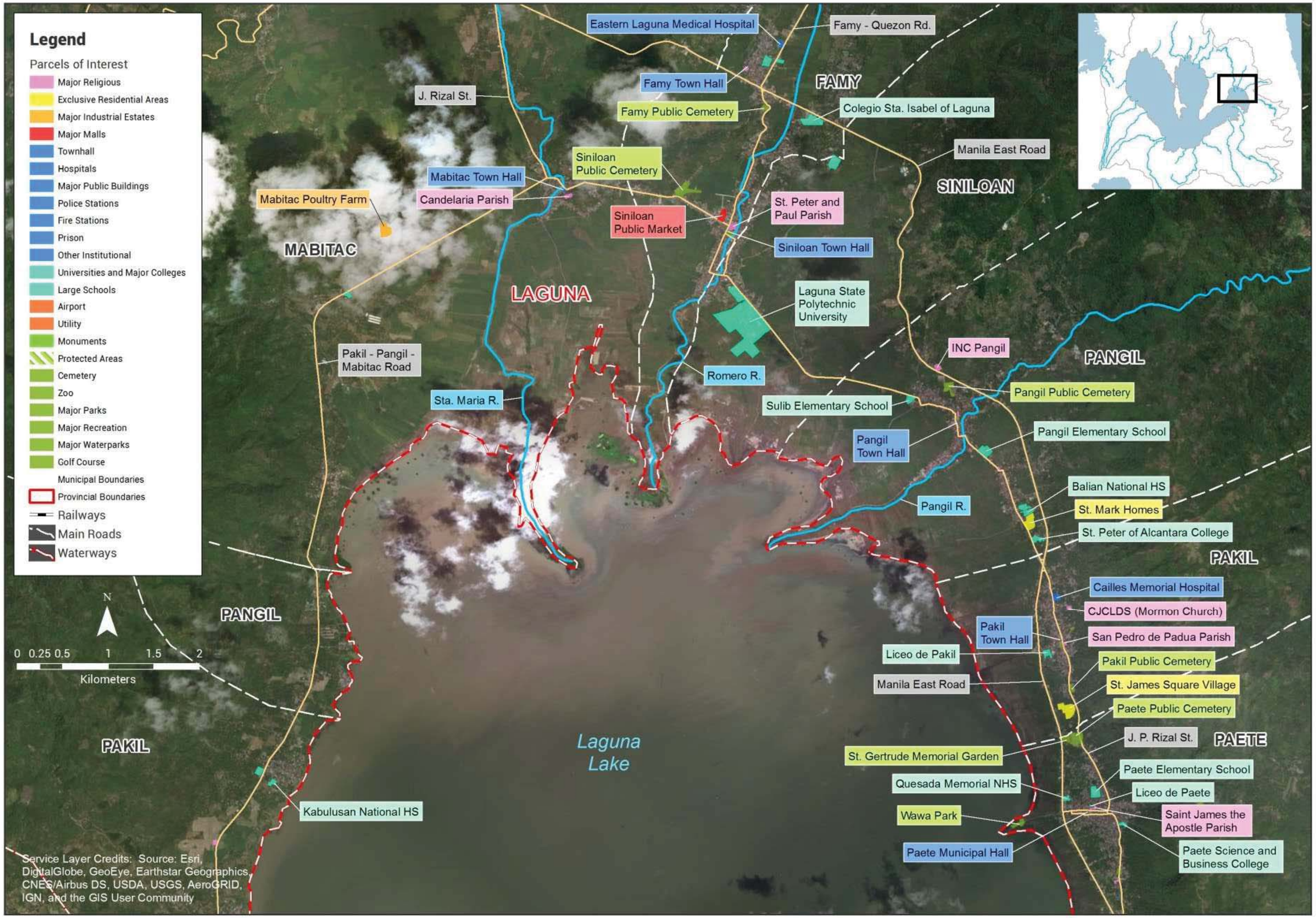
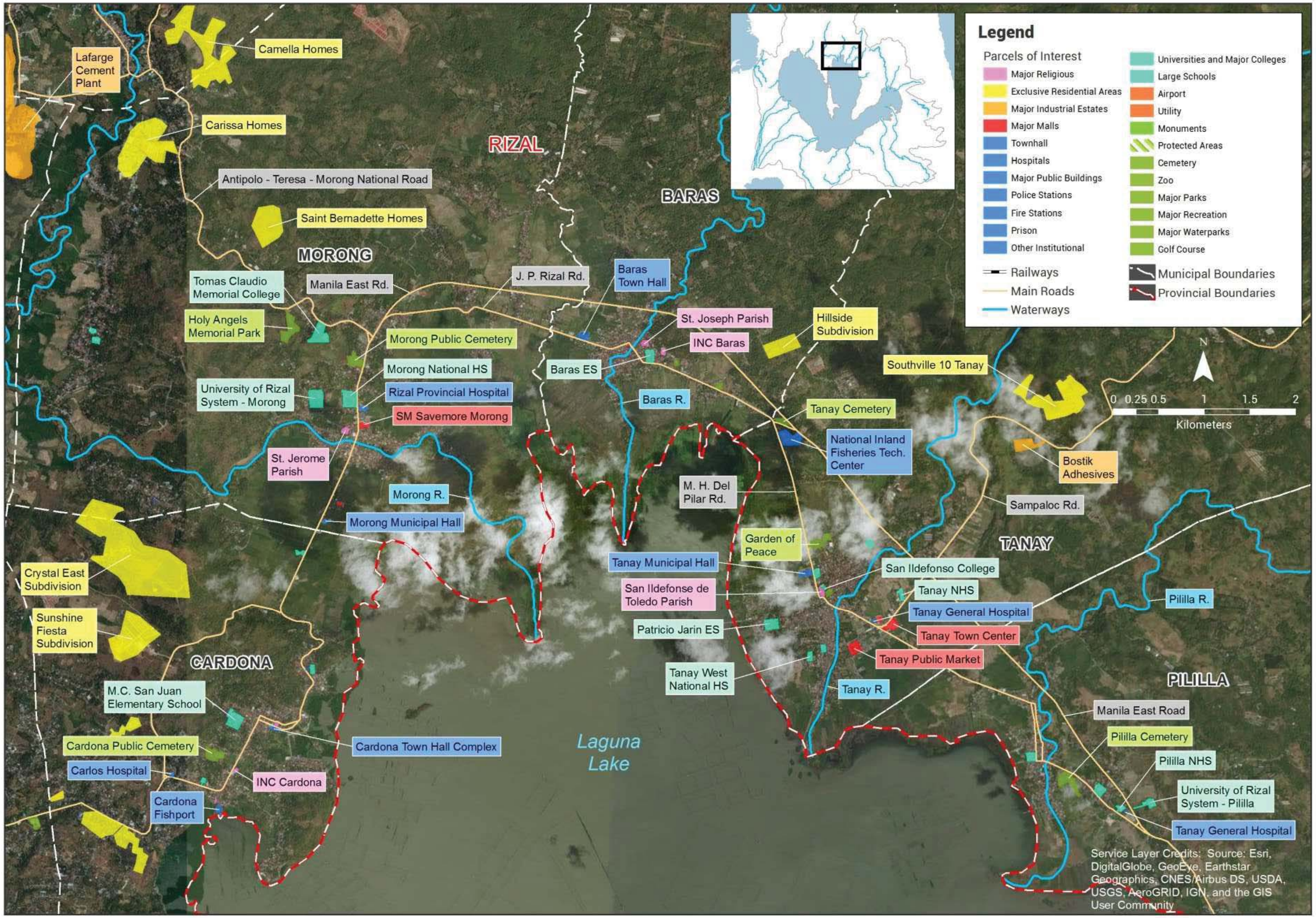


