Chapter 5. Effect of Flood Control on Parañaque Spillway

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

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

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

The flood control effect of Parañaque Spillway was examined according to (1) and (2) below.

(1) The flood control effect of Parañaque Spillway on lakeshore area (Section 5.1)

(2) The flood control effect of Parañaque Spillway when considering an integrated flood control plan for Laguna de Bay Basin and Pasig-Marikina River Basin (Section 5.2)

5.1 Flood Control Effect of Parañaque Spillway on Lakeshore Area

The flood control effect of Parañaque Spillway on the lakeshore area were examined. Economic analysis was conducted to verify the economic viability of project implementation.

5.1.1 Study Conditions

(1) Study on Additional Benefit Items Considering Laguna de Bay Flood Characteristic

Focusing on the impact of Laguna de Bay on industry and its flood characteristics (long-term inundation), this study examined and added benefit items considering the characteristics. Figure 5.1.1 shows the summary of benefits considering the flood characteristics (long-term inundation) of Laguna de Bay.

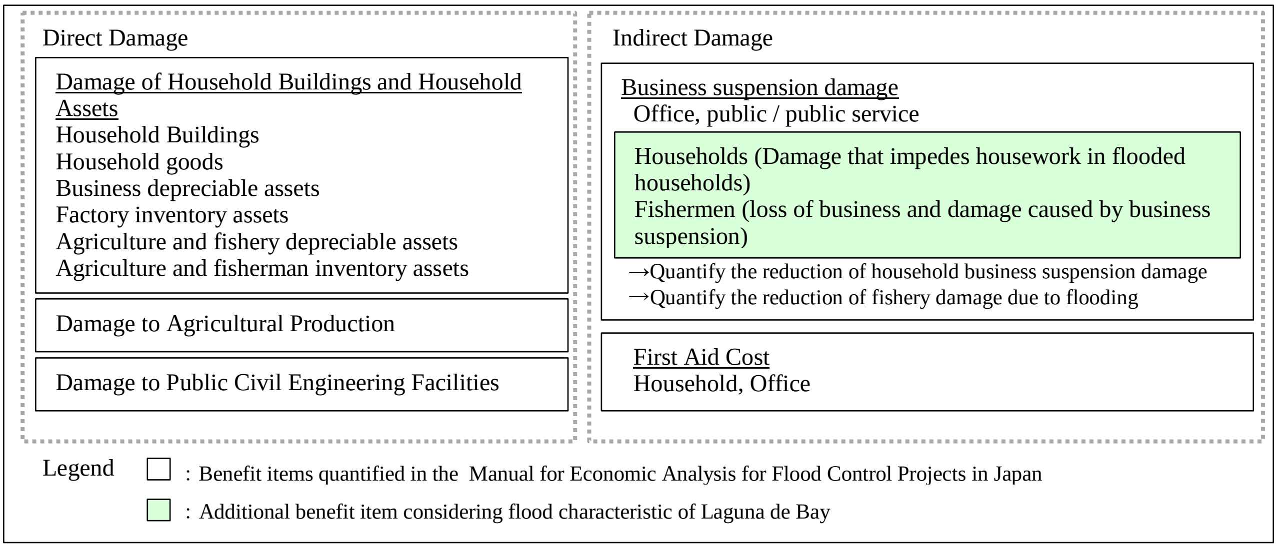


Figure 5.1.1 Extraction of Benefit Items Considering Characteristics of Laguna de Bay

＜Additional Benefit Items in this Study＞

- Household Business Suspension Damage [Refer to 5.1.1 (5) 7)]

  The prevention of obstruction to normal household activities such as domestic labor and leisure activities can be considered as a benefit.

  Source: Manual for Economic Analysis for Flood Control Projects in Japan, Ministry of Infrastructure, Land and Transportation, 2005s

- Reduction of fishery damage due to flooding [Refer to 5.1.1 (5) 6)]

  Benefits were calculated based on the amount of damage to the fishing industry and the number of inundation days in Laguna de Bay during the 2009 Typhoon Ondoy.

(2) General Assumptions of Economic Analysis

General assumptions for the economic analysis are as follows:

- Project Period: Construction period of spillway (7-11 years, depending on the route option) + 50 years of operation
- Target EIRR: 10% based on the NEDA ICC guideline
- Cost and benefit are calculated by price in 2019
- Population number is adjusted to the year 2020 when the study is conducted

(3) Outline of Quantified Costs and Benefit

Quantified Costs and Benefits are as summarized in Table 5.1.1.

Table 5.1.1 Economic Costs and Economic Benefits

Project Cost	Economic Benefits
(1) Initial Construction Cost (2) O&M Cost	(1) Reduced Economic Damage induced by Inundation (household assets, commercial/industrial assets, infrastructure, agricultural crops, suspension of economic activities)

The annual average value of “reduced economic damage induced by inundation” is calculated by multiplying the “avoided damage of assets/human life under different return period cases (2, 3, 5, 10, 20, 30, 50, 100 years)” and “occurrence rate of each case per year”. Reduced damage of more than

200 years of return period is not considered since the value reduces as the probability and damage value become smaller. The O&M costs and economic benefits are assumed to start in the year following the completion of construction works.

In case the dike is constructed, flood damage under the 100-year return period situation is assumed to be fully avoided. Benefit of dike starts after the 4th year of construction, and gradually increases until the inauguration year since the benefit could be realized even before the completion of each phase.

(4) Economic Cost

The following Standard Conversion Factor and Shadow Wage Rate are used to estimate the economic cost of the Project:

- Standard Conversion Factor (SCF): 0.833 = 1 / Shadow Exchange Rate (1.2)
- Shadow Wage Rate (SWR) for Non-Skilled Labor: 0.6

Based on the above assumptions, economic costs of initial construction cost and O&M cost are estimated in the following items.

a) Initial Construction Cost

To estimate the economic cost, price escalation and Tax are excluded from the project cost items shown in Subsection 4.7.2. Labor cost iss assumed at 10% of the local currency portion of the Project Cost for spillway. The cost for skilled labor takes 70% of the total labor cost, and the unskilled labor cost takes the rest (30% of the labor cost) and 50% each for lakeshore diking system. The disbursement schedule of financial cost and economic cost are as shown in Table 5.1.2.

Table 5.1.2 Financial Costs and Economic Costs under Each Option (PHP Million)

yYear	Parañaque Spillway (Route Option)				Parañaque Spillway (Diameter Option)		Lakeshore Diking System
	Route 1	Route 2-A	Route 2-B	Route 3	Route 1	Route 1	
	D 13.0m	D 13.0m	D 13.0m	D 13.0m	D14.0m	D15.0m	
2021	229	298	281	220	256	286	88
2022	458	597	562	447	514	574	911
2023	2,291	3,349	3,571	2,232	2,633	3,003	783
2024	5,105	8,006	8,496	5,068	5,716	6,382	803
2025	4,185	8,579	7,242	5,316	4,593	5,041	824
2026	7,127	13,442	12,934	6,102	7,973	8,890	1,968
2027	6,624	13,336	12,826	6,444	7,421	8,285	2,813
2028	12,400	1,461	2,858	13,504	14,065	15,858	2,815
2029	10,567	0	158	12,635	12,028	13,600	2,842
2030	2,667	0	0	6,703	2,926	3,210	2,872
2031	2,450	0	0	1,695	2,688	2,949	1,968
2032	0	0	0	1,456	0	0	1,974
2033-2050	0	0	0	0	0	0	1,980-3,216
Total	54,102	49,069	48,927	60,366	60,812	68,078	61,998

b) Operation and Maintenance Cost (O&M Cost)

Annual O&M cost is estimated as in Table 5.1.3. The economic cost is obtained by multiplying the average SCF at 0.833 with the financial cost.

Table 5.1.3 Annual O&M Costs of Each Option (Economic Cost): Tunnel Inner Diameter=13m

Item	Financial Cost (PHP million)				Economic Cost (PHP million)			
	Route 1	Route 2-A	Route 2-B	Route 3	Route 1	Route 2-A	Route 2-B	Route 3
Parañaque Spillway	223	259	299	302	186	216	249	251
Lakeshore Diking System (When completed)	283.2				235.9			
EFCOS	1.2				1.0			
Total	507.4	543.4	583.2	586.4	422.9	452.9	485.9	487.9

(5) Quantified Economic Benefits

The economic benefits induced by the Project's implementation are quantified as described below. The benefits of spillway are calculated under several diameter options from 13.0m to 15.0m. Benefits of dike are calculated separately for Phases 1 to 3.

a) Reduced Economic Damage induced by Inundation

In relation to the calculation of flood damage, there are no guidelines or past detailed damage data in the Philippines. Therefore, the calculation of flood damage is based on the methodology used in the "Manual for Economic Analysis for Flood Control Project in Japan", issued by the Ministry of Infrastructure, Land and Transportation, Japan, in 2005.

GIS is used for analyzing the flood area to count the number of inundated households and enterprises. The base map data for GIS analysis was originally taken from the Landsat 8 Satellite Image data, and the built-up and agricultural areas are recognized automatically by image analysis of 100 meters mesh. The land level data was taken from the IFSAR data provided by NAMRIA. Annual average reduced damage value was calculated utilizing such geographical data, as well as the census data for population and enterprises, estimated inundation depth in each return period, average asset value of households and enterprises, economic value of agricultural field, etc. The data source and detailed methodology are as explained below.

The 31 LGUs, which are located around Laguna Lake and have legislative territory below 14.7 m of land level (maximum water level under 200 years return period), are selected to calculate the economic damage caused by inundation (refer to Appendix 2-1).

b) Damage of Household Buildings and Household Assets

"Damage of Household Building" = "Number of Affected Households (affected population / average household size)" x "Value of Household Assets" x "Damage Rate" x 1.2 (including indirect damage)

"Damage of Household Assets" = "Number of Affected Households (affected population / average household size)" x (30% of "Value of Household Assets") x "Damage Rate" x 1.2 (including indirect damage)

Economic damages of household buildings and assets are estimated by multiplying the number of affected households, analyzed by GIS analysis, asset value per household building/assets and assumed damage rate. In addition, in consideration of the cleaning and rehabilitation works after the inundation, 20% of damaged asset value, which is the commonly adopted percentage for economic analysis, is added as the indirect damage. The amount of damage to houses by height of each LGU is shown in Appendix 2-2.

[Number of Affected Households]

For estimating the number of affected households, population living at the land level of 12.5 m to 15.5 m above sea level is calculated by GIS analysis for every 10cm in height. The population data is quoted from the 2015 census at barangay level, and the one in 2020 is assumed by using the projected population growth rate per province provided by the Philippine Statistics Authority (PSA). For the calculation, the population is assumed to live in the built-up area in each barangay at the same density. The built-up area is recognized by image analysis of Landsa t 8 Satellite Image data. The calculated population in every 10 cm land height is divided by the average number of household members of each region (NCR: 4.4; Region IV-A: 4.1) to estimate the affected household number per LGU.

[Value of Household Buildings and Household Assets]

Value of household assets is estimated by analyzing the survey results of Consumer Finance Survey issued by Bangko Sentral ng Pilipinas in 2014. Building values in target 31 LGUs around Laguna Lake are selected from interview samples and average value is calculated. The annual CPI is applied on the estimated value to convert them into the price in 2019. The value of household assets are assumed to be 30% of household buildings considering the assumption used in two studies of "Preparatory Survey for Cavite Industrial Area Flood Risk Management Project (2017)" and "Pasig-Marikina River Channel Improvement Project, Phase IV (2017)"

Table 5.1.4 Estimated Value of Household Building and Household Assets (PHP)

Area	Number of Samples	Average Value of Household Building (PHP)		Value of Household Assets (PHP)
		Price in 2013	Price in 2019	Price in 2019
NCR	245	776,862	903,411	271,023
Laguna	267	529,166	615,366	184,610
Rizal	227	459,195	533,997	160,199

Source: Consumer Finance Survey, 2014, Bangko Sentral ng Pilipinas

[Damage Rate of Household Buildings]

Damage rate is referred from the Japanese manual since the one in the Philippines is not available. In the manual, different damage rates are set depending on the inclination angle. The lowest rates, which are given on lower than 1/1000 of inclination angle, are used for the calculation based on the principle of conservatism for economic analysis.

Table 5.1.5 Damage Rate of Household Buildings and Household Assets

Inundation Depth	0.15 m-0.5 m	0.5 m - 1.0 m	1.0 m - 2.0 m	2.0 m - 3.0 m	> 3.0 m
Household Building	0.092	0.119	0.266	0.580	0.834
Household Assets	0.145	0.326	0.508	0.928	0.991

Source: Manual for Economic Analysis for Flood Control Projects in Japan, Ministry of Infrastructure, Land and Transportation, 2005s

c) Damage of Industrial and Commercial Assets

"Number of Affected Enterprises" x "Value of Industrial/Commercial Assets" x "Damage Rate" x 1.2 (including indirect damage)

Economic damage of industrial and commercial assets is obtained by multiplying the number of affected enterprises, asset value per enterprise, and damage rate. Moreover, considering the damage of cleaning and rehabilitation activities, the indirect cost, 20% of asset damage is added. The amount of damage to industrial and commercial by height of each LGU is shown in Appendix 2-3.

[Number of Affected Enterprises]

For estimating the number of affected enterprises, area of built-up area is analyzed for every 10 cm from 12.5 m to 14.7 m above sea level. The built-up area is made by image analysis of Landsat 8 Satellite Image data. Number of enterprises per industrial category was quoted from the Annual Survey of the Philippines Business and Industry, 2015 (PSA), and these enterprises are assumed to locate over the built-up area in each LGU at the same density. The number of enterprises is shown in Appendix 2-4.

[Value of Commercial Assets]

Three kinds of asset values of enterprises, value of building, depreciable asset and stocks, were quoted from the Annual Survey of Philippine Business and Industry, 2014 (PSA). The price is converted to the value in 2019 reflecting the past CPI.

Table 5.1.6 Average Asset Value of Enterprise per Industrial Category

(Unit: PHP)

Category	Price in 2014				Price in 2019
	Building	Depreciable	Stock	Total	Total
Manufacturing	13,639,250	25,984,837	39,126,669	78,750,756	107,405,794
Constructions	6,475,804	26,772,455	16,445,488	49,693,747	67,775,811
Wholesale and Retail Trade	95,867	99,239	6,134,050	6,329,156	8,632,146
Transportation and Storage	8,475,507	5,278,713	2,781,415	16,535,635	22,552,457
Accommodation and Food Service Activities	245,604	199,888	592,347	1,037,839	1,415,477
Financial and Communication	1,478,329	1,975,329	6,615,410	10,069,068	13,732,900
Real Estate Activities	6,403,978	869,013	86,511,338	93,784,329	127,909,633
Education	557,312	268,954	85,348	911,614	1,243,323
Human Health and Social Work Activity	881,656	843,548	1,222,959	2,948,163	4,020,911
Other Service Activities	18,713	20,079	194,245	233,037	317,832

Source: Annual Survey of Philippine Business and Industry, 2014 (PSA)

[Damage Rate]

Damage rate was quoted from the Japanese manual since data in the Philippines is not available. The lowest damage rate is chosen for estimating the damage amount of building asset, which varies depending on the inclination angle of the location.

Table 5.1.7 Damage Rate of Enterprises

Inundation Depth	0.15 - 0.5m	0.5 - 1.0m	1.0 - 2.0m	2.0 - 3.0m	> 3.0m
Damage Rate of Building	0.092	0.119	0.266	0.580	0.834
Damage Rate of Depreciable Asset	0.232	0.453	0.789	0.966	0.995
Damage Rate of Stocks	0.128	0.267	0.586	0.897	0.982

Source: Manual for Economic Analysis for Flood Control Projects in Japan, Ministry of Infrastructure, Land and Transportation, 2005s

d) Damage of Infrastructure Facilities

"Damage of Infrastructure Facilities" = 65% x "Damage of Household Building, Household Assets and Commercial Assets"

The past damage data of infrastructure facilities caused by inundations in the Philippines is not enough to estimate the economic damage. In the Japanese manual, the economic damage ratio compared to the direct damage of general assets is estimated based on the historical damage values caused by inundation in Japan. The economic values of damaged infrastructures of roads, bridges, sewerage and urban facilities corresponds to 65.4% (61.1%, 3.7%, 0.4% and 0.2%, respectively) of direct damage of general assets. Assuming the situation is similar in the Philippines, the economic damage of infrastructure facilities is estimated at 65% of direct damage of household building, household assets and commercial assets.

e) Damage to Agricultural Crops

Damage to agricultural crops (Paddy, Maize, commercial crops) is estimated as follows:

"Damage of Agricultural Crops" = "Affected Agricultural Area" x "Economic Value of Agricultural Crops per m^2" x "Damage Rate"

[Affected Agricultural Area]

Affected agricultural area in each LGU is estimated by GIS analysis from 12.5 m to 15.5 m above sea level by every 10 cm of height. The agricultural land is recognized automatically by image analysis of the Landsat 8 Satellite Image. There is a difference between the agricultural land in the GIS and statistical data, so that the total area recognized by GIS analysis is adjusted to match the total area of the statistical data in the calculation.

Produced crops are assumed to be paddy, maize and 11 kinds of other major commercial crops (coconut, coffee, banana, calamansi (lemon), mango, pineapple, sweet potatoes, cassava, eggplant, peanut, tomato). Cultivated area and total yield of each crop are referred from the agricultural census data called "Major Crops Statistics of the Philippines, 2010-2014", as of year 2014, as shown in Appendix 2 5. In the statistical data, there is no agricultural area in NCR; therefore, benefit is not added in the NCR region.

[Economic Value of Agricultural Crops per "m^2"]

Using the mentioned statistical data, the total produced value is calculated by multiplying the total yield and economic value of crops. The average economic value of agricultural land is estimated by dividing the said total value by total agricultural area.

The current farm-gate price in February 2020 was published by PSA as 15.89PHP/kg (paddy) and 12.42PHP/kg (Yellow Corn). For economic analysis, the future crop price is quoted from the most reliable projection data called "Commodity Market Outlook" issued by the World Bank as of February 2020. In the document, price of paddy and maize is forecast as of the year 2030. The economic values of paddy and maize are calculated by assuming that the crops are imported to the Philippines, considering the transportation cost and margins of wholesale companies, etc. As a result, economic costs of paddy and maize become 10.46 PHP/kg and 9.32 PHPkg, respectively. The calculation process of these prices is shown in Appendix 2 6.

Since there is no reliable projected future prices of 11 commercial crops, the current farm-gate price of each crop in 2017 is quoted from the Homepage of PSA.

In conclusion, the economic value of agricultural land including paddy, maize and 11 other commercial crops became 2.59 PHP/m^2 and 3.49 PHP/m^2 in Laguna Province and Rizal Province, respectively.

[Damage Rate]

In the Japanese manual, the damage rate of agricultural crops is determined by inundation depth (less than 0.5 m, 0.5 to 0.99 m, more than 1.0 m) and inundation period (1 to 2 days, 3 to 4 days, 4 to 6 days, more than 7 days). The rate of more than 7 days inundated is set at 0.74 to 1.00. It is difficult to closely estimate the inundated depth and period by GIS analysis. Also, the inundated period in the study area generally lasts for 1 week to several months as described. Therefore, the damage rate of 1.0 is used for the calculation.

f) Avoided Damage of Fishery and Aquaculture

According to "Laguna de Bay Basin Master Plan: 2016 and Beyond (LDDA, December 2015)", the annual economic damages caused by the typhoon and following flood in 2009 to 2011 were assumed at around USD 1 billion. Main reasons of economic damage are suspension of economic activities of fisheries and aquaculture, loss of fish caused by typhoon, demand reduction of fish in surrounding inundated area, etc.

The inundated period over 12.5m under 100 years of return period is 110 days. For economic analysis, it is assumed that the economic damage is in proportion to the inundated period. The daily economic loss of fishery and aquaculture in the whole lake is calculated at USD 10,540,000 after the price was updated in price level of 2019, and conversion factor is multiplied. The benefit is added based on the reduced inundation period of each return period.

"Economic Damage of Fishery and Aquaculture" = "Daily Economic Loss" x "Reduced Inundation Period"

g) Avoided Economic Loss of Suspended Business Activities

The economic loss of business entities and households by inundation between "With Project" and "Without Project" cases are calculated under each return period by the formula below, and the difference is considered as the economic benefit.

"Economic Loss of Suspended Business Activities" = "Number of Affected Enterprises" x "Period of Suspension" x "Average Daily Added Value per Enterprise"

"Economic Loss of Suspended Household Activities" = "Number of Affected Households" x "Period of Suspension" x "Average Daily Added Value per Household"

[Number of Affected Enterprises]

The number of affected enterprises is calculated for the estimation of damage to commercial assets by inundation, and the same number is used. Estimation of suspended period of economic activities under several return periods are made for every 50 cm, and the number of enterprises are counted for the water levels of 12.5 m, 13.0 m, 13.5 m, 14.0 m and 14.5 m.

[Average Daily Added Value per Enterprise]

The average daily added value per enterprise in several sectors is quoted from the national average figures of "2014, Annual Survey of Philippine Business and Industry", issued by the PSA, and converted to the price in 2019 by multiplying with the GDP growth rate.

Table 5.1.8 Average Daily Added Value per Industrial Category

(Unit: peso/days)

Category	Price in 2014	Price in 2019
Manufacturing	126,408	172,404
Constructions	200,416	273,341
Wholesale and Retail Trade	9,813	13,384
Transportation and Storage	166,252	226,746
Accommodation and Food Service Activities	13,203	18,007
Financial and Communication	199,751	272,434
Real Estate Activities	97,425	132,875
Education	22,951	31,302
Human Health and Social Work Activity	26,772	36,514
Other Servicer Activities	4,345	5,926

Source: Annual Survey of Philippine Business and Industry (PSA, 2014)

[Number of Affected Households]

The number of affected households are referred from the figure used for the calculation of asset loss.

[Average Daily Added Value per Household]

Value of works in household is assumed to be the same as the minimum wage in surrounding area. According to the published data from the National Wages and Productivity Commission, PHP 356/day is the minimum wage of non-plantation agriculture in Region IV-A.

[Period of Suspension]

In both “With Project” and “Without Project”, the water level fluctuation of Laguna de Bay is predicted for each probability year case, and the inundation period of the affected area at the water levels of 12.5m, 13.0m, 13.5m, 14.0m, 14.5m and 15.0m (Business suspension period) and the period shortened by project implementation were calculated.

The “With Project” case is shown below as an example of the numerical value at the time of construction of a 13m diameter spillway (with climate change).

Table 5.1.9 Suspended Period of Business Activities under Without Project Situation

(Unit: days)

Inundation Depth (m)	Return Period						
	5	10	20	30	50	100	200
>15.0	0	0	0	0	0	0	0
>14.5	0	0	0	0	0	0	17
>14.0	0	0	0	0	0	24	67
>13.5	0	0	13	20	64	72	91
>13.0	0	22	69	72	90	100	116
>12.5	64	78	99	106	117	127	143

Source: JICA Survey Team

Table 5.1.10 Suspended Period of Business Activities under "With Project" Situation
(With Parañaque Spillway, include climate change, tunnel inner diameter: 13m)

(Unit: days)

Inundation Depth (m)	Return Period						
	5	10	20	30	50	100	200
>15.0	0	0	0	0	0	0	0
>14.5	0	0	0	0	0	0	0
>14.0	0	0	0	0	0	0	10
>13.5	0	0	0	0	5	18	28
>13.0	0	0	15	19	26	46	66
>12.5	18	23	43	50	66	76	88

Source: JICA Survey Team

Table 5.1.11 Reduced Suspended Period of Business Activities by the Project
(With Parañaque Spillway, include climate change, tunnel inner diameter:13m)

(Unit: days)

Inundation Depth (m)	Return Period						
	5	10	20	30	50	100	200
>15.0	0	0	0	0	0	0	0
>14.5	0	0	0	0	0	0	17
>14.0	0	0	0	0	0	24	57
>13.5	0	0	13	20	59	54	63
>13.0	0	22	54	53	64	54	50
>12.5	46	55	56	56	51	51	55

Source: JICA Survey Team

h) Calculation of Annual Average Reduced Damage

As previously explained in this section, the damage due to the inundation of household assets, commercial assets, agricultural crops and the suspension of business are estimated separately for each LGU under different water levels of 12.5 m to 15.5 m above sea level. "Runoff and Inundation Analysis and Laguna de Bay Water Level Fluctuation Analysis", the water level of Laguna de Bay under "With Project" and "Without Project" situations of 2, 3, 5, 10, 20, 30, 50, 100 and 200-year return periods are calculated. The summed damage value corresponding to the water level is shown in the same table. The calculated Annual Average Reduced Damage in Taytay (urban area), Lumban (rural area) and the Total Value in 31 LGUs are as shown in the tables below.

The difference between the damage value under "With Project" and "Without Project" situations is multiplied with the probability, and the Annual Average Benefit Amount in 31 LGUs becomes 4,338 Million PHP

Table 5.1.12 Calculation of Annual Average Reduced Damage (Taytay)

(Unit: Thousand Peso)

Return Period	Water Level (m)			Damage Value			Beenfit of Reduced Business Suspention (b)	Total Economic Loss (c)=(a)+(b)	Probability (d)	Probability between two cases (e)	Average Damage of two cases(f)	Annual Economic Loss (e) x (f)
	Without	With	Difference	Without	With	Difference (a)						
200	14.6	14.1	0.5	19,123,347	10,044,369	9,078,978	1,813,327	10,892,305	0.005	0.00500	9,131,399	45,657
100	14.2	13.8	0.5	12,547,478	6,429,242	6,118,237	1,252,255	7,370,492	0.010	0.01000	6,237,749	62,377
50	14.0	13.6	0.4	8,556,840	4,586,857	3,969,984	1,135,023	5,105,006	0.020	0.01333	4,220,551	56,274
30	13.7	13.3	0.3	5,558,502	2,908,573	2,649,929	686,167	3,336,096	0.033	0.01667	3,102,503	51,708
20	13.6	13.2	0.3	4,586,857	2,333,949	2,252,907	616,003	2,868,910	0.050	0.05000	2,113,096	105,655
10	13.2	12.9	0.2	1,861,360	826,695	1,034,665	322,616	1,357,281	0.100	0.10000	842,219	84,222
5	12.9	12.8	0.1	598,507	454,713	143,794	183,363	327,157	0.200	0.13333	225,466	30,062
3	12.6	12.6	0.1	268,923	145,148	123,775	0	123,775	0.333	0.16667	61,887	10,315
2	12.3	12.3	0.0	0	0	0	0	0	0.500	0.50000	0	0
												446,270

Source: JICA Survey Team

Table 5.1.13 Calculation of Annual Average Reduced Damage（Lumban, D=13m）

(Unit: Thousand Peso)

Return Period	Water Level			Damage Value			Beenfit of Reduced Business Suspention (b)	Total Economic Loss (c)=(a)+(b)	Probability (d)	Probability between two cases (e)	Average Damage of two cases(f)	Annual Economic Loss (e) x (f)
	Without	With	Difference	Without	With	Difference (a)						
200	14.6	14.1	0.5	3,861,584	1,759,752	2,101,833	284,096	2,385,929	0.005	0.00500	2,002,649	10,013
100	14.2	13.8	0.5	2,434,830	965,005	1,469,825	149,544	1,619,368	0.010	0.01000	1,283,164	12,832
50	14.0	13.6	0.4	1,474,158	623,017	851,141	95,818	946,959	0.020	0.01333	698,064	9,308
30	13.7	13.3	0.3	783,671	387,875	395,796	53,373	449,169	0.033	0.01667	428,733	7,146
20	13.6	13.2	0.3	623,017	261,116	361,901	46,395	408,297	0.050	0.05000	269,278	13,464
10	13.2	12.9	0.2	205,016	97,609	107,407	22,853	130,260	0.100	0.10000	87,913	8,791
5	12.9	12.8	0.1	70,827	38,783	32,044	13,522	45,566	0.200	0.13333	30,026	4,003
3	12.6	12.6	0.1	24,733	10,248	14,486	0	14,486	0.333	0.16667	7,243	1,207
2	12.3	12.3	0.0	0	0	0	0	0	0.500	0.50000	0	0
												66,764

Source: JICA Survey Team

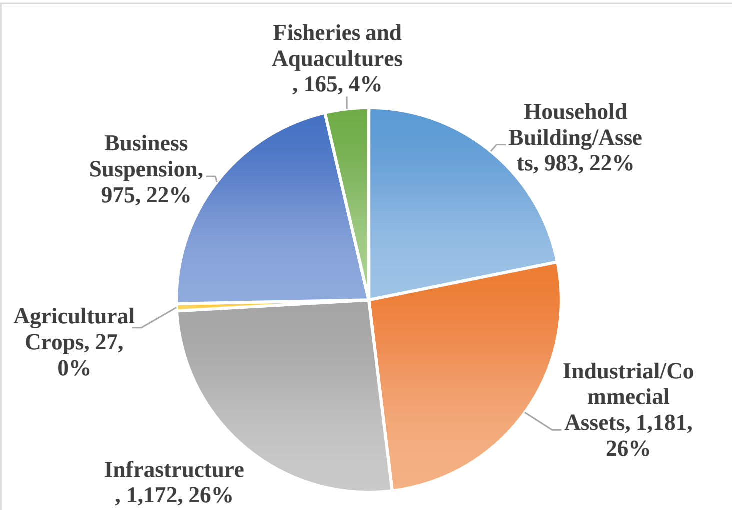
Table 5.1.14 Calculation of Annual Average Reduced Damage（31 LGUs, D=13.0m）

(Unit: Thousand Peso)

Return Period	Water Level (m)			Damage Value			Beenfit of Reduced Business Suspention (b)	Total Economic Loss (c)=(a)+(b)	Probability (d)	Probability between two cases (e)	Average Damage of two cases(f)	Annual Economic Loss (e) x (f)
	Without	With	Difference	Without	With	Difference (a)						
200	14.6	14.1	0.5	183,896,098	99,682,796	84,213,302	17,322,257	101,535,559	0.005	0.00500	86,434,113	432,171
100	14.2	13.8	0.5	123,788,855	64,435,161	59,353,694	11,978,973	71,332,667	0.010	0.01000	62,334,306	623,343
50	14.0	13.6	0.4	87,473,710	44,691,152	42,782,558	10,553,386	53,335,944	0.020	0.01333	42,392,135	565,228
30	13.7	13.3	0.3	54,236,185	29,486,625	24,749,559	6,698,765	31,448,325	0.033	0.01667	29,172,881	486,215
20	13.6	13.2	0.3	44,691,152	23,944,673	20,746,479	6,150,958	26,897,437	0.050	0.05000	19,628,793	981,440
10	13.2	12.9	0.2	19,032,137	9,792,041	9,240,096	3,120,053	12,360,149	0.100	0.10000	8,087,871	808,787
5	12.9	12.8	0.1	6,910,706	4,628,444	2,282,262	1,533,331	3,815,593	0.200	0.13333	2,528,298	337,106
3	12.6	12.6	0.1	2,391,653	1,150,652	1,241,002	0	1,241,002	0.333	0.16667	620,501	103,417
2	12.3	12.3	0.0	0	0	0	0	0	0.500	0.50000	0	0
												4,337,707

Source: JICA Survey Team

Figure 5.1.2 shows the breakdown of each damage in the annual average damage amount (when the diameter is 13.0 m). Household property damage was 22%, business property damage was 26%, infrastructure facilities damage was 26%, crop damage was 0%, business closure was 22%, and fishing and aquaculture loss reduction was 4%.



