CHAPTER 4. DRANAGE FACILITY PLAN

4.1 Details and Superiority of the Japanese Technologies which is Applicable to the Selected Areas, and Issues and Important Points for application

4.1.1 Concrete Method Examination of Tunnel Technologies in Japan

(1) Outlines and Features of the Japanese Tunnel Technologies

In Japan, subways, sewerage pipes, highways and underground diversion channels have been constructed by using underground tunneling technology.

Construction methods for those structures are broadly divided into “Cut and Cover Method” and “Tunnel Method.” Tunneling methods are classified as shown in Figure 4.1.1.

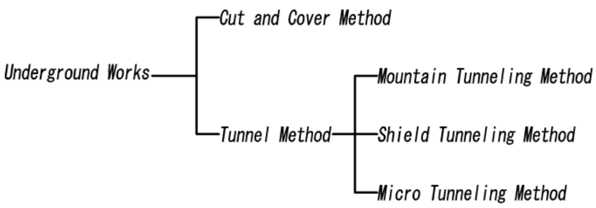


Figure 4.1.1 Tunneling Methods

Cut and Cover Method constructs a tunnel by excavation from ground surface down to a certain depth. The method will backfill and restore the ground surface after construction. The construction method is applied mostly for shallow excavation depth. In case of deep excavation and for the mountainous areas, Tunnel Method is applied.

As for the Tunnel Method, there are the “Mountain Tunneling Method”, “Shield Tunneling Method” and “Micro Tunneling (Pipe Jacking) Method”. These tunneling methods construct tunnels with a limited part of surface excavation area only, thus entailing less impact on the surrounding areas that a “Cut and Cover Method” has. The outlines of the abovementioned three tunneling methods are described below.

(a) Mountain Tunneling Method

Mountain Tunneling Method is suitable for rock excavation of mountainous area. The excavation methods are blasting, mechanical and hand excavations. Tunnel Boring Machine (TBM) method is a mechanical excavation method that presses cutter head on to the excavation surface to excavate. TBM is applied in case the construction speed is required, such as the headrace tunnel for power generation.

The standard construction method for tunnel structure is New Austrian Tunneling Method (NATM). The feature of NATM applies shotcrete, rock bolt and steel rib support as tunnel support to reinforce the original ground and construct a tunnel with the strength of the original ground itself.

The characteristics of the mountain tunneling method are that it needs the strength of the original ground for both excavation and construction of the tunnel. It is necessary to apply ground improvement in case the original ground is fragile.

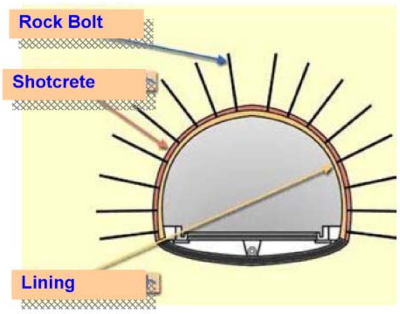


Figure 4.1.2 Mountain Tunneling Method

Characteristics of “Mountain Tunneling Method” are as follows;

- Cross sectional shapes are generally round in case of TBM and horseshoe for other cases.
- Applicable geologies are mainly hard rock to soft rock.
- Length: There is no limit on length for construction.

(b) Shield Tunneling Method

Shield tunneling method is a construction method that pushes a steel made cylindrical excavation machine called "Shield" by using the equipped jack for excavation, moves on excavation by preventing collapse of the original ground at the surface of excavation, repeats lining (segment erection for lining) to support the excavated surfaces, and further moves on excavation of the tunnel by using the erected linings as reaction force for the jack. Shield tunneling method is a construction method developed to cope with soft foundations in urban areas etc. and is applied for construction of tunnels under rivers. The range of finished inner diameter is from 1,350 mm to 14,000 mm.

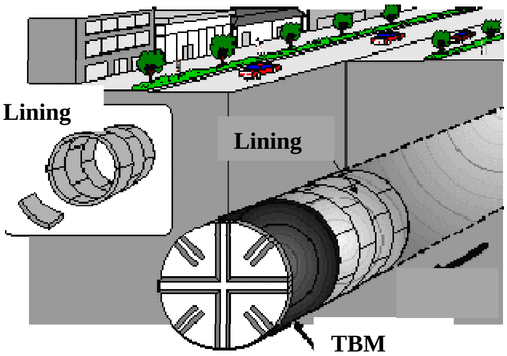


Figure 4.1.3 Shield Tunneling Method

The most significant feature is that it can be applied to soft and loose foundations without any ground improvement, which mountain tunneling method does not have. Other characteristics are as follows:

- The cross sectional shape of the tunnel is basically round. The maximum diameter of the shield machine is 17.045 m, which is made by Japanese manufacturer.
- Applicability for long distance is good. The Central Ring Road Shinagawa Line is constructed using one unit of shield machine for 8 km, for example.
- Geological applicability is also good and applicable to almost all types of foundations such as soft clay, loose sandy soil, gravel, or soft rock. Depending on the target geology for excavation specifications of cutters and face plates will be changed.

(c) Micro Tunneling (Pipe Jacking) Method

The same as shield tunneling method, Micro Tunneling (Pipe Jacking) Method is applied in the urban areas where the surface ground is already developed and where Cut and Cover Method is difficult to be applied. Micro Tunneling Method is defined as "An installation method of the pipe by putting lead body at the edge of the jacking pipe, press the jacking pipe with driving force with the installed reaction force receiver, excavate and muck the soil at cutting blade part, and construct the pipe through connection of the jacking pipe one by one. The range of finished inner diameter is from 200 mm to 3,000 mm.

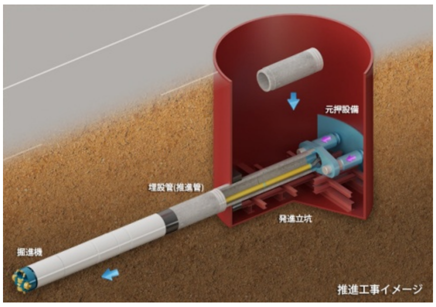


Figure 4.1.4 Micro Tunneling Method

Micro tunneling method expands the range of applicable geology through adoption of cutting face stabilization mechanism applied for shield tunneling method. Therefore, in Japan, medium to large diameter pipe jacking of more than or equal to 800 mm diameter is called as "Semi-Shield Method." The most significant difference from Shield Tunneling Method is applicable construction length. The most of micro tunnels have less than 500m length as it generates driving force at departing vertical shaft, and in case of planned length is longer, intermediate vertical shafts are required. Therefore, in case of longer distance construction, there will be effects on the road traffic by the increase of vertical shafts.

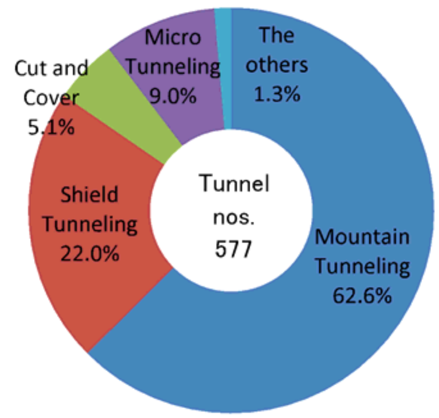
The other characteristics are as follows:

- The cross sectional shape of the tunnel is round. The structure of the tunnel is mostly reinforced concrete secondary products.
- The length of the tunnel is mostly less than 500 m. The longest span for micro tunneling in Japan is 1,450 m (for one span).
- Geological applicability is as wide as shield tunneling method.

The percent of tunnel construction usage in Japan is as shown Figure 4.1.5. The present conditions of tunnel construction are Mountain Tunneling Method, Shield Tunneling Method, Micro Tunneling Method, Cut and Cover Method in descending order of construction result. 94% of construction results are a tunnel method.

Tunnel method is advantageous in Japan construction condition. The reason is a construction environment. Tunnel method is suitable to the Japanese construction environment. The tunnel method of construction enables facilities construction assuming neighboring environmental conservation.

These contents are the feature of the Japanese tunnel technology.



Source: Japan Tunneling Association

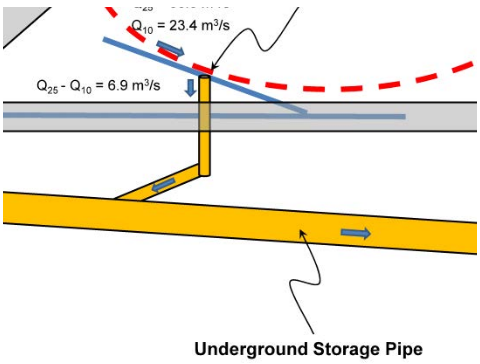
Figure 4.1.5 Construction Result

(2) The possibility of application to flood control in urban areas

The role of the tunnel is for flood control in Metro Manila. In Metro Manila, the condition of tunnel construction is location and tunnel scale (cross section and length). In case of Tunnel Method, Flood control measures are possible. Moreover, the traffic jam for the construction at the Metro Manila is small compared to the construction result in Japan.

The summary plan of the flood control is shown in Figure 4.1.6. The main structure is underground storage pipe and underground connection pipe. The features of these facilities are as follows. The construction method of these facilities is adequate for the Shield Tunnel Method and Micro Tunnel Method from the flood control plan.

- Underground storage pipe: Large-scale, Long distance
- Connect Pipe: Small, Medium-scale, short distance



Source: JICA Survey Team

Figure 4.1.6 Summary Plan

Furthermore, the construction method of storage pipe and connection pipe is a Shield Tunnel Method and Micro Tunnel Method. The basis for the selection is the applicable geology and inner diameter. The suitability of each method is shown in the following.

Shield tunneling method or Pipe jacking method are selected on the basis of "Japanese underground tunnel technology".

The ground condition is hard rock, the mountain tunneling method which is one of tunnel method is an applicable method. The comparison study has judged superiority for shield tunneling method higher advantage than the mountain tunneling method. The ground condition was unknown in the entire route.

The applicability to the underground storage pipe is high because the shield tunneling method can be applied to the inner diameter 1.35 m-14 m and a large section, and the applicability to the connect pipe is high because the Micro tunneling method can be applied to the inner diameter 0.2 m-3m. The feature of the two tunneling method is curve construction along road alignment.

When using the shield tunneling method and micro tunneling method, a deep shaft is not necessary to a joint of the underground storage pipe and the connecting pipe.

Shield Tunneling Method and Micro Tunneling Method both need a shaft. The purpose of the shaft is the import and export of the machine. Construction method of shaft is Cut and Cover Method. Japanese underground tunnel technology can be used for construction for a shaft. As the typical method of construction adopted by large-scale tunnel construction, there are 1) Diaphragm wall, 2) Open caisson method, and 3) pneumatic caisson method.

4.1.2 Adequacy of Applicability for the Selected Area, and Advantages compared with Other Countries

Japan has rich technology and know-how for construction and operation for both underground discharge channel and underground regulating pond (Stormwater storage pipe) among the developed countries.

In the background, there are terrain conditions such as shorter and steeper river channels compared with Western countries, which cause rapid increase of the river water levels and the arrival of the flood peak in a very short time. Another reason for the applicability of Japanese technology is that it is tested in the meteorological conditions that Japan is exposed to cause by typhoons or tropical and temperate zone cyclone.

Furthermore, there are situations of: 1) reduction of the water retention capacity of the urban river basin and difficulty of land acquisition for flood countermeasures due to rapid urbanization, as well as 2) land use conditions that cities have been developed in low-lying areas that are vulnerable to flood damages. Under such situations, Japan has been contrived and developed a technology for flood control utilizing underground tunnel.

Based on the above backgrounds, Japan has developed underground tunnel construction technologies such as shield tunneling method and pipe jacking method through applications to subways, road tunnels, sewerage development etc. Such technologies related to the construction of the underground tunnel were then applied to construction of underground discharge channels and underground regulating ponds in Japan.

The major projects are “Metropolitan Area Outer Underground Discharge Channel” as underground discharge channel, “Kanda River/Ring Road No.7 Underground Regulating Reservoir” as underground regulating pond, and “Katsura River Right Bank Stormwater Drainage Project in Kyoto Prefecture” as stormwater storage pipe. These projects started 20 to 30 years ago, and function well to contribute to mitigation of inundation damages caused by heavy rains in every year. Japan has rich experience of construction and operation of underground discharge channel and underground regulating pond as listed in Table 4.1.1.

Table 4.1.1 List of Major Underground Discharge Channel and Underground Regulating Pond Projects in Japan

No.	Project Name	Length	Diameter (m)	Capacity (m^3)	Total Project Cost	Project Cost per Capacity
1	Toyohira River Stormwater Storage Pipe Construction Project in Sapporo	1.9 km	4.25	24,000	6.9 billion JPY	287,500 JPY/m^3
2	Matsukawa Area Stormwater Treatment Facilities in Toyama	1,069 m	-	20,200	4.72 billion JPY	233,663 JPY/m^3
3	Ohoka River Right Bank Stormwater Drainage Project in Southern Area of Yokohama	2.8 km	3 to 5.7	50,000	7.95 billion JPY	159,000 JPY/m^3
4	Furukawa Underground Regulating Pond in Tokyo	3.3 km	7.5	135,000	27 billion JPY	200,000 JPY/m^3
5	Kanda River/Loop Road No.7 Underground Regulating Reservoir in Tokyo	4.5 km	12.5	540,000	103 billion JPY	190,741 JPY/m^3
6	Katsura River Right Bank Stormwater Drainage Project in Kyoto	9.2 km	3 to 8.5	238,200	45 billion JPY	188,917 JPY/m^3
7	Egawa Stormwater Storage Pipe in Kawasaki	1.5 km	8.50	81,000	---	---
8	Central Stormwater 1 Storage trunk in Chiba	5.1 km	5.25	110,000	---	---
9	Nakamura Central Stormwater trunk in Nagoya	2.5 km	3.75	28,000	---	---
10	Neya river North Underground river in Osaka	14.3 km	5.4 to 7.5	680,000	132 billion JPY	194,706 JPY/m^3

Source:

1 http://www.city.sapporo.jp/gesui/10kensetsu/01toyohirausui.html
2 http://www.city.toyama.toyama.jp/data/open/cnt/3/12981/1/14.pdf
3 http://www.city.yokohama.lg.jp/zaisei/org/kokyo/jigyouhyouka/jizen/h19/kansou02-tyousyo.pdf
4 http://www.nga.gr.jp/app/seisaku/details/2163/
5 http://www.ktr.mlit.go.jp/ktr_content/content/000001296.pdf
6 Article of the Daily Engineering & Construction News on 29 February 2012
7 http://www.city.kawasaki.jp/800/cmsfiles/contents/0000035/35839/book/pdf/egawa-choryu.pdf
8 https://www.city.chiba.jp/kensetsu/gesuidokensetsu/keikaku/tyuouusuikansenseibikeikaku.htm
9 http://www.water.city.nagoya.jp/category/30700kisyahappyou/12713.html
10 http://www.pref.osaka.lg.jp/nekouji/hokubu.html,

(Confirmation of the above link is as of 30 November 2015)

As shown above, Japan has accumulated the know-how on problem solutions by utilizing the technologies of underground discharge channel and underground regulating pond against inundation damage in urban area, and Japan has advantages in this aspect compared with Western countries.

4.1.3 Issues and Important Points for Application of each Method of Construction

Investigation methods are as shown in Table 4.1.2 which are important points when utilizing the Tunnel Method. The plan for the tunnel construction method have been implemented several times and have been thoroughly researched as well as the design. The reason for this is to eliminate the cause of the shield stop.

Especially in shield tunneling method and pipe jacking method, as the excavation surface is closed. it is mechanically difficult to confirm the geological conditions or the existence of underground facilities in the process of excavation.

There would be occasions to temporally suspend the works to take countermeasures when such difficulties occur. In addition, in some cases, a large-scale open excavation may be necessary depending on the countermeasures.

To avoid such cases, it is necessary to conduct survey and design several times prior to the construction works, to collect information related to location for the installation of facilities and to prepare the design and countermeasures. As influences to the surrounding environment after the completion of the excavation is another important issue to be concerned, surveys are necessary in each stage of tunneling method, i.e., during planning, designing, construction, and in operations and maintenance after the construction. Investigations method in each step are as shown in Table 4.1.2.

Table 4.1.2 Investigation Method

Levels		A Kind of Investigation	Investigation Method
Master Plan		Preparatory Investigation	Document Investigation, Site Survey
Design	Basic Design	Basic Investigation	Field Survey, Laboratory Test, Site Survey
	Detailed Design	Detailed Investigation	Field Survey, Laboratory Test, Site Survey
Construction	Auxiliary Measures	Works done Investigation	Field Survey, Laboratory Test, Field Measurement
	Shield Construction	Control Investigation	Field Survey, Laboratory Test, Field Measurement
Maintenance		Follow-up Investigation	Field Survey, Laboratory Test, Field Measurement

Source: JICA Survey Team

4.2 Drainage Facility Development Plan in each Candidate Area

Brief examinations were made on the drainage facilities proposed in the candidate two locations as indicated in Chapter 3 and as indicated below:

- Espana-UST candidate area
- Buendia-Maricaban candidate area

The probable flood discharges for the planning were assumed as below which are described in Chapter 3.

(1) The ongoing flood countermeasures, dredging and rehabilitation of the existing drainage channel by DPWH will accomplish the development level for a ten-year probable flood.

(2) The proposed drainage facility development plan will be able to cope with a 25-year probable flood which is planned by DPWH, and also has expandability to cope with 50-year probable flood in the future. Further, the following points ware taken care of for outline examination.

(3) The development plan was formulated based on the available information (the existing structures, geological information, land ownership etc.) at this moment.

(4) In case alternatives are considered, multiple candidates were indicated which were considered technically and financially executable, and also items were indicated which needs to be considered in detail in the next stage.

Bearing in mind the abovementioned assumptions and items to be taken care of, the following items were roughly examined and the development plans for the candidate areas where formulated.

<Items for Examination>

(1) Diameters and lengths of the underground storage pipe

(2) Plans and longitudinal alignments

(3) Construction method for the underground storage pipe

(4) Vertical shafts

(5) Intake facilities

(6) Drainage facilities

(7) Remote monitoring systems

(8) Ventilation and deodorization countermeasures

The following sections describe development plans in each candidate area.

4.3 Development Plan in Espana-UST Candidate Area

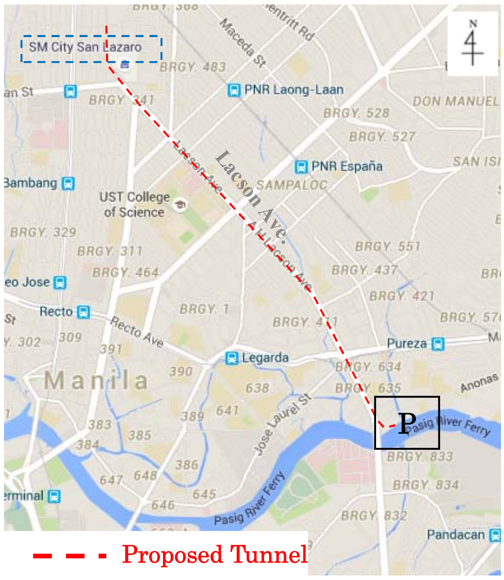
For the drainage facility development plan in Espana-UST candidate area, the following examinations were made on underground storage pipe based on the indicated base plan in Chapter 3 Drainage Plan.

A plan for Espana-UST underground storage pipe is as indicated in Figure 4.3.5. The topographic maps which were prepared during 2005 M/P were applied as base maps. For underground storage pipe examination, in view of construction with shield tunneling method, layouts were examined with the assumption that the required lands for both the departing and arrival vertical shaft could be secured. The result of the examination and as one of the possible layout, the underground storage pipe is designed to be installed along Lacson Avenue besides the campus of Sto. Thomas University (UST) in the northern part of Manila City. In concrete, a vertical shaft is to be constructed on the site located in the northern part of SM City San Lazaro (the land is currently used as material stockyard for hotel construction) and the underground storage pipe is to be constructed by shield tunneling method southeast ward along the Lacson Avenue. The length of the storage pipe will be 3.5 km at maximum. The arrival vertical shaft is to be constructed in the eastern side (upstream side) of the existing Valencia Pumping Station that is located on the right bank of the Pasig River. Drainage facilities to drain the water in the storage pipe are to be installed in the arrival vertical shaft in order to be utilized as a pumping station. In the pumping station, a staff is needed to monitor each facility of the drainage facilities.

The following sections describe examination results of relevant dimensions of the underground storage pipe.

4.3.1 Examination on the Diameter of the underground Storage Pipe

Based on the outlined layouts in Chapter 3, possible alignment for the underground storage pipe were determined in view of the available land for vertical shafts, and the required length of the storage pipe was determined to be 3.5 km. Considering the required storage volume of 690,000 m3 which is determined in the drainage plan, the required inner diameter is calculated to be at 17.0 m. In the plan, considering the maintenance works after the flood, the invert of the tunnel should be filled with concrete to be flat. Considering such allowance, the total diameter is determined to be at 17.05 m. This diameter took into consideration the drainage of the water after full storage in the underground storage pipe. For reference, additional examination was made for the idea of "Early start of the drainage works" that will drain the water inside the storage pipe when the rate of inflow into the storage pipe reached at the certain level. This idea aimed at reducing the storage volume of the underground storage pipe and thereby reducing the construction cost. Detailed explanations will be given in the sub-section "4.3.6 Drainage Plan."



Source: JICA Survey Team

Figure 4.3.1 Drainage Facility Development Plan

The result of calculation for the required diameter is shown in Table 4.3.1.

Table 4.3.1 Calculation of Required Diameter of the Underground Storage Pipe

No.	Contents of Calculation	Calculation Results
1	Required areas for underground storage pipe in case the length of the underground storage pipe is 3.5 km.	$A = 690{,}000\ m^3/3{,}500\ m = 197\ m^2$
2	By referring to "Guidelines for urban river planning – Three dimensional river facilities," 15% of the total area of the underground river structures were secured as a reserve.	$A = 197 \times 1.15 = 227\ m^2$
3	A diameter for the required area.	$D = \sqrt{(4 \times A/\pi)} = \sqrt{(4 \times 227/\pi)} = 17.00\ m \Rightarrow 17.0 m$
4	Volume of the underground storage pipe : V	$V = \pi \times D^2/4 \times L = \pi \times 17.0^2/4 \times 3{,}500 = 794{,}430\ m^3$

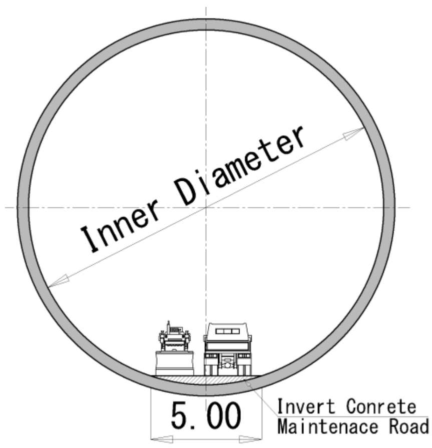
Source: JICA Survey Team

The above values are the required dimensions for drainage purpose. In addition, tunnel planning requires another 0.05 m for maintenance purpose, which makes the total inner diameter to be 17.050 m.

Another 0.05 m is required for removing deposit sand after draining the stored stormwater. For this purpose, additional concrete is to be placed at the invert of the underground storage pipe.

Invert concrete width was set at 5.0 m which enables the cleaning works and passages of a dump truck and a small bulldozer. (refer to)

The planned inner diameter satisfies the required cross sectional areas with 15% reserve even with the invert concrete.



Source: JICA Survey Team

Figure 4.3.2 Operation and Maintenance Plan for the Underground Storage Pipe

4.3.2 Horizontal and Longitudinal Alignments

Underground storage pipe alignment is determined with consideration of some restrictions, which include conditions of location, geology, obstacle and land. Layout study of tunnel alignment is conducted with considering of the situations of underground private land use and related laws in the Republic of Philippine. Results of layout study are as shown in the Figure 4.3.5 and Figure 4.3.6.

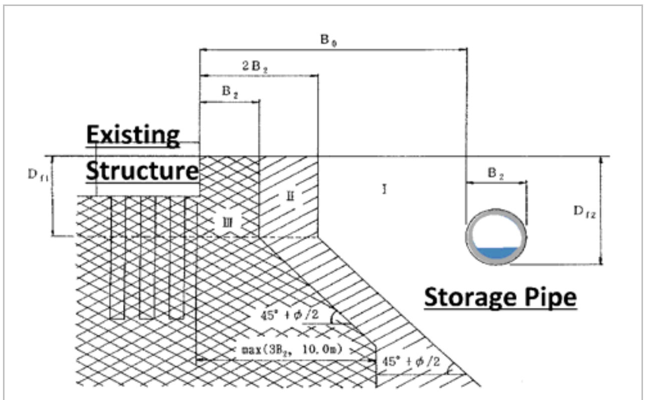
(1) Horizontal Alignment

Considering with workability of excavation, horizontal alignment shall be straight and large radius as much as possible. The basic horizontal alignment is determined under the Lacson Ave. and land of republic use. However, if it occupy private land, occupied width shall be reduced as much as possible. Influence to the existing structure on the road (road viaduct and railway viaduct) was considered.

Separation from an existing structure, position of horizontal alignment around intake and minimum curve radius are shown as below.

In addition, the investigation of the laws will be required for the as issue of underground space utilization of private land (shown in the chapter 7).

- The horizontal alignment around intake was planned at intake side with 50cm separation from the road border. This is for security of protective layer in Underground storage pipe sidepiece, and for reduction of connection construction length.
- The minimum curve radius was determined as 120m. It is result of interview from mechanical manufacturer of Japan.



Source: East Japan Railway Company

Figure 4.3.3 Rang of Influence

- Plane separation from existing structure shall be outside the territory it has stability. As a design concept, Underground storage pipe should not be located just under the foundation, and it should located more than a distance of 2D (D: storage pipe outer diameter) from an edge of an existing structure.

The horizontal alignment of the underground storage pipe is started from the Lacson Ave. where is in front of SM City San Lazaro. It go down southeast and turned to the left side (the east side) along the Pasig river in a point of Eulogio Amang Rodriguez (EAR) Institute of Technology.

It reaches to the planed pumping station of the point (the east side) of the Valencia pumping station. Total length will be approximately 3.5km. The alignment of the underground storage pipe was considered not to cause compensation for private land as far as possible.

In the Republic of Philippines, there is no clear law on land ownership of the underground. However, there is an example that has caused lawsuit. As a result of horizontal alignment study, private land was partially occupied. The reason is that the diameter of the underground storage pipe is larger than the road width. Characteristics of the horizontal alignment are as shown in Figure 4.3.4.

- The horizontal alignment is determined along the road alignment of Lacson Ave. At the starting point and end point, underground storage pipe is constructed as shape curve with the radius of 120m. There is the S-curve at the starting point.
- Plane separation from the road boundary is approximately 50cm around Intake1, 2.

・ Underground storage pipe alignment occupied private land at the shaped curved area. The area of private land occupation is summarized in Table 4.3.2.

Table 4.3.2 The Area of Private Land Occupation

No.	Ch.	Occupation
I	No.0~No.5	Length500m, Width9.5m
II	No.32+20~ 33+40	Length120m, Width18.05m

Source: JICA Survey Team

No. 0-No.4+60

No. 32+20-No. 33+40

Source: JICA Survey Team

Figure 4.3.4 The private land passage location

・ The ensuring the stable plane separation for existing structures is difficult because of the underground storage pipe outer diameter. The results of structure investigation are shown in the Table 4.3.3.

Table 4.3.3 Structure investigation result

No.	Ch.	Structures	Document
1	No.15+80	C-2（GOV. FORBES）/R-7(ESPAÑA) INTERCHANGE	Received
2	No.27+60	R.Magsaysay-Legarda Flyover	Not Receive
3	No.28	LRT Line2	Not Receive
4	No.30	A Lacson-Mahini Flyover	Not Receive

Source: JICA Survey Team

(2) Longitudinal Profile

Longitudinal alignment of the tunnel will be taken into consideration for the gradient, soil overburden and existing facilities by the complete structures.

The longitudinal profile consist of these requirements are shown below.

- Standard gradient is 0.1%.
- The minimum overburden is 1D (D: tunnel outer diameter), (18.540m).
- Distance from the foundation of the existing structure is 1D (D: tunnel outer diameter), (18.540m).

Table 4.3.4 Design criteria of Longitudinal Profile and design conditions

■ Standard gradient	0.1 %
	The role of the facilities once they are completed is to store the flooded water into the tunnel temporarily and release the water to the designated rivers using pumps after the rain. Therefore, it is necessary to have gradient on the side where pumping facility is located, so that the stored water will flow down the slope. The gradient is set 0.1% for this purpose based on the flow to the pumping facility and the accuracy of construction (mm/unit) at the time of shield tunneling. In addition, the range of gradient that the underground structures are not influenced is set for the purpose of reducing the depth of vertical shaft (including cost and construction period reduction)
■ Minimum overburden	1D (D: tunnel outer diameter), 18.54m
	The average minimum overburden of shield tunnel is 1D~1.5D (D: tunnel outer diameter) in general. Therefore, 1D was applied for this project. In Japan, there are many construction cases which apply less than 1D. Reduction of overburden depends on the pumping after the completion of construction and this needs to be reviewed. When reviewing, influence analysis is performed to secure the safety. In this project, when the soil condition is confirmed, the reduction of overburden can be reviewed too.
■ Distance from the foundation of the existing structure	1D (D: tunnel outer diameter), 18540m from the bottom of the foundation
	Distance from the foundation of the existing structure is taken sufficiently so that the existing structures can maintain the stability. The relationship between longitudinal profile of the tunnel and the horizontal position of the existing structure is important and when 2D (D: tunnel outer diameter) can't be secured, the tunnel has to be constructed within the range that leaves impact on the existing structure. In this project, because of width of roads, location of the existing structures and the diameter of the tunnel, the tunnel will be constructed within the abovementioned range. Therefore, 1D (D: tunnel outer diameter) from the bottom of the foundation is to be secured.

Source: JICA Survey Team

Information of the buried structures, such as water pipes, gas pipes, other buried cables, flyovers, piers, and the foundation piles of tall buildings are obtained from DPWH and longitudinal alignment was reviewed considering the location of those structures.

Longitudinal profile of underground storage pipe is shown in Figure 4.3.6. The location of buried structures and the tunnel are as shown in Figure 4.3.7.

The Longitudinal Profile of control points are securing the distance from the existing structures and the overburden. Longitudinal alignment of the tunnel is determined by setting the designated gradient at the location where securing the distance from the existing structures and the overburdens are considered.

As a result is shown in Figure 4.3.6, the overburden of the underground storage pipe will be set 18.5m at the departing shaft of near SM City San Lazaro, and 40m at the intersection of Lacson Ave. and Mabini Ave. considering the foundation piles for the planned flyover.

The gradient will be set 0.1% from the starting point to the ending point, however, in order to reduce the cost and period of construction by reducing the depth of the vertical shaft. The gradient is 1.7% between España Blvd and the vertical shaft.   The overburden at the end of storage piping is about 47m.

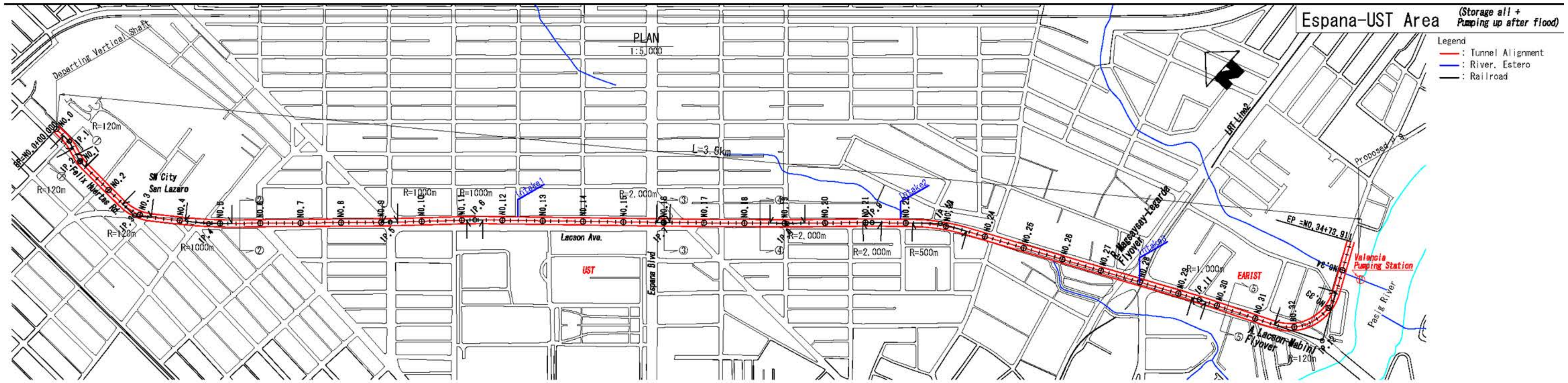


Figure 4.3.5 España-UST Candidate Area Horizontal Alignment

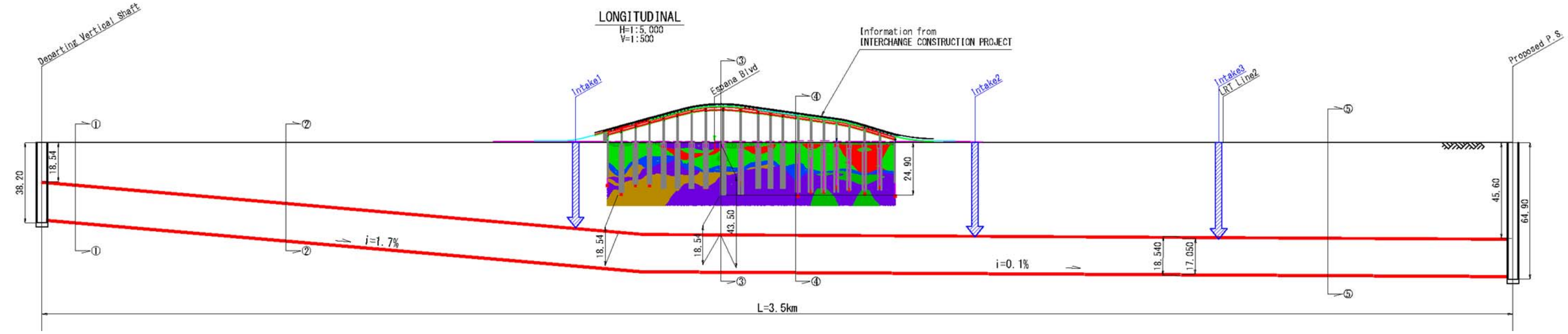
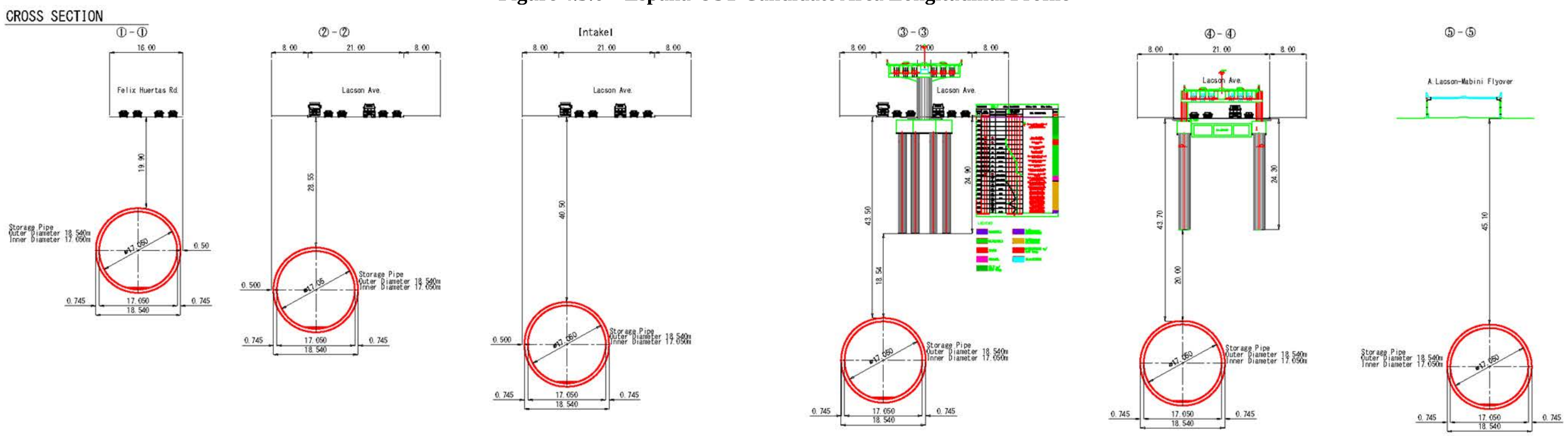


Figure 4.3.6 España-UST Candidate Area Longitudinal Profile



Source: JICA Survey Team

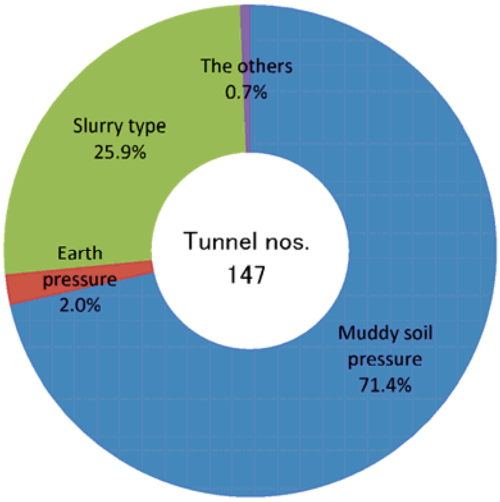
Figure 4.3.7 España-UST Candidate Area Cross Section

4.3.3 Construction Method for Underground Storage Pipe

The construction method of storage pipe has a shield tunneling method, mountains tunnel method and micro tunneling method. The study determined that the shield tunneling method is highly suitable as construction method. The reason for this is that it is corresponding to the necessary scale and most adaptable to the ground conditions.

The construction method for the underground storage pipe, in terms of technical applicability, among shied tunneling method, mountain tunneling method and pipe-jacking method, shield tunneling method is considered applicable.

Since the underground storage pipe has characteristics of the large section and long distance, the mountain tunneling method can be also considered. However, when applying this method, the soil condition has to be prioritized and to apply this methods, the ground has to stand independently. Based on the information obtained for this project, the soil of the construction area possibly contain tuffaceous siltstone and/or tuffaceous sandstone. However, since the data from geological survey is insufficient and the information obtained was only from the mid-section of the whole line, it is difficult to judge the condition of the soil for the whole line based on the information. Therefore, considering the applicability against the soil condition and the workability for the scale of the tunnel, shield-tunneling method is chosen. Shield tunneling method can be applied to both soft and hard ground, and used for the required scale of the section, which is φ17m or above, and 3.5km in length.



Source: Japan Tunneling Association

Figure 4.3.8 Types of Shield Machine

There are several methods in Shield tunneling method and in the basic design, and the high-density slurry shield was selected based on the outline of the project. The characteristics of the high-density slurry shield are explained below.

The main characteristic of shield tunneling method is to proceed the excavation by discharging the excavated soil while stabilizing the face (excavation surface) against earth pressure and water pressure and assembling linings within the space created by excavation. A series of these works is performed at the front of the shield machine.

The shield tunneling method is also divided into two types: one is open and the other is closed. Recently, most of the construction using this method is performed closed (99.3% as of December 2014). In the shield tunneling method, having stability at the face is a requirement. The closed type can achieve this requirement even in the excavation of the unstable ground, and it doesn’t affect the ground surface much. In open type, it is required that the face is stabilized by itself and when excavating the unstable soil, some support methods such as soil treatment will be necessary. Therefore, this method requires the cost by soil improvement to secure safety.

In Japan, there are many shield tunnels, which are constructed in the soft soil of urban area, and the closed type is applied in those constructions considering the stability of the face and that the support methods are not required. In addition, the impact on the road traffic is low.

When selecting the methods, it is important to see what kind of mechanisms, which stabilize the face of the shield machine, the machine has. For this project, based on the recent construction experiences, the closed type is adopted, has made a comparison between the muddy soil pressure shield and the slurry type shield. In this study, has selected the muddy soil pressure shield to the tunnel construction method. The selected reasons were adaptability in the Figure 4.3.5, in comparison with the slurry type shield.

Table 4.3.5 Compare selection of the Shield method

	Muddy soil pressure Shield	Slurry type Shield
The site securement difficulties by the congestion in the urban area	The small scale than slurry type Shield (1.0)	To need slurry treatment facilities, a site is more necessary than muddy soil pressure Shield (1.3)
The wide adaptability to the soil conditions	Soft ground to soft rock	Soft ground to soft rock Stability of a face is sometimes lacked by a permeable sand layer and the gravel.
Ease of surplus soil disposal	Special equipment is not needed.	It is necessary to need a treatment facility and reserve the installation space.

Source: JICA Survey Team

However, the shield machine will be required to select criteria a shield tunneling method from availability of construction and construction cost. The requirements for selecting machine of this project is shown in Table 4.3.6.

Table 4.3.6 Study Conditions

No.	Study Conditions		España-UST
1	Horizontal Alignment	Length（M）	3,500
		Curve Radius（M）	120（Minimum Curve Radius）
2	Longitudinal Profile	Gradient（%）	1.7%、0.1%
		Overburden（M）	Minimum18.54、Max45.60
3	Lining	Outer Diameter（M）	Φ18.540
		Width (M)	1.100
		Types of K lining	Longitudinal Direction
4	Ground Condition		Tuffaceous SANDSTONE, Tuffaceous SILTSTONE
5	Area		Urban Area
6	Site Area for Plant and Facilities	（SQM）	6,000

Optimal method should be selected from workability and construction cost based on the design conditions by the future studies. The high-density slurry shield and the lining to be used is explained for the below.

■ Muddy soil pressure Shield

The muddy soil pressure shield has kneading mechanism that strongly stirring and injecting mechanism of additive to drilling sediment material to promote the plastic flow. It press kneaded sediment by dividing force.

The muddy soil pressure shield is a Japanese invention technology. It is the mainstream of construction method of the world's shield tunnel technology.

Figure 4.3.9 Muddy soil pressure Shield Machines

■ Tunnel Lining

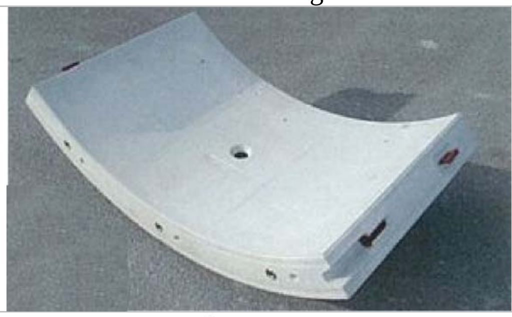
Recently, RC Lining, ST Lining and composite lining are applied as the lining for a shield tunnel.

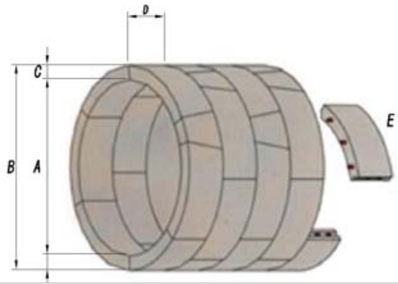
RC lining is often applied in large sectional tunnel. Therefore, underground storage pipe is planned as RC lining as a standard lining because tunnel inner diameter has large sectional area (=φ 17.050m). The structure is made of reinforced concrete. However, ST lining is applied at 120m radius curve and connection point of each intake facilities. Because main constituent structure is steel, ma it is easy to product the narrow lining, which is necessary in shaped curve area. At the connection part to the intake, superiority of production characteristics, construction characteristics and convertibility were considered in comparison with RC lining, while maintaining tunnel structure in the joint. Here, the tunnel structure plan shown in the Table 4.3.7.

The lining thickness was planned to secure approximately 4% of the outer diameter. This is a result of considering the safety during construction and actual records in Japan. The number and width of partitions were determined by thickness of the lining after definition arc length (4.5m~5.0m) and mass (100kN) per one piece. In addition, this lining width and number of partitions were used in the work schedule plan as a calculation basis of the excavation speed.

Table 4.3.7 Tunnel Lining

RC Linning





Dimensions		
Inner Diameter (M)	A	17.050
Outer Diameter (M)	B	18.540
Thickness (M)	C	0.715
Width (M)	D	1.100
Number of Divisions	E	K+12

4.3.4 Vertical Shaft

The study of vertical shaft for the shield tunneling method was conducted. The purpose of the construction of a vertical shaft is the loading and unloading of the shield machine.

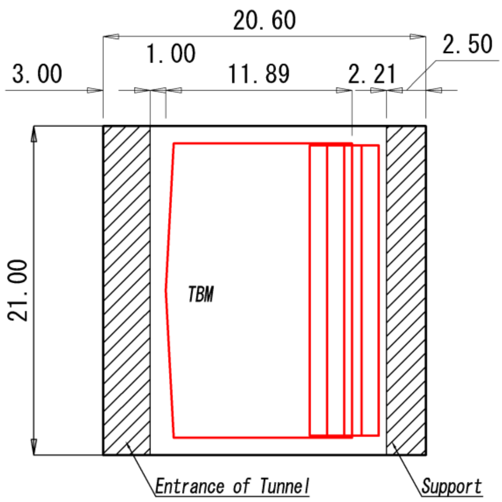
(1) Location and Size of Shaft

Vertical shaft is constructed in 2 points, a departing and arrival shaft.

The departing shaft is planned at north side of SM City San Lazaro. This shaft is starting point of underground storage pipe.

The inner diameter of departing shaft is planned as 20m. The inner diameter plan should secured the shield machine length, tunnel entrance and support. The depth of departing shaft is approximately 39m. The depth of shaft was calculated by adding overburden height (=18.5m) to outer underground storage pipe diameter (=18.5m).

The arrival shaft should secured inner diameter 20m. This inside diameter has necessary area to carry out The shield machine. The depth of arrival shaft is approximately 66m. The depth of shaft was calculated by adding overburden height (=47.2m) to outer underground storage pipe diameter (=18.5m).



Source: JICA Survey Team

Figure 4.3.10 Size of Shaft

(2) Construction Method of Shaft

Considering the diameter (20 ~ 25 m) and depth (39 ~ 66 m) of both of vertical shaft, Press caisson, pneumatic caisson, and earth retaining excavation and some other methods are applicable as the construction method. However, the adaptability of vertical shaft construction method shall be considered in next stage.

Vertical shaft of shield tunneling method is divided into Caisson method and Earth retaining excavation method. The characteristics of each method is as show in Table 4.3.8.

Source: JICA Survey Team

Figure 4.3.11 Caisson Method

Table 4.3.8 Comparison of vertical shaft construction method

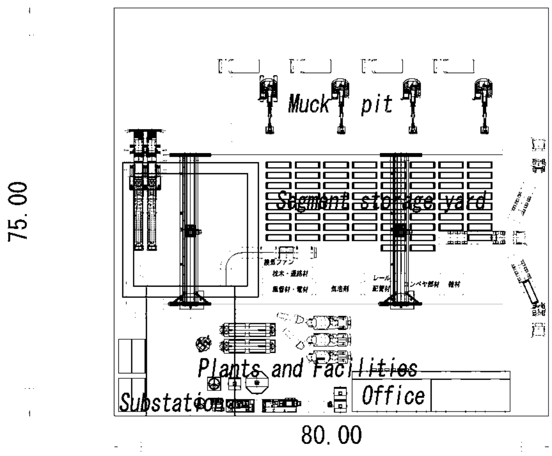
	Caisson Method		Earth Retaining Excavation Method	
Construction Principle	The main body, divided into lots, is firstly constructed at the ground level. It is pressed into the ground while the interior is excavated for installation of the main structure at the designed depth.		The trench excavation is carried out while preventing the collapse of soil, which is protected by the earth retaining walls and beams. Earth retaining walls are various types of materials (Cast-in-place concrete, Precast concrete, Steel sheet pile, Steel pipe pile).	
Construction Method	Press-In Caisson Method	Pneumatic Caisson Method	Diaphragm Wall Method	SMW Method
Summary for Construction Method	Hydraulic pumps are used with ground anchors as reactive force and the frame is settled by Press-in into the ground. Underwater excavation is carried out below the water level.	Pressure of working chamber at the bottom of structure is adjusted to be balanced with groundwater pressure. Excavation will be done in the dry state.	After excavating the trench and building the main structure, which serves as an earth retaining wall by means of RC column row pile. While protecting the porous walls by slurry pressure, the interior is excavated and the floor slab and walls are finished.	After excavation by auger, soil walls is constructed with H-beams as the core. It is treated as retaining walls. The interior is excavated and the main structure is constructed.

Source: JICA Survey Team

(3) Plant and Facilities Plan

Important one becomes the choice of the launch shaft position by the plan of the shield tunnel. In the shield departing shaft, it is necessary to maintain muck pit, material yard and the digging soil such as linings in a site other than the material import mouths such as linings, the export mouth of the digging earth and sand. Therefore, the departure shaft site has to secure large site space. The condition of the site space security considers the connection with the existing road such as an import road of the material, paths of export of the digging soil other than a material yard and earth and sand pit to quantity of digging. The plant and facilities for The shield machine it is shown in Figure 4.3.12.

This shield machine departing space needs approximately 6,000 SQM. It shows the basis of site area below.



75m×80m

Source: JICA Survey Team

Figure 4.3.12 Plant and Facilities Plan

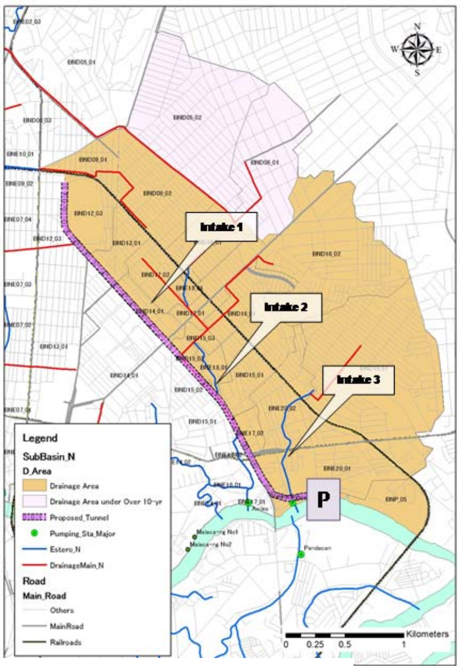
- The arrangement of the plant and facilities required for the shield tunneling construction.
- Securing lining yard tailored to excavation speed
- Securing musk pit volume tailored to excavation speed
- Securing of road traffic to the shield tunnel construction are

The departing shaft chose it from the condition mentioned above in open space near SM City Lazaro and Valencia P.S. The reason for selection is the ease of material handling. In addition, this site is private land.

4.3.5 Examination on Intake Facilities

Considering the locations with severe inundation damages under the DPWH study, and by referring to the drainage plan in their study, proposed location of intake facilities were selected by reflecting the site inspection results in view of efficient diversion of the flood water into the underground storage pipe . The following three (3) sites are planned as the location of intake facilities which utilize the existing drainage channel (estero, culvert etc.).

- Intake-1: Intersection between Don Quijote Drainage Main and P. Florentino Avenue
- Intake-2: Intersection between Estero de Sampaloc II and Lacson Avenue
- Intake-3: Intersection between Valencia Drainage Main and Ramon Magsaysay Boulevard



Source: JICA Survey Team

Figure 4.3.13 Locations of Intakes for Espana-UST Candidate Area

(1) Examination on Intake Type and Discharge

Each intake facility is designed as side-overflow intake installed on the sidewall of the existing drainage channel to take water as shown in Figure 4.3.14 as an example of intake facility in Japan (Ring Road No.7 Underground Storage Pipe, Myoshoji-gawa Intake in Tokyo).

Source: JICA Survey Team

Figure 4.3.14 An Example of Intake Facility (Ring Road No.7 Underground Storage Pipe, Myoshoji-gawa Intake in Tokyo)

A concrete flow of examination is as shown below.

1) At each proposed intake site, flood water levels of existing channel are computed for both 10-year flood and 25-year flood.
2) Crest elevation of the side-weir is determined at the level by which a 10-year flood can be released through the existing channel without overflow, and in case the flood water level is higher than the 10-year flood water level, excess water more than 10-year flood can be overflowed from the side-weir of the intake.
3) Width of the side-weir is designed to release the 25-year flood and expandable to cope with 50-year flood in the future.

Table 4.3.9 shows 10-year and 25-year probable flood discharges at each intake site. Differences between these discharges will be the target intake discharges for the proposed drainage facility plan.

Table 4.3.9 Design Intake Discharge at Each Intake Structure

	Intake-1 (m^3/s)	Intake-2 (m^3/s)	Intake-3 (m^3/s)
25-year Probable Flood	32.3	30.3	57.9
10-year Probable Flood	25.0	23.4	44.9
Target Intake Discharge	7.3	6.8	13.1

Source: JICA Survey Team

(2) Examination on Intake Facility Layout

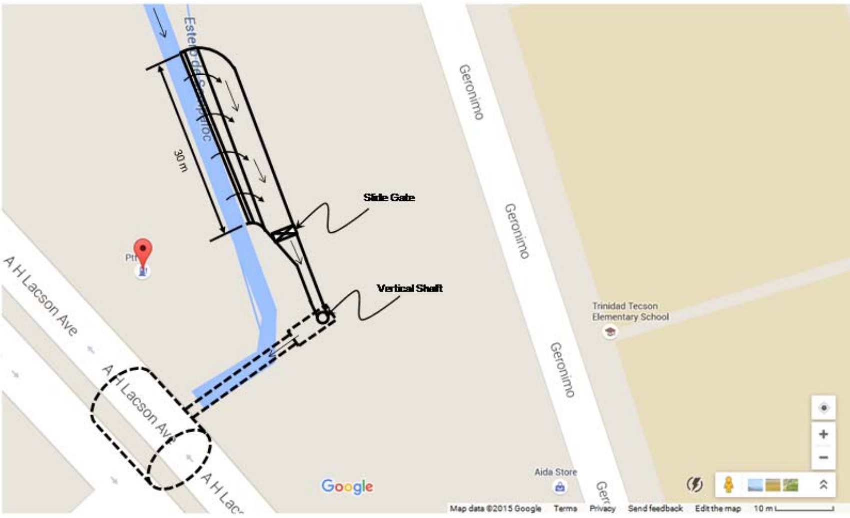
Based on the target intake discharge as examined above (1), layout plans for the intake facilities were prepared. The adequacy of the dimensions of the intake facilities was confirmed through site inspections.

At the intake site, flood water is to be diverted from the existing drainage channel with a side weir. The required width of the side weir was determined by assuming the discharge coefficient of 0.9 as the range of the discharge coefficient derived from the flood inundation analysis conducted by the Study Team was between 0.85 and 0.95.

There is a drop of around 70 m in height between the level of the intake facilities and the level of the connection point to the underground storage pipe. In order to smoothly divert the design intake discharge into the underground storage pipe, an energy dissipation system was considered.