出典: JICA 調査チーム

図 巻 1-8 土地利用及び施設・構造物の立地状況（エリア 8）



出典: JICA 調査チーム

図 巻 1-9　土地利用及び施設・構造物の立地状況（エリア 9）

出典: JICA 調査チーム

図 巻 1-10　土地利用及び施設・構造物の立地状況（エリア 10）

添付資料　5

リーフレット

Location Map

Republic of the Philippines
Department of Public Works and Highways

Japan International Cooperation Agency
CTI Engineering International Co., Ltd. (CTII)
Nippon Koei Co., Ltd. (NK)
CTI Engineering Co., Ltd. (CTIE)

PARAÑAQUE SPILLWAY PROJECT
(DRAFT)

October 2000
Typhoon Seniang

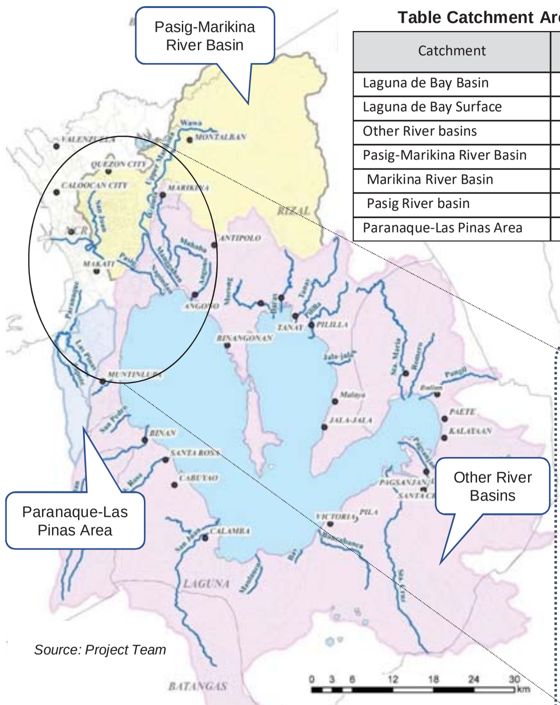
September,2009
Typhoon Ondoy

Background

Typhoon Ondoy occurred in September 2009 and recorded the daily rainfall of 453 mm which caused massive flood damage in the whole Metro Manila area including the areas along the Marikina River and around the Laguna de Bay. In the West Mangahan district located in the Laguna de Bay lakeshore area where measures were implemented in the project entitled "Metro Manila Flood Control Project – West of Mangahan Floodway", about 80% of the low-lying residential areas were inundated for 1 to 3 weeks due to the flooding caused by the overflow of the Marikina River, inland inundation, and the water level rise of Laguna de Bay. In the lakeshore area of Laguna de Bay, low-lying areas without flood management countermeasures widely spread and these areas experienced inundation for more than one month.
The flood management measures in the lakeshore area of Laguna de Bay are behind as compared to those implemented in the center of Manila, so that flood management countermeasures are urgent matters to be addressed.