Source: JICA Survey Team

Figure 5.1.2 Composition of Average Annual Damage Reduction

Table 5.1.15 Composition of Average Annual Damage Reduction of 31 LGUs

(Unit: Thousand Peso)

No.	Province	LGU	Household Building/Assets	Industrial/Commecial Assets	Infrastructure	Agricultural Crops	Business Suspension	Fisheries and Aquacultures	Total
1	Metro Manila	Taguig City	118,944	2,098	65,565	0	1,620	-	188,227
2	Metro Manila	Muntinlupa City	94,408	98,541	104,514	0	77,706	-	375,169
3	Laguna	San Pedro	51,369	62,706	61,791	3	35,856	-	211,725
4	Laguna	Binan	130,513	99,696	124,697	104	73,152	-	428,161
5	Laguna	Santa Rosa	48,673	38,096	47,000	197	27,943	-	161,909
6	Laguna	Cabuyao	77,760	133,500	114,433	625	83,425	-	409,743
7	Laguna	City of Calamba	42,143	48,551	49,126	1,952	27,675	-	169,447
8	Laguna	Los Banos	16,693	22,262	21,101	231	36,821	-	97,109
9	Laguna	Bay	22,893	43,387	35,902	1,482	67,079	-	170,743
10	Laguna	Calauan	313	494	437	1,041	297	-	2,582
11	Laguna	Victoria	24,534	25,653	27,185	2,718	25,549	-	105,639
12	Laguna	Pila	17,755	38,851	30,662	2,578	14,831	-	104,676
13	Laguna	Santa Cruz	59,061	63,626	66,456	3,206	67,353	-	259,702
14	Laguna	Pagsanjan	2,296	5,288	4,108	583	3,625	-	15,900
15	Laguna	Lumban	16,192	19,587	19,380	3,017	8,588	-	66,764
16	Laguna	Kalayaan	466	750	659	444	219	-	2,538
17	Laguna	Paete	16,463	65,075	44,166	286	45,991	-	171,981
18	Laguna	Pakil	2,628	6,775	5,093	312	9,352	-	24,160
19	Laguna	Pangil	5,871	5,150	5,970	1,090	3,946	-	22,027
20	Laguna	Siniloan	11,525	39,207	27,480	2,314	18,882	-	99,408
21	Laguna	Famy	1,309	614	1,042	659	560	-	4,183
22	Laguna	Mabitac	6,108	3,439	5,171	2,676	2,170	-	19,562
23	Rizal	Jalajala	9,734	9,413	10,371	76	13,765	-	43,358
24	Rizal	Pililia	7,565	22,022	16,026	312	18,635	-	64,561
25	Rizal	Tanay	34,155	31,706	35,675	166	30,594	-	132,296
26	Rizal	Baras	6,375	4,312	5,789	181	2,312	-	18,970
27	Rizal	Morong	8,789	25,728	18,696	395	21,567	-	75,175
28	Rizal	Cardona	5,587	11,943	9,495	163	20,749	-	47,938
29	Rizal	Binangonan	43,578	45,237	48,108	84	94,373	-	231,379
30	Rizal	Angono	31,532	52,755	45,655	0	36,462	-	166,403
31	Rizal	Taytay	67,818	154,420	120,379	71	103,582	-	446,270
Total			**983,050**	**1,180,883**	**1,172,131**	**26,966**	**974,677**	**164,726**	**4,502,433**
Share			**21.8%**	**26.2%**	**26.0%**	**0.6%**	**21.6%**	**3.7%**	**100.0%**

Source: JICA Survey Team

The damage amount is calculated based on prices as of 2019. Since it is considered that the number of houses and establishments will increase at least in line with the population growth rate, the annual average benefit amount reflects the future population growth forecast rate of each province. The annual benefit of each year is shown in Appendix 2-7.

[Annual Average Reduced Damage of Dike]

The damage mitigation amount when a lakeshore diking system is constructed is shown below. The method of calculating the amount of damage by water level is the same as the above-mentioned for spillway, but it is assumed that the damage of less than 100 years of the 31 LGUs around the lakeshore area will be eliminated by "with lakeshore diking system". The annual average reduced damage will be 7,765 million PHP as of 2019.

The benefits for each phase were the benefits of the target LGUs in each Phase, and were 1,990 million pesos in Phase 1, 2,475 million pesos in Phase 2 and 1,428 million pesos in Phase 3.

Note that these amounts are for the cases where lakeshore diking system is constructed independently, and when the Parañaque Spillway is constructed at the same time, the duplicate portion that reduces damage is excluded.

Table 5.1.16 Average Annual Damage Reduction of Dike: 31 LGUs

(Unit: Thousand peso)

Return Period	Water Level (m)			Damage Value			Benefit of Reduced Business Suspention (b)	Total Economic Loss (c)=(a)+(b)	Probability (d)	Probability between two cases (e)	Average Damage of two cases(f)	Annual Economic Loss (e) x (f)
	Without	With	Difference	Without	With	Difference (a)						
200	14.6	14.6	0.0	0	0	0	0	0	0.005	0.00500	0	0
100	14.2	12.5	1.8	123,788,855	0	123,788,855	18,761,765	142,550,620	0.010	0.01000	122,365,727	1,223,657
50	14.0	12.5	1.5	87,473,710	0	87,473,710	14,707,123	102,180,833	0.020	0.01333	82,946,854	1,105,958
30	13.7	12.5	1.2	54,236,185	0	54,236,185	9,476,690	63,712,875	0.033	0.01667	58,432,814	973,880
20	13.6	12.5	1.1	44,691,152	0	44,691,152	8,461,600	53,152,752	0.050	0.05000	38,035,804	1,901,790
10	13.2	12.5	0.7	19,032,137	0	19,032,137	3,886,719	22,918,856	0.100	0.10000	15,981,446	1,598,145
5	12.9	12.5	0.4	6,910,706	0	6,910,706	2,133,331	9,044,037	0.200	0.13333	5,717,845	762,379
3	12.6	12.5	0.2	2,391,653	0	2,391,653	0	2,391,653	0.333	0.16667	1,195,827	199,304
2	12.3	12.5	0.0	0	0	0	0	0	0.500	0.50000	0	0
												7,765,114

Source: JICA Survey Team

5.2 Flood Control Effect of Parañaque Spillway Considering an Integrated Flood Control Plan for Laguna de Bay Basin and Pasig-Marikina River Basin

5.2.1 Examination Policy

Flood control with the Parañaque Spillway is (1) effective on the Lakeshore Area and (2) effective on the Pasig-Marikina River Basin. Flood simulations were conducted to sort out the flood control effects of the Parañaque Spillway under (1) and (2).

Table 5.2.1 List of Flood Simulation Implementation Cases

Case	River Improvement			MCGS	MFW	Marikina Dam and retarding basin	NHCS	PSW	LDS
	Phase II and III	Phase IV	Phase V						
Case1	●				●		close		
Case2	●	●		●	●		close		
Case3	●	●		●	●	●	close		
Case4	●	●		●			close		
Case5	●	●		●			close		●
Case6	●	●		●	●		close	●	
Case7	●	●		●	●	●	close	●	
Case8					●				
Case9									
Case10	●	●	●				close		
Case11				●	●		close	●	
Case12						●	close		
Case13	●	●	●	●	●	●	close	●	
Case14	●			●	●		close	●	
Case15	●	●		●	●		close	●	
Case16	●	●	●	●	●		close	●	

*MFW:Manggahan Floodway, PSW: Paranaque Spillway, LDS: Lakeshore Diking System

5.2.2 Flood Control Benefit on Pasig-Marikina River Basin

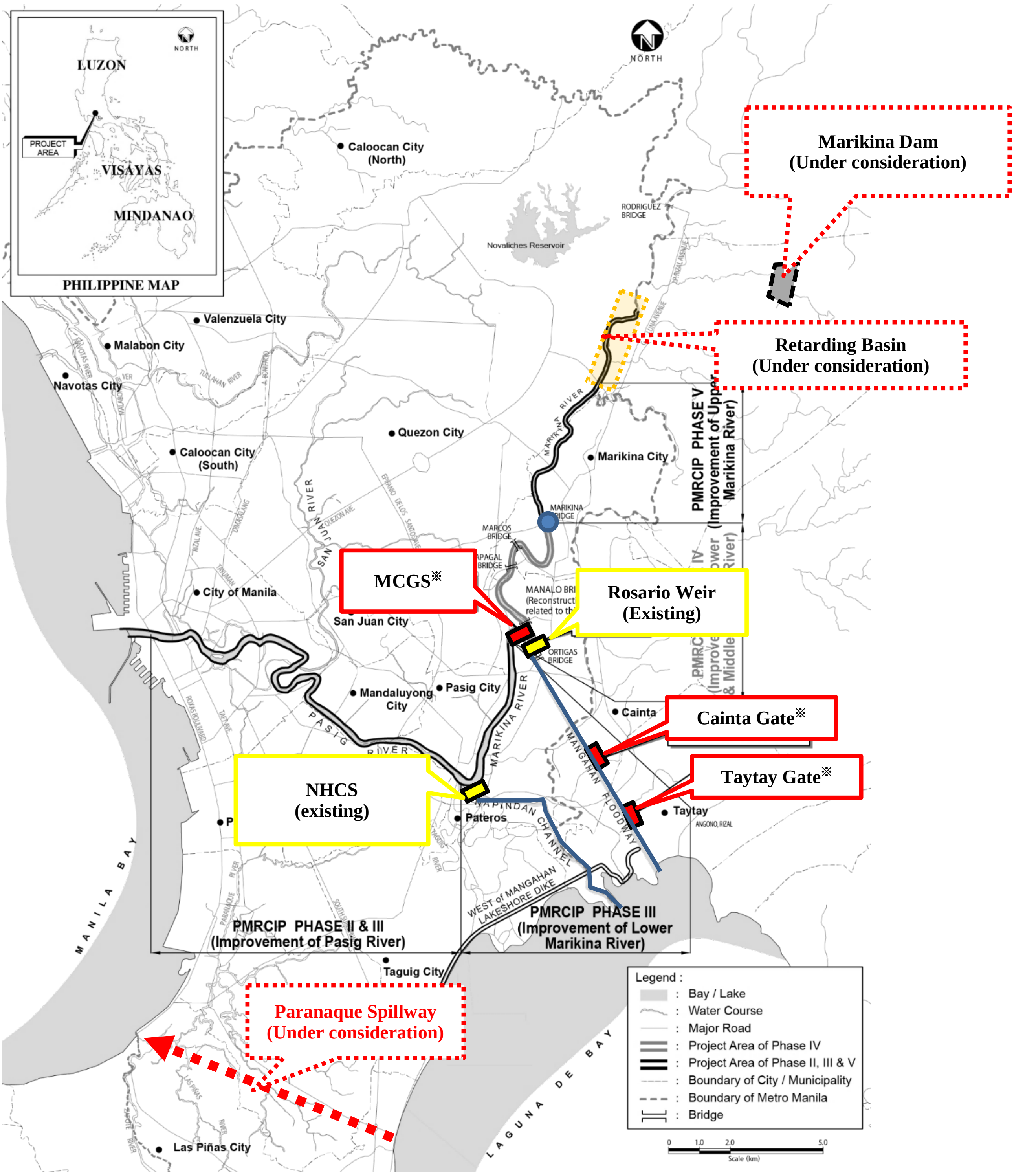
(1) Hydraulic System of Pasig-Marikina River Basin and Laguna de Bay Basin

All flood countermeasures in the Pasig-Marikina River basin have been compiled. Flood countermeasures are broadly classified into "(1) river channel network" and "(2) flood storage facility". The “diversion/discharge system” is a part of “(1), river channel network”, in the flood control measures for the Pasig-Marikina River basin. Parañaque Spillway which is under consideration in this study is one of the seven “diversion/discharge systems” in the Pasig-Marikina River basin.

Table 5.2.2 Flood Countermeasures in Pasig-Marikina River Basin

Category	River Improvement/Improvement Facility	Implementation Status
River Channel Network	Phase II River Improvement	Maintained
	Phase III River Improvement	Maintained
	Phase IV River Improvement	Implementation plan
	Phase V River Improvement	Partial implementation (DPWH)
Diversion/Discharge System	Manggahan Floodway	Maintained
	Rosario Weir	Maintained
	NHCS	Maintained
	MCGS	Implementation plan, Phase IV
	Cainta gate	Implementation plan, Phase IV
	Taytay gate	Implementation plan, Phase IV
	Parañaque Spillway	Under review
Flood Storage Facility	Retarding Basin	Planning / Under consideration (DPWH)

Category	River Improvement/Improvement Facility	Implementation Status
	Marikina Dam	Planning / Under consideration (DPWH)



*: Scheduled to be implemented in Pasig-Marikina River Improvement Project Phase IV

Figure 5.2.1 Hydraulic System in Pasig-Marikina River Basin and Laguna de Bay Basin

(2) Three Types of Lake Water Discharged from Parañaque Spillway

There are three (3) types of water that are to be discharged from the Parañaque Spillway: Water A, Water B and Water C. Benefits created by these discharges are the sum of the benefits created by each discharge.

<u>Rainfall Runoff to Lakeshore Basin</u>

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

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

<u>Flow from Other Basins</u>

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

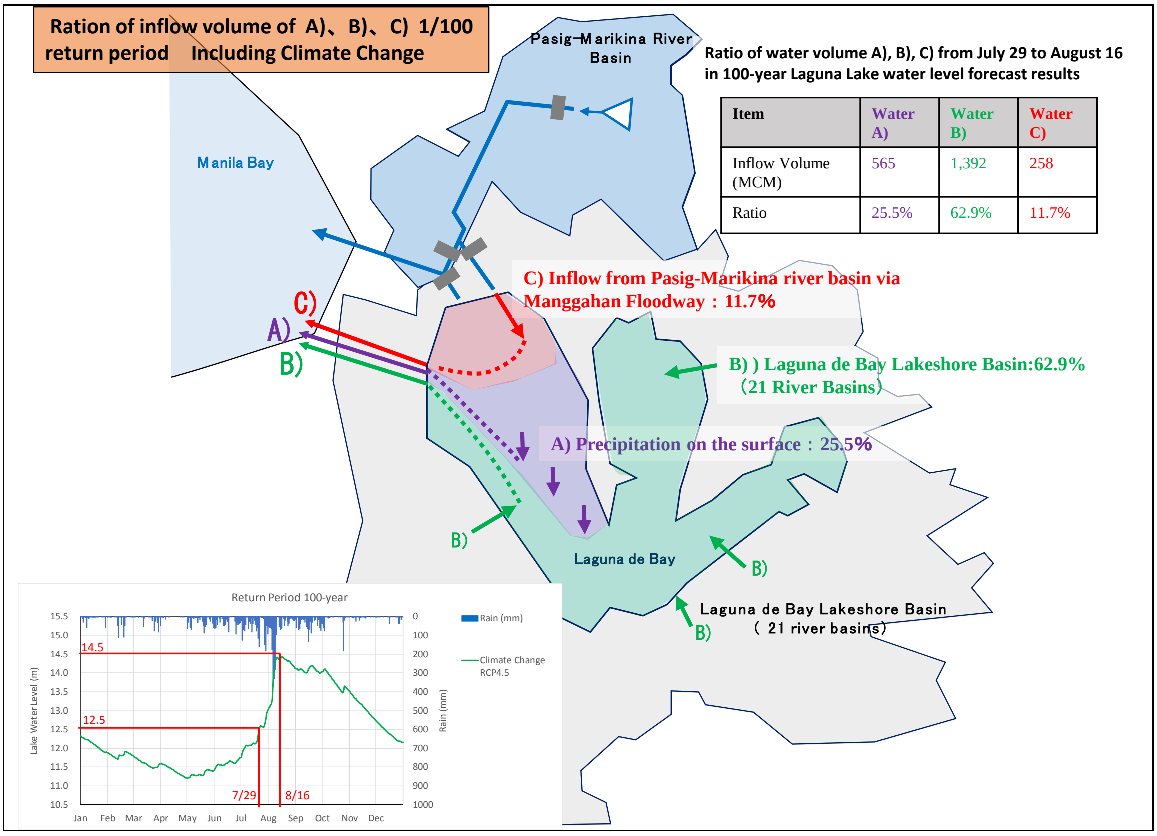


Figure 5.2.2 Drainage Image of Parañaque Spillway

In Water C in the figure above, the seven (7) facilities shown in the table below function as the "diversion/discharge system" that releases Water C from the Pasig-Marikina River Basin to the Manila Bay. With all seven facilities in place (including those that are currently under development), the effects will be realized without the occurrence of external diseconomy.

Table 5.2.3 Implementation Status of Diversion/Discharge System

Facility	Implementation Status
Manggahan Floodway	Maintained
Rosario Weir	Maintained
NHCS	Maintained
MCGS	Implementation Plan, Phase IV
Cainta gate	Implementation Plan, Phase IV
Taytay gate	Implementation Plan, Phase IV
Parañaque Spillway	Under consideration

5.2.3 Consideration of Contribution of Parañaque Spillway to the Mitigation of Flood Damage in Pasig-Marikina River

The project effect of Parañaque Spillway consists of: (1) the effect of draining inflow from surrounding river basins (21 river basins) and reducing the inundation of lakeshore area; and (2) the effect of reducing the inundation of Pasig-Marikina River Basin, as shown in Section 5.1.

The operation of Manggahan Floodway, which diverts part of Marikina River flood to Laguna de Bay to reduce flood damage in Metro Manila, temporarily raises the water level of Laguna de Bay. However, due to the operation of Parañaque Spillway, the raised water level, which will inflow from the Marikina river basin through Manggahan Floodway, will be offset.

Therefore, an economic analysis was conducted considering the contribution of Parañaque Spillway in mitigating flood damage in Pasig-Marikina river basin.

(1) Separation of Benefits by the Parañaque Spillway from the Overall Benefits of Flood Control in Pasig-Marikina River Basin

As described in 5.2.2(3), there are three types of water released from Parañaque Spillway, and the Water C that flows from the Pasig-Marikina river basin into the Laguna de Bay through the Manggahan Floodway, as shown in the figure below, is the contribution of Parañaque Spillway to the mitigation of flood damage in the Pasig-Marikina river basin.

■Rainfall Runoff to Lakeshore basin

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

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

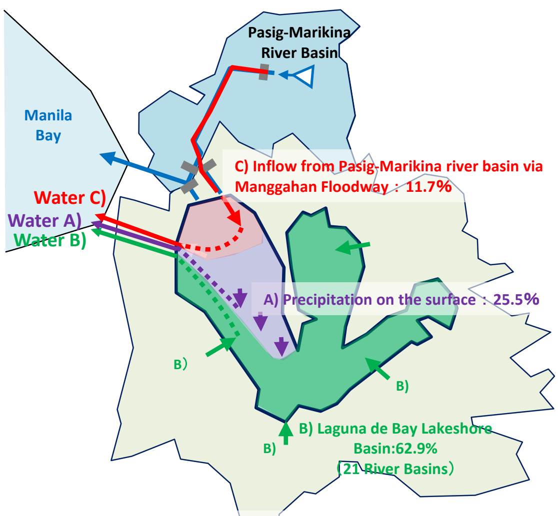
■Flowing from Other Basins

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

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

The benefits created by the release of the Parañaque spillway are the sum of the benefits created by each of the above A), B) and C).

Ration of inflow volume of A)、B)、C) 1/100 return period



Ratio of water volume A), B), C) from July 29 to August 16 in 100-year Laguna Lake water level forecast results

Item	Water A)	Water B)	Water C)
Inflow Volume（MCM）	565	1,392	258
Ratio	25.5%	62.9%	11.7%

Figure 5.2.3 Three Types of Lake Water Discharged from Parañaque Spillway

The benefit of a Parañaque spillway that discharges Water C is part of the benefits of flood control in the Pasig-Marikina river basin. As a method of separating the benefits of releasing Water C from Parañaque Spillway from the overall benefits of flood control in Pasig-Marikina river basin, the benefits were separated according to the procedures shown in Step 1 to Step 3 below.

Table 5.2.4 Procedure to Separate Benefits of Contribution of Pasig-Marikina River Basin

Step	Content	Benefit Distribution Method (See Table 5.2.6 for each distribution method)
Step-1	Separating the benefits of a "river channel network system" from all the benefits of flood control in Pasig-Marikina River basin	**Individual benefit proportional distribution** →Benefit of river channel network system →Benefit of Flood storage facility
Step-2	Separate the benefits of downstream of river network from Rosario point from the benefits of "river channel network system" distributed in Step-1.	**with/without method and individual benefit proportional distribution**※1 →Benefit of Upstream of river channel from Rosario point (PhaseIV ・V) →Benefit of Downstream of river network from Rosario point
Step-3	Separate the benefits of Parañaque Spillway from the benefits of "downstream of river network from Rosario point" distributed in Step-2	**Project cost proportional distribution** →Benefit of Phase II river channel →Benefit of Phase III river channel →Benefit of Diversion/Discharge system (7 facilities including Parañaque Spillway)

※1 If the benefits of river channel network are calculated by with/without method and added total benefit of "river channel network system", the total benefit does not match the benefit of "river channel network system" calculated in Step-1 in individual benefit proportional distribution method. Therefore, the benefits are adjusted by combining "individual benefit proportional distribution" method.

The benefits of Parañaque Spillway are: (1) the benefits around Laguna de Bay (Section 5.1) and (2) the benefits for Pasig-Marikina River Basin (Water C).

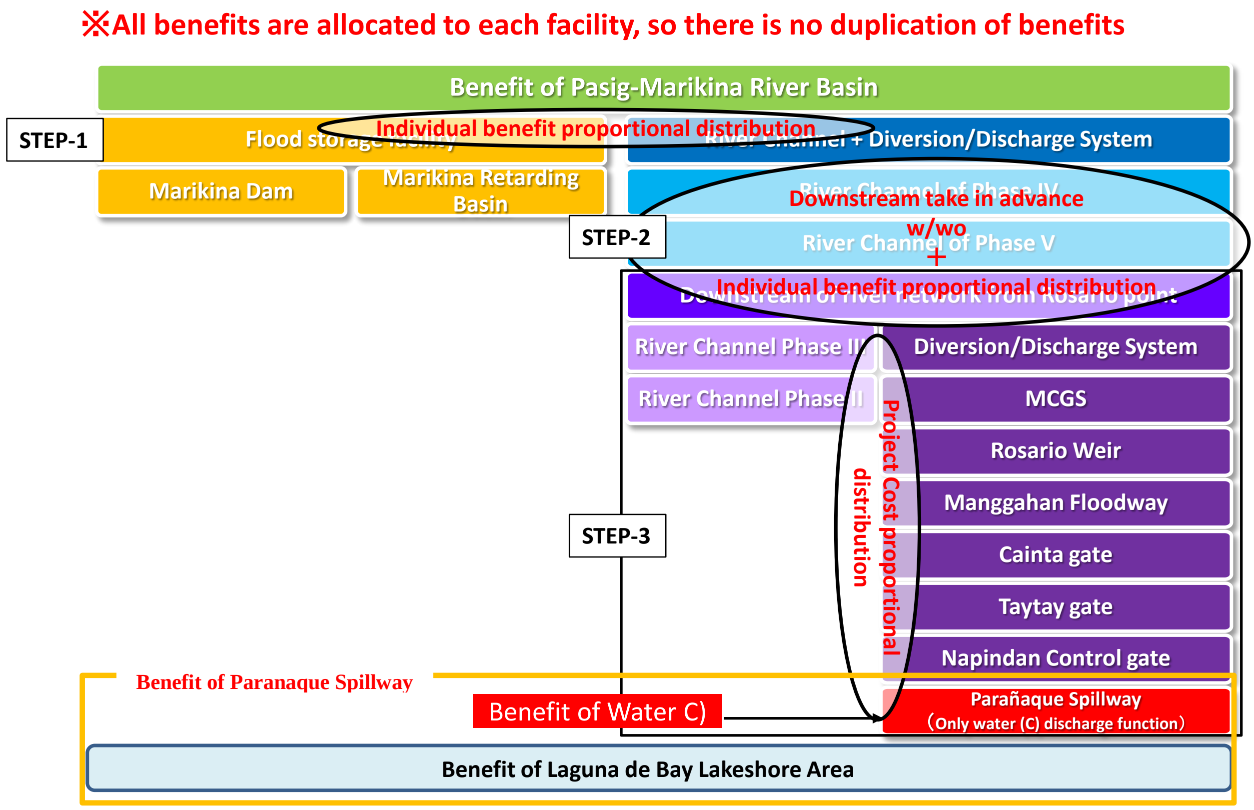


Figure 5.2.4 Image of the Composition and Benefits of All Flood Control in Pasig-Marikina River Basin

(2) Points to Consider When Separating the Benefits of Parañaque Spillway

- If the benefits of river channel network system are calculated in advance in with/without method and added up, the benefits of the entire river channel network system calculated by individual benefit proportional distribution in Step-1 do not match. Therefore, the benefits are adjusted by combining "individual benefit proportional distribution" methods.

- It was noted that part of the project cost of Parañaque Spillway (the following formula) will be used when the benefits of releasing Water C) from Parañaque Spillway are divided by project cost allocation.

Total Project Cost × (Water C) / (Water A) + (Water B) + (Water C)

- The benefit of “Phase IV Project” is the sum of the benefits of Phase IV river channel improvement, Cainta Gate, and Taytay Gate, and attention was paid to the handling of the benefit by arranging the Manggahan Floodway (removing houses).
- The operating costs of each business are converted into present value, and the benefits are calculated using the current assets.

(3) Benefit Distribution Method

The benefit distribution method is as shown below.

Table 5.2.5 Benefit Distribution Method

Method	Content
With/Without Method	・ Benefits of the element and benefits of other elements can be separated by “independence / contradiction”, and even if the context of the installation timing of that element and other elements is replaced, the benefits of each element calculated do not change. ・ Calculate the benefit by comparing with/without the elements to be evaluated. However, strictly speaking, river improvement projects that are carried out from downstream and road projects that are partially provisioned are not “independence / contradiction”, but the method of using with/without method to anticipate the benefits of advanced maintenance is used in many cases.
Individual Benefit Proportional Distribution Method	・ The benefits of that element and the benefits of other elements can be separated by “independence / contradiction”. If the context of the installation timing of that element and other elements is replaced, the calculated benefit of each element will fluctuate, and it will be underestimated or overestimated depending on the installation order. ・ Calculate the individual benefits individually using the with/without method and apportion the overall benefits using the “single benefit balance” of each element.
Project Cost Proportional Distribution	・ The benefits of that element and those of other elements cannot be separated by “independence / contradiction”. In the state where all the multiple elements are complete, the system functions properly and benefits are realized. In the middle stage, no benefits are realized or risks and external diseconomies remain. ・ If the with / without method is applied in this case, an appropriate benefit evaluation cannot be performed as shown below. ➢ Create all benefits by the final elements ➢ Due to the factors on the way, external diseconomy occurs while creating benefits. The final element to be completed eliminates benefits and creates external diseconomy. ➢ In this case, in order to evenly distribute the benefits to each element, the overall benefits should be apportioned on a “project cost balance” basis.

5.2.4 Economic Evaluation for Flood Control Measures in Pasig-Marikina River Basin

(1) Average Annual Damage Reduction of Parañaque Spillway for Contribution to Pasig-Marikina River Basin

The contribution of Parañaque Spillway for Pasig-Marikina River Basin is the benefit of Water C which inflow to Laguna de Bay through Manggahan Floodway as described in 5.2.1.

Average annual damage reduction of the contribution of Parañaque Spillway to Pasig-Marikina river basin was calculated based on the assumptions shown in Table 5.2.6, and the benefit (Water C) to Pasig-Marikina river basin was calculated as 15,173 million PHP.

Table 5.2.6 Average Annual Damage Reduction for all Flood Control Measures in Pasig-Marikina River Basin

【Precondition】
Benefits in lakeshore area are calculated under the following conditions:

- Route 1 Shield Method, Tunnel Inner Diameter D-13m
- Include Climate Change

Step	No.	Benefit	Average Annual Damage Reduction (Million PHP)
Step-1	1	Benefit of river channel network system	67,942
	2	Benefit of flood storage facility	7,263
Step-2	3	Phase IV river channel	785
	4	Phase V river channel	774
	5	Downstream of river channel at Rosario weir	66,383
Step-3	6	Phase III river channel	10,133
	7	Phase II river channel	7,895
	8	MCGS	3,294
	9	Manggahan Floodway, Rosario weir	28,685
	10	**Parañaque Spillway (Benefit of Water C))**	15,173
	11	Cainta gate/ Taytay gate	1,203

Note: Napindan Hydraulic Control Structure (NHCS) is not included because there was no data available at the time of construction in 1983 and the project cost could not be estimated. The construction cost of NHCS is estimated to be PHP265 million from the construction cost of Rosario Weir (PHP260 million) and the gate area ratio. The cost is estimated to be PHP 318 million.

The difference from the evaluation value of Paranaque Survey 2018 is due to the following reasons:

- The project effect due to the release of Water C was evaluated integrally with the drainage effect of Water A and Water B as a mitigation effect of the water level rise that has temporarily occurred along lakeshore area. In this study, the project effect due to the release of Water C was calculated as flood mitigation effect in Pasig-Marikina river basin.
- The effect of shortening the inundation time is newly recorded as a benefit of drainage of Water A and Water B.

(2) Economic Evaluation of Phase II and III

The result of economic evaluation of Phase II and Phase III in Pasig-Marikina river basin based on precondition shown in Table 5.2.6 is as shown below.

Portion	Item	Result	Remarks: At the time of appraisal
Phase Ⅱ	EIRR	54.7%	(18. 6%)*1
	B/C	11.1	
Phase Ⅲ	EIRR	62.9%	(45. 7%) *2
	B/C	14.1	

*1: Completion Report of PMRCIP PhaseII (2018)
*2: Values at the time of appraisal in parentheses: From the pre-project evaluation table (2011)

The difference from the evaluation at the time of Phase II / Phase III project appraisal is due to the following reasons:

- The concentration of assets on the riverside due to urban development after the river improvement.

- The benefit sharing with flood storage facilities and discharge facilities was reorganized within the framework of the overall flood control project.

