, Expansion of EFCOS

Table 4.10.4 Project Cost (Option 1: Route 1)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 1, Shield Tunneling Method)	18,230	27,973	46,203
	Lakeshore Diking Systems	8,964	35,858	44,822
	Expansion of EFCOS	86	37	123
	Sub-Total	27,281	63,868	91,149
Engineering Cost		4,557	4,557	9,115
Price Escalation		3,391	30,895	34,286
Contingency		3,523	9,932	13,455
Land Acquisition, Compensation		0	15,293	15,293
Administration Cost		0	3,266	3,266
VAT		0	19,596	19,596
Total (million PHP)		38,752	147,406	186,158

Source: JICA Study Team

Table 4.10.5 Project Cost (Option 2: Route 2A)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 2A, Shield Tunneling Method)	12,910	28,978	41,888
	Lakeshore Diking Systems	8,964	35,858	44,822
	Expansion of EFCOS	86	37	123
	Sub-Total	21,960	64,873	86,833
Engineering Cost		4,342	4,342	8,683
Price Escalation		2,760	29,559	32,318
Contingency		2,906	9,877	12,783
Land Acquisition, Compensation		0	16,028	16,028
Administration Cost		0	3,133	3,133
VAT		0	18,797	18,797
Total (million PHP)		31,967	146,609	178,576

Source: JICA Study Team

Table 4.10.6 Project Cost (Option 3: Route 2B)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 3, Shield Tunneling Method)	13,938	27,325	41,263
	Lakeshore Diking Systems	8,964	35,858	44,822
	Expansion of EFCOS	86	37	123
	Sub-Total	22,988	63,219	86,208
Engineering Cost		4,301	4,301	8,621
Price Escalation		2,828	29,331	32,159
Contingency		3,013	9,686	12,699
Land Acquisition, Compensation		0	16,428	16,428
Administration Cost		0	3,122	3,122
VAT		0	18,734	18,734
Total (million PHP)		33,140	144,831	177,971

Source: JICA Study Team

Table 4.10.7 Project Cost (Option 4: Route 3)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 3, Shield Tunneling Method)	20,125	30,611	50,736
	Lakeshore Diking Systems	8,964	35,858	44,822
	Expansion of EFCOS	86	37	123
	Sub-Total	29,175	66,506	95,681
Engineering Cost		4,784	4,784	9,568
Price Escalation		3,569	31,917	35,486
Contingency		3,753	10,321	14,074
Land Acquisition, Compensation		0	15,941	15,941
Administration Cost		0	3,415	3,415
VAT		0	20,490	20,490
Total (million PHP)		41,281	153,373	194,654

Source: JICA Study Team

(ii) Cost Disbursement

Cost Disbursement Schedules were considered based on the implementation schedule (four options) from 2021.

Table 4.10.8 Cost Disbursement Schedule (Option 1, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (route 2A Shield)			Lakeshore Diking System (inclusive backwater levee, Pumping station, Bridge)			Expansion of EFCOS			Total		
		F. C.	L. C.	Sub-Total	F. C.	L. C.	Sub-Total	F. C.	L. C.	Sub-Total	F. C.	L. C.	Sub-Total
1	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0	0	0	0	0	0
	2023	293	630	923	0	0	0	17	7	25	311	637	948
	2024	1,174	2,518	3,692	0	0	0	17	7	25	1,191	2,526	3,717
	2025	1,174	2,518	3,692	0	0	0	17	7	25	1,191	2,526	3,717
	2026	2,378	4,165	6,543	359	1,434	1,793	17	7	25	2,753	5,607	8,360
	2027	2,378	3,625	6,002	359	1,434	1,793	17	7	25	2,753	5,066	7,820
	2028	4,785	6,783	11,568	359	1,434	1,793	0	0	0	5,144	8,218	13,361
	2029	3,799	6,007	9,807	359	1,434	1,793	0	0	0	4,158	7,442	11,599
	2030	1,174	901	2,075	359	1,434	1,793	0	0	0	1,532	2,335	3,867
2	2031	1,076	826	1,902	359	1,434	1,793	0	0	0	1,435	2,260	3,695
	2032	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2033	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2034	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2035	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2036	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2037	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2038	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2039	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2040	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
3	2041	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2042	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2043	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2044	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2045	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2046	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2047	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2048	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2049	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2050	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
Total Cost		18,230	27,973	46,203	8,964	35,858	44,822	86	37	123	27,281	63,868	91,149

Source: JICA Study Team

Table 4.10.9 Cost Disbursement Schedule (Option 1)

(Unit: Million of PHP)

Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total
2021	0	0	0	154	154	308	16	16	31	1	4	6	0	0	0	0	7	7	0	41	41	171	222	393
2022	0	0	0	307	307	614	31	32	64	6	17	22	0	869	869	0	31	31	0	188	188	344	1,445	1,788
2023	311	637	948	223	223	445	55	93	148	15	72	86	0	1,951	1,951	0	72	72	0	429	429	603	3,476	4,079
2024	1,191	2,526	3,717	223	223	445	147	306	452	52	309	361	0	2,004	2,004	0	140	140	0	837	837	1,612	6,344	7,956
2025	1,191	2,526	3,717	223	223	445	148	314	462	65	392	456	0	941	941	0	120	120	0	723	723	1,626	5,238	6,864
2026	2,753	5,607	8,360	307	307	614	323	694	1,017	169	1,025	1,194	0	0	0	0	224	224	0	1,342	1,342	3,552	9,199	12,751
2027	2,753	5,066	7,820	307	307	614	326	647	973	198	1,102	1,300	0	992	992	0	234	234	0	1,404	1,404	3,584	9,753	13,337
2028	5,144	8,218	13,361	307	307	614	586	1,055	1,641	405	2,025	2,430	0	1,019	1,019	0	381	381	0	2,288	2,288	6,441	15,293	21,734
2029	4,158	7,442	11,599	306	306	613	484	985	1,469	375	2,099	2,474	0	1,047	1,047	0	344	344	0	2,064	2,064	5,323	14,287	19,610
2030	1,532	2,335	3,867	306	306	613	201	345	546	172	806	979	0	1,075	1,075	0	142	142	0	850	850	2,212	5,859	8,071
2031	1,435	2,260	3,695	288	288	576	190	342	532	178	868	1,046	0	0	0	0	117	117	0	702	702	2,091	4,576	6,667
2032	359	1,434	1,793	85	85	169	49	209	258	50	572	622	0	0	0	0	57	57	0	341	341	543	2,698	3,241
2033	359	1,434	1,793	85	85	169	50	215	265	55	629	683	0	0	0	0	58	58	0	349	349	548	2,770	3,317
2034	359	1,434	1,793	85	85	169	50	221	271	59	687	746	0	0	0	0	60	60	0	357	357	553	2,843	3,396
2035	359	1,434	1,793	85	85	169	51	227	277	64	746	810	0	0	0	0	61	61	0	366	366	558	2,918	3,476
2036	359	1,434	1,793	85	85	169	51	233	284	68	807	876	0	0	0	0	62	62	0	375	375	563	2,996	3,558
2037	359	1,434	1,793	85	85	169	52	239	291	73	870	943	0	1,295	1,295	0	90	90	0	539	539	568	4,552	5,120
2038	359	1,434	1,793	85	85	169	52	245	297	78	935	1,012	0	1,330	1,330	0	92	92	0	552	552	573	4,673	5,246
2039	359	1,434	1,793	85	85	169	53	252	305	82	1,001	1,083	0	1,366	1,366	0	94	94	0	566	566	578	4,798	5,376
2040	359	1,434	1,793	85	85	169	53	259	312	87	1,069	1,156	0	1,403	1,403	0	97	97	0	580	580	583	4,926	5,509
2041	359	1,434	1,793	85	85	169	53	266	319	92	1,139	1,231	0	0	0	0	70	70	0	421	421	588	3,415	4,003
2042	359	1,434	1,793	85	85	169	54	273	327	97	1,211	1,307	0	0	0	0	72	72	0	432	432	594	3,506	4,100
2043	359	1,434	1,793	85	85	169	54	280	335	101	1,284	1,386	0	0	0	0	74	74	0	442	442	599	3,599	4,198
2044	359	1,434	1,793	85	85	169	55	288	343	106	1,360	1,466	0	0	0	0	75	75	0	453	453	604	3,695	4,299
2045	359	1,434	1,793	85	85	169	55	296	351	111	1,438	1,549	0	0	0	0	77	77	0	463	463	610	3,793	4,403
2046	359	1,434	1,793	85	85	169	56	304	360	116	1,517	1,634	0	0	0	0	79	79	0	475	475	615	3,894	4,509
2047	359	1,434	1,793	85	85	169	56	312	368	121	1,599	1,721	0	0	0	0	81	81	0	486	486	621	3,997	4,618
2048	359	1,434	1,793	85	85	169	57	320	377	126	1,684	1,810	0	0	0	0	83	83	0	498	498	626	4,104	4,730
2049	359	1,434	1,793	85	85	169	57	329	386	131	1,770	1,902	0	0	0	0	85	85	0	510	510	632	4,213	4,845
2050	359	1,434	1,793	85	85	169	58	338	396	137	1,859	1,996	0	0	0	0	87	87	0	522	522	638	4,325	4,963
	27,281	63,868	91,149	4,557	4,557	9,115	3,523	9,932	13,455	3,391	30,895	34,286	0	15,293	15,293	0	3,266	3,266	0	19,596	19,596	**38,752**	**147,406**	**186,158**

Source: JICA Study Team

Table 4.10.10 Cost Disbursement Schedule (Option 2, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (route 2A Shield)			Lakeshore Diking System(inclusive backwater levee, Pumping station, Bridge)			Expansion of EFCOS			Total		
		F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total
1	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0	0	0	0	0	0
	2023	447	1,091	1,537	0	0	0	17	7	25	464	1,098	1,562
	2024	1,788	4,362	6,150	0	0	0	17	7	25	1,805	4,369	6,174
	2025	1,788	6,252	8,040	0	0	0	17	7	25	1,805	6,260	8,065
	2026	4,231	8,435	12,666	359	1,434	1,793	17	7	25	4,607	9,876	14,484
	2027	4,231	8,290	12,521	359	1,434	1,793	17	7	25	4,607	9,731	14,339
	2028	424	549	973	359	1,434	1,793	0	0	0	783	1,983	2,766
	2029	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2030	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
2	2031	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2032	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2033	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2034	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2035	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2036	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2037	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2038	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2039	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2040	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
3	2041	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2042	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2043	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2044	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2045	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2046	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2047	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2048	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2049	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2050	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
Total Cost		12,910	28,978	41,888	8,964	35,858	44,822	86	37	123	21,960	64,873	86,833

Source: JICA Study Team

Table 4.10.11 Cost Disbursement Schedule (Option 2)