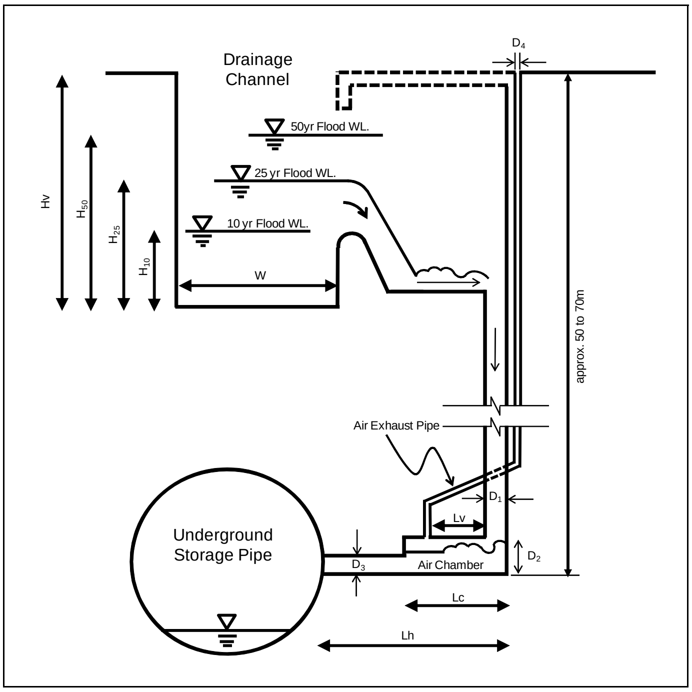
Regarding the drop dissipation system at the inlet of the deep underground storage pipe, stair type or drop shaft type can be considered. At this moment, taking into account of the density of houses etc. in the surrounding area of the intake, and also considering the compactness (saving spaces) and economic point of view, a vortex flow drop-shaft type (vortex flow vertical shaft) was applied for layout examination. The vortex flow drop-shaft was developed by the Bureau of Sewerage of Milwaukee City in USA, of which required dimensions can be estimated based on the examination result by a hydraulic model test report.

The layout plan of Intake 2 is presented in Figure 4.3.15 as an example of proposed three intake structures.



Source: JICA Survey Team

Figure 4.3.15 Proposed Layout of Intake Facilities of Intake 2 (Plan)



Source: JICA Survey Team

Figure 4.3.16 Proposed Layout of Intake Facilities of Intake 2 (Section)

Table 4.3.10 is summarized for the major dimensions of Intakes 1 to 3 In the layouts are shown in **Figure 4.3.15** and **Figure 4.3.16**.

Table 4.3.10 Dimensions of Each Proposed Intake Structure in Espana-UST Area

No.	Item	Intake 1	Intake 2	Intake 3
1	Design Intake Discharge (25-year probable flood) (m^3/s)	7.3	6.9	13.0
2	Depth of the Existing Drainage Channel Hv (m)	3	3	5
3	Width of the Existing Drainage Channel W (m)	6	5.5	8
4	Water Depth in case of 50-year Probable Flood Discharge H_{50} (m)	2.5	2.6	3.3
5	Water Depth in case of 25-year Probable Flood Discharge H_{25} (m)	2.2	2.3	2.9
6	Water Depth in case of 10-year Probable Flood Discharge H_{10} (m)	1.8	1.9	2.4
7	Width of the Intake Weir B (m)	32	30	41
8	Length of Connection Pipe Lh (m)	85	30	330
9	Distance between Air Exhaust Pipe and Vertical Shaft Lv (m)	9	9	12
10	Length of Air Chamber Lc (m)	31	31	40
11	Diameter of Vertical Shaft D_1 (m)	2.0	2.0	2.3
12	Diameter of Air Chamber D_2 (m)	3.3	3.3	4.1
13	Diameter of Connection Pipe D_3 (m)	2.0	2.0	2.1
14	Diameter of Air Exhaust Pipe D_4 (m)	0.9	0.9	1.1

Source: JICA Survey Team

(3) Trash Rack (Screen)

To prevent floating garbage in the existing drainage channel entering into the storage pipe, garbage removal screen is installed at the entrance of the intake facilities. In case garbage accumulates in front of the screen, wherein the intake is clogged and the design inflow cannot be secured, application of garbage removal screen which can release the floated garbage downstream (for example, a side scratching rake system) should be considered.

4.3.6 Examination on Drainage Facilities

(1) Draining within 48 hours after storage

To drain the stored water in the underground storage pipe, a pumping station is installed in the arrival vertical shaft. The drainage time is to be set to determine the capacity of the pump from the maintenance aspects, considering the importance of completing the draining of stored water before the sediment settles down and solidification starts, and also considering the importance of preventing odor generation.

As a general rule, solidification and odor generation of settled sediment start after 48 hours of storage. Taking this into consideration, a pump capacity capable of draining within 48 hours will be selected.

As the storage volume is 690,000 m^3 at maximum, the required drainage capacity will be calculated as follows:

Drainage Capacity Qout = 690,000 m^3 / (48 x 60 x 60) = 3.99 m^3/s → 4.0 m^3/s

As the vertical shaft depth is 66 m, considering the head loss in the drainage pipe, the total head of the pump is assumed to be 80 m. Considering the head, drainage capacity, and compactness of the required area for pump installation, two sets of vertical axis centrifugal pump with drainage capacity of 2.0 m^3/s each will be installed. The pump is designed to be of diesel fuel driven type, not by commercial electricity driven type, to save the operation and maintenance costs considering the frequency of the pump usage. The output of the pump engine can be obtained with the following equations (ref. A guideline for drainage pump facility technical standards (draft) design guidelines (draft) and its explanations p. 79).

$$P = \frac{\rho \times g \times Q \times H}{1{,}000 \times \eta_p \times \eta_g} \times (1+\alpha) = \frac{1{,}000 \times 9.8 \times 4.0 \times 80}{1{,}000 \times 0.84 \times 0.95} \times (1+0.15) = 4{,}519$$

$$\fallingdotseq 4{,}500\text{kW}$$

Therefore, the pump size with 80 m head and 4,500 kW output will be installed.

Where,

P	: Main engine output (kW)
ρ	: Density of water 1,000 (kg/m^3)
g	: 9.8 (m/s^2)
Q	: Pump discharge (4.0 m^3/s)
H	: Gross pump head (80.0 m)
η_p	: Pump efficiency (0.84)
η_g	: Efficiency of transmission equipment between pump and engine (0.95)
α	: Margin (0.15)

As the diesel driven pumps are to be installed at the bottom of the vertical shaft, operation and maintenance of the pumps after the completion will use a lift which is used for removal of the sand deposit in the underground storage pipe. The stored water will be drained by pumping up from the underground storage pipe to the desilting pond on the ground and be released to the river after the settlement of the sediment.

(2) In case of early start of drainage works

As discussed in the previous sub-section "4.3.1 Examination on the diameter of the storage pipe," the reduction of storage capacity and thereby reducing the construction cost of the underground storage pipe was examined by early drainage works of the flood flow stored in the storage pipe. The drainage works is considered to start when the inflow discharge into the storage pipe exceeds the assumed drainage capacity of the pumps, i.e., 4.0 m^3/s.

As a result of calculation, the required storage capacity was reduced to be 446,000 m^3.

In this case, by assuming the length of the underground storage pipe at 3.5 km, the required area for the underground storage pipe will be:

$A = 446{,}000\ m^3/3{,}500\ m = 128\ m^2$.

By referring to the "Guidelines for urban river planning – Three dimensional river facilities" to secure 15% of the required area for the open channel type underground river facilities, the area of the underground storage pipe will be: 128 x 1.15 = 147 m^2. The inner diameter corresponding to this area is as follows:

$D = \sqrt{(4 \times A/\pi)} = \sqrt{(4 \times 147/\pi)} = 13.68\ m \Rightarrow 13.7\ m$.

As the completed inner diameter is 13.7 m, the volume of the underground storage pipe (V) will be:

$V = \pi \times D2/4 \times L = \pi \times 13.72/4 \times 3{,}500 = 515{,}940\ m^3$ (by rounding up 1,000 m^3,the value will be 516,000 m^3).

In addition to the calculated cross sectional area, the volume of the invert concrete was considered for the maintenance purpose in the same manners as storage plan. In this connection, the inner diameter was set at 13.750 m.

From this part on, the inner diameter of 17.050 m and total volume of 795,000 m^3 for the underground storage pipe which assumed the drainage of the underground storage pipe after the flood (as examined in sub-section 4.3.1, hereinafter called as "Case 1"), and the abovementioned inner diameter of 17.050 m with total volume of 795,000 m^3 (hereinafter called as "Case 2") will be examined.

4.3.7 Examination on Remote Monitoring Systems

Remote monitoring systems will be installed to confirm the functions of relevant parts of the drainage facilities during the flood. The remote monitoring systems are consisted of a monitoring camera and lights, which can grasp the conditions of the facilities even during night and/or under rough weather conditions. The monitoring cameras are to be installed at each intake location of Espana-UST candidate area to monitor the problems such as clogging of the intake or overflow of the drainage channel at the intake. The monitoring camera is of movable type with telecommunication cables which can monitor the whole areas of intake sites as well as upstream and downstream conditions.

Figure 4.3.17 shows an example of remote monitoring systems at Myoshoji River intake of underground storage pipe for Ring Road No. 7 in Tokyo.

Source: JICA Survey Team

Figure 4.3.17 An example of remote monitoring system (Ring Road No. 7, Underground Storage Pipe, Myoshoji River Intake)

4.3.8 Examination on Countermeasures for Ventilation and Deodorization

According to the "Guidelines for urban river planning – Three dimensional river facilities," it is stipulated necessary to install ventilation systems to keep a good working environment for those workers who remove and clean the settled pollution materials inside the underground storage pipe after the drainage of the stored flood water. In addition, examination on the deodorization systems is also required to prevent the development of pollution to the neighboring households caused by odors from the settled material.

In the Espana-UST candidate area, the following ventilation and deodorization facilities were planned for the drainage facilities development as outlined examination stage.

(1) As the underground storage pipe (tunnel) is as long as 3.5 km, and the volumes of the tunnels are as large as 795,000 m^3 for Case 1 and 516,000 m^3 for Case 2, the ventilation system with forced air supply and forced air exhaust type will be applied to ensure the ventilation with planned amount of air.

(2) Ventilation time was set as "Within 30 minutes" as mentioned in the "Guidelines for urban river planning – Three dimensional river facilities" by referring to the "Design Guideline for Common Ducts for Utility Pipes and Cables" by Japan Road Association.

(3) Air supply fan will be installed at the departing vertical shaft and air exhaust fan will be installed at the arrival vertical shaft for 30 minutes ventilation against the tunnel volume of 795,000 m^3. The ventilation systems with the following capacity for Case 1 and Case 2 are to be installed, respectively.

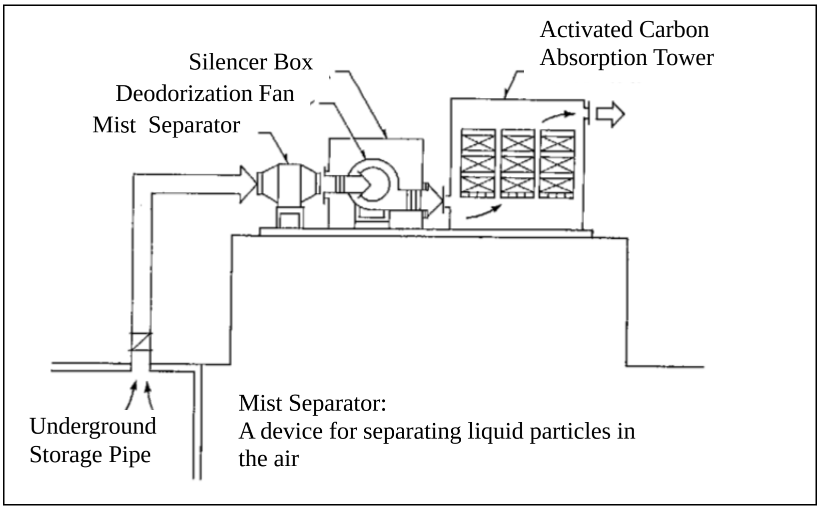
    (Case 1) 795,000 m^3 / 30 min = 26,500 → 26,500 m^3/min

    (Case 2) 515,940 m^3 /30 min = 17,200 → 17,200 m^3/min

    The wind velocity for 30 minute ventilation against the tunnel length of 3.5 km will be about 2 m/s, which is within the adequate range.

(4) At this moment, deodorization system applied "Activated Carbon Absorption Method" in view of capturing high density odor with possible minimum amount of air by referring to the "Guidelines for urban river planning – Three dimensional river facilities."

(5) The deodorization facilities are to be directly connected to the air exhaust fan at the departing vertical shaft. Figure 4.3.18 shows an example of deodorization facilities which applies "Activated Carbon Absorption Method.



Source: Guidelines for urban river planning – Three dimensional river facilities,

Figure 4.3.18 An Example of Deodorization System (Activate Carbon Absorption Method)

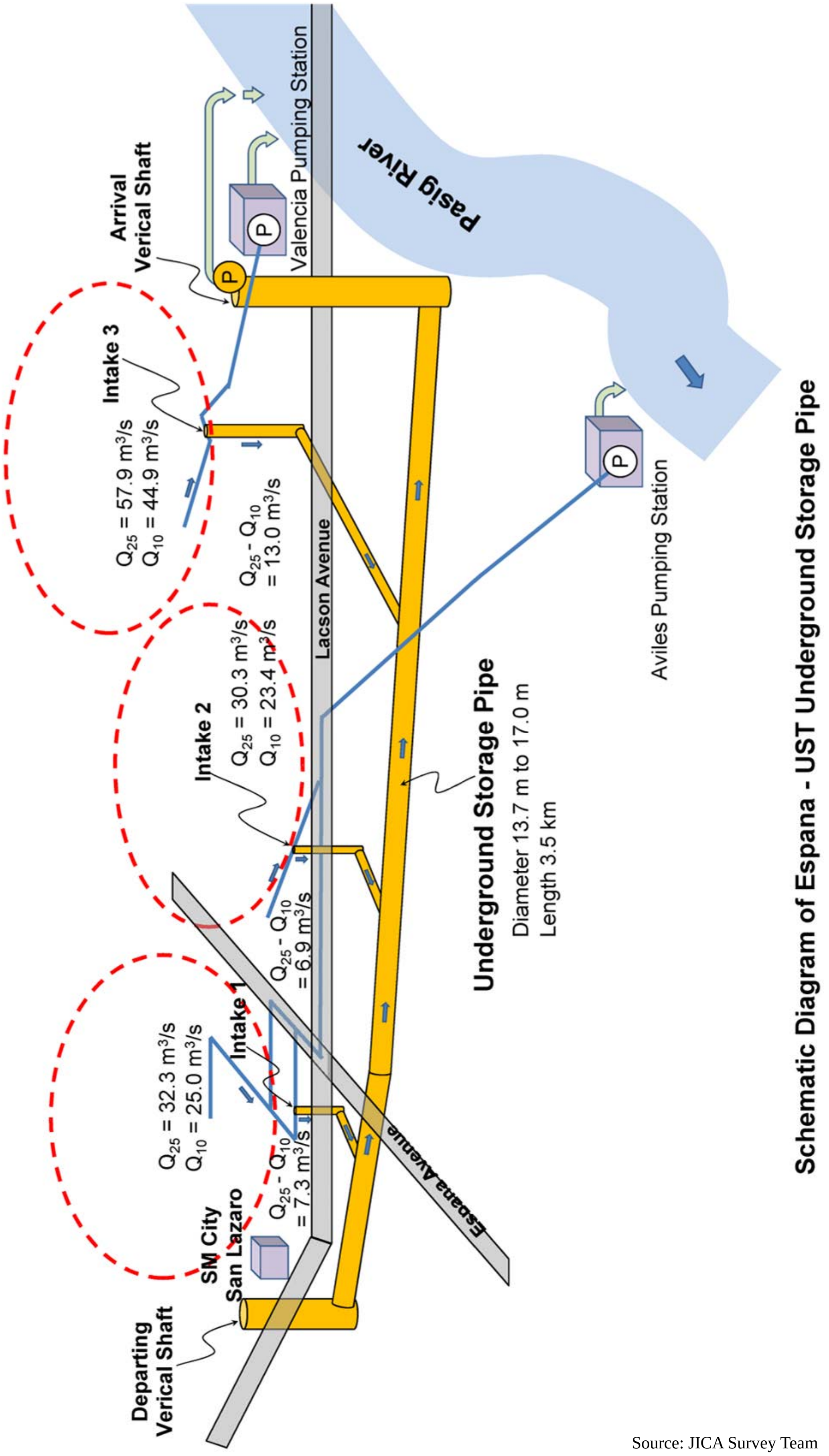
4.3.9 Summary of the Principal Features of the Plan

Table 4.3.11 shows the principal features which were examined through the above mentioned sub-sections from 4.3.1 to 4.3.8. The schematic diagram of the proposed development plan for the facilities are shown in in the Figure 4.3.19.

Table 4.3.11 Principal Features of Preliminary Facilities Development Plan at Espana-UST Candidate Area

Name of the Scheme	Alternatives	Total Length of the underground storage pipe (km)	Inner Diameter of the underground storage pipe	Storage Volume (m^3)
Espana-UST Underground Storage Pipe	Storage Plan	3.5	17.0	690,000
	Early Drainage Plan		13.7	446,000

Source: JICA Survey Team



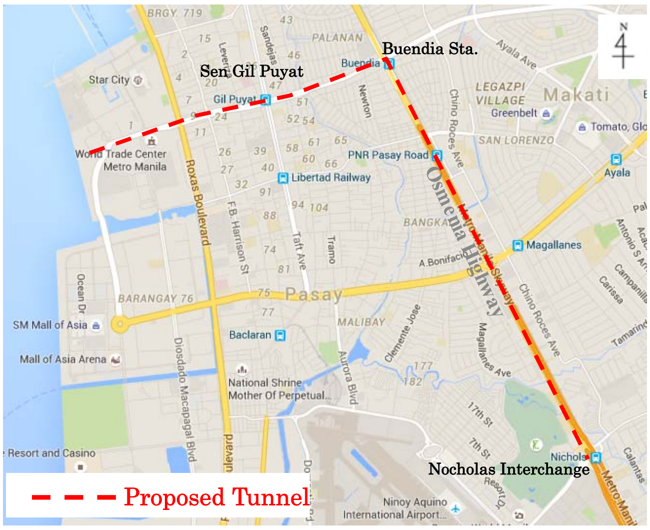
Source: JICA Survey Team

Figure 4.3.19 Schematic Diagram of Drainage Facilities for Espana-UST Candidate Area

4.4 Development Plan in Buendia-Maricaban Candidate Area

As a drainage facility development plan in Buendia-Maricaban candidate area, the following examinations were made on underground storage pipe based on the indicated base plan in Chapter 3 Drainage Plan.

A plan for Buendia-Maricaban underground storage pipe is as shown in Figure 4.4.3.



Source: JICA Survey Team

Figure 4.4.1 Drainage facility development plan

The underground storage pipe starts from Nicholas Interchange located northeast of Ninoy Aquino International Airport in Pasay City. The underground storage pipe is to be installed along Osmenia Highway for 4.1 km northward, and turns almost perpendicular to the Osmenia Highway near PNR Buendia station. The underground storage pipe continues along Sen Gil Puyat Avenue for 3.1 km toward Manila Bay to drain the stored water into Manila Bay. In view of securing wider working spaces, the departing vertical shaft is to be set at Manila Bay side to proceed the underground pipe excavation using shield tunneling method eastward along Sen Gil Puyat Avenue. The excavation direction changes southward near PNR Buendia station and proceed further excavation toward the arrival vertical shaft at Nicholas Interchange. The length of the underground storage pipe is 7.2 km. Drainage facilities for draining the stored water in the pipe are to be installed at the departing vertical shaft. The departing vertical shaft is to be used as pumping station and maintenance facilities are to be installed. Through the remote monitoring system, relevant parts of the drainage facilities are to be monitored at this pumping station.

4.4.1 Examination on the Diameter of the Underground Storage Pipe

Based on the outlined layouts in Chapter 3, the required length of the underground storage pipe was determined to be 7.2 km. Considering the required storage volume of 1,310,000 m^3 which is determined in the drainage plan, the required inner diameter is calculated to be 16.350 m, and the total diameter is determined to be 16.400 m taking into consideration of the maintenance works. The result of calculation for the required diameter is as shown in Table 4.4.1.

Table 4.4.1 Calculation of Required Diameter of the Underground Storage Pipe

No.	Contents of Calculation	Calculation Results
1	Required section areas for underground storage pipe in case the length of the underground storage pipe is 7.2 km.	A = 1,310,000 m^3/7,200 m = 182 m^2
2	By referring to "Guidelines for urban river planning – Three dimensional river facilities," 15% of the total area of the underground river structures were secured as a reserve.	A＝182 x 1.15 = 209.3 m^2
3	A diameter for the required area.	D = $\sqrt{}$(4 x A/π) = $\sqrt{}$(4 x 209.3/π) = 16.32 m ⇒ 16.35 m
4	Volume of the underground storage pipe : V	V = π x D^2/4 x L = π x 16.35^2/4 x 7,200 = 1,511,673 m^3

Source: JICA Survey Team

For reference, additional examination was made for the idea of “Early start of the drainage works” that will drain the water inside the underground storage pipe when the rate of inflow into the underground storage pipe reached at the certain level. This idea aimed at reducing the storage volume of the underground storage pipe and thereby reducing the construction cost. Detailed explanations will be given in the sub-section “4.4.6 Drainage Plan.”

4.4.2 Plans and Longitudinal alignments

Layout study of underground storage pipe as a drainage facilities was conducted. It is divided to horizontal alignment and longitudinal profile.

(1) Horizontal Alignment

The horizontal length of underground storage pipe was determined as 7.2km. The starting point is the Nichols interchange. It goes to 4.1km to the north along the Osemenia Highway. After bending near the Buendia Sta., it goes to 3.1km along the Sen. Gil Puyat Ave to the Manila Bay. The arrival point is the Manila Bay.

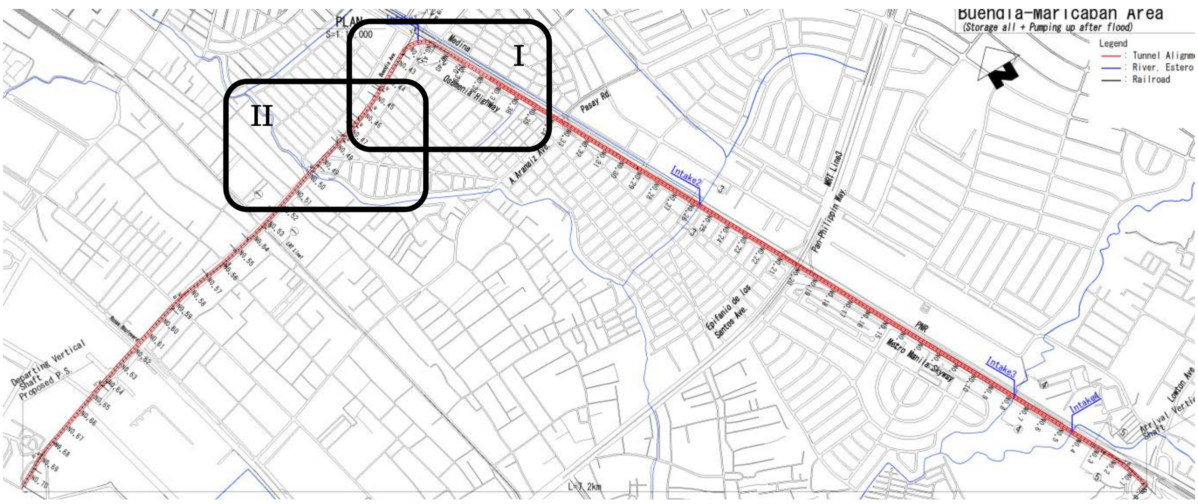
The alignment of the underground storage pipe was considered not to cause compensation for private land as far as possible. In the Republic of Philippines, there is no clear law on land ownership of the underground. However, there is an example that has caused lawsuit. As a result of horizontal alignment study, private land was partially occupied. The reason is that the diameter of the underground storage pipe is larger than the road width. Characteristics of the horizontal alignment are shown as below.

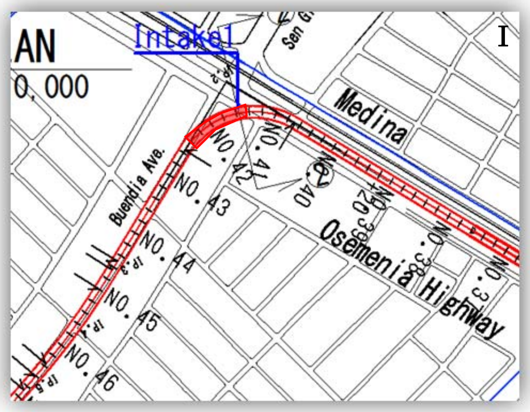
- The horizontal alignment is determined along the road alignment of Osemenia Highway. Around Buendia Sta., storage pipe is constructed as shape curve with the radius of 120m.
- Around the each intake, horizontal alignment was closer to the intake side.
- Underground storage pipe alignment occupied private land at the shaped curved area. The area of private land occupation is summarized in Figure 4.4.2 and Table 4.4.2.

Table 4.4.2 Private Land Occupation

No.	Ch.	Occupation
I	No.41+60~No.42+40	Length80m, Width17.83m
II	No.43+60~No.48+60	Length500m, Width3.53m

Source: JICA Survey Team





II

No.41+60-No.42+40 No. 43+60-No.48+60

Source: JICA Survey Team

Figure 4.4.2 The private Land Passage Location

- The ensuring the stable plane separation for existing structures is difficult because of the underground storage pipe outer diameter. The results of structure investigation are shown in Table 4.4.3.

Table 4.4.3 Structure Investigation Result

No.	Ch.	Structures	Document
1	No.2+80～No.34	Metro Manila Skyway	×
2	No.20	MRT Line3	×
3	No.39～No.41+40	Flyover	×
4	No.53+40	LRT Line1	○
5	No.61+80	Roxas Boulevard	×

Source: JICA Survey Team

(2) Longitudinal Profile

Information of the buried structures, such as water pipes, gas pipes, and other buried cables, flyovers, piers and the foundation piles of tall buildings were obtained from DPWH. In addition, longitudinal alignment was reviewed considering the location of those structures.

Longitudinal profile of underground storage pipe are shown in Figure 4.4.4 and the location of buried structures and the tunnel are as shown in .

As shown in the Longitudinal Profile, the controlling point is securing the distance from the existing structures and the overburden.

Longitudinal alignment of the tunnel is determined by setting the designated gradient at the location where securing the distance from the existing structures and the overburdens are considered.

As a results are as shown in Figure 4.4.4, the overburden of the underground storage pipe is 33.6m at the arrival shaft near the Nichols interchange considering the foundation piles for the flyover.

In addition, the depth of the foundation piles of LRT was 23.9m at the point where the underground storage pipe intersected LRT line in the Taft Ave. The required distance (17.8m outside diameter x 1.0) of the tunnel and the overburden of 41.7m are taken 41.7m. Currently, the information of the foundation piles of the Osumenia Highway viaduct was not provided from the DPWH, if the depth of the foundation pile is equal to or less than 16.3 m, the longitudinal profile is possible to apply the current layout.

The gradient is 0.15% from the arrival shaft to the PNR Buendia Sta., however, in order to reduce the cost and period of construction by reducing the depth of the vertical shaft, the gradient is 0.1% between the curve near PNR Buendia Sta. and the Departing shaft. The overburden at the end of storage piping is about 43.6m.

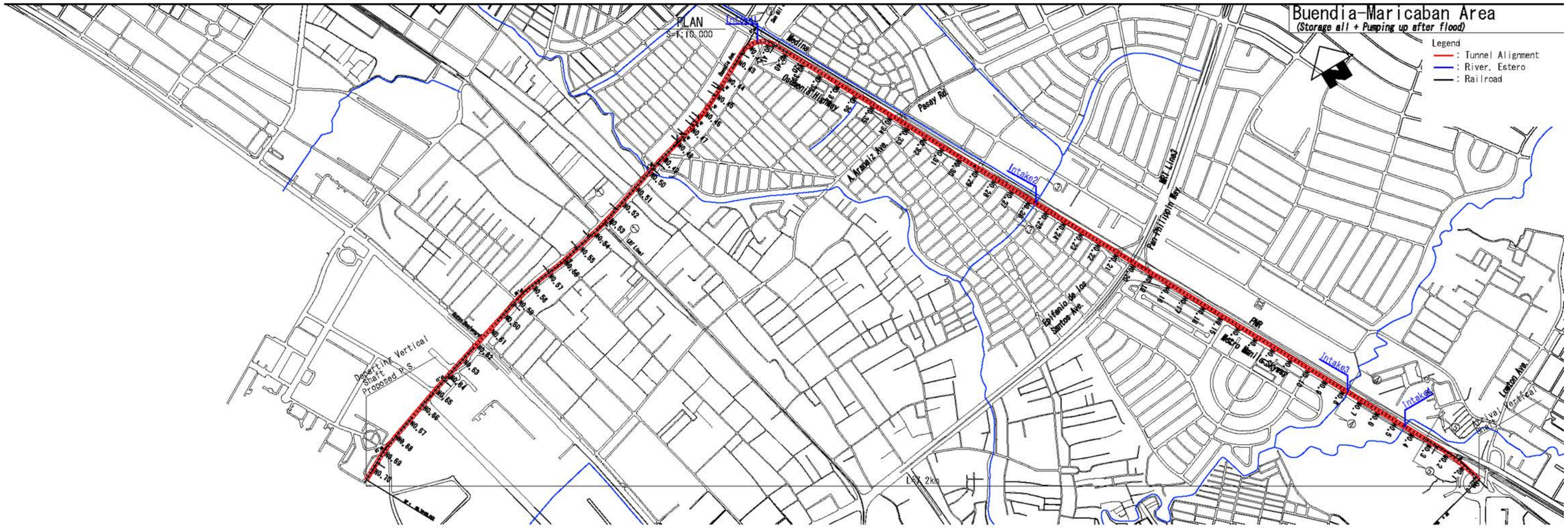


Figure 4.4.3 Bendia-Maricaban Candidate Area Horizontal Alignment

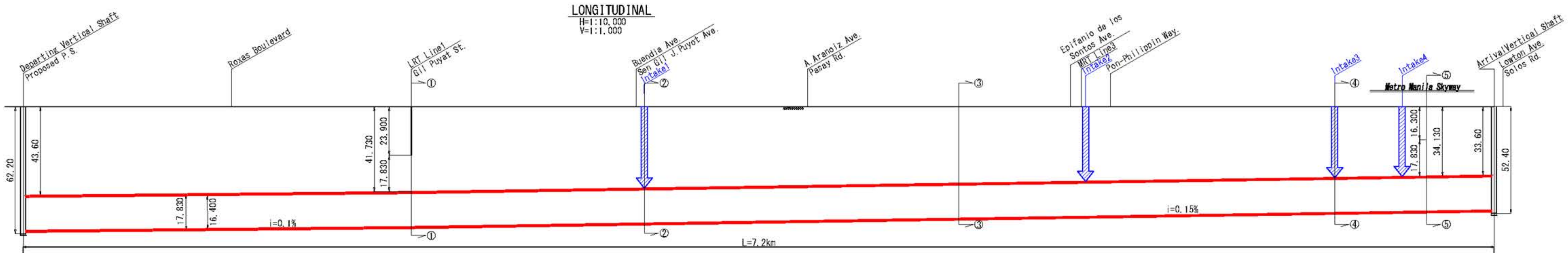
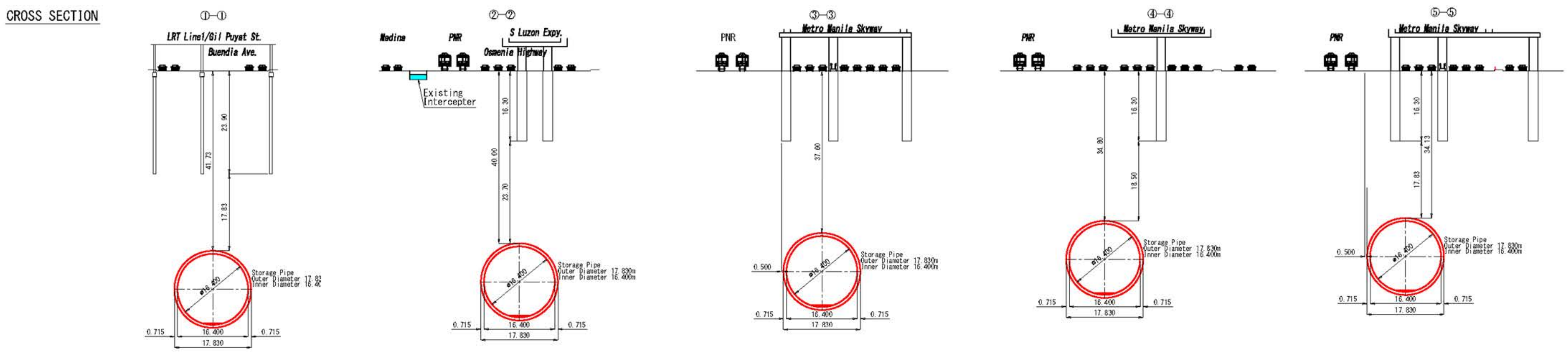


Figure 4.4.4 Buendia-Maricaban Candidate Are Longitudinal Profile



Source: JICA Study Team

Figure 4.4.5 Buendia-Maricaban Candidate Area Cross Section

4.4.3 Construction Method for the underground storage pipe

The construction method of underground storage pipe has a shield tunneling method, mountains tunnel method and micro tunneling method. In study, it was determined to be high suitability of shield tunneling method as construction methods. The reason for this is the corresponding of the necessary scale and adapt to the ground conditions.

4.4.4 Vertical Shaft

The shaft for the shield tunneling method was planned. The purpose of the construction of a shaft is the loading and unloading of the shield machine.

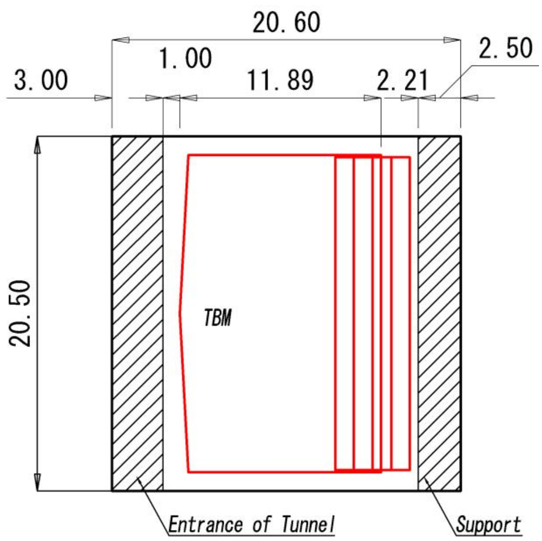
(1) Location and Size of Shaft

Vertical shaft is constructed in 2 points, a departing and arrival shaft.

The departing shaft planned at along Manila Bay. This shaft is starting point of underground storage pipe.

The inner diameter of departing shaft is planned as 20m. The inner diameter plan should secured the shield machine length, tunnel entrance and support. The depth of departing shaft is approximately 62.2m. The depth of shaft was calculated by adding overburden height (=43.6m) to outer underground storage pipe diameter (=17.8m).

The arrival shaft should secured inner diameter 20m. This inside diameter has necessary area to carry out The shield machine. The depth of arrival shaft is approximately 52.4m. The depth of shaft was calculated by adding overburden height (=33.6m) to outer underground storage pipe diameter (=17.8m).



Source: JICA Survey Team

Figure 4.4.6 Size of Shaft

(2) Construction Method of Shaft

Considering the diameter (20 ~ 25 m) and depth (39 ~ 66 m) of both of vertical shaft, Press caisson, pneumatic caisson, and earth retaining excavation and some other methods are applicable as the construction method. However, the adaptability of vertical shaft construction method shall be considered in next stage.

Vertical shaft of shield tunneling method is divided into Caisson method and Earth retaining excavation method. The characteristics of each method and shape of structure are as show in Figure 4.3.11 and Table 4.3.8.

4.4.5 Examination on Intake Facilities

Considering the locations with severe inundation damages under the DPWH study, and by referring to the drainage plan in their study, proposed location of intake facilities were selected by reflecting the site inspection results in view of efficient diversion of the flood water into the underground storage pipe . The following four (4) sites are planned as the location of intake facilities which utilize the existing drainage channel (estero, culvert etc.).

- Intake-1: Intake from the existing Pelita Creek near Buendia station
- Intake-2: Intersection between Osmenia Highway and Makati Diversion I
- Intake-3: Intersection between Osmenia Highway and the right tributary of Maricaban River
- Intake-4: Intersection between Osmenia Highway and the left tributary of Maricaban River

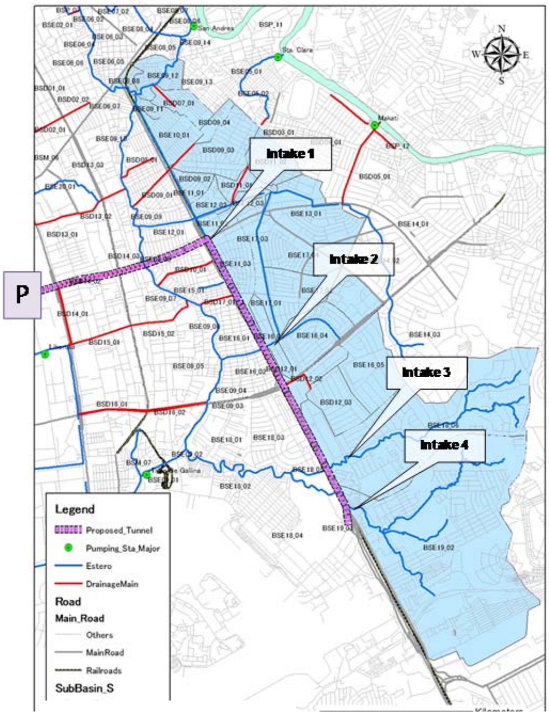


Figure 4.4.7 Locations of Intakes for Buendia-Maricaban Candidate Area

(1) Examination on Intake Type and Discharge

Each intake facility is designed as side-overflow intake installed on the side wall of the existing drainage channel to take water as shown in Figure 4.3.14 in sub-section 4.3.5 as an example of intake facility in Japan (Ring Road No.7 Underground Storage Pipe, Myoshoji-gawa Intake in Tokyo).

In the same manner as sub-section 4.3.5, a concrete flow of examination is as shown below.

1) At each proposed intake site, flood water levels of existing channel are computed for 10-year flood and 25-year flood.
2) Crest elevation of the side-weir is determined at the level by which a 10-year flood can be released through the existing channel without overflow, and in case the flood water level is higher than the 10-year flood water level, excess water more than 10-year flood can be overflowed from the side-weir of the intake.
3) Width of the side-weir is designed to release the 25-year flood and expandable to cope with 50-year flood in the future.

Table 4.4.4 shows 10-year and 25-year probable flood discharges at each intake site. Differences between these discharges will be the target intake discharges for the proposed drainage facility plan.

Table 4.4.4 Design Intake Discharge at Each Intake Structure

	Intake-1 (m^3/s)	Intake-2 (m^3/s)	Intake-3 (m^3/s)	Intake-4 (m^3/s)
25-year Probable Flood	68.4	21.8	39.1	67.7
10-year Probable Flood	54.8	16.9	30.3	52.5
Target Intake Discharge	13.6	4.9	8.8	15.2

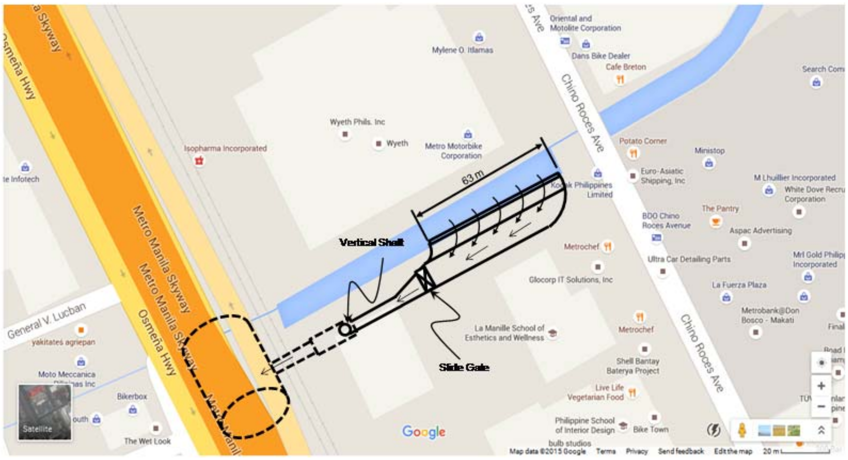
Source: JICA Survey Team

(2) Examination on Intake Facility Layout

Based on the target intake discharge as examined above (1), layout plans for the intake facilities were prepared. The adequacy of the dimensions of the intake facilities was confirmed through site inspections.

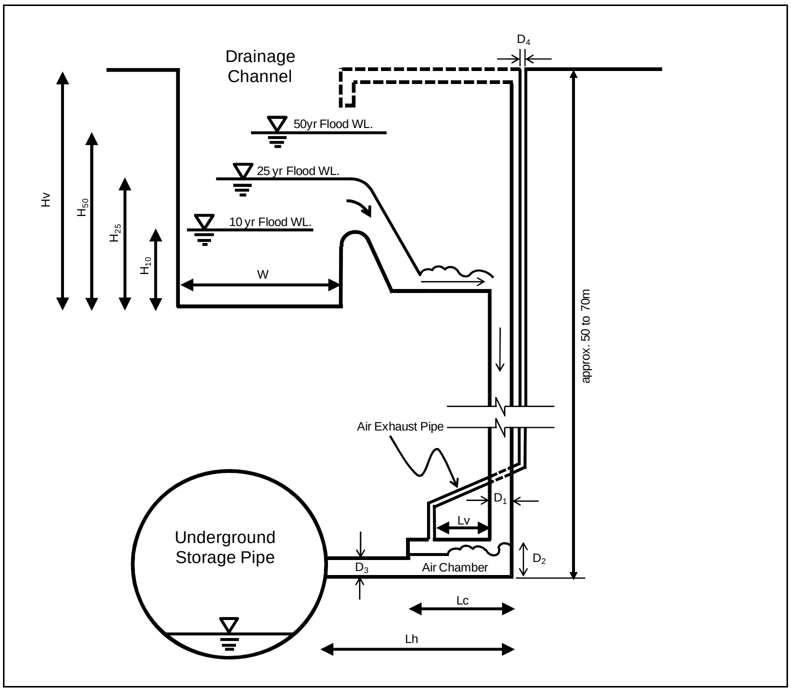
There is a drop of around 70 m in height between the level of the intake facilities and the level of the connection point to the underground storage pipe. In the same manner as the examination in sub-section 4.3.5, considering the compactness (saving spaces) and economic point of view, a vortex flow drop-shaft type (vortex flow vertical shaft) was applied for layout examination.

The layout plan of Intake 2 is presented in Figure 4.4.8 as an example of proposed four intake structures.



Source: JICA Survey Team

Figure 4.4.8 Proposed Layout of Intake Facilities of Intake 2 (Plan)



Source: JICA Survey Team

Figure 4.4.9 Proposed Layout of Intake Facilities of Intake 2 (Section)

Table 4.4.5 is summarized for the major dimensions of Intakes 1 to 4 In the layouts are shown in Figure 4.4.9.

Table 4.4.5 Dimensions of Each Proposed Intake Structure in Buendia-Maricaban Area

No.	Item	Intake 1	Intake 2	Intake 3	Intake 4
1	Design Intake Discharge (25-year probable flood) (m^3/s)	13.6	4.9	8.8	15.2
2	Depth of the Existing Drainage Channel Hv (m)	3	4	4	6
3	Width of the Existing Drainage Channel W (m)	9	12	6	5
4	Water Depth in case of 50-year Probable Flood Discharge H_{50} (m)	2.9	1.1	2.9	5.4
5	Water Depth in case of 25-year Probable Flood Discharge H_{25} (m)	2.6	1.0	2.5	4.7
6	Water Depth in case of 10-year Probable Flood Discharge H_{10} (m)	2.2	0.8	2.1	3.8
7	Width of the Intake Weir B (m)	63	63	40	22
8	Length of Connection Pipe Lh (m)	95	50	320	250
9	Distance between Air Exhaust Pipe and Vertical Shaft Lv (m)	12	8	10	12
10	Length of Air Chamber Lc (m)	40	26	33	41
11	Diameter of Vertical Shaft D_1 (m)	2.4	1.6	2.0	2.5
12	Diameter of Air Chamber D_2 (m)	4.2	2.8	3.5	4.3
13	Diameter of Connection Pipe D_3 (m)	2.1	1.4	1.8	2.2
14	Diameter of Air Exhaust Pipe D_4 (m)	1.2	0.8	1.0	1.2

(3) Trash Rack (Screen)

To prevent floating garbage in the existing drainage channel entering into the storage pipe, garbage removal screen is installed at the entrance of the intake facilities. In case garbage accumulates in front of the screen, wherein the intake is clogged and the design inflow cannot be secured, application of garbage removal screen which can release the floated garbage downstream (for example, a side scratching rake system) should be considered.

4.4.6 Examination on Drainage Facilities

(1) In Case of Drainage within 48 hours after storage

To drain the stored water in the underground storage pipe, a pumping station is installed in the departing vertical shaft. The drainage time is to be set to determine the capacity of the pump from the maintenance aspects, considering the importance of completing the drainage of stored water before the sediment settles down and solidification starts, and also considering the importance of preventing the odor generation.

It is generally said that solidification and odor generation of settled sediment will start after 48 hours of storage. In this connection, the pump capacity will be decided considering the drainage within 48 hours.

As the storage volume is 1,310,000 m^3 at maximum, the required drainage capacity is calculated as follows:

Drainage Capacity Qout = 1,310,000 m^3 / (48 x 60 x 60) = 7.58 m^3/s → 8.0 m^3/s

As the vertical shaft depth is 62.2 m, considering the head loss in the drainage pipe, the total head of the pump is assumed to be 80 m. Considering the head, drainage capacity, and compactness of the required area for pump installation, four sets of vertical axis centrifugal pump with drainage capacity of 2.0 m^3/s each will be installed. The pump is designed to be of diesel fuel driven type, not by commercial electricity driven type, to save the operation and maintenance costs considering the frequency of the pump usage. The output of the pump engine can be obtained with the following equations (ref. A guideline for drainage pump facility technical standards (draft) design guidelines (draft) and its explanations p. 79).

$$P = \frac{\rho \times g \times Q \times H}{1{,}000 \times \eta_p \times \eta_g} \times (1+\alpha) = \frac{1{,}000 \times 9.8 \times 8.0 \times 80}{1{,}000 \times 0.84 \times 0.95} \times (1+0.15) = 9{,}038$$

$$\fallingdotseq 9{,}000 \text{ kW}$$

Therefore, the pump size with 80 m pump head and 9,000 kW output will be installed.

Where,

P	: Main engine output (kW)
ρ	: Density of water 1,000 (kg/m^3)
g	: 9.8 (m/s^2)
Q	: Pump discharge (8.0 m^3/s)
H	: Gross pump head (80.0 m)
η_p	: Pump efficiency (0.84)
η_g	: Efficiency of transmission equipment between pump and engine (0.95)
α	: Margin (0.15)

As the diesel driven pumps are to be installed at the bottom of the vertical shaft, operation and maintenance of the pumps after the completion will use a lift which is used for removal of the sand deposit in the underground storage pipe . The stored water will be drained by pumping up from the underground storage pipe to the desilting pond on the ground, and be released to the river after the settlement of the sediment.

(2) In case of early start of drainage works

As was touched upon in the previous sub-section “4.4.1 Examination on the diameter of the underground storage pipe ,” the reduction of storage capacity and thereby reducing the construction cost of the underground storage pipe was examined by early start of the drainage works of the flood flow stored in the underground storage pipe . The drainage works is considered to start when the inflow discharge into the underground storage pipe exceeds the assumed drainage capacity of the pumps, i.e., 8.0 m^3/s.

As a result of calculation, the required storage capacity was reduced to be 844,000 m^3.

In this case, the required section area for the underground storage pipe by assuming the length of the underground storage pipe at 7.2 km will be:

A = 844,000 m^3/7,200 m = 117.23 m^2.

By referring to the “Guidelines for urban river planning – Three dimensional river facilities” to secure 15% of the required area for the open channel type underground river facilities, the section area of the underground storage pipe will be: 117.23 x 1.15 = 134.82 m^2. The inner diameter corresponding to this area is as follows:

D = $\sqrt{(4 \times A/\pi)} = \sqrt{(4 \times 134.82/\pi)}$ = 13.11 m ⇒ 13.2 m.

As the completed inner diameter is 13.2 m, the volume of the underground storage pipe (V) will be:

$V = \pi x D^2/4 \times L = \pi x 13.2^2/4 \times 7{,}200 = 985{,}000 m^3$.

From this part on, the inner diameter of 16.4 m and total volume of 1,521,000 m^3 for the underground storage pipe which assumed the drainage of the underground storage pipe after the flood (hereinafter called as "Case 1"), and the abovementioned inner diameter of 13.2 m with total volume of 985,000 m^3 (hereinafter called as "Case 2") will be examined.

4.4.7 Examination on Remote Monitoring Systems

Remote monitoring systems will be installed to confirm the functions of relevant parts of the drainage facilities during the flood. The remote monitoring systems consist of a monitoring camera and lights, which can grasp the conditions of the facilities even during night and/or under rough weather conditions. The monitoring cameras are to be installed at each intake location of Buendia-Maricaban candidate area to monitor the problems such as clogging of the intake or overflow of the drainage channel at the intake. The monitoring camera is of movable type with telecommunication cables which can monitor the whole areas of intake sites as well as upstream and downstream conditions (An example of remote monitoring systems, refer to Figure 4.3.7 in sub-section 4.3.5).

4.4.8 Examination on Countermeasures for Ventilation and Deodorization

The examination was carried out taking into consideration of the following two points in the same manner as the examination for Espana-UST candidate area described in sub-section 4.3.8:

(1) The ventilation systems shall be installed in order to maintain a good working environment for those workers who remove and clean the settled pollution materials inside the underground storage pipe after the drainage of the stored flood water.

(2) The deodorization systems shall be equipped in order to prevent the development of pollution to the neighboring households caused by odors from the settled material.

In the Buendia-Maricaban candidate area, the following ventilation and deodorization facilities were planned in the drainage facilities development as outlined examination stage.

- As the underground storage pipe (tunnel) is as long as 7.2 km, and the volumes of the tunnels are as large as 1,521,000 m^3 for Case 1 and 985,000 m^3 for Case 2, the ventilation system with forced air supply and forced air exhaust type will be applied to ensure the ventilation with planned amount of air.
- Ventilation time was set as "Within 30 minutes" as mentioned in the "Guidelines for urban river planning – Three dimensional river facilities" by referring to the "Design Guideline for Common Ducts for Utility Pipes and Cables" by Japan Road Association.
- Air supply fan will be installed at the departing vertical shaft and air exhaust fan will be installed at the arrival vertical shaft for 30 minutes ventilation against the tunnel volume of 1,521,000 m^3. The ventilation systems with the following capacity for Case 1 and Case 2 are to be installed, respectively.

  (Case 1) 1,521,000 m^3 / 30 min = 50,700 m^3/min

  (Case 2) 985,000 m^3 /30 min = 32,833 → 32,900 m^3/min

The wind velocity for 30 minute ventilation against the tunnel length of 7.2 km will be about 4 m/s, which is within the adequate range.

- At this moment, deodorization system applied "Activated Carbon Absorption Method" in view of capturing high density odor with possible minimum amount of air by referring to the "Guidelines for urban river planning – Three dimensional river facilities."
- The deodorization facilities are to be directly connected to the air exhaust fan at the arrival vertical shaft. An example of deodorization facilities are shown in Figure 4.3.18.

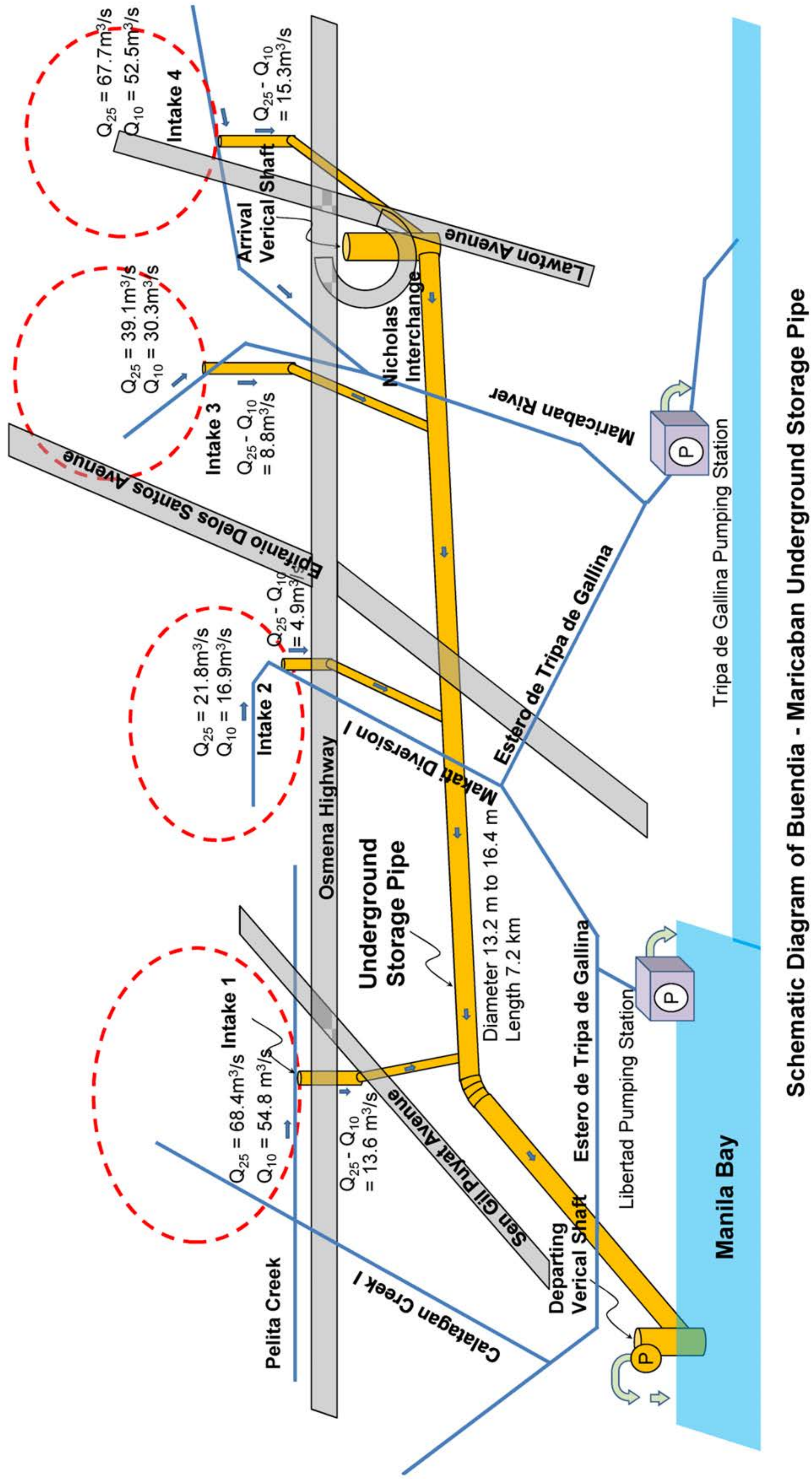
4.4.9 Summary of the Principal Features of the Plan

Table 4.4.6 shows the principal features which were examined through the above mentioned sub-sections from 4.4.1 to 4.4.8. Figure 4.4.10 shows the schematic diagram of the proposed development plan for the facilities.