Table 5.2.7 Cost-Effectiveness Analysis Result (Phase II)

パシマリ川流域における費用対効果（ Phase II）

(Pasig-Marikina River Basin River Improvement Project) Million Peso

Year		Discount Rate		Cost			Benefit					Net Benefit
				Phase II		Cost Total	Pasig-Marikina River Basin		Lakeshore Area		Benefit Total	
		10%	Present Value	Cost Plan	Present Value		Actual Base (from 2030)	Present Value	Benefit Plan	Present Value		
2007	0	1.0		115.0		115.0					0.0	-115.0
2008	1	0.9		360.0		360.0					0.0	-360.0
2009	2	0.8		486.0		486.0					0.0	-486.0
2010	3	0.8		792.0		792.0					0.0	-792.0
2011	4	0.7		953.0		953.0					0.0	-953.0
2012	5	0.6		1,207.0		1,207.0					0.0	-1,207.0
2013	6	0.6		10.0		10.0	5,190.7				5,190.7	5,180.7
2014	7	0.5		10.0		10.0	5,190.7				5,190.7	5,180.7
2015	8	0.5		10.0		10.0	5,190.7				5,190.7	5,180.7
2016	9	0.4		10.0		10.0	5,190.7				5,190.7	5,180.7
2017	10	0.4		10.0		10.0	5,190.7				5,190.7	5,180.7
2018	11	0.4		10.0		10.0	5,190.7				5,190.7	5,180.7
2019	12	0.3		10.0		10.0	5,190.7				5,190.7	5,180.7
2020	13	0.3		10.0		10.0	5,190.7				5,190.7	5,180.7
2021	14	0.3		10.0		10.0	5,190.7				5,190.7	5,180.7
2022	15	0.2		10.0		10.0	5,190.7				5,190.7	5,180.7
2023	16	0.2		10.0		10.0	5,190.7				5,190.7	5,180.7
2024	17	0.2		10.0		10.0	5,190.7				5,190.7	5,180.7
2025	18	0.2		10.0		10.0	5,190.7				5,190.7	5,180.7
2026	19	0.2		10.0		10.0	5,190.7				5,190.7	5,180.7
2027	20	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2028	21	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2029	22	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2030	23	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2031	24	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2032	25	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2033	26	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2034	27	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2035	28	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2036	29	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2037	30	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2038	31	0.1		10.0		10.0	5,190.7				5,190.7	5,180.7
2039	32	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2040	33	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2041	34	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2042	35	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2043	36	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2044	37	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2045	38	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2046	39	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2047	40	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2048	41	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2049	42	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2050	43	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2051	44	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2052	45	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2053	46	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2054	47	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2055	48	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2056	49	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2057	50	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2058	51	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2059	52	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2060	53	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2061	54	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2062	55	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2063	56	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2064	57	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2065	58	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2066	59	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2067	60	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2068	61	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2069	62	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2070	63	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2071	64	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2072	65	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2073	66	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2074	67	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2075	68	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2076	69	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2077	70	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2078	71	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7
2079	72	0.0		10.0		10.0	5,190.7				5,190.7	5,180.7

Discount Rate	10.0%
EIRR	54.7%
NPV	26,613
B/C	11.09

Table 5.2.8 Cost-Effectiveness Analysis Result (Phase III)

パシマリ川流域における費用対効果（ Phase III）

(Pasig-Marikina River Basin River Improvement Project)

Million Peso

Year		Discount Rate		Cost			Benefit					Net Benefit
		10%		Phase III		Cost Total	Pasig-Marikina River Basin		Lakeshore Area		Benefit Total	
			Present Value	Cost Plan	Present Value		Actual Base (from 2030)	Present Value	Benefit Plan	Present Value		
2007												
2008												
2009												
2010												
2011												
2012												
2013	0	1.0		237.4		237.4				0.0	0.0	-237.4
2014	1	0.9		1,100.9		1,100.9				0.0	0.0	-1,100.9
2015	2	0.8		1,574.0		1,574.0				0.0	0.0	-1,574.0
2016	3	0.8		1,574.0		1,574.0				0.0	0.0	-1,574.0
2017	4	0.7		544.6		544.6				0.0	0.0	-544.6
2018	5	0.6		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2019	6	0.6		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2020	7	0.5		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2021	8	0.5		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2022	9	0.4		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2023	10	0.4		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2024	11	0.4		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2025	12	0.3		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2026	13	0.3		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2027	14	0.3		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2028	15	0.2		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2029	16	0.2		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2030	17	0.2		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2031	18	0.2		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2032	19	0.2		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2033	20	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2034	21	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2035	22	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2036	23	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2037	24	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2038	25	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2039	26	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2040	27	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2041	28	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2042	29	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2043	30	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2044	31	0.1		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2045	32	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2046	33	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2047	34	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2048	35	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2049	36	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2050	37	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2051	38	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2052	39	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2053	40	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2054	41	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2055	42	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2056	43	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2057	44	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2058	45	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2059	46	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2060	47	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2061	48	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2062	49	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2063	50	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2064	51	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2065	52	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2066	53	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2067	54	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2068	55	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2069	56	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2070	57	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2071	58	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2072	59	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2073	60	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2074	61	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2075	62	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2076	63	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2077	64	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2078	65	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1
2079	66	0.0		11.7		11.7	8,634.8			0.0	8,634.8	8,623.1

Discount Rate	10.0%
EIRR	62.9%
NPV	49,676
B/C	14.09

(3) Economic Evaluation of Phase IV

There are four types of benefits for Phase IV project related facilities: (1) Phase IV benefits, (2) MCGS benefits, (3) Benefits of Cainta Gate, and (4) Benefits of Taytay Gate.

Portion	Item	Result	Remarks: At the time of appraisal
Phase IV	EIRR	13.5%	(14.8%)*1
	B/C	1.4	

*1: Values at the time of appraisal in parentheses: From the pre-project evaluation table (2018)

The difference from the evaluation at the time of Phase IV project appraisal is due to the following reasons:

- ➢ The benefit sharing with flood storage facilities and discharge facilities was reorganized within the framework of the overall flood control project.

Table 5.2.9 Cost-Effectiveness Analysis Result (Phase IV)

パシマリ川流域における費用対効果（ Phase IV）

(Pasig-Marikina River Basin River Improvement Project) Million Peso

Year		Discount Rate 10%	Present Value	Cost: Phase III Cost Plan	Cost: Phase III Present Value	Cost Total	Benefit: Pasig-Marikina River Basin Actual Base (from 2030)	Benefit: Pasig-Marikina River Basin Present Value	Benefit: Lakeshore Area Benefit Plan	Benefit: Lakeshore Area Present Value	Benefit Total	Net Benefit
2019	0	1.0		37.0		37.0				0.0	0.0	-37.0
2020	1	0.9		5,168.0		5,168.0				0.0	0.0	-5,168.0
2021	2	0.8		9,041.0		9,041.0				0.0	0.0	-9,041.0
2022	3	0.8		4,302.0		4,302.0				0.0	0.0	-4,302.0
2023	4	0.7		3,100.0		3,100.0				0.0	0.0	-3,100.0
2024	5	0.6		3,057.0		3,057.0				0.0	0.0	-3,057.0
2025	6	0.6		2,405.0		2,405.0	3,169.1			0.0	3,169.1	764.1
2026	7	0.5		911.0		911.0	5,281.8			0.0	5,281.8	4,370.8
2027	8	0.5		119.0		119.0	5,281.8			0.0	5,281.8	5,162.8
2028	9	0.4		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2029	10	0.4		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2030	11	0.4		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2031	12	0.3		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2032	13	0.3		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2033	14	0.3		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2034	15	0.2		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2035	16	0.2		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2036	17	0.2		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2037	18	0.2		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2038	19	0.2		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2039	20	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2040	21	0.1		195.0		195.0	5,281.8			0.0	5,281.8	5,086.8
2041	22	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2042	23	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2043	24	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2044	25	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2045	26	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2046	27	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2047	28	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2048	29	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2049	30	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2050	31	0.1		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2051	32	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2052	33	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2053	34	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2054	35	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2055	36	0.0		316.0		316.0	5,281.8			0.0	5,281.8	4,965.8
2056	37	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2057	38	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2058	39	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2059	40	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2060	41	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2061	42	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2062	43	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2063	44	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2064	45	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2065	46	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2066	47	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2067	48	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2068	49	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2069	50	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2070	51	0.0		195.0		195.0	5,281.8			0.0	5,281.8	5,086.8
2071	52	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2072	53	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2073	54	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2074	55	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2075	56	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2076	57	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2077	58	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2078	59	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8
2079	60	0.0		98.0		98.0	5,281.8			0.0	5,281.8	5,183.8

Discount Rate	10.0%
EIRR	13.5%
NPV	8,745
B/C	1.44

(4) Economic Evaluation of Other Facilites

The economic evaluation of other facilities in the Pasig-Marikina River basin is summarized below.

Portion	Item	Result	Remarks
Phase V	EIRR	10.7%	
	B/C	1.1	
Manggahan Floodway	EIRR	368.1%	・ Completed in 1987. ・ Although the project cost is currently valued in the economic evaluation, the current assets are used to calculate the benefits. ・ High EIRR and B/C due to rapid concentration of assets by rapid urban development along the Manggahan Floodway after the development of Manggahan Floodway.
	B/C	214.6	
Marikina Dam	EIRR	36.0%	・ As shown in Step 1, average annual damage reduction is adjusted so that there is no duplicate of benefits by calculating (1) river channel network system and (2) flood storage facility by individual benefit proportional distribution method.
	B/C	4.6	
All Flood control measures in Pasig-Marikina river basin	EIRR	368.1%	・ The EIRR and B/C of the entire project are large because the effect of the Manggahan Floodway is large.
	B/C	38.6	

Table 5.2.10 Cost-Effectiveness Analysis Result (Phase V)

パシマリ川流域における費用対効果（ Phase V）

(Pasig-Marikina River Basin River Improvement Project) Million Peso

Year		Discount Rate 10%	Cost: Present Value	Cost: Phase III Cost Plan	Cost: Phase III Present Value	Cost Total	Benefit: Pasig-Marikina River Basin Actual Base (from 2030)	Benefit: Pasig-Marikina River Basin Present Value	Benefit: Lakeshore Area Benefit Plan	Benefit: Lakeshore Area Present Value	Benefit Total	Net Benefit
2018	0	1.0		204.0		204.0				0.0	0.0	-204.0
2019	1	0.9		2,040.0		2,040.0				0.0	0.0	-2,040.0
2020	2	0.8		2,516.0		2,516.0				0.0	0.0	-2,516.0
2021	3	0.8		2,040.0		2,040.0	478.8			0.0	478.8	-1,561.2
2022	4	0.7		32.6		32.6	797.9			0.0	797.9	765.4
2023	5	0.6		32.6		32.6	797.9			0.0	797.9	765.4
2024	6	0.6		32.6		32.6	797.9			0.0	797.9	765.4
2025	7	0.5		32.6		32.6	797.9			0.0	797.9	765.4
2026	8	0.5		32.6		32.6	797.9			0.0	797.9	765.4
2027	9	0.4		32.6		32.6	797.9			0.0	797.9	765.4
2028	10	0.4		32.6		32.6	797.9			0.0	797.9	765.4
2029	11	0.4		32.6		32.6	797.9			0.0	797.9	765.4
2030	12	0.3		32.6		32.6	797.9			0.0	797.9	765.4
2031	13	0.3		32.6		32.6	797.9			0.0	797.9	765.4
2032	14	0.3		32.6		32.6	797.9			0.0	797.9	765.4
2033	15	0.2		32.6		32.6	797.9			0.0	797.9	765.4
2034	16	0.2		32.6		32.6	797.9			0.0	797.9	765.4
2035	17	0.2		32.6		32.6	797.9			0.0	797.9	765.4
2036	18	0.2		32.6		32.6	797.9			0.0	797.9	765.4
2037	19	0.2		32.6		32.6	797.9			0.0	797.9	765.4
2038	20	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2039	21	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2040	22	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2041	23	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2042	24	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2043	25	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2044	26	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2045	27	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2046	28	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2047	29	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2048	30	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2049	31	0.1		32.6		32.6	797.9			0.0	797.9	765.4
2050	32	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2051	33	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2052	34	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2053	35	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2054	36	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2055	37	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2056	38	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2057	39	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2058	40	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2059	41	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2060	42	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2061	43	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2062	44	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2063	45	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2064	46	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2065	47	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2066	48	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2067	49	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2068	50	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2069	51	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2070	52	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2071	53	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2072	54	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2073	55	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2074	56	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2075	57	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2076	58	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2077	59	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2078	60	0.0		32.6		32.6	797.9			0.0	797.9	765.4
2079	61	0.0		32.6		32.6	797.9			0.0	797.9	765.4

Discount Rate	10.0%
EIRR	10.7%
NPV	379
B/C	1.07

Table 5.2.11 Cost-Effectiveness Analysis Result (Manggahan Floodway)

(Manggahan Floodway) Million Peso

Year		Discount Rate	Cost			Benefit					Net Benefit
			Manggahan Floodway		Cost Total	Pasig-Marikina River Basin		Lakeshore Area		Benefit Total	
		10%	Cost Plan	Present Value		Actual Base	Present Value	Benefit Plan	Present Value		
1975	-45	72.9									
1976	-44	66.3									
1977	-43	60.2									
1978	-42	54.8									
1979	-41	49.8									
1980	-40	45.3									
1981	-39	41.1									
1982	-38	37.4									
1983	-37	34.0	17.2		17.2					0.0	-17.2
1984	-36	30.9	239.1		239.1					0.0	-239.1
1985	-35	28.1	139.2		139.2					0.0	-139.2
1986	-34	25.5	100.3		100.3	5,905				5,904.7	5,804.4
1987	-33	23.2	24.3		24.3	6,638				6,637.8	6,613.4
1988	-32	21.1	8.3		8.3	7,371				7,370.9	7,362.5
1989	-31	19.2	8.3		8.3	8,104				8,103.9	8,095.6
1990	-30	17.4	8.3		8.3	8,837				8,837.0	8,828.7
1991	-29	15.9	8.3		8.3	9,570				9,570.1	9,561.8
1992	-28	14.4	8.3		8.3	10,303				10,303.2	10,294.9
1993	-27	13.1	8.3		8.3	11,036				11,036.3	11,028.0
1994	-26	11.9	8.3		8.3	11,769				11,769.4	11,761.0
1995	-25	10.8	8.3		8.3	12,502				12,502.5	12,494.1
1996	-24	9.8	8.3		8.3	13,236				13,235.6	13,227.2
1997	-23	9.0	8.3		8.3	13,969				13,968.6	13,960.3
1998	-22	8.1	8.3		8.3	14,702				14,701.7	14,693.4
1999	-21	7.4	8.3		8.3	15,435				15,434.8	15,426.5
2000	-20	6.7	8.3		8.3	16,168				16,167.9	16,159.6
2001	-19	6.1	8.3		8.3	16,901				16,901.0	16,892.6
2002	-18	5.6	8.3		8.3	17,634				17,634.1	17,625.7
2003	-17	5.1	8.3		8.3	18,367				18,367.2	18,358.8
2004	-16	4.6	8.3		8.3	19,100				19,100.2	19,091.9
2005	-15	4.2	8.3		8.3	19,833				19,833.3	19,825.0
2006	-14	3.8	8.3		8.3	20,566				20,566.4	20,558.1
2007	-13	3.5	8.3		8.3	21,299				21,299.5	21,291.2
2008	-12	3.1	8.3		8.3	22,033				22,032.6	22,024.3
2009	-11	2.9	8.3		8.3	22,766				22,765.7	22,757.3
2010	-10	2.6	8.3		8.3	23,499				23,498.8	23,490.4
2011	-9	2.4	8.3		8.3	24,232				24,231.8	24,223.5
2012	-8	2.1	8.3		8.3	24,965				24,964.9	24,956.6
2013	-7	1.9	8.3		8.3	25,698				25,698.0	25,689.7
2014	-6	1.8	8.3		8.3	26,431				26,431.1	26,422.8
2015	-5	1.6	8.3		8.3	27,164				27,164.2	27,155.9
2016	-4	1.5	8.3		8.3	27,897				27,897.3	27,888.9
2017	-3	1.3	8.3		8.3	28,630				28,630.4	28,622.0
2018	-2	1.2	8.3		8.3	29,363				29,363.4	29,355.1
2019	-1	1.1	8.3		8.3	30,097				30,096.5	30,088.2
2020	0	1.0	8.3		8.3	30,830				30,829.6	30,821.3
2021	1	0.9	8.3		8.3	30,830				30,829.6	30,821.3
2022	2	0.8	8.3		8.3	30,830				30,829.6	30,821.3
2023	3	0.8	8.3		8.3	30,830				30,829.6	30,821.3
2024	4	0.7	8.3		8.3	30,830				30,829.6	30,821.3
2025	5	0.6	8.3		8.3	30,830				30,829.6	30,821.3
2026	6	0.6	8.3		8.3	30,830				30,829.6	30,821.3
2027	7	0.5	8.3		8.3	30,830				30,829.6	30,821.3
2028	8	0.5	8.3		8.3	30,830				30,829.6	30,821.3
2029	9	0.4	8.3		8.3	30,830				30,829.6	30,821.3
2030	10	0.4	8.3		8.3	30,830				30,829.6	30,821.3
2031	11	0.4	8.3		8.3	30,830				30,829.6	30,821.3
2032	12	0.3	8.3		8.3	30,830				30,829.6	30,821.3
2033	13	0.3	8.3		8.3	30,830				30,829.6	30,821.3
2034	14	0.3	8.3		8.3	30,830				30,829.6	30,821.3
2035	15	0.2	8.3		8.3	30,830				30,829.6	30,821.3
2036	16	0.2	8.3		8.3	30,830				30,829.6	30,821.3
2037	17	0.2	8.3		8.3	30,830				30,829.6	30,821.3
2038	18	0.2	8.3		8.3	30,830				30,829.6	30,821.3
2039	19	0.2	8.3		8.3	30,830				30,829.6	30,821.3
2040	20	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2041	21	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2042	22	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2043	23	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2044	24	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2045	25	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2046	26	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2047	27	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2048	28	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2049	29	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2050	30	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2051	31	0.1	8.3		8.3	30,830				30,829.6	30,821.3
2052	32	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2053	33	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2054	34	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2055	35	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2056	36	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2057	37	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2058	38	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2059	39	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2060	40	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2061	41	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2062	42	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2063	43	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2064	44	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2065	45	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2066	46	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2067	47	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2068	48	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2069	49	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2070	50	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2071	51	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2072	52	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2073	53	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2074	54	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2075	55	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2076	56	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2077	57	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2078	58	0.0	8.3		8.3	30,830				30,829.6	30,821.3
2079	59	0.0	8.3		8.3	30,830				30,829.6	30,821.3

Discount Rate	10.0%
EIRR	368.1%
NPV	96,802
B/C	214.59

Table 5.2.12 Cost-Effectiveness Analysis Result (Marikina Dam)

パシマリ川流域における費用対効果（ Marikina Dam）

(Pasig-Marikina River Basin River Improvement Project) Million Peso

Year		Discount Rate		Cost			Benefit					Net Benefit
		10%		Dam		Cost Total	Pasig-Marikina River Basin		Lakeshore Area		Benefit Total	
			Present Value	Cost Plan	Present Value		Actual Base (from 2030)	Present Value	Benefit Plan	Present Value		
2007												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020	0	1.0		84.8		84.8				0.0	0.0	-84.8
2021	1	0.9		1,728.8		1,728.8				0.0	0.0	-1,728.8
2022	2	0.8		3,167.5		3,167.5				0.0	0.0	-3,167.5
2023	3	0.8		4,199.6		4,199.6				0.0	0.0	-4,199.6
2024	4	0.7		3,582.0		3,582.0				0.0	0.0	-3,582.0
2025	5	0.6		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2026	6	0.6		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2027	7	0.5		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2028	8	0.5		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2029	9	0.4		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2030	10	0.4		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2031	11	0.4		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2032	12	0.3		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2033	13	0.3		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2034	14	0.3		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2035	15	0.2		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2036	16	0.2		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2037	17	0.2		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2038	18	0.2		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2039	19	0.2		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2040	20	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2041	21	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2042	22	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2043	23	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2044	24	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2045	25	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2046	26	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2047	27	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2048	28	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2049	29	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2050	30	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2051	31	0.1		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2052	32	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2053	33	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2054	34	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2055	35	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2056	36	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2057	37	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2058	38	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2059	39	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2060	40	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2061	41	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2062	42	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2063	43	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2064	44	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2065	45	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2066	46	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2067	47	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2068	48	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2069	49	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2070	50	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2071	51	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2072	52	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2073	53	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2074	54	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2075	55	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2076	56	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2077	57	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2078	58	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9
2079	59	0.0		132.7		132.7	7,262.6			0.0	7,262.6	7,129.9

Discount Rate	10.0%
EIRR	36.0%
NPV	35,059
B/C	4.58

Table 5.2.13 Cost-Effectiveness Analysis Result (All Flood Control Measures)

パシマリ川流域全事業における費用対効果

Million Peso

Year	Cost								Benefit									Net Benefit
									Pasig-Marikina River Basin							Lakeshore Area		
	Manggahan Floodway	Phase II	Phase III	Phase IV	Phase V	Marikina Dam	Parañaque Spillway	Cost Total	Manggahan Floodway	Phase II	Phase III	Phase IV	Phase V	Marikina Dam	Parañaque Spillway	Parañaque Spillway	Benefit Total	
1975																		
1976																		
1977																		
1978																		
1979																		
1980																		
1981																		
1982																		
1983	17.2							17.2	0.0								0.0	-17.2
1984	239.1							239.1	0.0								0.0	-239.1
1985	139.2							139.2	0.0								0.0	-139.2
1986	100.3							100.3	5,904.7								5,904.7	5,804.4
1987	24.3							24.3	6,637.8								6,637.8	6,613.4
1988	8.3							8.3	7,370.9								7,370.9	7,362.5
1989	8.3							8.3	8,103.9								8,103.9	8,095.6
1990	8.3							8.3	8,837.0								8,837.0	8,828.7
1991	8.3							8.3	9,570.1								9,570.1	9,561.8
1992	8.3							8.3	10,303.2								10,303.2	10,294.9
1993	8.3							8.3	11,036.3								11,036.3	11,028.0
1994	8.3							8.3	11,769.4								11,769.4	11,761.0
1995	8.3							8.3	12,502.5								12,502.5	12,494.1
1996	8.3							8.3	13,235.6								13,235.6	13,227.2
1997	8.3							8.3	13,968.6								13,968.6	13,960.3
1998	8.3							8.3	14,701.7								14,701.7	14,693.4
1999	8.3							8.3	15,434.8								15,434.8	15,426.5
2000	8.3							8.3	16,167.9								16,167.9	16,159.6
2001	8.3							8.3	16,901.0								16,901.0	16,892.6
2002	8.3							8.3	17,634.1								17,634.1	17,625.7
2003	8.3							8.3	18,367.2								18,367.2	18,358.8
2004	8.3							8.3	19,100.2								19,100.2	19,091.9
2005	8.3							8.3	19,833.3								19,833.3	19,825.0
2006	8.3							8.3	20,566.4								20,566.4	20,558.1
2007	8.3	115.0						123.3	21,299.5	0.0							21,299.5	21,176.2
2008	8.3	360.0						368.3	22,032.6	0.0							22,032.6	21,664.3
2009	8.3	486.0						494.3	22,765.7	0.0							22,765.7	22,271.3
2010	8.3	792.0						800.3	23,498.8	0.0							23,498.8	22,698.4
2011	8.3	953.0						961.3	24,231.8	0.0							24,231.8	23,270.5
2012	8.3	1,207.0						1,215.3	24,964.9	0.0							24,964.9	23,749.6
2013	8.3	10.0	237.4					255.7	25,698.0	5,190.7	0.0						30,888.8	30,633.0
2014	8.3	10.0	1,100.9					1,119.2	26,431.1	5,190.7	0.0						31,621.8	30,502.6
2015	8.3	10.0	1,574.0					1,592.3	27,164.2	5,190.7	0.0						32,354.9	30,762.6
2016	8.3	10.0	1,574.0					1,592.3	27,897.3	5,190.7	0.0						33,088.0	31,495.7
2017	8.3	10.0	544.6					562.9	28,630.4	5,190.7	0.0						33,821.1	33,258.2
2018	8.3	10.0	11.7		204.0			234.0	29,363.4	5,190.7	8,634.8						43,189.0	42,955.0
2019	8.3	10.0	11.7	37.0	2,040.0			2,107.0	30,096.5	5,190.7	8,634.8	0.0					43,922.1	41,815.1
2020	8.3	10.0	11.7	5,168.0	2,516.0	84.8	963.9	8,762.8	30,829.6	5,190.7	8,634.8	0.0	0.0	0.0	0.0	0.0	44,655.2	35,892.4
2021	8.3	10.0	11.7	9,041.0	2,040.0	1,728.8	974.8	13,814.6	30,829.6	5,190.7	8,634.8	0.0	478.8	0.0	0.0	0.0	45,134.0	31,319.4
2022	8.3	10.0	11.7	4,302.0	32.6	3,167.5	3,418.5	10,950.5	30,829.6	5,190.7	8,634.8	0.0	797.9	0.0	0.0	0.0	45,453.1	34,502.6
2023	8.3	10.0	11.7	3,100.0	32.6	4,199.6	3,423.7	10,785.8	30,829.6	5,190.7	8,634.8	0.0	797.9	0.0	0.0	0.0	45,453.1	34,667.3
2024	8.3	10.0	11.7	3,057.0	32.6	3,582.0	5,405.6	12,107.1	30,829.6	5,190.7	8,634.8	0.0	797.9	0.0	0.0	0.0	45,453.1	33,346.0
2025	8.3	10.0	11.7	2,405.0	32.6	132.7	7,659.7	10,260.0	30,829.6	5,190.7	8,634.8	3,169.1	797.9	7,262.6	0.0	0.0	55,884.8	45,624.8
2026	8.3	10.0	11.7	911.0	32.6	132.7	7,338.0	8,444.2	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	0.0	0.0	57,997.6	49,553.3
2027	8.3	10.0	11.7	119.0	32.6	132.7	7,231.0	7,545.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	0.0	0.0	57,997.6	50,452.3
2028	8.3	10.0	11.7	98.0	32.6	132.7	5,323.3	5,616.6	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	0.0	0.0	57,997.6	52,381.0
2029	8.3	10.0	11.7	98.0	32.6	132.7	2,517.5	2,810.8	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	0.0	0.0	57,997.6	55,186.8
2030	8.3	10.0	11.7	98.0	32.6	132.7	515.6	808.8	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	4,880.2	78,051.2	77,242.4
2031	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	4,966.5	78,137.5	77,696.2
2032	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,054.5	78,225.5	77,784.2
2033	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,144.1	78,315.1	77,873.8
2034	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,235.5	78,406.5	77,965.1
2035	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,328.6	78,499.6	78,058.2
2036	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,417.8	78,588.8	78,147.5
2037	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,508.7	78,679.7	78,238.4
2038	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,601.3	78,772.3	78,330.9
2039	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,695.5	78,866.5	78,425.1
2040	8.3	10.0	11.7	195.0	32.6	132.7	148.1	538.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,791.4	78,962.4	78,424.1
2041	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,881.8	79,052.7	78,611.4
2042	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	5,973.6	79,144.6	78,703.3
2043	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,067.1	79,238.1	78,796.7
2044	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,162.1	79,333.1	78,891.7
2045	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,258.8	79,429.8	78,988.4
2046	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,357.1	79,528.1	79,086.8
2047	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,457.1	79,628.1	79,186.8
2048	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,558.9	79,729.9	79,288.5
2049	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,662.4	79,833.4	79,392.0
2050	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,767.6	79,938.6	79,497.3
2051	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,874.7	80,045.7	79,604.3
2052	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	6,983.6	80,154.6	79,713.3
2053	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,094.4	80,265.4	79,824.0
2054	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,207.1	80,378.1	79,936.7
2055	8.3	10.0	11.7	316.0	32.6	132.7	148.1	659.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,321.7	80,492.7	79,833.3
2056	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,438.3	80,609.3	80,167.9
2057	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,556.9	80,727.9	80,286.5
2058	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,677.5	80,848.5	80,407.1
2059	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,800.2	80,971.2	80,529.8
2060	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	7,925.0	81,096.0	80,654.6
2061	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	8,051.9	81,222.9	80,781.6
2062	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	8,181.0	81,352.0	80,910.7
2063	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	8,312.4	81,483.4	81,042.0
2064	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	8,446.0	81,617.0	81,175.6
2065	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	8,581.9	81,752.9	81,311.5
2066	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	8,720.1	81,891.1	81,449.7
2067	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	8,860.7	82,031.7	81,590.3
2068	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	9,003.7	82,174.7	81,733.4
2069	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	9,149.2	82,320.2	81,878.8
2070	8.3	10.0	11.7	195.0	32.6	132.7	148.1	538.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	9,297.1	82,468.1	81,929.8
2071	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	9,447.6	82,618.6	82,177.3
2072	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	9,600.7	82,771.7	82,330.4
2073	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	9,756.5	82,927.5	82,486.1
2074	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	9,914.9	83,085.8	82,644.5
2075	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	10,076.0	83,247.0	82,805.6
2076	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	10,239.8	83,410.8	82,969.5
2077	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	10,406.5	83,577.5	83,136.2
2078	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	10,576.1	83,747.1	83,305.7
2079	8.3	10.0	11.7	98.0	32.6	132.7	148.1	441.3	30,829.6	5,190.7	8,634.8	5,281.8	797.9	7,262.6	15,173.4	10,748.6	83,919.6	83,478.2

Discount Rate	10.0%
EIRR	368.1%
NPV	105,290
B/C	38.55

5.3 Result of Economic Evaluation

Regarding the benefits of mitigating inundation damage by Parañaque Spillway, (1) benefits in lakeshore area and (2) benefits to Pasig-Marikina River basin were examined, and the project effects of Parañaque Spillway were examined more accurately.

As for economic evaluation, structural measures (Parañaque Spillway, lakeshore diking system) and non-structural measures (OP-1 to OP-7) in Comprehensive Flood Control Plan for Laguna de Bay Basin (draft) were carried out, and then the economic evaluation (OP-8 to OP-11) of the Parañaque Spillway, which is a priority project, was examined.

Table 5.3.1 Estimated Cases for Comprehensive Flood Control Plan in Laguna de Bay Basin (Draft) and Parañaque Spillway

Category	Content	Option	Route	Tunnel Inner Diameter	Lakeshore Diking System	Climate Change
Comprehensive Flood Control Plan in Laguna de Bay Basin (Draft)	Including Climate Change Diameter Option	OP-1	Route 1	D=13m	✔	✔
		OP-2		D=14m	✔	✔
		OP-3		D=15m	✔	✔
	Including Climate Change Route Option	OP-4	Route 1	D=13m	✔	✔
		OP-5	Route 2-A	D=13m	✔	✔
		OP-6	Route 2-B	D=13m	✔	✔
		OP-7	Route 3	D=13m	✔	✔
Priority Project	Including Climate Change Route Option (Individual evaluation of Parañaque Spillway)	OP-8	Route 1	D=13m	—	✔
		OP-9	Route 2-A	D=13m	—	✔
		OP-10	Route 2-B	D=13m	—	✔
		OP-11	Route 3	D=13m	—	✔

(1) Result of Economic Evaluation for Each Option

The economic analysis results for the cases shown in Table 5.3.1 are shown in Table 5.3.2. The benefit of lakeshore diking system is assumed to gradually increase from 4 years after the start of construction of each Phase to completion because the benefits can be exhibited even if the entire Phase is not completed.

＜Including Climate Change (RCP4.5 Scenario, 20cm sea level raise)＞

In order to reduce the 100-year-probable lake water level with climate change to 13.8m of DFL, the tunnel inner diameter required for Parañaque Spillway will be D=13m.