(Unit: Million of PHP)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2021	0	0	0	187	187	375	19	19	38	2	5	7	0	0	0	0	8	8	0	50	50	208	271	479
	2022	0	0	0	374	374	748	38	39	78	7	20	27	0	869	869	0	34	34	0	207	207	419	1,544	1,963
	2023	464	1,098	1,562	290	290	579	77	150	228	21	115	136	0	2,314	2,314	0	96	96	0	578	578	852	4,642	5,494
	2024	1,805	4,369	6,174	290	290	579	217	518	735	76	524	600	0	2,376	2,376	0	209	209	0	1,256	1,256	2,388	9,543	11,931
	2025	1,805	6,260	8,065	290	290	579	219	748	967	96	933	1,029	0	941	941	0	232	232	0	1,390	1,390	2,410	10,793	13,203
	2026	4,607	9,876	14,484	374	374	748	526	1,203	1,728	275	1,777	2,052	0	0	0	0	380	380	0	2,281	2,281	5,782	15,892	21,674
	2027	4,607	9,731	14,339	374	374	748	530	1,218	1,748	322	2,072	2,394	0	992	992	0	404	404	0	2,427	2,427	5,834	17,218	23,053
	2028	783	1,983	2,766	302	302	604	117	283	399	81	543	624	0	1,019	1,019	0	108	108	0	649	649	1,282	4,888	6,170
	2029	359	1,434	1,793	85	85	169	48	193	241	37	412	449	0	1,047	1,047	0	74	74	0	444	444	528	3,688	4,216
	2030	359	1,434	1,793	85	85	169	48	198	247	42	464	505	0	1,075	1,075	0	76	76	0	455	455	533	3,786	4,319
2	2031	359	1,434	1,793	85	85	169	49	204	253	46	517	563	0	0	0	0	56	56	0	333	333	538	2,629	3,167
	2032	359	1,434	1,793	85	85	169	49	209	258	50	572	622	0	0	0	0	57	57	0	341	341	543	2,698	3,241
	2033	359	1,434	1,793	85	85	169	50	215	265	55	629	683	0	0	0	0	58	58	0	349	349	548	2,770	3,317
	2034	359	1,434	1,793	85	85	169	50	221	271	59	687	746	0	0	0	0	60	60	0	357	357	553	2,843	3,396
	2035	359	1,434	1,793	85	85	169	51	227	277	64	746	810	0	0	0	0	61	61	0	366	366	558	2,918	3,476
	2036	359	1,434	1,793	85	85	169	51	233	284	68	807	876	0	0	0	0	62	62	0	375	375	563	2,996	3,558
	2037	359	1,434	1,793	85	85	169	52	239	291	73	870	943	0	1,295	1,295	0	90	90	0	539	539	568	4,552	5,120
	2038	359	1,434	1,793	85	85	169	52	245	297	78	935	1,012	0	1,330	1,330	0	92	92	0	552	552	573	4,673	5,246
	2039	359	1,434	1,793	85	85	169	53	252	305	82	1,001	1,083	0	1,366	1,366	0	94	94	0	566	566	578	4,798	5,376
	2040	359	1,434	1,793	85	85	169	53	259	312	87	1,069	1,156	0	1,403	1,403	0	97	97	0	580	580	583	4,926	5,509
3	2041	359	1,434	1,793	85	85	169	53	266	319	92	1,139	1,231	0	0	0	0	70	70	0	421	421	588	3,415	4,003
	2042	359	1,434	1,793	85	85	169	54	273	327	97	1,211	1,307	0	0	0	0	72	72	0	432	432	594	3,506	4,100
	2043	359	1,434	1,793	85	85	169	54	280	335	101	1,284	1,386	0	0	0	0	74	74	0	442	442	599	3,599	4,198
	2044	359	1,434	1,793	85	85	169	55	288	343	106	1,360	1,466	0	0	0	0	75	75	0	453	453	604	3,695	4,299
	2045	359	1,434	1,793	85	85	169	55	296	351	111	1,438	1,549	0	0	0	0	77	77	0	463	463	610	3,793	4,403
	2046	359	1,434	1,793	85	85	169	56	304	360	116	1,517	1,634	0	0	0	0	79	79	0	475	475	615	3,894	4,509
	2047	359	1,434	1,793	85	85	169	56	312	368	121	1,599	1,721	0	0	0	0	81	81	0	486	486	621	3,997	4,618
	2048	359	1,434	1,793	85	85	169	57	320	377	126	1,684	1,810	0	0	0	0	83	83	0	498	498	626	4,104	4,730
	2049	359	1,434	1,793	85	85	169	57	329	386	131	1,770	1,902	0	0	0	0	85	85	0	510	510	632	4,213	4,845
	2050	359	1,434	1,793	85	85	169	58	338	396	137	1,859	1,996	0	0	0	0	87	87	0	522	522	638	4,325	4,963
Total Cost		21,960	64,873	86,833	4,342	4,342	8,683	2,906	9,877	12,783	2,760	29,559	32,318	0	16,028	16,028	0	3,133	3,133	0	18,797	18,797	**31,967**	**146,609**	**178,576**

Source: JICA Study Team

Table 4.10.12 Cost Disbursement Schedule (Option 3, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (route 2B Shield)			Lakeshore Diking System(inclusive backwater levee, Pumping station, Bridge)			Expansion of EFCOS			Total		
		F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total	F.C.	L.C.	Sub-Total
1	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0	0	0	0	0	0
	2023	459	1,168	1,627	0	0	0	17	7	25	476	1,176	1,652
	2024	1,837	4,673	6,510	0	0	0	17	7	25	1,854	4,680	6,534
	2025	1,837	4,831	6,667	0	0	0	17	7	25	1,854	4,838	6,692
	2026	4,453	7,681	12,134	359	1,434	1,793	17	7	25	4,829	9,123	13,952
	2027	4,453	7,536	11,989	359	1,434	1,793	17	7	25	4,829	8,978	13,807
	2028	855	1,373	2,229	359	1,434	1,793	0	0	0	1,214	2,808	4,022
	2029	44	62	106	359	1,434	1,793	0	0	0	403	1,497	1,899
	2030	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
2	2031	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2032	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2033	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2034	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2035	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2036	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2037	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2038	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2039	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2040	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
3	2041	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2042	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2043	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2044	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2045	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2046	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2047	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2048	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2049	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2050	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
Total Cost		13,938	27,325	41,263	8,964	35,858	44,822	86	37	123	22,988	63,219	86,208

Source: JICA Study Team

Table 4.10.13 Cost Disbursement Schedule (Option 3)