Table 4.4.6 Principal Features of Preliminary Facilities Development Plan at Buendia-Maricaban Candidate Area

Name of the Scheme	Alternatives	Total Length of the underground storage pipe (km)	Inner Diameter of the underground storage pipe (m)	Storage Volume (m^3)
Buendia-Maricaban Underground Storage Pipe	Storage Plan	7.2	16.4	1,310,000
	Early Drainage Plan		13.2	844,000

Source: JICA Survey Team



Source: JICA Study Team

Figure 4.4.10 Schematic Diagram of Drainage Facilities for Buendia-Maricaban Candidate Area

4.5 Preliminary Construction Plan for España-UST Area and Buendia-Maricaban Area

4.5.1 General outline

The construction plan is carried out in the schematic process in the case of adopting the shield method for storage. Study results for General outline of plan are as shown in Table 4.5.1.

Table 4.5.1 General Outline of the Plan

Project Area	Alternative case of Drainage Plan	Storage length (KM)	Inner Diameter (M)	Storage (CBM)
España-UST	Storage all + Pumping after flood	3.5	17.050	690,000
	Pumping Start during flood		13.750	446,000
Buendia-Maricaban	Storage all + Pumping after flood	7.2	16.400	1,310,000
	Pumping Start during flood		13.200	844,000

Source : JICA Survey Team

[Construction Method]

- Underground storage pipe Construction Method : Shield Tunneling Method
- Shaft Construction Method : Pneumatic Caisson Method

4.5.2 Preliminary Construction Schedule

Construction schedule will be created based on the specifications of the drainage facilities maintenance plan shown in Table 4.5.1. Shield construction process is construction capacity in the Philippines is considered to Japanese standard.

Approximate construction schedule is estimated from six (6) years to nine (9) years. The shortest construction period has been shown the case of the Espana-UST which has been estimated at 6.1 years.

Approximate construction schedule are as shown in Table 4.5.2.

Table 4.5.2 Approximate Construction Schedule

Project Area	Alternative case of Drainage Plan	Storage length (KM)	Inner Diameter (M)	Construction Period (Year)
España-UST	Storage all + Pumping after flood	3.5	17.050	7.3
	Pumping Start during flood		13.750	6.1
Buendia-Maricaban	Storage all + Pumping after flood	7.2	16.400	8.9
	Pumping Start during flood		13.200	7.6

Source: JICA Survey Team

Construction schedule period has been considered on the basis of the work process. Work capacity of shield machines are estimated from Japanese past record. The construction schedule is included drainage pump station and intake structure. The alternative studies for process of construction are shown in the construction time and construction order of construction. The each construction schedule of are shown in the Figure 4.5.1~Figure 4.5.4. Critical path of construction will be a shield construction.

Work item for processing requiring the greatest amount of a time will be underground excavation and machine production.

■ The machine production days : The required Machine production period will be a result of the interviews to the Japanese manufacturer which is manufactured in Japan. After that, transport to the Philippines.

■ Excavation Speed : Work capacities of shield machine are calculated on the basis of the plan for each schematic design. Consideration of items will be lining width, standard excavation amount to the number of divisions and construction restraint time. Average work capacity of shield machine are became 8.0m~10m. Daily and monthly of average work capacities are shown in the Table 4.5.3.

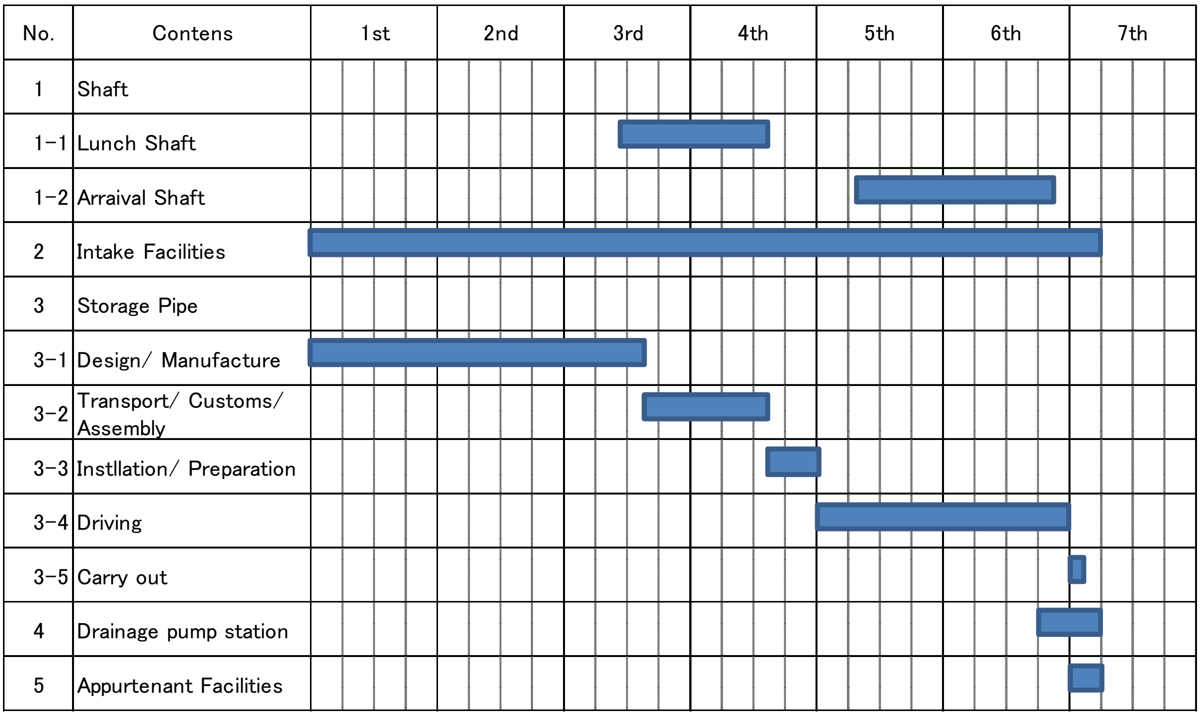
Table 4.5.3 Excavation Speed

Project Area	Alternative case of Drainage Plan	Storage length （KM）	Excavation Speed/Day (M/day)	Excavation Speed/Month (M/Month)
España-UST	Storage all + Pumping after flood	3.5	8.4	168
	Pumping Start during flood		10.8	216
Buendia-Maricaban	Storage all + Pumping after flood	7.2	8.3	166
	Pumping Start during flood		10.3	206

Source: JICA Survey Team

(1) Underground Storage Pipe Construction Work Schedule of Españ-UST Area

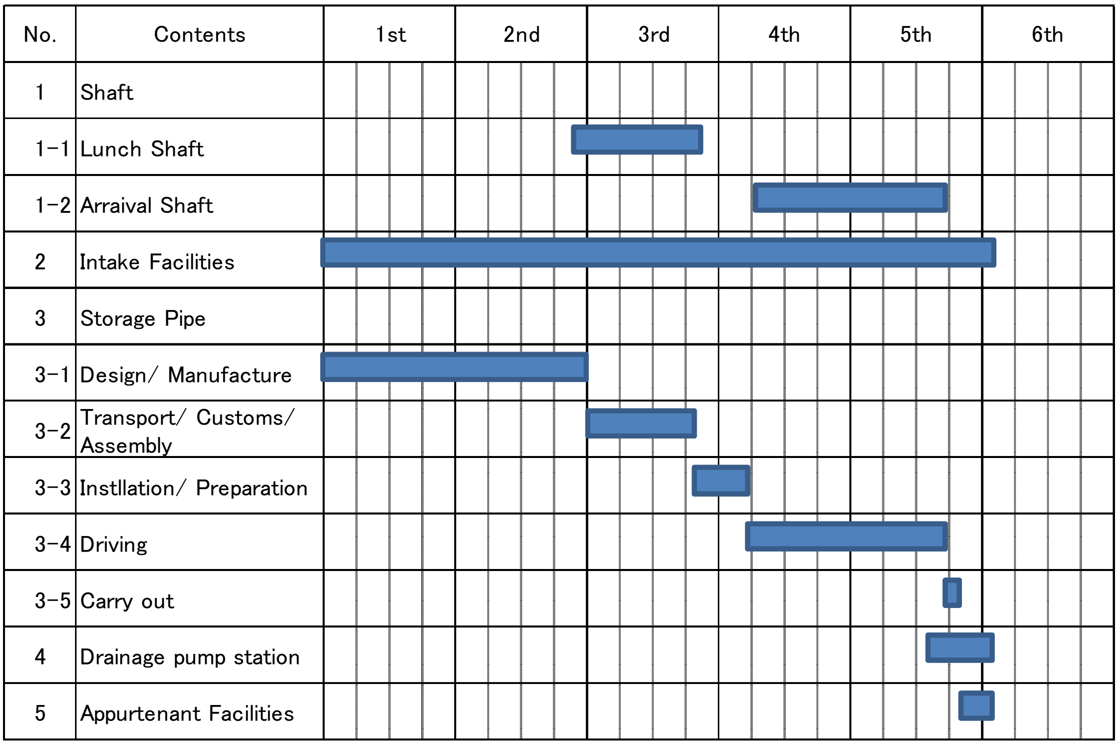
(a) Storage all + Pumping after flood



Source: JICA Survey Team

Figure 4.5.1 Construction Work Plan of Storage all + Pumping after flood

(b) Pumping Start during flood

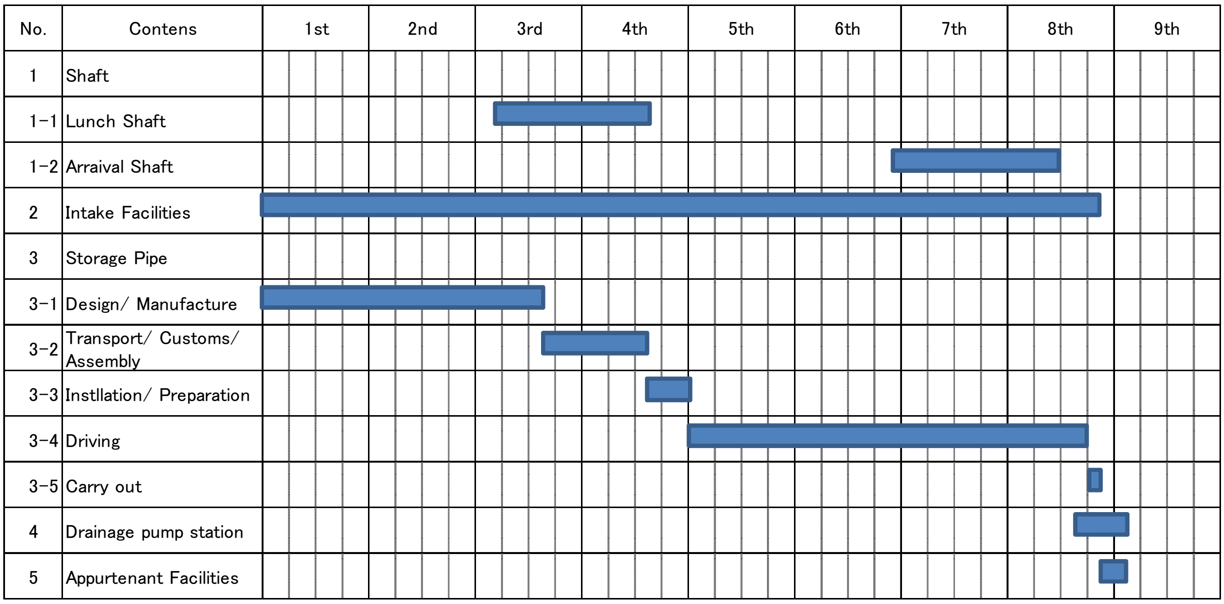


Source: JICA Survey Team

Figure 4.5.2 Construction Work Plan of Pumping Start during flood

(2) Underground storage pipe Construction Work Schedule of Buendia-Maricaban Area

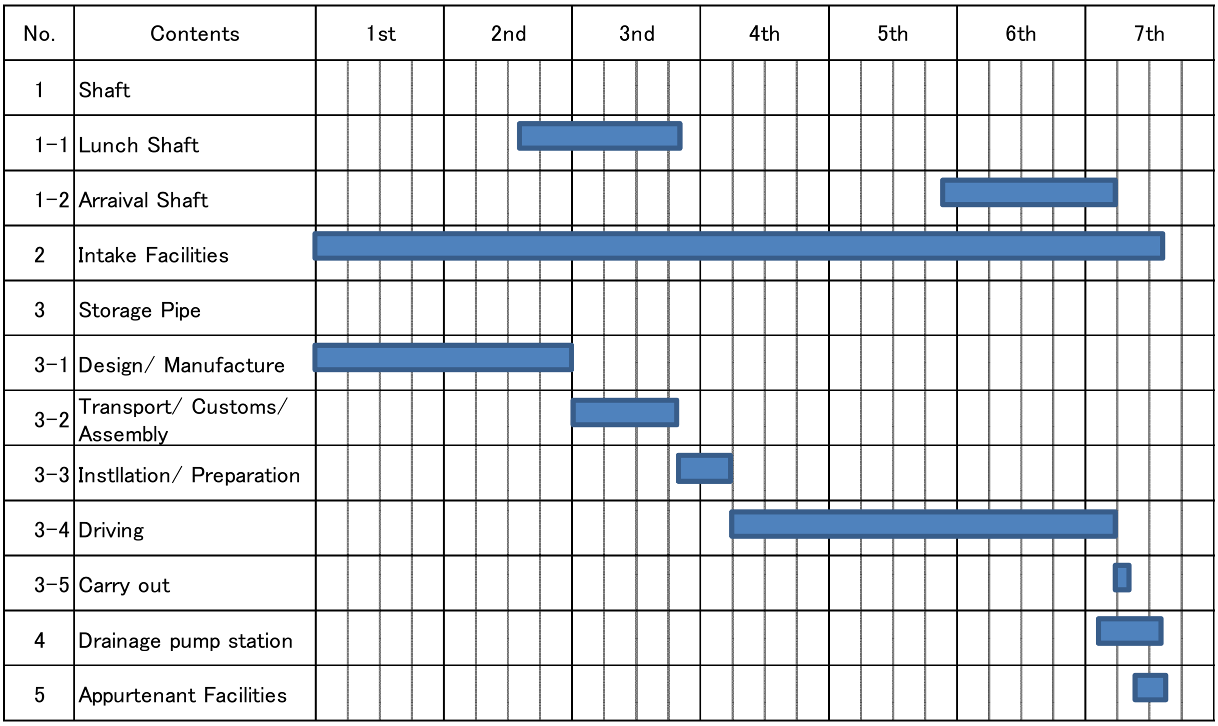
(a) Storage all + Pumping after flood



Source: JICA Survey Team

Figure 4.5.3 Construction Work Plan of Storage all + Pumping after flood

(b) Pumping Start during flood



Source: JICA Survey Team

Figure 4.5.4 Construction Work Plan of Pumping Start during flood

4.6 Preliminary Estimation of Construction Cost

Each project cost are estimated by the layout study. Construction Quantity (excavation and concrete) and unit price will be adjusted to the based on the actual achievement of similar construction in Japan.
In addition, construction cost are discounted assume the unit price of the Philippines. The project cost survey is carried out for the actual achievement of similar project in Japan. The estimate project cost calculated at this chapter is shown in Table 4.6.1 and Table 4.6.2.

Table 4.6.1 Estimated Project Cost (Japanese yen)

(Unit: million JPY)

	Philippines Base		Japan Base		Note.
	Early Drainage Plan	Storage Plan	Early Drainage Plan	Storage Plan	
España-UST	56,408	84,179	84,700	131,100	
Buendia-Maricaban	95,103	138,158	160,400	248,900	

出典：JICA 調査団

Table 4.6.2 Estimated Project Cost (Philippine peso）

(Unit: million PHP)

	Philippines Base		Japan Base		Note.
	Early Drainage Plan	Storage Plan	Early Drainage Plan	Storage Plan	
España-UST	22,033	32,880	33,100	51,200	
Buendia-Maricaban	37,147	53,963	62,700	97,200	

出典：JICA 調査団

In case of Early Drainage Plan in this Survey, pumping capacity was computed as all storage volume to be drained within 48 hours. As mentioned in 3.5.2 and 3.5.3, the diameter of storage pipe becomes smaller by increasing pumping capacity. According to very rough and simple estimation, the construction cost may be reduced by several billion Php scale.

4.6.1 Calculation of Construction Cost Level in case of Philippines

Construction costs calculation of storage facilities construction work are necessary to understand the breakdown of construction cost in each work items. Therefore, the storage facilities construction have to understand the Work item and the item cost.
The breakdown of storage facilities project cost were carried out each item cost calculation from reference to the similar project in japan. Analysis results for the unit price were used in the cost estimation that were assumed the unit price of Philippines. Construction costs are as shown in the below.

(1) Analysis of the construction cost by dividing into cost items

The storage facilities construction costs were split and the cost calculation for each work item. The project of storage facilities in japan will be split by the each main item. Each main work item will be set by the tunnel construction, drainage facilities construction, Intake facilities construction, land compensation and detailed design/ Supervision.

The construction costs are estimated to 153.0 billion JPY by the above-mentioned conditions. Alternative case of the Buendia-Maricaban (Storage Plan) is as shown in the Table 4.6.3.

Table 4.6.3 Buendia-Maricaban Candidate Area (Storage Plan)

Cost Item	Specifications	Estimated Cost
Tunnel Construction (including departing and arrival vertical shafts)	Inner diameter 16.4 m, Length 7.2 km	148.0 billion JPY (57.8 billion Peso)
Pumping Facilities	Drainage Capacity: 8.0 m^3/s	5.0 billion JPY (2.0 billion Peso)
Intake and Auxiliary Facilities	Four intakes, remote monitoring systems, ventilations etc.	
Total construction cost		**153.0 billion JPY (59.7 billion Peso)**
Non-construction cost (Administration cost, Consultancy service cost, Land compensation, Physical and Price contingency)		76.5 billion JPY (29.9 billion Peso)
Total Project cost		**229.5 billion JPY (89.6 billion Peso)**

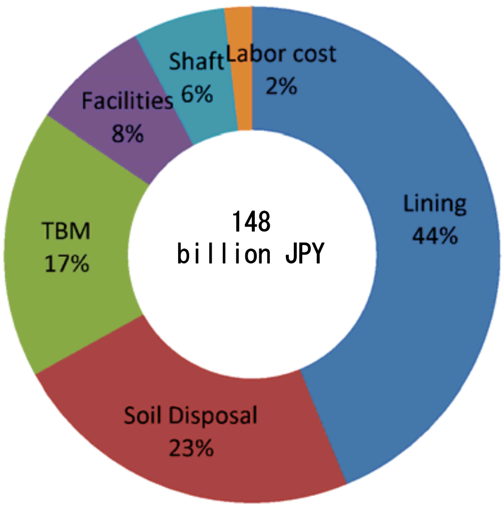
Source: JICA Survey Team based on data from Japan Tunneling Association

The tunnel construction cost, which occupies the most of the construction cost, was further broken down as shown in the Figure 4.6.1.

As shown in Figure 4.6.1, the ratio of lining and soil disposal costs occupies a large percentage (67% of tunnel construction). The ratio will be 64 % against the total construction cost of the storage facilities.

The analysis result shows that in the tunnel construction in Japan, material costs (lining) and disposal costs occupies a large percentage against the total cost. In addition, the lining costs and the soil disposal costs were estimated based on the conditions below.

- Lining unit price: unit price per cubic meter as of 2014
- Soil disposal costs: Industrial waste disposal cost



Source: JICA Survey Team

Figure 4.6.1 Ratio of Tunnel Construction Cost

(2) Estimate of the construction cost and the project cost considering the national conditions of the Philippines

Construction cost for Storage facilities has been converted into construction costs in the Philippines based on the breakdown ratio described above. Construction costs in the Philippines will be discount for main work items of different from the Japan unit price.

Construction costs are estimated by the most expensive alternative case for Buendia-Maricaban Candidate Area (Storage Plan) which are as shown in Table 4.6.2.

Table 4.6.4 Comparison with Japan Base and Philippines Base cost estimate for Buendia-Maricaban Candidate Area (Storage Plan)

	Aggregate Construction Cost	
	Japan Base	Philippines Base
Storage Plan	153.0 billion JPY (59.8 billion Peso)	91.6 billion JPY (35.8 billion Peso)

Source: JICA Survey Team

Construction costs in the Philippines will be 91.6 billion JPY (draft storage tube) which become about 60% of the project cost in Japan. Breakdown of Construction costs are shown in Table 4.6.3

.

The components of cost reduction were considered to Unit price of lining, Soil disposal cost and Labor cost. Each Breakdown of unit price and construction costs are shown in Table 4.6.5 - Table 4.6.6.

Table 4.6.5 Summary for Breakdown Construction Cost

Work item	Japan	Philippines	Remarks
Shield machine cost	10.0 billion JPY (3.9 billion Peso)	10.0 billion JPY (3.9 billion Peso)	
Lining cost	52.5 billion JPY (20.5 billion Peso)	38.7 billion JPY (15.1 billion Peso)	
Labor cost	2.2 billion JPY (0.9 billion Peso)	0.5 billion JPY (0.2 billion Peso)	
Equipment cost	9.1 billion JPY (3.6 billion Peso)	9.1 billion JPY (3.6 billion Peso)	
Soil disposal cost	27.8 billion JPY (10.9 billion Peso)	0.7 billion JPY (0.3 billion Peso)	
Vertical shaft cost	3.8 billion JPY (1.5 billion Peso)	2.8 billion JPY (1.1 billion Peso)	
Direct construction cost	105.4 billion JPY (41.2 billion Peso)	61.8 billion JPY (24.1 billion Peso)	
Construction cost for Tunnel work	148.0 billion JPY (57.8 billion Peso)	86.6 billion JPY (33.8 billion Peso)	Expense 40%
Drainage facilities cost	5.0 billion JPY (2.0 billion Peso)	5.0 billion JPY (2.0 billion Peso)	
Construction cost	153.0 billion JPY (59.8 billion Peso)	91.6 billion JPY (35.8 billion Peso)	Storage volume /1,310,000m^3
(m^3/JPY) / (m^3/Peso)	117,500 JPY (46,000 Peso)	70,000 JPY (27,500 Peso)	
Non-construction cost (admin., C/S, Land compensation, Physical & Price contingency .VAT)	76.5 billion JPY (29.9 billion Peso)	46.6 billion JPY (18.2 billion Peso)	Refer from to Table 4.6.3
Project Cost	229.5 billion JPY (89.6 billion Peso)	138.2 billion JPY (54.0 billion Peso)	
(m^3/JPY) / (m^3/Peso)	≒176,000 JPY (69,000 Peso)	≒105,000 JPY (41,000 Peso)	

Source: JICA Survey Team

The reasons for cost reduction of respective components are as described in Table 4.6.7.

Table 4.6.6 Summary of Settings for Unit Price

1	Lining costs	Unit price as of 2011 in Japan was applied for the unit lining costs. By referring to the ongoing tunnel construction plans in other countries, comparison was made to set the unit price levels. The unit price as of 2014 in Japan hiked about 1.4 times compared with that of 2011 caused by construction rush. The unit price level was set considering the fact that there are few achievements in Philippines on the lining fabrication, and based on information derived from the interview surveys to Japanese construction company who said that there were not much differences in concrete unit prices between the Philippines and Japan.
2	Disposal costs	The disposal standard of the excavated soil in the Philippines is that in case a toxic substance is detected the necessary treatment will be conducted. Therefore, if the hazardous material is not detected through the test of the excavated soil of the tunnel, only transportation costs need to be considered. In this connection, only the transportation costs were estimated at this time. In addition, during the actual construction works, based on the result of geological investigations, the excavated soil of the vertical will be tested.
3	Labor costs	10% of the labor cost in Japan was assumed as the labor cost in the Philippines. The 10% was assumed by referring to the fact that the GDP of the Philippines was 6% of GDP in Japan in 2014, and that the monthly basic salary of workers in 2011 was 8.2 % of that in Japan. Based on such referred facts, 10% was decided by rounding of those values. The unit price in Japan is the Tokyo unit price as of 2015 indicated by the Ministry of Land, Infrastructure and Transportation. In addition, considering the leadership functions of labors, important workers such as tunnel supervisors and skilled tunnel workers were assumed to be Japanese, and the unit labor costs in Japan was applied.

Source: JICA Survey Team

In addition, construction costs of each drainage plan are shown in Table 4.6.7 and Table 4.6.8.

Table 4.6.7 Espana-UST Candidate Area

	Aggregate Construction Cost	
	Japan Base	Philippines Base
Storage Plan	92.1 billion JPY (36.0 billion Peso)	58.0 billion JPY (22.7 billion Peso)
Early Drainage Plan	62.3 billion JPY (36.0 billion Peso)	39.4 billion JPY (15.4 billion Peso)

Table 4.6.8 Buendia-Maricaban Candidate Area

	Aggregate Construction Cost	
	Japan Base	Philippines Base
Storage Plan	154.0 billion JPY (60.1 billion Peso)	91.6 billion JPY (35.8 billion Peso)
Early Drainage Plan	105.0 billion JPY (41.0 billion Peso)	63.7 billion JPY (24.9 billion Peso)

4.6.2 Alternative study for Project Cost

Project cost are Construction costs, Non-construction costs (administration, Consultancy services for Detailed design and Supervision, Compensation) , Physical and Price escalation and VAT.

Based on the revised cost levels, in addition to the estimated project costs, non-project costs such as Administration Cost, Consultancy Services Cost and Land Compensation Costs were estimated as shown in Table 4.6.9 to Table 4.6.12. Methods and assumptions for estimating the non-project costs are as follows:

1) Administration Cost: Assumed at 3.5% of the construction cost plus consultancy services cost including price and physical contingencies
2) Consultancy Services Cost: 18% of construction cost, consisted of 8% for detailed design and 10% for construction supervision
3) Land Compensation Costs: Estimated based on the required land areas as described in Chapter 7 Environmental Considerations and as summarized in Table 4.6.11.
4) Physical Contingency Cost: 3% of the construction cost and non-construction cost.
5) VAT : 5% of the project cost

Table 4.6.9 Estimated Project Cost for Espana-UST Candidate Area (Storage Plan)

Espana-UST (Storage all + Pumping of after flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
Sub-total I	32,700	9,882	58,000	22,654	
II.Non-construction Cost					
II.1 Administration Cost	---	1,056	2,704	1,056	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	7,308	1,223	10,440	4,078	8%(D/D), 10%(SV)
II.3 Land Compensation	---	77	197	77	
Sub-total II	7,308	2,356	13,340	5,211	
Sub-total for [I] + [II]	40,008	12,238	71,340	27,865	
Price Escalation Rate					
III.Price Escalation	2,609	1,613	6,740	2,632	
IV.Physical Contingency	1,151	367	2,091	817	
Sub-total for [I] + [II] + [III] + [IV]	43,768	14,219	80,170	31,314	
V.VAT	2,188	711	4,009	1,566	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	45,956	14,929	84,179	32,880	

Source: JICA Survey Team

Table 4.6.10 Estimated Project Cost for Espana-UST Candidate Area (Early Drainage Plan)

Espana-UST (Pumping Start during flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
Sub-total I	22,900	6,445	39,400	15,389	
II.Non-construction Cost					
II.1 Administration Cost	---	707	1,810	707	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	4,964	831	7,092	2,770	8%(D/D), 10%(SV)
II.3 Land Compensation	---	74	190	74	
Sub-total II	4,964	1,612	9,092	3,551	
Sub-total for [I] + [II]	27,864	8,057	48,492	18,941	
Price Escalation Rate					
III.Price Escalation	1,522	880	3,775	1,475	
IV.Physical Contingency	836	242	1,455	568	
Sub-total for [I] + [II] + [III] + [IV]	30,223	9,179	53,722	20,984	
V.VAT	1,511	459	2,686	1,049	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	31,734	9,638	56,408	22,033	

Source: JICA Survey Team

Table 4.6.11 Estimated Project Cost for Buendia-Maricaban Candidate Area(Storage Plan)

Buendia-Maricaban area (Storage all + Pumping of after flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
I. Construction cost (Direct cost)	43,000	18,983	91,600	35,778	
II.Non-construction Cost					
II.1 Administration Cost	---	1,707	4,370	1,707	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	11,484	1,922	16,406	6,408	8%(D/D), 10%(SV)
II.3 Land Compensation	---	920	2,355	920	
Sub-total II	11,484	4,549	23,131	9,035	
Sub-total for [I] + [II]	54,484	23,532	114,731	44,813	
Price Escalation Rate					
III.Price Escalation	4,011	2,757	11,070	4,324	
IV.Physical Contingency	1,883	1,521	5,778	2,257	
Sub-total for [I] + [II] + [III] + [IV]	60,378	27,810	131,579	51,394	
V.VAT	3,019	1,391	6,579	2,570	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	63,397	29,201	138,158	53,963	

Source: JICA Survey Team

Table 4.6.12 Estimated Project Cost for Buendia-Maricaban Candidate Area(Early Drainage Plan)

Buendia-Maricaban area (Pumping Start during flood) (Unit: million*JPY, million PHP)

Work Item	Total		Equivalent (JPY)	Equivalent (PHP)	Note
	F.C.(JPY)	L.C.(PHP)			
I. Construction cost (Direct cost)	32,000	12,382	63,700	24,881	
II.Non-construction Cost					
II.1 Administration Cost	---	1,165	2,984	1,165	(I+II.2+III+IV)*3.5%
II.2 Consultancy Services Cost	7,986	1,337	11,409	4,456	8%(D/D), 10%(SV)
II.3 Land Compensation	---	917	2,348	917	
Sub-total II	7,986	3,419	16,739	6,538	
Sub-total for [I] + [II]	39,986	15,801	80,439	31,419	
Price Escalation Rate					
III.Price Escalation	2,711	1,957	7,722	3,016	
IV.Physical Contingency	1,200	474	2,413	943	
Sub-total for [I] + [II] + [III] + [IV]	43,897	18,232	90,575	35,378	
V.VAT	2,195	912	4,529	1,769	VAT=5%
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	46,092	19,144	95,103	37,147	

Source: JICA Survey Team

Table 4.6.13 Required Land Areas and Compensation Cost

(1) Espana-UST Area

Facility	Occupation area (sq.m.)	Land Status (Government / Private)	Zonal Value (PhP. / m2)	Land Purchase Cost in Zonal Value (PhP.)	Nos. of existing houses	Compensation cost for houses (PhP./unit w/ 40m2)	Compensation for Residiential buidings	**Total (PhP.)**
a. Storage all +Pumping after flood								
Departing Shaft	620	Private	26,410	16,374,200	0	-	0	**16,374,200**
Arrival Shaft	620	Government	6,000	3,720,000	0	-	0	**3,720,000**
Intake 1	544 (17 x 32 m)	Private	-	6,510,000	0	-	0	**6,510,000**
Intake 2	1,100 (55 x 20 m)	Private	6,600	7,260,000	40	400,000	16,000,000	**23,260,000**
Intake 3	648 (27 x 24 m)	Private	-	26,950,000	0	-	0	**26,950,000**
Total				**60,814,200**	**40**		**16,000,000**	**76,814,200**
b. Pumpinmg Start durring flood								
Departing Shaft	560	Private	26,410	14,789,600	0	-	0	**14,789,600**
Arrival Shaft	560	Government	6,000	3,360,000	0	-	0	**3,360,000**
Intake 1	544 (17 x 32 m)	Private	-	5,880,000	0	-	0	**5,880,000**
Intake 2	1,100 (55 x 20 m)	Private	6,600	7,260,000	40	400,000	16,000,000	**23,260,000**
Intake 3	648 (27 x 24 m)	Private	-	26,950,000	0	-	0	**26,950,000**
Total				**58,239,600**	**40**		**16,000,000**	**74,239,600**

(2) Buendia-Maricavan Area

Facility	Occupation area (sq.m.)	Land Status (Government / Private)	Zonal Value (PhP. / m2)	Land Purchase Cost (PhP.)	Nos. of ISFs	Unit cost for ISFs relocation (PhP./ISF)	Relocation Cost of ISFs (PhP.)	**Total (PhP.)**
a. Storage all +Pumping after flood								
Departing Shaft	600	Government	22,000	13,200,000	0	-	0	**13,200,000**
Arrival Shaft	600	Private	15,000	9,000,000	0	-	0	**9,000,000**
Intake 1	3,266 (71 x 46 m)	Government	150,000	489,900,000	0	-	0	**489,900,000**
Intake 2	2,000 (100 x 20 m)	Private	70,000	140,000,000	0	-	0	**140,000,000**
Intake 3	3,200 (80 x 40 m)	Government	55,000	176,000,000	0	-	0	**176,000,000**
Intake 4	1,568 (56 x 28 m)	Government	55,000	86,240,000	180	30,000	5,400,000	**91,640,000**
Total				**914,340,000**	**180**		**5,400,000**	**919,740,000**
b. Pumpinmg Start durring flood								
Departing Shaft	530	Government	22,000	11,660,000	0	-	0	**11,660,000**
Arrival Shaft	530	Private	15,000	7,950,000	0	-	0	**7,950,000**
Intake 1	3,266 (71 x 46 m)	Government	150,000	489,900,000	0	-	0	**489,900,000**
Intake 2	2,000 (100 x 20 m)	Private	70,000	140,000,000	0	-	0	**140,000,000**
Intake 3	3,200 (80 x 40 m)	Government	55,000	176,000,000	0	-	0	**176,000,000**
Intake 4	1,568 (56 x 28 m)	Government	55,000	86,240,000	180	30,000	5,400,000	**91,640,000**
Total				**911,750,000**	**180**		**5,400,000**	**917,150,000**

Source: JICA Survey Team

4.6.3 Grasp of Project Cost Based on a Comparison to Existing Storage Facilities Project Cost in Japan

Outline of facilities and project cost for existing storage facilities in japan are as shown in the Table 4.6.14 and Table 4.6.15.

(1) Kanda River/ Ring Road No.7 Underground Regulating Reservoir in Tokyo Metropolis

Table 4.6.14 Kanda River/ Ring Road No.7 Underground Regulating Reservoir

	Total	**The 1st Stage**	**The 2nd Stage**
Storage volume(m^3)	540,000	240,000	300,000
Tunnel Length (km)	4.5	2.0	2.5
Tunnel Inner Diameter (m)	12.5m (Overburden about 40 meter)		
Project Cost (billion JPY) (billion Peso)	103 (40.2)	54 (21.1)	49 (19.1)

Source: http://www.ktr.mlit.go.jp/ktr_content/content/000001296.pdf

Project cost per storage volume:

103 billion JPY / 540,000 m^3 = 190,741 JPY/ m^3 (40.2 billion Peso / 540,000 m^3 = 74,444 Peso/ m^3)

(2) Katsura River Right Bank Stormwater Drainage Project in Kyoto Prefecture

Table 4.6.15 Katsura River Right Bank Stormwater Drainage Project

	Total	**The North Main Drainage**	**The South Main Drainage**
Storage volume(m^3)	282,200	107,000	131,200
Tunnel Length (km)	9.2	4.9	4.3
Tunnel Inner Diameter (m)	3~8.5	3~8.5	3.5
Project Cost (billion JPY) (billion Peso)	45 (17.6)	25 (9.8)	20 (7.8)

Source: Nikkan Kogyo Shimbun Ltd., Article of February 29, 2012

Project cost per storage volume:

45 billion JPY / 238,200 m^3 = 188,917 JPY/ m^3 (17.6 billion Peso / 238,200 m^3 = 73,887 Peso/ m^3)

The project cost are composed of tunnel work, pumping station work and vertical shaft work. Therefore, existing storage facilities project cost (Kanda River project and Katsura River project) and this project are not a simple comparison. The construction cost per storage volume have been estimated the approximately 19,000 JPY per stage volume from 2 example of existing projects.

The storage projects for Espana-UST area and Buendia area were estimated by using unit price per storage volume. The results are shown in Table 4.6.16 and Table 4.6.17.

Table 4.6.16 Summary Project Cost of España-UST

	Storage all + Pumping after flood	**Pumping Start during flood**
Storage (m^3)	690,000	446,000
Tunnel Length (km)	3.5	3.5
Tunnel Inner Diameter (m)	17.050	13.750
Project Cost (billion JPY) (billion Peso)	131 (51.2)	85 (33.2)

Source: JICA Survey Team

Table 4.6.17 Summary Project Cost of Buendia-Maricaban

	Storage all + Pumping after flood	**Pumping Start during flood**
Storage (m^3)	1,310,000	844,000
Tunnel Length (km)	7.2	7.2
Tunnel Inner Diameter (m)	16.400	13.200
Project Cost (billion JPY) (billion Peso)	249 (97.3)	160 (62.5)

Source: JICA Survey Team

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CHAPTER 5. OPERATION AND MAINTENANCE (O&M) PLAN

Required items for operation and maintenance (O&M) activities were listed up and examined for the proposed structures to be constructed in the candidate areas. Aggregate operation and maintenance costs were estimated as well.

In addition, issues and items to be taken care of were listed up and described, of which issues and items were recognized during the course of the study.

The above two items are described hereunder.

5.1 Outlines of Operation and Maintenance (O&M) Plan

Operation and maintenance (O&M) plan for the proposed facilities (underground storage pipe) was examined based on the assumed functions and operation methods of the facilities which were briefly examined on the proposed development plan for the drainage facilities as described in Chapter 4.

In addition, interview surveys and data collection were conducted to grasp the current situations of O&M for the existing drainage channels and pumping stations, which will be referred to for the proposed facilities. The frequency of the O&M works was assumed to estimate aggregate O&M costs.

5.1.1 Items of Operation and Maintenance (O&M) and Work Flow

In the O&M plan, necessary O&M activities are to be conducted to secure the full functions of the proposed drainage facilities (underground storage pipe). The range of O&M works covers the each intake, the storage pipe and the vertical shafts. The O&M works for the existing drainage channel that is connected to the intake is assumed to be covered by the O&M budget for the usual activities. Required work items are described hereunder for the cases of “during flood” and “normal time.”

(1) O&M works during flood

The O&M works and work flow during flood which is assumed at this moment is as follows:

Sequential procedures are described hereunder from the start of flood inflow into the facility (underground storage pipe) by the occurrence of the flood up to the preparatory works against the next flood.

1) Monitoring of smooth inflow conditions into the intake by using remote monitoring system
   a) To confirm the securement of smooth inflow from the existing drainage channel into the storage pipe without any clogging at the intake by floating garbage etc.
2) Drainage of the stored water, ventilation and cleaning
   a) In case of storage plan, the drainage works of the stored water starts after flood, and in case of early start of drainage plan, drainage works starts after the inflow exceeds a certain amount.
   b) After the drainage works, by confirming the recurrence of flood for a moment through meteorological information, ventilation of the storage pipe will start. After securing the sufficient oxygen density inside the storage pipe, a working car will be lowered into the storage pipe to start the cleaning works.
   c) The cleaning works will be conducted by high-pressure washing car for the purpose of cleaning the wall of the storage pipe to remove the adhered floating objects and settled

objects to the wall.

d) The floating and settled objects are collected through the gutter installed on the invert concrete of the storage pipe toward the pit installed at the vertical shaft at the flow end. Liquid will be drained by the drainage pumps and solid objects are to be removed and carried out with container box etc using the lift in the vertical shaft.

Through the above O&M works after the occurrence of the flood, the preparedness against the coming flood will be arranged.

(2) Normal O&M works

The O&M works and work flow during normal period which is assumed at this moment is as follows:

Descriptions are given hereunder on the check items during normal period (non-flood period) which are important to ensure the full functions of the proposed drainage facilities (underground storage pipe) against the operations during floods.

1) Check and measurement inside the storage pipe
   a) Visual check will be made for the whole area of the storage pipe to confirm the nonexistence of abnormal conditions such as deformations, cracks and water leakage etc.
   b) In case any abnormal conditions found, detailed measurements and evaluations will be made to find out the reason for further countermeasures. The detailed procedures will be examined in the next stage.
2) Maintenance and check of the equipment instrument
   a) Operation check of equipment instruments such as remote monitoring systems, elevators, drainage pumps are to be conducted to ensure that those equipment instruments have no problems.
   b) In case of any problems found, repair and adjustment works are to be conducted and further confirmations will be made.

5.1.2 Survey on the current condition through interviews

Metropolitan Manila Development Authority (MMDA) has been in charge of operation and maintenance works for the existing drain channels and pumping stations in Metropolitan Manila area since 2002. To get reference information on the operation and maintenance of the proposed drainage facilities, interview surveys were made to the persons in charge in MMDA. After the explanation of the operation and maintenance items and the work flow as described in sub-section 5.1.1, interview surveys were made on the operation and maintenance of the existing drainage channel and pumping stations.

The results are as follows:

1) As for the periodical cleaning and dredging of the existing drainage channel, the intervals of the works are as follows:
   a) Removal of garbage is done once in three months; and
   b) Dredging of the sediment is done once a year.
2) MMDA is in charge of drainage channel which are connected to the pumping stations.
3) Total annual budget for O&M for the drainage channels and pumping stations are about 260 million pesos.

4) 500 numbers of contract-based staff is employed for cleaning and dredging of the drainage channel with a budget size of 50 million pesos.

5) The above contract-based staff is in charge of dredging and garbage cleaning after major typhoons and heavy rains.

6) Total annual budget for the removal of accumulated garbage at pumping stations is 500 million pesos, which is secured separately from the O&M budget for the drainage channels and pumping stations.

7) Garbage collected at pumping stations are carried out to the disposal site with a rate of 172 pesos per cubic meter.

8) Actual expenditures for operation and maintenance for 32 pumping stations, related gates, storages, bridges etc. under the control of MMDA were derived from MMDA. Table 5.1.2 shows the annual total budget only.

Table 5.1.1 Actual Expenses for Operation and Maintenance of MMDA Pumping Stations etc.

Year	Total Expenditure for Operation and Maintenance (Peso)
2010	112,495,321.46
2011	132,065,471.22
2012	155,433,456.58
2013	141,458,438.17
2014	129,937,017.99
2015 (Jan.-Aug.)	68,437,252.50

Source: MMDA

9) The above data includes total operation hours of the pumping stations, total operation hours of generators, fuel consumptions, cost for fuel, electricity, water supply, telephone, labor and other spare parts and lubricants (details are given in the coming Table 5.1.3.).

5.1.3 Conceivable Organization and Budget for O&M

(1) Organization for operation and maintenance

MMDA is currently in charge of O&M works of drainage channels and pumping stations in Metropolitan Manila. However, it is supposed that neither DPWH nor MMDA has know-how on the O&M activities of the proposed drainage facilities (underground storage pipe), as the facilities are to be introduced to the Philippines for the first time. On the other hand, considering the fact that DPWH would be the main implementation body for the construction of the proposed drainage facilities, and also considering that DPWH has an intension on securing the budget and implementing the future O&M works for the proposed facilities, O&M plan will be considered based on the assumptions that DPWH would be in charge of O&M works.

Further, to make full use of the know-how that MMDA has for the O&M works on the existing drainage channels and pumping stations, it is expected that MMDA should be involved into the implementation of the project by DPWH to enable effective O&M works for both the existing and the proposed facilities. It is hoped during the project implementation stage in the future, that coordination between DPWH and MMDA would be made on the systems of O&M works. The budget for operation and maintenance

(2) The budget for operation and maintenance

From the 32 pumping stations annual O&M expenditures as described in sub-section 5.1.2, data for five pumping stations were extracted and shown in Table 5.1.3. These five pumping stations were visited by the JICA Study Team on October 17, 2015.

Table 5.1.2 Annual Expenditures for Five Major Pumping Stations visited by The JICA Study Team

	Pump Station Name (unit capacity)	Year	TOTAL NO. OF OPERATING HOURS (hr.)		TOTAL DIESEL FUEL/ GASOLINE CONSUMPTION	liter per hour	peso per liter	TOTAL COST OF DIESEL FUEL/ GASOLINE	TOTAL AMOUNT PAID TO MERALCO FOR POWER SERVICES	TOTAL AMOUNT PAID TO MWSS/ MAYNILAD FOR WATER SUPPLY	TOTAL COST OF LABOR	TOTAL COST OF MISCELLANEOUS	TOTAL
			Pump (hr)	Generator (hr)	Liters			Peso	Peso	Peso	Peso	Peso	Peso
1	Aviles	2010	1,726.56	38.37	82,360	2,146	32	2,671,347.00	436,126.35	87,105.80	2,511,009.75	922,906.63	6,628,495.53
		2011	2,026.95	69.07	94,510	1,368	45	4,209,302.80	481,178.68	91,491.70	2,650,197.73	709,655.05	8,141,825.96
		2012	2,023.65	84.44	99,435	1,178	46	4,583,744.92	428,788.50	148,207.42	2,711,189.24	263,116.32	8,135,046.40
		2013	2,213.03	60.75	103,350	1,701	45	4,642,829.75	425,535.65	135,761.78	2,937,162.68	207,753.95	8,349,043.81
		2014	1,300.06	351.42	69,360	197	44	3,074,052.10	508,290.88	291,952.78	3,446,531.24	80,840.96	7,401,667.96
		2015 (1-8)	243.63	82.62	11,825	143	39	462,265.05	1,272,597.82	97,872.30	2,199,721.76	1,950.46	4,034,407.39
	(3.625 m^3/s)												
	2010-2014 Ave. Ope. Hrs		**1,858.05**					**2010-2014 Ave.**	**2,279,920.06**		**2010-2014 Ave. Ope. Cost**		**7,731,215.93**
2	Libertad	2010	1,375.26	134.19	93,740	699	34	3,142,480.20	1,288,863.30	409,356.65	2,688,681.18	227,778.77	7,757,160.10
		2011	1,493.50	46.08	102,860	2,232	45	4,611,501.90	1,331,916.64	604,290.57	2,728,309.71	203,651.05	9,479,669.87
		2012	1,884.82	152.09	131,640	866	43	5,711,425.00	1,397,773.21	1,180,730.14	2,688,041.15	84,121.17	11,062,090.67
		2013	1,746.23	17.47	108,790	6,227	45	4,891,156.50	1,207,066.44	1,733,635.34	2,649,346.30	179,841.86	10,661,046.44
		2014	1,617.18	363.47	114,970	316	43	4,960,955.50	1,265,150.36	1,096,178.92	2,064,251.27	80,027.01	9,466,563.06
		2015 (1-8)	725.25		50,050		36	1,789,467.50	556,660.66	498,428.14	1,502,422.06	47,754.80	4,394,733.16
	(7.000 m^3/s)	**2010-2014**											
	2010-2014 Ave. Ope. Hrs		**1,623.40**					**2010-2014 Ave.**	**6,490,769.95**		**2010-2014 Ave. Ope. Cost**		**9,685,306.03**
3	Quiapo	2010	1,259.46	65.58	46,700	712	32	1,502,206.00	410,986.80	36,786.77	1,978,350.07	1,403,260.35	5,331,589.99
		2011	1,315.66	58.91	47,065	799	43	2,033,829.50	479,928.33	47,430.68	1,915,999.98	205,163.77	4,682,352.26
		2012	1,782.78	87.28	64,535	739	45	2,875,888.80	481,144.25	56,329.02	1,909,626.52	69,675.01	5,392,663.60
		2013	1,245.77	97.48	46,155	473	44	2,019,456.25	461,112.93	70,859.46	2,016,375.25	273,405.25	4,841,209.14
		2014	1,391.33	170.85	48,035	281	43	2,076,153.00	474,663.46	87,933.01	2,063,801.60	156,013.53	4,858,564.60
		2015 (1-8)	163.41	488.71	17,040	35	36	606,624.00	246,389.46	57,155.21	1,440,911.37	26,268.98	2,377,349.02
	(2.375 m^3/s)	**2010-2014**											
	2010-2014 Ave. Ope. Hrs		**1,399.00**					**2010-2014 Ave.**	**2,307,835.77**		**2010-2014 Ave. Ope. Cost**		**5,021,275.92**
4	Tripa de Gallina	2010	2,132.62	69.46	131,360	1,891	32	4,213,040.50	1,161,038.20	140,064.95	3,546,252.16	735,956.37	9,796,352.18
		2011	1,903.12	47.24	114,820	2,431	44	5,079,461.00	1,492,136.24	180,617.14	3,335,213.39	645,042.27	10,732,470.04
		2012	2,507.83	11.08	147,000	13,267	44	6,479,231.50	1,589,748.70	424,286.37	3,545,106.44	1,090,361.85	13,128,734.86
		2013	2,240.27	72.59	137,670	1,897	45	6,151,011.50	1,592,317.64	213,931.90	3,812,926.86	846,548.32	12,616,736.22
		2014	2,417.42	43.48	142,630	3,280	43	6,118,603.50	1,572,091.49	567,112.61	3,282,674.04	236,986.74	11,777,468.38
		2015 (1-8)	501.55	319.83	73,210	229	36	2,640,437.50	757,733.42	508,814.06	2,001,071.32	12,343.30	5,920,399.60
	(7.000 m^3/s)	**2010-2014**											
	2010-2014 Ave. Ope. Hrs		**2,240.25**					**2010-2014 Ave.**	**7,407,332.27**		**2010-2014 Ave. Ope. Cost**		**11,610,352.34**
5	Valencia	2010	2,473.71	30.94	70,030	2,263	33	2,323,923.40	268,929.15	44,886.40	2,307,252.33	367,651.78	5,312,643.06
		2011	2,751.98	66.98	78,280	1,169	44	3,430,511.10	239,830.12	52,963.03	2,326,949.57	459,162.12	6,509,415.94
		2012	2,194.45	118.13	66,370	562	44	2,891,004.50	192,424.05	217,490.97	2,451,316.44	111,399.13	5,863,635.09
		2013	1,700.99	66.00	51,600	782	45	2,297,136.50	186,163.60	57,775.66	2,513,250.63	227,967.50	5,282,293.89
		2014	3,073.50	38.45	61,100	1,589	42	2,594,698.50	185,638.72	182,402.60	2,587,063.94	107,487.06	5,657,290.82
		2015 (1-8)	914.61	23.67	10,050	425	37	374,362.52	1,011,110.78	65,565.33	1,667,420.54	23,066.44	3,141,525.61
	(2.625 m^3/s)	**2010-2014**											
	2010-2014 Ave. Ope. Hrs		**2,438.93**					**2010-2014 Ave.**	**1,072,985.64**		**2010-2014 Ave. Ope. Cost**		**5,725,055.76**

Source: MMDA

Of the above listed five pumping station, data for Aviles pumping station was used to make a trial estimate the operation and maintenance cost for the proposed drainage facilities, because Aviles pumping station has average annual expenditure levels among the five and the required power output for the pumping was known.

Aviles pumping station had been operated with 230 kW class vertical axial flow pump before its rehabilitation in January 2015. The average operation hours of Aviles pumping station for five years from 2010 to 2014 was about 1,860 hours, which means that the average power consumption was, 230 kW x 1,860 hr. = 427,800 kWh.

To achieve the above operation, the required annual expenditure was 7,731,216 peso in average.

The power consumption cost is calculated as follows:

7,731,216 / 427,800 = 18.07 peso/kWh

The above unit cost includes required costs for pump and other heavy equipment operations such as fuel, electricity, water supply, labor and spare parts etc. as described in Table 5.1.3. In this connection, required O&M costs are estimated based on the assumptions that the cost for the power consumption by the proposed drainage pump will be a dominant part of the drainage cost, which can also cover the required costs for ventilation, removal of settled mud and cleaning works.

For the proposed two candidate areas, the following pumps with relevant output will be installed.

(1) Espana-UST candidate area: Pump output 4,500 kW

(2) Buendia-Maricaban candidate area: Pump output 9,000 kW

By assuming that the factors of head and discharge are considered as pump output in kilo watt, operation and maintenance costs for draining the water from the underground storage pipes can be estimate as follows:

By assuming drainage in 48 hours from the full storage,

(1) Espana-UST candidate area: Pump output 4,500 kW

4,500 kW x 48 hrs x 18.07 pesos = 3,903,000 pesos

(2) Buendia-Maricaban candidate area: Pump output 9,000 kW

9,000 kW x 48 hrs x 18.07 pesos = 7,806,000 pesos

Considering the full storage capacity of 690,000 m^3 for Espana-UST candidate area and 1,310,000 m^3 for Buendia-Maricaban area, drainage cost per storage (operation costs during floods) will be in orders of 5.7 to 6.0 pesos per cubic meter.

The required cost for full drainage (3,903,000 to 7,806,000 peso) is equivalent to 3 to 6% of the total annual O&M costs for all the MMDA pumping stations (average between 2010 to 2014: 134,277,941 peso).

5.1.4 Assumed Frequency of the Works and Aggregate Budget for O&M

Of the assumed conditions for the brief examinations on the proposed drainage facilities (underground storage pipe), the scale of the flood is of 25 year probable flood as described in Chapter 3. Further, as a precondition for drainage facilities development, it was assumed that countermeasures against 10 year probable flood would be accomplished by DPWH through the development/rehabilitation of the existing drainage facilities. In this connection, the frequency of the usage of the proposed drainage facilities will be more than or equal to “once in ten years” and less than or equal to “once in 25 years,” for the purpose of probability calculations.

On the other hand, it is necessary to assume the frequency of the usage of the facilities for the purpose of estimating O&M costs. It was assumed that 50% storage of the flood water might occur once in ten years and 100% storage might occur once in 25 years.

(1) O&M cost during flood

By applying the above frequency to the O&M costs estimated in sub-section 5.1.3, in 25 years, 100% storage will occur once, and 50% storage will occur 2.5 times, which will give the following O&M costs. Total O&M costs required during the project period (50 years) are also estimated.

1) Espana-UST candidate area

100% storage 3,903,000 peso x 1 time + 50% storage 3,903,000 peso x 50% x 2.5 times

= 8,781,750 peso/25 years, 17,653,500 peso for 50 year project period.

2) Buendia-Maricaban candidate area

100% storage 7,806,000 peso x 1 time + 50% storage 7,806,000 peso x 50% x 2.5 time

= 17,563,500 peso/25 years, 35,127,000 peso for 50 year project period.

To be precise, the frequency of the usage of the facility should be estimated by flood inundation analysis, however, the above calculation was made at this moment from the aspect of probable flood. Details should be examined in the next stage.

(2) O&M cost for normal period

O&M cost for normal period is mainly for visual inspections and checking of operations for equipment instrument, and was estimated by referring to the average annual O&M expenditures for Aviles pumping station as was referred to in sub-section 5.1.1 (2). In Espana-UST candidate area, 3/365 (3 days equivalent) of annual O&M expenditures were applied. In Buendia-Maricaban candidate area, as the length of the storage pipe is about two times of the Espana-UST candidate area, the doubled expenditures were applied as follows.

1) Espana-UST candidate area

Average annual expenditures in Aviles pumping station 7,731,216 peso x 3/365

= 63,445 peso/year

2) Buendia-Maricaban candidate area

Average annual expenditures in Aviles pumping station 7,731,216 peso x 3/365 x 2

= 126,890 peso/year

The above figures show minimum cost for inspections which needs detailed examinations on schematic design of the facilities during the detailed examination stage in the future.