About Laguna de Bay

The survey area is the entire lakeshore of Laguna de Bay in Metro Manila, Rizal Province and Laguna Province in the Philippines.



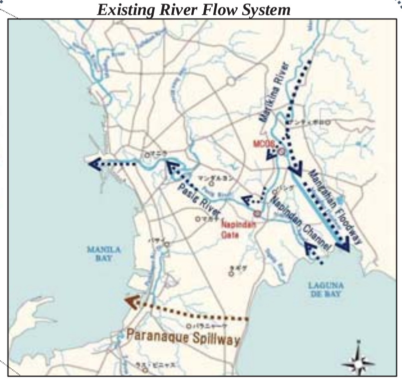
Source: Project Team

Table Catchment Area

Catchment	Area (km²)
Laguna de Bay Basin	3,280
Laguna de Bay Surface	900
Other River basins	2,380
Pasig-Marikina River Basin	640
Marikina River Basin	538
Pasig River basin	102
Paranaque-Las Pinas Area	74

Photo taken in 2009

Existing River Flow System



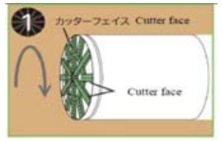
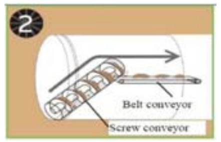
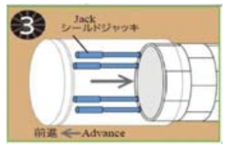
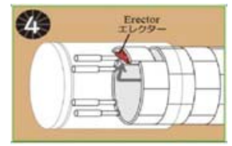
Source: Project Team

Mangahan Floodway

Floodwaters of the Pasig-Marikina River and Laguna de Bay were once flowing into Manila Bay. However, the completion of the Mangahan Floodway changed the hydrological system. From the viewpoint of Laguna de Bay side, the current hydrological system is that the large volume of flood water from the Marikina River is temporarily stored in Laguna de Bay, and the stored water is released via Napindan Channel and the Mangahan Floodway.

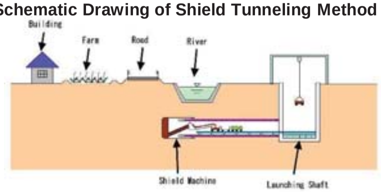
Shield Tunneling Method

Excavate with the shield machine by stabilizing the face against earth pressure and water pressure using mud pressure or muddy water pressure and assemble segments to retain the ground.

Step-1: Excavation			Step-2: Segment Assembly
1.Cutting	2.Transporting excavated soil	3.Advancing Shield Machine	4. assemble/insert segment
			
Revolve the cutter face to cut the ground	Load excavated soil into the machine by a screw conveyor and transport it to the outside	Apply reaction force with jacks installed in the machine against segments and advance the machine accommodating the speed of excavation	Secure the space to assemble segments by shortening jacks situated at the element to assemble and insert the segment using an erector

Source: North Line HP from Metropolitan Expressway Company Limited

Schematic Drawing of Shield Tunneling Method

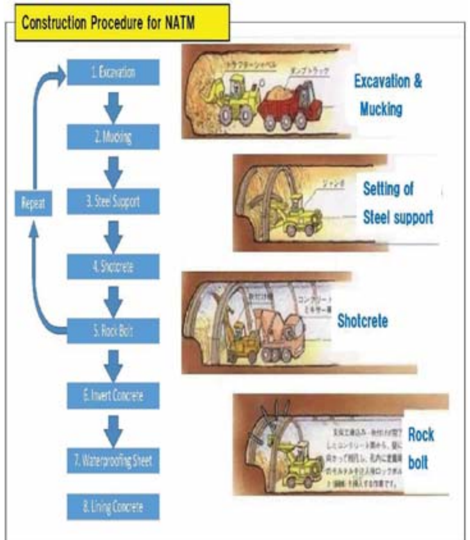


Source: Introduction of Tunnel Construction Method from Japan Water Agency

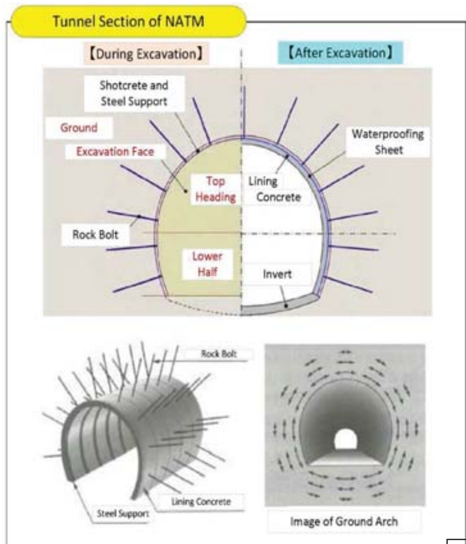
Source: Picture of Road Tunnel from Highway Technology Research Center