(Unit: Million of PHP)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
		F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total
1	2021	0	0	0	179	179	358	18	18	36	2	5	6	0	0	0	0	8	8	0	48	48	199	258	457
	2022	0	0	0	357	357	715	36	38	74	6	20	26	0	869	869	0	34	34	0	202	202	400	1,519	1,919
	2023	476	1,176	1,652	273	273	546	77	157	234	20	121	141	0	2,512	2,512	0	102	102	0	610	610	847	4,949	5,796
	2024	1,854	4,680	6,534	273	273	546	220	551	771	78	557	635	0	2,579	2,579	0	221	221	0	1,328	1,328	2,425	10,190	12,615
	2025	1,854	4,838	6,692	273	273	546	222	584	806	97	728	826	0	941	941	0	196	196	0	1,177	1,177	2,446	8,737	11,184
	2026	4,829	9,123	13,952	357	357	715	547	1,112	1,660	286	1,643	1,930	0	0	0	0	365	365	0	2,191	2,191	6,020	14,792	20,812
	2027	4,829	8,978	13,807	357	357	715	552	1,125	1,677	336	1,914	2,250	0	992	992	0	389	389	0	2,333	2,333	6,074	16,088	22,162
	2028	1,214	2,808	4,022	357	357	715	169	392	560	117	752	869	0	1,019	1,019	0	144	144	0	862	862	1,857	6,333	8,190
	2029	403	1,497	1,899	107	107	214	55	204	259	43	435	477	0	1,047	1,047	0	78	78	0	468	468	608	3,835	4,443
	2030	359	1,434	1,793	85	85	169	48	198	247	42	464	505	0	1,075	1,075	0	76	76	0	455	455	533	3,786	4,319
2	2031	359	1,434	1,793	85	85	169	49	204	253	46	517	563	0	0	0	0	56	56	0	333	333	538	2,629	3,167
	2032	359	1,434	1,793	85	85	169	49	209	258	50	572	622	0	0	0	0	57	57	0	341	341	543	2,698	3,241
	2033	359	1,434	1,793	85	85	169	50	215	265	55	629	683	0	0	0	0	58	58	0	349	349	548	2,770	3,317
	2034	359	1,434	1,793	85	85	169	50	221	271	59	687	746	0	0	0	0	60	60	0	357	357	553	2,843	3,396
	2035	359	1,434	1,793	85	85	169	51	227	277	64	746	810	0	0	0	0	61	61	0	366	366	558	2,918	3,476
	2036	359	1,434	1,793	85	85	169	51	233	284	68	807	876	0	0	0	0	62	62	0	375	375	563	2,996	3,558
	2037	359	1,434	1,793	85	85	169	52	239	291	73	870	943	0	1,295	1,295	0	90	90	0	539	539	568	4,552	5,120
	2038	359	1,434	1,793	85	85	169	52	245	297	78	935	1,012	0	1,330	1,330	0	92	92	0	552	552	573	4,673	5,246
	2039	359	1,434	1,793	85	85	169	53	252	305	82	1,001	1,083	0	1,366	1,366	0	94	94	0	566	566	578	4,798	5,376
	2040	359	1,434	1,793	85	85	169	53	259	312	87	1,069	1,156	0	1,403	1,403	0	97	97	0	580	580	583	4,926	5,509
3	2041	359	1,434	1,793	85	85	169	53	266	319	92	1,139	1,231	0	0	0	0	70	70	0	421	421	588	3,415	4,003
	2042	359	1,434	1,793	85	85	169	54	273	327	97	1,211	1,307	0	0	0	0	72	72	0	432	432	594	3,506	4,100
	2043	359	1,434	1,793	85	85	169	54	280	335	101	1,284	1,386	0	0	0	0	74	74	0	442	442	599	3,599	4,198
	2044	359	1,434	1,793	85	85	169	55	288	343	106	1,360	1,466	0	0	0	0	75	75	0	453	453	604	3,695	4,299
	2045	359	1,434	1,793	85	85	169	55	296	351	111	1,438	1,549	0	0	0	0	77	77	0	463	463	610	3,793	4,403
	2046	359	1,434	1,793	85	85	169	56	304	360	116	1,517	1,634	0	0	0	0	79	79	0	475	475	615	3,894	4,509
	2047	359	1,434	1,793	85	85	169	56	312	368	121	1,599	1,721	0	0	0	0	81	81	0	486	486	621	3,997	4,618
	2048	359	1,434	1,793	85	85	169	57	320	377	126	1,684	1,810	0	0	0	0	83	83	0	498	498	626	4,104	4,730
	2049	359	1,434	1,793	85	85	169	57	329	386	131	1,770	1,902	0	0	0	0	85	85	0	510	510	632	4,213	4,845
	2050	359	1,434	1,793	85	85	169	58	338	396	137	1,859	1,996	0	0	0	0	87	87	0	522	522	638	4,325	4,963
Total Cost		22,988	63,219	86,208	4,310	4,310	8,621	3,013	9,686	12,699	2,828	29,331	32,159	0	16,428	16,428	0	3,122	3,122	0	18,734	18,734	**33,140**	**144,831**	**177,971**

Source: JICA Study Team

Table 4.10.14 Cost Disbursement Schedule (Option 4, Breakdown of Construction Cost)

(Unit: Million of PHP)

Phase	Year	Paranaque Spillway (route 3 Shield)			Lakeshore Diking System (inclusive backwater levee, Pumping station, Bridge)			Expansion of EFCOS			Total		
		F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total
1	2021	0	0	0	0	0	0	0	0	0	0	0	0
	2022	0	0	0	0	0	0	0	0	0	0	0	0
	2023	338	264	601	0	0	0	17	7	25	355	271	626
	2024	1,351	2,066	3,416	0	0	0	17	7	25	1,368	2,073	3,441
	2025	1,351	3,481	4,832	0	0	0	17	7	25	1,368	3,489	4,857
	2026	2,261	3,177	5,438	359	1,434	1,793	17	7	25	2,637	4,619	7,256
	2027	2,565	3,076	5,641	359	1,434	1,793	17	7	25	2,941	4,517	7,458
	2028	4,994	7,117	12,111	359	1,434	1,793	0	0	0	5,352	8,551	13,904
	2029	4,094	6,991	11,085	359	1,434	1,793	0	0	0	4,452	8,426	12,878
	2030	1,822	3,721	5,542	359	1,434	1,793	0	0	0	2,180	5,155	7,335
2	2031	675	359	1,034	359	1,434	1,793	0	0	0	1,034	1,793	2,827
	2032	675	359	1,034	359	1,434	1,793	0	0	0	1,034	1,793	2,827
	2033	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2034	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2035	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2036	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2037	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2038	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2039	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2040	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
3	2041	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2042	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2043	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2044	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2045	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2046	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2047	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2048	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2049	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
	2050	0	0	0	359	1,434	1,793	0	0	0	359	1,434	1,793
Total Cost		20,125	30,611	50,736	8,964	35,858	44,822	86	37	123	29,175	66,506	95,681