(3) Annual total O&M cost

The abovementioned costs for during flood and normal period can be summarized as follows.

Candidate Area	O&M cost during flood (Required budget for 50 year project period)	O&M cost for normal period (Peso/year)
Espana-UST candidate area	17,563,500	63,445
Buendia-Maricaban candidate area	35,127,000	126,890
Total	52,690,500	190,335

Source: JICA Study Team

5.2 Issues and points to be considered for the next stage

There are several issues and points to be considered that were realized during the course of examination of the proposed drainage facility development plan. Such issues and points to be considered need further considerations in the next stages of preparatory studies and basic design.

(1) Confirmation on effective and assured diversion of the flood water

In the study, the drainage facility development plan was prepared by referring to the results of ongoing flood study by DPWH, and in view of removing the inundation damages of significantly flooded areas. The development plan was prepared by referring to the divided drainage areas proposed in 2005 M/P study and decided the drainage areas which were to be covered by relevant intake facilities for the diversion of the flood water into the underground storage pipe.

For the intake site, possible locations were assumed on the Google Earth to prepare possible layouts, of which adequacy was confirmed through site visit to the relevant candidate sites.

There were some candidate locations for intake that need further invent on layout as the available land was not necessarily sufficient. It is necessary to examine in detail on more compact design layout for the intake in the next stage.

Further, to ensure the assured intake of the flood water, confirmation on the hydraulic phenomena through inundation analysis model and non-uniform calculations etc. as well as confirmation on structural dimensions and designed diversion amount (inflow).

(2) Assured removal of floating garbage and sediment in the existing drainage channel

The proposed underground storage pipe is designed to install screen at the intake facilities to prevent inflow of the floated garbage. It is important to conduct periodical cleaning of the existing drainage channel to prevent the intake from clogging by floated garbage during the flood.

Further, removal of sediment deposit in the existing drainage channel is also important. The screen installed at the intake facility can prevent the inflow of floated garbage, however, inflow of the sediment cannot be prevented. Once the sediment deposit in the existing channel enter into the underground storage pipe, the sediment density of the stored water will be bigger, which may increase the load of the drainage pump and thereby increase the drainage cost.

From this point of view, it is important to remove the floated garbage and sediment in the existing drainage channel.

(3) Reconfirmation of underground facilities (embedded items) and determination of longitudinal profile

The proposed facility development plan was prepared based on available information on embedded underground facilities. It is necessary in the future to confirm the detailed information on the embedded underground facilities, and calculate the required offset distance based on the diameter of the storage pipe to determine the vertical alignment of the storage pipe. Based on the vertical alignment, it is important to conduct geological investigations to select the required machine for excavation, and scrutinize the required construction cost and construction schedule.

(4) Determination of layout considering expandability

The proposed drainage facility is designed for 25 year probability and not designed for 50 year probability in terms of the required storage capacity. Although further detailed examinations in the next stage is required, in case of more than25 year probability (for example 50 year probability), it is necessary to utilize the planned storage pipe under pressure flow, for instance, and it is necessary to drain the stored water continually with larger drainage capacity. For this, it is necessary to design the proposed storage pipe as pressure tunnel and also design the segment to be durable against inner water pressure. Further, in case of designing the storage pipe under pressure flow condition, a surge tank and ventilation shafts should be examined to ensure the smooth flow under the pressure flow conditions. Detailed examinations in the next stage of schematic design is required.

(5) Necessity of development of riverbank protection structures

Under the proposed drainage facility development plan, Intakes 3 and 4 of the Buendia-Maricaban candidate area need to divert the water from Maricaban River. There are several stretches in the Maricaban River without sufficient riverbank protection works. To secure the necessary intake (diversion) amount it is necessary to develop the required riverbank protection works.

(6) Estimate of frequency of facilities usage and confirmation of disappearance of the inundation areas through flood inundation analysis

For the proposed drainage facility plan, the intake (diversion) amount was roughly estimated by setting the presumable drainage areas. In the next stage, it is necessary to define the dimensions of the intake in more detail, and by applying actual floods or several patterns of inland inundation to conduct inundation simulation analysis, to confirm and ensure the prevention of flood and inland inundation damages.

CHAPTER 6. PRELIMINARY ECONOMIC EVALUATION

6.1 Preliminary Economic Evaluation Method

6.1.1 EIRR and NPV

Taking the NEDA policy into consideration, economic evaluation was made according to the following steps for this kind of project:

1) Identify the most likely damaged item.
2) Estimate the basic unit value per unit and/or unit area (amount/unit, or amount/ha) for each damage item.
3) Evaluate the damage by existing floods to be used as the basis of evaluation.
4) Estimate the annual average flood damage by means of probability analysis for each return period under the “With-” and the “Without-Project” concept.
5) Identify the economic benefit as differences of damages in the “With-” and the “Without-Project” conditions.
6) Compare the economic benefit with the economic cost of project, and evaluate project feasibility by means of some indices such as the economic internal rate of return (EIRR), the net present value (B – C), and the B/C Ratio.

The Economic Internal Rate of Return (EIRR) was calculated using the cash flow of economic cost and economic benefit during the project life. This EIRR is defined by the following formula:

$$\sum_{t=1}^{t=T}\frac{C_t}{(1+R_e)^t}=\sum_{t=1}^{t=T}\frac{B_t}{(1+R_e)^t}$$

Where, T = the last year of the project life;

C_t = the annual economic cost flow of the project under study in year t;

B_t = annual benefit flow derived from the project in year t; and

Re = the EIRR (a discount rate which equates the net present values of cost and benefit steams).

When the resulting EIRR is of the same rate as or higher than the discount rate applied for the calculation of present value of both the benefit and cost, the project has the feasibility for execution.

The NPV is expressed as “B-C” and defined by the following formula:

$$NPV = B - C = \sum_{t=1}^{t=T}\frac{B_t}{\left(1+R_e\right)^t}-\sum_{t=1}^{t=T}\frac{C_t}{\left(1+R_e\right)^t}$$

If “B-C” (subtract present value of cost from present value of the benefit) is positive, it means that the project under study has a reliability for execution.

6.1.2 With/Without Project

The basic principle of project economic evaluation is to define both economic benefits and costs pertaining exclusively to the domain of influence of the project in question. The costs and benefits of the project are calculated by deriving the incremental differences of each brought by the implementation of the project, i.e. Δ = With Project − Without Project. The definition is easily applied to the case of a single project which has a single impact to society. However, the boundary definition requires careful attention when a project has wide impacts to society and/or a multiple of projects are implemented concurrently. There is a host of projects that affect the impacts of the project concerned.

- A program of flood control projects is now underway in accordance with the master plan prepared by JICA in 2005. The program will establish the capacity of the city to cope with the flood of a 10-year return period.
- Urban transport projects that will improve the economic disruption and traffic congestions to be caused by floods in concern.

For the first point, the Without Project is based on the assumption that the city has the capacity to control flood with a return period of less than 10 years. For the second point, it is very difficult to estimate the future impacts of the numerous proposed urban transport projects such as LRT and Skyways, let alone their impacts on the future traffic congestions. However, according to the latest report, the future modal share of road transport is set at the level projected by the optimal scenario (Without Project condition. See Section 6.2.7.)

6.2 Economic Benefit

6.2.1 Composition of Economic Benefit

The economic benefit arising from flood control are largely composed of two categories, direct and indirect benefits. The direct benefits are composed of 1) reduction in physical damages to building and other facilities; 2) forgone expenditures incurred to provide reliefs to evacuated refugees; and 3) foregone clean-up expenses, whereas the indirect benefits are composed of 1) reduction of traffic congestion and diversion costs; 2) reduction in disruption of economic activities to generate income, and 3) prospective increase in land use values.

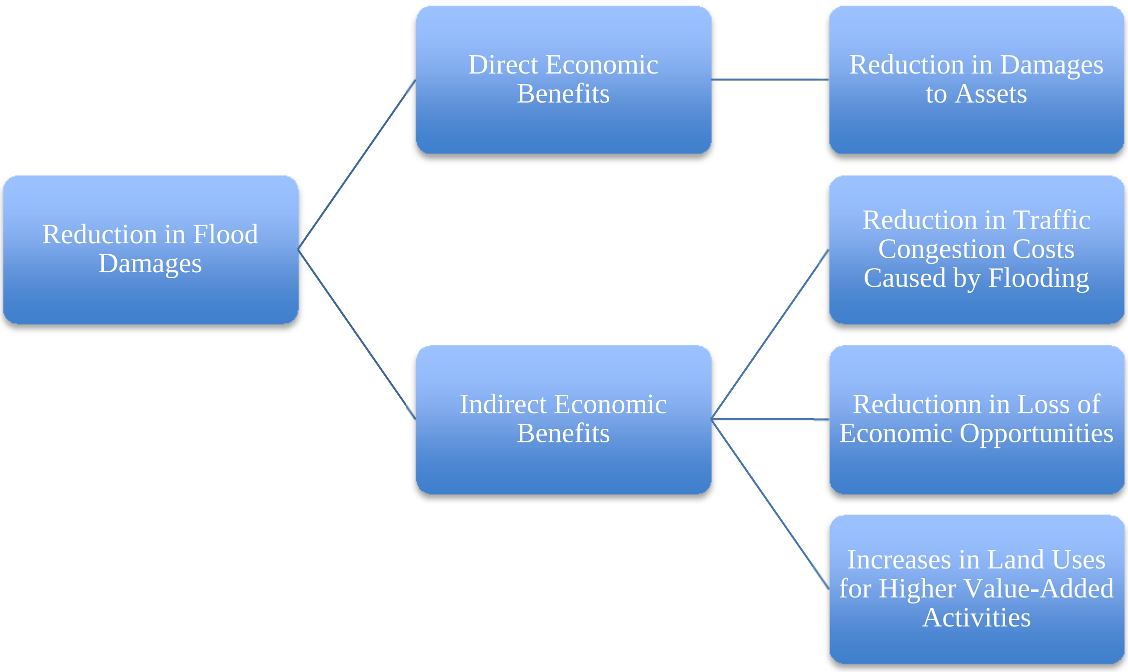

Figure 6.2.1 Economic Benefits of Flood Control Projects

6.2.2 Basic Unit for Estimation of Economic Benefit

The basic unit used fot the estimation of economic benefit is the same as the one used in a previous study in Metro Manila the "PMRCIP Phase IV and Phase V"[1].

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[1] Supplemental Agreement No.1 for the Consulting Engineering Services for Assistance to Procurement of Civil Works and Construction Supervision on the JICA-assisted PASIG-MARIKINA River Channel Improvement Project, Phase III (PH-P252)

(1) Buildings, Household Effect, Durable Assets and Inventory Stocks in Build-up Area

The following table shows the share rate of buildings by type..

Table 6.2.1 Share Rate of Buildings by Type

REGION / PROVINCE / CITY / MUNICIPALITY	Industry Major Division												
	B	D	E	F	G	H	I	J	K	M	N	O	Residence
MANILA	0.01	0.74	0.00	0.02	5.25	1.17	0.38	0.44	1.13	0.19	0.45	0.60	89.62
MANDALUYONG CITY	0.00	0.63	0.00	0.06	3.06	0.85	0.07	0.26	0.60	0.19	0.63	0.44	93.21
MARIKINA CITY	0.00	0.86	0.00	0.09	4.72	1.37	0.18	0.30	1.35	0.15	0.41	0.60	89.96
PASIG CITY	0.00	0.80	0.00	0.06	3.12	0.59	0.04	0.22	0.39	0.18	0.33	0.41	93.84
QUEZON CITY	0.00	0.81	0.03	0.08	4.21	1.14	0.11	0.33	1.33	0.23	0.51	0.50	90.70
SAN JUAN	0.00	1.03	0.00	0.11	6.42	1.38	0.15	0.48	1.44	0.25	0.67	0.83	87.24
MAKATI CITY	0.02	1.15	0.07	0.12	6.19	2.70	0.35	1.05	3.59	0.40	0.70	1.12	82.56
PATEROS	0.00	1.42	0.00	0.00	2.65	0.79	0.05	0.22	0.48	0.12	0.52	0.54	93.20
TAGUIG	0.01	0.53	0.00	0.01	1.93	0.62	0.04	0.09	0.30	0.13	0.18	0.27	95.89
PARANAQUE CITY	0.00	0.88	0.01	0.06	4.17	1.18	0.15	0.38	1.18	0.20	0.49	0.59	90.69
KALOOKAN CITY	0.00	0.88	0.01	0.06	4.17	1.18	0.15	0.38	1.18	0.20	0.49	0.59	90.69
NAVOTAS	0.00	0.88	0.01	0.06	4.17	1.18	0.15	0.38	1.18	0.20	0.49	0.59	90.69
PASAY CITY	0.00	0.49	0.00	0.02	3.42	0.94	0.20	0.31	0.47	0.10	0.25	0.40	93.41
MALABON CITY	0.00	0.49	0.00	0.02	3.42	0.94	0.20	0.31	0.47	0.10	0.25	0.40	93.41
VALENZUELA CITY	0.00	0.49	0.00	0.02	3.42	0.94	0.20	0.31	0.47	0.10	0.25	0.40	93.41
LAS PINAS CITY	0.00	0.49	0.00	0.02	3.42	0.94	0.20	0.31	0.47	0.10	0.25	0.40	93.41

B: FISHING
D: MANUFACTURING
E: ELECTRICITY, GAS AND WATER
F: CONSTRUCTION
G: WHOLESALE/RETAIL TRADE AND REPAIR 0RVICES
H: HOTELS AND RESTAURANTS
I: TRANSPORT, STORAGE AND COMMUNICATIONS
J: FINANCIAL INTERMEDIATION
K: REAL ESTATE, RENTING AND BUSINESS ACTIVITIES
M: EDUCATION
N: HEALTH AND 0CIAL WORK
O: OTHER 0RVICE ACTIVITIES

Source: PMRCIP Phase IV and Phase V

The economic units for the evaluation of floof damage area as shown below.

Table 6.2.2 Economic Basic Units for the Estimation of Flood Damage

Assets			Total Sample	Building (*1) (Pesos/ unit)	Durable Assets (Pesos/unit)	H. Effects/ Inv. Stock(*2) (Pesos/unit)	Value Added (*3) (Pesos/day)
1.	Residence						
	A.	Residential Unit		155,765		99,248	
2.	Industrial, Educational and Medical Facilities(*5)						
	B.	Fishery	31	1,802,474	5,949,956	6,146,798	135,412
	D.	Manufacturing	15,229	1,910,265	2,459,588	22,419,920	61,497
	E.	Electricity, Gas and Water	12	1,131,865,727	343,180,557	89,638,170	4,753,056
	F.	Construction	651	1,910,013	3,548,461	23,148,315	129,735
	G.	Wholesale & Retail Trade	82,074	560,054	326,313	8,782,541	17,756
	H.	Hotels & Restaurants	19,382	2,252,393	471,710	163,253	11,700
	I.	Transport, etc.	4,841	7,720,985	10,204,521	2,485,306	319,141
	J.	Financial Intermediation	12,392	7,063,874	1,242,379	262,409	281,983
	K.	Real Estate & Business Activities	18,915	2,080,328	736,221	16,408,026	54,416
	M.	Private Education	6,052	6,345,506	878,587	149,227	45,668
	N.	Health & Social Work	6,202	2,374,027	1,422,910	903,628	25,420
	O.	Other Community, Social and Personal Services	2,196	4,295,673	843,818	391,871	39,671

Source: PMRCIP Phase IV and Phase V

The following table shows the damage rate by inundation depth.

Table 6.2.3 Damage Rate by Inundation Depth

Item		Below Floor /Ground Level	Inundation Depth — Over Floor/Ground Level: 0.15-0.49 m	0.5-0.9 m	1.0-1.9 m	2.0-2.9 m	More than 3.0m
1	Building						
a.	Building*[1]	0.000	0.092	0.119	0.266	0.38	0.834
2	Residence						
a.	Household Effects	0.000	0.145	0.326	0.508	0.928	0.991
3	Industrial, Educational and Medical Facilities						
a.	Depreciable Assets	-	0.232	0.453	0.789	0.966	0.995
b.	Inventory Stock	-	0.128	0.267	0.586	0.897	0.982

Note: *1 In case of all buildings, floor level is 15cm higher than the ground level, because t almost all buildings have the threshold of around 15cm in height in front of their entrances according to the field investigation.

Source: Guideline for flood control project evaluation, Ministry of Land, Infrastructure, Transport and Tourism in Japan, 2005

(2) Income Losses due to Cleaning of Building and/or Houses and Business Suspension

Once flood occurs and houses are inundated, several days will be needed for cleaning the houses. In case of business activities, they should be suspended for several days. The economic disruption loss reduction benefits from inundation is estimated separately in Section 6.2.7.

Table 6.2.4 Estimated Days for Cleaning and Business Suspension by Inundation Depth

Item		Below Floor Level	Inundation Depth — Above Floor Level: Less than 0.5m	0.5-0.99 m	1.0-1.99 m	2.0-2.99 m	More than 3.0m
1	Residence						
	Cleaning (days)	-	2.5	4.3	8.7	14.1	16.7
2	Business Facilities*[2]						
	Suspension of Business (days)	-	1.5	2.1	3.4	5.6	7.5
	Stagnant Days of Business after Suspension*[1]	-	0.7	1.1	1.7	2.8	3.8
	Total	-	2.2	3.2	5.2	8.4	11.3

Note: *1 Businesses shall be suspended during the stagnation days.

Source: JICA Survey Team prepared from Guideline for flood control project evaluation, Ministry of Land, Infrastructure, Transport and Tourism in Japan, 2005

Days are set by 1/3 of the case of river flood in consideration of the target flood type (inland flood).

(3) Damage to Social Infrastructures (Roads, Bridges, Drainage Ditches)

Once flood occurs, social infrastructures such as roads, bridges and drainages sustain heavy damage. This is the other kind of damage to be checked. According to some previous flood control projects in the Philippines, the damage of social infrastructures is approximately 35% of direct damage. Therefore, the damage is assumed to be 35% of total amount of item (1) and (2) above in this Study the same as the previous study[2] in Metro Manila.

6.2.3 Reduction in Damages to Assets

The results of flood simulation of estimated damage and potential reduction with the projects are shown in Table 6.2.5 to calculate the differences between "With" and "Without Project" situations.

The annual expected values of reduction in flood damage to assets are expressed as follows:

Annual expected benefit of reduction in flood damages = $\sum_{i=1}^{5}\frac{1}{2}(D(Q_i)+D(Q_{i-1}))(P(Q_{i-1})-P(Q_i))$

[2] Pasig-Marikina River Channel Improvement Project (Phase III), JICA, 2013

Whereas Q_i is i=0 flood occurrence of 3 yearn return period, i=1: flood occurrence of 5 yearn return period, i=2: flood occurrence of 10 yearn return period, i=3: flood occurrence of 25 yearn return period, i=4: flood occurrence of 50 yearn return period, i=5: flood occurrence of 100 yearn return period, i=2

$D(Q_i)$: Flood damage reduction benefits from controlling Q_i

$P(Q_i)$: Probability of occurrence ofQ_i

Table 6.2.5 Reduction in Direct Damages to Assets in Buendia-Maricaban Area

Espana-UST Area

Return Period	Occurrence Probability	Flood Damage			Average of Damage Reduction	Interval Provability	Annual Average Damage Reduction	Remarks
		Without Project (1)	With Project (2)	Damage Reduction (1)-(2)				
1/3	0.333	0	0	0				
					2,093	0.133	278	
1/5	0.200	7,430	3,243	4,187				
					4,208	0.100	421	
1/10	0.100	10,484	6,256	4,229				
					4,191	0.060	251	
1/25	0.040	14,019	9,865	4,154				
					4,352	0.020	87	
1/50	0.020	17,025	12,475	4,550				
					4,508	0.010	45	
1/100	0.010	20,265	15,799	4,466				
						Annual Benefit :	1,082	million peso

Buendia-Maricaban Area

Return Period	Occurrence Probability	Flood Damage			Average of Damage Reduction	Interval Provability	Annual Average Damage Reduction	Remarks
		Without Project (1)	With Project (2)	Damage Reduction (1)-(2)				
1/3	0.333	0	0	0				
					5,005	0.133	666	
1/5	0.200	25,093	15,083	10,010				
					10,198	0.100	1,020	
1/10	0.100	34,857	24,471	10,386				
					7,461	0.060	448	
1/25	0.040	45,246	40,711	4,535				
					4,154	0.020	83	
1/50	0.020	54,925	51,152	3,772				
					3,604	0.010	36	
1/100	0.010	63,246	59,811	3,435				
						Annual Benefit :	2,253	million peso

Source: JICA Survey Team

6.2.4 Opportunity Cost Pricing

(1) Economic Disruption Pricing

Assessment of the economic opportunity costs of flood damages require pricing of economic disruption as well as quantification of damages. Flooding will cut off the physical access to the impacted areas thereby hampering the local economy from income generations to be accrued from various commercial activities during the time of inundation. The most adequate price tag to be used for such broad-based activities would be the use of gross regional domestic product which represents the overall value-added generated by the region concerned under normal circumstances. The unit adopted herein is a worker.

The reason why this investigation has adopted the use of gross domestic product instead of average wage or other income indicators is that such indicator only represents the value created by human capital. In reality, the net values lost by floods accrue not only to labor but also to the capital. The combined net values represent more accurate measures of lost values by the flooding. For instance, taxi service cost is comprised of operation overhead, machine and building depreciation in addition to the wage paid to the driver. Gross domestic product includes in its calculation wages, profits and depreciation, providing a better measure for economic opportunity cost.

In 2014, the Philippines generated the GRDP of 12.6 trillion pesos as a whole while the National Capital Region (NCR) generated approximately 4.7 trillion pesos. The population aged more than 15 years comprised 65% of the total population of which the working population comprised 63%. Applying these parameters, the GRDP per worker in NCR is estimated to be 890,000 peso/worker/year.

Table 6.2.6 Time Value Pricing

	Unit	Area	2010	2011	2012	2013	2014
GRDP	Million Php	NCR	3,650,000	3,790,000	4,050,000	4,420,000	4,679,830
		Philippines	10,110,000	10,430,000	11,130,000	11,920,000	12,642,736
Population	Number	NCR	11,855,975	12,070,000	12,290,000	12,510,000	12,740,000
		Philippines	92,337,852	94,090,000	95,880,000	97,700,000	99,560,000
Age 15+	Number	NCR	7,716,625	7,855,926	7,999,116	8,142,306	8,290,000
		Philippines	60,100,000	61,240,000	62,400,000	63,590,000	64,800,000
Labor Force	Number	NCR	4,880,000	4,960,000	5,060,000	5,150,000	5,240,000
		Philippines	37,980,000	38,700,000	39,440,000	40,190,000	40,950,000
GRDP Per Person	Php per person	NCR	310,000	310,000	330,000	350,000	370,000
		Philippines	110,000	110,000	120,000	120,000	130,000
GRDP Per Age15+	Php per person	NCR	470,000	480,000	510,000	540,000	560,000
		Philippines	170,000	170,000	180,000	190,000	200,000
GRDP Per Worker	php per person	NCR	750,000	760,000	800,000	860,000	890,000
		Philippines	270,000	270,000	280,000	300,000	310,000

Source: *1 Philippines Statistical Authority, Regional Accounts of the Philippines with JICA Study Team Estimates
*2 Philippines Statistical Authority, Employment Situations in April 2015 (Final Results) with JICA Study Team Estimates

The City of Makati where the Buendia-Maricaban Project is located is a national hub of business whereas the locality of Espana-UST is more of an old Manila downtown enmeshed with higher education institutions. There is no economic measure to account for the differences in magnitude of economic values between the two districts. Therefore, it is simply presumed on a conservative scale to assign 20%[3] more unit value to the Buendia-Maricaban areas' per worker GRDP and NCR average to the Espana-UST areas' per worker GRDP. Furthermore, in converting financial prices to economic prices, the standard conversion factor (SCF) and shadow wage rate are applied to these prices. By assuming away 100% of GRDP are domestic generated and non-traded values, the SCF is applied to the entire GRDPs and the proportion of unskilled labour is assumed at 30%[4] to which the shadow wage rate is applied.

[3] The assumed increase is based on the level of living standards including the rents.
[4] Adopted from Philippine Commission on Women, 2014-05-13

Table 6.2.7 Time Value Pricing

	Unit	Buendia-Maricaban	Espna-UST
Location Adjusted Per Worker GRDP	peso/year/capita	1,068,000	712,000
Economic Price Conversion of Per Worker GRDP	peso/year/capita	892,848	595,232
per day	peso/day/capita	4,464	2,976
per hour	peso/hour/capita	558	372

Source：JICA Survey Team

(2) Increases in GDP

During the decade of 2004 through 2014, the Philippine economy achieved a remarkable progress with annual growth rate of 3.5% per capita and the NCR is estimated to have grown at rates similar to the national trend if not faster. However, the two decades of 1994-2014 shows a slightly lower average of 2.6%[5]. Apart from the rates of growth, it is evident that the unit economic loss caused by floods is bound to increase as the economic growth continues in Philippines. Here it is assumed that the rate of per capita economic growth is 3% for the next 20 years.

(3) Population Growth Rates

The population of the Philippines grew at the rate of 2% per annum for two decades until 2014 to reach 99.4 million[6]. The population census of 2010 shows that the population of Manila Metropolitan Area grew at 2.3 per annum during the period of 1990 through 2000 and at 1.8% per annum during the period of 2000 through 2010.[7] The Mega-Manila Area which includes Bulacan, Rizal, Laguna, and Cavite recorded 4.8% per annum and 3.4% annum growth during the same periods, indicating aggressive urbanization in the surrounding areas of the metropolis. Given the fact that the project areas are located in the dense urban cores of the metropolis, it is highly likely that the population growth will come to an end. However, the population affected by floods are not the residing population but the working population that goes in and out of the areas concerned. Thus the affected population is assumed to grow at the rate of 2% per annum for the next 20 years. The overall economic growth of the areas combining per capita GRDP and population growth combined are assumed to be 5% for the next 20 years.

6.2.5 Economic Benefits from Reduction in Loss of Economic Opportunities

(1) Reduction in Loss of Economic Opportunities

The areas under study are not ordinary residential areas but the core business areas of the National Capital Region. Makati City where Buendia is located hosts international firms/organizations, finance headquarters. Espana-UST is located in the old downtown of Manila City where traditional mixed use of commerce and residence are prominent features in addition to prominent university and other higher education institutions. Once a flood inundates these areas, not only the residents will be forced to move out of the areas for work but also, the incoming commuting workers and business persons will lose access to work, trades and other economic activities. Therefore the economic impacts are quite large even for a short duration of flooding. A flood control project makes it possible to evade such losses of economic opportunities. In order to evaluate the averted economic losses in light of with/without projects, the following formula of economic loss is adopted:

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http://www.pcw.gov.ph/statistics/201405/statistics-filipino-women-and-mens-labor-and-employment

[5] IMF, World Economic Outlook, October 2015: http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx

[6] Same as above

[7] JICA/NEDA ”Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Areas (Summary),”, March 2014

Economic Loss (per day) = Estimated Working Population in Affected Area X GRDP per Worker

The value for GRDP per worker is estimated in Subsection 6.2.6(1).

(2) Affected Workforce

In this economic evaluation, economic disruption cost caused by floods is defined as aforementioned per worker GRDP to the workforce displaced from economic activities. There is no commercial statistics of small geographic areas in Philippines. Moreover, the concerned areas constitute the central business districts of Manila where a large number of workers and business visitors visit. For the purpose of estimating the working population engaged in economic activities including the influx of workforce to the areas, the JICA Study Team has utilized the Origin-Destination Matrix tabulated from comprehensive person trip survey undertaken in Manila[8] In the analysis, a trip is regarded as one person. The tabulation formula is as follows:

Trip Generation Formula:

$\sum_{if\ i \in N} \sum_{j=1}^{all} X_{ij}$, $N: Affected\ Areas,\ X_{ij}$: $Number\ of\ Trips\ from\ Zone\ i\ to\ Zone\ j$,

The total number of zone is 432

Trip Attraction Formula:

$\sum_{if\ i \in N} \sum_{j=1}^{all} X_{ji}$, $N: Affected\ Areas,\ X_{ji}$: $Number\ of\ Trips\ from\ Zone\ j\ to\ Zone\ i$

Using the formula, the ratio of daytime population to night time population was calculated by taking the ratio of the net incoming working population to the residential workforce with the following formula.

$$\text{Day/Night Working Population Ratio} = \frac{\sum_{if\ i \in N}^{all} \sum_{if\ j \notin \square}^{all} X_{ji}}{\sum_{if\ i \in N}^{all} \sum_{j=1}^{all} X_{ij}}$$

The formula is the ratio of all the trips arriving at the flooding zonings from the outside zones to all outgoing trips generated from the flooding zone. The ratio is used as a proxy for the day/night workforce ratio. The ratios for Buendia-Maricaban is 4.7, and the one for Espana-UST is 2.07.

In the first the working population who are inhibited from working are tabulated from the population estimation derived from flooding simulation and duration of immobility estimated from the depths of inundation. Conversion from population to working population is tabulated by the formula as follows:

Working Population = Population x the population ratio of the age above 15 (65%) x labor participation ratio (63%) x day/night working population ratio.

(3) Estimated Loss of Economic Opportunities

One the immobilized working force is estimated, the economic values of lost opportunities are tabulated by applying per worker GRDP to the lost working days. The lost values are estimated as shown in Table 6.2.8. and Table 6.2.9.

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[8] Department of Transport and Communication（DOTC）undertook a comprehensive person-trip interview survey in 2013 by dividing the National Capital Region into 432 zones. Based on the Origin-Destination Matrixes (O-D Matrixes), one of the main outputs of the study, sum up the estimated trips between zones by purpose, the JICA Study Team estimated the estimated number of working population in the affected zones and also the traffics to be affected by floods to derive indirect opportunity costs.

Table 6.2.8 Economic Loss Estimation by Floods (Espana-UST)

Affected Population										Daytime/Night Population Ratio	2.07
										Economic Loss (Peso/Day)	3,720
Affected Population	Depth	Flooding Occurrences									Days
		05yr	05y-w/Project	10yr	10y-w/Project	25yr	25y-w/Project	50yr	50y-w/Project	100yr	100y-w/Project	
Night Population	0.15 - 0.5m	106,672	49,614	145,655	91,971	152,804	138,522	147,508	151,726	126,428	156,350	2.2
	0.5 - 1.0m	3,614	82	7,488	1,988	30,242	6,325	55,430	19,482	89,187	41,864	3.2
	1m – 2m	0	0	0	0	197	0	197	0	750	197	5.2
	2m - 3m	0	0	0	0	0	0	0	0	0	0	8.4
	> 3.0m	0	0	0	0	0	0	0	0	0	0	11.3
Daytime Population	0.15-0.5m	90,422	42,056	123,467	77,961	129,52	117,420	125,037	128,613	107,169	132,533	2.2
	0.5 - 1.0m	3,064	70	6,348	1,685	25,635	5,361	46,986	16,515	75,601	35,486	3.2
	1 - 2.0m	0	0	0	0	167	0	167	0	636	167	5.2
	2m - 3.0m	0	0	0	0	0	0	0	0	0	0	8.4
	>3.0m	0	0	0	0	0	0	0	0	0	0	11.3
Lost Working Days		208,629	92,743	291,728	176,849	367,000	275,301	424,734	335,245	478,459	404,810	
Economic Loss (Peso million)		776	345	1,085	658	1,365	1,024	1,580	1,247	1,780	1,506	

Source: JICA Survey Team

Table 6.2.9 Economic Loss Estimation by Floods (Buendia-Maricaban)

Affected Population										Daytime/Night Population Ratio	4.7
										Economic Loss (Peso/Day)	4,464
Affected Population	Depth	Flooding Occurrences									Days
		05yr	05y-w/Project	10yr	10y-w/Project	25yr	25y-w/Project	50yr	50y-w/Project	100yr	100y-w/Project	
Night Population	0.15 - 0.5m	156,148	106,385	190,590	144,047	204,173	185,891	192,147	200,684	169,887	196,092	2.2
	0.5 - 1.0m	55,471	22,607	91,935	54,010	131,353	115,040	179,575	156,692	221,611	190,940	3.2
	1m – 2m	8,124	4,552	10,863	8,124	20,343	13,641	29,781	21,637	39,050	33,527	5.2
	2m - 3m	0	0	0	0	0	0	0	0	820	0	8.4
	> 3.0m	0	0	0	0	0	0	0	0	0	0	11.3
Daytime Population	0.15-0.5m	300,530	204,754	366,818	277,240	392,961	357,776	369,816	386,247	326,972	377,409	2.2
	0.5 - 1.0m	106,763	43,511	176,943	103,950	252,808	221,411	345,619	301,578	426,523	367,493	3.2
	1 - 2.0m	15,637	8,761	20,907	15,637	39,153	26,254	57,319	41,644	75,157	64,529	5.2
	2m - 3.0m	0	0	0	0	0	0	0	0	1,578	0	8.4
	>3.0m	0	0	0	0	0	0	0	0	0	0	11.3
Lost Working Days			633,506	1,475,337	1,019,894	1,867,365	1,623,885	2,204,203	2,019,902	2,458,306	2,327,426	
Economic Loss (Peso million)			2,828	6,586	4,553	8,336	7,249	9,840	9,017	10,974	10,390	

Source: JICA Survey Team

The differences between "With" and "Without Project" are the economic benefits accruing to the projects. By applying the interval probability, the annual expected values are derived as follows:

Table 6.2.10 Economic Activity Conservation Benefits: Espana-UST

Unit: Million Peso

Return Period	Occurrence Probability	Flood Damage			Average of Damage Reduction	Interval Provability	Annual Average Damage Reduction
		Without Project	With Project	Damage Reduction			
1/3	0.333	0	0	0			
					216	0.133	29
1/5	0.200	776	345	431			
					429	0.100	43
1/10	0.100	1,085	658	427			
					384	0.060	23
1/25	0.040	1,365	1,024	341			
					337	0.020	7
1/50	0.020	1,580	1,247	333			
					304	0.010	3
1/100	0.010	1,780	1,506	274			
					Annual Benefit:		105

Source: JICA Survey Team

Table 6.2.11 Economic Activity Conservation Benefits: Buendia-Maricaban

Unit: Million Peso

Return Period	Occurrence Probability	Flood Damage			Average of Damage Reduction	Interval Provability	Annual Average Damage Reduction
		Without Project	With Project	Damage Reduction			
1/3	0.333	0	0	0			
					997	0.133	133
1/5	0.200	4,821	2,828	1,993			
					2,013	0.100	201
1/10	0.100	6,586	4,553	2,033			
					1,560	0.060	94
1/25	0.040	8,336	7,249	1,087			
					955	0.020	19
1/50	0.020	9,840	9,017	823			
					704	0.010	7
1/100	0.010	10,974	10,390	584			
					Annual Benefit:		454

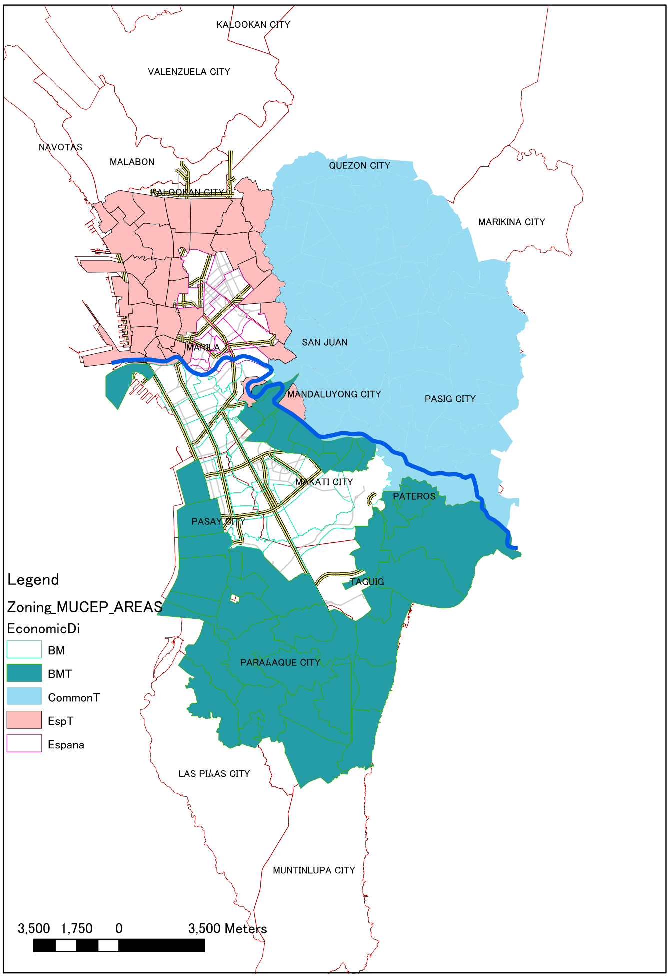
Source: JICA Survey Team

6.2.6 Reduction in Traffic Congestion Costs Caused by Flooding

It is often said that a rain in some part of Manila will spread traffic congestion to the entire gridlock of the city. Definitely flooding will result in traffic congestion. However, the evaluation of projects here are limited to priority projects individually and do not cover the entire city areas. Therefore one project improvement without the concurrent implementation of other projects may not solve the city-wide flood traffic congestion leaving network effects largely in place. Nevertheless, each project will have at least marginal impact to reduce traffic congestion at the time of floods.

When the traffic cannot pass flooded areas, it will bypass the areas and face delays from traffic congestions. Such costs of delay time cost and additional fuel form part of the flood damages and thus reduction of floods, leading to reduction in traffic congestions need to be accounted for as part of economic benefits. However, the accurate traffic congestions and delay time would require urban transport simulation by a model designed for the city of Manila which is beyond the scope of the current study. Therefore, some rough estimation and assumption are employed in efforts to incorporate traffic congestion reduction benefits.

The areas affected by traffic congestion are shown in the following Figure. The dark green areas designated as BMT and the light blue areas designated as “CommonT” are the areas affected by Buendia-Maricaban floods whereas the light red areas designated as “EspT” and the light blue areas are the areas affected by Espana-UST floods. The light blue areas are commonly affected areas. The person trips between the designated impact areas are tabulated by the reducing the original the DOTC OD Matrix into the affected areas. The previously designated inaccessible areas by floods represented by the central areas without colours are excluded from the traffic congestion calculations to avoid double counting of trips.



Source: JICA Survey Team

Figure 6.2.2 Traffic Congestion Areas Caused by Floods

According to the latest urban transport study, there will remain a substantial share of road transport[9]. As the next Table indicates, the road transport occupy 68% with the rest of 32% by the railway under the optimal scenario of the development of public transport. Based on this result, it is assumed here that 70% of daily trips generated will rely on road transport thus be subject to the traffic congestion caused by floods.

Table 6.2.12 Modal Share of Urban Trips in Manila in 2030

	Person-km	Share
Private Car	80,130	24%
Public Road Transport	145,956	44%
Rail	105,025	32%
Total	331,111	100%

Source : JICA/NEDA"ROADMAP FOR TRANSPORT INFRASTRUCTURE DEVELOPMENT FOR METRO MANILA AND ITS SURROUNDING AREAS (REGION III & REGION IV-A), TECHNICAL REPORT NO. 2 TRANSPORT DEMAND ANALYSIS", March 2014

[9] JICA/NEDA "Roadmap for Transport Infrastructure Development for Metro Manila and its Surrounding Areas (Region III & Region IV-A), Technical Report No.2 Transport Demand Analysis", March 2014

Based on the above assumption, the affected trips within the defined affected areas are estimated according to the formula as follows:

Trip Generation and Attraction Formula：

$\sum_{if\ i\in M}\sum_{if\ i\in M}X_{ij}$ ， M: $Affected\ Areas,\ X_{ij}$ ： $Number\ of\ Trips\ from\ Zone\ i\ to\ Zone\ j$

It is assumed that the average delay time of two hours for Buendia-Maricaban areas and four hours for Espana-UST which suffer from the flood twice as long as that of Buendia-Maricaban as the marginal effects by the respective flood[10]. The total delay person-hours are tabulated by applying the delay hours to the affected trips to arrive at approximately 1.6 million hours for Buendia-Maricaban areas and 2.8 million hours for Espana-UST areas. The economic opportunity costs are derived by applying the economic hourly price of per capita GRDP derived above to the delayed hours. In Buendia-Maricaban areas floods could claim congestion costs of 877 million pesos while in US-Espana areas, they could claim 1,052 million pesos. Similarly to the economic income loss, the one-time costs are converted into annualized delay costs by applying the flood probability of 29%. The costs for year 2024 are derived by inflating the base values of 2015 by economic growth and population growth.

Table 6.2.13 Traffic Congestion Benefits

		Unit	Buendia-Maricaban	Espana-UST
Trips Generation in Affected Areas	Work	Trips/Day	888,785	729,294
	Business	Trips/Day	233,310	281,069
	Home	Trips/Day	1,122,095	1,010,363
	Total	Trips/Day	2,244,190	2,020,726
Road Trips Affected by Floods		Trips/Day	1,570,933	1,414,508
Time Delay by Floods		Hour	2	2
Person-hour Loss		Person-hour	3,141,866	2,829,016
Traffic Delay Reduction Benefit		peso million /flood time	1,753	1,315
Annualized Total Disruption Economic Benefits (2015)		peso million /year	514	385
Annualized Total Disruption Economic Benefits (2024)		peso million /year	759	569

Source：JICA Survey Team

6.3 Economic Costs

6.3.1 Shadow Labor Costs

Shadow wage rate of 0.6 to be applied to unskilled labour wages in economic evaluation is adopted according to the recommendation in the guideline published by ICC (Investment Coordination Committee).

[10] Marginal impacts are delays caused by the project in concern only after excluding other factors. Therefore, the current transport bottleneck caused congestions and those caused by other floods need to be subtracted from the expected congestion and subsequent delays to arrive at the project specific congestion impacts. It would require a sophisticated urban transport model to tabulate such marginal impacts.

6.3.2 Standard Conversion Factor

The NEDA-ICC (Investment Coordination Committee) recommends the use of shadow exchange rate of 1.2. However, according to JICA study, the old rate is due for revision and it suggest the use of 0.95 for standard conversion factor[11]. SCF of 0.95 is adopted.

6.3.3 Investment Costs

The economic prices of the direct construction costs are derived by the application of Shadow Wage Rate to unskilled work wages and the application of SCF to non-tradable goods, in this case, only labor costs. As a result, the economic investment costs for Buendia-Maricaban was converted to be 24,335 million peso while that for Espana-UST was 15,078 million peso.

In addition, project implementation incurs administration, consulting service, land acquisition, provisions for price contingency and physical contingency as well as VAT. Economic evaluation is based on actual prices, not nominal prices, therefore the price escalation is excluded. It also excludes transfer costs such as VAT which does not incur actual costs to the economy but simple changes in ownership. After undertaking such processes, the economic cost disbursements and total costs are presented in Table 6.3.1.

[11] JICA, "Study on Standard Conversion Factors for Project Evaluation of Loan Assistance", 2012.

Table 6.3.1 Economic Investment Costs and Disbursement Schedule (Espana-UST)

Work Item	2016	2017	2018	2019	2020	2021	2022	TOTAL
I. Construction cost (Direct cost)	0	1,133	1,250	2,266	5,039	5,273	117	15,078
II.Non-construction Cost	0	0	---	---	---	---	0	---
II.1 Administration Cost	141	113	113	113	113	113	0	707
II.2 Consultancy Services Cost	1,086	326	326	326	326	326	0	2,714
II.3 Land Compensation	74	0	---	---	---	---	0	74
Sub-total II	1,301	439	439	439	439	439	0	3,495
Sub-total for [I] + [II]	1,301	1,572	1,689	2,704	5,478	5,712	117	18,573
Price Escalation Rate	0	0	---	---	---	---	0	---
III.Price Escalation	0	0	---	---	---	---	0	---
IV.Physical Contingency	39	47	51	81	164	171	4	557
Sub-total for [I] + [II] + [III] + [IV]	1,340	1,619	1,739	2,786	5,642	5,883	121	19,130
V.VAT	0	0	---	---	---	---	0	---
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	1,340	1,619	1,739	2,786	5,642	5,883	121	19,130

Source: JICA Survey Team

Table 6.3.2 Economic Investment Costs and Disbursement Schedule (Buendia-Maricaban)

Work Item	2016	2017	2018	2019	2020	2021	2022	2023	TOTAL
I. Construction cost (Direct cost)	0	1,094	1,367	2,031	4,609	5,547	5,937	3,750	24,335
II.Non-construction Cost	0	0	0	0	0	0	0	0	---
II.1 Administration Cost	146	146	146	146	146	146	146	146	1,165
II.2 Consultancy Services Cost	1,752	372	372	372	372	372	372	372	4,358
II.3 Land Compensation	917	0	0	0	0	0	0	0	917
Sub-total II	2,815	518	518	518	518	518	518	518	6,411
Sub-total for [I] + [II]	2,815	1,612	1,885	2,549	5,127	6,065	6,455	4,268	30,776
Price Escalation Rate	0	0	0	0	0	0	0	0	---
III.Price Escalation	0	0	0	0	0	0	0	0	---
IV.Physical Contingency	84	48	57	76	154	182	194	128	923
Sub-total for [I] + [II] + [III] + [IV]	2,899	1,660	1,942	2,626	5,281	6,246	6,649	4,396	31,699
V.VAT	0	0	0	0	0	0	0		---
VI. Project cost ([I] + [II] + [III] + [IV] + [V])	2,899	1,660	1,942	2,626	5,281	6,246	6,649	4,396	31,699

Source: JICA Survey Team

6.3.4 Reinvestment and Residual Value

Reinvestment takes place 25 years after the commissioning to replace electrical and mechanical equipment. The residual value of the project at the end of project evaluation period is set at the remaining years worth of tunnel structure which has another 50 years of life.

6.3.5 O/M Costs

The main expenditure for operation and maintenance costs are incurred on cleaning the tunnels after the incident of rainwater intakes. The cleaning costs for Buendia-Maricaban is estimated to be 7.8 million peso per incident, and the ones for Espana-UST cost 3.9 million peso per incident. After applying the occurrence probability of such intake will lead to annual expected values of OM costs for Buendia-Maricaban at 0.83 million pesos, and for Espana-UST at 0.41 million pesos annually. The OM costs are assumed to be subjected to the cost increases driven by economic growth and consequent income rises of 3% per annum.

6.4 Economic Evaluation

6.4.1 Evaluation Assumptions

The evaluation period starts from the engineering design and tender, followed by construction activities. The economic evaluation period is set at 50 years after the start of operation as a normative evaluation period. The life of each facility is set as shown in the following table. The replacement timing and residual value of the facilities are tabulated accordingly.

Table 6.4.1 Life of Facilities

Facility	Lifespan
Tunnel	100Years
Machinery	25Years
Electric Equipment	25Years

6.4.2 Evaluation Results – Base Case

The original intention was to evaluate the combined projects of 1) the flood control projects currently underway, and 2) the flood tunnels. However, due to the preliminary nature of the current study, there is no definite information on the costs of the current control projects, so that this evaluation is based on the comparison of with the tunnel discharge projects and the without projects under the present situation. Therefore this evaluation excludes the benefits or costs related to 10-year return period flood control. The EIRRs for Buendia-Maricaban and Espana-UST are 14% and 12% respectively.

However, possibility of project cost reduction was indicated with a combination of the pump and the storage pipe as mentioned in 3.5.2, 3.5.3 and 4.4.6. If the cost decreases EIRR will be improved.

Table 6.4.2 Cash Flow Table (Espana-UST)

UST-Espana

Economic Evaluation Cash Flow

Million Pesos

Year	Investment (Peso million)	Operation Cost (Peso million)	Economic Benefit (Peso million)		Operation Net Cash Flow (Peso million)	Total Net Cash Flow (Peso million)	Note
			Direct Benefit	Indirect Benefit			
2016	1,340					(1,340)	Engineerig Start
2017	1,619			0		(1,619)	
2018	1,739			0		(1,739)	Construction Start
2019	2,786			0		(2,786)	
2020	5,642			0		(5,642)	
2021	5,883			0		(5,883)	
2022	121			0	0	(121)	
2023		0.53	1,599	724	2,322	2,322	
2024		0.54	1,679	761	2,439	2,439	Operation Start
2025		0.57	1,762	799	2,561	2,561	
2026		0.60	1,851	839	2,689	2,689	
2027		0.63	1,943	880	2,823	2,823	
2028		0.66	2,040	925	2,964	2,964	
2029		0.69	2,142	971	3,112	3,112	
2030		0.72	2,249	1,019	3,268	3,268	
2031		0.76	2,362	1,070	3,431	3,431	
2032		0.80	2,480	1,124	3,603	3,603	
2033		0.84	2,604	1,180	3,783	3,783	
2034		0.88	2,734	1,239	3,972	3,972	
2035		0.92	2,871	1,301	4,171	4,171	
2036		0.92	2,871	1,301	4,171	4,171	
2037		0.92	2,871	1,301	4,171	4,171	
2038		0.92	2,871	1,301	4,171	4,171	
2039		0.92	2,871	1,301	4,171	4,171	
2040		0.92	2,871	1,301	4,171	4,171	
2041		0.92	2,871	1,301	4,171	4,171	
2042		0.92	2,871	1,301	4,171	4,171	
2043		0.92	2,871	1,301	4,171	4,171	
2044		0.92	2,871	1,301	4,171	4,171	
2045		0.92	2,871	1,301	4,171	4,171	
2046		0.92	2,871	1,301	4,171	4,171	
2047	5,571	0.92	2,871	1,301	4,171	(1,400)	
2048		0.92	2,871	1,301	4,171	4,171	
2049		0.92	2,871	1,301	4,171	4,171	
2050		0.92	2,871	1,301	4,171	4,171	
2051		0.92	2,871	1,301	4,171	4,171	
2052		0.92	2,871	1,301	4,171	4,171	
2053		0.92	2,871	1,301	4,171	4,171	
2054		0.92	2,871	1,301	4,171	4,171	
2055		0.92	2,871	1,301	4,171	4,171	
2056		0.92	2,871	1,301	4,171	4,171	
2057		0.92	2,871	1,301	4,171	4,171	
2058		0.92	2,871	1,301	4,171	4,171	
2059		0.92	2,871	1,301	4,171	4,171	
2060		0.92	2,871	1,301	4,171	4,171	
2061		0.92	2,871	1,301	4,171	4,171	
2062		0.92	2,871	1,301	4,171	4,171	
2063		0.92	2,871	1,301	4,171	4,171	
2064		0.92	2,871	1,301	4,171	4,171	
2065		0.92	2,871	1,301	4,171	4,171	
2066		0.92	2,871	1,301	4,171	4,171	
2067		0.92	2,871	1,301	4,171	4,171	
2068		0.92	2,871	1,301	4,171	4,171	
2069		0.92	2,871	1,301	4,171	4,171	
2070		0.92	2,871	1,301	4,171	4,171	
2071		0.92	2,871	1,301	4,171	4,171	
2072	(4,700)	0.92	2,871	1,301	4,171	8,871	
Total	20,001	43		60,964	195,459	175,458	
NPV(@10%)	13,257	7	22,580	5,776	29,822	3,939	

EIRR =	12.1%

Source: JICA Survey Team

Table 6.4.3 Cash Flow Table (Espana-UST)

Buendia/Maricaban

Economic Evaluation Cash Flow

Million Pesos

Year	Investment (Peso million)	Operation Cost (Peso million)	Economic Benefit (Peso million)		Operation Net Cash Flow (Peso million)	Total Net Cash Flow (Peso million)	Note
			Direct Benefit	Indirect Benefit			
2016	2,899					(2,899)	Engineering Start
2017	1,660					(1,660)	
2018	1,942					(1,942)	Construction Start
2019	2,626					(2,626)	
2020	5,281					(5,281)	
2021	6,246					(6,246)	
2022	6,649				0	(6,649)	
2023	4,396				0	(4,396)	
2024		1.08	3,495	1,501	4,995	4,995	Operation Start
2025		1.08	3,670	1,673	5,342	5,342	Operation Start
2026		1.13	3,853	1,757	5,609	5,609	
2027		1.19	4,046	1,845	5,890	5,890	
2028		1.25	4,248	1,937	6,184	6,184	
2029		1.31	4,461	2,034	6,493	6,493	
2030		1.38	4,684	2,136	6,818	6,818	
2031		1.45	4,918	2,242	7,159	7,159	
2032		1.52	5,164	2,354	7,517	7,517	
2033		1.60	5,422	2,472	7,893	7,893	
2034		1.68	5,693	2,596	8,287	8,287	
2035		1.76	5,978	2,726	8,702	8,702	
2036		1.76	5,978	2,726	8,702	8,702	
2037		1.76	5,978	2,726	8,702	8,702	
2038		1.76	5,978	2,726	8,702	8,702	
2039		1.76	5,978	2,726	8,702	8,702	
2040		1.76	5,978	2,726	8,702	8,702	
2041		1.76	5,978	2,726	8,702	8,702	
2042		1.76	5,978	2,726	8,702	8,702	
2043		1.76	5,978	2,726	8,702	8,702	
2044		1.76	5,978	2,726	8,702	8,702	
2045		1.76	5,978	2,726	8,702	8,702	
2046		1.76	5,978	2,726	8,702	8,702	
2047		1.76	5,978	2,726	8,702	8,702	
2048	10,544	1.76	5,978	2,726	8,702	(1,842)	
2049		1.76	5,978	2,726	8,702	8,702	
2050		1.76	5,978	2,726	8,702	8,702	
2051		1.76	5,978	2,726	8,702	8,702	
2052		1.76	5,978	2,726	8,702	8,702	
2053		1.76	5,978	2,726	8,702	8,702	
2054		1.76	5,978	2,726	8,702	8,702	
2055		1.76	5,978	2,726	8,702	8,702	
2056		1.76	5,978	2,726	8,702	8,702	
2057		1.76	5,978	2,726	8,702	8,702	
2058		1.76	5,978	2,726	8,702	8,702	
2059		1.76	5,978	2,726	8,702	8,702	
2060		1.76	5,978	2,726	8,702	8,702	
2061		1.76	5,978	2,726	8,702	8,702	
2062		1.76	5,978	2,726	8,702	8,702	
2063		1.76	5,978	2,726	8,702	8,702	
2064		1.76	5,978	2,726	8,702	8,702	
2065		1.76	5,978	2,726	8,702	8,702	
2066		1.76	5,978	2,726	8,702	8,702	
2067		1.76	5,978	2,726	8,702	8,702	
2068		1.76	5,978	2,726	8,702	8,702	
2069		1.76	5,978	2,726	8,702	8,702	
2070		1.76	5,978	2,726	8,702	8,702	
2071		1.76	5,978	2,726	8,702	8,702	
2072		1.76	5,978	2,726	8,702	8,702	
2073	(9,300)	1.76	5,978	2,726	8,702	18,002	
Total	32,943	83		128,847	411,556	378,613	
NPV(@10%)	20,414	14	48,442	22,003	58,207	12,912	

EIRR =	14.2%

Source: JICA Survey Team

6.4.3 Sensitivity Analysis

In terms of sensitivity analyses for the projects, there are two alternative scenarios of 20% investment cost escalation and 20% reduction as well as two scenarios of 50% increase in economic benefits and 50% reduction in addition to base case scenario. A total of nine cases are assumed and evaluated with the results in the following tables.