NATM (New Austrian Tunneling Method)

Excavate by stabilizing the ground using shotcrete, rock-bolts and steel support, etc., utilizing the support function of surrounding ground



Source: Design Practice to Understand the Concept Well 7 from Tunnel Designing



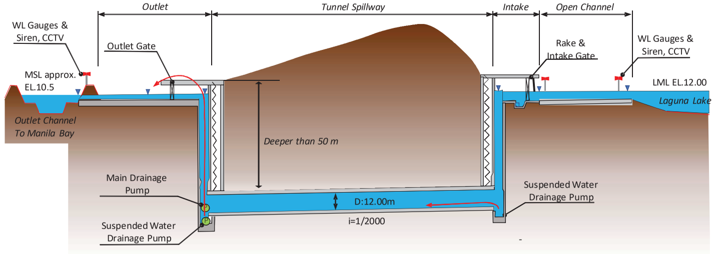
Source: Design Practice to Understand the Concept Well 7 from Tunnel Designing

■ Basic Design of Parañaque Spillway

Concept of Parañaque Spillway

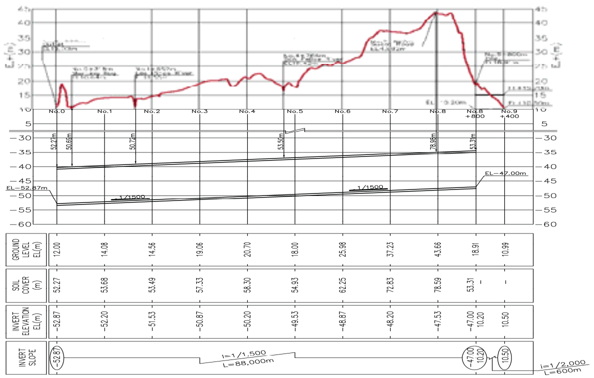
- Tunnel is planned deeper than fifty (50) m from the surface*1.
- Siphon discharges excess water using the pressure difference caused by the water head.
- Siphon will do without pump discharge

*1 IRR of RA10752 (2016) states that the government shall not be prevented from use of such private and government lands by surface owners or occupants, if such entry and use are made more than fifty (50) m from the surface.



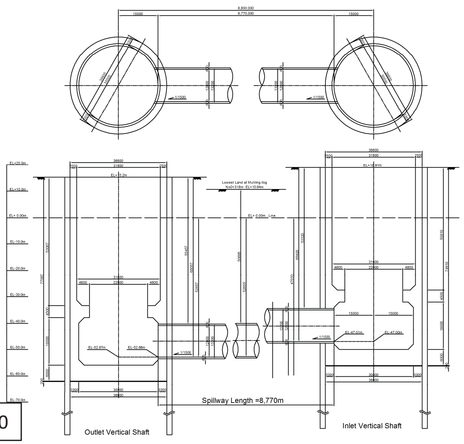
Source: Project Team

i) Longitudinal Profile of Paranaque Spillway

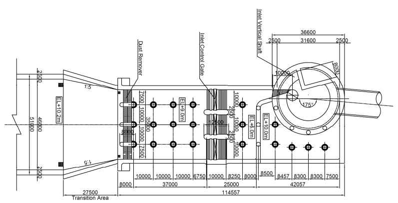


Source: Project Team

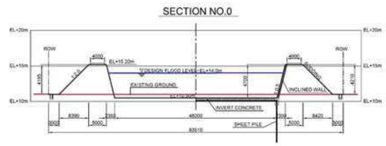
ii) Plan Drawing of Vertical Shaft of Inlet and Outlet



iii) Outline Drawing



Ⅳ) Standard Cross Section of Intake Open Channel



Source: Project Team

■ Historical Flooding Damage

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

Although Laguna de Bay is a large lake where flood waters can be stored, the only main river outflowing from the lake is the Napindan Channel. Therefore, the area has the characteristics that once the water level rises, the high water level continues for a long period and the extended area is damaged by inundation.

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

Source: Project Team

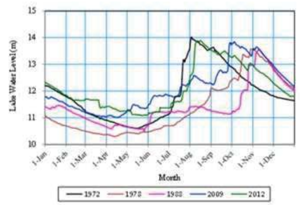
Source: LLDA ,Floodings in the Laguna de Bay Region

Source: LLDA ,Floodings in the Laguna de Bay Region

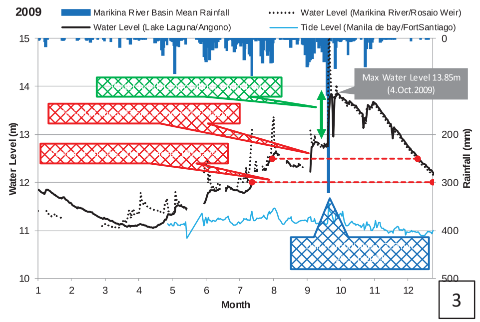
Source: LLDA ,Floodings in the Laguna de Bay Region