Source: JICA Study Team

Table 4.10.15 Cost Disbursement Schedule (Option 4)

(Unit: Million of PHP)

Phase	Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
		F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total
1	2021	0	0	0	158	158	317	16	16	32	1	4	6	0	0	0	0	7	7	0	43	43	176	229	404
	2022	0	0	0	316	316	632	32	33	65	6	17	23	0	869	869	0	32	32	0	191	191	354	1,458	1,811
	2023	355	271	626	231	231	463	60	54	115	16	42	58	0	2,271	2,271	0	71	71	0	424	424	662	3,364	4,027
	2024	1,368	2,073	3,441	231	231	463	166	256	422	58	259	318	0	2,332	2,332	0	140	140	0	837	837	1,823	6,129	7,952
	2025	1,368	3,489	4,857	231	231	463	167	425	592	73	530	603	0	941	941	0	149	149	0	895	895	1,840	6,660	8,500
	2026	2,637	4,619	7,256	316	316	632	312	579	891	163	855	1,018	0	0	0	0	196	196	0	1,176	1,176	3,428	7,741	11,169
	2027	2,941	4,517	7,458	316	316	632	347	582	929	211	991	1,202	0	992	992	0	224	224	0	1,346	1,346	3,814	8,969	12,783
	2028	5,352	8,551	13,904	316	316	632	609	1,097	1,706	421	2,106	2,528	0	1,019	1,019	0	396	396	0	2,375	2,375	6,699	15,861	22,560
	2029	4,452	8,426	12,878	315	315	630	517	1,111	1,628	400	2,368	2,769	0	1,047	1,047	0	379	379	0	2,274	2,274	5,684	15,920	21,604
	2030	2,180	5,155	7,335	315	315	630	273	714	987	234	1,670	1,904	0	1,075	1,075	0	239	239	0	1,432	1,432	3,002	10,599	13,602
2	2031	1,034	1,793	2,827	315	315	630	149	283	432	140	718	858	0	0	0	0	95	95	0	570	570	1,638	3,774	5,412
	2032	1,034	1,793	2,827	200	200	400	137	274	412	140	751	891	0	0	0	0	91	91	0	544	544	1,511	3,653	5,164
	2033	359	1,434	1,793	85	85	169	50	215	265	55	629	683	0	0	0	0	58	58	0	349	349	548	2,770	3,317
	2034	359	1,434	1,793	85	85	169	50	221	271	59	687	746	0	0	0	0	60	60	0	357	357	553	2,843	3,396
	2035	359	1,434	1,793	85	85	169	51	227	277	64	746	810	0	0	0	0	61	61	0	366	366	558	2,918	3,476
	2036	359	1,434	1,793	85	85	169	51	233	284	68	807	876	0	0	0	0	62	62	0	375	375	563	2,996	3,558
	2037	359	1,434	1,793	85	85	169	52	239	291	73	870	943	0	1,295	1,295	0	90	90	0	539	539	568	4,552	5,120
	2038	359	1,434	1,793	85	85	169	52	245	297	78	935	1,012	0	1,330	1,330	0	92	92	0	552	552	573	4,673	5,246
	2039	359	1,434	1,793	85	85	169	53	252	305	82	1,001	1,083	0	1,366	1,366	0	94	94	0	566	566	578	4,798	5,376
	2040	359	1,434	1,793	85	85	169	53	259	312	87	1,069	1,156	0	1,403	1,403	0	97	97	0	580	580	583	4,926	5,509
3	2041	359	1,434	1,793	85	85	169	53	266	319	92	1,139	1,231	0	0	0	0	70	70	0	421	421	588	3,415	4,003
	2042	359	1,434	1,793	85	85	169	54	273	327	97	1,211	1,307	0	0	0	0	72	72	0	432	432	594	3,506	4,100
	2043	359	1,434	1,793	85	85	169	54	280	335	101	1,284	1,386	0	0	0	0	74	74	0	442	442	599	3,599	4,198
	2044	359	1,434	1,793	85	85	169	55	288	343	106	1,360	1,466	0	0	0	0	75	75	0	453	453	604	3,695	4,299
	2045	359	1,434	1,793	85	85	169	55	296	351	111	1,438	1,549	0	0	0	0	77	77	0	463	463	610	3,793	4,403
	2046	359	1,434	1,793	85	85	169	56	304	360	116	1,517	1,634	0	0	0	0	79	79	0	475	475	615	3,894	4,509
	2047	359	1,434	1,793	85	85	169	56	312	368	121	1,599	1,721	0	0	0	0	81	81	0	486	486	621	3,997	4,618
	2048	359	1,434	1,793	85	85	169	57	320	377	126	1,684	1,810	0	0	0	0	83	83	0	498	498	626	4,104	4,730
	2049	359	1,434	1,793	85	85	169	57	329	386	131	1,770	1,902	0	0	0	0	85	85	0	510	510	632	4,213	4,845
	2050	359	1,434	1,793	85	85	169	58	338	396	137	1,859	1,996	0	0	0	0	87	87	0	522	522	638	4,325	4,963
Total Cost		29,175	66,506	95,681	4,784	4,784	9,568	3,753	10,321	14,074	3,569	31,917	35,486	0	15,941	15,941	0	3,415	3,415	0	20,490	20,490	**41,281**	**153,373**	**194,654**