Table 5.3.2 Result of Economic Evaluation

Category	Case	Option	Route	Tunnel Inner Diameter	Lakeshore Diking System	Project Cost (PHP million)	NPVof Cost (PHP million)	NPV of Benefit (PHP million)	EIRR	B/C
Comprehensive Flood Control Plan in Laguna de Bay Basin (Draft)	Including Climate Change Diameter Option	OP-1	Route 1	13m	○	186,158	41,043	80,132	16.3%	1.95
		OP-2	Route 1	14m	○	195,645	44,278	85,708	16.2%	1.94
		OP-3	Route 1	15m	○	205,913	47,785	91,056	16.1%	1.91
	Including Climate Change Route Option	OP-4	Route 1	13m	○	186,158	41,043	80,132	16.3%	1.95
		OP-5	Route 2-A	13m	○	178,576	42,474	95,871	19.6%	2.26
		OP-6	Route 2-B	13m	○	177,971	42,427	95,459	19.7%	2.25
		OP-7	Route 3	13m	○	194,654	44,060	84,165	16.2%	1.91
Priority Project	Including Climate Change Route Option (Parañaque Spillway)	OP-8	Route 1	13m	—	75,959	26,013	69,586	18.9%	2.68
		OP-9	Route 2-A	13m	—	68,376	27,444	86,201	23.1%	3.14
		OP-10	Route 2-B	13m	—	67,771	27,397	85,790	23.1%	3.13
		OP-11	Route 3	13m	—	84,454	29,030	73,619	18.6%	2.54

- In all cases, the EIRR exceeds the standard of 10%, and the B/C is 1 or more.
- Comprehensive Flood Control Plan in Laguna de Bay Basin (draft) by diameter option, the inner diameter of 13m shows the largest EIRR (16.3%) and B/C (1.95).
- Comprehensive Flood Control Plan in Laguna de Bay Basin (draft) by route option (OP-4 to OP-7), EIRR 16.2% to 19.7% and B/C 1.91 to 2.26 are highly economically relevant. The inlet vertical shaft can be omitted, the cost will be lower than other route options, and the EIRR of Route 2-A and Route 2-B, which will be completed in a short construction period, will be about 3% higher than other cases.
- Parañaque Spillway alone project (OP-8 to OP-11), which is a priority project, has an EIRR of 18.6% to 23.1% and a B/C of 2.54 to 3.14, which are economically relevant. The inlet vertical shaft can be omitted and the cost will be lower than other routes, and the EIRR of Route 2-A and Route 2-B, which will be completed in a short construction period, will be about 4% higher than other cases.

(2) Sensitivity Analysis

In order to analyze the impact of various factors on the business effect, sensitivity analysis was conducted in the following three cases in addition to the above base case.

- Sensitivity Analysis 1: Project Cost (Initial Investment Cost, O&M Cost) + 10%
- Sensitivity Analysis 2: Project Benefit is -10%
- Sensitivity Analysis 3: Simultaneous occurrence of Sensitivity Analysis 1 and Sensitivity Analysis 2 (Project Cost + 10%, Project Benefit is -10%)

The results of sensitivity analysis are shown in Table 5.3.3. For example, in Option 1, a 10% increase in project cost (sensitivity analysis 1) reduced EIRR by 1.0%, and a 10% decrease in benefit (Sensitivity Analysis 2) also reduced EIRR by 1.1%.

If both costs and benefits deteriorated (Sensitivity Analysis 3), the EIRR deteriorated by 2.1%.

Each option had the same effect, but the EIRR of all options exceeded 10%, confirming the economic validity of the project.

Table 5.3.3 Result of Sensitivity Analysis

Category	Case	Option	Route	D	LDS*	Base Case	Project Cost: +10%	Benefit -10%	Project Cost +10% Benefit -10%
Comprehensive Flood Control Plan in Laguna de Bay Basin (Draft)	Including Climate Change Diameter Option	OP-1	Route 1	13m	○	16.3%	15.3%	15.2%	14.2%
		OP-2	Route 1	14m	○	16.2%	15.2%	15.1%	14.1%
		OP-3	Route 1	15m	○	16.0%	15.0%	14.9%	14.0%
	Including Climate Change Route Option	OP-4	Route 1	13m	○	16.3%	15.3%	15.2%	14.2%
		OP-5	Route 2-A	13m	○	19.6%	18.3%	18.2%	16.9%
		OP-6	Route 2-B	13m	○	19.7%	18.3%	18.2%	16.9%
		OP-7	Route 3	13m	○	16.2%	15.2%	15.1%	14.1%
Priority Project	Including Climate Change Route Option (Parañaque Spillway)	OP-8	Route 1	13m	—	18.9%	17.9%	17.8%	16.8%
		OP-9	Route 2-A	13m	—	23.1%	21.7%	21.5%	20.2%
		OP-10	Route 2-B	13m	—	23.1%	21.7%	21.6%	20.2%
		OP-11	Route 3	13m	—	18.6%	17.5%	17.4%	16.4%

*LDS: Lakeshore Diking System

Chapter 6. Study on Draft Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area including Parañaque Spillway

6.1 Summary of Draft Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area

The Draft Comprehensive Flood Management for Laguna de Bay Lakeshore Area is as summarized below.

(1) Goals and Safety Level of Flood Management

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

(2) Design Flood Level (DFL)

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

(3) Comprehensive Flood Management Plan

<u>Structural Measures (Water Level Rise Suppression and Flood Damage Reduction)</u>

- Construction of Parañaque Spillway: (Underground Channel, Diameter: 13m) Inner diameter should be closely inspected in about 0.1 m in the next F/S stage.
- Lakeshore Diking System: (Total length: 82.75km, including drainage channels, drainage stations, back levee, bridges, etc.)

<u>Non-Structural Measures</u>

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

(4) Outline of Parañaque Spillway

1) Scale of Structures

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

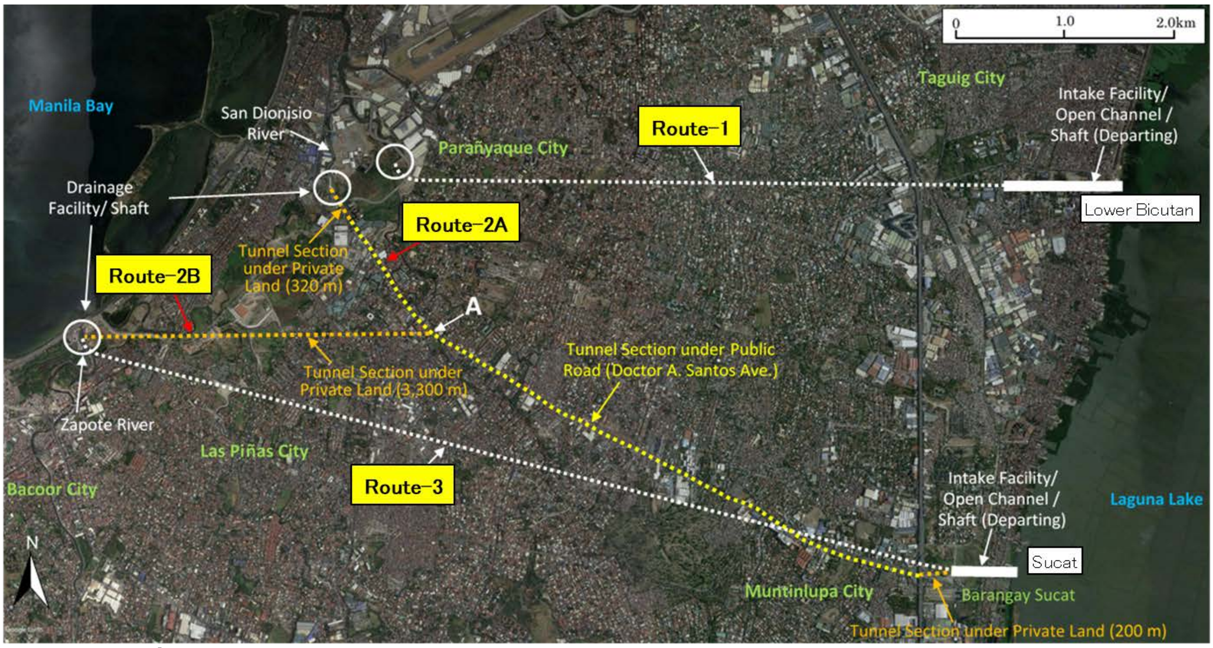
In case of climate change, Parañaque Spillway will require a channel inner diameter of 13m and a maximum discharge rate of 240 m^3/s to reduce the highest water level of Laguna de Bay of 14.5m during a 1/100 probability flood to 13.8m (DFL).

2) Operation Water Level of Parañaque Spillway

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

3) Alignment Plan

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



Source: JICA Study Team

Figure 6.1.1 Four Alternatives of Parañaque Spillway Route

Table 6.1.1 Main Features of Four Alternatives of Parañaque Spillway Route

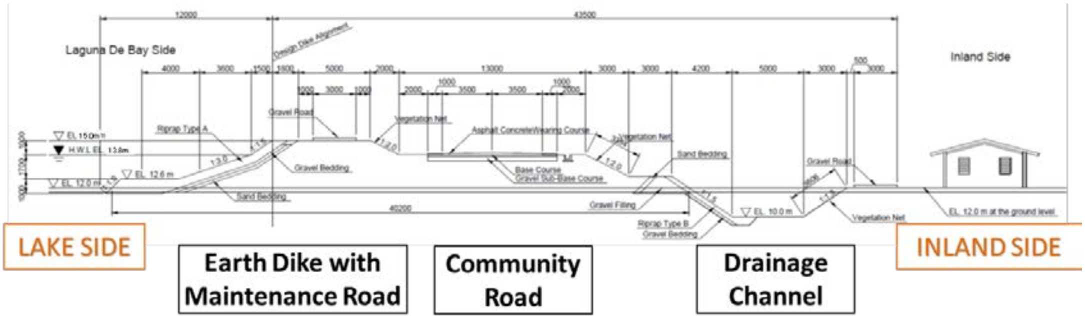
Item		Route-1	Route-2A	Route-2B	Route-3
Route	Location of Intake	Lower Bicutan	Sucat	Sucat	Sucat
	Location of Outlet	South Parañaque River	San Dionisio River	Zapote River	Zapote River
Length of Open Channel		1.2km	0.7km	0.7km	0.6km
Inner Diameter of Tunnel		D13m	D13m	D13m	D13m
Length of Tunnel		6.0km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

Source: JICA Study Team

(5) Outline of Lakeshore Diking System

1) Design

To construct the Lakeshore Diking System in the priority area along the lakeshore area and prevent inundation, the Lakeshore Diking System consisting of lakeshore dike, drainage canals, pumping stations, community roads, bridges, etc., shall be installed, and to resolve flood damage caused by rising water levels in Laguna de Bay, the lakeshore dike elevation shall be 15.0m, including a 1.2m freeboard [added to the 13.8m (DFL)].



Source: JICA Study Team

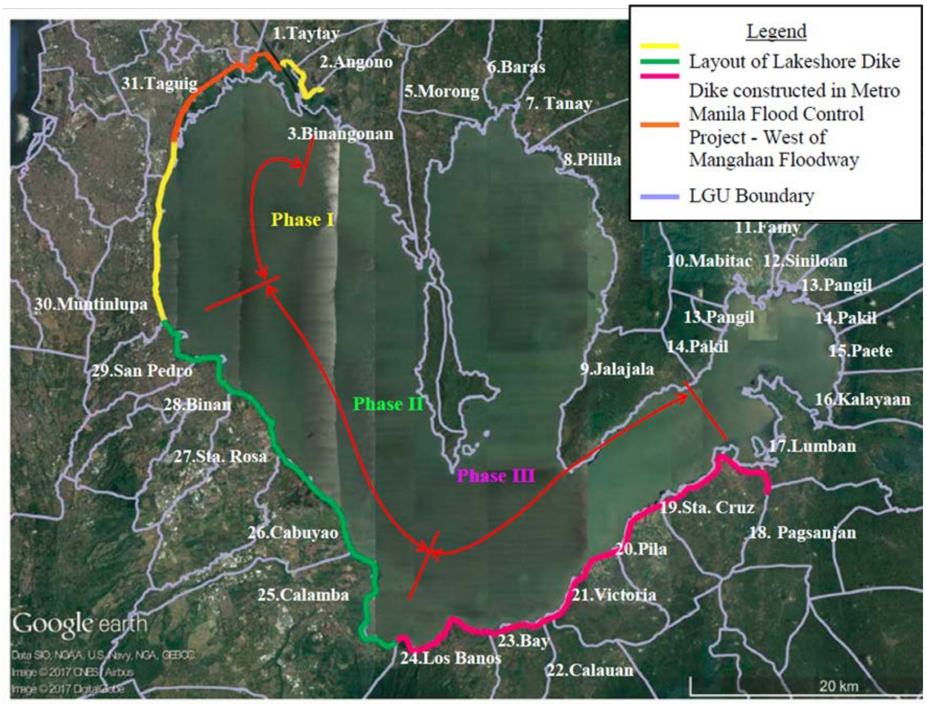
Figure 6.1.2 Typical Cross Section of Lakeshore Dike

- Construct the Lakeshore Dike on lakeshores of Laguna de Bay with elevation of 12m to 12.5m.
- Prioritize the location of lakeshore diking systems based on land use, beneficiary population, beneficiary area, etc., in the shore area, and arrange lakeshore diking from areas with higher priority.
- Length of the planned lakeshore dike shall be about 83km compared to about 220km around the lakeshore, and non-structural measures (warning systems, etc.) shall be used for areas where there are few assets and the economic effect is low for arranging the lakeshore diking system.

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

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

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



Source: JICA Study Team

Figure 6.1.3 Layout of Lakeshore Diking System（Phase I, II, III）

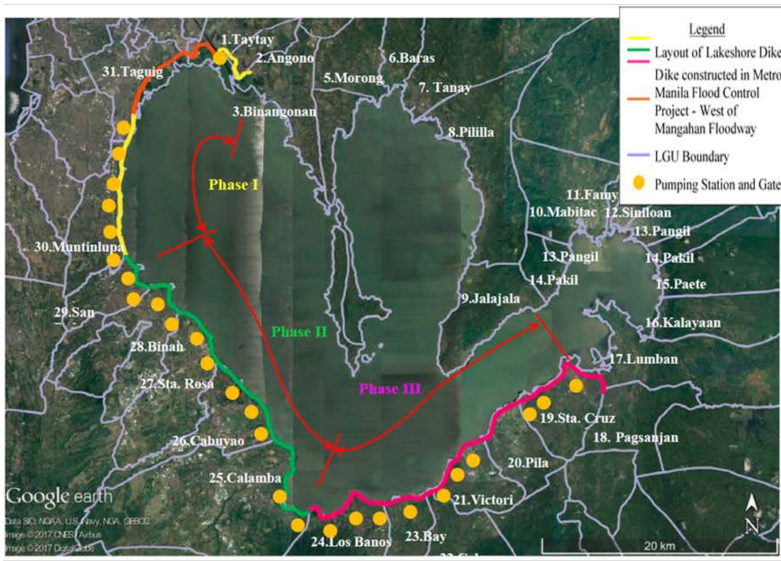
Table 6.1.2 Main Features of FourAlternatives of Parañaque Spillway Route

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

Source: JICA Study Team

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

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



Drainage Stations（Phase I, II, III）

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

Source: JICA Study Team

Figure 6.1.4 Layout of Drainage Stations（Phase I, II, III）

(6) Non-Structural Measures

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

Table 6.1.3 Proposed Non-Structural Measures for Flood Mitigation of Lowland Area

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

Source: JICA Study Team

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

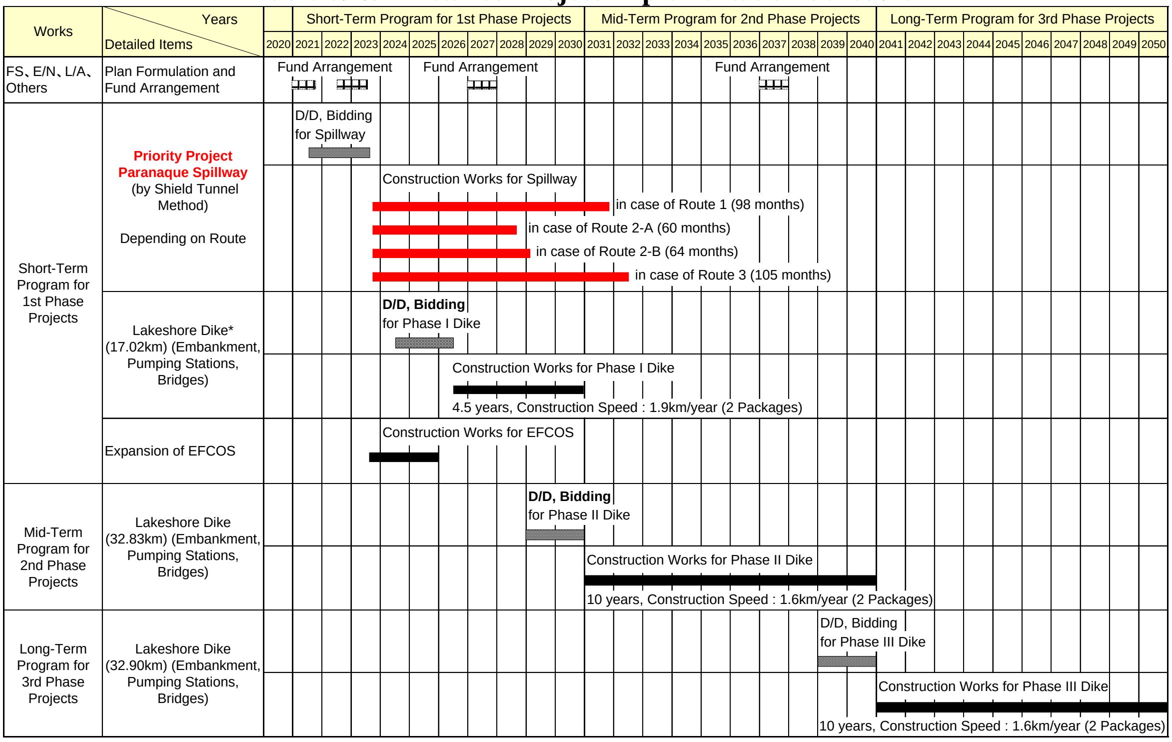
The Parañaque Spillway is expected to be completed in about 5 to 9 years (depending on route), and flood mitigation effect is expected over the entire Laguna Lakeshore Area soon after completion. On the other hand, the Lakeshore Diking System requires a lot of resettlement and land acquisition, and it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

Table 6.1.4 Project Implementation Plan

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

Source: JICA Study Team

Table 6.1.5 Detailed Project Implementation Schedule



* : At the West Mangahan Lakeshore Dike Project completed in 2007, it took about 7 years to construct a 10km Lakeshore Diking System (Average 1.4km/year).

Source: JICA Study Team

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

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

Table 6.1.6 Project Cost of Draft Comprehensive Flood Management Plan (with Climate Change、PSW D=13m、Shield)

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

Table 6.1.7 Compensation Cost under the Draft Comprehensive Flood Management Plan (with Climate Change, PSW: D=13m, Shield)

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

Table 6.1.8 Evaluation of Draft Comprehensive Flood Management Plan (with Climate Change, PSW: D=13m, Shield)

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

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

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

Table 6.1.9 Project Cost of Parañaque Spillway (with Climate Change, PSW: D=13m, Shield)

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

Table 6.1.10 Compensation of Parañaque Spillway (with Climate Change, PSW: D=13m, Shield)

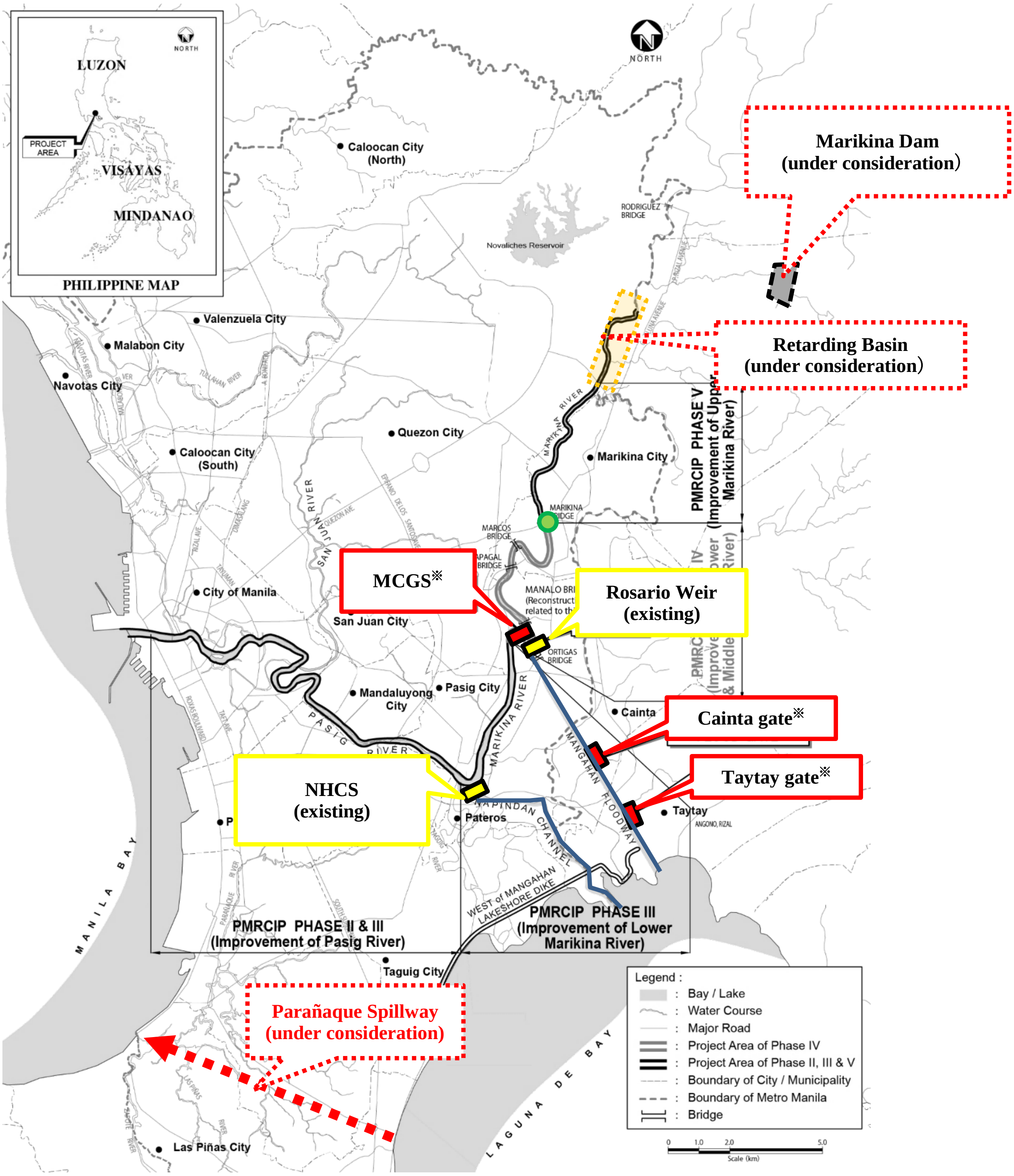
Parañaque Spillway (PSW)	Parañaque Spillway				
	Compensation Cost (million PHP)	Land Acquisition (ha)	House Evacuation (house)	Affected People (person)	Construction Period (month)
PSW (Route-1)	2,147	12.8	340	1,390	98
PSW (Route-2A)	2,882	7.7	360	1,470	60
PSW (Route-2B)	3,283	12.9	360	1,470	64
PSW (Route-3)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

Table 6.1.11 Evaluation of Parañaque Spillway (with Climate Change, PSW: D=13m, Shield)

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

6.2 Study on Integrated Operation and Maintenance of Parañaque Spillway, Rosario Weir, MCGS, etc.

The hydraulic system in the Pasig-Marikina River Basin is as shown below.



*: Scheduled to be implemented in Pasig-Marikina River Improvement Project, Phase IV

Figure 6.2.1 Hydraulic System in Pasig-Marikina River Basin

(1) Operation Rules for Rosario Weir, NHCS and MCGS

The operation rules for Rosario Weir, NHCS, and MCGS are based on the short-term flood of the Pasig-Marikina River, and these operation rules are being considered in the Pasig-Marikina River Improvement Project, Phase IV Detailed Design (DD). In addition, operation of the NHCS is being considered based on the water level of Laguna de Bay.

The operation rules of Rosario Weir, NHCS, and MCGS, which are under consideration in the Pasig-Marikina River Improvement Project, Phase IV-DD, are as shown below.

- The reference water level is at Sto. Niño. When the water level of Sto. Niño is higher than 13.8m, gates will be opened gradually. Also, when the water level is reduced, the gate operation will be performed stepwisely according to the water level at the reference point (Sto. Niño).
- NHCS is basically closed at the time of flood, and if the water level of Laguna de Bay is 11.5 m or more and the water level of Pasig River is high, there will be a backflow from Pasig River to Laguna de Bay, so that the gate will continue to be fully closed.

Table 6.2.1 Operation Rules of Rosario Weir, NHCS and MCGS

River Condition	Existing Operation Rule of Rosario Weir			Existing Operation Rule	
	Reference Discharge	Reference level (EL.)	Rosario Weir	NHCS	MCGS
Normal	< 180 m^3/s	< 13.0m	Fully closed	As before	Fully closed
During water level rise	>180 m^3/s	13.0m	Fully closed(waring)	Basically Open*1	Fully Open
	> 300 m^3/s	13.8m	No.4 gate open		
	> 300 m^3/s	13.9m	No.5 gate open		
	> 350 m^3/s	14.0-14.4m	No.3 & 6 gates open		
	> 400 m^3/s	14.5 – 15.1m	No.2 & 7 gates open		
	> 600 m^3/s	> 15.2m	No.1 & 8 gate open	Fully Closed	Wide gate will be Closed
Excess Flood	> 2,900 m^3/s	> 21.17m	Fully Open		
During Water level decrease	< 550 m^3/s	15.0 m	No. 1&8 gate close	Basically Closed*1	Fully Open
	< 450 m^3/s	14.5 m	No. 2&7 gate close		
	< 350 m^3/s	14.0 m	No. 3&6 gate close		
	< 300 m^3/s	13.8 m	No. 5 gate close		
		13.6 m	No. 4 gate close	As before	

*1 NHCS is basically closed at the time of flood, and if the water level of Laguna Lake is 11.5 m or more and the water level of Pasig River is high, there will be a backflow from Pasig River to Laguna de Bay, so the gate shall continue to be fully closed.
Source: Pasig-Marikina River Improvement Project Phase IV DD, 2019, JICA

The operation rules of Rosario Weir, NHCS, and MCGS are being considered for short-term floods (one to several days flood) in Pasig-Marikina River basin. However, the peak water level of Laguna de Bay occurs after the flooding of Pasig-Marikina River basin.

At the time of Typhoon Ondoy in 2009, the flood in Pasig Marikina River basin was from September 26 to 27, 2009 or two days (peak time was September 26, 15:00), while the water level in Laguna de Bay was at its peak. It was on October 5, 2009 (lake water level: 13.83m) that Laguna de Bay peaked for about one week after the flood peak in the Pasig-Marikina River basin.

Thus, while the floods in Pasig-Marikina River basin are "short-term floods," rising water levels in Laguna de Bay have different characteristics ("long-term floods").

Since the water level of Pasig-Marikina river is affected by the water level of Laguna de Bay, it is necessary to operate Rosario Weir and NHCS considering not only the water level of Pasig-Marikina River, but also the water level of Laguna de Bay.

Therefore, in this study, long-term water level fluctuations in Laguna de Bay were also taken into consideration, and Pasig-Marikina River Basin and the lakeshore areas were integrally analyzed in order to understand the impacts to the Pasig-Marikina River basin in the 100-year return period of Laguna de Bay.

On the other hand, the operation and maintenance of Parañaque Spillway is intended for long-term floods in Laguna de Bay. The Parañaque Spillway will operate independently according to the water level of Laguna de Bay regardless of the water level of Pasig-Marikina River.

(2) Impact on Pasig-Marikina River Basin of 100-year Return Period of Laguna de Bay

The lake water level of 100-year return period is 14.5m and the high lake level continues for a long time (12.5m or more continues for about 4 months).

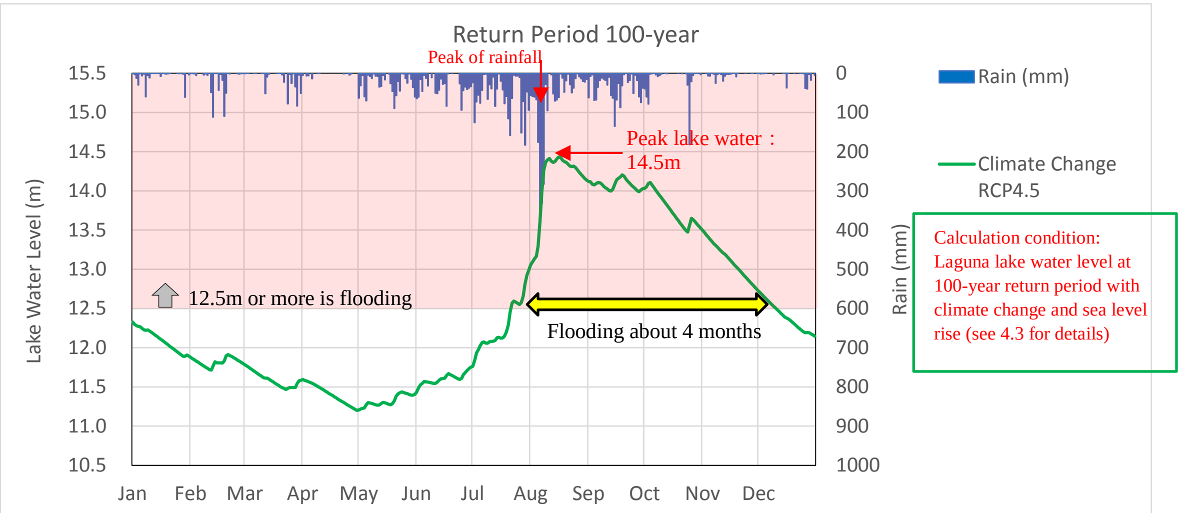


Figure 6.2.2 Lake Water Level with 100-Year Return Period (With Climate Change)

The gates of Rosario Weir, NHCS, etc., are operated according to the water level at Sto. Niño point on Marikina River (marked by green circle in Figure 6.2.1). When the water level at Rosario Weir decreases to 15.0 m at the Sto. Niño point, the gate is gradually closed, and when the water level at Sto. Niño is decreased to 13.6 m, the gate is fully closed.

However, due to the Laguna Lake water level fluctuation of 100-year return period (Figure 6.2.2), the period when the water level of Laguna de Bay is 13.6 m or more is about 3 months, and in the case of the above, the gates of Rosario Weir during floods in Pasig-Marikina River basin will be fully closed for about 3 months after the water level of Laguna de Bay decreases to 13.6 m.

When the water level in Laguna de Bay is high, backflow occurs from Laguna de Bay through Mangahan Floodway to Marikina River. Therefore, the water level at Sto. Niño will remain high even after floods in Pasig-Marikina River basin due to the influence of lake-water level.

Figure 6.2.3 shows the water level of Laguna de Bay with 100-year return period, the water level at Sto. Niño point of Marikina River, and the discharge of Manggahan Floodway.

- Due to the high water level in Laguna de Bay, lake water flows backward from Manggahan Floodway (flows from Laguna de Bay to Marikina River through Manggahan Floodway), and the water level at Sto. Niño remains high even after floods in Pasig-Marikina River basin. The gates of Rosario Weir will not be closed.
- Between February and July when the water level of Laguna de Bay is low, but flood occurs in Pasig-Marikina river basin, the Rosario Weir is operated. The gate is closed when the water level of Marikina River is low.