Major Flood Events in Laguna de Bay

No.	Year	Month	Day	Surface water level m	Typhoon or Cyclon	Date	
						Start	End
1	1972	8	3	14.03	Tropical Storm Winnie	1972/7/29	1972/8/3
2	2009	10	4	13.85	Typhoon Ondoy	2009/9/25	2009/9/30
3	2012	8	11	13.83	2012 Habagat		
4	1978	10	28	13.58	Super Typhoon Rita	1978/10/15	1978/10/29
5	1988	11	9	13.55	Tropical Storm Tess	1988/11/1	1988/11/6



Flood Event in Laguna de Bay by Typhoon Ondoy and Typhoon Pepeng in 2009



■ Past Flooding Damage

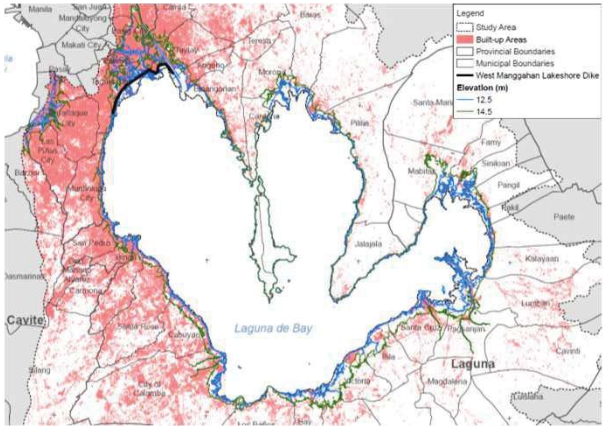
Since Laguna de Bay has a nearly trapezoidal shape and the capacity of the Napindan River (the outflow river) is limited, it has the characteristics of long flood duration. This indicates that flooding of Laguna de Bay has reached the same ground elevation as the flood level.

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

Water Level (m)	Inundation Area*1 (km²)	Number of affected People*2 (person)
12.0	0.0	0
12.5	20.8	48,000
13.0	44.6	179,000
13.5	69.6	353,000
14.0	95.6	554,000
14.5	120.9	749,000

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

For example, when the highest water level reaches 13.0 m, it is assumed that 44.6 km² of the residential area is flooded and the inundated population is 179 thousand from the water level 12.0 m.



Source: Project Team

Laguna de Bay Lakeshore Area and Assumed Flood Area (12.5 m, 14.5 m Ground Elevation Lines)

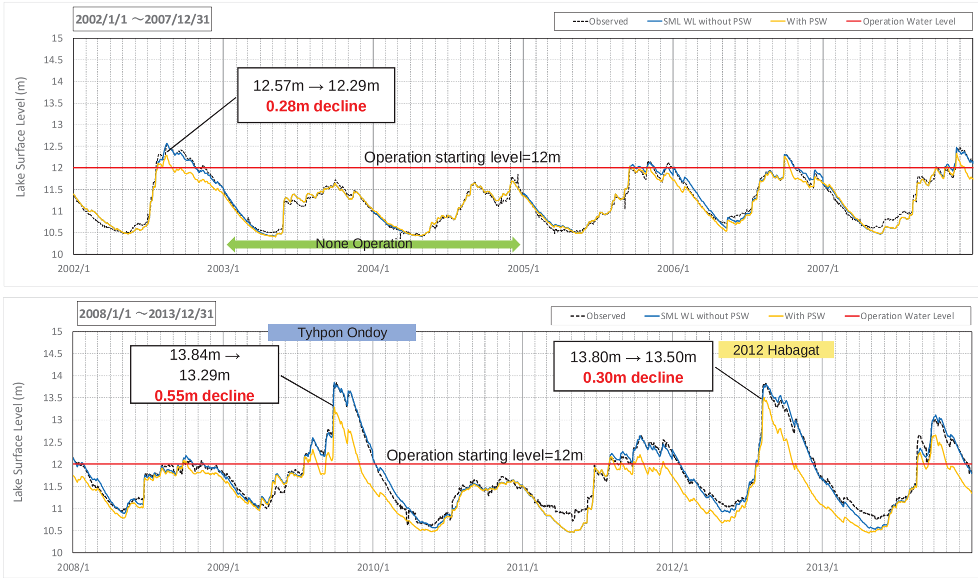
■ Setting of Design Scale

The design scale is set by comprehensively evaluating the importance of the target basin, the actual condition of the past flood damages, the existing plan in the vicinity area and the design scale specified in the DPWH Standard Guideline of 2015.

- ✓ For the **Pasig – Marikina River Basin** which is the vicinity of this study, the design scale is the **100-year return period**. Typhoon Ondoy in 2009 brought massive damages to the Laguna de Bay Basin, and the basin average rainfall in the Marikina River Basin was 290.8mm (one day) which is equivalent to a 100-year return period.
- ✓ According to the "Manual on Flood Control Planning , March 2003" which was prepared in the JICA Technology Cooperation Project - ENCA, the eighteen (18) principal river basins in the Philippines are specified, including **Laguna de Bay in the Pasig-Laguna Bay Basin**.
- ✓ According to the DPWH Standard Guideline of 2015, design scales have been specified for rivers and drainage canals. In addition to the DPWH Standard Guideline, there is the memorandum of understanding in 2011 which specifies the design scales.
- ✓ The catchment area of Laguna de Bay is 3,280km², and the design scale in the DPWH Standard Guideline (Rivers) is a **100-year scale**.