Table 6.4.4 Sensitivity Analysis

Espana-UST

	Benefit +50%	Base Case	Benefit -50%
Investment Cost +20%	14%	11%	6%
Base Case	16%	12%	7%
Investment Cost -20%	18%	14%	9%

Buendia/Maricaban

	Benefit +50%	Base Case	Benefit -50%
Investment Cost +20%	16%	13%	7%
Base Case	18%	14%	9%
Investment Cost -20%	21%	16%	10%

Source：JICA Survey Team

6.5 Alternative Scenario

Proposed Scenario: Improved Land Used Due to Flood Control

The scenario addresses the case in which there will be vigorous real estate development for high rise buildings with higher value added economic activities. The scenario assumes a case where the proposed flood control will promote such more intense land uses. However, it requires further examination on the likelihood since there are numerous location specific socio-economic factors other than flooding that determine land use changes such as transport accessibility. Land use changes will result in the development of high-rise housings and shopping malls which bring higher values to the land. At present, the property market in central Manila is reported to be growing at the rate of 6% per year. For this scenario it is assumed that the flood control projects will bring annual 3% increases to the land in the flooding areas for 10 years after the operation of the projects.

First, the flooding areas the areas freed from flooding owing to the projects are tabulated by taking the difference of inundation areas of with and without projects. Three percent (3%) increment of the land values for the 50-year return period flooding areas are tabulated as shown in Table 6.5.1.

Table 6.5.1 Incremental Value of Land

Espana-UST

Area(km2)	Inundation Areas			Price of Land (peso/m2)	Marginal Annual Incremental Value3%	Total Increases million pesos
	Without	With	Benefit			
25-yr	3.35	2.08	1.27	50,000	1,500	1,905
50-yr	4.09	3.09	1	50,000	1,500	1,500
100-yr	4.57	3.82	0.75	50,000	1,500	1,125

Buendia Maricaban

Area(km2)	Inundation Areas			Price of Land (peso/m2)	Marginal Annual Incremental Value3%	Total Increases million pesos
	Without	With	Benefit			
25-yr	5.63	4.17	1.46	140,000	4,200	6,132
50-yr	6.65	5.61	1.04	140,000	4,200	4,368
100-yr	7.97	7.09	0.88	140,000	4,200	3,696

Source: JICA Survey Team

The cash flow tables are generated as shown in Table 6.5.2 and 6.5.3 with the EIRR of Buendia-Maricaban at 19% and that of Espana-UST at 15%.

Table 6.5.2 Cash Flow Table of Alternative Scenario (Espana-UST)

UST-Espana

Economic Evaluation Cash Flow

Million Pesos

Year	Investment (Peso million)	Operation Cost (Peso million)	Economic Benefit (Peso million)			Operation Net Cash Flow (Peso million)	Total Net Cash Flow (Peso million)	Note
			Direct Benefit	Indirect Benefit	Land Value Increase			
2016	1,340						(1,340)	Engineerig Start
2017	1,619			0			(1,619)	
2018	1,739			0			(1,739)	Construction Start
2019	2,786			0			(2,786)	
2020	5,642			0			(5,642)	
2021	5,883			0			(5,883)	
2022	121			0		0	(121)	
2023		0.53	1,599	724	1,500	3,822	3,822	
2024		0.54	1,679	761	1,500	3,939	3,939	Operation Start
2025		0.57	1,762	799	1,500	4,061	4,061	
2026		0.60	1,851	839	1,500	4,189	4,189	
2027		0.63	1,943	880	1,500	4,323	4,323	
2028		0.66	2,040	925	1,500	4,464	4,464	
2029		0.69	2,142	971	1,500	4,612	4,612	
2030		0.72	2,249	1,019	1,500	4,768	4,768	
2031		0.76	2,362	1,070	1,500	4,931	4,931	
2032		0.80	2,480	1,124	1,500	5,103	5,103	
2033		0.84	2,604	1,180		3,783	3,783	
2034		0.88	2,734	1,239		3,972	3,972	
2035		0.92	2,871	1,301		4,171	4,171	
2036		0.92	2,871	1,301		4,171	4,171	
2037		0.92	2,871	1,301		4,171	4,171	
2038		0.92	2,871	1,301		4,171	4,171	
2039		0.92	2,871	1,301		4,171	4,171	
2040		0.92	2,871	1,301		4,171	4,171	
2041		0.92	2,871	1,301		4,171	4,171	
2042		0.92	2,871	1,301		4,171	4,171	
2043		0.92	2,871	1,301		4,171	4,171	
2044		0.92	2,871	1,301		4,171	4,171	
2045		0.92	2,871	1,301		4,171	4,171	
2046		0.92	2,871	1,301		4,171	4,171	
2047	5,571	0.92	2,871	1,301		4,171	(1,400)	
2048		0.92	2,871	1,301		4,171	4,171	
2049		0.92	2,871	1,301		4,171	4,171	
2050		0.92	2,871	1,301		4,171	4,171	
2051		0.92	2,871	1,301		4,171	4,171	
2052		0.92	2,871	1,301		4,171	4,171	
2053		0.92	2,871	1,301		4,171	4,171	
2054		0.92	2,871	1,301		4,171	4,171	
2055		0.92	2,871	1,301		4,171	4,171	
2056		0.92	2,871	1,301		4,171	4,171	
2057		0.92	2,871	1,301		4,171	4,171	
2058		0.92	2,871	1,301		4,171	4,171	
2059		0.92	2,871	1,301		4,171	4,171	
2060		0.92	2,871	1,301		4,171	4,171	
2061		0.92	2,871	1,301		4,171	4,171	
2062		0.92	2,871	1,301		4,171	4,171	
2063		0.92	2,871	1,301		4,171	4,171	
2064		0.92	2,871	1,301		4,171	4,171	
2065		0.92	2,871	1,301		4,171	4,171	
2066		0.92	2,871	1,301		4,171	4,171	
2067		0.92	2,871	1,301		4,171	4,171	
2068		0.92	2,871	1,301		4,171	4,171	
2069		0.92	2,871	1,301		4,171	4,171	
2070		0.92	2,871	1,301		4,171	4,171	
2071		0.92	2,871	1,301		4,171	4,171	
2072	(4,700)	0.92	2,871	1,301		4,171	8,871	
Total	20,001	43		60,964		210,459	190,458	
NPV(@10%)	13,257	7	22,580	5,776		38,201	8,669	

EIRR =	15.0%

Source: JICA Survey Team

Table 6.5.3 Cash Flow Table of Alternative Scenario (Buendia-Maricaban)

Buendia/Maricaban

Economic Evaluation Cash Flow

Million Pesos

Year	Investment (Peso million)	Operation Cost (Peso million)	Economic Benefit (Peso million)			Operation Net Cash Flow (Peso million)	Total Net Cash Flow (Peso million)	Note
			Direct Benefit	Indirect Benefit	Land Value Increase			
2016	2,899						(2,899)	Engineering Start
2017	1,660						(1,660)	
2018	1,942						(1,942)	Construction Start
2019	2,626						(2,626)	
2020	5,281						(5,281)	
2021	6,246						(6,246)	
2022	6,649					0	(6,649)	
2023	4,396					0	(4,396)	
2024		1.08	3,495	1,501	4,368	9,363	9,363	Operation Start
2025		1.08	3,670	1,673	4,368	9,710	9,710	
2026		1.13	3,853	1,757	4,368	9,977	9,977	
2027		1.19	4,046	1,845	4,368	10,258	10,258	
2028		1.25	4,248	1,937	4,368	10,552	10,552	
2029		1.31	4,461	2,034	4,368	10,861	10,861	
2030		1.38	4,684	2,136	4,368	11,186	11,186	
2031		1.45	4,918	2,242	4,368	11,527	11,527	
2032		1.52	5,164	2,354	4,368	11,885	11,885	
2033		1.60	5,422	2,472	4,368	12,261	12,261	
2034		1.68	5,693	2,596		8,287	8,287	
2035		1.76	5,978	2,726		8,702	8,702	
2036		1.76	5,978	2,726		8,702	8,702	
2037		1.76	5,978	2,726		8,702	8,702	
2038		1.76	5,978	2,726		8,702	8,702	
2039		1.76	5,978	2,726		8,702	8,702	
2040		1.76	5,978	2,726		8,702	8,702	
2041		1.76	5,978	2,726		8,702	8,702	
2042		1.76	5,978	2,726		8,702	8,702	
2043		1.76	5,978	2,726		8,702	8,702	
2044		1.76	5,978	2,726		8,702	8,702	
2045		1.76	5,978	2,726		8,702	8,702	
2046		1.76	5,978	2,726		8,702	8,702	
2047		1.76	5,978	2,726		8,702	8,702	
2048	10,544	1.76	5,978	2,726		8,702	(1,842)	
2049		1.76	5,978	2,726		8,702	8,702	
2050		1.76	5,978	2,726		8,702	8,702	
2051		1.76	5,978	2,726		8,702	8,702	
2052		1.76	5,978	2,726		8,702	8,702	
2053		1.76	5,978	2,726		8,702	8,702	
2054		1.76	5,978	2,726		8,702	8,702	
2055		1.76	5,978	2,726		8,702	8,702	
2056		1.76	5,978	2,726		8,702	8,702	
2057		1.76	5,978	2,726		8,702	8,702	
2058		1.76	5,978	2,726		8,702	8,702	
2059		1.76	5,978	2,726		8,702	8,702	
2060		1.76	5,978	2,726		8,702	8,702	
2061		1.76	5,978	2,726		8,702	8,702	
2062		1.76	5,978	2,726		8,702	8,702	
2063		1.76	5,978	2,726		8,702	8,702	
2064		1.76	5,978	2,726		8,702	8,702	
2065		1.76	5,978	2,726		8,702	8,702	
2066		1.76	5,978	2,726		8,702	8,702	
2067		1.76	5,978	2,726		8,702	8,702	
2068		1.76	5,978	2,726		8,702	8,702	
2069		1.76	5,978	2,726		8,702	8,702	
2070		1.76	5,978	2,726		8,702	8,702	
2071		1.76	5,978	2,726		8,702	8,702	
2072		1.76	5,978	2,726		8,702	8,702	
2073	(9,300)	1.76	5,978	2,726		8,702	18,002	
Total	32,943	83		128,847		455,236	422,293	
NPV(@10%)	20,414	14	48,442	22,003		80,388	25,432	

EIRR =	18.6%

Source: JICA Survey Team

6.6 Conclusion

The preliminary nature of this study undertaken on a very short period did not permit the confirmation of costs or benefits accruing to the current on-going projects or drainage networks. The limitation of time availability severely restricted the determination of the scopes of the projects concerned.

As a challenge to the next survey, it is summarized below.

- The analysis has achieved to estimate the size of affected working population using the data made available from the available comprehensive person trip survey. However, flooding in urban areas cause severe traffic problems, so that the quantitative impacts are limited to rough assumptions. In order to scientifically estimate the impacts, linkages with an urban transport model is much desired in a detailed study to follow.
- Evaluation parameters should be reviewed cautiously including the future rapid development and the adaptation of climate change in order to determine its applicability to the project.

CHAPTER 7. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

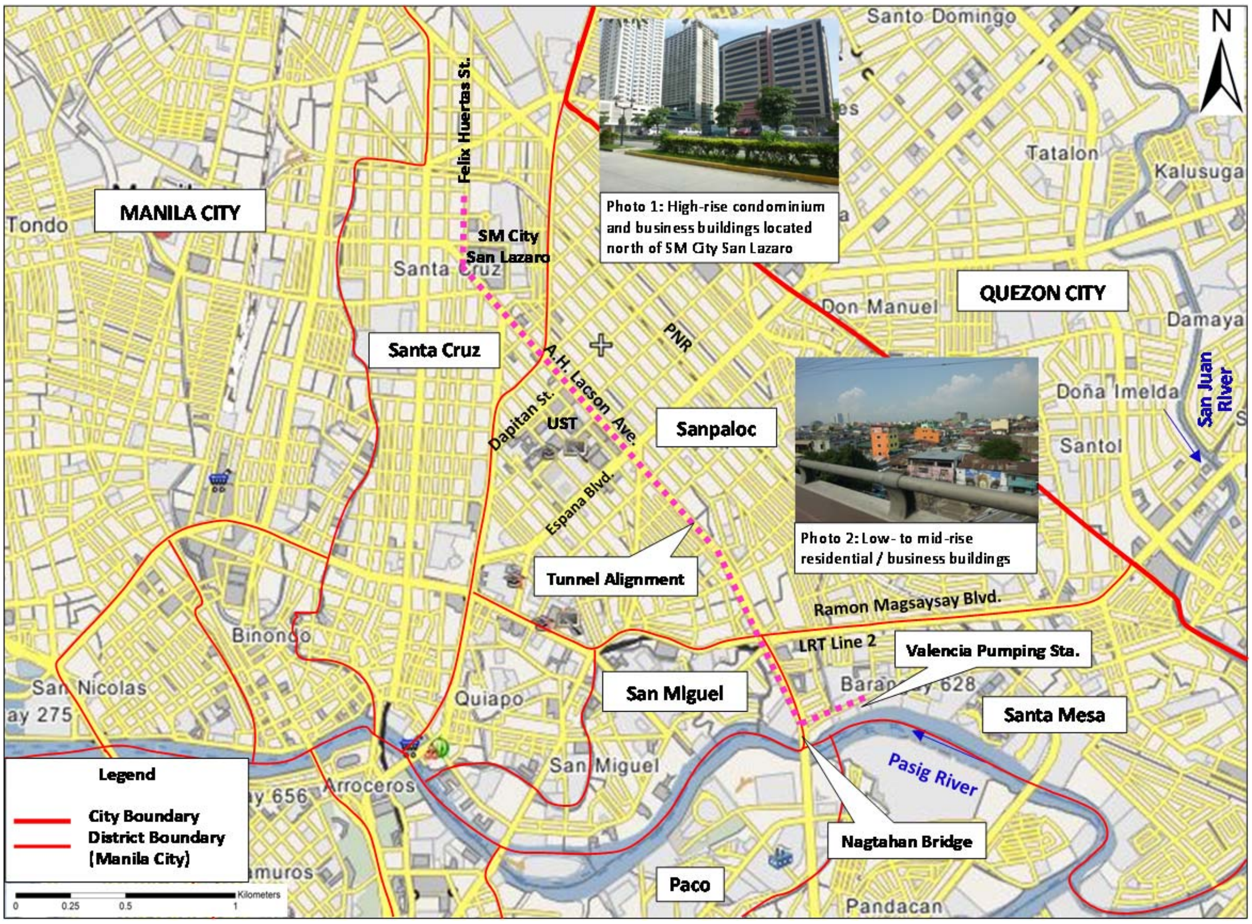
7.1 Environmental Settings in the Project Areas of the Proposed Drainage System

7.1.1 España-UST Area

The proposed underground storage facility in the Espana-UST Area is located in the northern area of Manila City. The alignment of the facility is proposed to depart from Felix Huertas Street, north of SM City San Lazaro, through A. H. Lacson Avenue and Aceite Street, until the next land lot of Valencia Pumping Station. Environmental settings including natural and social elements are as described below:

(1) Administrative Jurisdiction, Demography and Land Use

Manila City is composed of 17 administrative districts, and the proposed underground storage facility is to be located in four districts: Sta. Cruz, Sampaloc, San Miguel and Sta. Mesa from north to south. (Figure 7.1.1)



Source: JICA Study Team

Figure 7.1.1 Project Site and Surrounding Area (España-UST Area)

Table 7.1.1 shows the 2010 demographic profiles of the project area, NCR and the whole country. It reveals that Sampaloc, located east of the proposed alignment of the project facility, ranks first in population and population density.

Table 7.1.1 Population in the Project Area, NCR and the Philippines (España-UST Area)

No. / Area		Nos. of Barangays	Population (2010)	Area (ha / km2)	Population Density (/km2)
Project area	Sta. Cruz	82	115,747	309.01 ha	37,457
	Sampaloc	192	341,461	513.71 ha	66,470
	San Miguel	12	15,992	91.37 ha	17,502
	Sta. Mesa	51	99,933	261.01 ha	38,287
Manila City		896	1,652,171	38.55 km2	42,858
NCR		-	11,855,975	619.54 km2	19,137
Philippines		-	92,337,852	300,000 km2	308

Source: National Statistics Office (NSO)

Current land use along the project facility consists of the complex of business, commercial and residential use (refer to photos in Figure 7.1.1). As for the city's land use plan, Official Zoning Map (City Planning and Development Office, Manila City, 2006) stipulates High Intensity Commercial/ Mixed Use Zone at the north (until UST) of the proposed alignment of the project facility, and High Density Residential/ Mixed Use Zone at southern area (until Ramon Magsaysay Blvd.). Further in the southern area (Nagtahan Bridge), it stipulates the mixture of High & Medium Intensity Commercial/ Mixed Use Zones and University Cluster Zone.

(2) Structures and Facilities

Main facilities along the underground storage facility are SM City San Lazaro (shopping mall), Caritas FCI Hospital and Colleges, Complex of University of Santo Tomas, MMDA Valencia Pumping Station, GSIS Metrohomes, Polytechnic University of the Philippines (PUP), etc. Main roads that intersect with A. H. Lacson Ave. include Dapitan St., España Blvd. (Quezon Ave.), Ramon Magsaysay Blvd. In addition, the Philippine National Railway (PNR) runs north east the Lacson Ave. and LRT (Light Rail Transit) Line 2 crosses Lacson Ave. through a flyover (bridge) (Figure 7.1.1).

The main underground structures along the proposed project facility include the foundations España Flyover (under planning), Nagtahan Flyover, Ramon Magsaysay Flyover, LRT Line 2 and Nagtahan Bridge, and it was confirmed that the foundation of España Flyover is approx. 25 m deep from the ground level.

(3) Environmental Pollution and Contamination

As for air quality, total suspended particles (TSP) monitored by DENR-EMB indicate that TSP values in Metro Manila are beyond the environmental standard in most of the monitored stations. The data at the nearest monitoring station from the project site, which is located at Rizal Ave., Manila City, (approx. 300m west of Laczon Ave.) shows 101～138μg/ NCM during these ten years from 2004 to 2013, exceeding the standard value of 90 μg/NCM.

Regarding ambient noise, no data is available monitored and disclosed by the government agency. The noise level data obtained in Pasig-Marikina River Channel Improvement Project (PMRCIP) show that the noise level in residential area along the rivers is beyond the standard value at most of the monitoring locations. It is, therefore, anticipated to be the same level or worse along Lacson Ave. considering the traffic situation threat.

With regard to river water quality, Pasig River, which will be a recipient river of the stored flood water in the project facility, is classified as Class C (Fresh Surface Waters/ Recreational Water Class II) by DAO No.1990-34. Water quality of representative parameters monitored at the Nagtahan Bridge by the Pasig River Rehabilitation Commission (PRRC) shows that there are many monitored data which do not satisfy the environmental standards, such as coliform, DO and BOD. The cause for it can be attributed to the wastewater discharge from nearby residential areas and business districts along the river without any treatment.

(4) Natural Environment

There is no large area vegetation along the proposed facility since the project site is located in densely populated area. Instead, there is only limited woods and grasslands exist, such as an open space covered by grasses east of the candidate site of departing vertical shaft, street trees along Lacson Ave. those in the University of Santo Tomas area, etc.

Protected areas in the Philippines are designated in Republic Act No, 7586 (1992), titled the National Integrated Protected Areas System (NIPAS) Act. With regard to the project area, no protected area is located along the proposed facility or in the whole area of Manila City.

(5) Groundwater Use

Groundwater use in Metro Manila is managed by the National Water Resources Board (NWRB) in a centralized manner. The NWRB issues water permits for groundwater use imposing the users to pay a fee. The number of water permits for groundwater use issued in Manila City is 27 as of October 2015, and 26 ones of which are for deep wells (Table 7.1.2). In this regard, shallow wells, which are targeted for shallow groundwater, are not required for obtaining a water permit. According to NWRB, no new water permit is issued at present in Metro Manila in accordance with NWRB Resolution No.001-0904 and No. 020-1209. In this regard, NWRB Resolution No.001-0904 stipulates the conditions for water permits in the critical areas in Metro Manila, and No. 020-1209 prohibit acceptance of water permit applications in the specified areas in order to prevent further degradation of groundwater resources.

In the case that the existing groundwater well is located near the project area, there would be a possibility of impact on the well due to tunnelling. Thus, it is necessary to gather the details about the well (location, depth, volume of groundwater extraction, etc.) to evaluate the possibility of impact.

Table 7.1.2 Number of Issued Water Permits in the Concerned Cities

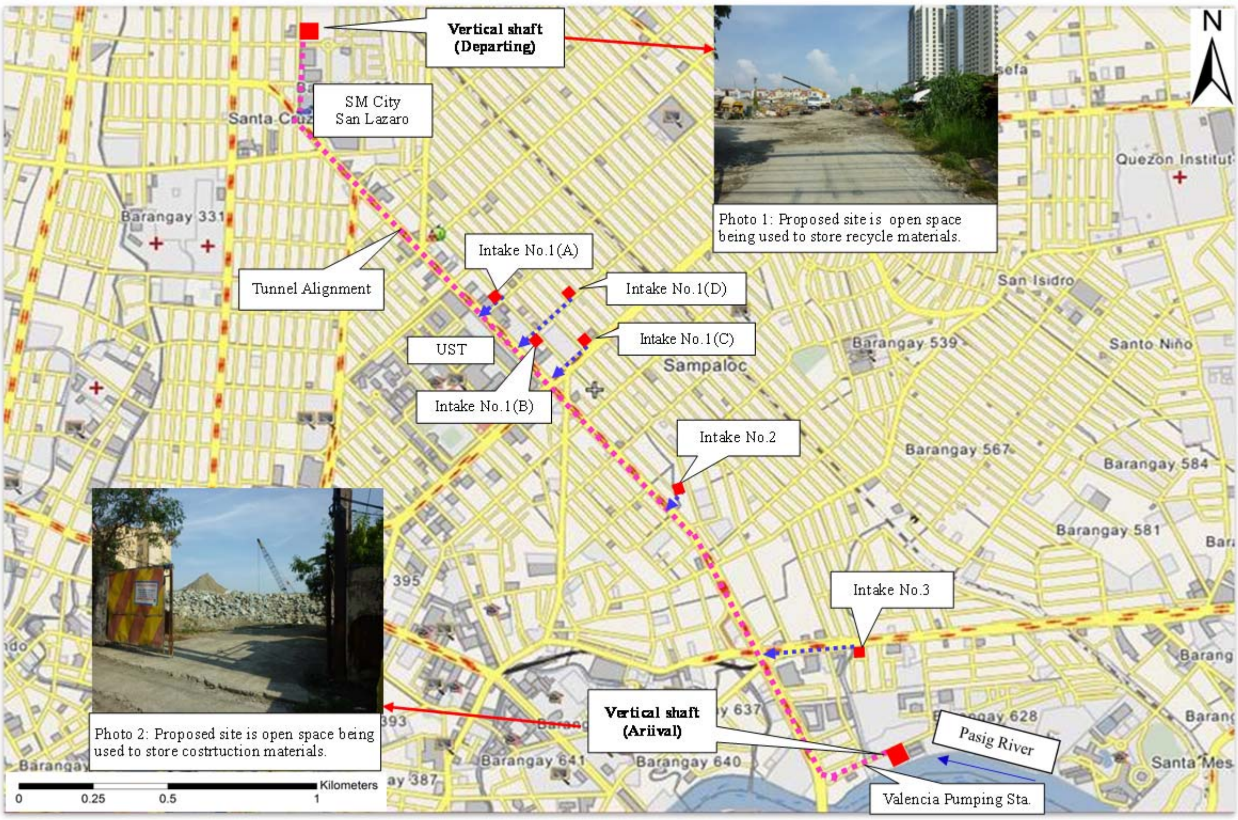
Area (City)	No. of Issued Water Permits by NWRB		
	Deep Well	Others	Total
Manila City	26	1	27
Makati City	104	0	104
Pasay City	11	0	11
Taguig City	63	3	66

Source：National Water Resources Board (NWRB), Oct. 2015

(6) Current Status of Proposed Sites for Vertical Shafts and Flood Water Intakes

The proposed site for departing vertical shaft which is located at north of SM City San Lazaro (Figure 7.1.2) is a private land (Table 7.1.3), being utilized as a stockyard of recycling materials at present (Photo 1). Medium to high-rise residential buildings are located in the surrounding area. The proposed site for arrival shaft, on the other hand, is located in a land lot of Government Service Insurance System (GSIS) (Table 7.1.3) located east of Valencia Pumping Station (Figure 7.1.2). The lot is being used as a stockyard of construction materials for Pasig-Marikina River Channel Improvement Project (Photo 2). There are residential buildings owned by GSIS and Polytechnic University of the Philippines (PUP) in the surrounding area.

Floodwater intakes are proposed to be constructed at three locations in the project. Locations and current land use, etc. of the intakes are shown in Figure 7.1.2 and Table 7.1.3, respectively. In this regard, there are four candidate sites for intake No.1. All the proposed sites of intakes, including intake No.2 and 3 are located in private lots.



Source: JICA Study Team

Figure 7.1.2 Location Map of Candidate Sites for Project Facilities (España-UST Area)

Table 7.1.3 Land Status of Candidate Sites for Project Facilities (España-UST Area)

Site/ Facility	Current Land Status	Landowner (Government/Private)	Street (Manila City)
Departing Shaft	Open space	Private (company)	F. Huertas St.
Arrival shaft/ Pumping Station	Open space	Government (GSIS)	Aceite St.
Intake No.1 (A), (B), (C), (D)	A: Open space, B: Parking lot, C: Garden D: Cinema (unused)	A: Private (company), B: Private (company), C: Private, D: Private	A: Dos Castillas St. B: Dos Castillas St., C: España Ave., D: Florentino St.
Intake No.2	Residential area (partly open space)	Private	Brgy. 432, Manila,
Intake No. 3	Open space	Private (company)	Ramon Magsaysay Blvd.

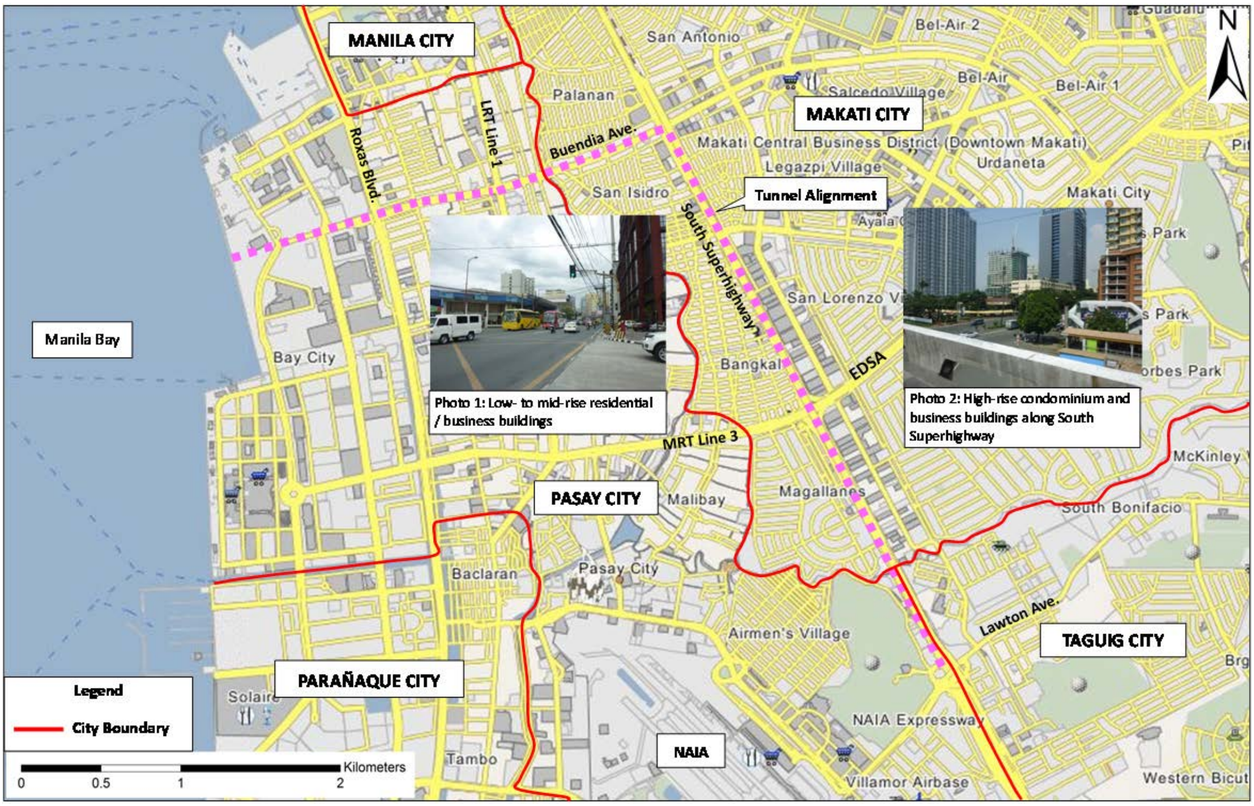
Source: JICA Study Team

7.1.2 Buendia-Maricaban Area

The proposed underground storage facility is located in the cities of Pasay, Makati and Taguig (Figure 7.1.3). The facility is proposed to depart from the site near seashore of Manila Bay, through Bundia Ave. and South Superhighway, until Nichols Interchange. Environmental settings including natural and social elements are described as follows:

(1) Administrative Jurisdiction, Demography and Land Use

The underground storage facility is located in or bounded by eight barangays in the area of Makati City. In Taguig City, it is bounded by two barangays at the east end of the facility. In Pasay City, it goes through the northern part of the city, going out of the city and enters Makati City, and again enters Pasay City at the east end of the facility.



Source: JICA Study Team

Figure 7.1.3 Project Site and Surrounding Area (Buendia-Maricaban Area)

Table 7.1.4 shows 2010 demographic profiles of the project area, NCR and the whole country. It reveals that Makati City, located in the center of the proposed project site, shows the maximum population density of approx. 26,600 (/km^2).

Table 7.1.4 Population in Project Area, NCR and the Philippines (Buendia-Maricaban Area)

Area		Population (2010)	Area (km^2)	Population Density (/km^2)
Project area	San Antonio	11,443	0.89	12,900
	Palanan	17,283	0.65	26,600
	San Ishidro	7,589	0.50	15,200
	Pio Del Pilar	27,035	1.20	22,500
	San Lorenzo	10,006	2.09	4,790
	Dasmariñas	5,654	1.90	2,980
	Magallanes	5,576	1.20	4,650
Makati City		529,039	21.57 km2	24,500
Project area	Fort Bonifacio	23,144	-	-
	Western Bicutan	72,926	-	-
Taguig City		644,473	45.21	14,255
Pasay City		392,869	13.97	28,122
NCR		11,855,975	619.54 km2	19,137
Philippines		92,337,852	300,000 km2	308

Source: National Statistics Office (NSO)

Current land use along the underground storage facility consists of low- to mid-rise buildings of the complex of business, commercial and residential use along Buendia Ave. while it consists of high-rise buildings of residential and business use along South Superhighway (Figure 7.1.3). With regard to the city's land use plan, the Official Zoning Map (Makati City, 2013) stipulates Medium & High Density Commercial Use along South Superhighway and Buendia Ave. partly including Medium Density Residential/ Mixed Use. In Taguig City, the Official Zoning Map (2000-2020) stipulates Institutional Zone along South Superhighway. In Passay City, Commercial Use along Buendia Ave. and Planned Unit Development (complex facilities under planning) at west parts (Manila Bay side) from Roxas Blvd. are stipulated in the city's Zoning Ordinance (2003).

(2) Structures and Facilities

Main facilities along the underground storage facility in Makati City include business ones such as Federal Hardware, Coca-Cola, Universal Motors Co. along South Superhighway as well as commercial ones such as SM Hypermarket, and Cash & Carry at the west of South Superhighway. In Taguig City, there are facilities of Armed Forces of the Philippines (AFP) and in Pasay City, there are the Villlamor Golf Course, Manilad Water Supply Service (MWSS), Philippine State College of Aeronautics, Philippine Trade Center, and Amazing Phil. Theater along Buendia Ave.

The main underground structures along the proposed project facility include the foundations of Roxas Boulevard Flyover, LRT Line 1, South Superhighway Flyover (at Buendia Ave.), MRT Line 3, and Metro Manila Skyway, and it was confirmed that the foundation of LRT Line 1 is approx. 24 m deep from the ground level.

(3) Environmental Pollution and Contamination

As for air quality, total suspended particles (TSP) monitored by DENR-EMB indicate that TSP values in Metro Manila are beyond the environmental standard in most of the monitored stations. The data at the nearest monitoring station from the project site, which is located in Makati City (approx. 1.0km east of South Superhighway) shows 128～211μg/ NCM during these ten years from 2004 to 2013, much exceeding the standard value of 90 μg/NCM.

Regarding ambient noise, the noise level data obtained in the Pasig-Marikina River Channel Improvement Project (PMRCIP) show that the noise level in residential area along the rivers is beyond the standard values at most of the monitoring locations. It is anticipated to be the same level or worse along South Superhighway considering the traffic situation of the highway.

With regard to river water quality, there is no available data of cestero/reeks in the project area. According to ocular inspection on site, it is easily estimated that the river water quality is substantially polluted. Manila Bay, which will be a recipient water body of the stored flood water in the project facility, is classified as Class SB (Coastal and Marine Waters/ Recreational Water Class I) by DAO No.1990-34. It is said, however, that the water quality of Manila Bay has deteriorated. The survey results of DENR-EMB (2013) reveal that among the data monitored at 19 locations in the Manila Bay, only three locations (16%) and one location (5%) were satisfied with environmental standards for total and fecal coliform counts, respectively. As for DO, only 11 locations (58%) satisfied the standard.

(4) Natural Environment

Since there are some open spaces along the proposed locations of the project facility, there is vegetation in clusters. They are distributed in Villamor Golf Course and in AFP grounds. There is also grassland vegetation in open spaces near Manila Bay. The vegetation, however, is not in natural condition but affected by human activities. Protected area, which is designated in the Republic Act No, 7586 (1992), does not exist in the cities of Makati, Pasay or Taguig.

(5) Groundwater Use

As mentioned earlier, groundwater use in Metro Manila is managed by the National Water Resources Board (NWRB) in a centralized manner. The number of deep wells with a water permit for groundwater use is 104, 11 and 63 are in the cities of Makati, Pasay and Taguig, respectively (Table 7.1.2). No new water permit is issued at present in Metro Manila in accordance with NWRB Resolution No.001-0904 and No. 020-1209.

(6) Current Status of Proposed Sites for Vertical Shafts and Flood Water Intakes

The proposed site of departing vertical shaft which is located at the site near seashore of Manila Bay is a lot of the Cultural Center of the Philippines (Table 7.1.5), where reclamation is being done and there is no specific land use at present (Photo 1 in Figure 7.1.4). There is a parking lot for trucks of DPWH and Amazing Phil. Theater, etc. in the surrounding area. On the other hand, proposed site of arrival shaft, located within Nichols Interchange, is a private lot, where no specific land use is recognized (Photo 2). The east and south sides of the lot are roads, and the west side is a golf course.

Floodwater intakes are proposed to be constructed at four locations in the project (Figure 7.1.4). Current land status of the candidate sites, etc. of the intakes are summarized in Table 7.1.5.Intake No. 4, proposed in a lot of AFP, is occupied by approximately 180 of Informal Settler Families (ISFs).

Source: JICA Study Team

Figure 7.1.4 Location Map of Candidate Sites for Project Facilities (Buendia-Maricaban Area)

Table 7.1.5 Land Status of Candidate Sites for Project Facilities (Buendia-Maricaban Area)

Site/ Facility	Current Land Status	Landowner	Street (City)
Departing Shaft/ Pumping Station	Open space	Government (CCP)	J. Diokno Blvd. (Pasay City)

Arrival Shaft	Open space	Private	Nichols Interchange (Pasay City)
Intake No.1	Plant nursery/ Parking lot	Government (Makati City)	Buendia Ave. (Makati City)
Intake No.2	Business lot	Private (company)	Pasong Tamo St. (Makati City)
Intake No.3	Open space	AFP (Armed Forces of the Philippines)	Pasong Tamo St. (Taguig City)
Intake No.4	Open space (occupied by ISFs)	AFP (Armed Forces of the Philippines)	Lawton Ave.(Taguig City)

Source: JICA Study Team

7.2 Confirmation of Potential Impacts on Natural and Social Environment

7.2.1 Confirmation of Impact Sources and Potential Impacts

Table 7.2.1 summarizes the impact sources, potential impacts and impact recipients to be included in the project.

Table 7.2.1 Summary of Potential Impacts of the Project

Stage	Impact Source	Potential Impacts	Impact Recipients
1. Pre-construction Stage			
(1)	Land Acquisition	Conflicts between project proponent and landowners regarding land purchase	Landowner of the project area
		Displacement of Project Affected People (PAPs) including ISFs, and impacts on their livelihood	People living in the project area
		Displacement of existing infrastructures, public service facilities and private facilities as well as impacts on daily life and economic activities	Managers and users of infrastructures and facilities, and those who are doing economic activities
		Conflicts between project proponent and landowners whose underground space will be used for construction of project facility	Landowners whose underground space will be used for construction of project facility
2. Construction Stage			
(1)	Mobilization of construction materials and equipment	Increase of road traffic, possibility of congestion, and risk of traffic accident	Users (drivers and pedestrians) of roads to be used for the mobilization, and nearby residents
(2)	Mobilization of construction workers	Conflicts between construction workers and local people, regarding public service, safety and security issues	LGUs and local community, and managers of public service facilities located near the project area
(3)	Establishment and operation of contractor basecamp	Generation of garbage and wastewater, which will deteriorate sanitary condition	LGUs and local community near the contractor basecamp
(4)	Construction works to be conducted on the ground	Generation of emission gas, dust, noise and vibration due to the operation of construction equipment	Local residents, schools, hospitals, etc. located near the construction work sites on the ground
(5)	Tunnelling by shield machine	Generation of low frequency sound	Local residents located near the tunnel alignment
		Ground movements due to tunnelling and impacts on existing underground structures	Manager and users of existing underground structures, and nearby local residents of the structures
		Drawdown of groundwater level, hindrance of groundwater flow and consequent impacts on groundwater usage	Those who own wells and extract groundwater near the project area
(6)	Transportation of excavated materials	Impacts related to the staging area of excavated materials (land procurement and offensive odor), and impacts on traffic due to transportation of the	Local residents near the staging area, and users of roads of transportation route and nearby residents

Stage	Impact Source	Potential Impacts	Impact Recipients
		materials	
(7)	Final disposal of the excavated materials	Necessity of land procurement for final disposal, and possibility of soil contamination	Landowner of disposal site, and local residents around the disposal site
3. Operation Stage			
(1)	Flood water drainage to the underground storage facility	Generation of noise due to a fall of flood water at the intake facility	Local residents near the intake facility
(2)	Operation of pumping station	Generation of noise due to operation of pumping facility, and offensive odor	Local residents near the pumping station

Source: JICA Study Team

7.2.2 Confirmation of Possibility of Impact Occurrence

It is pointed out that tunnelling method by shield machine will cause less impact to the surrounding area in general. It would, however, bring about negative impacts unless appropriate method and measures are adopted. The possibility of environmental and social impacts mentioned above are discussed below:

(1) España-UST Area

(a) Pre-construction Stage

Potential impacts during pre-construction stage include displacement of PAPs and existing structures and facilities due to land acquisition for the project site as follows.

(i) Conflicts between the Proponent and Land Owners regarding Land Acquisition

In the project, it is necessary to acquire the lands for departing vertical shaft at the north of SM City San Lazaro, flood water intake facilities and arrival vertical shaft and pumping station. In case of DPWH projects, negotiation on land acquisition will be done following RA 8974 (2000) and LARRIPP (2007). In case of an acquisition of private land, there might be a conflict between the proponent (DPWH) and landowner regarding the price of land purchase. It might finally need court’s judgement for land price and eventually reached through a process of expropriation. In case of España-UST area, proposed site for departing vertical shaft and intake facilities sites (3 sites) are located in private lots, requiring negotiation for land acquisition between the proponent and landowners.

(ii) Resettlement of PAPs and Impacts on Livelihood

No resident including ISFs is identified within the proposed sites for vertical shaft at present, and it is not necessary to displace any of the residents due to the project. Regarding the intake facilities, however, there are residents in the proposed site for Intake No.2. Thus, land acquisition, displacement of the residents and compensation for structures to be evicted will be needed. The activities for compensation shall be done in accordance with RA 8974 (2000) and LARRIPP (2007). There will be a possibility of impact on livelihood of the residents (PAPs) and their economic activities unless the activities are appropriately conducted.

(iii) Impacts on Existing Structures and Public Service Facilities

In case of España-UST area, no structures or public service facilities exist in the proposed project sites for vertical shaft at present. It is, therefore, not necessary to demolish or relocate any structures or facilities. Thus, no impacts due to demolition or relocation will happen. There are, however, junk materials for recycling and unused structures in the proposed site for the vertical shafts, and it is necessary to remove the same in advance accordingly.

As for intake facilities, there is un-used facility required to be removed in the Intake No. 1 (D) if this location is selected. In addition, other candidate site (Intake No. 1 (C)) is currently being used as a garden where plants and trees are growing. It is, therefore, necessary to compensate for it based on the assessment of DENR or other concerned party in case this site is selected.

(iv) Conflicts between the Proponent and Land Owners regarding Underground Land Use

According to the result of "The Survey on Drainage System in Metro Manila," (A report prepared by the mission of the Ministry of Land, Infrastructure, Transport and Tourism, Japan, Sep. 2015) it is confirmed that compensation money will be required in the case of the underground land use below the private land lot for tunnel construction. As for España-UST area, such cases may happen along Felix Huertas St. from departing vertical shaft to SM City San Lazaro and bending stretch of the tunnel from Lacson Ave. to Aceite St. Compensation for underground use will be required and a conflict might happen regarding the compensation between the proponent and the landowner.

(b) Construction Stage

There will be many impact sources and anticipated potential impacts during construction stage, such as public pollution and deterioration of environmental quality, impacts on land stability and groundwater including their propagation to the existing structures and ground facilities, and contamination by hazardous materials. The possibilities of these potential impacts are discussed below:

(i) Impacts on Traffic due to Transportation of Construction Materials and Equipment

Construction equipment necessary for the project includes shield tunnelling machine and other general machine such as piling machine, crane, backhoe, cram shell, ventilation facility, and so on. With regard to construction materials, the main one is segments for lining to be used in the shield tunnelling.

Assuming that the segments are to be transported by a trailer, the number of necessary segments per day (8) based on the drilling rate, the number of parcellation of rings (10 or 13), and the number of segment pieces to be loaded on a trailer (2), the number of necessary trailer transportation of segments per day is estimated as 52 in number (in case of all storage and drainage afterward), and 40 (in case of storage and early drainage):

- Case 1 (all storage and drainage afterward) : Trailers (Nos. / day) = 8 x 13/2 = 52
- Case (storage and early drainage) : Trailers (Nos. / day) = 8 x 10/2 = 40

Considering that there will be other transportation required during construction works such as those for transportation of construction equipment and construction workers' commute, etc., the potential impacts on road traffic will not be minor. Further, the possibility of traffic accidents cannot be denied due to the project-related vehicles. Thus, it is necessary to formulate a traffic management plan to cope with these potential impacts by means of conducting traffic survey at the transportation route and examining necessary mitigation measures in the next stage of the project.

(ii) Impacts due to Mobilization of Construction Workers

Construction labor to be mobilized for the project consists of skilled and non-skilled workers. Employment of construction workers shall be done in accordance with RA 6685 (1988): i.e., the contractor shall prioritize the local residents near the project site for employment in such that at least 30% of the skilled and 50% of the unskilled workers must come from qualified local residents. Thus, no mass influx of non-residential construction workers will occur, and no excess pressure to public service facilities will happen due to the population increase.

(iii) Impacts due to Establishment and Operation of Contractor's Base Camp

Generation of garbage (solid waste) and discharge of wastewater are anticipated, which will result in environmental pollution and aesthetic deterioration around the contractor basecamp (a complex of office and accommodation) and nearby areas. As for this potential impact, it can be minimized by strictly enforcing the specifications in contract documents of the contractor to keep sanitary situation around the basecamp in good condition. Further, it will be effective for keeping the sanitary situation in good condition to stipulate a mandate of the contractor in the CCEP (Construction Contractor's Environmental Program) through supervision by the construction supervision consultant. Thus, the possibility of this impact will be minor.

(iv) Impacts of Public Pollution due to Construction Works at Vertical Shafts and Intake Facilities

Impacts of emission gas, dust generation, noise and vibration due to the operation of construction equipment to be used on the ground at the sites of vertical shafts and intake facilities are anticipated. Noise and vibration due to the operation of piling work, depending on the construction method, will also be generated to some extent. Schools and residential buildings are located around the proposed vertical shaft sites, and thus, the impact will become significant unless appropriate measures are undertaken.

(v) Generation of Low Frequency Sound

Low frequency sound is defined as "a sound with a frequency of 1 to 80 Hz including low frequency zone of audibility" by the Institute of Noise Control Engineering of Japan. It is pointed out that low frequency sound can cause a physiological symptom such as headache and boke and a psychological symptom such as a feeling of oppression, etc.

Low frequency sound to be generated during shield tunnelling works include those caused by ventilation blower, vibration sieve to be used at slurry treatment plant, operation of vacuum pump, etc. As for these cases, installation of a silencer and a sound insulation house will be effective to minimize the impact. Regarding the vacuum pump, however, it is difficult to figure out an effective prevention measure other than isolating the vacuum pump as far as possible from the impact recipients. In such a case, the measure to be taken should depend on the actual site situation. Thus, possibility of the impact of low frequency sound cannot be denied.

(vi) Impacts on Ground Movements due to Tunnelling

Potential impacts of tunnelling by shield machine in underground space include ground movements around the face (tip) of excavation and propagation to existing underground structures. Possibility of the ground movements depends on geologic conditions in general: possibility and potential area will be higher and wider in soft ground. Existing underground structures include flyovers of roads and railway crossing Lacson Ave. where the proposed tunnel alignment is located. Among available data of the depth of foundation of these structures, maximum is approximately 25m from the ground level. Clearance between the existing underground structure and the tunnel crown is provisionally planned to be more than one (1) diameter (D) of the tunnel in this study (refer to Chapter 4). In the next stage, a detailed analysis on ground stability shall be done based on results of geological survey.

Furthermore, there will be a possibility of slurry seeping into the earth in case of slurry type shield tunnelling. Blowing-out of the ground and diffusion of oxygen deficient air might also be anticipated in case of pneumatic method according to "Standard Specifications for Tunneling-2006: Shield Tunnels."

Possibility of impact occurrence of ground movements is a matter of construction technology rather than a matter of environmental issue. It can be avoided by undertaking an appropriate construction method and countermeasures taking into account the underground conditions. The possibility of impacts, therefore, can be minimized by an appropriate investigation and technical measures.

(vii) Impacts on Groundwater due to Tunnelling

Potential impacts on groundwater due to tunnelling include groundwater discharge from tunnelling face and drawdown of groundwater level, hindrance of groundwater flow by the tunnel structure, and the impact on groundwater usage. In case the depth of groundwater aquifer and that of tunnelling coincide, a large volume of groundwater might discharge into the tunnel, which might result in not only drawdown of groundwater level but an accident causing injury or death. Further, groundwater contamination might be generated in case of injection of chemical grout for soft ground stabilization, slurry seeping into the earth. At this moment, however, no data is available to show geological condition, the depth of groundwater aquifer, so that is difficult to discuss the possibility of impacts in detail. In the next stage of the project, detailed geological survey including that for groundwater level and piezometric head shall be conducted, as basis to figure out the necessary measures.

As far as groundwater is concerned, NWRB is managing the same in Metro Manila by issuing a water permit for groundwater extraction. New water permit is not issued by NWRB at present but groundwater extraction is done based on the existing water permit. In the next stage, well inventory shall have to be conducted to clarify the groundwater usage, details of targeted groundwater aquifer of the wells, including both deep and shallow wells along the tunnel alignment. The survey results can be the basis to discuss the possibility of impacts on groundwater use and necessary mitigation measures.

(viii) Impacts of Transportation of Excavated Materials

Impacts on road traffic of transportation of excavated materials can be discussed in a similar way to that for transportation of construction materials as described in item a) above.

Assuming that the excavated materials are to be transported by a dump truck, drilling rate per day (8.36m or 10.78m) , cross-section area of the tunnel (269.966 m^2 or 175.538 m^2), truckload capacity (10t), possible transportation period (12 hours in daytime), and unit weight of excavated materials (1.8t/m^3), the number of necessary transportation per day is estimated at maximum as 204 in numbers. (in case of all storage and drainage afterward), and 171 (in case of storage and early drainage):

- Case 1 (all storage and drainage afterward):

  Dump truck transportation (No. / day) = 269.966 x 8.36 /2/(10/1.8) = 203.1 = 204

- Case (storage and early drainage):

  Dump truck transportation (No. / day) = 175.538 x 10.78 /2/(10/1.8) = 170.3 = 171

Impact of 204 truck transportation on road traffic per day is anticipated as not minor. Further, the possibility of traffic accidents cannot be denied due to the project-related vehicles. Thus, it is necessary to formulate a traffic management plan to cope with the potential impacts by means of conducting traffic survey at the transportation route, and examining necessary mitigation measures in the next stage of the project.

In addition, staging area/s for excavated materials shall be procured to secure working space for tunnelling through immediate removal of excavated materials from the work site and drying for transportation to the disposal site. In the procurement for staging area/s, the same issues as that of land acquisition for project site might generate, namely, a conflict between the proponent and land owner regarding the negotiation on land purchase/ lease price. As for the environmental impact from the staging area, there will be a possibility of offensive odor and deterioration of landscape.

(ix) Impacts of Disposal of Excavated Materials

It is necessary to procure the land for final disposal of the excavated materials. Estimated volume of the excavated materials to be disposed for tunnelling (except for the volume from construction of vertical shafts and intake facilities)is approx. 945,000 m^3 (in case of all storage and drainage afterward) or 614,000 m^3 (in case of storage and early drainage). There are several candidate areas for final disposal sites including open space along the Manila Bay, reclamation area in the Manila Bay, and the shore land area around the Laguna de Bay. The Baseco Reclamation Area was recommended as a candidate for a final disposal site by the Philippine Reclamation Authority (PRA). According to PRA, the site is located in Manila Port Area, south of the Pasig River mouth. Total area of the site is approx. 20ha, and it is to be utilized as residential area which will developed by NHA after the completion of reclamation.

There are two conditions for utilizing the disposal site to be reclaimed by PRA: one is that the filling materials can be provided for free, and the other is that the filling materials have no problem in chemical characteristics (no contamination). The issue on the necessity of securing a disposal site will be solved upon clarification of these conditions.

As far as possible causes of contamination is concerned, there are two cases of contamination source: natural source and human-induced one. A typical case of natural source is high concentration of arsenic in mudstone area. That for human-induced source includes contamination by wastewater from nearby factories containing harmful materials and/or oil. With regard to these issues, it is necessary to conduct surveys to clarify land history, and to analyse for possible soil contamination at the depth of underground storage facility, which will be the basis for criteria of hazardous wastes stipulated in DAO No. 2013-22.

(c) Operation Stage

Potential impacts during operation stage include noise to be generated when flood water falls at intake facility as impulsive sound, and noise during operation of pumping station and offensive odor. The possibilities of these potential impacts are discussed below:

(i) Generation of Noise (Impulsive Sound) at Intake Facilities

An impulsive sound will be generated during flood water falling from ground level to the depth of underground storage facility at intake facilities, which might cause negative impacts to nearby residents. One appropriate measure is to install a noise prevention curtain at intake facilities to minimize the sound and propagate it to a nearby area. Thus, the possibility of this impact will be minor.

(ii) Generation of Pollution due to Operation of Pumping Station

There will be noise from pumping station to drain the stored flood water in the underground storage facility.In this regard, the noise will be larger in case diesel generators are used as power source. This noise, depending on the capacity of diesel power generator and distance between the generator and PAPs, might cause significant disturbance of daily lives of nearby residents. This issue, however, will be mitigated by the installation of noise prevention wall, etc. and the possibility of noise issue will be minor.

Another possible pollution is offensive odor during the operation of pumping station. This issue was recognized during site inspection on October 17, 2015 of the existing pumping stations. This impact will be mitigated by the installation of a deodorizing equipment (refer to Chapter 4), and therefore the magnitude of the impact will be minor.

(2) Buendia-Maricaban Area

(a) Pre-construction Stage

Potential impacts during the pre-construction stage are basically similar to those of España-UST Area as follows.

(i) Conflicts between the Proponent and Land Owners regarding Land Acquisition

The possibility of impact is similar to that of España-UST Area. At the Buendia-Maricaban Area, it is necessary to acquire lands for the vertical shaft and the water intake facilities. Of these proposed sites, those for the arrival vertical shaft and Intake Facility No.2 are located in private lots and, therefore, there will be conflict between the proponent (DPWH) and landowner on the cost of land, which might need a court decision on land price and/or a process of expropriation.

(ii) Resettlement of PAPs and Impacts on Livelihood

Based on site inspection, ISFs are dwelling in the proposed site of Intake No.4 (left tributary of Maricaban River). According to local people, the number of ISFs is approximately180. Implementation of the project will need relocation of the ISFs, which will have impact on the ISFs livelihood and economic activities. Intake No. 4 is located within the land of the Armed Forces of the Philippines (AFP). Similarly, there are ISFs at the site, but according to the City Government of Taguig, the AFP has the responsibility for the ISF as they are residing within the property of the AFP. The issue need to be clarified to determine the party responsible for the relocation of the ISFs. .

(iii) Impacts on Existing Structures and Public Service Facilities

There is no existing structure or facility being used within the proposed project sites for vertical shafts. Thus, there will be no need for demolition or relocation of existing structures. As for the sites for intake facilities, there are plants in the proposed site for Intake No.1, and also business facilities at the Intake No.2. These lots need removal of existing plants and demolition of existing facilities with just compensation in accordance with RA 8974 (2000) and LARRIPP (2007).

(iv) Conflicts between the Proponent and Land Owners regarding Underground Land Use

Similar to the España-UST Area, there is a possibility of conflict regarding compensation between the proponent (DPWH) and land owners whose underground space is to be used for storage facility. As for Buendia-Maricaban Area, the stretch of Buendia Ave. (in the administrative area of Makati City) including the bending portion toward South Superhighway correspond to this case.

(b) Construction Stage

(i) Impacts on Traffic due to Transportation of Construction Materials and Equipment

Similar to the España-UST Area, the same calculation was used. The number of necessary trailer transportation of segments per day is projected at 48 in numbers (in case of all storage and drainage afterward), and 36 (in case of storage and early drainage):

- Case 1 (all storage and drainage afterward) : Trailers (No. / day) = 8 x 12/2 = 48
- Case (storage and early drainage) : Trailers (No. / day) = 8 x 9/2 = 36

These figures are less than those calculated for the España-UST Area, but the impact of the maximum 48 of transportation by trailers is not minor. It is, therefore, necessary to formulate a traffic management plan to cope with the anticipated impacts by means of conducting traffic survey at the transportation route and examining necessary mitigation measures in the next survey stage of the project.