Source: JICA Study Team

(5) Preliminary Cost Estimate of Parañaque Spillway

1) Preliminary Cost Estimate

The preliminary cost estimate of the Parañaque spillway (Inner Diameter: 13m) component implemented independently is estimated as follows:

Table 4.10.16 Project Cost of Parañaque Spillway (Option 1: Route 1)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 1, Shield Tunneling Method)	18,230	27,973	46,203
Engineering Cost		2,310	2,310	4,620
Price Escalation		1,419	6,379	7,797
Contingency		2,196	3,666	5,862
Land Acquisition, Compensation		0	2,147	2,147
Administration Cost		0	1,333	1,333
VAT		0	7,996	7,996
Total (million PHP)		24,155	51,884	75,959

Source: JICA Study Team

Table 4.10.17 Project Cost of Parañaque Spillway (Option 2: Route 2A)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 2A, Shield Tunneling Method)	12,910	28,978	41,888
Engineering Cost		2,094	2,094	4,189
Price Escalation		787	5,042	5,830
Contingency		1,579	3,612	5,191
Land Acquisition, Compensation		0	2,882	2,882
Administration Cost		0	1,200	1,200
VAT		0	7,197	7,197
Total (million PHP)		17,370	51,006	68,376

Source: JICA Study Team

Table 4.10.18 Project Cost of Parañaque Spillway (Option 3: Route 2B)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 2B, Shield Tunneling Method)	13,938	27,325	41,263
Engineering Cost		2,063	2,063	4,126
Price Escalation		856	4,815	5,671
Contingency		1,686	3,420	5,106
Land Acquisition, Compensation		0	3,283	3,283
Administration Cost		0	1,189	1,189
VAT		0	7,134	7,134
Total (million PHP)		18,543	49,228	67,771

Source: JICA Study Team

Table 4.10.19 Project Cost of Parañaque Spillway (Option 4: Route 3)

Cost Items	Work Items	F/C (million PHP)	L/C (million PHP)	Total (million PHP)
Construction Cost	Parañaque Spillway (Route 3, Shield Tunneling Method)	20,125	30,611	50,736
Engineering Cost		2,537	2,537	5,074
Price Escalation		1,597	7,401	8,997
Contingency		2,426	4,055	6,481
Land Acquisition, Compensation		0	2,795	2,795
Administration Cost		0	1,482	1,482
VAT		0	8,890	8,890
Total (million PHP)		26,684	57,770	84,454

Source: JICA Study Team

2) Cost Disbursement

Similarly with the cost disbursement of the total project, it is assumed that implementation of the Parañaque Spillway is started in 2021.

Table 4.10.20 Cost Disbursement Schedule of Parañaque Spillway (Option 1, Breakdown of Construction Cost)

(Unit: Million of PHP)

Year	Tunnel (Route-1 Shield)			Vertical Shafts			Open Channel			River Improvement			Surplus Soil Disposal			Total		
	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	0	0	0	293	156	450	0	404	404	0	0	0	0	69	69	293	630	923
2024	0	0	0	1,174	624	1,798	0	1,618	1,618	0	0	0	0	276	276	1,174	2,518	3,692
2025	0	0	0	1,174	624	1,798	0	1,618	1,618	0	0	0	0	276	276	1,174	2,518	3,692
2026	1,204	1,647	2,850	1,174	624	1,798	0	1,618	1,618	0	0	0	0	276	276	2,378	4,165	6,543
2027	1,204	1,647	2,850	1,174	624	1,798	0	135	135	0	942	942	0	276	276	2,378	3,625	6,002
2028	3,611	4,940	8,551	1,174	624	1,798	0	0	0	0	942	942	0	276	276	4,785	6,783	11,568
2029	3,310	4,529	7,839	489	260	749	0	0	0	0	942	942	0	276	276	3,799	6,007	9,807
2030	0	0	0	1,174	624	1,798	0	0	0	0	0	0	0	276	276	1,174	901	2,075
2031	0	0	0	1,076	572	1,648	0	0	0	0	0	0	0	253	253	1,076	826	1,902
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9,329	12,762	22,091	8,901	4,734	13,636	0	5,392	5,392	0	2,827	2,827	0	2,257	2,257	18,230	27,973	46,203

Source: JICA Study Team

Table 4.10.21 Cost Disbursement Schedule of Parañaque Spillway (Option 1)

(Unit: Million of PHP)

Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total
2021	0	0	0	111	111	222	11	11	23	1	3	4	0	0	0	0	5	5	0	30	30	123	160	283
2022	0	0	0	222	222	444	23	23	46	4	12	16	0	0	0	0	10	10	0	61	61	248	328	576
2023	293	630	923	222	222	444	53	92	145	14	71	85	0	1,059	1,059	0	53	53	0	319	319	582	2,446	3,028
2024	1,174	2,518	3,692	222	222	444	145	305	449	51	308	359	0	1,088	1,088	0	121	121	0	724	724	1,591	5,286	6,877
2025	1,174	2,518	3,692	222	222	444	146	313	459	64	390	454	0	0	0	0	101	101	0	606	606	1,605	4,151	5,756
2026	2,378	4,165	6,543	222	222	444	274	515	789	144	760	904	0	0	0	0	174	174	0	1,042	1,042	3,017	6,877	9,894
2027	2,378	3,625	6,002	222	222	444	277	463	740	168	789	957	0	0	0	0	163	163	0	977	977	3,044	6,238	9,283
2028	4,785	6,783	11,568	222	222	444	538	867	1,405	372	1,664	2,036	0	0	0	0	309	309	0	1,854	1,854	5,917	11,699	17,616
2029	3,799	6,007	9,807	222	222	444	436	792	1,228	338	1,688	2,026	0	0	0	0	270	270	0	1,620	1,620	4,795	10,599	15,394
2030	1,174	901	2,075	222	222	444	153	147	299	131	343	473	0	0	0	0	66	66	0	395	395	1,679	2,072	3,751
2031	1,076	826	1,902	203	203	407	141	138	279	133	350	483	0	0	0	0	61	61	0	368	368	1,553	1,947	3,500
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18,230	27,973	46,203	2,310	2,310	4,620	2,196	3,666	5,862	1,419	6,379	7,797	0	2,147	2,147	0	1,333	1,333	0	7,996	7,996	**24,155**	**51,804**	**75,959**