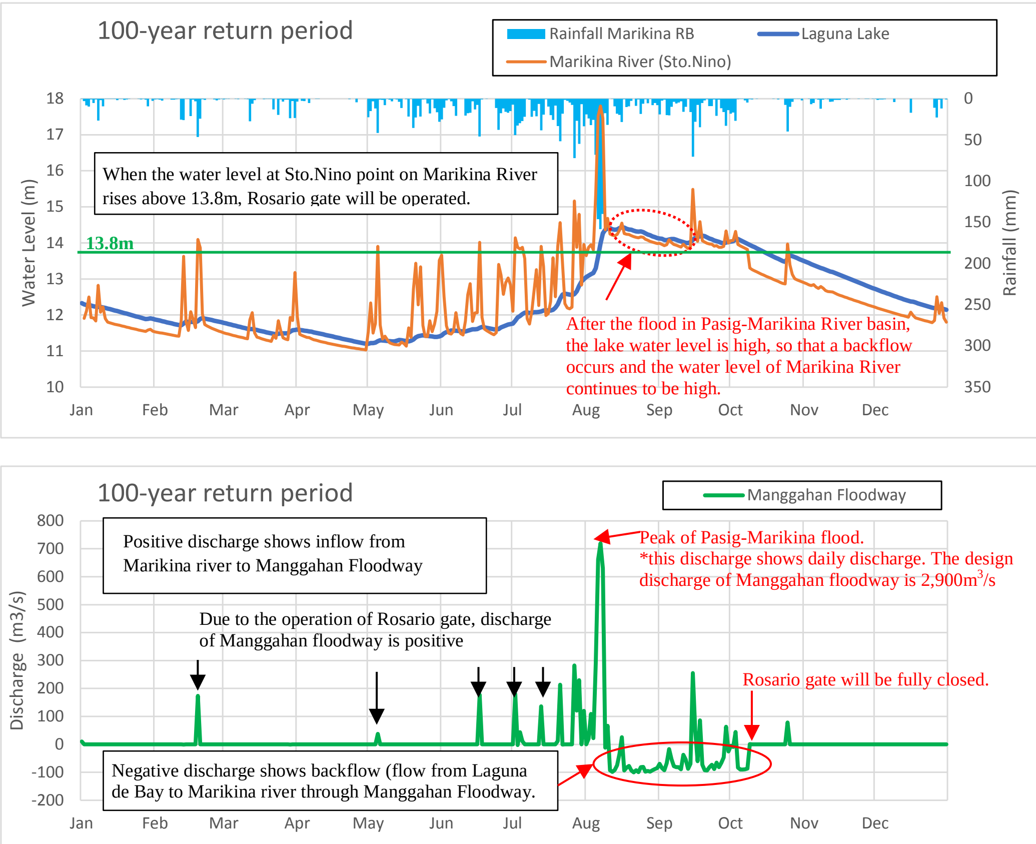


Figure 6.2.3 Lake Water Level, Marikina River Water level and Manggahan Floodway Discharge with 100-year Return Period (with climate change)

In addition, based on the cross section of Rosario Weir (Fig. 6.2.4), the gate crown height is 14.0 m when the Rosario Weir is fully closed. Therefore, even if the water level of Laguna de Bay is high, when floods in the Pasig-Marikina River basin occur, water will overflow from the gate top of Rosario Weir and back into the Pasig-Marikina River.

In the Pasig Marikina River Improvement Project, Phase IV-DD, the operation rules of Rosario Weir and NHCS in a short-term flood are planned at the Laguna lake water level of 13.8 m.

Therefore, if the water level of Laguna de Bay is higher than 13.8 m and Rosario Gate is open, the water level at Sto. Niño will also be high due to the effect of lake-water level. If flooding of Pasig-Marikina River basin occurs in this condition, the river water level will be higher than the water level at the beginning of flooding. There is therefore a possibility that the Pasig-Marikina River basin is inundated even with rainfall below the design flood.

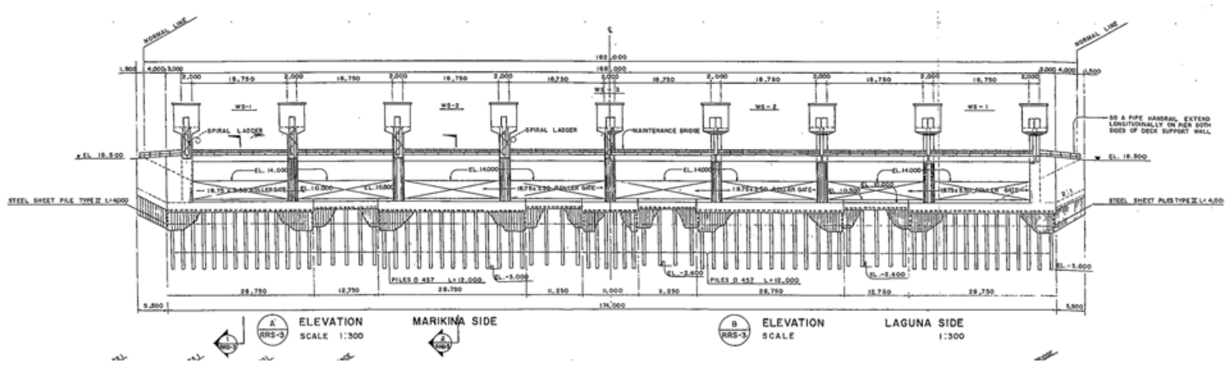


Figure 6.2.4 Cross Section of Rosario Weir

(3) Issues of Rosario Weir and NHCS on Long-Term Floods in Laguna de Bay

1） Rosario Weir

As mentioned above, since the lake water level with a 100-year return period is 14.5 m, the lake water level may affect the flood control plan for Pasig-Marikina River basin under the current development conditions. After implementation of Parañaque Spillway, it is possible to reduce the water level of Laguna de Bay to the level of 13.8 m or less with a 100-year return period.

On the other hand, when the lake water level is 12.5 m or more, the backflow from Laguna de Bay to Marikina River through the Manggahan Floodway is effective for lowering the lake water level (see Figure 6.2.3). In this present study, the operation rule of Rosario Weir was not examined from the viewpoint of "the function of lowering the water level of Laguna de Bay". In the future, it is necessary to consider the operation of Rosario Weir based on the lake-water level.

2） NHCS

NHCS has a planned water level of 13.8m with 0.3m freeboard, and a parapet wall height of 14.1m. In the Parañaque 2018 Survey. The latest cross section survey of Napindan Channel was in 2002.

According to the 2002 Napindan hydrographic survey results, the height of the parapet wall is planned to be lower than those planned in some sections. Therefore, if the lake water level is high, water will overflow from this notch. In the future, it is necessary to scrutinize the condition of Napindan Channel, and repair shall be executed.

6.3 Operation Rule of Parañaque Spillway

According to the results of this study, the operation rules of Parañaque Spillway (especially starting water level) are based on the following plan, in principle.

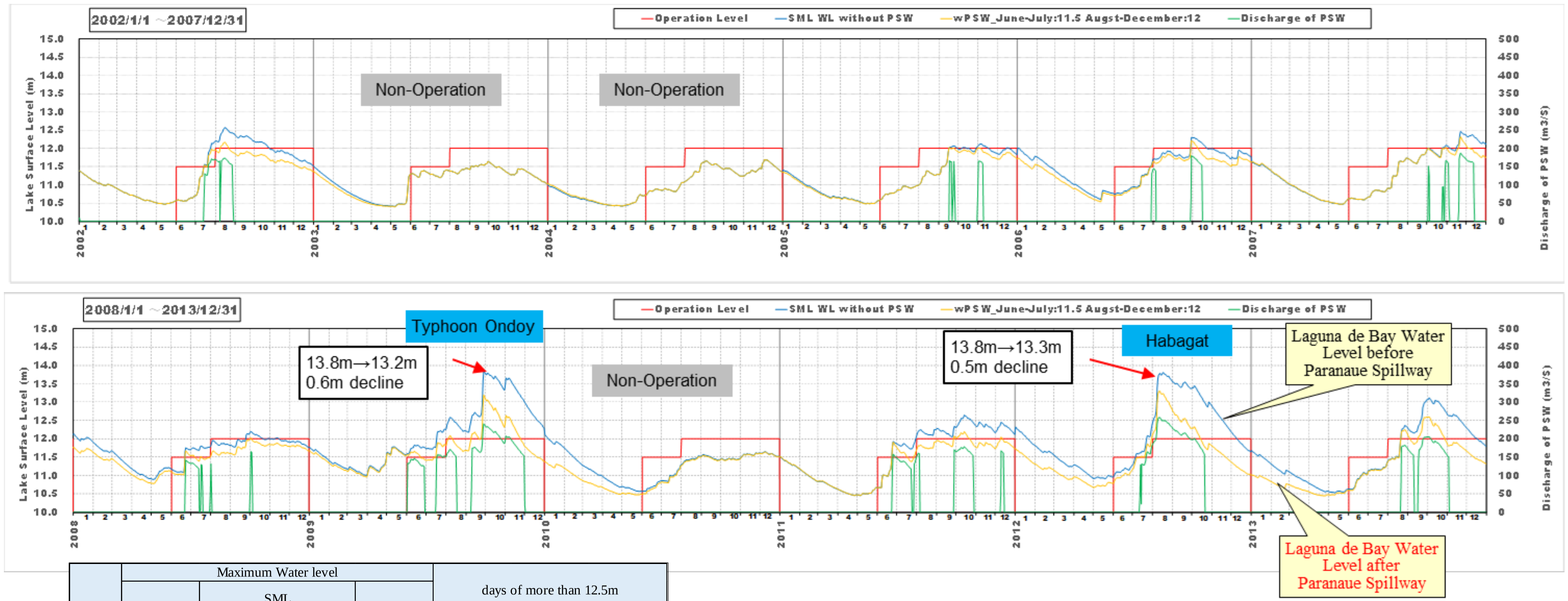
Operation Start Water Level of Parañaque Spillway

January to May (Non-Flood Season):	Non-Operation
June to July (Pre-Flood Season):	11.5m
August to December (Flood Season):	12.0m

Figure 6.3.1 shows the results of the Laguna de Bay water level fluctuation analysis for 12 years, including 2009 and 2012, when large inundation damages occurred. Table 6.3.1 shows the number of operation and operating days of Parañaque Spillway.

Table 6.3.1 Number and Days of Flood Occurrence (2002 to 2013: 12-Year Period)

Year	June to July (61 days)		August to December (153 days)		Yearly (From June to December: 214 days)		
	Frequency	Flooding Days	Frequency	Flooding Days	Frequency	Flooding Days	% of Flooding Days
2002	1	18	0	27	1	45	21.0%
2003	0	0	0	0	0	0	0.0%
2004	0	0	0	0	0	0	0.0%
2005	0	0	3	18	3	18	8.4%
2006	1	3	1	22	2	25	11.7%
2007	0	0	4	36	4	36	16.8%
2008	2	27	2	6	4	33	15.4%
2009	2	44	1	101	3	145	67.8%
2010	0	0	0	0	0	0	0.0%
2011	2	35	2	42	4	77	36.0%
2012	1	20	0	81	1	101	47.2%
2013	1	0	1	69	2	69	32.2%
Total	10	147	14	402	24	549	21.4%
Average	0.8	12.3	1.2	33.5	2.0	45.8	21.4%



	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	12.6	12.6	12.2	0.4	8	0	8
2003	11.7	11.6	11.6	0.0	0	0	0
2004	11.9	11.7	11.7	0.0	0	0	0
2005	12.2	12.1	12.0	0.1	0	0	0
2006	12.3	12.3	12.2	0.1	0	0	0
2007	12.5	12.5	12.3	0.1	0	0	0
2008	12.1	12.2	12.0	0.2	0	0	0
2009	13.9	13.8	13.2	0.6	110	38	72
2010	12.1	12.1	11.6	0.5	0	0	0
2011	12.7	12.7	12.2	0.5	17	0	17
2012	13.8	13.8	13.3	0.5	108	42	66
2013	13.0	13.1	12.6	0.5	62	12	50
Min	**11.7**	**11.6**	**11.6**	**0.0**	**0**	**0**	**0**
Ave	**12.6**	**12.5**	**12.3**	**0.3**	**25**	**8**	**18**
Max	**13.9**	**13.8**	**13.3**	**0.6**	**110**	**42**	**72**

Figure 6.3.1 Results of Laguna Lake Water Level Fluctuation Analysis (2002-2013)

Operation start water level June-July: 11.5m, August-December: 12.0m Tunnel inner diameter, D=13m, Climate Change

The results of Table 6.3.1 are as summarized below:

- The Parañaque Spillway has been in operation for 9 of the 12 years considered.
- In 12 years, the Parañaque Spillway has an average number of operations twice a year and 46 days a year (21% of 214 days)'
- The average number of operation days in June and July is 0.8 (Total number of operation days is 12), and from August to December, the average number of operation days is 1.2 (Total number of operation days is 34).
- The maximum number of operation days in 2009 is 145 days (68% of 214 days).

From June to December, the Parañaque Spillway needs to be in service. However, it is necessary to consult with the facility administration to determine whether the gates are always open during the period or whether the gates will be opened and closed only during floods. Decisions need to be made and shall be discussed in the future.

At this time, in order to minimize the impact on the water environment (for fish resources) and to prevent the accumulation of aquatic plants, it is proposed to open and close the gate when the water level reaches the operation start level. Unlike river flooding, the rise in Laguna Lake water level is a matter of days and there is enough time to open and close the gate. On the other hand, if the gate is always open, some water will always flow down from Laguna de Bay to Manila Bay. As a result, the environmental load is expected to increase and this has to be avoided.

In addition to the above, "Design Discharge, Qp = 240m^3/s" is set as the flood management plan, but its operation and control rule have the following issues and hence a study is necessary for future projects;

- Flow Control for Available Flow Capacity and Low Tide of Manila Bay

  At present, the design average water level in Manila Bay is planned to be MSL 10.47m + 0.2m (Climate Change, Sea Level Rise) = 12.5m and the available flow capacity is 268 m^3/s at this water condition. In addition, in the case of Manila Bay at low tide (MLLW: 10.0m), the discharge will further increase. Therefore, it is necessary to review the facility design flow volume or study the control method for future projects.

- Correspondence to Cross Section Increase Ratio

  In this project, "10% of cross section increase ratio" is adopted in the facility design in consideration of air mixing, reduction of flow capacity by sedimentation, and deterioration of the lining surface due to aging. Therefore, it is necessary to determine responses to the flow rate increase in addition to the flow rate change due to low tide and other conditions. It is desirable to review the facility design discharge (increase of flow) as a proposal for the current countermeasures. However, it is necessary to consider the capacity of the downstream drainage rivers, which is an issue in future projects.

- Desirable Gate Structure

  In the present design, flow control is by the gate (roller gate) control planned for intake and drainage facilities. However, at the roller gate, there is an underflow discharge, and there may be "the problem of vibration due to discharged water". (The Pasig-Marikina River Project has adopted the fully-open discharge gate confirmed by hydraulic model tests, considering that it is difficult to handle both hydraulically and during flood operation.) Therefore, as measures to cope with this condition, the following shall be examined: (i) the shape of lower edge of gate (to be confirmed by hydraulic model test and others); (ii) change of gate structure (tilting gate, parent-child gate and others); and (iii) adoption of a control sub-gate. After comparative study, it may be necessary to change the facility plan and design.

Based on the above-mentioned reasons regarding the method of operation of Parañaque Spillway and after the flood management plan has been finalized, a study on issues shall be implemented for future projects, including the change of facility plan and maintenance management rules.

6.4 Position of Parañaque Spillway Project in Sustainable Development and Environmental Conservation

The Laguna de Bay is variously utilized for irrigation water, hydropower generation, industrial water (cooling), source of domestic water supply, etc. Moreover, the lake is used for inland fishery (open fishery and fish-pen operation), water transport, etc., and lake services to the surrounding communities.

Laguna de Bay Basin is adjacent to southeastern Metro Manila and provides rich resources. The Basin plays an important role in national development and economics because of its proximity to Metro Manila, and has also received the expansion of population, housing and industry in Metro Manila.

Due to the expansion of Metro Manila, rapid increase in population and development in the lake and lakeshore areas cause problems and issues such as the decrease in lake water quality, due to domestic and industrial wastes into the lake and increase in flood damage, etc.

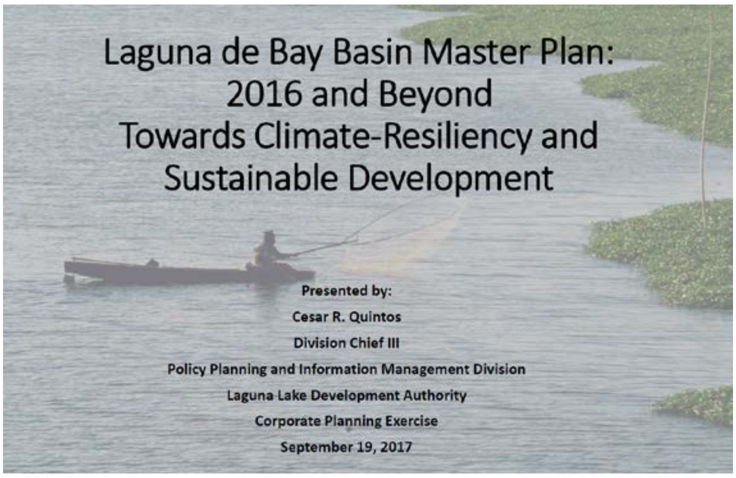
Source : LLDA

Figure 6.4.1 Rapid Increase in Population and Development in Lakeshore Area

Source : LLDA

Figure 6.4.2 Laguna de Bay Inland Fishery and Decrease in Lake Water Quality

The LLDA had updated the master plan prepared in 1995, the Master Plan: 2016 and beyond – Towards Climate-Resilience and Sustainable Development in December 2015. From the long list of issues and problems discussed in the said updated master plan, the vulnerability of lakeshore settlements and developments to flood hazards and related health and economic risks were prioritized as the most critical for basin administrative authorities to address given the influence and control of contributing factors, impact on the lake, and urgency.



Source : LLDA

Figure 6.4.3 Laguna de Bay Inland Fishery and Decrease in Lake Water Quality

The Parañaque Spillway Project matches the above and is positioned as the most important innovation to support safety and stability in people's lives and economic activities along the lakeshore area. Moreover, the project can support the mitigation of floods in the center of Metro Manila, together with the operation of the existing Manggahan Floodway.

Increase in damage by natural disasters caused by climate change is a serious issue that cannot be overlooked in aiming for sustainable development. However, the Parañaque Spillway would also be very effective in the mitigation of increase in lake-water level caused by climate change, resulting in reduction of flood damage.

In order to ensure the sustainable effectiveness of the Parañaque Spillway, the LLDA is obliged to regulate and lead properly the developments in the lake and lakeshore area through the full involvement of all stakeholders such as agencies concerned, residents, people organizations, and NGOs.

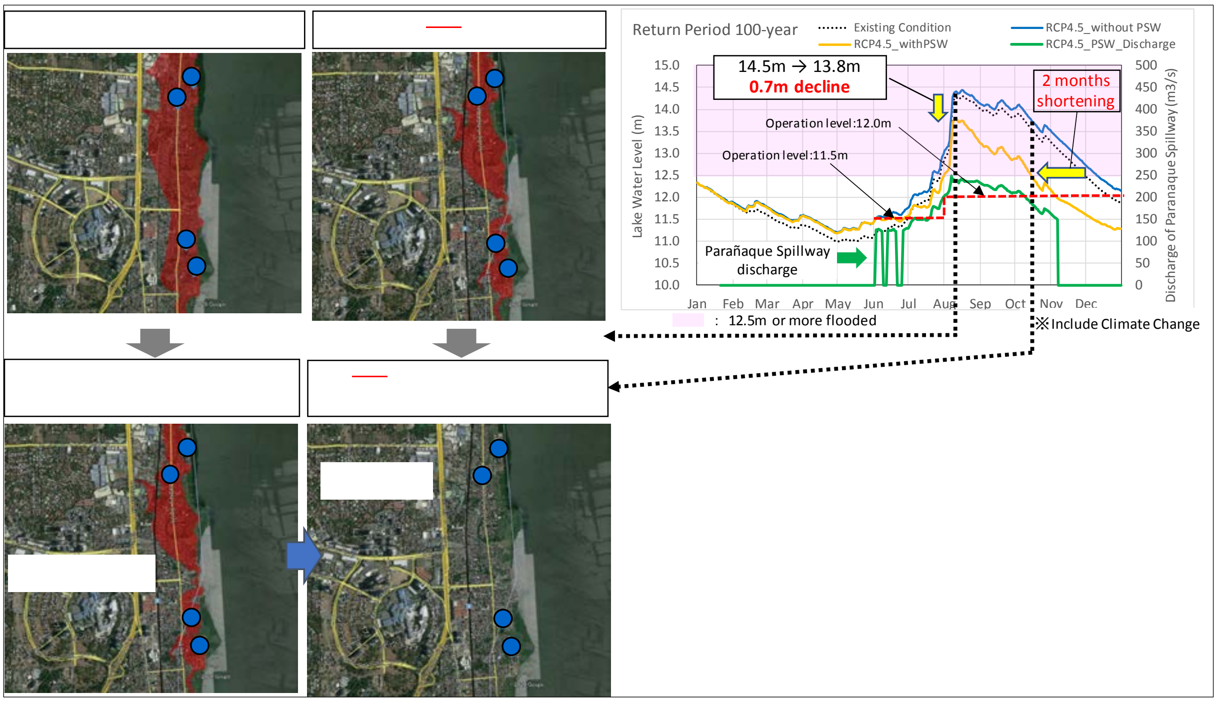
6.5 Study and Proposal of Method of Presenting the Project Effect of Parañaque Spillway

6.5.1 Easy-to-Understand Project Effects of Parañaque Spillway

(1) Effect of Parañaque Spillway in 100-Year Probability of Water Level

The 100-year probable water level will be reduced from 14.5 m to DFL 13.8 m by the development of Parañaque Spillway. From this, the inundation area above 12.5 m is reduced by 32.5 km^2 from 98.6 km^2 without the Parañaque Spillway. to 66.1 km^2. The inundation period is shortened by 2.3 months from 4.8 months to 2.5 months, and the inundation damage population is reduced by 340,000 people from 853,000 to 513,000. Economic and social damages are greatly reduced (refer to Table 6.5.1, Figure 6.5.2 and Figure 6.5.3).

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



Source: JICA Study Team

Figure 6.5.1 Image of Mitigating Inundation Damage by Effect of Parañaque Spillway

Table 6.5.1 Effect of Parañaque Spillway against Probable Flood

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

Source: JICA Study Team

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

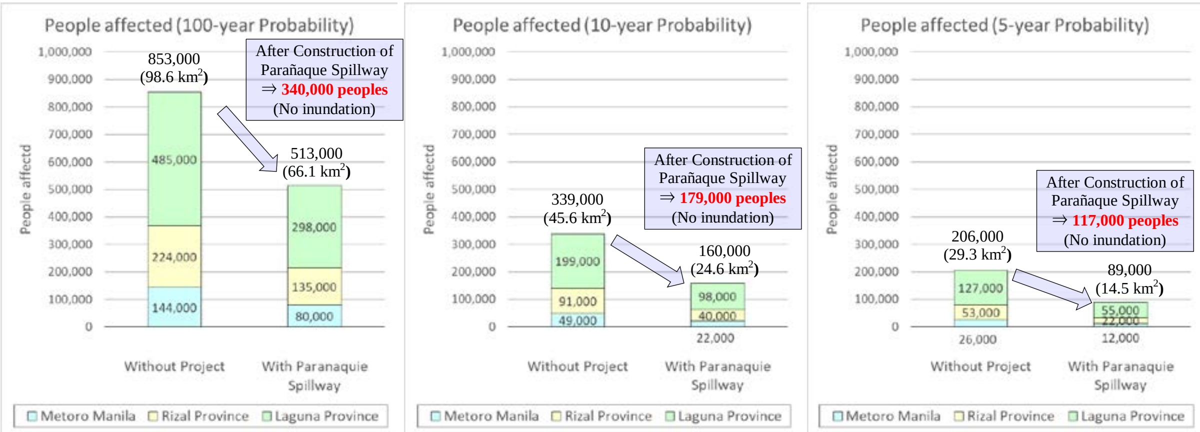


Figure 6.5.2 Reducing Inundation Population by Effect of Parañaque Spillway

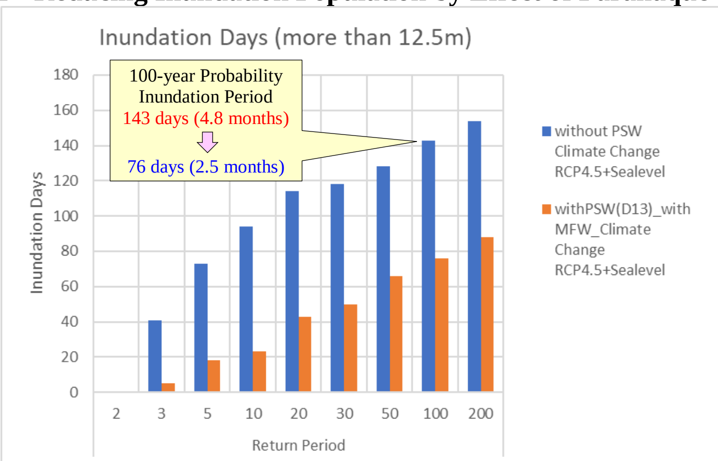


Figure 6.5.3 Reducing Inundation Period by Effect of Parañaque Spillway

(2) Effect of Parañaque Spillway during Typhoon Ondoy in 2009

Figure 6.5.4 to Figure 6.5.6 show the effects of Parañaque Spillway, such as water level reduction, inundation period reduction, and inundation population reduction during the 2009 Typhoon Ondoy. The maximum lake water level was 13.85 m during tTyphoon Ondoy in 2009. With Parañaque Spillway, the lake water level will decrease by approximately 60 cm to 13.2 m. The inundation period is shortened from 110 days (about 4 months) to 38 days, and the inundation population is reduced from 544,000 to 249,000 by 295,000, greatly reducing economic and social damage.

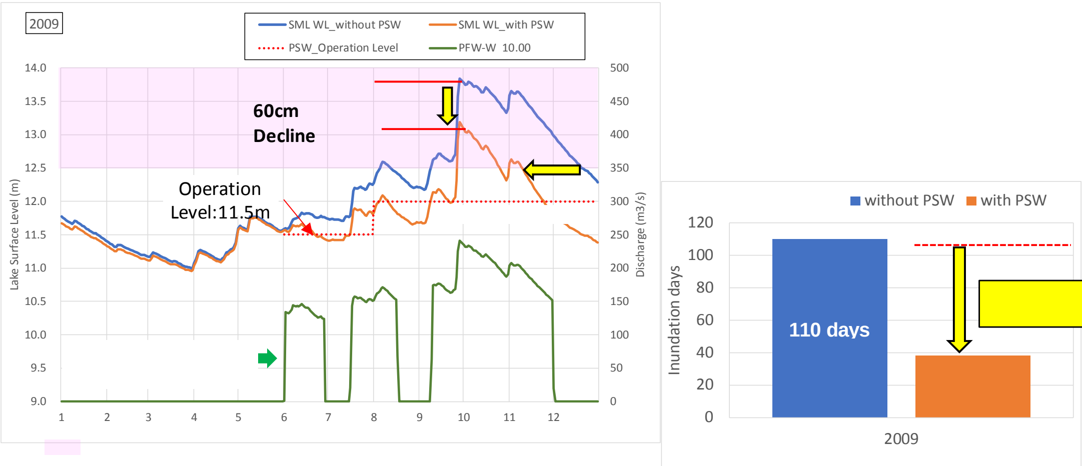


Figure 6.5.4 Reduction of Water Level and Inundation Period Effect of Parañaque Spillway (2009 Situation)

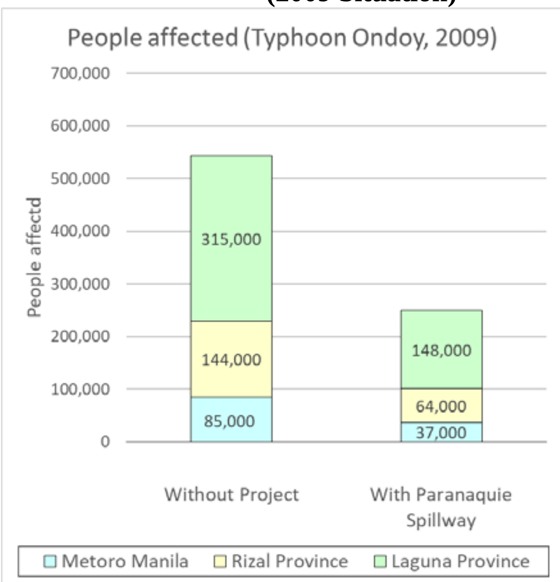
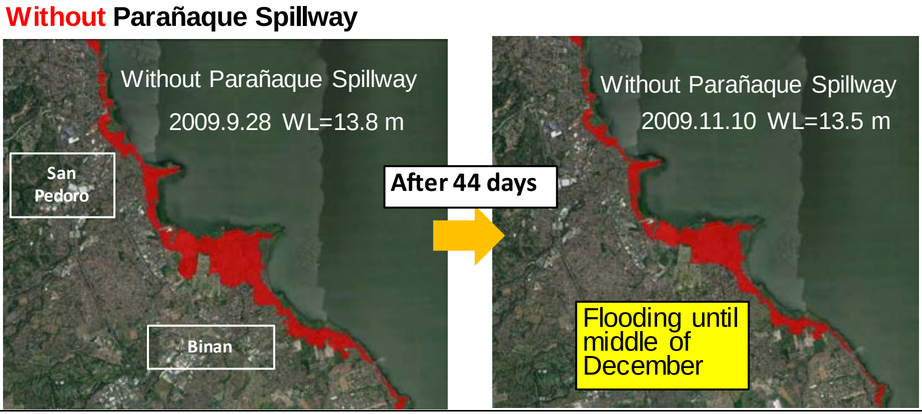


Figure 6.5.5 Reduction of Inundation Population Effect of Parañaque Spillway (2009 Situation)

Without Parañaque Spillway
Inundation Area: 66.8km^2, Inundation Population: 513,000, Inundation Period: 4 months



With Parañaque Spillway
Inundation Area: 34.7km^2, Inundation Population: 249,000, Inundation Period: 1.3 month

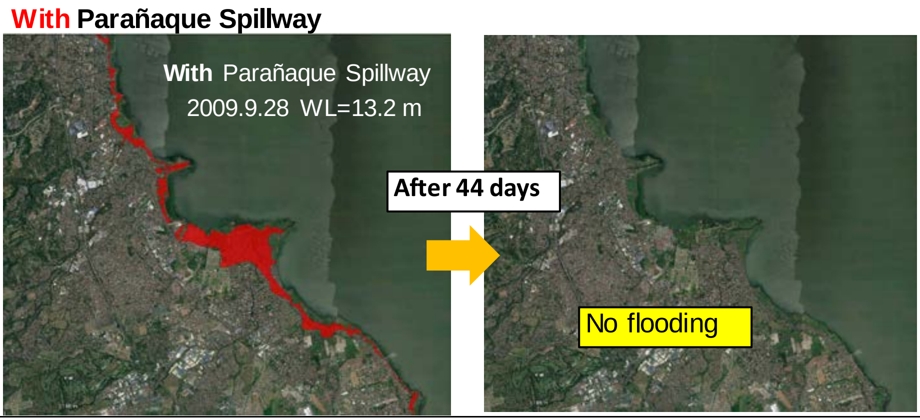


Figure 6.5.6 Reduction of Inundation Damage Area Effect of Parañaque Spillway (2009 Situation)

6.5.2 Clarification of Allowable Inundation Area and Allowable Level

Although Parañaque Spillway will contribute to the reduction of inundation depth and inundation period along the lakeshore area, it will not reduce the inundation damage to zero. However, if the lakeshore diking system is implemented (Phase I to Phase III sections), inundation in the implementation sections will be zero, but inundation damage will still occur on the east side of Laguna de Bay.