(ii) Impacts due to Mobilization of Construction Workers

Same as España-UST Area, possibility of the impact is anticipated to be minor.

(iii) Impacts due to Establishment and Operation of Contractor's Base Camp

Same as España-UST Area, possibility of the impact is anticipated to be minor.

(iv) Impacts of Public Pollution due to Construction Works at Vertical Shafts and Intake Facilities

Potential impact is similar to that of España-UST Area. However, since there is no resident or facility that needs quiet condition such as school, hospital, etc., the impacts due to the construction works on the ground on the surrounding area will not be significant.

(v) Generation of Low Frequency Sound

Same as España-UST Area, there will be a possibility of negative impact.

(vi) Impacts on Ground Movements due to Tunnelling

Potential impact is similar to that of España-UST Area. Impact occurrence of ground movements due to tunnelling is a matter of construction technology rather than a matter of environmental issue. It can be avoided by adopting an appropriate construction method and countermeasures taking into account the underground conditions.

(vii) Impacts on Groundwater due to Tunnelling

Similar with España-UST Area, in the next stage, it is necessary to clarify the wells to extract groundwater, details of targeted groundwater aquifer, etc., and to discuss the possibility of impacts on groundwater use and necessary mitigation measures.

(viii) Impacts of Transportation of Excavated Materials

Potential impact is similar to that of España-UST Area. Assuming that the excavated materials are to be transported by a dump truck, drilling rate per day (8.25m or 10.27m) , cross-section area of the tunnel (249.685m^2 or 161.731m^2), truckload capacity (10t), possible transportation period (12 hours in daytime), and unit weight of excavated materials (1.8t/m^3), dump truck transportation per day is predicted at maximum as 186 in number (in case of all storage and drainage afterward), and 150 nos. (in case of storage and early drainage):

- Case 1 (all storage and drainage afterward):

  Dump truck transportation (nos. / day) = 249.685 x 8.25 /2/(10/1.8) = 185.4 = 186

- Case (storage and early drainage):

  Dump truck transportation (nos. / day) = 161.731 x 10.27 /2/(10/1.8) = 149.5 = 150

These figures are less than that for España-UST Area, but the impact of the maximum 186 nos. of transportation by trucks a day is not minor. It is, therefore, necessary to formulate a traffic management plan to cope with the anticipated impacts for the construction period by means of conducting traffic survey at the transportation route and examining necessary mitigation measures in the next stage of the project.

(ix) Impacts of Disposal of Excavated Materials

Similar to España-UST Area, there is a need for a disposal site. The estimated volume of the excavated materials from the tunnelling (except for the volume from construction of vertical shafts and intake facilities) is approximately 1,798,000 m^3 (in case of all storage and drainage afterward) or 1,164,000 m^3 (in case of storage and early drainage) from Buendia-Maricaban Area. To secure a disposal site to accommodate the volume of excavated materials, the DPWH must enter into an agreement with the PRA for the use of their reclaimed land. The agreement, among others, should include soil contamination tests of the excavated materials to determine their suitability for final disposal.

(c) Operation Stage

Potential impacts during operation stage include noise to be generated when flood water falls at intake facility as impulsive sound, and noise during operation of pumping station and offensive odor. The possibilities of these anticipated impacts will be minor, being similar to those of España-UST Area.

7.3 Confirmation of Requirements for the Proposed Drainage System under PEISS

7.3.1 Legal Framework of the Philippine Environmental Impact Statement System (PEISS)

In the Philippines, any project or undertakings that may potentially have a negative impact on the environment is subject to an Environmental Impact Assessment (EIA) under the Philippine Environmental Impact Statement System (PEISS). The PEISS was initially set up under Presidential Decree (PD) No. 1151 in 1977, known as the Philippine Environmental Policy. It stipulates the necessity to prepare an Environmental Impact Statement (EIS) for the proposed project and/or undertakings which might cause significant environmental impacts. In the following year, PD No. 1586 was promulgated to formalize the EIS System under the PD No. 1151.

The EIS process is applied to projects that are identified as Environmentally Critical Projects (ECPs) and the ones to be located in Environmentally Critical Areas (ECAs), two of which are presumed to have significant impacts on the environment. The ECPs and ECAs have been defined and identified in the Presidential Proclamation (PP) No. 2146 (1981) and PP No. 803 (1996), respectively. In order to strengthening the implementation of the PEISS, DENR Administrative Order No. 37 in 1996 (DAO No. 96-37) was issued, which was revised to partly simplify the procedures by AO No. 42 (2002) and DAO No.03-30 (2003). In November 2011, Memorandum Circular 005 (EMB 2011-005) was issued by DENR-EMB to streamline EIA requirements and include climate change adaptation and disaster risk reduction into the EIA. In 2014, another Memorandum Circular (2014-005) was issued by DENR-EMB, in which coverage screening and standardized requirements were updated.

7.3.2 Screening

Screening of projects and undertakings for adaptation of PEISS is stipulated in DAO No. 03-30 (DAO 03-30) and described in detail in the Revised Procedural Manual of DAO 03-30 (2007). Afterward, EMB MC 2014-005 was issued as the guidelines for coverage screening and standardized requirements under the PEISS. Section 1 of EMB MC 2014-005 provides the screening to determine coverage, proposed projects or undertakings shall be screened according to the following categories:

Category A: projects or undertakings which are classified as environmentally critical projects (ECPs) under PP No. 2146 (1981) and Proclamation No. 803 (1996);

Category B: projects or undertakings which are not classified as ECP under **Category A**, but which are likewise deemed to significantly affect the quality of the environment by virtue of being located in an Environmentally Critical Area (ECA) as declared under Proclamation No. 2146;

Category C: projects or undertakings not falling under **Category A** or **B** which are intended to directly enhance the quality of the environment or directly address existing environmental problems; and

Ca**tegory D**: projects or undertakings that are deemed unlikely to cause significant adverse impact on the quality of the environment according to the parameters set forth in the screening guidelines.

Proponents of projects falling under the Category A or B must secure Environmental Compliance Certificate (ECC). Proponents of projects that intend to directly enhance the quality of the environment or directly address existing environmental problems are not required to obtain ECC but submit a Project Description (PD) to DENR-EMB to confirm that it falls within Category C, by which Certificate of Non-coverage (CNC) will be issued by EMB. Proponents of Category D projects are not be required to submit any documents to DENR-EMB. Proponents of these projects may, however, still opt to secure a CNC from the EMB. A pro-forma project description attached in EMB MC 2014-005 shall be accomplished and submitted for the CNC application.

As for this project, it is to be categorized as “3. Infrastructure Projects” in Annex A of EMB MC 2014-005. However, the tunnel construction listed in it is under “3.4 Roads and Bridges.” There is no description for tunnel construction under the category of “Flood Project.” Clarifications were made with the EIA Division, DENR-EMB, Central Office to obtained their opinion regarding the project. The EMB-EIA Division clarified that based on the purpose of the tunnel, the proposed project is classified as “Flood Control Project and Category B” and also based on the storage volume of the facility of less than 5 million m3 (Table 7.3.1). Thus, the project only needs to prepare an IEE Checklist. In case of multiple facilities, individual facilities are required to prepare IEE Checklist.

Table 7.3.1 Project Thresholds for Coverage Screening and Categorization

Projects/ Description	Covered (Required to secure ECC)			Not covered	Project size parameters / Remarks
	Category A: ECP	Category B: Non-ECP		Category D	
	EIS	EIS	IEE Checklist	PD	
3. Infrastructure Projects					
3.1.1 Dams, Water Supply and Flood Control Project	≥ 25 ha OR ≥ 20 million m^3	< 25 ha, > 5 ha OR < 20 million m^3, > 5 million m^3	≤ 25 ha AND ≤ 5 million m^3	None	Reservoir flooded/ inundated area and/or water storage capacity

Source: DENR-EMB MC 2014-005 (Extraction)

However, components of structures/facilities and activities included in the project are not only tunnel but also pumping stations and disposal of excavated materials from tunnelling. Furthermore, the project can be categorized as C because it is aimed to directly address existing environmental problem, i.e., flood water. In such a case, EIA for ECC is not required.

The JICA Survey Team explained these points to DENR-EMB for their opinion on the EIS requirements of the project and eventually obtained the following comment: “The project is considered to be an environment enhancement project, which is therefore to be categorized as C. However, taking into account that the project contains several components of structures/ facilities and activities, it is necessary for the Proponent (DPWH) to submit Project Description (PD) to the competent authority in advance for determination of EIS requirements.”

7.3.3 Scoping

Based on the discussion results in Section 7.2, a scoping and necessary survey and analysis in the next stage of the project are shown in Table 7.3.2.

Table 7.3.2 Scoping and Necessary Survey and Analysis in the Next Stage of the Project

Elements		Evaluation	Explanation of Evaluation	Survey and Analysis in the Next Stage
P	Air Pollution	B-	Air pollution due to emission gas and	Survey on baseline condition of ambient

Elements		Evaluation	Explanation of Evaluation	Survey and Analysis in the Next Stage
			dust generation to be caused by construction equipment and vehicles are anticipated.	air quality in the project area, and impacts of emission gas by the implementation of the project
	Water Pollution	D	No additional water pollution is anticipated considering that the drainage water from pumping station is floodwater, which is the same as current status.	Water quality in the recipient water body from pumping station (as general information)
	Waste	B-	There will be generation of construction wastes during construction stage including excavated materials from tunnelling works.	Prediction of the volume of construction wastes including excavated materials as well as preparation of treatment and disposal plan.
	Soil Contamination	C-	There will be a possibility of soil contamination in case the excavated materials are contaminated with heavy metals.	Survey on chemical characteristics of excavated materials including TCLP test to identify soil contamination and its degree.
	Noise and Vibration	B-	There will be generation of noise and vibration due to construction work on the ground including that of vertical shaft, low frequency sound due to tunnelling work by shield machine, and noise during operation of pumping station.	Baseline condition of noise and vibration around the construction work sites on the ground, prediction of the degree of noise and vibration, low frequency sound, and noise from pumping stations, etc.
	Ground Movements	C-	There will be a possibility of ground movements due to tunnelling work, and a possibility to affect existing underground structures.	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	C-	There will be a possibility of offensive odor due to the operation of pumping station.	Examination of a possibility of offensive odor through analysis of similar cases of existing pumping stations.
Natural Environment	Topography and Geology	B-	There will be geological alteration due to tunnelling work.	Ground survey by means of borehole tests and geotechnical tests, and the degree of geological alteration.
	Groundwater	C-	There will be a possibility of impacts on groundwater level and flow as well as a possibility of groundwater contamination in case of the usage of slurry and chemical grout.	Survey on groundwater level by means of borehole tests and secondary data collection, inventory of wells and survey on groundwater use.
	Water Regime	D	There will be no change in catchment area by the project. Increase of river water discharge will not be anticipated.	Data collection on river water regime of recipient water body (as necessary data for planning)
	Terrestrial Flora and Fauna	D	No removal of vegetation or no disturbance of habitat will be anticipated due to the project.	Baseline condition of terrestrial flora and fauna around the project site (as general information)
	Aquatic Organisms	D	No additional impact on aquatic organisms will be anticipated since the drainage from pumping station is floodwater discharge, which is the same condition as current status.	Baseline condition of aquatic organisms at the recipient water body (as general information)
	Coral Reef/ Mangrove Forest	D	There is no coral reef or mangrove forests in the recipient water body.	-

Elements		Evaluation	Explanation of Evaluation	Survey and Analysis in the Next Stage
	Protected Area	D	There is no protected area around the project site.	Confirmation of the designation of a new protected area around the project site.
Social Environment	Land Acquisition/ Involuntary Resettlement	C-	Land acquisition for the project facilities will be needed. Involuntary resettlement will be required since there are residential areas including occupation by ISFs.	Confirmation of necessary land acquisition based on the facility plan of the project, inventory of ISFs, formulation of resettlement plan, and preparation of RAP, etc.
	Land Use	D	Project facility plan is not contradictory to LGU's land use plan.	Confirmation of land use plan to be renewed by LGUs from now on.
	Economic Activity/ Employment / Livelihood	C-	There will be impacts on employment and livelihood of the PAPs who will be displaced by the project.	Socio-economic survey for PAPs and preparation of RAP, etc.
	Social Infrastructure and Services	D	Influx of construction workers will be suppressed in accordance with the law, and the possibility of impact will be minor.	Prediction of necessary construction workers based on the construction plan.
	Traffic	B-	There will be an impact on road traffic and possibility of traffic accidents due to the transportation of construction materials and excavated materials.	Confirmation of transportation plan (route of hauling), baseline survey on road traffic, prediction of additional traffic based on construction plan, etc.
	Other Elements on Social Impacts	C-	No 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. (A further examination is needed, and the impact could be clarified as the study progresses.)
D: No impact is expected.

Source: JICA Study Team

7.4 Confirmation of Policies and Issues on Land Acquisition and Resettlement

7.4.1 Legal Basis and Policies on Land Acquisition, Resettlement and ISFs

(1) The Philippine Constitution

The basic legal foundation for resettlement policies in the country is enshrined in the following provisions of the 1987 Philippine Constitution:

- Article III, Section 9 - Private property shall not be taken for public use without just compensation;
- Article III, Section 11 - Free access to the courts and quasi-judicial bodies and adequate legal assistance shall not be denied to any person by reason of poverty;
- Article XIII, Section 10 - Urban or rural poor dwellers shall not be evicted nor their dwellings demolished, except in accordance with the law and in a just humane manner. No resettlement of urban or rural dwellers shall be undertaken without adequate consultation with them and the communities where they are to be relocated.

(2) The Water Code of the Philippines (PD 1067, 1976)

The Code administers river areas in Article No. 51 as follows: The banks of rivers and streams and the shores of the seas and lakes throughout their entire length and within a zone of three (3) meters in urban areas, 20m in agricultural areas, and 40m in forest areas along their margins, are subject to the easement of public use. No person shall be allowed to build structures of any kind or to stay in this zone longer than necessary for recreation, navigation, floatage, fishing, or salvage.

(3) Urban Development and Housing Act (UDHA) (RA 7279, 1992)

The Act mandates the local governments, with the support of the national government, to undertake urban development and renewal, paying attention to underprivileged and homeless citizens. It also sets the guidelines and the procedures in the eviction of informal settlers and demolition of their dwellings (Section 28) and resettlement (Section 22, 23 and 29).

(4) An Act to Facilitate the Acquisition of Right-Of-Way (ROW), Site or Location for National Government Infrastructure Projects and for other Purposes (RA 8974, 2000)

The Act aims to facilitate the acquisition of private lots needed as right-of-way (ROW), site or relocation for any national government infrastructure project through donation, negotiated sales, expropriation or any other mode of acquisition as provided by law (Section 3). The law and its IRR also prescribe the standards for the assessment of the values of lands for the project, existing improvements and/or structures (Section 5).

(5) DPWH Land Acquisition, Resettlement, Rehabilitation and Indigenous Peoples Policy (LARRIPP) (2007)

The Land Acquisition, Resettlement, Rehabilitation and Indigenous People's Policy (LARRIPP) (3rd edition in April, 2007) embodies the principles and guidelines governing land acquisition and involuntary resettlement caused by DPWH infrastructure projects. Specifically, the LARRIPP prescribes (1) Eligibility, (2) Severity of Impact, (3) Entitlement, and (4) Public Consultation and Participation.

(6) National Government Programs for ISFs

At the national level, the government has extended its efforts in taking measures in conferring legal security of tenure for the informal settler families (ISFs) as anchored on the Urban Development and Housing Act (UDHA). Under the National Housing Authority (NHA), in-city and off-city relocation sites are provided for the ISFs. Under the Community Mortgage Program (CMP), the government can allow the ISFs to own the blighted lots they occupy through a financing scheme of the Social Housing Finance Corporation (SHFC). While these existing housing programs aim to address the secure tenure problem, it does not specifically target the ISFs within the danger zones until recently, in the 2009 aftermath of typhoon Ondoy when the Department and Social Welfare and Development (DSWD) decided to allocate post-disaster housing assistance for victims of disaster but on a limited scale.

Since there is no targeted intervention for housing provisions on danger areas, the PhP. 50 billion ISF fund was mobilized for relocation of informal settlers to a safer ground. The government has set aside Php10 billion per year (for five years from 2011 to 2016) to relocate ISFs living dangerously along river banks, esteros and other water ways. This commitment was auxiliary to the 2011-2016 Philippine Development Plan, particularly under Agenda 16 which states the recognized need to achieve resilience and adaptability of the communities in natural disasters. This was also further mobilized through the Metro Manila's Flood Control Master Plan and the Supreme Court Mandamus on Manila Bay Clean-Up (SC.gov.ph, 2011), in pursuit of a flood-resilient Metro Manila by clearing up and de-silting of the waterways for a safer Metro Manila.[1)]

Furthermore, the Philippine Government launched an Oplan Likas Program aiming at facilitating the relocation of ISFs dwelling in dangerous places through partly allocating the PhP50 billion ISF fund (as mentioned above). The program, with a purpose to supplement the insufficient housing availability, is implemented by DILG in collaboration with DSWD. Cash subsidy of PhP.18,000 is to be provided for ISFs in relocating to more decent residence. The targeted areas of the program are eight (8) dangerous areas in Metro Manila, in which the Maricaban River is selected as one of the eight targets.

(Source[1)] : Housing subsidies as a viable alternative in solving problems of informal settlements in danger zones, Asia Pacific Sociological Association (APSA) Conference, 2014)

7.4.2 Issues on Land Acquisition and Resettlement related to the Project

(1) Confirmation of Resettlement of ISFs in the Project Area (Manila City)

According to the Manila City Government, it was confirmed that the resettlement of ISFs is being implemented prioritizing those dwelling in dangerous areas along rivers and creeks following the Metro Manila's Flood Control Master Plan and the Supreme Court Mandamus on Manila Bay Clean-Up (mentioned above). It is also confirmed that there is no ISFs dwelling in España-UST area of the project.

In spite of the resettlement of ISFs, there are remaining ISFs who are still dwelling in the dangerous zone. A site inspection at Quiapo Pumping Station (Oct. 17, 2015) revealed that ISFs are dwelling along the estero (Estero de San Miguel) occupying left bank of it, where a lot of garbage thrown by ISFs are accumulated near the pumping station (Figure 7.4.1).

Photo 1：ISFs are dwelling on the left bank of the estero (Estero de San Miguel)

Photo 2：Accumulated garbage thrown by ISFs

Source: JICA Study Team

Figure 7.4.1 ISFs Dwelling along the Estero near Quiapo Pumping Station and Accumulated Garbage (Oct. 17, 2015)

(2) Confirmation of Resettlement of ISFs along Maricaban River (Pasay City)

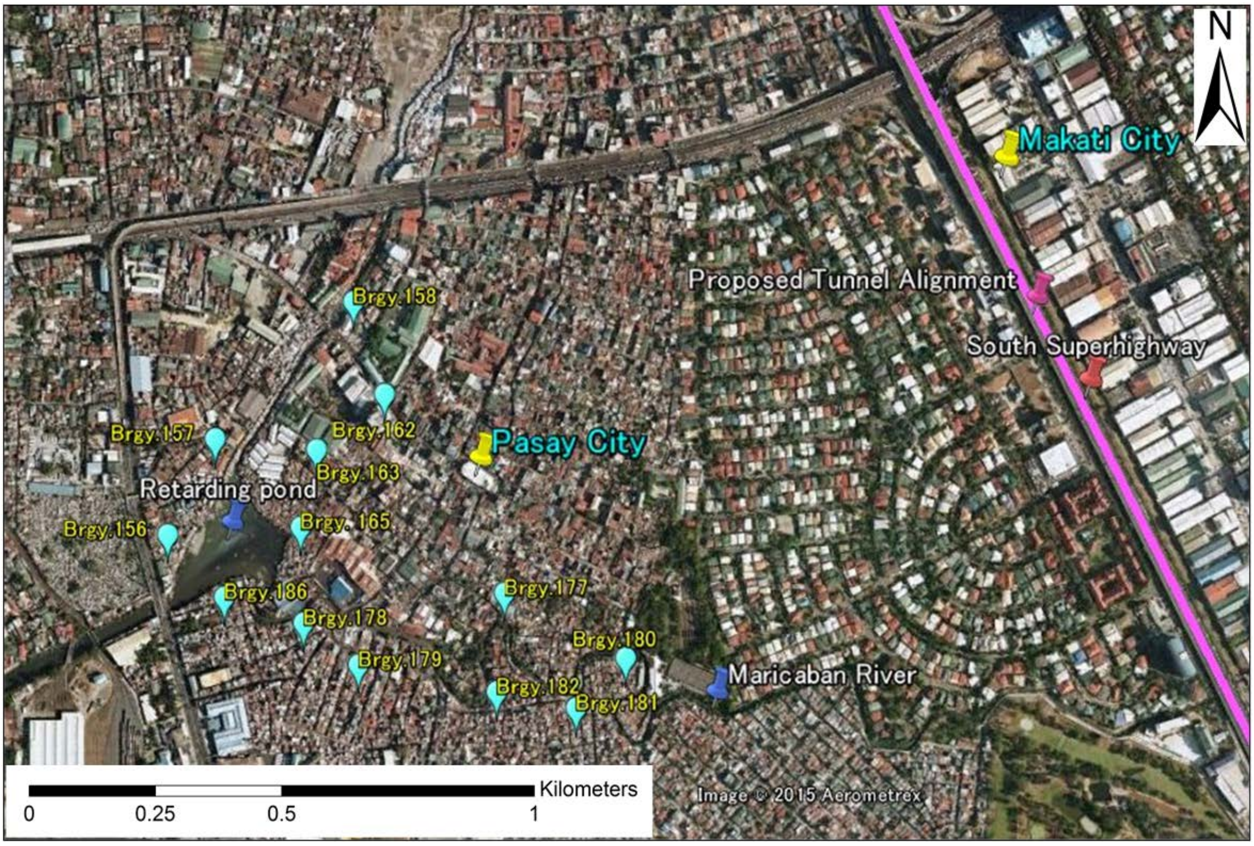
Resettlement of ISFs dwelling along the Maricaban River has been implemented by the LGU in collaboration with Government Agencies. Implementing agencies of the resettlement are Pasay City and NHA, DPWH and DILG, etc. The resettlement was implemented for two years from 2013 and will be completed by the end of 2015. Table 7.4.1 shows accomplishment of resettlement of ISFs dwelling along the Maricaban River.

Target of the ISFs for resettlement are those along Maricaban River totalling to 1,421 families and those around the retarding pond totalling to 1,424 families (as of Sep. 23, 2015). According to the Urban Development and Housing Office of the Pasay City Government, ISFs dwelling in the dangerous areas, or 3-m easement along the river are prioritized for resettlement. Remaining ISFs will be resettled sequentially from now on. The latest resettlement is the one conducted on October 8 and 9 targeting Barangay 186 that has 200 ISFs around the retarding pond. DPWH is requesting Pasay City to implement the resettlement of 86 ISFs dwelling around the retarding pond in the area of Barangay 165.

Table 7.4.1 Accomplishment of Resettlement of ISFs Dwelling along the Maricaban River

Area	Barangay	No. of ISFs in census	Non Residing (Absentee Structure Owners)	No. of Relocated. (as of Sep. 23,2015)	Balance (as of Sep. 23,2015)	With Holders (as of Sep. 23,2015)
Marikaban Creek	156	137	4	118	15	0
	157	151	15	71	65	0
	158	8	1	7	0	0
	162	244	10	86	148	0
	177	94	13	71	10	0
	178	95	11	75	9	0
	179	201	27	146	28	0
	180	276	28	167	81	0
	181	31	0	31	0	0
	182	184	28	133	23	0
	Total	**1,421**	**137**	**905**	**379**	**0**
Retarding Pond	165	620	54	165	401	1
	186	804	17	0	787	115
	Total	**1,424**	**71**	**165**	**1,188**	**116**
Grand Total		**2,845**	**208**	**1,070**	**1,567**	**116**

Source: Urban Development and Housing Office, Pasay City (Sep.2015)



Source: Urban Development and Housing Office, Pasay City (Sep.2015)

Figure 7.4.2 Location Map of Targeted Areas of ISFs Resettlement along Maricaban River

Relocation site of ISFs of Pasay City are four sites, located in two cities in Cavite Province, as follows:

1. Bgry. Aguado, Trece Martires City;
2. Brgy. Hugo Perez, Trece Martires City;

3. Bgry. Cabuco, Trece Martires City;

4. Bgry. Halang, Naic City.

Total capacity of these relocation sites is 5,500 households. The area of one lot is 40 m^2 and floor area is 22 m^2 / household.

(3) Confirmation of Resettlement of ISFs (Makati City)

Inventory and resettlement of ISFs are being implemented in the area of Makati City. Table 7.4.2 shows the inventory results of ISFs indicating that the total number of ISFs identified in government lands is 2,059 families (as of Oct. 2015) and those identified in the private lots is 2,577 families (as of Sep. 2015).

Table 7.4.2 Inventory Results of ISFs in Makati City

Barangay	Street/ Area	Site Condition	No. of ISFs	Time of Inventory
A. Government Land				
La Paz	2016 Mola St.	Sidewalk	4	Oct. 2015
Magallanes	Pason Tamo Extension	Creekside	20	ditto
Tejeros	Kalayaan Ave. etc.	Creekside/ Sidewalk	446	ditto
Cembo	Guiho St. MCDA	Creekside/ Gov't property	926	ditto
Comembo	Apitong St., etc.	Creekside	62	ditto
Guadalupe Nuebo	San Jose St.	Creekside/ Riverbank	68	ditto
Northside	Progreso St., etc.	Creekside	125	ditto
Pembo	Waling-waling St., etc.	Creekside/ Riverbank	26	ditto
Pitogo	Kalayaan St., etc.	Creekside	31	ditto
Pinagkaisahan	Balabac St., etc.	Creekside/ ROW	88	ditto
Rizal	Quirino St.	Creekside	5	ditto
South Cembo	Pinos St.	Creekside	4	ditto
West Rembo	Napindan Area, etc.	River Bank	254	ditto
Total	-	-	**2,059**	ditto
B. Private Land				
La Paz	Caton St.	-	64	Sept. 2015
Olympia	8063 Hondradez St., etc	-	72	ditto
Palanan	Durango St., etc.	-	196	ditto
Poblacion	3172 Mabini St., etc.	-	22	ditto
San Antonio	Lumbayao St., etc.	-	183	ditto
San Isidro	Guatemala St., etc.	-	275	ditto
Singkamas	207 Sunrise St.	-	166	ditto
Sta. Cruz	3015 Kararong St., etc.	-	142	ditto
Tejeros	Kalayaan Ave. etc.	-	527	ditto
Valenzuela	9153 Pateros St., etc.	-	197	ditto
Guadalupe Nuebo	2363 Antipolo St.	-	70	ditto
Guadalupe Viejo	4050 Bemardino St., etc.	-	613	ditto
Pinagkaisahan	3703 Gabong St.	-	34	ditto
West Rembo	Napindan	-	16	ditto
Total	-	-	**2,577**	ditto

Source：Makati Social Welfare Department, Makati City (Oct. 2015)

Resettlement of ISFs, which prioritize those dwelling along the dangerous zone (3-m easement), is implemented by Makati City in collaboration with Government Agencies including NHA, MMDA, DSWD, DPWH and DILG. In addition, Makati City's own resettlement program has also been implemented from 2008. Resettlement of ISFs in the areas related to this project is that of 23 ISFs implemented in October 2015 and additional relocation will be done for 20 ISFs dwelling in Barangay Magallanes along Pasong Tamo St. However, there is no ISFs identified in other areas of

West Makati City where the project is located. According to a government official of Makati City, resettlement of these identified ISFs will be implemented from now on sequentially.

Relocation sites of ISFs identified in Makati City includes the one developed by NHA in Barangay Cabuco, Trece Martirez, Cavite Province, and other two sites developed by the Makati City Government as follows:

1. Location: Bgry. Dayap, Calauan City, Laguna Province, Area: 40 ha, Capacity: 6,000 units, Occupation (as of Oct. 2015): 1,031 units, Lot area: 40-60 m^2/unit.
2. Location: Bgry. Dreamland, San Jose Del Monte City, Bulacan Province, Area 4.0 ha, No. of housing units: 412 (As of Oct. 2015), Lot area: 40-60 m^2/unit.

(4) Confirmation of Resettlement of ISFs (Taguig City)

As far as the project facility plan is concerned, Intake No.3 (right tributary of Maricaban River) and No.4 (left tributary of Maricaban River) are located in the area of Taguig City. Land owner of these locations is the Armed Forces of the Philippines (AFP), where there are facilities of AFP and these two intakes are located in the AFP facilities.

Proposed site of intake No.4 of the project is occupied by ISFs as shown in Figure 7.4.3. According to an interview with local people, the number of ISFs is approx. 180. It is necessary to relocate these ISFs for construction of the intake facility although it depends on the size/ dimension of the intake facility. As for relocation of ISFs within the area of AFP, there is a contradiction in stances of APF and Taguig City (City Planning and Development Office) in terms of responsibility for it. In the next stage, it is necessary to clarify the responsible organization for relocation of ISFs to accomplish a smooth implementation of relocation by coordination of these two parties as needed.

Photo 1: Current status of ISFs along left tributary of Maricaban River at proposed site of Intake No.4

Photo 2: Same as Photo 1 (status of farther location from the river)

Source: JICA Study Team

Figure 7.4.3 ISFs along Left Tributary of Maricaban River at the Proposed Site of Intake No.4 (Oct. 24, 2015)

CHAPTER 8. ISSUES IN FUTURE AND RECOMMENDATION

8.1 Challenges

8.1.1 Challenges for the Proposed Projects

(1) Engineering Aspects

The detailed study, such as 1) development flood simulation model with current data and evaluation of flow capacity of existing drainages/esteros, 2) geological survey along the alignment for designing and planning, 3) survey for shafts and intakes with adequate accuracy, 4) confirmation of tunnel hydraulic condition, 5) environmental impact assessment and 6) proposal including non-structural measures, were not carried out because the Survey is just a preliminary stage and has been expected the result within a short period of time. These items should be considered in the next step.

(2) Project Cost

Possibility of project cost reduction was indicated with a combination of the pump and the storage pipe as mentioned in 3.5.2, 3.5.3 and 4.4.6. If the cost decreases the EIRR will be improved as described in 6.4.2. Appropriate project cost should be estimated with above-mentioned engineering surveys in the coming study.

8.1.2 Present Issued on Drainage Improvement in Metro Manila

(1) Promotion of Recovery and Improvement of Drainage Capacity of Existing Drainage Systems

The discharge capacity of existing drainage system was estimated to be at the level of 2 to 3 year return period in DICAMM 2005. Significant sedimentation and garbage deposition was seen in the Survey, therefore, this situation has not changed. Moreover, major pumping stations are affected by solid wastes flowed in and mechanical efficiencies of pumping facilities are also affected and damaged. The proposed underground tunnels in the Survey cannot function adequately under existing condition being reduced capacity of drainage channels and pumps.

(2) Strengthening of Cooperation between DPWH and MMDA on the Drainage Sector

In Metro Manila the responsibility for management of drainage facilities is devided; i.e., the planning and implementation of drainage facilities are under the DPWH and the Operation and Maintenance (O&M) activities are under the MMDA. Although the budget is increasing for the last 3-4 years, MMDA is carrying out of maintenance works for the drainage channel and pumping stations under the limited budget.

8.2 Activities to the Next Stage

8.2.1 Further Study for the Proposed Projects

(1) Required Basic Surveys such as Geological Survey along the Alignment for Designing and Planning

As for the underground tunnelling methods, the shield machine shall be designed and the construction plan shall be prepared based on the geological and other basic data along the alignment in order to avoid problems during the construction. Since the actual geological/soil conditions and obstacles have not been confirmed in advance, in the case of shield tunnelling methods, the actual conditions may require large scale countermeasures.

To avoid possible problems beforehand, it would be necessary to collect basic data as much as possible and utilize them for the designing of shield machines and for preparing the construction plans and execution of the shield tunnelling works.

Also during and after the shield tunnelling works, it is necessary to grasp the negative impacts of the construction to the environment, and follow-up survey should be required.

(2) Determination of Layout considering Expandability

The proposed drainage facility is designed at 25-year probability and not 50-year probability in terms of required storage capacity. Therefore, in case of more than 25-year probability (for example 50-year probability), it is necessary to utilize the planned storage pipe under pressure flow and it is necessary to drain the stored water continually with large drainage capacity. For this, it is necessary to design the proposed storage pipe as pressure tunnel and also design the segment for its durability against inner water pressure.

(3) Confirmation on Effective and Assured Diversion of the Flood Water

It is necessary for Metro Manila to attain the safety level of 10-year probable floods by the drainage improvement and flood control measures of DPWH, and by dredging and cleaning up and rehabilitation activities of MMDA.

The formulation of drainage improvement plans are to correspond to the 25-year flood return period and, if possible, to the 50-year food return period.

As a precondition, it is necessary during floods to have a secure intake function to reduce or prevent inundation steadily. It is therefore, necessary to confirm the intake function through case studies like flood simulation of flood patterns.

(4) Estimate of Frequency of Facilities Usage and Confirmation of Disappearance of the Inundation Areas through Flood Inundation Analysis

For the proposed drainage facility plan, the intake (diversion) amount has been roughly estimated by setting the presumable drainage areas. In the next stage, it is necessary to define the dimensions of intake in more detail, and by applying actual floods or several patterns of inland inundation to the inundation simulation analysis, to confirm and ensure the prevention of flood and inland inundation damages.

(5) Necessity under the Drainage Improvement Plan to Conduct Necessary Procedures for the Environmental Impact Statement (EIS)

For this project, the Philippine Environmental Impact Statement System (PEISS) is to be applied and the Environmental Impact Statement (EIS) is to be required. This project involves pumping stations and disposal of excavated soil which require an Environmental Compliance Certificate (ECC). For this reason, it is necessary for the project to submit the EIS when the facility plan is prepared, and based on the EIS submitted, DENR-EMB will decide necessary conditions for the project.

(6) Implementation of Basin Management to the Maricaban River

In the Maricaban River basin, the flood discharge seems to have been increasing due to the land use change and river basin development. Presently DPWH is planning to conduct river improvement works as the countermeasures, but sustainable flood risk management will be required as basic measures.

(7) Necessary Preparation of Laws for Deep Underground Development and Public Use of deep Underground Facilities

According to the Survey on Drainage Facility Improvement in Metro Manila [Field Report of the Mission of MLIT (September 2015)] the followings is prescribed "When the underground tunnel construction use the underground of the private land, compensation will be necessary to be considered to the surface landowner."

In the present Survey, the alignment of underground tunnel structures is planned basically under public lands like roads and in case of under the private land, the space utilized is minimized.

In future for effective public use of the underground, preparation of laws for deep underground development and public use of deep underground will be necessary.

(8) Introduction of Operation and Management System for Drainage Facilities using Rainfall and Meteorological Observation and Forecast System

The drainage facilities proposed under the Survey are formulated with 25-year probable floods as the target and also have possible functions to cope with 50-year probable floods. Furthermore, in order to minimize the flood risks caused by severe torrential rainfalls due to climate change, it is necessary to examine effective operation and management methods and conduct an appropriate management of drainage pump facilities using rainfall observation and forecast system.

8.2.2 Activities for Drainage Improvement in Metro Manila

(1) Promotion of Recovery and Improvement of Drainage Capacities of Existing Drainage Systems

The 2005 JICA M/P and the DPWH Survey has aimed for the improvement of drainage systems for the core area of Metro Manila. Given that urgent projects identified in the 2005 MP have started to be implemented, and, hopefully, will be finished in the next five years. It is important to attain improvement to the targeted drainage capacities for Metro Manila. Also, it is necessary to assess the attained safety level of the drainage facilities and to identify the necessary remedial measures to attain the target of 25-year return period (RP), that has been set by the DPWH as the safety level of drainage improvement.

(2) Improvement of Dumping Solid Wastes and of Water Quality in Drainage Channels

It is necessary to reduce the dumping of solid wastes into the drainage channels and to improve water quality. The current conditions of water quality in the drainage channels is not clear, because there is no water quality monitoring data for esteros/creeks, however, the on-site inspections, have revealed that polluted water and solid wastes exists in the drainage channels. According to the water quality data of the Pasig River at the Nagtahan bridge site, the values of coliform, DO and BOD do not satisfy the environmental standards. The cause could be the untreated waste water from the urban areas along the river.

Major pumping stations are affected by the inflow of solid wastes, htat the mechanical efficiency of pumping facilities are also affected and eventually become damaged.

It is, therefore, necessary to reduce solid wastes and improve the water quality in the drainage channels.

(3) Strengthening of Cooperation between DPWH and MMDA on the Drainage Sector

In Metro Manila, the responsibility for management of drainage facilities is divided; i.e., the planning and implementation of drainage facilities are under the DPWH and the Operation and Maintenance (O&M) activities are under the MMDA. In order to conduct the planning, implementation and O&M activities for drainage facilities more effectively, DPWH and MMDA need to establish a closer relationship and to share information on drainage improvement activities in Metro Manila. In future, as for big scale drainage facilities like deep underground tunnel storages their planning, implementation and O&M should require a seamless management and a new organization for their implementation.

(4) Promotion of Land Use Management and River Basin Management considering Flood Disaster Risk Reduction (DRR)

The five (5) rivers in the surrounding area of Metro Manila do not have their own flood control plan ad are the new target areas for river improvement. The plan is composed of river improvement, flood plain management and river basin management. It is, therefore, necessary for each river basin to promote an integrated river basin management and to sustain the water retention function by introducing land use management considering flood disaster risks reduction.

The DPWH and MMDA must establish a good working relationship with the city/municipality government units to pursue and implement appropriate land use management for each river basin since this must be integrated with their respective land use plans and zoning ordinances.

8.3 Recommendation

The results of the Survey:

The Survey has been carried out for two candidate areas: España-UST and Buendia-Maricaban. A preliminary study on the possibility of applying the deep underground tunnel technologies to their drainage system improvement was also conducted and concluded that they are feasible measures in technical terms.

However, the deep underground tunnel facility should be the final measure to attain the target safety levels of 25-year RP and 50-year RP. The drainage improvement works proposed by the 2005 JICA M/P and the DPWH survey have just been commenced and the results of the works should be assessed and necessary remedial measures to attain the target of 25-year RP and 50-year RP should be identified.

It is necessary for DPWH to conduct a further study on the effects of the works before finalizing the proposed deep underground tunneling drainage facilities as the final measures to sustain the future development of Metro Manila.

DPWH has set the target safety level of as high as 25-year return period (RP) and 50-year RP for the safety level of flood and drainage projects and require new basis for project evaluation.

In order to realize the proposed deep underground drainage projects it is recommended that DPWH should conduct further studies including the activities in 8.2 as follows:

Further Study:

(1) Consistent implementation and the evaluation of the items mentioned in 8.2.2 should be assessed.

(2) For evaluation and assessment purposes, the on-going and planned drainage improvement works in the core area are to be assessed as to their effects in the disaster risk reduction, and their functions in the short term are to be identified for attaining the target safety levels of 25-year RP and 50-year RP in the Core Area.

(3) Formulation of necessary drainage improvement measures including their O&M measures to attain the target safety levels of 25-year RP and 50-year RP in the Core Area.

(4) Study on the bases of project evaluation for challenging drainage improvement works including adaptation measures against inevitable climate change.

Appendix 2-1
Outline of DPWH Survey

Department of Public Works and Highways

UNIFIED PROJECT MANAGEMENT OFFICE

FLOOD CONTROL MANAGEMENT CLUSTER

Consulting Services for the Review and Detailed Engineering Design of Comprehensive River Management for San Juan River

and

Review and Updating of Feasibility Studies and Detailed Engineering Design of Various Urgent Flood Control Projects in Metro Manila

PRESENTATION

WOODFIELDS ENGINEERS COMPANY

PLANNERS, ARCHITECTS, ENGINEERS, CONSTRUCTION MANAGERS AND ENVIRONMENT SPECIALISTS

Projects to be presented:

1. San Juan River Improvement Works
2. Various Flood Control Projects in MM

Scope of Work:

1. Review of Previous Studies

- Study on Comprehensive River Management for San Juan River under the Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project (March 2002)

- The Study on Drainage Improvement in the Core Area of Metropolitan Manila, Republic of the Philippines DICAMM(March 2005)

- The Feasibility Study on Flood Control and Drainage Improvement Project for MIAA Compound and Parañaque-Las Piñas River System in the Republic of the Philippines (March 2004)

2. Detailed Engineering Design of selected priority improvement works

Technical Approach:

MM's drainage networks are designed for a 10-year flood only. Being continuously silted and clogged with garbage, they have become increasingly inadequate to convey flood. Present set up also allows surface runoff to flow directly from higher elevations to the flood prone areas downstream, which usually results to flashfloods. Because of increased urbanization and more frequent high intensity rainfalls, DPWH Memorandum of June, 2011 now requires drainage systems be designed for a 25-year flood with a freeboard that can accommodate a 50-year flood. But existing MM's drainage systems are undersized for a 50-year flood.

The Consultant's approach is to reconfigure the whole existing drainage system by

1) Decreasing the drainage/sub-drainage areas so that existing drainage can carry the 50-year flood using its present design capacity (10-year flood), thus avoiding additional ROW acquisitions and replacement costs;

2) Installing flood gates along waterways, i.e., to divide flood flows and drainage/sub-drainage areas; and

3) Introducing new interceptors/drainage mains that will receive the 50-year flood from higher elevations and carry them directly either to Manila Bay or Pasig River, thus minimizing flooding downstream; they will also serve as flood storage because of their sizes and lengths. These interceptors will be located, designed and constructed with minimum disturbance on existing traffic and present social and economic activities in the area, using new construction technique: "trench" method (see Annex 1).

Note also that hydrojet technology can possibly be used to declog drainage mains and laterals with hardened silt and garbage combined.

PROPOSED NONSTRUCTURAL MEASURES

(1) **Reducing flood risk through Sustainable Urban Drainage Systems (SUDS) in urban watersheds.** Currently, the set of best practices for water management of the urban environment in developed countries like USA, Europe, Canada, Australia and New Zealand is considered to be the SUDS. SUDS are designed to allow water either to infiltrate into the ground or be retained in devices (wet ponds, infiltration wells, stormwater wetlands, sand filters, rain gardens, grassy swales) in order to mimic the natural disposal of surface water. SUDS reduces the peak flow runoff rates, siltation and water pollution in waterways.

(2) **Reducing flood risk in floodplains through building code enforcement**, i.e., adapting in the National Building Code the flood provisions of the **2015 International Building Code**, which includes flood resistant construction and structural systems; design flood elevations; lowest floor requirements; protection of mechanical and electrical systems; and the protection of water supply and sanitary sewage systems.

(3) **Creation of Environmental Crimes Strike Force** under the PNP: Environmental Police will be responsible for enforcing environmental laws and educating the public about environment and natural resource protection. The Environmental Police, as members of Environmental Crimes Strike Force, will investigate criminal violations of the Philippine environmental laws and regulations (especially solid waste management act and clean water act among others) in conjunction with the DENR and OSG or DOJ. This should address the unabated street littering, in which litters are carried by runoff into the storm water drains, and unceasing throwing of garbage in waterways and drainage systems.

(4) **GIS-based digitization of the whole Metro Manila drainage networks** for more accurate planning, programming and budgeting of drainage improvement works.

What is a 100 Year Flood?

The magnitude of a storm or flood is described in terms of 100 year flood, 50 year storm, or 200 year flood. The larger the number before 'year flood', the greater will be the effect on river levels and on anything out on the river's flood plain. Also, it is understood from the words '100 year flood' that it has a flood return period of 100 years, or in other words, it should only happen every 100 years ***on the average***, but questions remaining are 'Could a 100 year flood occur the next year after one has just occurred?' and 'What is the likelihood of its occurring within any given time period?'

Definitions:

1. **Return Period (T)** - The ***average*** length of time in years for an event (e.g. flood or river level) of given magnitude to be equaled or exceeded. For example, if the river level with a 50 year return period at a given location is 2 meters above flood stage, this is just another way of saying that a river level of 2 meters above flood stage, or greater, should occur at that location ***on the average*** only once every 50 years. ($T = 1/p$)

2. **Probability of Occurrence (p)** (of an event of specified magnitude) - The probability that an event of the specified magnitude will be equaled or exceeded during a one year period. ($p = 1/T$)

3. **Probability of Occurrence within a period of N years** (p_N)- The probability that an event of specified magnitude will be equaled or exceeded within a period of N years. ($p_N = 1 - (1 - p)^N$)

Question #1: Could a 100 year flood occur in the next year after a 100 year flood has taken place?

Solution: The answer is yes. A 100 year flood has a return period of T = 100, so the probability of a flood of equal or greater magnitude occurring in <u>any one year period</u> is $p = 1/T = 1/100 = 0.01$. Thus there is a probability of 0.01 or 1 in 100 that a 100 year flood will occur in any given year. It is not likely, but it is possible. The fact that a 100 year flood occurred in one year has no effect on the probability of its occurring in the next year.

Question #2: What is the probability that a 50 year river level will occur within the next 10 years at any given location?

Solution: The answer to this can be found using the equation, $p_N = 1 - (1 - p)^N$. Given a 10 year period of time, N = 10, and a 50 year river level, p = 1/50 = 0.02. Substituting into the equation: $P_{10} = 1 - (1 - 0.02)^{10} = 1 - 0.98^{10} = 0.183$. Thus the probability of a 50 year river level occurring in a 10 year period is about **18%**.

Return Period	Probability of Occurrence (%) in N years									
	1	2	5	10	15	20	25	30	50	100
2	50.00	75.00	96.88	99.90	100.00	100.00	100.00	100.00	100.00	100.00
5	20.00	36.00	67.23	89.26	96.48	98.85	99.62	99.88	100.00	100.00
10	10.00	19.00	40.95	65.13	79.41	87.84	92.82	95.76	99.48	100.00
20	5.00	9.75	22.62	40.13	53.67	64.15	72.26	78.54	92.31	99.41
25	4.00	7.84	18.46	33.52	45.79	55.80	63.96	70.61	87.01	98.31
30	3.33	6.56	15.59	28.75	39.86	49.24	57.15	63.83	81.64	96.63
50	2.00	3.96	9.61	18.29	26.14	33.24	39.65	45.45	63.58	86.74
100	1.00	1.99	4.90	9.56	13.99	18.21	22.22	26.03	39.50	63.40

Flood Return Period Calculator

Though this calculator is worded for the flood event return period it would work for any extreme weather event.

Percent chance of occurrence	
Enter the return period (ie..100 year flood)	
50	year flood
Enter the number of years (ie..over the next 10 years)	
10	year(s)
There is a	
18.29%	chance that a
50	year flood will occur over the next
10	year(s)

Note however that the magnitude of the 100-year flood today will not be exactly the same as the magnitude of the 100 year flood 30 years ago because of the changes in the watershed (drainage area) environment.

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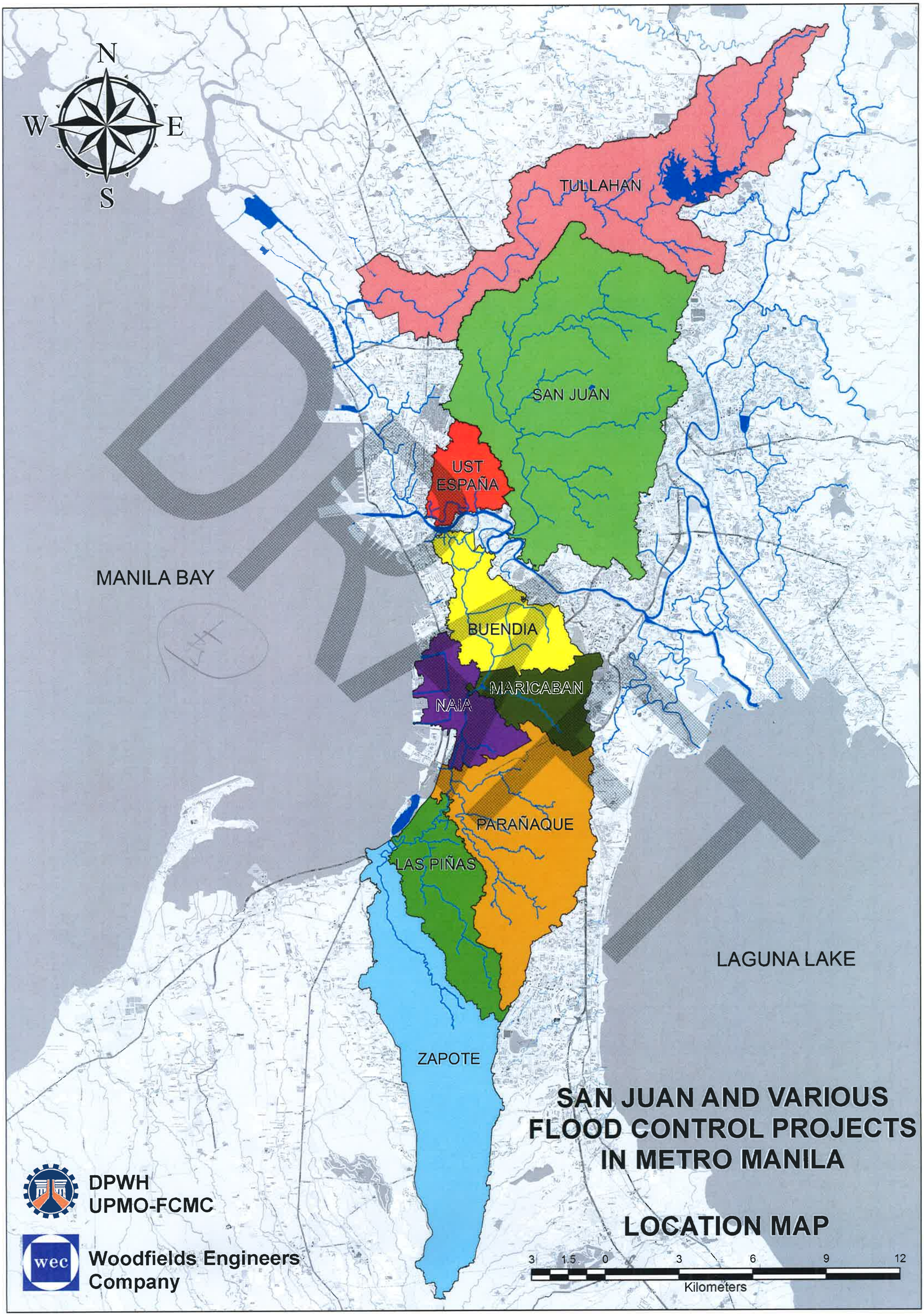
TULLAHAN RIVER IMPROVEMENT WORKS

SAN JUAN RIVER PROJECT

SAN JUAN DRAINAGE IMPROVEMENT WORKS

Location Map



SAN JUAN AND VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA

LOCATION MAP

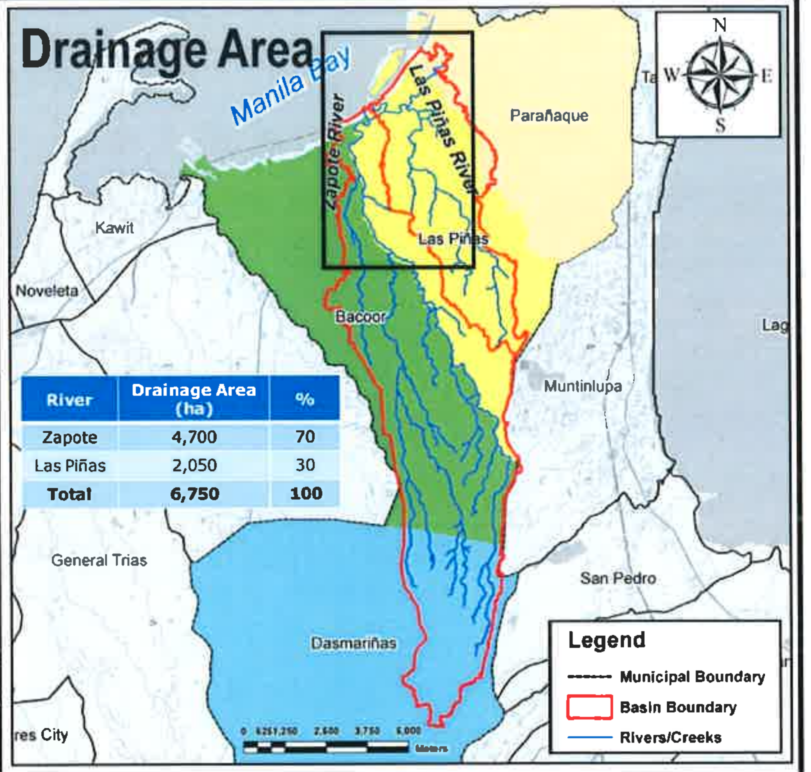
DPWH
UPMO-FCMC

Woodfields Engineers Company

Zapote-Las Piñas River Improvement

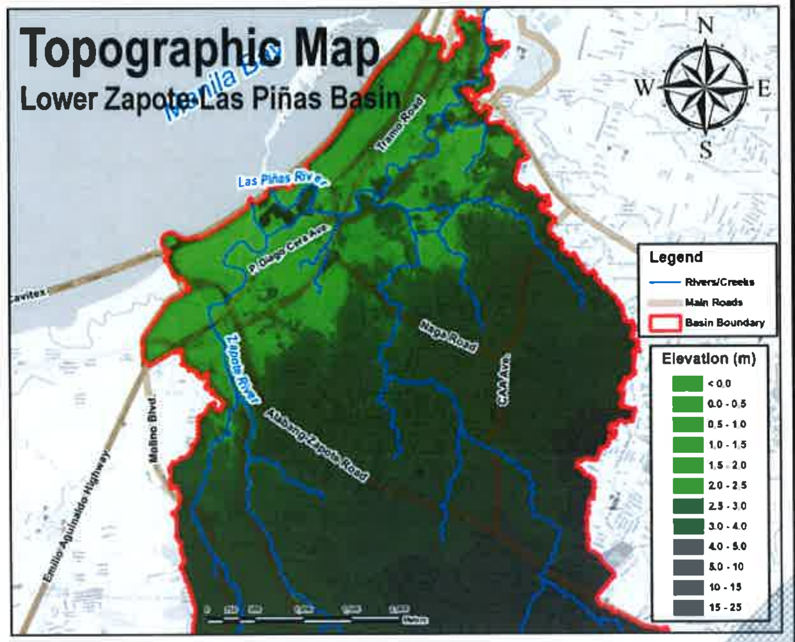
Various Flood Control Projects

Drainage Area



River	Drainage Area (ha)	%
Zapote	4,700	70
Las Piñas	2,050	30
Total	**6,750**	**100**