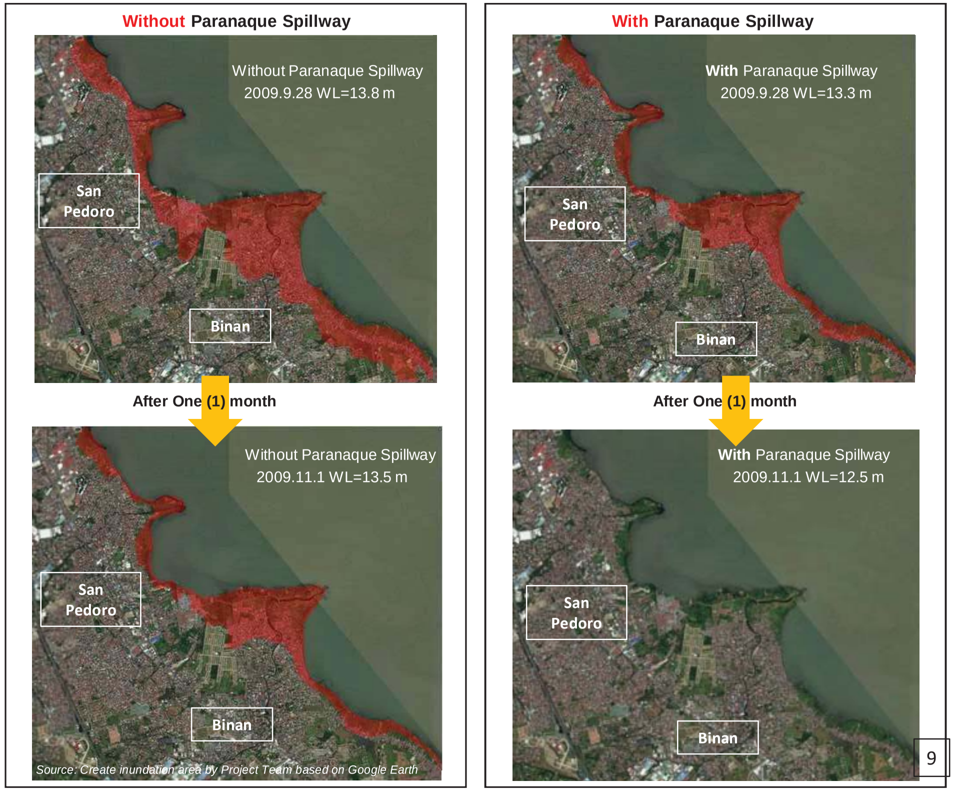
Table Design Scale of Flood Management in the Laguna de Bay Basin

Classification	Evaluation Index	Design Scale	Setting Rationale
Flood caused by water level rise of Laguna de Bay	Water Level	**100-year**	• Since Laguna de Bay is considered as one of the important basins in the Philippines, the design scale is set to a 100-year which is equivalent to the value for the Pasig-Marikina River Basin. • The water level observed for Laguna de Bay has accumulated over a long period of time as compared to the rainfall data. Therefore, the water level probability scale is adopted.
Laguna de Bay Basin (21 River Basins)	Rainfall	【Rivers】 A≧40km² **50-year** 10km²≦A＜40km² **25-year** A≦10km² **15-year**	• Since there are several rivers in 21 river basins located in the Laguna de Bay Lakeshore Area, the design scale is set based on the basin area of each river. • The design scale used in the DPWH Standard Guideline of 2015 may be an excessive design scale; therefore, the design scale of each basin area is set based on the memorandum of 2011.
		【Drainage canal】 Drainage canal: **15-year**	• This will be the design scale when internal water (drainage) countermeasures are targeted.
Las Piñas-Parañaque District	Rainfall	【Rivers】 A≧40km² **50-year** 10km²≦A＜40km² **25-year** A≦10km² : **15-year**	• This will be the design scale when the external water countermeasures are targeted.
		【Drainage Canal】 Drainage Canal: **15-year**	• This will be the design scale when internal water (drainage) countermeasures are targeted.



Source: Project Team

Long-term Prediction Calculation Results from 2002 to 2013 with Operation Starting Level of EL 12.0m



Source: Create inundation area by Project Team based on Google Earth

■ Effect of Water Level Reduction by Parañaque Spillway

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

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

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

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

Inflow V

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

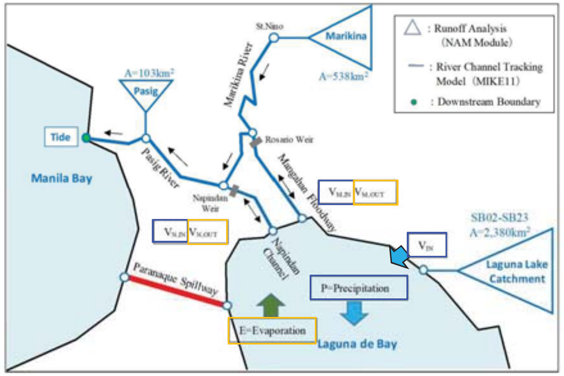
outflow V

= 1,139.8 – 66.9

= **1,072.6 MCM**

(1.11m water level up)