Source: JICA Study Team

Table 4.10.22 Cost Disbursement Schedule of Parañaque Spillway (Option 2, Breakdown of Construction Cost)

(Unit: Million of PHP)

Year	Tunnel (Route-2A Shield)			Vertical Shafts			Open Channel			River Improvement			Surplus Soil Disposal			Total		
	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	305	472	778	141	90	231	0	435	435	0	0	0	0	93	93	447	1,091	1,537
2024	1,222	1,889	3,111	566	360	926	0	1,741	1,741	0	0	0	0	372	372	1,788	4,362	6,150
2025	1,222	1,889	3,111	566	360	926	0	1,741	1,741	0	1,890	1,890	0	372	372	1,788	6,252	8,040
2026	3,666	5,667	9,333	566	360	926	0	145	145	0	1,890	1,890	0	372	372	4,231	8,435	12,666
2027	3,666	5,667	9,333	566	360	926	0	0	0	0	1,890	1,890	0	372	372	4,231	8,290	12,521
2028	0	0	0	424	270	694	0	0	0	0	0	0	0	279	279	424	549	973
2029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10,081	15,585	25,665	2,829	1,800	4,629	0	4,062	4,062	0	5,671	5,671	0	1,861	1,861	12,910	28,978	41,888

Source: JICA Study Team

Table 4.10.23 Cost Disbursement Schedule of Parañaque Spillway (Option 2)

(Unit: Million of PHP)

Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total
2021	0	0	0	144	144	289	15	15	29	1	4	5	0	0	0	0	6	6	0	39	39	160	208	369
2022	0	0	0	289	289	578	29	30	60	5	16	21	0	0	0	0	13	13	0	79	79	324	427	751
2023	447	1,091	1,537	289	289	578	76	149	225	20	115	135	0	1,422	1,422	0	78	78	0	468	468	831	3,611	4,442
2024	1,788	4,362	6,150	289	289	578	215	517	733	76	523	599	0	1,460	1,460	0	190	190	0	1,142	1,142	2,368	8,484	10,852
2025	1,788	6,252	8,040	289	289	578	217	747	964	95	932	1,027	0	0	0	0	212	212	0	1,273	1,273	2,389	9,706	12,095
2026	4,231	8,435	12,666	289	289	578	477	1,024	1,501	250	1,512	1,762	0	0	0	0	330	330	0	1,981	1,981	5,247	13,570	18,817
2027	4,231	8,290	12,521	289	289	578	481	1,034	1,515	293	1,759	2,051	0	0	0	0	333	333	0	2,000	2,000	5,294	13,704	18,998
2028	424	549	973	217	217	433	69	95	164	48	182	230	0	0	0	0	36	36	0	216	216	757	1,295	2,052
2029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12,910	28,978	41,888	2,094	2,094	4,189	1,579	3,612	5,191	787	5,042	5,830	0	2,882	2,882	0	1,200	1,200	0	7,197	7,197	**17,370**	**51,006**	**68,376**

Source: JICA Study Team

Table 4.10.24 Cost Disbursement Schedule of Parañaque Spillway (Option 3, Breakdown of Construction Cost)

(Unit: Million of PHP)

Year	Tunnel (Route-2B Shield)			Vertical Shafts			Open Channel			River Improvement			Surplus Soil Disposal			Total		
	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total	F. C	L. C	Sub-Total
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	327	546	873	132	84	216	0	435	435	0	0	0	0	103	103	459	1,168	1,627
2024	1,308	2,184	3,492	528	337	866	0	1,741	1,741	0	0	0	0	411	411	1,837	4,673	6,510
2025	1,308	2,184	3,492	528	337	866	0	1,741	1,741	0	158	158	0	411	411	1,837	4,831	6,667
2026	3,925	6,551	10,476	528	337	866	0	145	145	0	236	236	0	411	411	4,453	7,681	12,134
2027	3,925	6,551	10,476	528	337	866	0	0	0	0	236	236	0	411	411	4,453	7,536	11,989
2028	327	546	873	528	337	866	0	0	0	0	79	79	0	411	411	855	1,373	2,229
2029	0	0	0	44	28	72	0	0	0	0	0	0	0	34	34	44	62	106
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11,120	18,562	29,682	2,818	1,800	4,618	0	4,062	4,062	0	709	709	0	2,192	2,192	13,938	27,325	41,263

Source: JICA Study Team

Table 4.10.25 Cost Disbursement Schedule of Parañaque Spillway (Option 3)

(Unit: Million of PHP)

Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total
2021	0	0	0	136	136	272	14	14	28	1	4	5	0	0	0	0	6	6	0	37	37	151	196	347
2022	0	0	0	272	272	544	28	29	56	5	15	20	0	0	0	0	12	12	0	74	74	305	402	707
2023	459	1,168	1,627	272	272	544	75	156	231	20	120	140	0	1,620	1,620	0	83	83	0	499	499	826	3,918	4,745
2024	1,837	4,673	6,510	272	272	544	219	550	769	77	556	633	0	1,663	1,663	0	202	202	0	1,214	1,214	2,404	9,131	11,535
2025	1,837	4,831	6,667	272	272	544	221	583	803	97	727	824	0	0	0	0	177	177	0	1,061	1,061	2,426	7,650	10,076
2026	4,453	7,681	12,134	272	272	544	499	933	1,432	261	1,379	1,640	0	0	0	0	315	315	0	1,890	1,890	5,485	12,470	17,955
2027	4,453	7,536	11,989	272	272	544	503	941	1,444	306	1,601	1,907	0	0	0	0	318	318	0	1,906	1,906	5,534	12,574	18,108
2028	855	1,373	2,229	272	272	544	121	204	325	84	391	475	0	0	0	0	71	71	0	429	429	1,332	2,740	4,072
2029	44	62	106	23	23	45	7	11	18	6	23	29	0	0	0	0	4	4	0	24	24	80	147	226
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13,938	27,325	41,263	2,063	2,063	4,126	1,686	3,420	5,106	856	4,815	5,671	0	3,283	3,283	0	1,189	1,189	0	7,134	7,134	**18,543**	**49,228**	**67,771**