Topographic Map
Lower Zapote-Las Piñas Basin



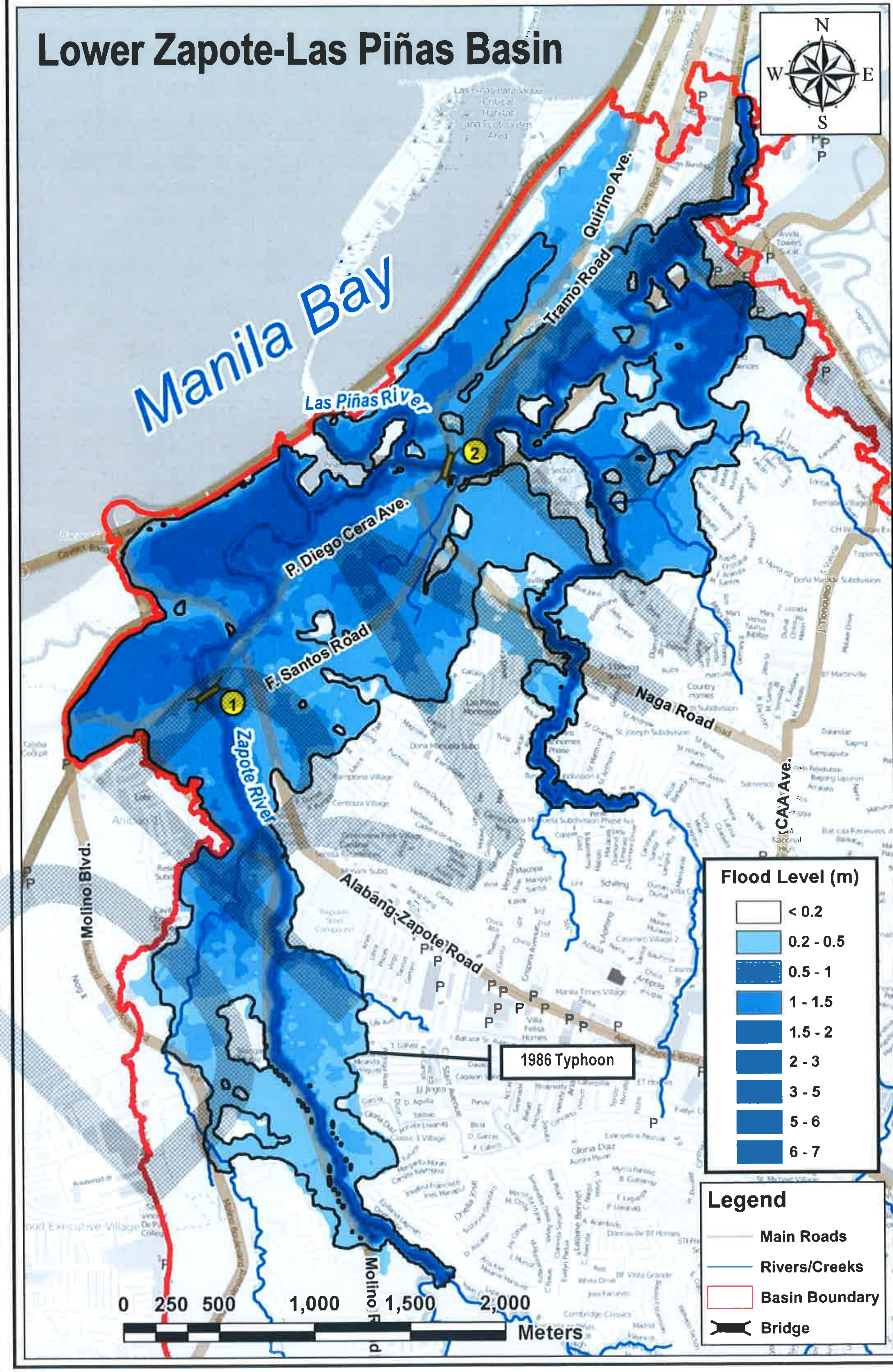
Causes of Flooding

Zapote Historical Bridge
- Causes bottleneck being an arch type bridge with limited opening
- Its opening is only 35% of the area of the upstream river cross-section
- Blocks approximately 65% of the flow area which causes flooding in the surrounding area

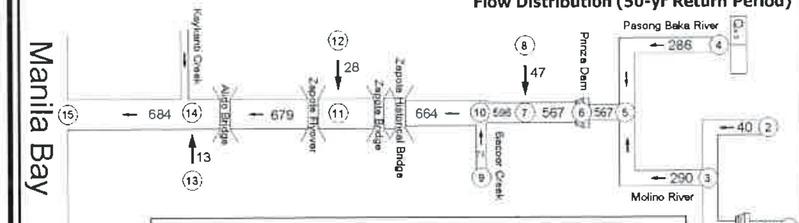
Diego Cera Bridge
- Arch type bridge
- Its opening is only 22% of the area of the upstream river cross-section
- Blocks approximately 78% of the flow area which causes flooding in the surrounding area

Other causes:
- Low riverbank elevations
- Encroachment of informal settlers
- High tide coinciding with extreme rainfall events

Lower Zapote-Las Piñas Basin

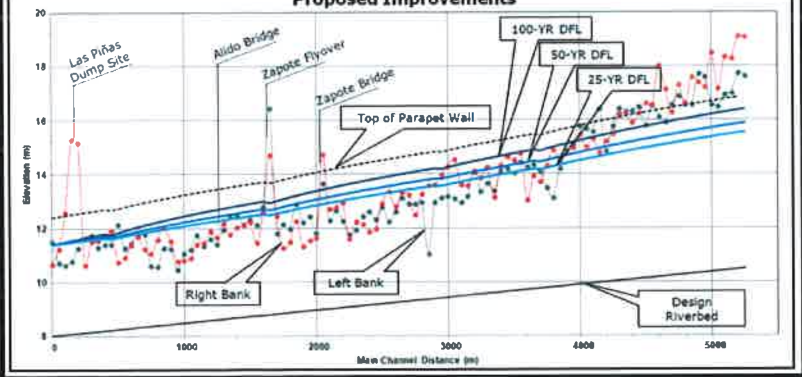


Zapote River
Flow Distribution (50-yr Return Period)

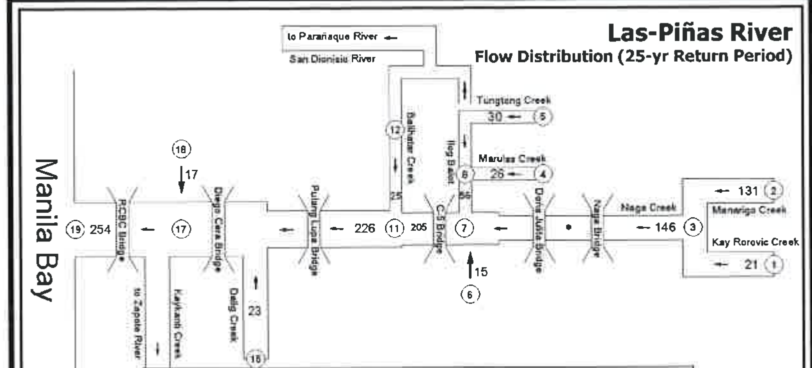


50-yr (100-yr Freeboard)						
Reach	Link	Length (m)	Width (m)		Discharge (cms)	
			Existing	Required	Existing	Required
5	6-7	1663	20	47	178	567
4	7-10	738	21	54	188	596
3	10-11	1296	22	69	209	664
2	11-14	1212	25	83	213	679
1	14-15	465	38	103	215	684

Zapote River Flood Water Surface Profile for Different Return Periods after Proposed Improvements

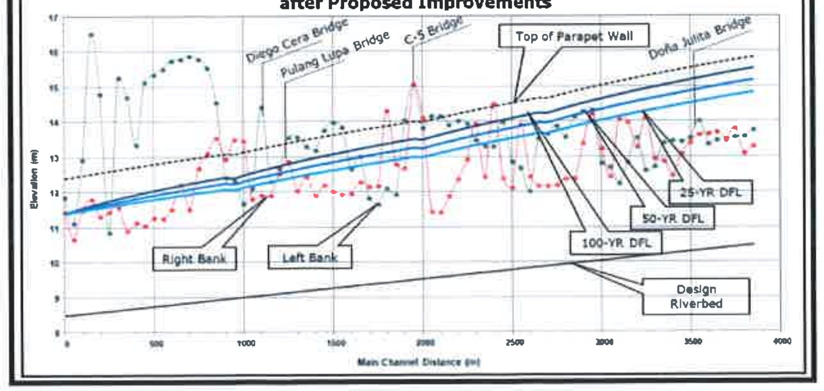


Las-Piñas River
Flow Distribution (25-yr Return Period)



25-yr(50-yr Freeboard)						
Reach	Link	Length (m)	Width (m)		Discharge (cms)	
			Existing	Required	Existing	Required
4	3-7	1249	12	20	54	146
3	7-11	747	14	28	75	205
2	11-17	1029	15	36	82	226
1	17-19	918	18	48	93	254

Las Piñas River Flood Water Surface Profile for Different Return Periods after Proposed Improvements



VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
Zapote-Las Piñas River Improvement

100-Year Return Period Inundation Map of Zapote-Las Piñas

Woodfields Engineers Company

DPWH UPMO FCMC

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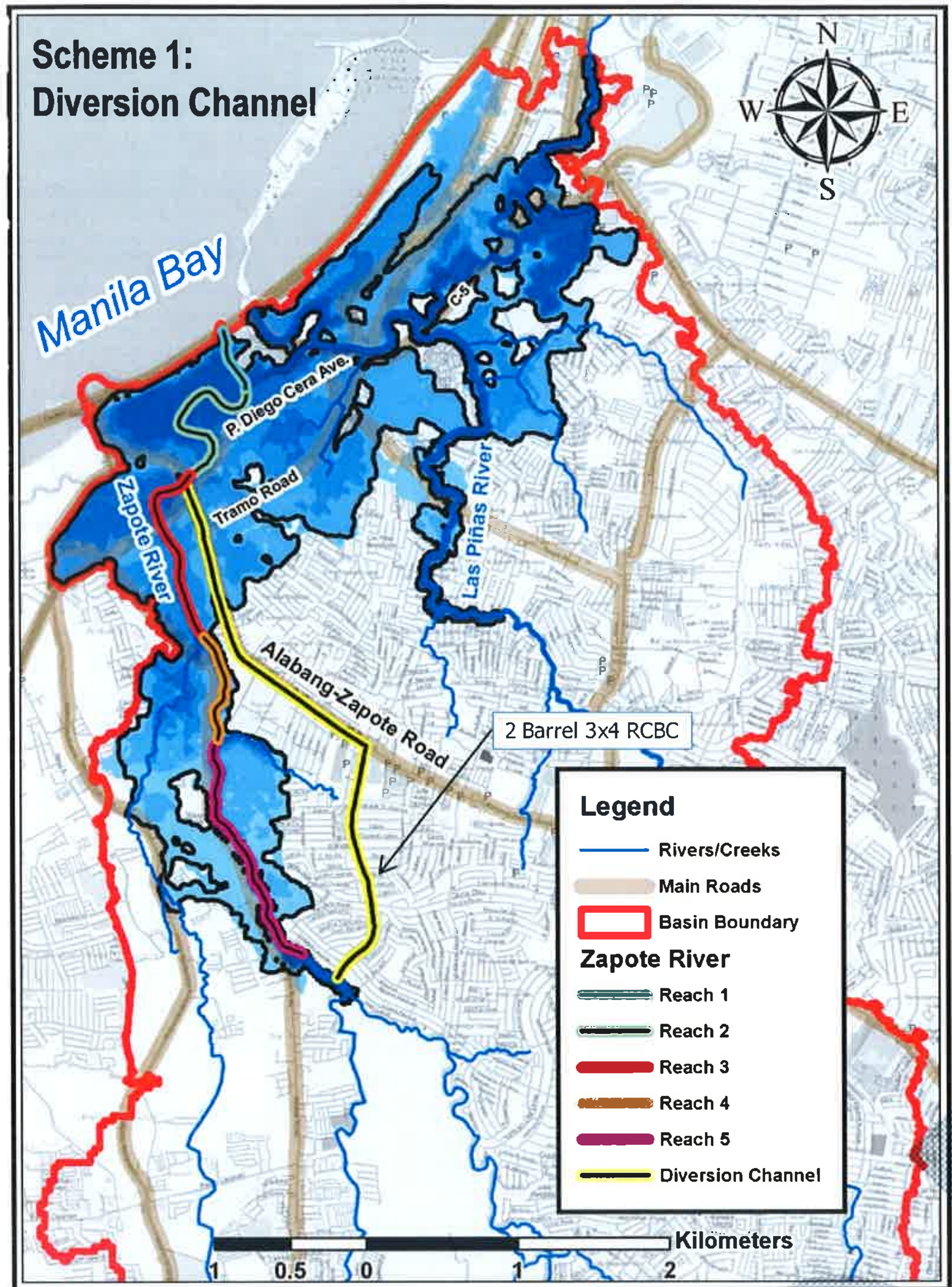
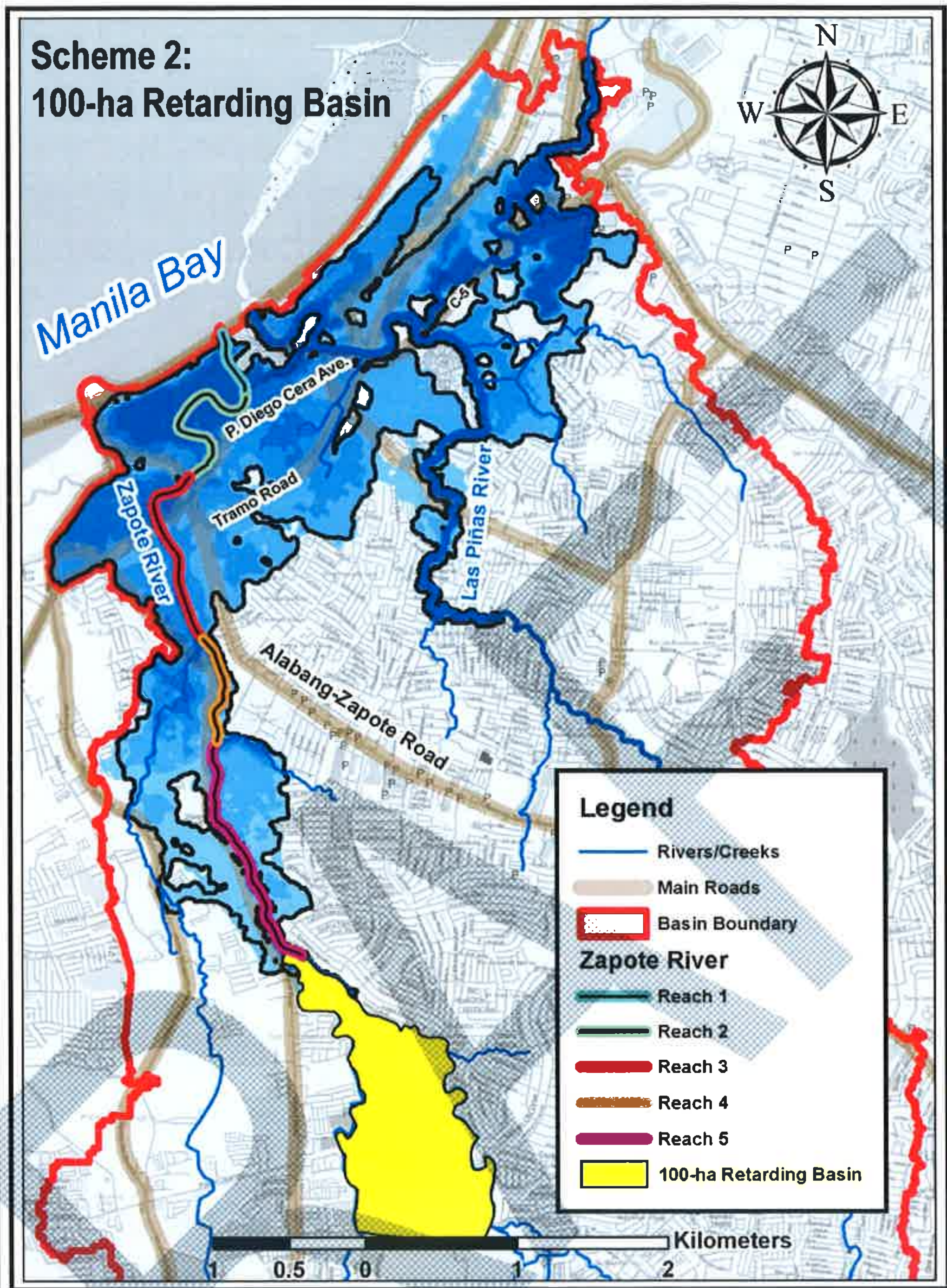
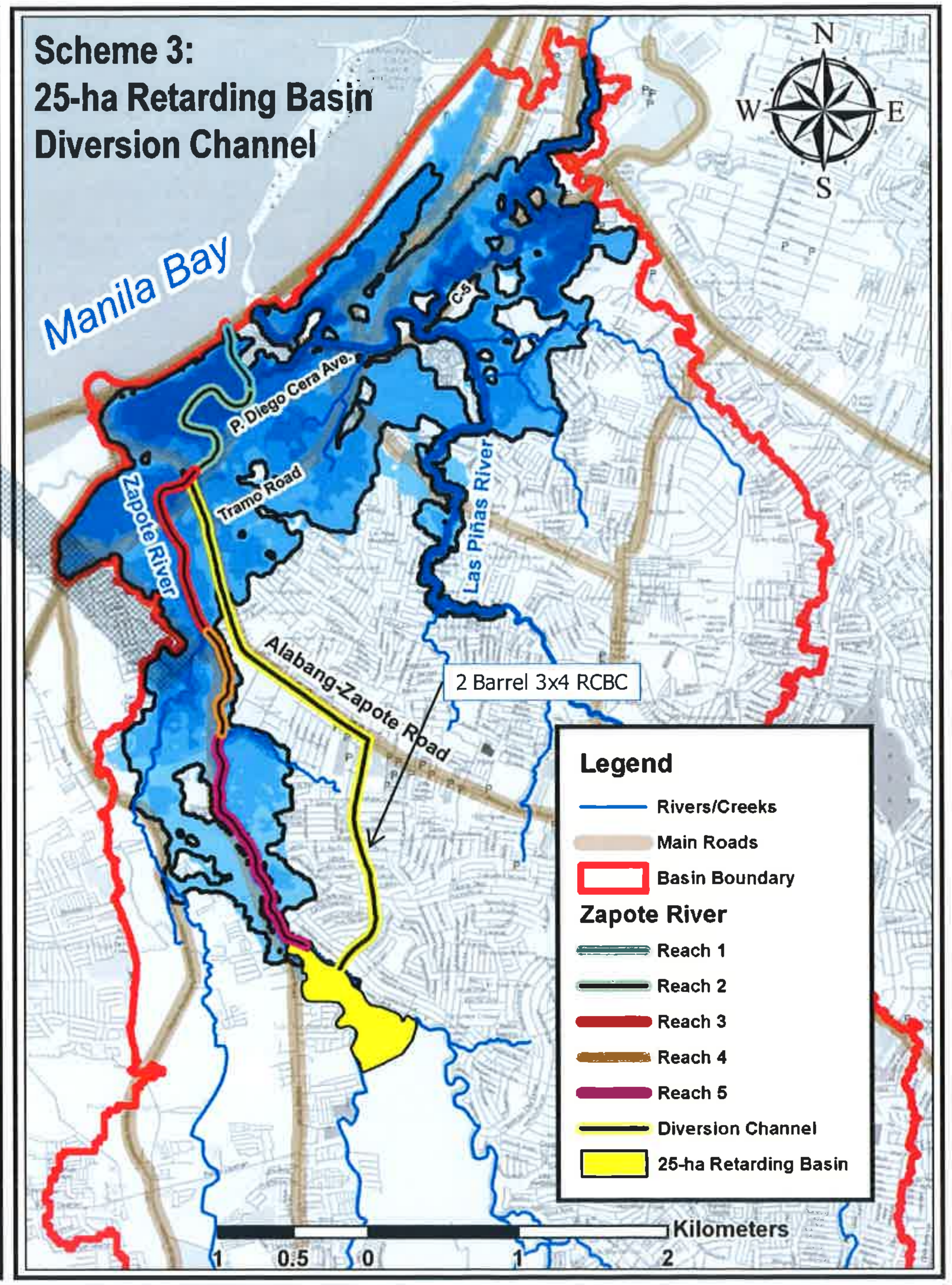
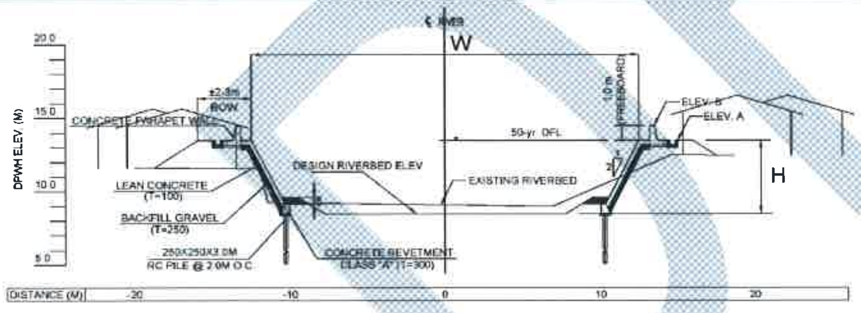






Required River Width Comparison per Scheme



Reach	H (m)	Average Width (m)	Scheme 1		Scheme 2		Scheme 3		Design Riverbed Elev.
			W_{25}	W_{50}	W_{25}	W_{50}	W_{25}	W_{50}	
5	5.5	20	38	43	30	33	36	41	10.5
4	5.0	21	44	50	34	38	42	47	9.9
3	4.5	22	56	64	43	47	53	60	9.4
2	4.0	25	66	77	50	56	69	78	8.8
1	3.5	38	89	103	61	68	85	96	8.2

Cost Comparison per Scheme

Work Items	Scheme 1			Scheme 2			Scheme 3			
	River Improvement		Diversion Channel	River Improvement		Retarding Basin	River Improvement		Retarding Basin	Diversion Channel
	Dredging Excavation	Revetment Works		Dredging Excavation	Revetment Works		Dredging Excavation	Revetment Works		
Cost	908	1331	2178	666	1331	4840	938	1331	1210	2178
Compensation Cost	2850		0	1850		3000	2950		750	0
Bridge Reconstruction Cost	685			685			685			
Total Cost	7952			12372			10042			

Units: Php 1,000,000.00

VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
Zapote-Las Piñas River Improvement

Woodfields Engineers Company

DPWH UPMO FCMC

Recommended River Improvement Schemes for Zapote River

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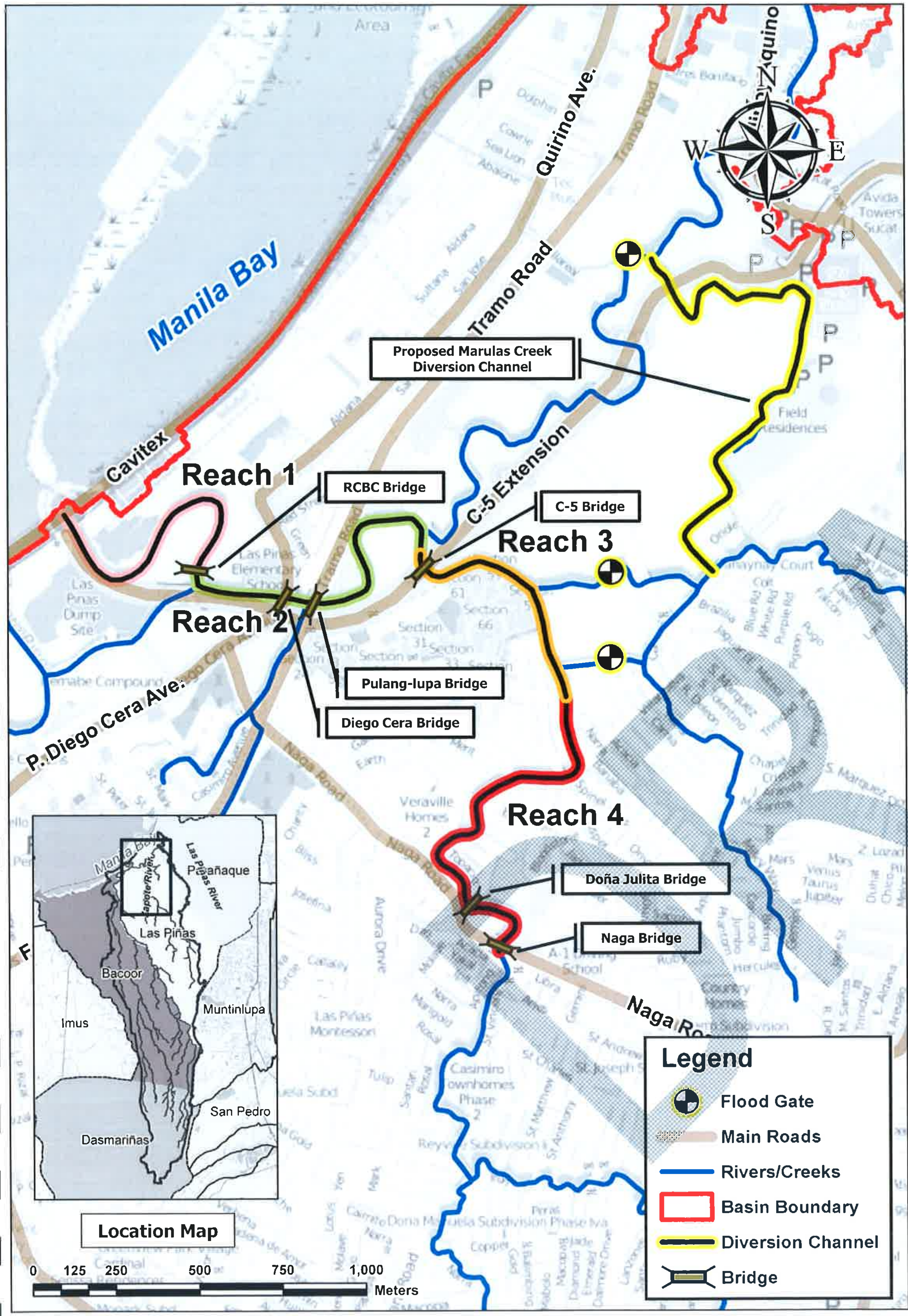
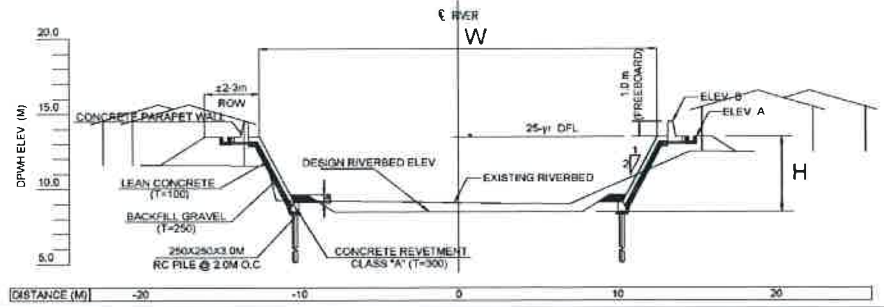


Typical Cross Section

Reach	W (m)	H (m)	Design Riverbed Elev.
Marulas Creek	16.5	4.0	9.8
4	20	4.5	10.5
3	23	4.0	9.8
2	28	3.5	9.5
1	37	3.0	8.9



Las-Piñas River Improvement Works

Package 1

- Reach 2-2 (650 m)
  - Dredging/Excavation
  - Revetment Works
- Pulang-lupa Bridge
  - Bridge Reconstruction
- RCBC Bridge
  - Bridge Reconstruction
- Sandbar
  - Dredging
- Marulas Creek (1600 m)
  - Diversion Channel

Package 2

- Reach 3 (747 m)
  - Dredging/Excavation
  - Revetment Works
- C-5 Bridge
  - Bridge Reconstruction

Package 3

- Reach 4 (1249 m)
  - Dredging/Excavation
  - Revetment Works
- Doña Julita Bridge
  - Bridge Reconstruction
- Naga Bridge
  - Bridge Reconstruction

Package 4

- Reach 1 (918 m)
  - Dredging/Excavation
  - Revetment Works
- Cavitex Bridge
  - Bridge Reconstruction

Package 5

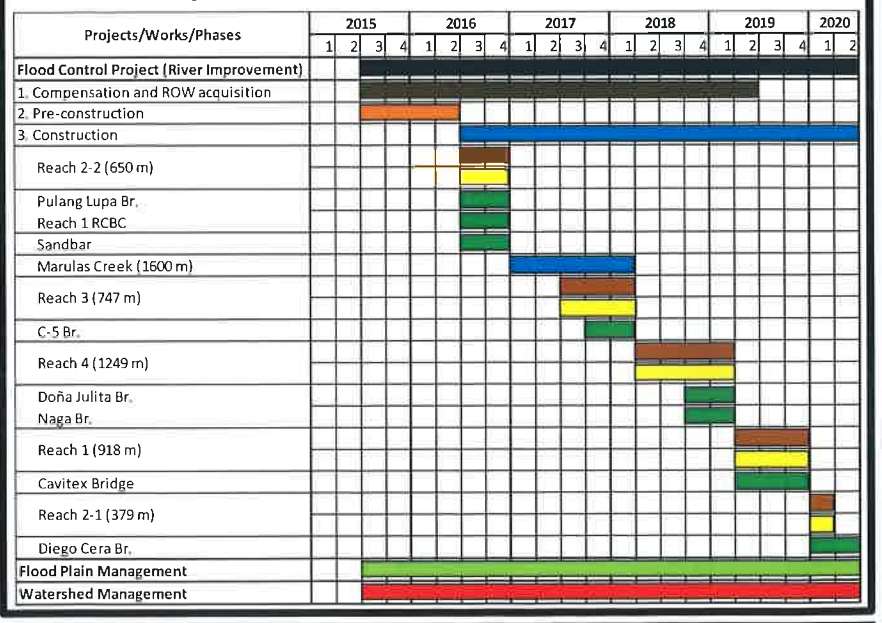
- Reach 2-1 (379 m)
  - Dredging/Excavation
  - Revetment Works
- Diego Cera Bridge
  - Bridge Reconstruction

Project Cost Estimates

Item	Main Civil Works	2015	2016	2017	2018	2019	2020	Total Cost
Reach 2-2	Dredging/Excavation		60					**60**
	Revetment Works		160					**160**
Pulang Lupa Br.	Bridge Reconstruction		85					**85**
Reach 1 RCBC			85					**85**
Sandbar	Dredging		315					**315**
Marulas Creek	Diversion channel			387	157			**544**
Reach 3	Dredging/Excavation			46	23			**69**
	Revetment Works			123	61			**184**
C-5 Br.	Bridge Reconstruction			43	43			**86**
Reach 4	Dredging/Excavation				88	28		**116**
	Revetment Works				232	74		**306**
Doña Julita Br.	Bridge Reconstruction				43	43		**86**
Naga Br.					43	43		**86**
Reach 1	Dredging/Excavation					85		**85**
	Revetment Works					225		**225**
Cavitex Bridge	Bridge Reconstruction					200		**200**
Reach 2-1	Dredging/Excavation						36	**36**
	Revetment Works						94	**94**
Diego Cera Br.	Bridge Reconstruction						85	**85**
Compensation/Land Aqcuisition Cost		220	220	220	220	220		**1100**
Total Cost								**4007**

Units: Php 1,000,000.00

Implementation Schedule



VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA

Zapote-Las Piñas River Improvement

wec Woodfields Engineers Company	DPWH UPMO FCMC	Recommended River Improvement Plan for Las- Piñas River	3/4

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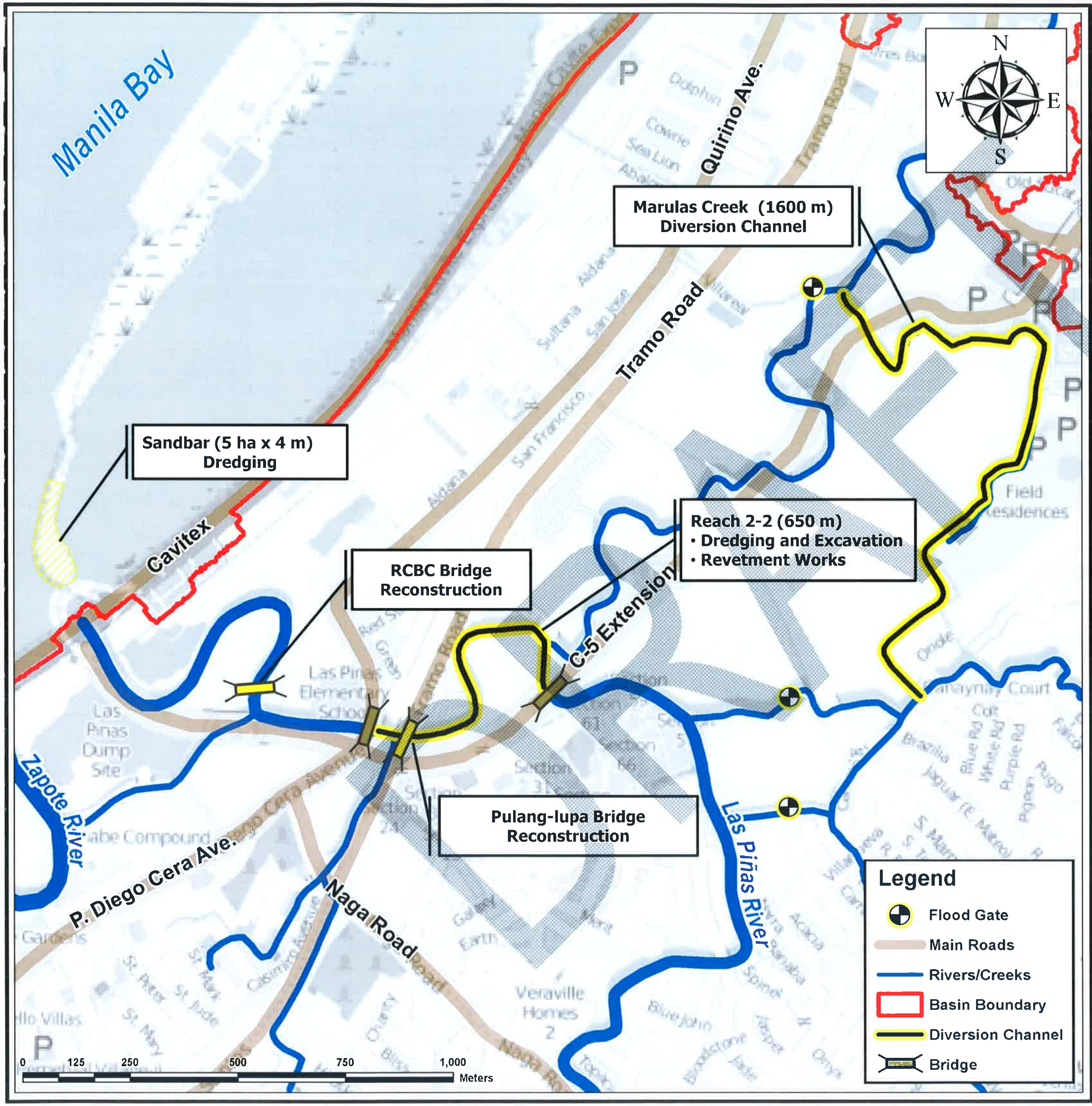
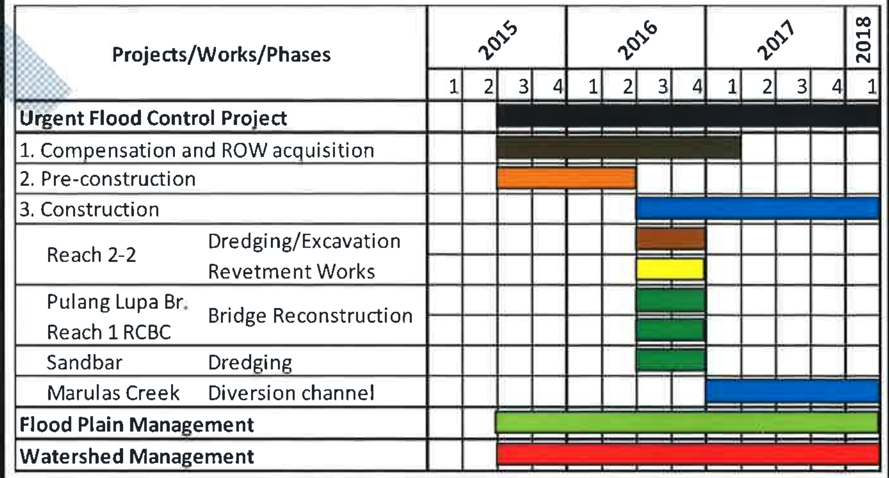


Project Cost Estimates

Item	Main Civil Works	Total Cost
Reach 2-2	Dredging/Excavation	60
	Revetment Works	160
Pulang Lupa Br.	Bridge reconstruction	85
Reach 1 RCBC		85
Sandbar	Dredging	315
Marulas Creek	Diversion channel	544
Compensation/Land Aqcuisition Cost		**440**
Total Cost		**1689**

Units: Php 1,000,000.00

Implementation Schedule



Urgent Works

1. **Dredging and Excavation**
   - **Reach 2-2 (650 m)**
2. **Revetment Works**
   - **Reach 2-2 (650 m)**
3. **Bridge Reconstruction**
   - **RCBC Bridge**
   - **Pulang-lupa Bridge**
4. **Dredging**
   - **Sandbar (5 ha x 4 m)**
5. **Diversion Channel**
   - **Marulas Creek (1600 m)**

VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
Zapote-Las Piñas River Improvement

Urgent Works for Las-Piñas River

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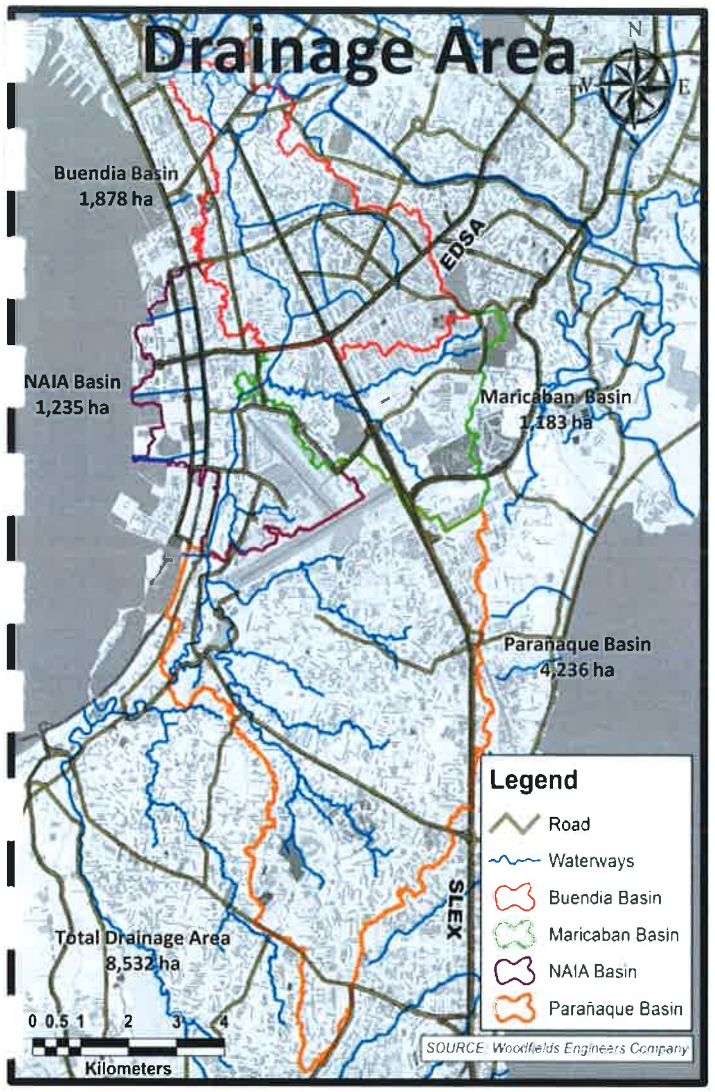
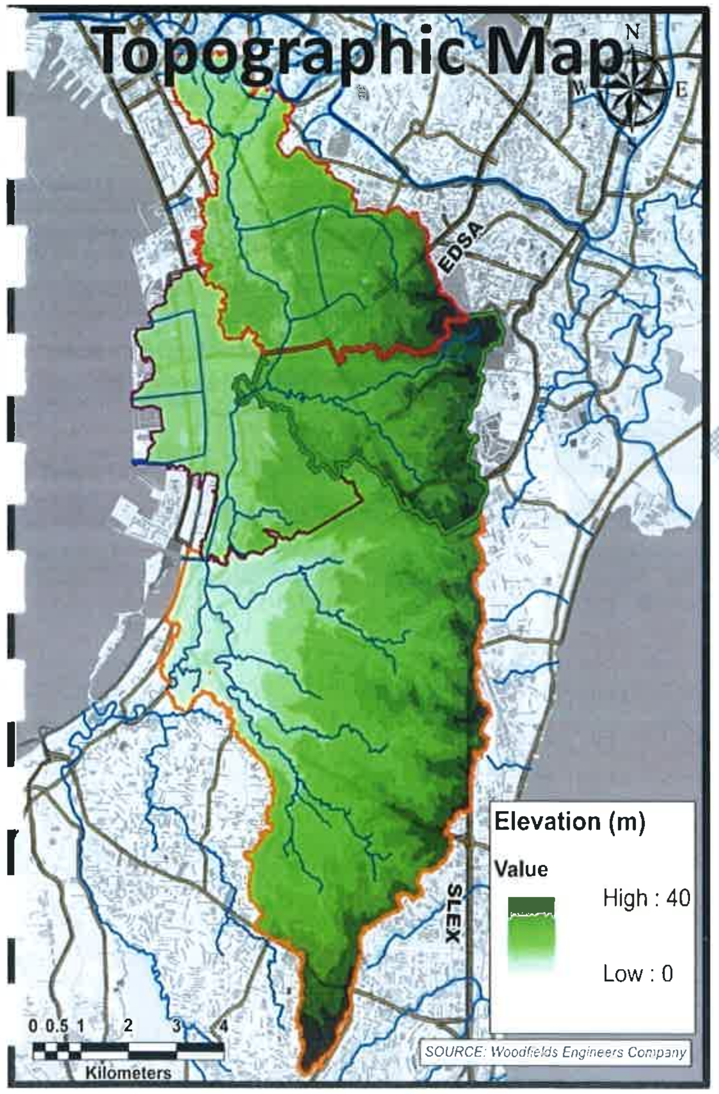
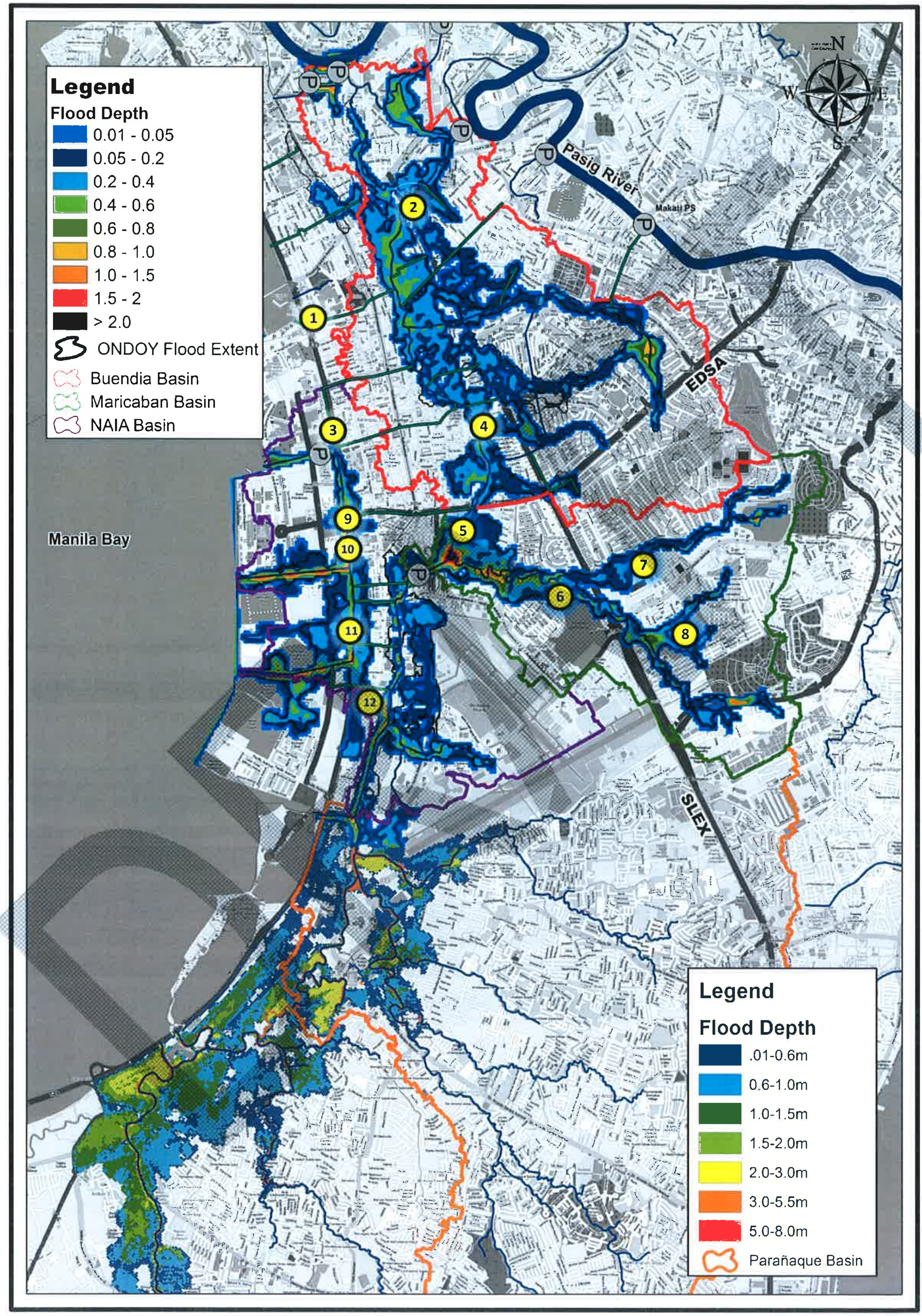
Buendia-Maricaban-NAIA-Parañaque Drainage Improvement Works

Various Flood Control Projects







VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
BUENDIA – MARICABAN – NAIA – PARANAQUE
DRAINAGE IMPROVEMENT WORKS

50-Year Return Period Inundation Map

Woodfields Engineers Company	DPWH UPMO FCMC	1/3

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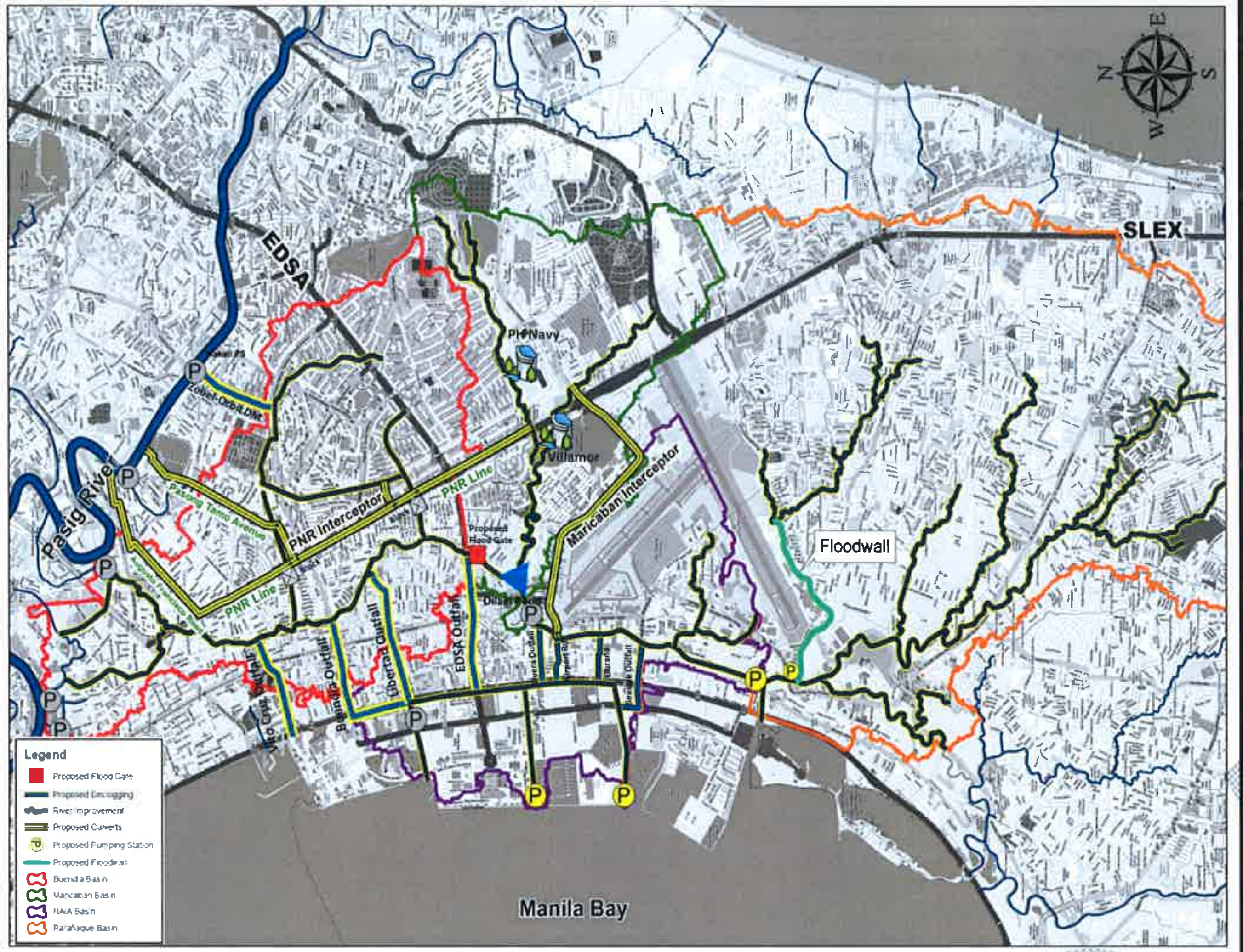
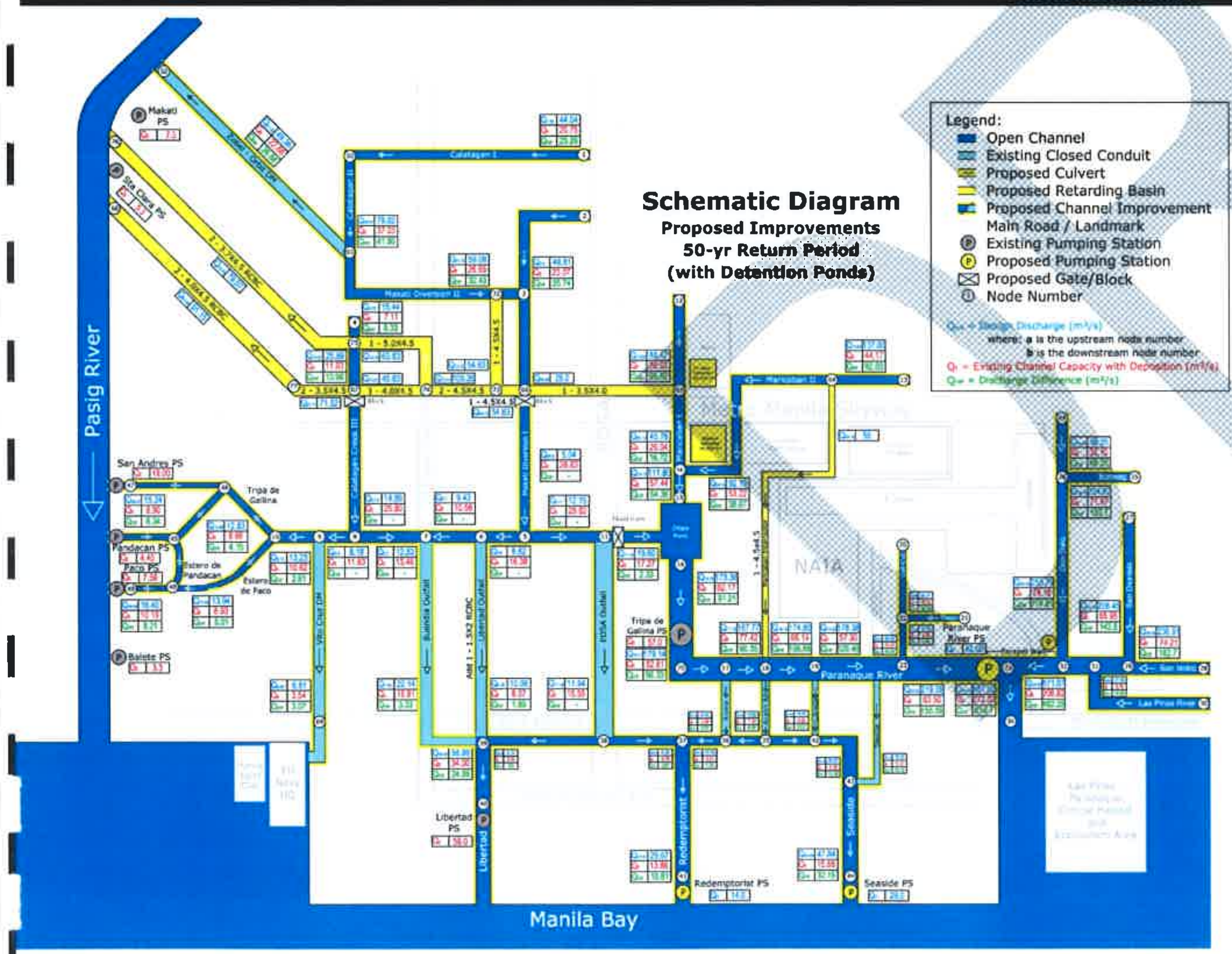




Estimated Project Cost

Buendia Basin		
Work Items	**Quantity**	**Cost (M Php)**
Priority 1. Declogging		**29**
1. Libertad	1,847 m^3	6
2. EDSA	2,450 m^3	6
3. Vito Cruz	264 m^3	5
4. Zobel-Orbit	2,654 m^3	5
5. Buendia	2,886 m^3	7
Priority 2. Dredging		**257**
1. Calatagan Creek I	1,710 m	15
2. Calatagan Creek II	1,000 m	9
3. Calatagan Creek III	2,560 m	23
4. Makati Diversion Channel I	1,083 m	12
5. Makati Diversion Channel II	1,990 m	22
6. Estero de Pandacan	3,123 m	60
7. Estero de Provisor	1,020 m	31
8. Estero de Paco	887 m	15
9. Estero de Tripa de Gallina	4,378 m	69
Priority 3. PNR Interceptor		**6,455**
1. 1 barrel of 3.5x4.0	1850 m	581
2. 1 barrel of 4.5x4.5	658 m	280
3. 2 barrels of 4.5x4.5	1500 m	1,248
4. 1 barrel of 5.0x4.5	560 m	259
5. 1 barrel of 4.0x4.5	115 m	44
6. 2 barrels of 3.7x4.5	2100 m	1,398
7. 2 barrels of 3.5x4.5	730 m	459
8. 2 barrels of 4.0x4.5	3070 m	2,186
Priority 4. Flood Gate		**16**
1. Flood Gate	10x3.0 m	16