For this reason, **it would be necessary to take measures to protect human lives and minimize inundation damage by combining, not only structural measures (hard measures), but also non-structural measures (soft measures).**

Table 6.5.2 Allowable Area and Allowable Level of Priority Project (Parañaque Spillway) and Comprehensive Flood Control Plan (Draft)

Category	Structural Measures	Nonstructural Measures	Allowable Area	Allowable Level
Priority Project	Parañaque Spillway	Strengthen early warning system, create / share flooded area map, etc.	• All areas are covered except the West Mangahan lakeshore dike Area	• Since lake-water level with 100-year return period will be 13.8 m, housing, offices, schools, etc., less than 13.8 m will be inundated by up to 1.3 m. • The maximum flooding period for a 100-year flood is 1.2 months

Category	Structural Measures	Nonstructural Measures	Allowable Area	Allowable Level
				(1.2 months of flooding at an altitude of 12.5 m).
Comprehensive Flood Control Plan (Draft)	Parañaque Spillway Lakeshore Diking System	Strengthen early warning system, create / share flood area map, etc.	• Areas where the lake bank system is not implemented • Target LGUs are shown in Chapter 4 (4.6.3), 6th prioritize area and 7th prioritized area.	• In West Mangahan area and lakeshore diking system implemented area (Phase1 to Phase3), inundation damage will be zero until 100-year flood due to the effect of Parañaque spillway and lakeshore diking system. • As shown in the priority project category, the east side of Laguna de Bay, where lakeshore diking system is not implemented, has a maximum flooding period of approximately 1.2 months and a maximum flooding depth of 1.3 m in a 100-year flood.

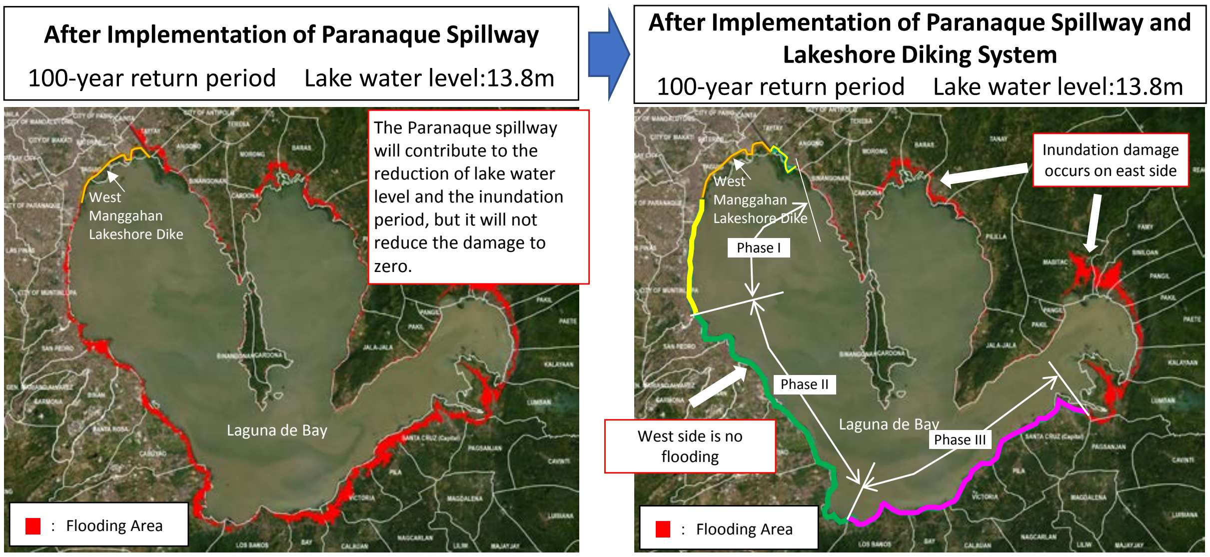


Figure 6.5.7 Image of Mitigation of Inundation Damage after Construction of Parañaque Spillway and the Completion of Parañaque Spillway and Lakeshore Diking System

Figure 6.5.8 and Figure 6.5.9 show the inundation population and the inundation area when the Parañaque Spillway (priority project) and the Parañaque Spillway and Lakeshore Diking System are implemented [Comprehensive Flood Control Plan Full Menu (Draft)].

- Population affected by a 100-year return period of inundation is about 850,000 in total without structural measures (current situation). The implementation of Parañaque Spillway, which is a priority project, will reduce inundation population to approximately 340,000 from 510,000 In addition, the implementation of lakeshore diking system, inundation population will be approximately 110,000, which is approximately 740,000 reduction compared to before the structural measures are implemented [Figure 6.5.8 (1)].
- In the flood damage population by province in Metro Manila [Figure 6.5.8 (2) to (4)], the flood damaged population without Parañaque Spillway is about 140,000, and about 80,000 with Parañaque Spillway. (Reduction of inundation population of 60,000 people). If the lakeshore diking system (Phase 1 section) is constructed, the inundatedion population will be zero.
- Regarding the inundation area (Figure 6.5.9), it is approximately 98.6 km^2 without structural measures (current situation). The area will be reduced to 66.1 km^2 by the Parañaque Spillway and 26.7 km^2 by the lakeshore diking system. The inundation area will be eliminated at the west side,

because the lakeshore diking system is planned to be implemented in the populated area (Phase 1 to 3). However, inundation damage will remain in the east side of Laguna de Bay [Figure 6.5.9 (2) to (4)]

- In the coastal area on the east side of Laguna de Bay where lakeshore diking system is not planned, it is not the residential area that receives flood damage, but mainly the agricultural land.

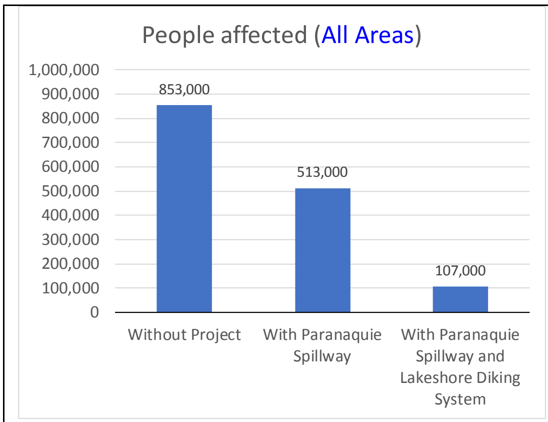


Figure 6.5.8 (1) Inundated population in all regions

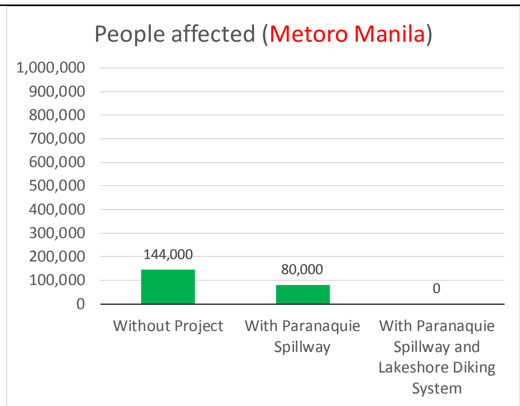


Figure 6.5.8 (2) Inundated population in Metro Manila

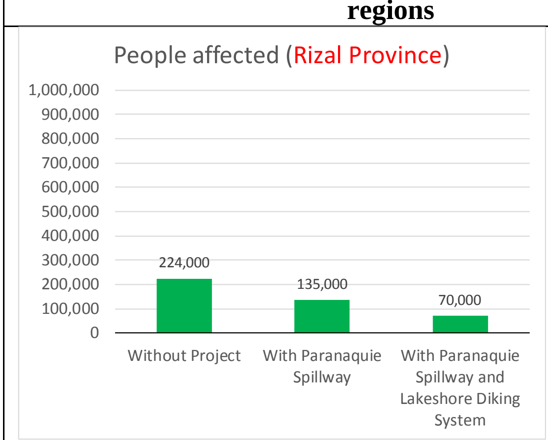


Figure 6.5.8 (3) Inundated population in Rizal Province

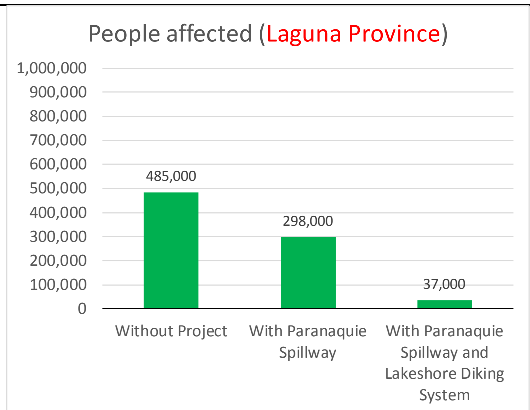
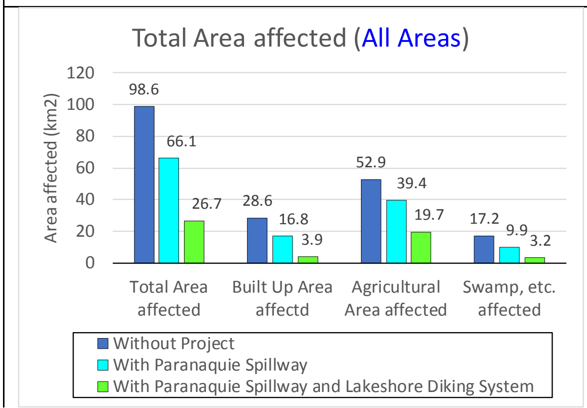


Figure 6.5.8 (3) Inundated population in Laguna Province



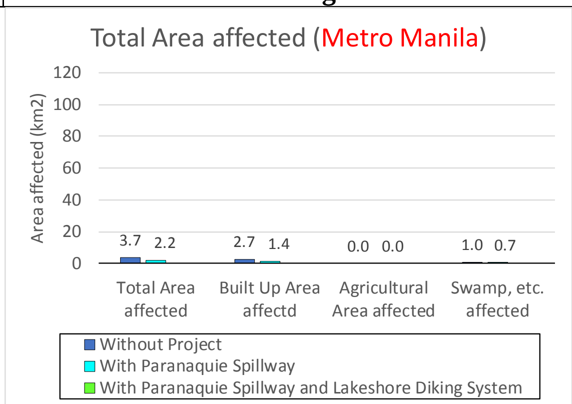


Figure 6.5.9 (1) Inundation Area	**Figure 6.5.9 (2) Inundation Area in Metro Manila**

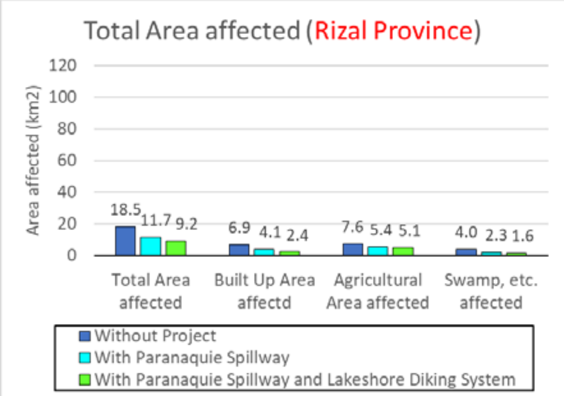


Figure 6.5.9 (3) Inundation Area in Rizal Province

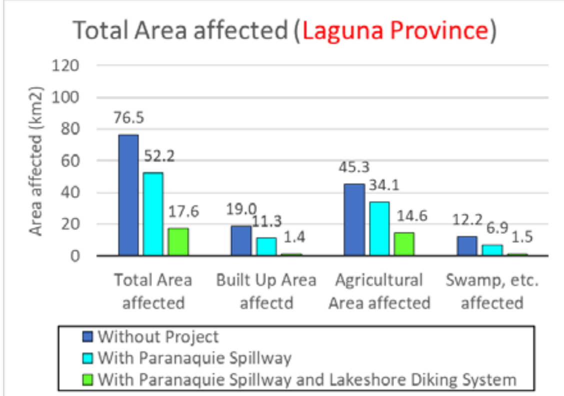


Figure 6.5.9 (4) Inundation Area in Laguna Province

6.5.3 Non-Structural Measures after Parañaque Spillway Construction

As mentioned above, inundation damage will not be reduced to zero by the construction of Parañaque Spillway. Therefore, even after Parañaque Spillway is constructed, the warning system shall be strengthened as a non-structural measure, and the inundation area map created and shared, so that the combination of hard measures (Parañaque Spillway) and soft measures will save human life and minimize economic damage.

Table 6.5.3 Non-Structural Measures after Parañaque Spillway Construction (Draft)

Non-Structural Measure	Target Area	Contents
Non-structural measures for operation of Parañaque Spillway	Inflowing river (Intake facility) Drainage destination river	• Laguna lake water level observation • Water level observation of inflowing and draining rivers • Issuing an alarm regarding the operation of Parañaque Spillway • Construction of information network for operation of Parañaque Spillway
Non-structural measures for raising the water level of Laguna Lake	Lakeshore Area	• Lake water level observation • Issuing an alert regarding the rise of water level in Laguna de Bay • Construction of information network • Installation of flood related signs, etc., that clearly indicate the estimated inundation depth, and creation and sharing of the inundation expected area map due to the rise of water level in Laguna de Bay • Evacuation planning, sharing, and evacuation training

Warning System for Lake Level Rise (Existing)	
• Warning system installed in "Sucat People's Park" in Sucat, Muntinlupa • According to an on-site interview survey, it is managed by the city and installed last year (2019), and warning is issued when Laguna Lake water level rises.	 Source: JICA Study Team（2020/02/13）

①Non-structural measures for the operation of Parañaque spillway (soft measures)

- Water level observation related to the operation of Parañaque spillway
- Issuance of warning regarding the operation of Parañaque spillway
- Construction of an information network on the operation of the Parañaque spillway

② Non-structural measures for raising Laguna de Bay water level

- Lake level observation
- Issuing warning about the rising of Laguna de Bay water level
- Construction of information network
- Creation and sharing of hazard map
- Evacuation planning, sharing, and evacuation training

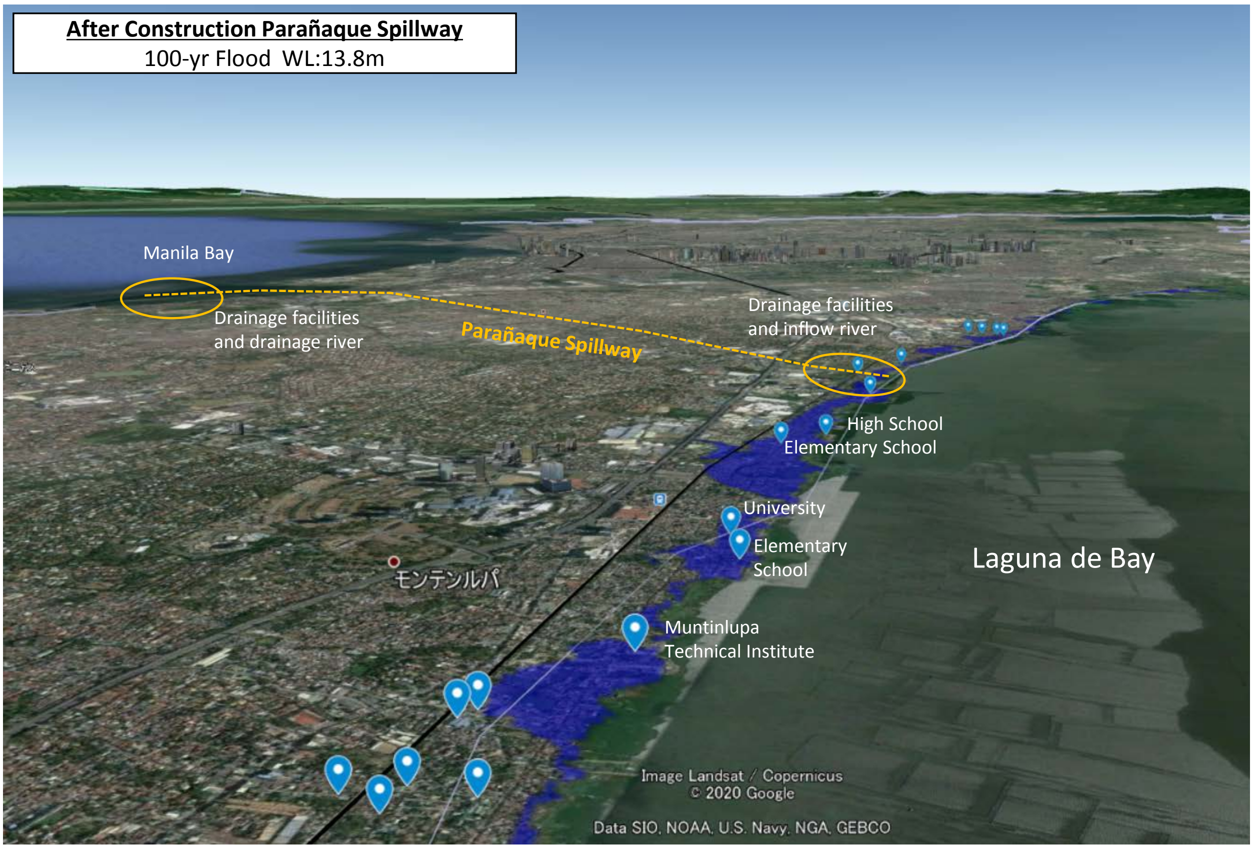


Figure 6.5.10 Non-Structural Measures after Parañaque Spillway Construction (Draft)

6.6 Environmental Impact Assessment of Parañaque Spillway Project during F/S

6.6.1 Summary of Potential Environmental Impact of Parañaque Spillway

Data collection for environmental settings has been undertaken and the existing situation of the project site was confirmed through reconnaissance during the Parañaque 2018 Survey. The following summarizes the survey results as well as potential impacts of Parañaque Spillway on the environment.

(1) Existing Environmental Settings

1) Natural Environment

Water Quality of Manila Bay

Water of Manila Bay is contaminated with human waste, sewage, and industrial effluent, according to water quality reports issued by the Department of Environment and Natural Resources (DENR) and the Bureau of Fisheries and Aquatic Resources (BFAR). Water quality data in 2017 indicates that dissolved oxygen, fecal coliform, oil and grease, chromium and lead do not meet the Class SC standard under DAO 2016-08. Class SC is the standard for seawater available for commercial fishing and recreation, as well as mangrove areas declared as wildlife sanctuaries.

The number of fecal coliform, among others, is considerably large. It is more than one million times larger than the standard value of Class SC, comparable to untreated wastewater. The contamination is attributed to intrusion of wastewater from the coastal urban area, including effluent from the informal settlers along rivers and beaches who directly dispose their wastes into Manila Bay.

The low dissolved oxygen (DO) in Manila Bay is not suitable for fishes. In addition, toxic substances, oil and grease, chromium, and lead exceeded the standard according to the survey in May 2017, which is attributed to industrial effluent.

Water Quality of Laguna de Bay

Most water quality parameters of Laguna de Bay pass the Class C standard in DAO 2016-08, meaning that the lake is available for fishing although some parameters of inflowing rivers fail to meet the standard according to LLDA’s water quality reports. Class C is the standard for freshwater, which is the indicative standard suitable for fishery, boating, fishing, agriculture and livestock watering.

The measurement results in 2016 and 2017 show that DO is enough for fishes and phosphate-phosphorus, and nitrate meets Class C. Among the measured parameters, only ammonia fails the Class C standard. Human waste that enters through tributaries in the urban area on the west and north-west side of the lake is thought to be the major cause of high ammonia concentration.

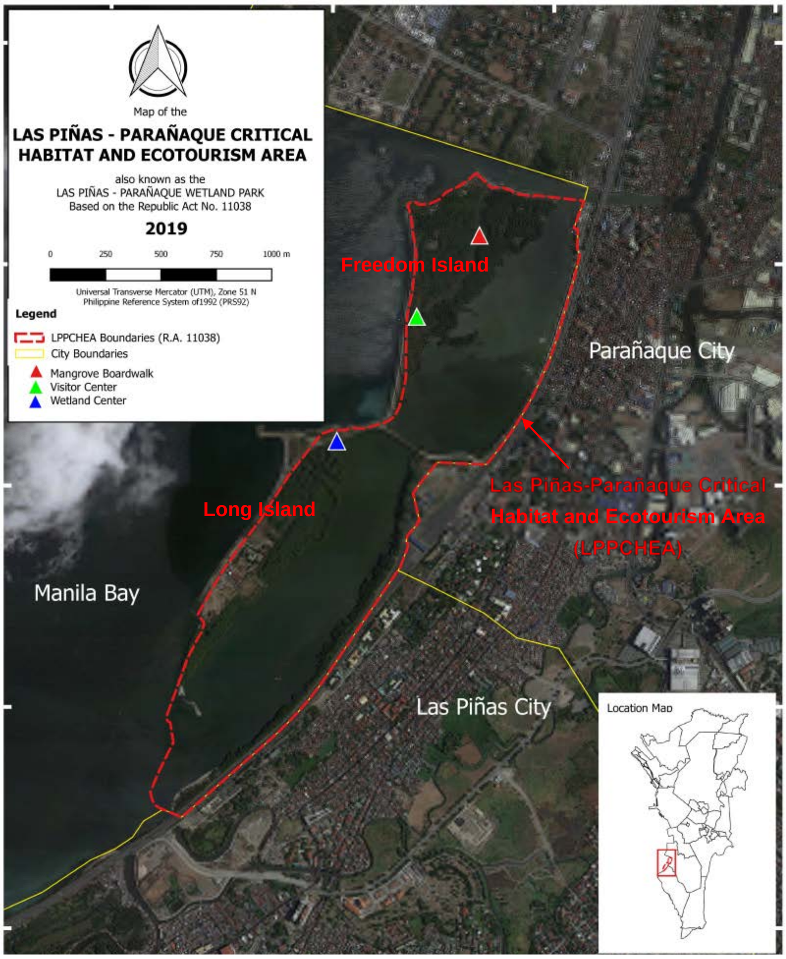
Protected Area (LPPCHEA)

The Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA), a protected area designated by Philippine law, is located in the Manila Bay off-shore of the candidate rivers, where drainage water from Parañaque Spillway is to be released. The table below gives an outline of LPPCHEA.

Table 6.6.1 Outline of Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA)

Parameter	Description
Location	LPPCHEA is located in Manila Bay (Figure 6.6.1), composed of two islands, i.e., Long Island and Freedom Island, and, administratively, located in the cities of Las Piñas and Parañaque, NCR.
Area	181 ha
Designation	Designation under international treaty: Registration with the Ramsar Convention (2013) Designation under domestic law: Critical Habitat and Ecotourism Area (2007)
Flora	Twenty three (23) plant species are identified to grow as major ones in the islands. Mangrove forests, among others, growing over the area of approx. 36 ha accounting 18% of the islands, are the last ones remaining in the Manila Bay Area where development is progressing.
Aves	Owning to the 114 ha of mudflats that are abundant in bird food, molluscs and other bottom dwelling and small aquatic animals, LPPCHEA is a good habitat for avian species. In addition, a lot of migratory birds visit the protected area as an overwintering site from August to April and number of birds amount to 5,000. Based on the survey by DENR in 2004 to 2008, 44 species of birds roosted in LPPCHEA. Twenty-nine (29) of these species were migratory birds and include Egretta eulophotes, an endangered species. The other 15 species were resident birds that include another endangered species, the Philippine Duck.
Fish and Macro-Invertebrate	Vast mudflats around LPPCHEA, many macro-invertebrates and fish species live. Macro-invertebrates include polychaetas represented by mud worms, crustaceans and molluscs. Molluscs are the most abundant, and they include 23 species of bivalves and 14 species of gastropods. Eight (8) species of juvenile to sub-adult are also found near LPPCHEA, which indicates the significant function of mangroves as spawning grounds, nursery, feeding and temporary shelter.

Source: Parañaque Survey, 2018



Source: DENR-NCR

Figure 6.6.1 Location Map of Las Piñas-Parañaque Critical Habitat and Ecotourism Area

2) Social Environmental Setting

Current Status near the Candidate Sites of Intake Facility and Open Channel

There are two candidate sites of intake facility and open channel. Candidate Site No. 1 is located in Barangay Lower Bicutan, Taguig City, in which the Taguig Lakeshore Hall and its park area are along Laguna de Bay. There is the residential area, police facility (Camp Bagong Diwa), university (Polytechnic University of the Philippines), and government facility (Department of Science and Technology: DOST) along the candidate site of open channel.

On the other hand, land use along Candidate Site No. 2 of the intake facility and open channel with the length of 0.6 km includes a residential area along M. Quezon Avenue, PNR and SLEX westward. There is a vacant lot located in-between the PNR and SLEX. Further westward, there are built-up areas, mostly residential areas, as well as cemeteries (Loyola Memorial Park, Manila Memorial Park).

Current Status near the Candidate Sites of Drainage Facility

There are two candidate sites of drainage facility: one is located at the lower section of the Parañaque River System (Barangay San Dionisio, Parañaque City) and the other is located at the lowermost section of the Zapote River (Barangay Pulang Lupa Uno, Las Piñas City).

Candidate Site No. 1 of the drainage facility is a vacant lot covered by grasses and bushes. There is the business district (Amvel Business Park) and the warehouse near the sites, enclosed by Carlos P. Garcia Avenue (C-5 Extension) running from north to south of the candidate site. Terrestrial ecosystem around the candidate site is not natural vegetation but undergo anthropogenic impacts.

On the other hand, Candidate Site No. 2 of the drainage facility is located at the right bank of the Zapote River and it is being used as a parking lot by Las Piñas City. The south side of it was formerly used as garbage dumping site and is currently a private lot (according to Las Piñas City) where there are many Informal Settler Families (ISFs). CAVITEX runs along Manila Bay at the west side of the candidate site. Carlos P. Garcia Avenue (C-5) runs east of the site in east-west direction.

Current Status along the Candidate Routes (Underground Section) of Parañaque Spillway

Underground structures along Candidate Route No. 1 and No. 3 of Parañaque Spillway include foundations of the elevated sections of the South Luzon Expressway (SLEX), high-rise buildings, etc. In addition, there are foundations of the subway and railway (LRT-1) to be constructed near the candidate routes of Parañaque Spillway.

The number of water permits granted within the area until approximately 500 m away from the candidate routes of Parañaque Spillway are shown in Table 6.6.2. It is revealed that there are 35 and 40 water rights along Route 1 and Route 3, respectively. Most of them are deep wells, but there are two (2) cases of water permit for surface water use within the jurisdiction of Parañaque City along Route 3.

Table 6.6.2 Number of Water Permits Granted Within Areas 500m Away from Parañaque Spillway

Location		Route 1			Route 3		
Province	City / Municipality	Groundwater	Surface Water	Total	Groundwater	Surface Water	Total
Metro Manila	Parañaque	29	0	29	30	2	32
	Las Piñas	-	-	-	4	0	4
	Taguig	6	0	6	-	-	-
	Muntinlupa	-	-	-	4	0	4
Cavite	Bacoor	-	-	-	0	0	0
Total		**35**	**0**	**35**	**38**	**2**	**40**

Source: Parañaque Survey, 2018 (Developed from the data of National Water Resources Board (NWRB), 2017)

(2) Potential Impacts on Natural Environment and Necessary Consideration

Potential impacts of Parañaque Spillway on natural environment include the change of water quality in Manila Bay and negative impact on the protected area (LPPCHEA), which are discussed as follows.

1) Impact on Water Quality in Manila Bay

Possibility to cause deterioration of water quality of the whole Manila Bay is minor because of the following reasons:

- Pampanga River contributes approximately 50% of all freshwater that enters Manila Bay. Compared to the water from Pampanga River, the increase in flow rate by the Parañaque Spillway is much smaller, and the change in total amount of freshwater will be minimal. Therefore, the rate of decrease in salinity of Manila Bay is minor.
- Water quality of Laguna de Bay is better than that of Manila Bay in general. Water with better quality would not cause water pollution.
- Possibility of siltation in Manila Bay due to drainage through the Spillway is minor as Laguna de Bay is working as a sedimentation pond of sands and silts coming through the rivers inflowing the lake, and the drainage water through the spillway is supernatant water after sedimentation.

2) Impact on the Protected Area (LPPCHEA)

The drainage from Laguna de Bay to Manila Bay through Parañaque Spillway is not likely to cause negative impacts on LPPCHEA but seems to bring about positive ones. There are three reasons as follows.

- Water quality of Laguna de Bay is better than that of Manila Bay around LPPCHEA, especially in dissolved oxygen (DO). The inflow of oxygen-rich water will improve the water around LPPCHEA with relatively low dissolved oxygen and be effective to increase DO around the protected area, which will be effective for improving the habitat of fish.
- Even if the Parañaque Spillway increases the amount of freshwater entering the area near LPPCHEA, the mangroves will not be devastated because they do not need saltwater to survive.
- The drainage through the spillway is a temporary event that lasts for one to three months. After drainage finishes, the environment restores to its original state. The salinity also rises to its normal level and it maintains the environment that is suitable for mangroves.

For these three reasons, the negative impact on the LPPCHEA is less likely to happen. However, the impact of the increased inflow of 200 m^3/s through Parañaque Spillway was not quantitatively assessed because the flow regimes of the Zapote River and Parañaque River system (South Parañaque River and San Dionisio River) were not surveyed in this study. Therefore, a flow regime survey should be done during the next study stage, or F/S. It is also necessary to compute water quality changes, extents and durations with a water quality simulation model. (Refer to Parañaque 2018 Report for the details of water quality simulation method.)

(3) Potential Impacts on Social Environment and Necessary Consideration

1) Impacts of Intake Facility and Necessary Considerations

Major potential impacts of construction of intake facility will be the following four:

- Impacts on fishery (open lake fishing and aquaculture) in Laguna de Bay;
- Impacts on water transportation and navigation routes in Laguna de Bay;
- Impacts on cultivation and harvesting of water plants in Laguna de Bay; and
- Impacts on water use (irrigation, domestic water supply, etc.) in Laguna de Bay.

The details of these potential impacts and necessary considerations are shown in Table 6.6.3.