Source: JICA Study Team

Table 4.10.26 Cost Disbursement Schedule of Parañaque Spillway (Option 4, Breakdown of Construction Cost)

(Unit: Million of PHP)

Year	Tunnel (Route-3 Shield)			Vertical Shafts			Open Channel			River Improvement			Surplus Soil Disposal			Total		
	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	0	0	0	338	180	517	0	0	0	0	0	0	0	84	84	338	264	601
2024	0	0	0	1,351	718	2,069	0	1,011	1,011	0	0	0	0	337	337	1,351	2,066	3,416
2025	0	0	0	1,351	718	2,069	0	2,427	2,427	0	0	0	0	337	337	1,351	3,481	4,832
2026	911	1,516	2,426	1,351	718	2,069	0	607	607	0	0	0	0	337	337	2,261	3,177	5,438
2027	1,214	2,021	3,235	1,351	718	2,069	0	0	0	0	0	0	0	337	337	2,565	3,076	5,641
2028	3,643	6,062	9,706	1,351	718	2,069	0	0	0	0	0	0	0	337	337	4,994	7,117	12,111
2029	3,643	6,062	9,706	450	239	690	0	0	0	0	353	353	0	337	337	4,094	6,991	11,085
2030	1,822	3,031	4,853	0	0	0	0	0	0	0	353	353	0	337	337	1,822	3,721	5,542
2031	0	0	0	675	359	1,034	0	0	0	0	0	0	0	0	0	675	359	1,034
2032	0	0	0	675	359	1,034	0	0	0	0	0	0	0	0	0	675	359	1,034
	11,234	18,692	29,926	8,891	4,729	13,620	0	4,044	4,044	0	706	706	0	2,440	2,440	20,125	30,611	50,736

Source: JICA Study Team

Table 4.10.27 Cost Disbursement Schedule of Parañaque Spillway (Option 4)

(Unit: Million of PHP)

Year	Construction Works			Engineering Services			Physical Contingency			Price Escalation			Land Acquisition			Administration Cost			VAT			Total		
	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total	F.C	L.C	Sub-Total
2021	0	0	0	115	115	231	12	12	23	1	3	4	0	0	0	0	5	5	0	31	31	128	166	294
2022	0	0	0	231	231	461	23	24	48	4	13	17	0	0	0	0	11	11	0	63	63	258	341	599
2023	338	264	601	231	231	461	58	54	112	15	41	57	0	1,379	1,379	0	52	52	0	313	313	642	2,333	2,976
2024	1,351	2,066	3,416	231	231	461	164	255	419	58	258	316	0	1,416	1,416	0	121	121	0	724	724	1,803	5,071	6,873
2025	1,351	3,481	4,832	231	231	461	165	424	589	72	529	601	0	0	0	0	130	130	0	778	778	1,819	5,573	7,392
2026	2,261	3,177	5,438	231	231	461	263	400	663	138	591	728	0	0	0	0	146	146	0	875	875	2,893	5,419	8,312
2027	2,565	3,076	5,641	231	231	461	298	398	696	181	678	859	0	0	0	0	153	153	0	919	919	3,274	5,454	8,729
2028	4,994	7,117	12,111	231	231	461	561	909	1,471	388	1,745	2,134	0	0	0	0	324	324	0	1,941	1,941	6,174	12,267	18,441
2029	4,094	6,991	11,085	231	231	461	469	918	1,387	363	1,957	2,320	0	0	0	0	305	305	0	1,830	1,830	5,156	12,232	17,388
2030	1,822	3,721	5,542	231	231	461	224	516	740	192	1,206	1,399	0	0	0	0	163	163	0	977	977	2,469	6,813	9,282
2031	675	359	1,034	231	231	461	100	79	179	94	201	295	0	0	0	0	39	39	0	236	236	1,100	1,145	2,245
2032	675	359	1,034	115	115	231	88	65	153	90	179	268	0	0	0	0	34	34	0	202	202	968	955	1,923
	20,125	30,611	50,736	2,537	2,537	5,074	2,426	4,055	6,481	1,597	7,401	8,997	0	2,795	2,795	0	1,482	1,482	0	8,890	8,890	**26,684**	**57,770**	**84,454**

Source: JICA Study Team

(6) Operation and Maintenance Cost

Operation and maintenance cost of the proposed Parañaque Spillway is composed of the operation cost of drainage pumps (fuel, manpower), maintenance cost of hydro-mechanical facilities (repair and replacement), and maintenance cost of underground tunnels (inspection and repairs). These are estimated to be approximately 0.5% of construction cost and approximately 1.0% of procurement cost of hydro-mechanical facilities. Costs for sediment removal from tunnels and cleaning of tunnels are added, referring to the actual costs for operation and maintenance in tunnel spillways in Japan.

Operation and maintenance cost for lakeshore diking system is estimated at approximately 0.5% of civil works such as construction of earth dikes and drainage and approximately 1.0% of procurement cost of electrical and mechanical equipment.

Table 4.10.28 Operation and Maintenance Cost for Comprehensive Flood Control 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, ✓Sediment removal and cleaning of spillway tunnel	Route1	223
	Route 2A	259
	Route 2B	299
	Route 3	302
Lakeshore Diking System	O&M of Civil Works	167
	O&M of Electrical and Mechanical Equipment	115
	Sub-Total	282
Expansion of EFCOS	O&M of Electrical and Mechanical Equipment	1

Source: JICA Study Team