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



Source: Project Team

◆ Effect of Water Level Reduction by the Construction of Parañaque Spillway

＜ Operation Starting Water Level ＝ 12.0m ＞

- Regarding the peak water level, the maximum water level decrease of 0.55 m was in 2009, the water level lowering effect of 0.24 m on a 12-year average.
- The duration of water level over 12.5m was shortened from 110 days to 46 days (42% reduction) in 2009, from 108 days to 63 days (58% reduction) in 2012, and from 62 days to 15 days (24% reduction) in 2013.
- Laguna de Bay is utilized as source of drinking and irrigation water, and fishery. The operation starting water level of 12.0 m does not affect these water utilization purposes.

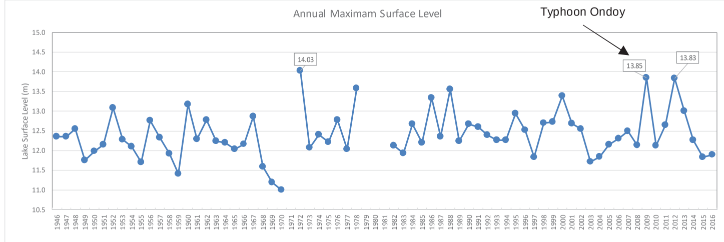
Year	Observed	Maximum Water level			Days of more than 12.5m		
		SML					
		[1] WL without PSW	[2] With PSW	[3]=[1]-[2] Difference	[4] WL without PSW	[5] With PSW	[6]=[4]-[5] Days
2002	12.55	12.57	12.29	0.28	8	0	8
2003	11.72	11.64	11.64	0.00	0	0	0
2004	11.85	11.69	11.69	0.00	0	0	0
2005	12.15	12.12	12.03	0.10	0	0	0
2006	12.30	12.30	12.27	0.03	0	0	0
2007	12.49	12.47	12.33	0.14	0	0	0
2008	12.14	12.19	12.10	0.10	0	0	0
2009	13.85	13.84	13.29	0.55	110	46	64
2010	12.12	12.12	11.64	0.48	0	0	0
2011	12.65	12.65	12.22	0.43	17	0	17
2012	13.83	13.80	13.50	0.30	108	63	45
2013	13.01	13.11	12.66	0.45	62	15	47
Min	**11.72**	**11.64**	**11.64**	**0.00**	**0**	**0**	**0**
Ave	**12.56**	**12.54**	**12.31**	**0.24**	**25**	**10**	**15**
Max	**13.85**	**13.84**	**13.50**	**0.55**	**110**	**63**	**64**

[Parañaque Spillway]

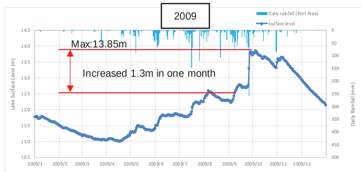
Design Discharge : 200m³/S
Floodway Length : it is considered as 10km.

Pipe Diameter : 12.0m
Inflow Gate : 10.0m x 3 sluice gates

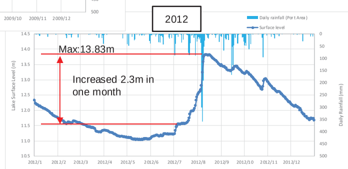
■ Changes of Lake Level



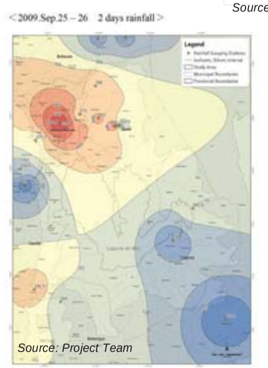
Long-term Change of Year Maximum Lake Level



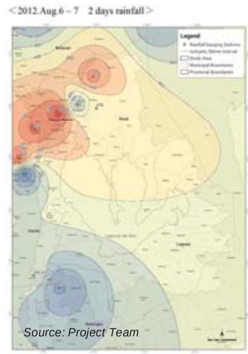
Source: Project Team



Source: Project Team



Source: Project Team



Source: Project Team

Maximum Lake Level at Laguna de Bay (1946 to 2016)