Table 6.6.3 Potential Impact of Intake Facility and Necessary Consideration

Potential Impact	Description of Impact	Consideration
1. Impact on Fishery	Area around Candidate Site No. 1: Aquaculture (fish pens/fish cages), and mooring facilities used for fishery, which are located at offshore of Barangay Lower Bicutan, might be affected. Area around Candidate Site No. 2: Aquaculture (fish traps and fish pens/ fish cages) distributed at offshore might be affected.	Consideration in selection of location of intake facility and construction planning for avoidance/minimization of the potential impacts on fishery. In case the impact on fishery is inevitable, proper compensation should be provided through coordination with relevant fisher folks/associations, mutual agreement on compensation amount and the timing of provision of compensation, namely; before construction of the project facility, etc.
2. Impact on water transportation	Water transportation route at the south of Candidate Site No. 2 to transport oil used in the Sucat Thermal Power Plant might be affected.	The water transportation is currently not used but it is necessary to clarify if the route would be re-used in the future through hearing from LLDA.
3. Impact of cultivation and harvesting of water plants	Cultivation and harvesting of water plants being implemented in Laguna de Bay at around Taguig Lakeside Hall might be affected.	Consideration in selection of location of intake facility and construction planning for avoidance/minimization of the potential impacts on the cultivation. Provision of proper compensation in case the impact on cultivation is inevitable through coordination with LGUs and other relevant organization.
4. Impact on water use	Currently, no water permit for taking water from Laguna de Bay is granted near the candidate sites of intake facility of the Project. Therefore, there is no impact under the current situation.	It is necessary to check/confirm if a new water permit will be issued near the proposed location of intake facility of the Project through coordination with NWRB.

Source: Parañaque Survey, 2018

2) Impacts of Open Channel and Necessary Considerations

Major potential impacts of open channel construction will be the following three:

- Land acquisition of project site for the construction of open channel;
- Involuntary resettlement due to land acquisition and impacts on livelihood of project affected persons (PAPs); and
- Impacts of land acquisition on existing facilities and structures.

The details of these potential impacts and necessary considerations are shown in Table 6.6.4 and summarized as follows:

In the case of Candidate Site No. 1, necessary land acquisition area for open channel is estimated at approximately 10.3 ha. If the area for drainage facility (approximately 0.1 ha) is added, the total area of land acquisition will be approximately 10.4 ha. The number of affected buildings and PAPs is estimated at approximately 280 and 860, respectively. Compensation costs for land acquisition and replacement cost for affected buildings are estimated to be 979 million pesos, and 218 million pesos, respectively, amounting to 1,197 million pesos in total (refer to Table 6.6.4). The number of ISFs included in the PAPs is not clear because the details of the settlement of ISFs were not surveyed in this study.

In the case of Candidate Site No. 2, the land acquisition area necessary for open channel is estimated at approximately 5.4 ha. If the area for drainage facility (approximately 0.1 ha) is added, the total area of land acquisition will be approximately 5.5 ha. The number of affected buildings and PAPs is estimated at approximately 290 and 1,190, respectively. Compensation costs for land acquisition and replacement cost for affected buildings are estimated to be 939 million and 225 million pesos, respectively, amounting to 1,165 million pesos in total (refer to Table 6.6.4). The details of ISFs are not clear as with the case of Candidate Site No. 1.

Table 6.6.4 Estimation of Compensation Cost for Affected Lands and Buildings

Candidate Site	Facility	Barangay, Municipality /City	Magnitude of Impact			Compensation Cost		
			Area of Land Acquisition (ha)	Affected Buildings (No.)	Project-Affected Persons (No.)	Land (million Pesos)	Building (million Pesos)	Total (million Pesos)
Candidate Site No. 1	Open channel (including departing shaft)	Lower Bicutan, Taguig City	10.3	280	860	970	218	1,188
	Drainage Facility (Arrival shaft)	San Dionisio, Parañaque City	0.1	0	0	9	0	9
	Total	-	**10.4**	**280**	**860**	**979**	**218**	**1,197**
Candidate Site No. 2	Open channel (including departing shaft)	Sucat, Muntinlupa City	5.4	290	1,190	935	225	1,161
	Drainage Facility (Arrival shaft)	Pulang Lupa Uno, Las Piñas City	0.1	0	0	4	0	4
	Total	-	**5.5**	**290**	**1,190**	**939**	**225**	**1,165**

Source: Parañaque Survey,2018

3) Impacts of Underground Spillway and Necessary Considerations

Major potential impacts of construction of underground spillway will be the following two:

- Impacts of underground excavation and tunneling works on existing underground structures; and
- Impacts of underground excavation and tunneling works on groundwater.

The details of these potential impacts and necessary considerations are shown in Table 6.6.5. With regard to land acquisition for underground spillway, the position of the spillway is proposed to be deeper than 50m from the ground surface and, therefore, land acquisition and compensation for surface owners or occupants will not be required in accordance with RA No. 10752 and its IRR. Thus, impact on social environment related to land acquisition will not be a matter of concern.

Table 6.6.5 Potential Impacts of Underground Spillway and Necessary Considerations

Potential Impact	Description of Impact	Consideration
1. Impact on underground structures	Underground structures such as water supply and sewerage system, the foundations of elevated road (SLEX) and the planned subway system and railway projects are likely to be affected by the construction of underground spillway.	Clarification of the depth of foundations along the candidate site of underground spillway should be done. Consideration by adjustment of the alignment of the spillway is required when necessary to avoid the impact.
2. Impact on groundwater use	Deep wells located along Route 1 (35 deep wells.) and along Route 3 (38 ones.) might be affected. Surface water intake (2 points) might be affected as well.	Clarification of hydrogeological conditions around the deep wells and surface water intake points should be made through geological and hydrological surveys. In addition, an investigation of actual conditions of water use at the deep wells should be carried out, and based on which mitigation measures should be figured out to avoid/minimize the impacts on water use.

Source: Parañaque Survey, 2018

4) Impacts of Drainage Facility and Necessary Considerations

Major potential impacts of construction of drainage facility will be the following three:

- Land acquisition of project site for the construction of drainage facility;
- Involuntary resettlement due to land acquisition and impacts on livelihood of project affected persons (PAPs); and
- Impacts on the residents and existing facilities in the downstream area.

The details of these potential impacts and necessary considerations are shown in Table 6.6.6.

Table 6.6.6 Potential Impacts of Drainage Facility and Necessary Considerations

Potential Impact	Description of Impact	Consideration
1. Land acquisition for construction of drainage facility	Necessary area of land acquisition for the construction of drainage facility is estimated at approximately 1,000 m^2.	Consideration to minimize the area of land acquisition during design stage. Land acquisition and compensation in accordance with relevant laws and regulations, in particular, RA No. 10752 for compensation.
2. Involuntary resettlement and impacts on livelihood of PAPs	There is no formal and/or informal settler family dwelling in any of the candidate sites at this moment, and therefore, resettlement of residents is not necessary.	Resettlement and livelihood rehabilitation of PAPs, when necessary, in accordance with RA No. 7279 and the DPWH Land Acquisition, Resettlement, Rehabilitation and Indigenous People Policy (LARRIP), with providing necessary consideration.
3. Impact on residents and existing facilities in the downstream area	River improvement such as widening, dredging, etc., of the downstream river for increase of river flow capacity when necessary as well as land acquisition and resettlement of riparian people necessary for river improvement works.	Consideration to minimize land acquisition and resettlement during design stage. Land acquisition and compensation in accordance with relevant laws and regulations, especially, RA No. 10752 for compensation.

Source: Parañaque Survey, 2018

5) Impacts of Disposal of Excavated Materials and Necessary Consideration

Major potential impacts of disposal of excavated materials from tunneling will be the following two:

- Impacts of development of disposal site of excavated materials; and
- Impacts of transportation of excavated materials on road traffic.

The details of these potential impacts and necessary considerations are shown in Table 6.6.7.

Table 6.6.7 Potential Impacts of Disposal of Excavated Materials and Necessary Consideration

Potential Impact	Description of Impact	Consideration
1. Impact of development of disposal site	Disposal site of the excavated materials has yet to be fixed at the moment. There will be various types of impacts in case the disposal site is to be developed in the lakeshore area of Laguna de Bay, including those on fishery, water use, water transportation, and impacts on aquatic ecosystem, etc.	Investigation on fishing ground, aquaculture (fish pen and fish cage,) fish sanctuaries and mooring facilities, etc., should be conducted focusing on those located along the lakeshore. Based on the investigation results, concrete mitigation measures should be formulated. In case of difficulty to avoid or minimize the adverse impact on these economic activities, it is necessary to compensate for the impact upon consultation/coordination with relevant fisher folks, organizations and LGUs.
2. Impact of transportation of the excavated materials on road traffic	Refer to the following subsection "(4), Impacts of Construction Works and Necessary Consideration."	Refer to the following subsection "(4), Impacts of Construction Works and Necessary Consideration."

Source: Parañaque Survey, 2018

(4) Impacts of Construction Works and Necessary Considerations

Major potential impacts of construction work of project facilities (intake and drainage facility, open channel, underground spillway, etc.) will be the following three:

- Generation of public pollution (air pollution, noise pollution, generation of low-frequency sound, water pollution, etc.) due to construction works;
- Impacts of solid wastes to be generated by demolition of existing structures/facilities; and
- Impacts of transportation of construction equipment and materials, and excavated materials on road traffic.

The details of these potential impacts and necessary considerations are shown in Table 6.6.8.

Table 6.6.8 Potential Impacts of Construction Works and Necessary Considerations

Potential Impact	Description of Impact	Consideration
1. Generation of public pollution due to construction works	Air pollution (dust and emission gas) due to operation of construction equipment and vehicles.	Watering during dry period, thorough maintenance of construction equipment and vehicles, idling stop, consideration in driving and operation of vehicles and equipment, Information, Education and Communication (IEC) for the dissemination of information on the project.
	Noise pollution, generation of vibration and low frequency sound due to operation of construction equipment and vehicles.	Thorough maintenance of construction equipment and vehicles, consideration in driving and operation of vehicles and equipment, introduction of low-noise and low vibration type equipment, adjustment of working

Potential Impact	Description of Impact	Consideration
		time, IEC, etc.
	Discharge of earth materials in Laguna de Bay during rains, generation of turbid water and oil and their diffusion, generation of high alkali water, and impacts on fishing activities in the lake.	Installation of sedimentation pond, drainage channel, installation of diffusion prevention curtain/fence, IEC, etc.
	Generation of wastes (solid waste, waste water) from base camp and construction yards of contractor, including contamination and deterioration of aesthetics.	Formulation of waste management plan by contractor and thorough implementation of reduction, segregation, reuse and recycle of construction wastes.
	Ground movements, groundwater discharge and drawdown of groundwater level during excavation works for construction of open channel and tunneling works.	Implementation of enough supporting work for prevention of ground movements, investigation of hydrogeological conditions and actual condition of water use at the deep wells, and formulation of mitigation measures based on the investigation results.
2. Impact of solid wastes to be generated by demolition of existing structures/ facilities	Solid wastes to be generated by implementation of the project will include debris of demolished structures/facilities, etc. In case proper treatment or disposal is not done, environmental contamination would occur.	Solid wastes should be treated based on RA No. 9003, which is the basic policy. Reuse and recycling of the demolished structures/facilities should be facilitated in collaboration with LGUs. Harmful wastes should be properly treated based on RA No. 6969.
3. Impact of transportation of construction equipment and materials, and excavated materials	The number of transportation times is estimated in case of shield tunneling method as follows: Approx. 37 times /day (by 27-ton trailer) for transportation of segments; Approx. 28 times/hour (at maximum) for transportation of excavated materials.	Investigation of existing traffic conditions around the planned transportation routes, and formulation of traffic management plan by the Construction Contractor(s), including such management measures as consideration of transportation route and time, prevention of traffic accident in collaboration with police authorities, appointment of traffic control person(s), public relations/dissemination campaign about the project and traffic control.

Source: Parañaque Survey, 2018

6.6.2 Environmental Issues Clarified during the Follow-up Study

(1) Update of Existing Environment of Project Sites

1) Surveyed Area

Surveyed area under the Follow-up Survey is the candidate site of project facilities including intake facility and open channel, which are to be constructed on the ground. The survey was done focusing on the identification of any change in environmental settings after the Parañaque 2018 Study.

2) Survey Results

<u>Candidate Sites of Intake Facility and Open Channel</u>

- Candidate Site No. 1: Barangay Lower Bicutan, Taguig City (Photo 1, Figure 6.6.2)

Further encroachment of residential area on Laguna de Bay toward offshore compared with the Parañaque 2018 Study is identified. The encroachment area is supposed to be occupied by informal settlers who shall be relocated.

- Candidate Site No. 2: Barangay Sucat, Muntinlupa City (Photo 2, Figure 6.6.2)

  Residential area along the shoreline of Laguna de Bay is almost the same as that during the Parañaque 2018 Study. It was, however, found that the thermal power plant (Sucat Thermal Power Plan) which was being shutdown then, has been dismantled.

<u>Candidate Sites of Drainage Facility</u>

- Candidate Site No. 1: Barangay San Dionisio and La Huelta, Parañaque City (Photo 3, Figure 6.6.2)

  It was found that a building has been newly constructed in the vacant lot along the right bank of San Dionisio River. In case the drainage facility is constructed in the lot, it is necessary to avoid or minimize the impact on the building.

- Candidate Site No. 2: Barangay Pulang Lupa Uno, Las Piñas City (Photo 4, Figure 6.6.2)

  The left bank of Zapote River has been improved with revetment, and a river bank road is currently available. It was informed from the city official that relocation of informal settlers who occupy the river bank is being initiated by the city. Even so, there are still remaining settlers along the river bank. It is necessary to confirm the progress/status of relocation of the informal settlers during F/S because the river bank is the potential impact area of the drainage from Parañaque Spillway during operation period of the Project.

Photo 1: Candidate Site No. 1 of Intake Facility
(Barangay Lower Bicutan, Taguig City)

Photo 2: Candidate Site No. 2 of Intake Facility
(Barangay Sucat, Muntinlupa City)

Photo 3: Candidate Site No. 1 of Drainage Facility
(Barangay San Dionisio, Parañaque City)

Photo 4: Candidate Site No. 2 of Drainage Facility
(Barangay Pulang Lupa Uno, Las Piñas City)

Source: JICA Survey Team

Figure 6.6.2 Update of Existing Environment at Candidate Site of Project Facilities

(2) Update of Informal Settlers at the Candidate Project Sites and Resettlement

1) Method of Survey

Collection of data and information on current situation of ISFs in the candidate project sites and their resettlement was conducted through interview with the LGU staffs in charge. Site reconnaissance was also done afterwards.

2) Survey Results

Results of interview with LGUs and site reconnaissance are summarized in Table 6.6.9.

Table 6.6.9 Survey Results on Informal Settlers in Candidate Project Sites and Resettlement Program

Interview Survey		Related Project Facility / Route of Spillway	Situation of Informal Settlers and Resettlement Program
Date/ LGU (Office)	Name (Position) of Interviewee		
January 16, 2020/ Las Piñas City/ UPAO (Urban Poor Affairs Office)	Ms. Mylene M. Castilla (Program Coordinator)	Drainage Facility No. 2 / Route 3	Candidate site of drainage facility No. 2 is located in Barangay Pulang Lupa Uno, Las Piñas City. The site where no ISFs are seen is used as parking lot of garbage trucks of the city. There are, however, ISFs at the south of the parking lot. According to the joint census conducted in September, 2019 by Las Piñas City in collaboration with concerned organizations, 96 of ISFs were identified (Photo 1, Figure 6.6.3). The site is adjacent to the LRT-1 extension and ISFs agreed with resettlement upon the request of the city and concerned organizations. ISFs are supposed to be relocated to a resettlement site in General Trias

Interview Survey		Related Project Facility / Route of Spillway	Situation of Informal Settlers and Resettlement Program
Date/ LGU (Office)	Name (Position) of Interviewee		
			City developed by NHA.
January 17, 2020/ Muntinlupa City/ UPAO (Urban Poor Affairs Office)	Ms. Alita A. Ramirez (Chief, UPAO,), Ms. Nida M. Cheng (ISF's community association	Intake Facility (including Open Channel and Shaft) / Route 2-A, 2-B and 3	Candidate site for open channel is located in Purok 2 and 3 of Barangay Sucat, Muntinlupa City. The residents occupying the site are mostly ISFs according to the interviewed staff of UPAO. There are three associations (Figure in parenthesis shows the number of ISFs) in the site as follows: 1) Samahang Nagkakaisang Magkakapitbahay ng Damayan/ Purok 2 (111) 2) Samahang Magkakapitbahay ng Kakabagong / Purok 3 (103) 3) Langyaw / Purok 2 (195). Candidate site of Shaft (departing), on the other hand, is a lot owned by a developer, which is vast vacant lot (grassland). This status has not changed from two years ago when the Parañaque 2018 Study was done (Photo 2, Figure 6.6.3).
January 21, 2020/ Bacoor City/ CDSSD (Community Development and Support Services Division)	Ms. Annie Nacianceno (Officer in Charge, CDSSD), Ms. Ester Copter (Consultant of CDSSD)	Drainage Facility No. 2/ Route 3	Candidate site of Drainage Facility No. 2 is located on the right bank of Zapote River, which is in Barangay Pulan Lupa Uno, Las Piñas City. The left bank side, on the other hand, is in Barangay Zapote 5, Bacoor City, which is occupied by ISFs, divided into two groups: one is located in Sitio Wawa, near the river mouth of the Zapote River, and the other is in Sitio Miyape, upstream of the river. Relocation of ISFs in Sitio Wawa was initiated by the District Engineering Office of DPWH Region IV-A along with river improvement with revetment along the river. Relocation of ISFs was almost completed in 2019. Resettlement site for the ISFs is located in the Municipality of Naic, Cavite. Relocation of the ISFs located upstream in Sitio Miyape, on the other hand, is on-going, but to be completed within 2020.
January 22, 2020/ Parañaque City/ UMADO (Urban Mission Area Development Office)	Mr. Rodolfo F. Ojo (Officer in Charge, UMADO), Mr. Marlon Balbastro (Staff of UMADO)	Drainage Facility No. 1/ Route 1 and 2-A	A census of ISFs was conducted in 2014/2015 associated with the LRT-1 extension project at the downstream area of the confluence point of San Dionisio River and South Parañaque River. The survey results are as follows (same as that described in Parañaque 2018 Study Report). The survey result has yet to be updated then. 1) Lopez Jaena Extension: 175 ISFs, 2) Christian-Muslim Area: 60 ISFs, 3) Back of La Huerta Elementary School: 20 ISFs. It was recognized through site reconnaissance that there is no big change in ISFs occupation area by visual observation (Photo 4, Figure 6.6.3). Parañaque City does not initiate any resettlement program in collaboration with NHA at the moment because of financial reason: the city cannot allocate necessary budget to develop necessary infrastructure/public facility at the resettlement site of ISFs required by recipient LGU.
February 12, 2020 (through e-mail)/ Taguig City / UPAO (Urban Poor Affairs Office)	Mr. Agapito (Head of UPAO)	Intake Facility No. 1/ Route 1	Candidate site of Intake Facility No. 1 is located at the shore of Laguna de Bay in Barangay Lower Bicutan. It was identified through census conducted in January 2020 that there are 798 ISFs in Barangay Lower Bicutan and its surrounding area along the lakeshore where six associations of residents are organized at the moment.

Source: JICA Study Team

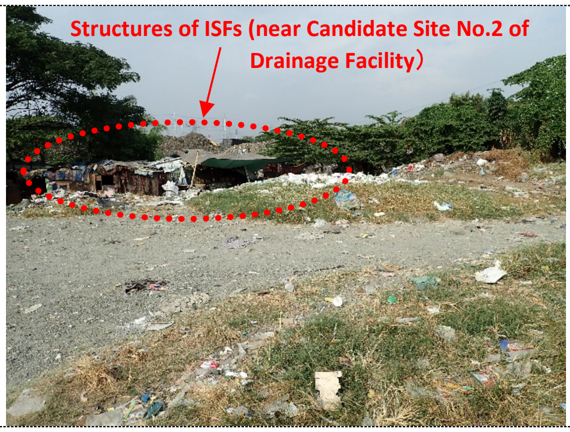


Photo 1: Candidate Site No. 2 of Drainage Facility
(Barangay Pulan Lupa Uno, Las Piñas City)

Photo 2: Candidate Site No.2 of Intake Facility
(Barangay Sucat, Muntinlupa City)

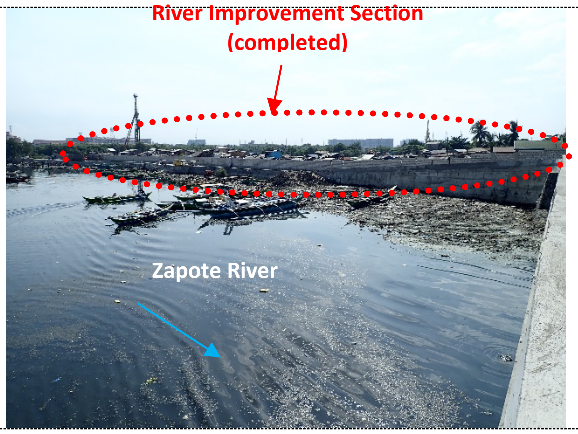


Photo 3: Left Bank of the Zapote River (Opposite site of Candidate Site No.2 of Drainage Facility)
(Barangay Zapote 5, Bacoor City)

Photo 4: Candidate Site No. 1 of Drainage Facility
(Barangay San Dionisio, Parañaque City)

Source: JICA Study Team

Figure 6.6.3 Current Situation of Informal Settlers in and around Candidate Project Sites

(3) Land Acquisition for Newly Proposed Route of Parañaque Spillway and Considerations

A new route of Parañaque Spillway was proposed under this Follow-Up Study (ref. Section 4.2.2). Location of intake facility of the new route is located in Barangay Sucat, Muntinlupa City. However, the route of underground tunnel section is located along Doctor A. Santos Avenue (Sucat Road). As for drainage facility, there are two candidate sites at this moment. Figure 6.6.4 shows the proposed location of the route and project facilities.

Compensation cost was estimated based on the proposed new route focusing on costs for land acquisition and compensation (replacement cost) for affected buildings. The result of calculation is shown in Table 6.6.10.

Since the underground tunnel section of the new route is partially located under private lots, compensation for perpetual easement for sub-surface usage for the project facility is required. The amount of the compensation is calculated pursuant to the prescription of the IRR of RA 10752 (2016) that the easement price shall be 20% of current market value of the land at ground surface, taking the assumption that the width of ROW of Parañaque Spillway as approx. 16.5m (ref. Section 4.2.2).

Compensation costs calculated were PHP 2,210 million for Route 2-A and PHP 1,940 million for Route 2-B.

Table 6.6.10 Estimated Compensation Cost for Affected Lands and Buildings for New Proposed Routes

Route	Facility	Barangay/ City	Magnitude of Impact				Compensation Cost		
			Area of Land Acquisition (ha)	Area of Easement for ROW (ha)	Affected buildings (No.)	Project-Affected Persons (PAPs) (No.)	Land / Easement (million Pesos)	Building (million Pesos)	Total (million Pesos)
Route 2A	Open channel (including departing shaft)	Sucat/ Muntinlupa	5.4	0	290	1,190	1,604	262	1,866
	Underground spillway (under private lots at Laguna de Bay side)	Sucat/ Muntinlupa	0	0.3	0	0	19	0	19
	Underground spillway (under public road)	Muntinlupa and Parañaque City	0	0	0	0	0	0	0
	Underground spillway (under private lots at Manila Bay side)	San Dionisio, Manuyo Dos, Pulang Lupa Uno/ Parañaque	0	5.1	0	0	310	0	310
	Drainage Facility (Arrival shaft)	San Dionisio/ Parañaque	0.1	0	0	0	16	0	16
	Total	**-**	**5.5**	**5.4**	**290**	**1,190**	**1,949**	**262**	**2,210**
Route 2B	Open channel (including departing shaft)	Sucat/ Muntinlupa	5.4	0	290	1,190	1,604	262	1,866
	Underground spillway (under private lots at Laguna de Bay side)	Sucat/ Muntinlupa	0	0.3	0	0	19	0	19
	Underground spillway (under public road)	Muntinlupa and Parañaque City	0	0	0	0	0	0	0
	Underground spillway (under private lots at Manila Bay side)	San Dionisio/ Parañaque	0	0.5	0	0	40	0	40
	Drainage Facility (Arrival shaft)	Pulang Lupa Uno/ Las Piñas	0.1	0	0	0	16	0	16
	Total	**-**	**5.5**	**0.8**	**280**	**1,190**	**1,661**	**262**	**1,940**

Note) Refer to Figure Figure 6.6.4 for location of proposed routes of the spillway.
Source: JICA Survey Team

The newly proposed Route 2-A and 2-B are both located under Doctor A. Santos Avenue (Sucat Road), a public road. The width of ROW is assumed to be approx. 16.5 m as mentioned above, which will be well within the width of the avenue which has 6 lanes. However, it cannot be completely denied that there might be such sections that the ROW cannot be covered within the road width because of winding section or necessity to avoid negative impact on foundation of existing structures. In such cases, additional compensation cost will be spawned for perpetual easement under private lots for such section.

The compensation cost shown in Table 6.6.10 is calculated based on the assumption that ROW of the spillway is approx. 16.5m and that the necessary acquisition of perpetual easement is only for the ROW. However, it should be noted that the acquisition area of perpetual easement would depend on negotiations between the Implementing Agency and the Property Owner of the land as stipulated in Section 11, IRR of RA 10752.

Note: Route 2-A is from Barangay Sucat, Muntinlupa City along Dr. A. Santos Avenue to San Dionisio River turning left at Point A. Route 2-B is from the same location above but toward Zapote River, going straight along Dr. A. Santos Avenue.

Figure 6.6.4 Location Map of New Proposed Routes of Parañaque Spillway

6.6.3 Environmental Impact Assessment for Parañaque Spillway Construction during F/S

(1) Project Categorization based on JICA Guidelines for Environmental and Social Considerations

The project would cause various types of environmental and social impacts, most of which are discussed in Subsections 6.6.1 and 6.6.2 including necessary considerations. It is anticipated that construction of project facilities on the ground surface including intake facility, open channel, drainage facility, etc., will require land acquisition and resettlement amounting to 300 households at the maximum, although construction of the underground spillway proposed in case the depth of more than 50m from ground surface will not require any land acquisition and compensation in accordance with the legislation of the Philippines (RA No. 10752).

Generation of solid wastes is estimated to be enormous, consisting of debris of demolished structures and facilities for the construction of project facilities. The volume of excavated materials from tunneling works for underground spillway is anticipated at 2 million cubic meters at the maximum. Thus, it is indispensable to pay attention to these potential impacts to conduct necessary mitigation measures through the formulation of an Environmental Management Plan (EMP).

Accordingly, it is proposed that the project is classified as Category A in accordance with the JICA Guidelines for Environmental and Social Considerations.

(2) Preliminary Scoping and Necessary Study and Analysis in Feasibility Study Stage

Based on the results of study and discussion under the Parañaque 2018 Study, preliminary scoping and the necessary study and analysis in the Feasibility Study stage are as summarized in Table 6.5.11.

Table 6.5.11 Preliminary Scoping and Necessary Study and Analysis in the Feasibility Study Stage

Environmental Elements		Evaluation		Description of Evaluation	Study and Analysis in F/S Stage
		Planning/ Construction	Operation		
Pollution	Air Pollution	B-	D	Air pollution due to emission gas and dust generation caused by construction equipment and vehicles during earth work, etc., is anticipated.	Survey for primary data on baseline condition of ambient air quality in the project area, and impact prediction of emission gas by the implementation of the project
	Water Pollution	B-	D	If sediment in the construction sites of inlet or outlet contains toxic substances (e.g. heavy metals), they might stir up during the construction and contaminate the water. The discharge through Parañaque Spillway is not likely to affect the water quality of Manila Bay.	Collect and confirm the latest water quality survey result of Manila Bay and Laguna de Bay. Survey the sediment of the inlet site in Laguna de Bay and the outlet site on the Zapote River or Parañaque River to check whether it contains toxic substances.
	Wastes	A-	D	Solid wastes will be generated by implementation of the project including debris of demolished structures/facilities. In addition, generation of excavated materials due to tunneling works is anticipated with the volume of 200 million m^3 at the maximum.	Prediction of the volume of construction wastes including excavated materials, as well as preparation of waste management policy including collection, recycling, treatment and disposal of the wastes.
	SoC contaminati on	C-	C-	There will be a possibility of soil contamination in case the excavated materials are contaminated with hazardous substances (heavy metals) with concentration exceeding the Philippine criteria (DAO No. 2013-22).	Laboratory analysis on chemical characteristics of earth (excavated materials) by TCLP and elutriate tests to identify soil contamination and its degree.
	Noise and	B-	D	There will be generation of noise and	Baseline survey for primary data on

Environmental Elements		Evaluation: Planning/ Construction	Evaluation: Operation	Description of Evaluation	Study and Analysis in F/S Stage
	Vibration			vibration due to construction works on the ground such as construction of intake facility, open channel, drainage facility and vertical shaft, and those due to transportation by vehicles. Low frequency sound due to tunneling work (shield tunneling) also may be anticipated.	ambient noise and vibration around the construction work sites on the ground, prediction of the degree of noise and vibration, low frequency sound, etc.
	Ground Movement	C-	D	There will be a possibility of ground movements due to tunneling work, and the possibility of affecting the existing underground structures such as foundations.	Ground survey by means of borehole tests and geotechnical tests, inventory of underground structures, as well as analysis on the possibility of ground movements.
	Offensive Odor	B-	C-	There will be a possibility to generate offensive odor during the construction work for intake and drainage facilities, especially due to dredging works in Laguna de Bay and rivers/creeks. In the operation stage, offensive odor may be emitted from drainage facility during draining floodwater of Laguna de Bay.	Examination of the possibility of offensive odor through site survey on baseline condition and analysis of similar cases of spillway operation.
Natural Environment	Topography and Geology	B-	B-	There will be topographical and geological alteration due to construction work for open channel, tunneling work, etc.	Ground survey by means of borehole tests and geotechnical tests, and description of the degree of topographical and geological alteration.
Natural Environment	Groundwater	C-	C-	There will be a possibility of impacts on groundwater level and flow.	Survey on groundwater level by means of borehole tests and secondary data collection, inventory of deep wells and survey on groundwater use.
Natural Environment	Water Regime	D	A+	Flood risk will be alleviated around Laguna de Bay in operation stage as consequence of the implementation of the project.	Change in water level of Laguna de Bay and degree of the positive effect by the implementation of the project.
Natural Environment	Terrestrial Flora and Fauna	C-	D	There will be a possibility of impacts of clearing of vegetation and disturbance of habitats of wildlife on terrestrial flora and fauna and protected species, if any.	Inventory of flora and fauna in the area of project sites, especially in case the project site covered by vegetation is modified.
Natural Environment	Aquatic Biota	C-	D	In case the excavated materials from tunneling works are to be disposed in Laguna de Bay, there will be an impact on aquatic biota in the lake.	Inventory of aquatic biota in Laguna de Bay, as well as coordination with relevant organizations (LLDA, etc.) on identification/development of disposal site of the excavated materials.
Natural Environment	Protected Area (LPPCHEA)	D	C	LPPCHEA locates near the outfalls of the Zapote River and Parañaque River. The drainage through spillway increases the river discharge, which may pose negative impact on the area such as scouring. On the other hand, the drainage might improve the water quality around LPPCHEA (e.g. increase of DO).	Carry out water quality simulation to evaluate the impact of drainage through Parañaque Spillway. Based on the result above, study the impact on LPPCHEA.
Social Environment	Land Acquisition / Involuntary Resettlement	A-	C-	Land acquisition for the project sites will be required. Involuntary resettlement will also be required since there are residential areas including ISFs in the project sites. Existing structures and facilities will be affected, too. The number of affected buildings will be approximately 280 to 290.	Confirmation of necessary land acquisition based on the facility plan of the project, inventory of ISFs, preparation of resettlement action plan (RAP), including socio-economic survey for PAPs, survey on replacement costs for affected buildings, improvements and structures, and survey on market prices of affected lands, trees and crops, etc.
Social Environment	Land Use	D	B-	Existing land use will be drastically	Confirmation of comprehensive land

Environmental Elements		Evaluation		Description of Evaluation	Study and Analysis in F/S Stage
		Planning/ Construction	Operation		
				modified in and around the project sites.	use plan (CLUP) of concerned LGUs and conformance of the development plan under the project within the CLUPs.
	Economic Activity/ Employment/ Livelihood	B-	C-	There will be a possibility of adverse impact on fishery, water transportation, cultivation and harvesting of aquatic plants, etc., in Laguna de Bay. Livelihood of PAPs, including employment conditions will be affected due to resettlement caused by the project.	Baseline survey on fishing activities, mooring facilities, water transportation, water intake and cultivation of water plants, etc., near the project sites in Laguna de Bay; Socio-economic survey targeted for PAPs and preparation of RAP, including livelihood rehabilitation programs.
	Cultural Heritage	C-	D	There are four (4) registered heritage sites near the candidate sites of the project. These might be affected depending on the location/determination of project site.	Baseline survey on existing heritage sites near the project sites.
	Water Use	C-	C-	There are many cases of water use on which water permit is granted by NWRB around the proposed project sites. There will be a possibility of impact on the water use.	Survey on hydrogeological condition, groundwater use (deep well survey), and analysis on possibility of impact on water use based on the survey results, as well as formulation of mitigation measures.
	Traffic	B-	D	There will be impacts on road traffic caused by project-related transportation of construction materials and equipment, excavated materials, etc.	Investigation of existing traffic conditions around the planned transportation routes, prediction of traffic volume of project-related vehicles, and formulation of traffic management policy.
	Other Elements on Social Impacts	C-	C-	Sufficient data or information for anticipation of social impacts has yet to be gathered.	Baseline survey, impact prediction regarding social elements based on project plan.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Possibility of impact and its magnitude are unknown. (Further examination is needed, and the impact could be clarified as the study progresses.)
D: No impact is expected.
Source: Parañaque 2018 Study Report

(3) Considerations Necessary for the EIA Study of Parañaque Spillway Confirmed during this Follow-Up Study

1) Points of Consideration for Screening of the Project

An interview with DENR-EMB-CO was carried out to clarify the category of the Parañaque Spillway Construction Project under PEISS during the Parañaque 2018 Study. As a result, the following comment was obtained from the authority ((DENR-EMB): “The project is considered to be an environment enhancement project, which is, therefore, to be categorized as “C”. However, based on the project scale and size of the structures/facilities and taking into account that similar projects were required to conduct EIA to secure an ECC, it is natural to require EIA study for the structures/facilities proposed in the Project. It is, therefore, necessary for the Proponent (DPWH) to submit a Project Description (PD) to the competent authority (DENR-EMB) in advance for determination of EIS requirements.”