Year	Surface water level m	Days of above 12.5m	Year	Surface water level m	Days of above 12.5m
1946	12.36	0	1983	11.94	0
1947	12.36	0	1984	12.67	16
1948	12.54	19	1985	12.20	0
1949	11.76	0	1986	13.34	93
1950	11.98	0	1987	12.35	0
1951	12.15	0	1988	13.55	48
1952	13.08	68	1989	12.24	0
1953	12.28	0	1990	12.67	21
1954	12.10	0	1991	12.60	26
1955	11.71	0	1992	12.39	3
1956	12.76	38	1993	12.27	0
1957	12.33	0	1994	12.27	0
1958	11.92	0	1995	12.94	81
1959	11.41	0	1996	12.52	0
1960	13.17	64	1997	11.83	0
1961	12.29	0	1998	12.70	20
1962	12.77	36	1999	12.72	37
1963	12.24	0	2000	13.39	65
1964	12.20	0	2001	12.69	6
1965	12.04	0	2002	12.55	5
1966	12.16	0	2003	11.72	0
1967	12.87	3	2004	11.85	0
1968	11.59	0	2005	12.15	0
1969	11.19	0	2006	12.30	0
1970	11.00	246	2007	12.49	0
1971	No data	-	2008	12.14	0
1972	14.03	88	2009	13.85	108
1973	12.08	0	2010	12.12	0
1974	12.40	0	2011	12.65	21
1975	12.22	0	2012	13.83	111
1976	12.77	16	2013	13.01	61
1977	12.03	0	2014	12.26	0
1978	13.58	62	2015	11.83	0
1979	No data	-	2016	11.89	0
1980	No data	-	**Min**	**11.00**	**0**
1981	No data	-	**Ave**	**12.41**	**22**
1982	12.13	119	**Max**	**14.03**	**246**

■ Hydrological Statistical Analysis

Lake Water Level Statistical Analysis

- Probable lake water level was computed using annual maximum lake water level from 1946 to 2016.
- Lake water level in 100-year return period is at 14.3m.

Return Period (year)	Water Level (m)
2	12.3
3	12.6
5	12.9
10	13.2
20	13.6
30	13.7
50	14.0
80	14.2
100	14.3
200	14.7

□ Lake Water Level*
- Mean Lower Water Level : 10.69 m
- Maximum Lower Water Level : 11.19 m
- Mean Water Level : 11.33 m
- Mean Higher Water Level : 12.07 m
- Maximum Higher Water Level : 14.03 m

* Estimated using by observed data from 1947 to 2016.

□ Tide Level
- Mean Sea Level : 10.47 m
- Maximum Sea Level : 11.87 m
- Syzygy average high water level : 11.24 m

Source: Project Team

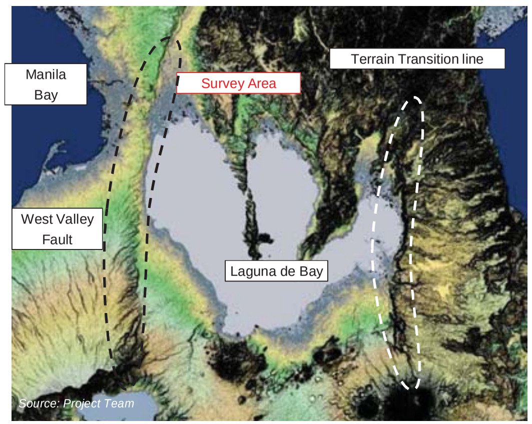
■ Route

Route	Route-1: Lower Bicutan to South Paranaque River	Route-2: Sucat to San Dionisio River	Route-3: Sucat to Zapote River
Summary	Basically straight line between Lower Bicutan and South Paranaque River	Basically straight line between Sucat and San Dionisio River	Basically straight line between Sucat and Zapote River
Spillway Length	Spillway Lp=6.0km Open Channel Lo=1.2km	Spillway Lp=7.2km Open Channel Lo=0.6km	Spillway Lp=8.8km Open Channel Lo=0.6km
Site	It is necessary to relocate large-scale facilities. such as Polytechnic University	Mainly unused ground is widely spaced but adjacent to church.	
River Improvement	Wide river improvement area required due to the narrow channel.	Required river improvement areas are up & downstream of drainage facility.	Required river improvement area is smallest among 3 rivers.
Social Environment	The length of 1200m of the Open Channel is longer than Route-2.	Resettlement is necessary in the Laguna de Bay lakeshore area.	
Evaluation	O: Possible	△	O: Promising

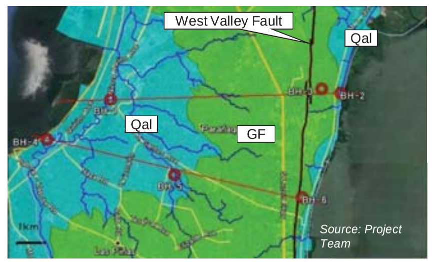
Source: Project Team

Alignment Plan Drawing of Parañaque Spillway

■ Geological Condition



Source: Project Team



Source: Project Team

<u>Basement rock in this hilly land:</u>
Pleistocene Guadalupe Formation (GF), mainly composed of volcanic clastic rocks (tuff, lapilli tuff, tuff gravel rock, volcanic ash, silt, etc.,), the so-called "soft rocks."
<u>Lowlands on the western side of the hill and the lakeshore area of Laguna de Bay</u>: Holocene Quaternary Alluvium (Qal), unconsolidated deposits such as clay, silt, sand, and gravel covers the basement soft rocks.

- The West Valley Fault in the Valley Fault System can be seen in north-south direction, west side of Laguna de Bay.
- The elevation becomes gradually higher toward Laguna de Bay. After the peak of hilly land at around 40m, the elevation drops at lakeshore area of Laguna de Bay.


Exposed soft rock (Guadalupe Formation)

Source: Project Team

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