During the Follow-Up Study, the JICA Study Team explained to DNER-EMB-CO the details of the Parañaque Spillway Construction Project using a brochure (project description), and re-confirmed the screening of the Project under PEISS. Officials of the EMB-CO mentioned that although there is no description of the screening threshold for Spillway Construction in EMB-MC 2014-005, it is reasonable to categorize the Project as "A" considering its dimensions and potential impacts.

Thus, it is concluded that the Parañaque Spillway Project will be required to conduct a full-blown EIA Study. In this connection, DNER-EMB-Co also pointed out that the IA of the Project shall use an updated screening checklist during the screening process of the Project under PEIISS.

2) Points of Consideration during the EIA Study for the Project

The following three (3) points were advised by DENR-EMB-CO to be made sure during the EIA Study:

<u>Determination of the Route of Parañaque Spillway as Object of EIA Study</u>

There are several candidate routes of Parañaque Spillway at this moment. It is necessary to select/determine one route based on the result of study for alternatives. The selected one will be the object of the Study.

<u>Recognition of the Importance of Initial Perception Survey</u>

The Initial Perception Survey prescribed in DAO No. 2017-15 is a process to be carried out at the initial stage of the EIA study. It is recognized that the process is an important one to clarify the level of understanding, concern and inquiry of local people about the Project. Therefore, it shall be ensured to be conducted.

<u>Consideration of DRR-CCA (Disaster Risk Reduction – Climate Change Adaptation)</u>

The JICA Study Team was advised by EMB-CO that it is necessary to consider DRR-CCA (Disaster Risk Reduction – Climate Change Adaptation) in the EIA study for the Project. In this regard, the impact assessment shall be done referring to climate projections prepared by PAGASA (2020-2050) as described in EMB-MC 2011-005, according to EMB-CO. It should be noted that the climate projection of PAGASA has been updated to the period 2036-2065, which should be referred for the EIA study of the Project.

The JICA Study Team also coordinated with DENR-NCR, and obtained the following advices and suggestions from its Conservation and Development Division.

<u>Necessity of Coordination with Protected Area Management Board (PAMB) of LPPCHEA</u>

Since the drainage point of Parañaque Spillway is located near the protected area, Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA), it is important to execute the survey, including the impact prediction and mitigation measures necessary to avoid/minimize the potential impacts on the protection area. The Protected Area Management Board (PAMB) specified for LPPCHEA has been organized, with which coordination is indispensable to move the Project forward. PAMB is a committee to be organized by protected area pursuant to RA No. 11038 (2018), which has the mandate to formulate the policy and measures necessary for the protection and utilization of the protected area. PAMB, LPPCHEA, chaired by the Regional Director of DENR-NCR, is composed of 16 members, including representatives of relevant GAs and LGUs.

Importance of Impact Assessment on Natural Environment of Manila Bay

There will be several potential impacts of Parañaque Spillway on the natural environment of Manila Bay, including deterioration of water quality, siltation, and possibility to transport invasive species through the spillway between Laguna de Bay and Manila Bay. It was pointed out by the DENR-NCR that proper impact assessment and consideration of mitigation measure are indispensable.

It is necessary to conduct the EIA Study for the Project during the Feasibility Study (F/S) stage in consideration of the points and advices mentioned above through coordination with the concerned organizations.

6.7 LiDAR Topographic Survey of Parañaque Spillway Route 2-B

6.7.1 Survey Details

(1) Purpose

LiDAR topographic survey was conducted on Route 2-B, which is the most likely route among the four routes of the Parañaque Spillway, and an orthophoto map and contour map were created. Based on the survey results, the feasibility of Route 2-B was examined.

(2) Survey Area

The LiDAR topographic survey range (Route 2-B) is shown in the figure below. The total measured area is 120 ha. The survey results will be a 1: 200 scale topographic map showing contour lines at 1-meter intervals. Detailed topographic survey results are shown in Volume 2: Topographic Survey.

Table 6.7.1 LiDAR Topographic Survey Range (Route 2-B)

Area No.	Length (m)	Width (m)	Area (ha)
Survey Area 1	1,100	500	55.0
Survey Area 2	5,100	50	25.5
Survey Area 3	3,200	100	32.0
Survey Area 4	250	300	7.5
Total	**9,650**	**-**	**120.0**

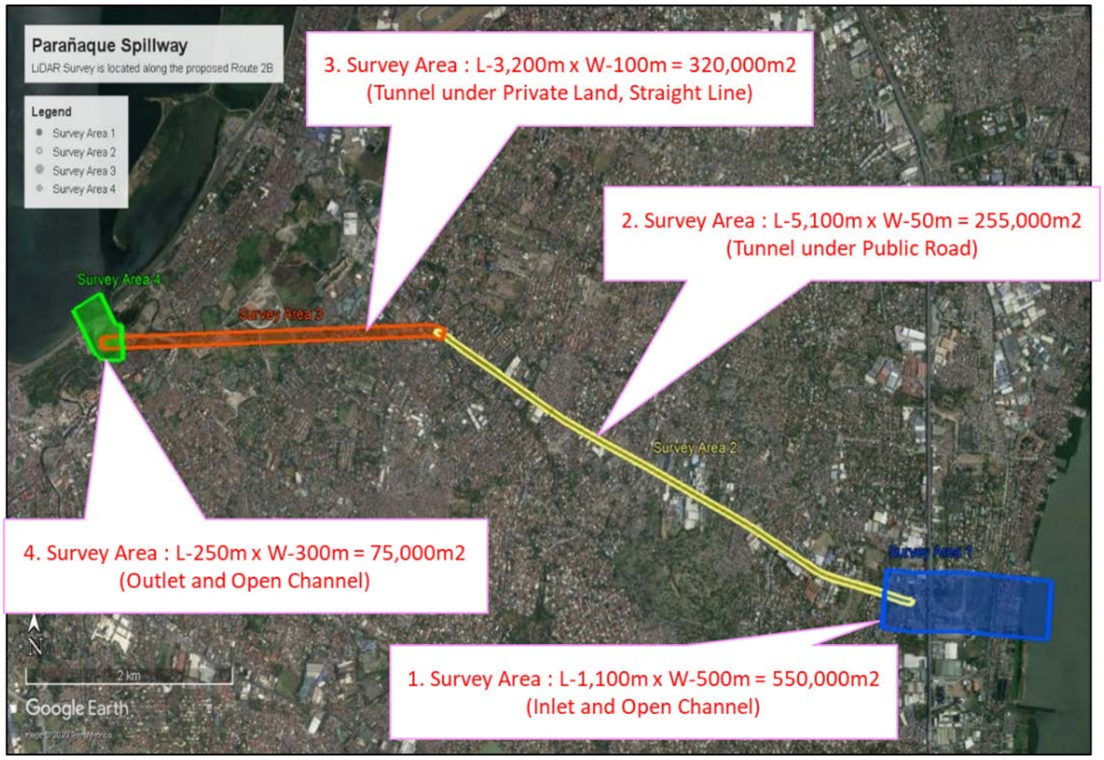


Figure 6.7.1 LiDAR Topographic Survey Area (Route 2-B)

6.7.2 Survey Result

(1) Planar Topographic Map

Sample topographic maps and orthophoto maps for each Survey Area are shown below.

Figure 6.7.2 Survey Area 1：Topographic map and orthophoto map sample near inlet facility of Spillway

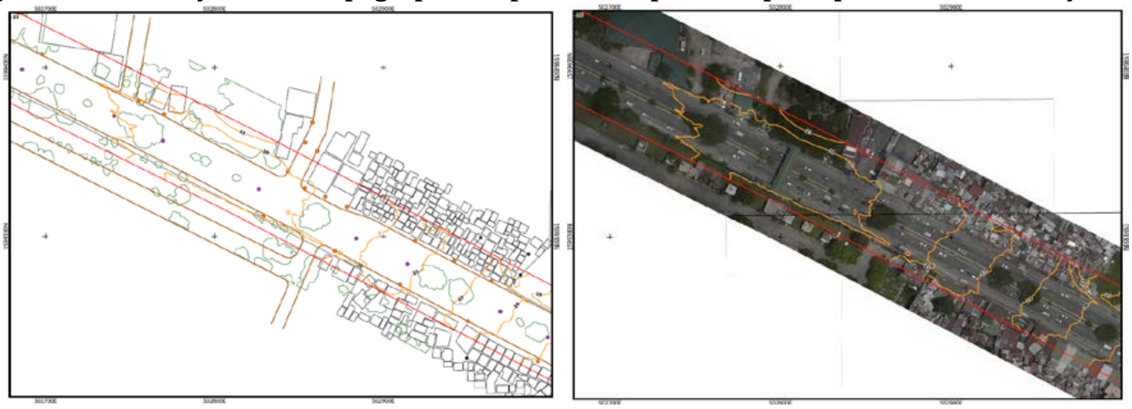


Figure 6.7.3 Survey Area 2：Topographic map and orthophoto map sample of Dr.A.Santos Avenue

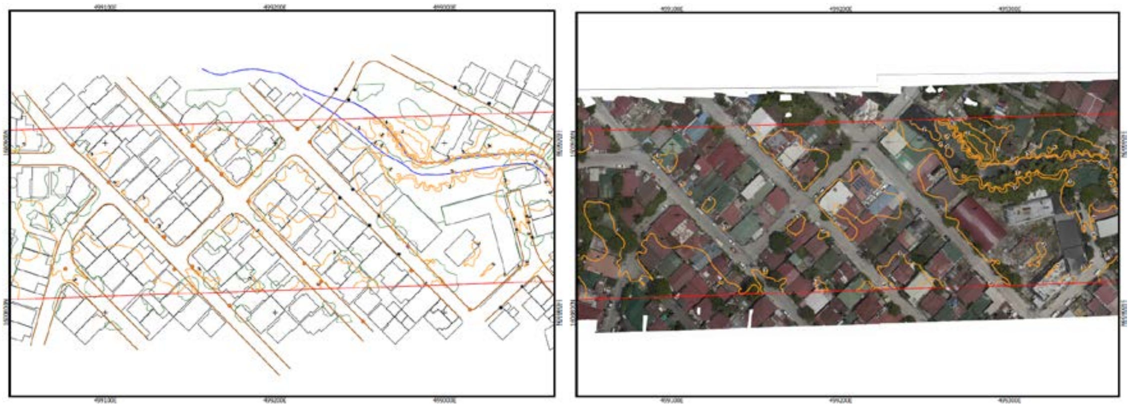


Figure 6.7.4 Survey Area 3：Topographic map and orthophoto map sample from Dr.A.Santos Avenue to Zapote River

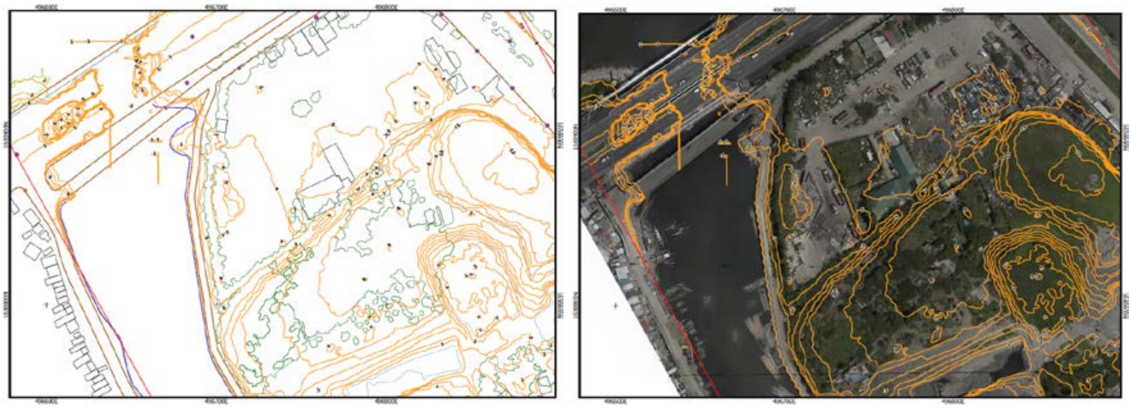


Figure 6.7.5 Survey Area 4：Topographic map and orthophoto map sample near outlet facility of Spillway

(2) Longitudinal Topographic Map

From the topographic survey results, the vertical topographic map of Route 2-B is shown below.

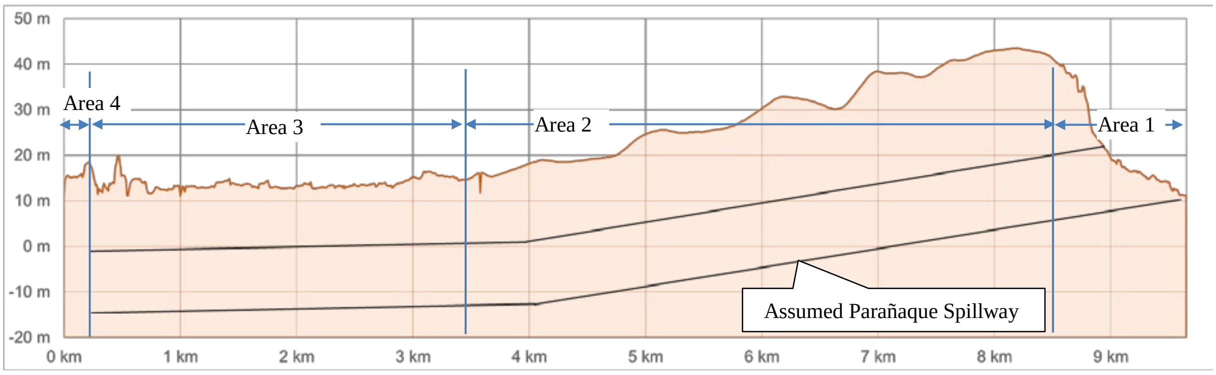


Figure 6.7.6 Longitudinal Topographic Map of Parañaque Spillway Route 2-B

6.7.3 The Feasibility of Route 2-B plan

The feasibility of Route 2-B based on the survey results is summarized below.

<u>Survey Area 1</u>

- It was confirmed that the underground tunnel, open channel, and tunnel entrance on the Lake Laguna side are densely populated areas with gentle slopes and unused land with relatively steep slopes, as initially expected.
- It is assumed that tunnel excavation can be started directly from the ground surface by using this steep slope, and the construction period can be significantly shortened by omitting the inlet vertical shaft.
- For densely populated areas, land expropriation and house relocation are required.
- See 4.10.2 (5) for estimated compensation costs. This compensation cost is an approximation, and it is necessary to examine it in detail in the next F / S survey based on the results of this survey and the facility layout plan.

<u>Survey Area 2</u>

- The width of Dr. Santos A. Avenue, which is a public road, is about 25 m, which is wide enough for the spillway channel (inner diameter 13 m).
- It was also confirmed that the road alignment is almost straight and it is easy to plan a spillway using the underground space of the public road.
- The road has a gentle descent of about 0.6%, and the tunnel can be designed with a downhill slope that matches the slope of the ground surface by securing a cover of 13 m (about the inner diameter of the tunnel) from the ground surface.

<u>Survey Area 3</u>

- It was confirmed that the part that turns from the public road toward the Zapote River is a flat residential area as initially expected.
- Since the terrain is flat, it is assumed that the tunnel will be covered from the ground surface to the inside diameter of the tunnel and will be designed with a very gentle downward slope for drainage.
- Since this part is less than 50m underground, it is necessary to compensate for the underground use right (Perpetual Easement). The compensation cost is 20% of the market price of private land on the ground according to the detailed implementation rules of THE IRR OF R.A. 10752 (Implementing Rules and Regulations of Republic ACT NO. 10752). See 4.10.2 (5) for estimated compensation costs.
- In this survey, permission for ground surveying of some sections was not obtained. In the next F / S survey, it is necessary to examine in detail based on the results of this survey and the final route plan.

<u>Survey Area 4</u>

- It was confirmed that the shaft and the outlet of the spillway on the Manila Bay side are flat land with almost no buildings as initially expected.
- It is envisioned that this flat land will be used to construct drainage shafts and outlet facilities, including gate facilities.

Chapter 7. Recommendation

7.1 Recommendation

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

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

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

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

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

1) To obtain approval from the Philippine government and NEDA of the "Draft Comprehensive Flood Management Plan for Laguna de Bay Lakeshore Area" as a Master Plan; and

2) To carry out a Feasibility Study (F/S) on the Parañaque Spillway, which is a priority project in the Master Plan in which feasibility was shown in this study.

7.2 Contents to be studied in the F/S

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

(1) Topographic Survey

In the previous surveys and this survey, existing terrain data (IFSAR data; 5m grid elevation data, NAMRIA) was utilized and the longitudinal gradient of spillway and designed intake facility (vertical shaft, water intake and drainage facilities) were examined. Since there was an error in the grid elevation data and actual elevation, it is necessary to carry out a detailed topographic survey and review the consideration in the F/S.

(2) Sounding Survey (Laguna de Bay)

In the previous surveys and this survey, the condition of bottom of Laguna de Bay was studied by using existing data of NAMRIA and the water intake facility was examined. However, there is inaccurate data in the actual bottom elevation/situation and existing data and hence the necessary dredging quantity of Laguna de Bay for the placement of water intake facilities cannot be accurately estimated. Therefore, it is necessary to review the design of the open channel section of water intake facility by conducting sounding survey and accurately grasping the current lake bottom situation.

(3) Longitudinal and Cross-Sectional River Survey and Evaluation of Effect to Downstream River

In the previous surveys and this survey, the effects of the downstream river due to drainage of Parañaque Spillway have been evaluated. The design scale was set for each river in the Pre-F/S stage because no flood control plan had been formulated for the Las Piñas and Parañaque areas. The downstream river water level raising due to drainage by Parañaque Spillway and the river improvement plan based on embankment have been evaluated.

Rivers in Las Piñas and Parañaque are connected by channels and they present a complex river network. The effect of drainage by Parañaque Spillway is not only for the downstream river, but also for other rivers connected by channels. In the F/S, additional river survey is necessary where there is no survey data in order to improve the analysis model. Then it is necessary to evaluate the effect of the downstream river.

In addition, it was found that flooding in Las Piñas and Parañaque is caused by overflow from the river. At present, no flood management plan has been formulated in the area, so it is desirable to formulate a flood management master plan at the same time as the F/S of the Parañaque Spillway.

In this study, the drainage destination of the Parañaque Spillway is assumed to be a river in the Parañaque-Las Piñas area (Route 1 drainage destination: South Parañaque River; Route 2-A: San Dionisio River; Routes 2-B and 3: Zapote River). In order to minimize the impact of the Parañaque Spillway on the downstream river, a plan for direct drainage to the sea area shall be studied.

(4) Borehole Drilling Survey

In the previous surveys and this survey, six (6) boring surveys were conducted to grasp the approximate geological composition and groundwater level. The excavation depth of boring was set to 70 m, the geological structure in deep underground was grasped, and the Shield Tunneling Method and NATM were proposed as construction methods.

However, the results of the drilling survey were not sufficient geological information for the 10km extension of structure, so it is necessary to conduct additional investigations. In particular, the effect of the Valley Fault System, located around the intake facility of Parañaque Spillway, on the design and construction of the drainage channel has not been sufficiently grasped. At least 20 additional borehole drilling survey should be conducted to examine the construction method and to examine the design of underground spillway structure.

(5) Hydraulic Model Experiment

In the previous surveys and this survey, the drainage facilities were examined and designed based on the existing study (The Metropolitan Area Outer Underground Discharge Channel and so on) of Japan. However, in the F/S, hydraulic model experiments should be conducted, and detailed drainage facilities (drop shaft) should be examined and designed, and the hydraulic specifications of tunnels should also be examined.

(6) Diffusion Analysis of Discharge from Parañaque Spillway

In the previous surveys and this survey, three (3) locations have been proposed as drainage facility, but in selecting the location of drainage facilities, it is necessary to determine the local LGU's opinions and the environmental impact. In the F/S, water diffusion analysis should be conducted to examine the effect of Laguna de Bay water on Manila Bay and the effect on LPPCHEA should be quantitatively assess.

(7) Operation and Maintenance Plan

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 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 works.

(8) Operation Plan of Rosario Weir

Due to the connection with the Manggahan Floodway, fluctuations in the water level of Laguna de Bay may affect the flood management plan for Pasig-Marikina River. After the completion of Parañaque Spillway, it is possible to set the Laguna lake water level at 100-year probability to DFL 13.8m. However, before the completion of the Parañaque Spillway, it is necessary to consider the operation of Rosario Weir based on the water level of Laguna de Bay.

In addition, when the water level of Laguna de Bay is 12.5 m or more, the backflow from Laguna de Bay to Marikina River through the Manggahan Floodway is effective for lowering the water level of Laguna de Bay. At present, the operation rule of Rosario Weir has not been examined from the viewpoint of the function of lowering the water level of Laguna de Bay. It is necessary to consider the operation of the Rosario Weir based on the water level of Laguna de Bay.

(9) Environment Impact Assessment (EIA) and Preparation of the Resettlement Action Plan (RAP)

It is assumed that land acquisition, house evacuation, and environmental impact of construction of water intake facilities, open channels and drainage facilities on the ground will occur. In the F/S, environmental impact assessment (EIA) and resettlement action plan (RAP) should be prepared and these issues should be thoroughly studied.

7.3 Future Issues on Parañaque Spillway Routes 2-A and 2-B for F/S

Since it was confirmed that the tunnel alignment greatly affects the construction cost and construction period, it is important to determine the tunnel alignment at an early design stage. For this purpose, the following items a) to f) are to be obtained, and the proposed route finalized in the F/S stage together with the plan and vertical alignment considering these existing structures. In addition, since it is assumed that these existing structures and the tunnel will be constructed close to each other, impact study shall be conducted to confirm the safety of existing structures. For places where the necessary safety factors cannot be secured, measures such as protective construction methods shall be considered, as follows:

a) As-built drawing of the Skyway pier and foundation pile (S104～S108) [See Point 1-A]

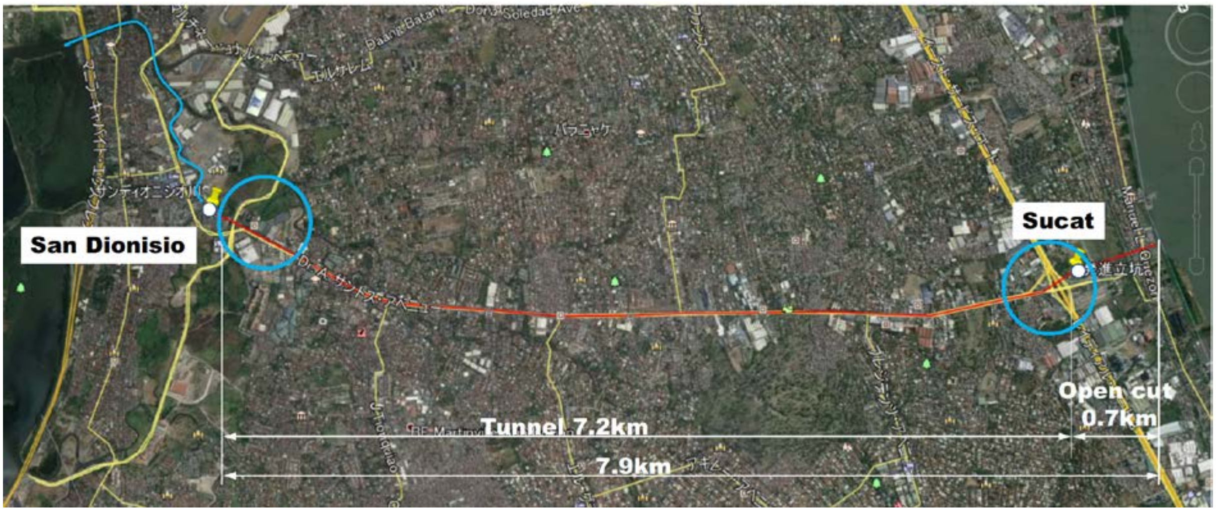
b) As-built drawing of the abutment of the road bridge and the foundation pile that goes over the road under the Skyway [See Point 1-A]

c) As-built drawing of the Skyway ramp pier and foundation pile [See Point 1-B]

d) Foundation pile for footbridge [See Point 2-C]

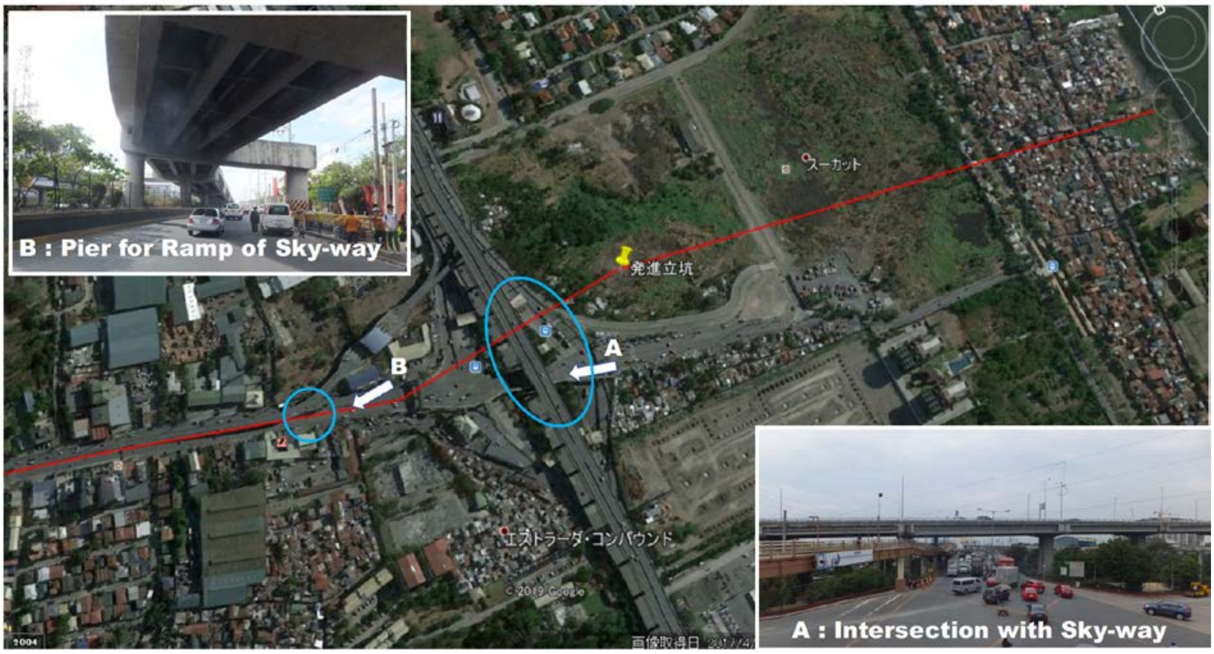
e) As-built drawing of piers and foundation piles of Carlos P. Garcia Avenue Extension [See Point 2-D]

f) Metro Manila Subway Project, Phase II section design documents [Details are unknown]



Source: JICA Study Team

Figure 7.3.1 Tunnel Alignment Control Map



Source: JICA Study Team

Figure 7.3.2 Tunnel Alignment Control Location Map (Point 1)

i) This alignment plan intersects in a plane with the Skyway in Section A. From this, a) and b) are obtained, and the plane and longitudinal alignment of the project spillway tunnel are set based on the arrangement and length of the foundation pile.

ii) The Skyway ramp is constructed with a portal pier structure. Based on the information in c), check the arrangement and construction depth of the foundation piles and set the plane and vertical alignment of the tunnel.

Source: JICA Study Team

Figure 7.3.3 Tunnel Alignment Control Location Map (Point 2)

iii) Since the footbridge foundation of d) is on this alignment plan, check the pile length and confirm that there is no effect on tunnel construction.

iv) This alignment plan intersects with the elevated road in the D section. Obtain e) from this, and set the plane and vertical alignment of this tunnel based on the arrangement of foundation piles and construction depth.

v) Metro Manila Subway Project Phase II section is planned to intersect this alignment plan in a plane. For this reason, after obtaining f) and clarifying the intersection location, confirm the construction time of both sides and examine the necessary separation to determine the vertical alignment of the tunnel.