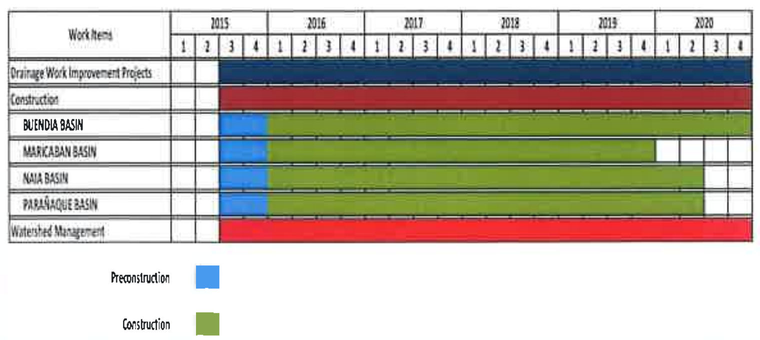
Maricaban Basin		
Work Item	**Quantity**	**Cost (M Php)**
Priority 1.a. Dredging		**206**
1. Maricaban Creek I	2,275 m	48
2. Maricaban Creek II	4052 m	86
3. Maricaban Creek III	4268 m	72
Priority 1.b. Retarding Pond		**119**
1. Villamor Detention	96,000 m^3	65
2. PH Navy	80,000 m^3	54
Priority 3. Maricaban Interceptor		**1,706**
1. 1 Barrel of 4.5 x 4.5	4,012 m	1,706

NAIA Basin		
Work Items	**Quantity**	**Cost (M Php)**
Priority 1. Dredging		**395**
1. Inland Channel	2,760 m	47
2. Libertad Channel	970 m	49
3. Baclaran Channel	1,490 m	68
4. Seaside Channel	1,520 m	49
5. Parañaque Channel	3,650 m	150
6. Cut-cut	1922 m	22
7. Ibayo	1057 m	11
Priority 2. Declogging		**9**
1. Rivera	267 m^3	2
2. Airport Rd	701 m^3	2
3. Librada	324 m^3	2
4. Seaside	55 m^3	3
Priority 3a. Pumping Station		**5,005**
1. Redemptorist PS	14 m^3/s	834
2. Seaside PS	28 m^3/s	1,668
3. Parañaque PS	42 m^3/s	2,502
Priority 3b. Detention Basin		**1,131**
1. Redemptorist PS	104389 m^3	71
2. Seaside PS	106349 m^3	72
3. Parañaque PS	1455271 m^3	988

Parañaque Basin		
Work Items	**Quantity**	**Cost (M Php)**
Priority 1. Dredging		**363**
1. Baliwag	5,000 m	28
2. South Parañaque	793 m	33
3. San Dionisio	2,831 m	26
4. San Isidro	16,809 m	246
5. Don Bosco	2,468 m	31
Priority 2. Parapet Wall		**1,823**
1. Don Galo	5,238 m	1,823
Priority 3. Relief Pumping Station		**60**
1. NAIA PS	1 m^3/s	60

Total Project Cost **Php 17,573 M**

Project Implementation

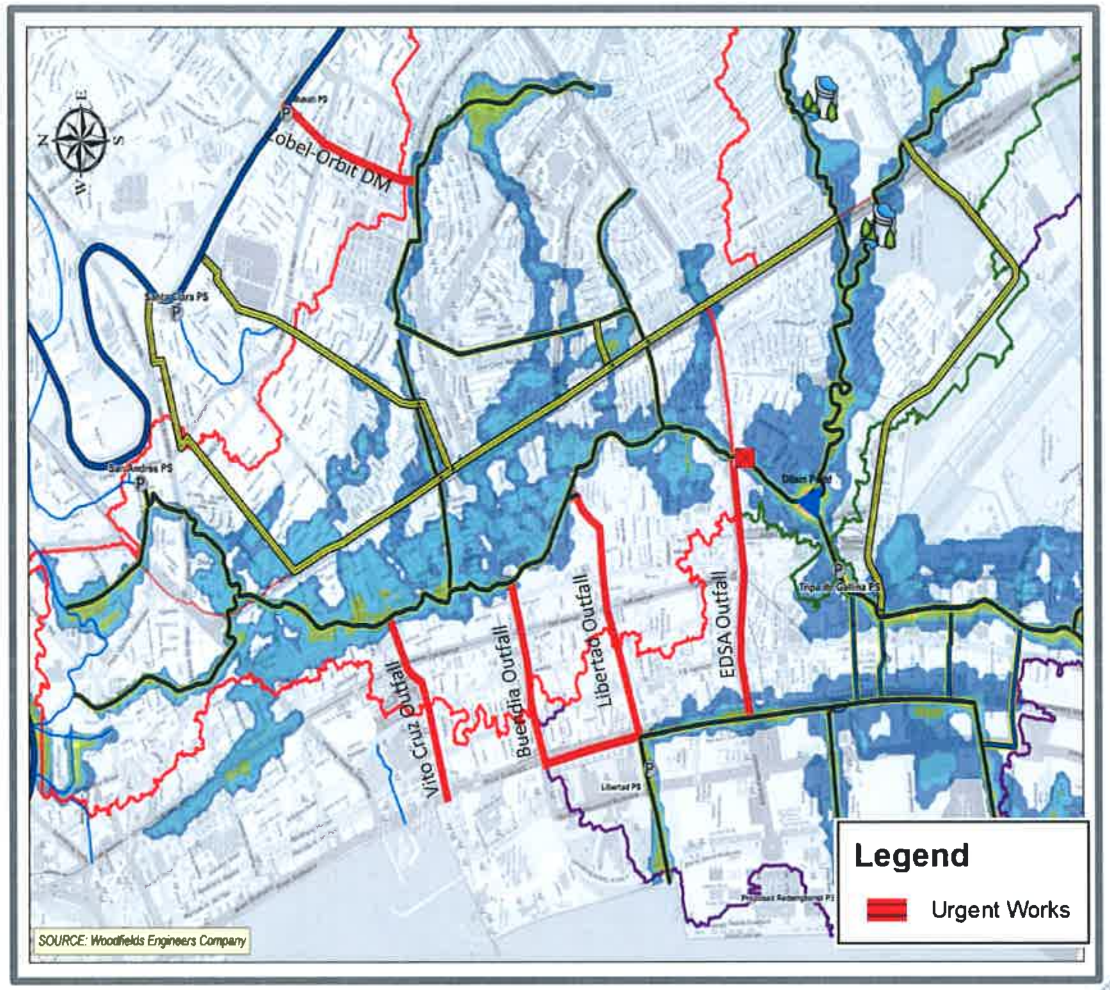


VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
BUENDIA – MARICABAN – NAIA – PARANAQUE
DRAINAGE IMPROVEMENT WORKS

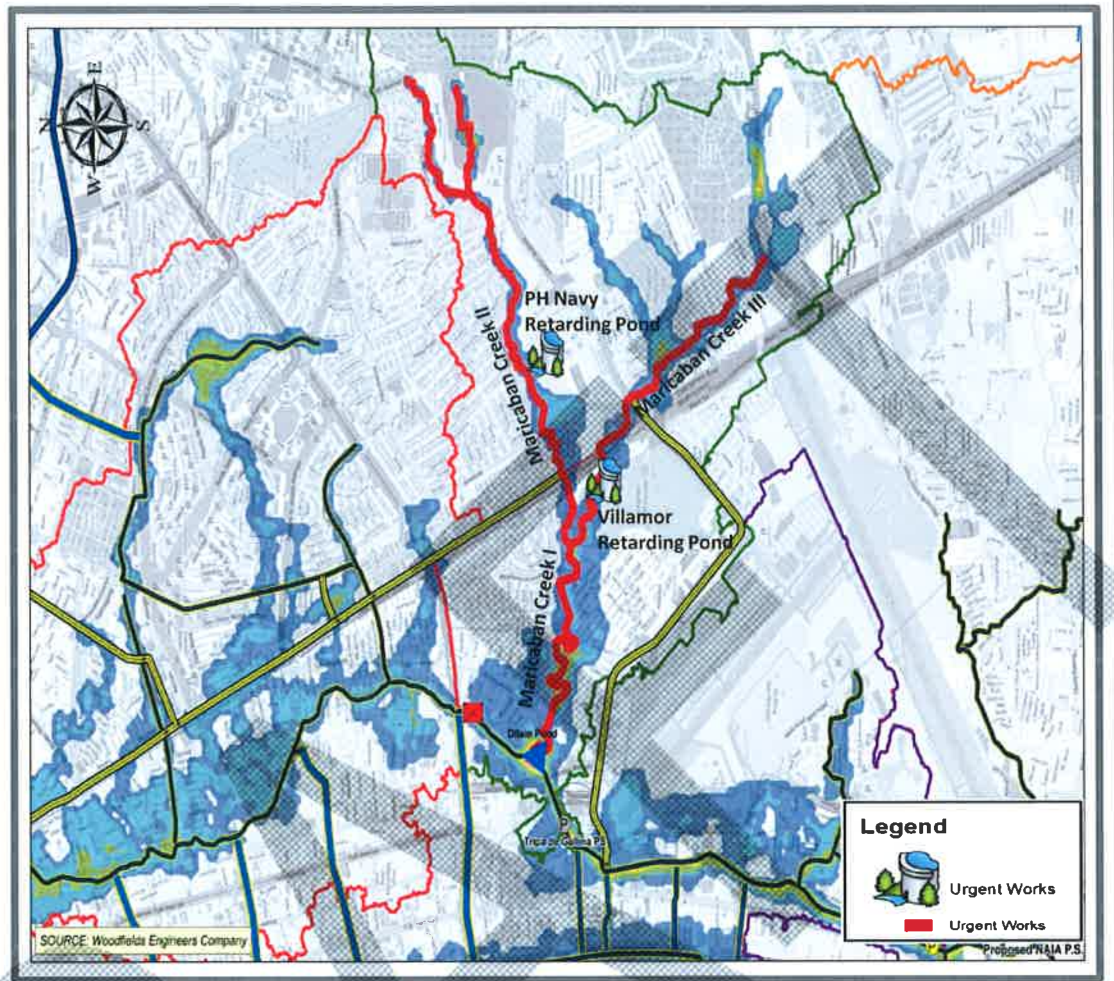
Drainage Improvement Plan
(50-Year Return Period)

Woodfields Engineers Company | DPWH UPMO FCMC | 2/3

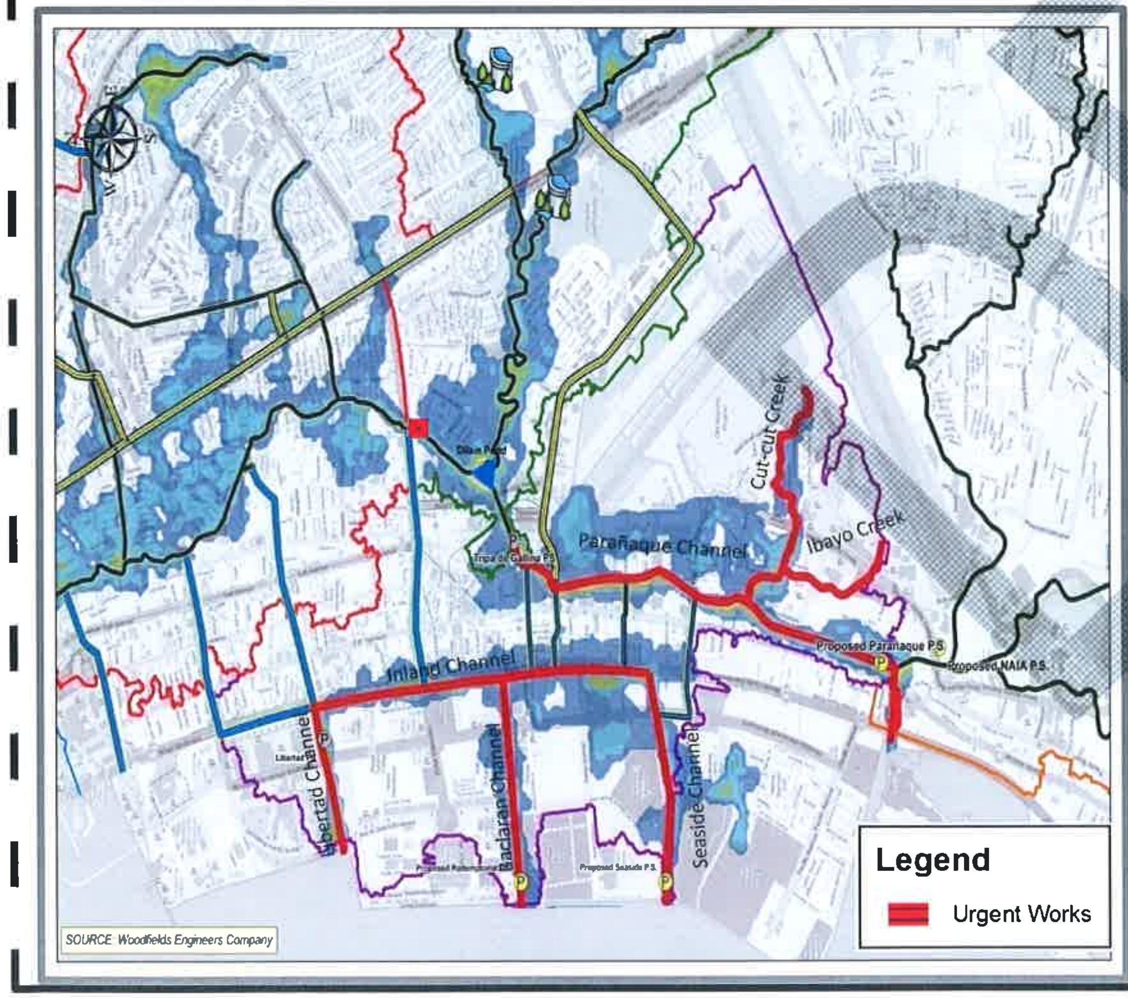
Buendia Basin



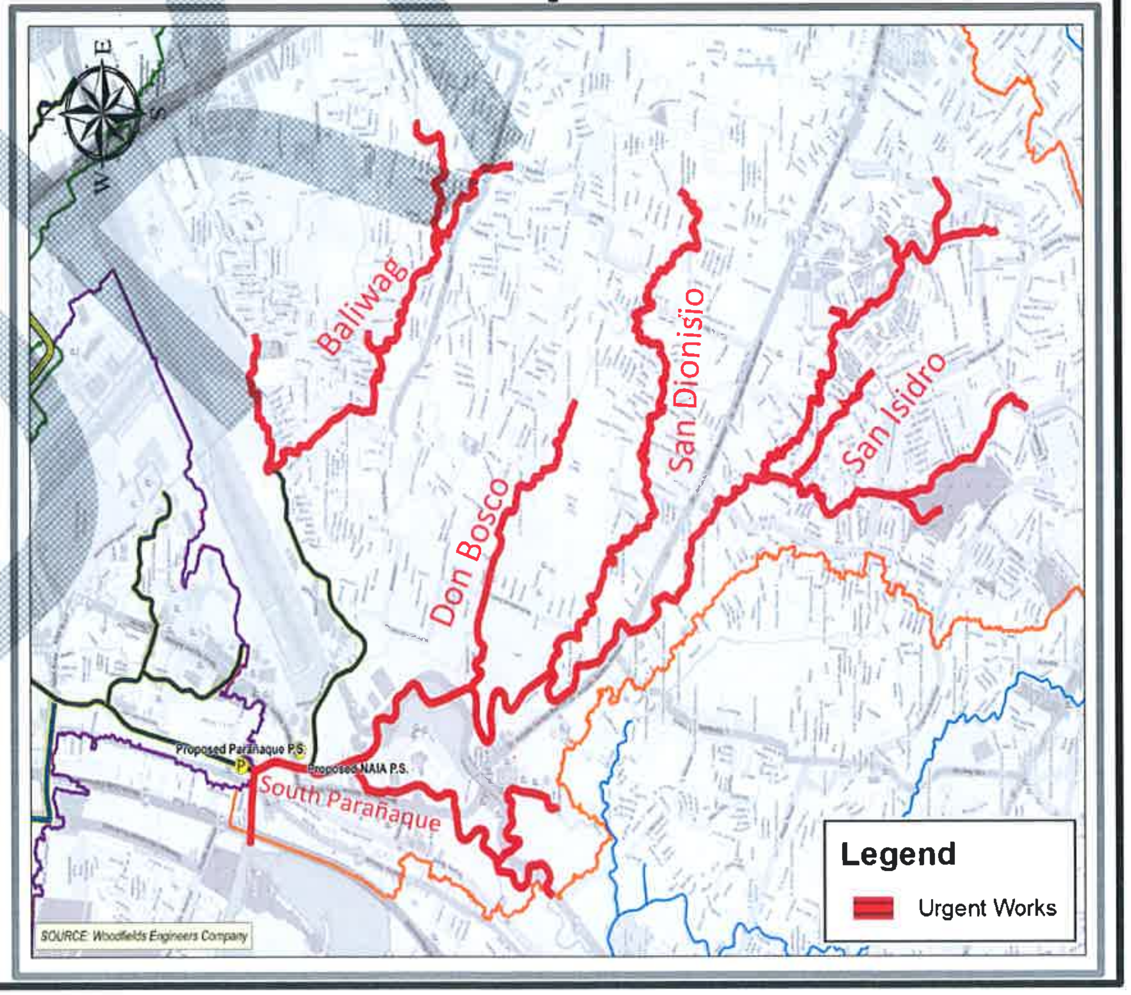
Maricaban Basin



NAIA Basin



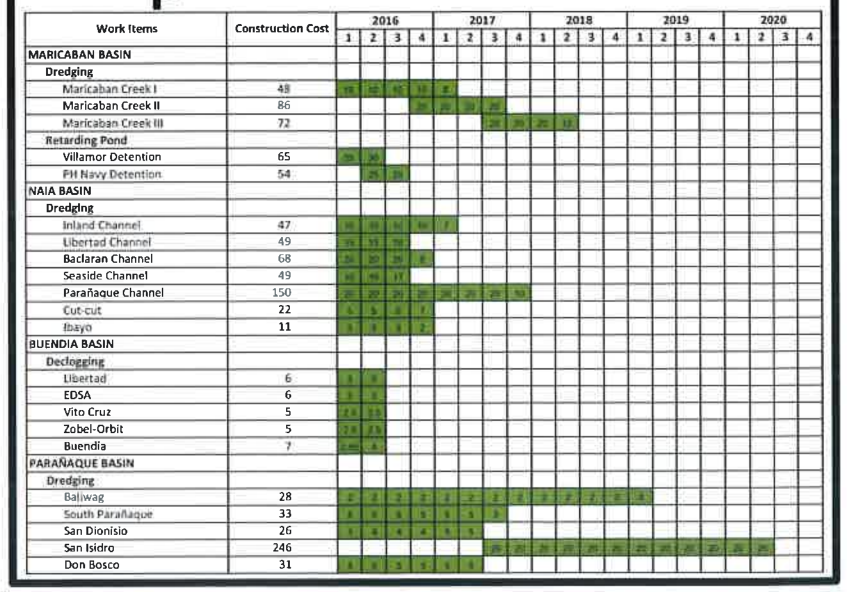
Parañaque Basin



Construction Cost

Work Items	Quantity	Cost (Mil Php)
Buendia Basin		
Declogging		**29**
1. Libertad	1,847 m3	6
2. EDSA	2,450 m3	6
3. Vito Cruz	264 m3	5
4. Zobel-Orbit	2,654 m3	5
5. Buendia	2,886 m3	7
Maricaban Basin		
Dredging		**206**
1. Maricaban Creek I	2,275 m	48
2. Maricaban Creek II	4052 m	86
3. Maricaban Creek III	4268 m	72
Retarding Pond		**119**
1. Villamor Detention	96,000 m^3	65
2. PH Navy	80,000 m^3	54
NAIA Basin		
Dredging		**395**
1. Inland Channel	2,760 m	47
2. Libertad Channel	970 m	49
3. Baclaran Channel	1,490 m	68
4. Seaside Channel	1,520 m	49
5. Parañaque Channel	3,650 m	150
6. Cut-cut	1922 m	22
7. Ibayo	1057 m	11
Parañaque Basin		
Dredging		**363**
1. Baliwag	5000 m	28
2. South Parañaque	793 m	33
3. San Dionisio	2831 m	26
4. San Isidro	16809 m	246
5. Don Bosco	2468 m	31

Implementation Schedule



VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
BUENDIA – MARICABAN – NAIA – PARANAQUE
DRAINAGE IMPROVEMENT WORKS

Urgent Works

Woodfields Engineers Company	DPWH UPMO FCMC	3/3

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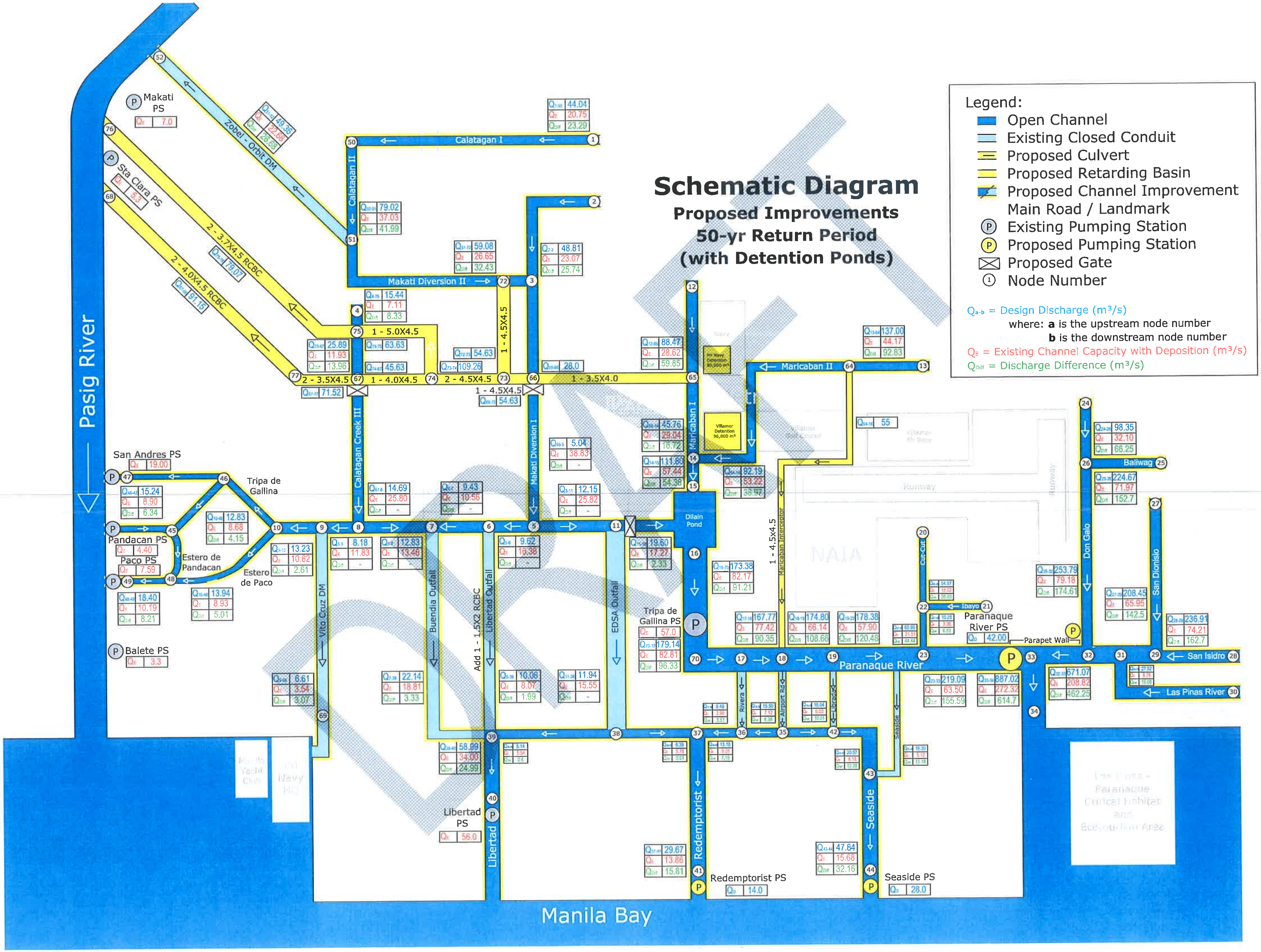
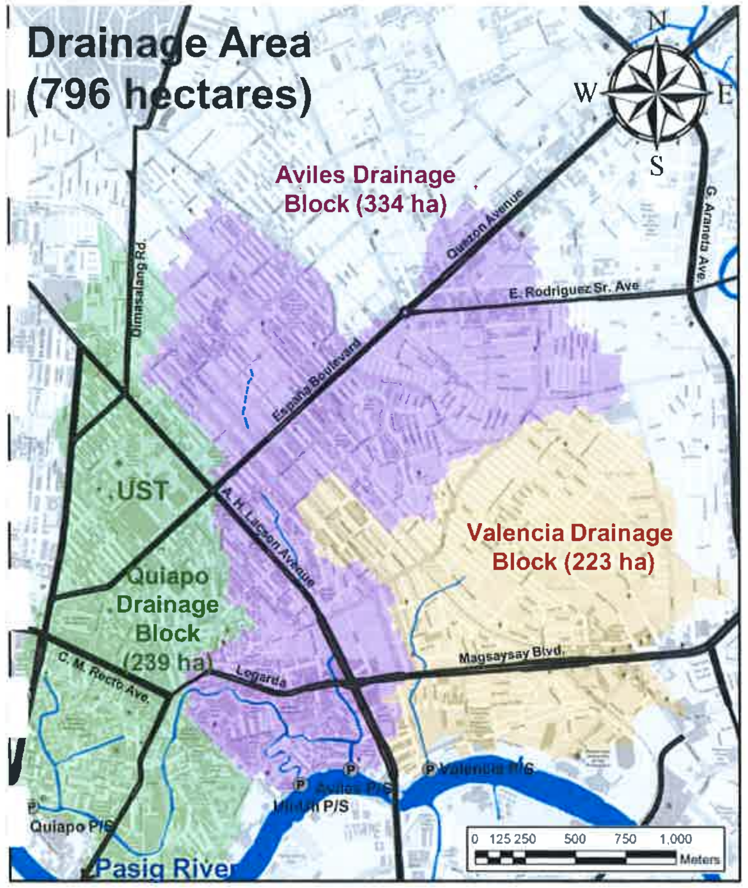
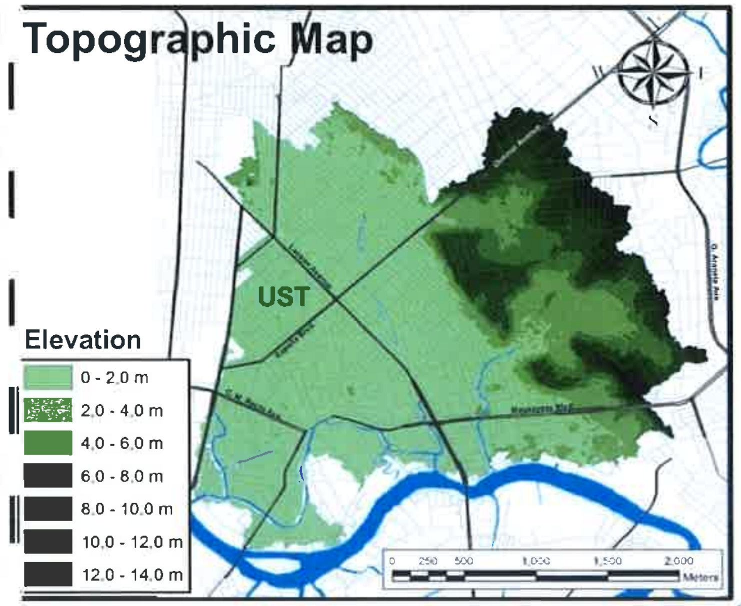


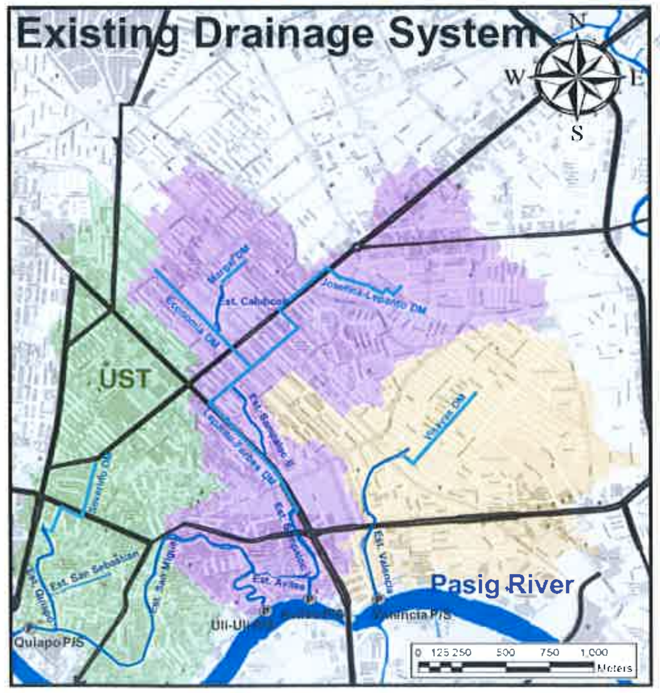
Schematic Diagram
Proposed Improvements
50-yr Return Period
(with Detention Ponds)
Legend:
Open Channel
Existing Closed Conduit
Proposed Culvert
Proposed Retarding Basin
Proposed Channel Improvement
Main Road / Landmark
Existing Pumping Station
Proposed Pumping Station
Proposed Gate
Node Number
Qa-b = Design Discharge (m³/s)
where: a is the upstream node number
b is the downstream node number
QE = Existing Channel Capacity with Deposition (m³/s)
QDiff = Discharge Difference (m³/s)
Pasig River
Manila Bay
Makati PS
Sta Clara PS
San Andres PS
Pandacan PS
Paco PS
Balete PS
Tripa de Gallina
Estero de Pandacan
Estero de Paco
Zobel - Orbit DM
2 - 3.7X4.5 RCBC
2 - 4.0X4.5 RCBC
Calatagan I
Calatagan II
Calatagan Creek III
Makati Diversion I
Makati Diversion II
1 - 5.0X4.5
2 - 3.5X4.5
1 - 4.0X4.5
2 - 4.5X4.5
1 - 4.5X4.5
1 - 3.5X4.0
1 - 4.5X4.5
Maricaban I
Maricaban II
Maricaban Interceptor
Dilain Pond
Villamor Detention 96,000 m³
Runway
NAIA
Vito Cruz DM
Buendia Outfall
Add 1 - 1.5X2 RCBC
Libertad Outfall
EDSA Outfall
Tripa de Gallina PS
Libertad PS
Libertad
Redemptorist
Redemptorist PS
Seaside
Seaside PS
Paranaque River
Paranaque River PS
Parapet Wall
Ibayo
Don Galo
Baliwag
San Dionisio
San Isidro
Las Pinas River
Rivera
Airport Rd
Lubrado
Manila Yacht Club
Old Navy HQ
Las Pinas - Paranaque Critical Habitat and Ecotourism Area
DRAFT

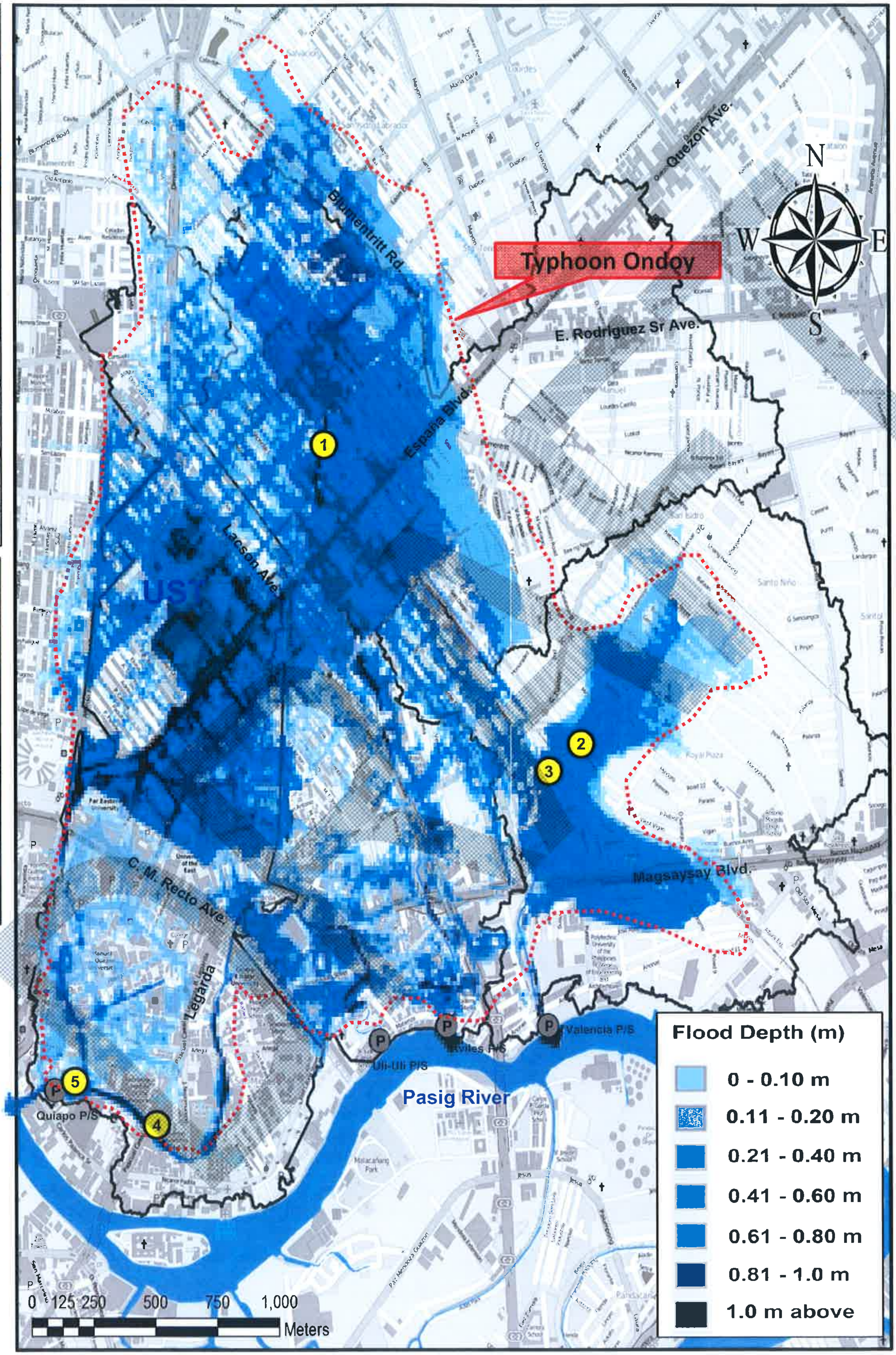
España-UST
Drainage Improvement Works

Various Flood Control Projects









Existing Conditions

Other Causes of Flooding

1. Siltation & garbage deposition inside the existing drainage mains
2. Raising of roads resulting to alteration of ground surface/topography
3. Upward invert slope of within drainage mains resulting to inadequacy
4. Undersized design of drainage mains

VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA

ESPAÑA-UST DRAINAGE IMPROVEMENT WORKS

50-Year Return Period Inundation Map

Woodfields Engineers Company | DPWH UPMO FCMC | 1/3

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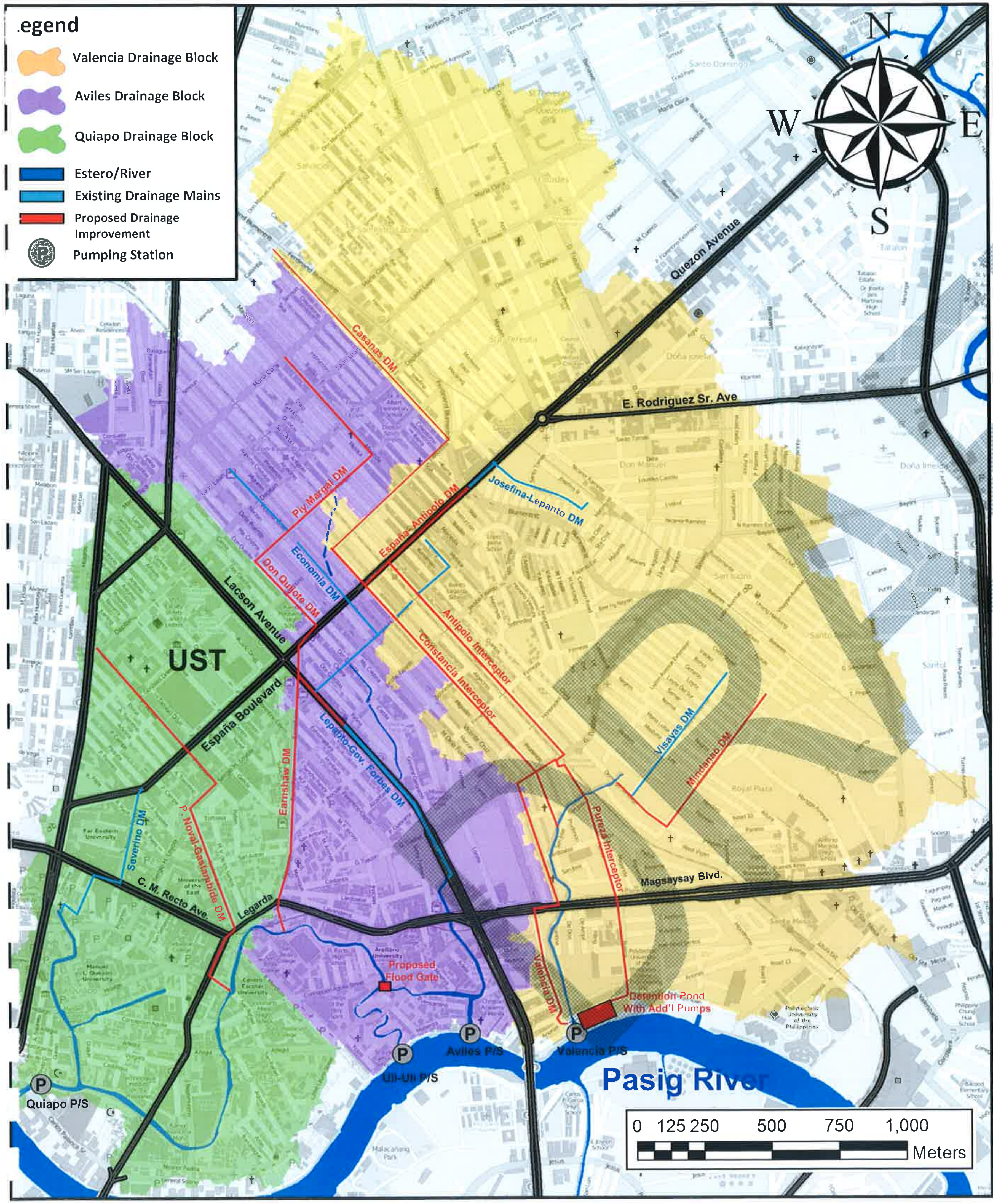

Project Cost of Proposed Drainage Improvement Plan

VALENCIA DRAINAGE BLOCK	
WORK ITEM	ESTIMATED COST (in Million Pesos)
A. ADD'L DRAINAGE MAINS	
Mindanao DM	219.40
España-Antipolo DM	189.04
Antipolo Interceptor	540.03
Constancia Interceptor	541.48
Pureza Interceptor	542.30
Valencia DM	278.45
Casanas DM	397.90
B. DECLOGGING	
Visayas DM	4.34
Josefina-Lepanto DM	3.54
C. DREDGING	
Estero de Valencia with Widening	15.27
D. DETENTION AREA	225.94
E. ADDITIONALPUMPS	2502.47
F. BRIDGE RECONSTRUCTION	77.75
TOTAL	5537.91

AVILES DRAINAGE BLOCK	
WORK ITEM	ESTIMATED COST (in Million Pesos)
A. ADD'L DRAINAGE MAINS	
Piy Margal Extension DM	170.64
Don Quijote DM	187.94
Lacson DM	30.81
Earnshaw DM	240.16
B. DECLOGGING	
Economia DM	2.72
Piy Margal DM	0.72
Lepanto - Gov. Forbes DM	7.06
C. DREDGING	
Estero de Calubcob	0.91
Estero de Sampaloc I	5.86
Estero de San Miguel	38.53
D. RECONSTRUCTION	
Lepanto - Gov. Forbes DM	180.41
E. FLOOD GATE	17.60
TOTAL	883.36

QUIAPO DRAINAGE BLOCK	
WORK ITEM	ESTIMATED COST (in Million Pesos)
A. ADD'L DRAINAGE MAINS	
P. Noval-Gastambide DM	393.11
B. DECLOGGING	
Severino DM	3.35
C. DREDGING	
Estero de Quiapo	22.10
TOTAL	418.57

GRAND TOTAL: Php 6.84 B

Implementation Schedule

Projects/Works/Phases	CONSTRUCTION COST	PROJECT DURATION																			
		2015				2016				2017				2018				2019			
ESPAÑA-UST DRAINAGE IMPROVEMENT	(in Php Million)	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
I. Valencia Drainage Block																					
1 Dredging of Esteros	16			8	8																
2 Declogging of Existing Drainage Mains	8			4	4																
4 Detention Pond	113			16	16	16	16	16	16	16											
5 Bridge Reconstruction	78						19	19	19	19											
6 Installation of Add'l Pumping Stations	2502						626	626	626	626											
7 Pureza Interceptor	542								77	77	77	77	77	77	77						
8 Valencia DM	278										56	56	56	56	56						
9 Mindanao DM	219														110	110					
10 Antipolo Interceptor	540														135	135	135	135			
11 Constancia Interceptor	541			135	135	135	135														
12 España-Antipolo DM	189																		189		
13 Casanas DM	398																			199	199
II. Aviles Drainage Block																					
1 Dredging of Esteros	45			23	23																
2 Declogging of Existing Drainage Mains	11			11																	
3 Earnshaw DM	240			120	120																
4 Rehabilitation of Lepanto-Forbes DM	180				180																
5 Lacson DM	31					31															
6 Don Quijote DM	188													94	94						
7 Piy Margal DM	171															171					
8 Flood Gate	18															9	9				
III. Quiapo Drainage Block																					
1 Dredging of Esteros	22			7	7	7															
2 Declogging of Existing Drainage Mains	3			2	2																
3 Gastambide DM	393							66	66	66	66	66	66								
COMPENSATION COST	113																				
TOTAL	6840																				

VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA

ESPAÑA-UST DRAINAGE IMPROVEMENT WORKS

Recommended Drainage Improvement Plan (50-year Return Period)

Woodfields Engineers Company

DPWH UPMO FCMC

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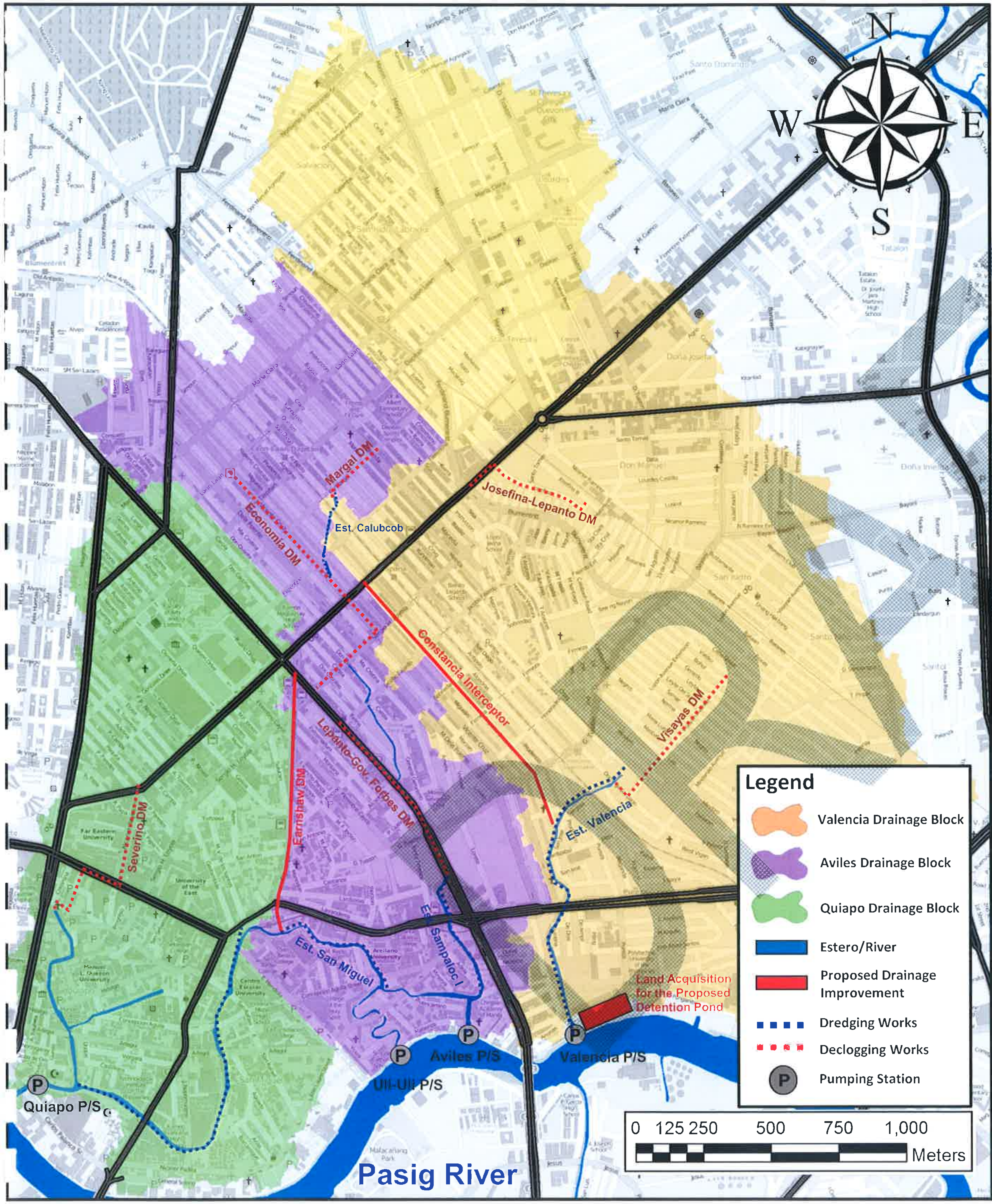

Project Cost for Urgent Works

WORK ITEM	Estimated Cost (in Million Pesos)
I. Valencia Drainage Block	
1. Dredging of Esteros	
a. Estero de Valencia	15.3
2. Declogging of Drainage Mains	
a. Josefina-Lepanto DM	3.54
b. Visayas DM	4.34
3. Land Acquisition for Detention Pond	205.8
4. Constancia Interceptor	541.5
5. Additional Pumps	2,500
II. Aviles Drainage Block	
1. Dredging of Esteros	
a. Estero de Calubcob	0.91
b. Estero de Sampaloc I	5.86
c. Estero de San Miguel	38.53
2. Declogging of Drainage Mains	
a. Economia DM	2.72
b. Margal DM	0.72
c. Lepanto-Forbes DM	7.06
4. Earnshaw DM	240.2
5. Reconstruction of Lepanto-Forbes DM	180.4
6. Lacson DM	30.8
III. Quiapo Drainage Block	
1. Dredging of Esteros	
a. Estero de Quiapo	22.1
2. Declogging of Drainage Mains	
a. Severino DM	3.4
TOTAL	3,802.80

Implementation Schedule for Urgent Works

Projects/Works/Phases	CONSTRUCTION COST	PROJECT DURATION							
		2015				2016			
ESPAÑA-UST DRAINAGE IMPROVEMENT	(in Php Million)	1	2	3	4	1	2	3	4
I. Valencia Drainage Block									
1 *Dredging of Esteros*	15.3			7.65	7.65				
2 *Declogging of Existing Drainage Mains*	7.9			3.95	3.95				
4 *Land Acquisition for Detention Pond*	205.8			51.45	51.45	51.45	51.45		
5 *Installation of Add'l Pumps*									
5a Package 1	833.20						833.2		
5b Package 2	833.20							833.2	
5c Package 3	833.20								833.2
6 Constancia Interceptor	541.5			135.38	135.38	135.38	135.38		
II. Aviles Drainage Block									
1 *Dredging of Esteros*	45.3			22.65	22.65				
2 *Declogging of Existing Drainage Mains*	10.5			10.5					
3 *Earnshaw DM*	240.2			120.1	120.1				
4 *Rehabilitation of Lepanto-Forbes DM*	180.4				180.4				
5 *Lacson DM*	30.8					30.8			
III. Quiapo Drainage Block									
1 *Dredging of Esteros*	22.1			7.3667	7.3667	7.3667			
2 *Declogging of Existing Drainage Mains*	3.4			1.7	1.7				
TOTAL	3802.80								

VARIOUS FLOOD CONTROL PROJECTS
IN METRO MANILA
ESPAÑA-UST DRAINAGE IMPROVEMENT WORKS

Urgent Works

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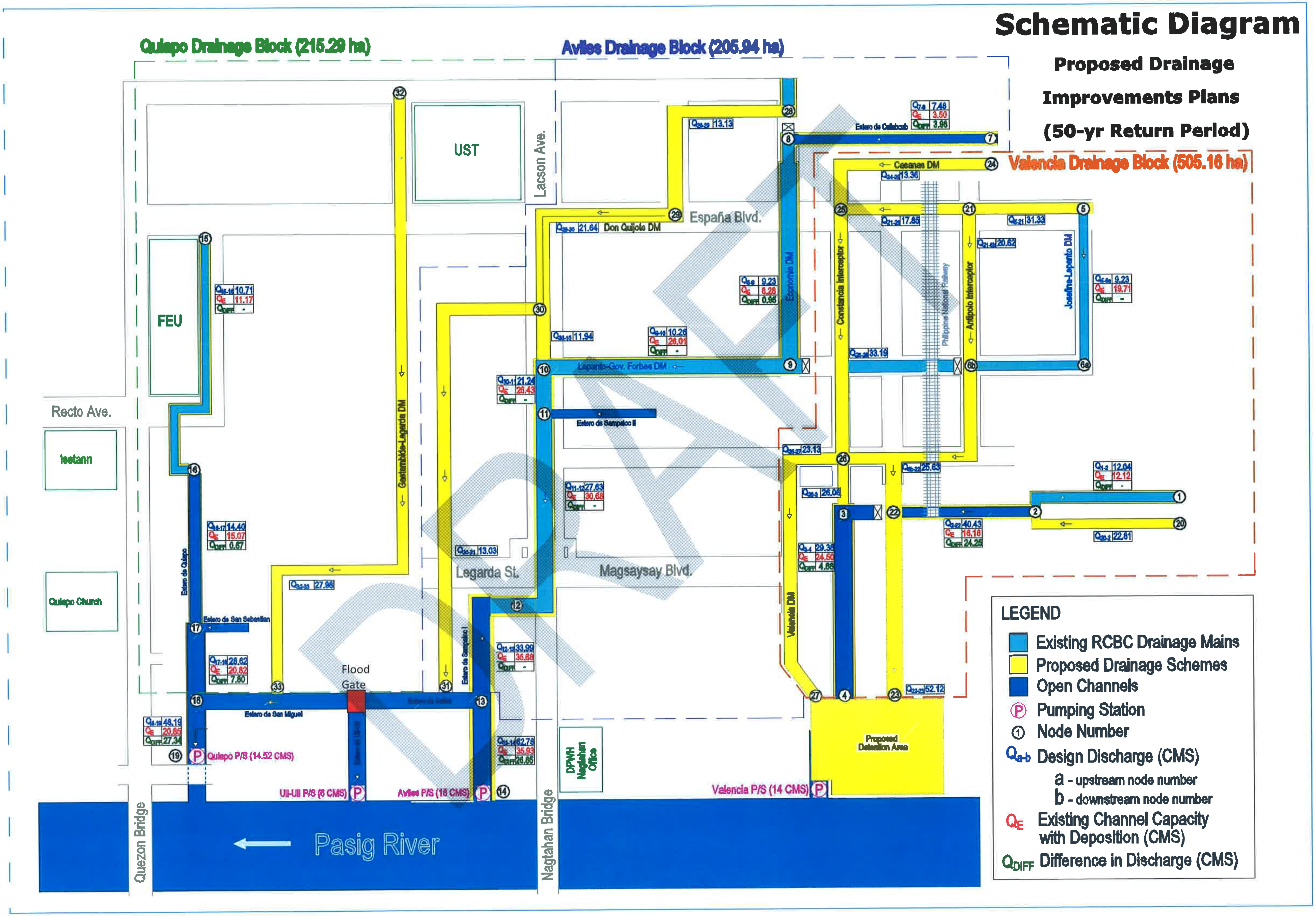
Schematic Diagram

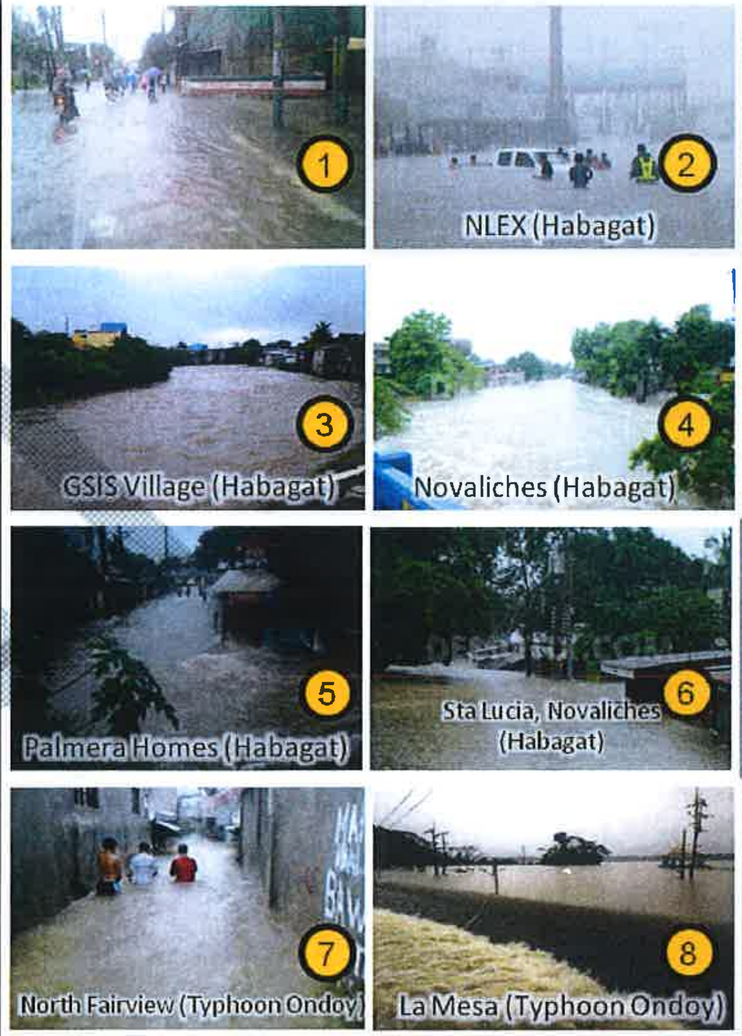
Proposed Drainage Improvements Plans (50-yr Return Period)



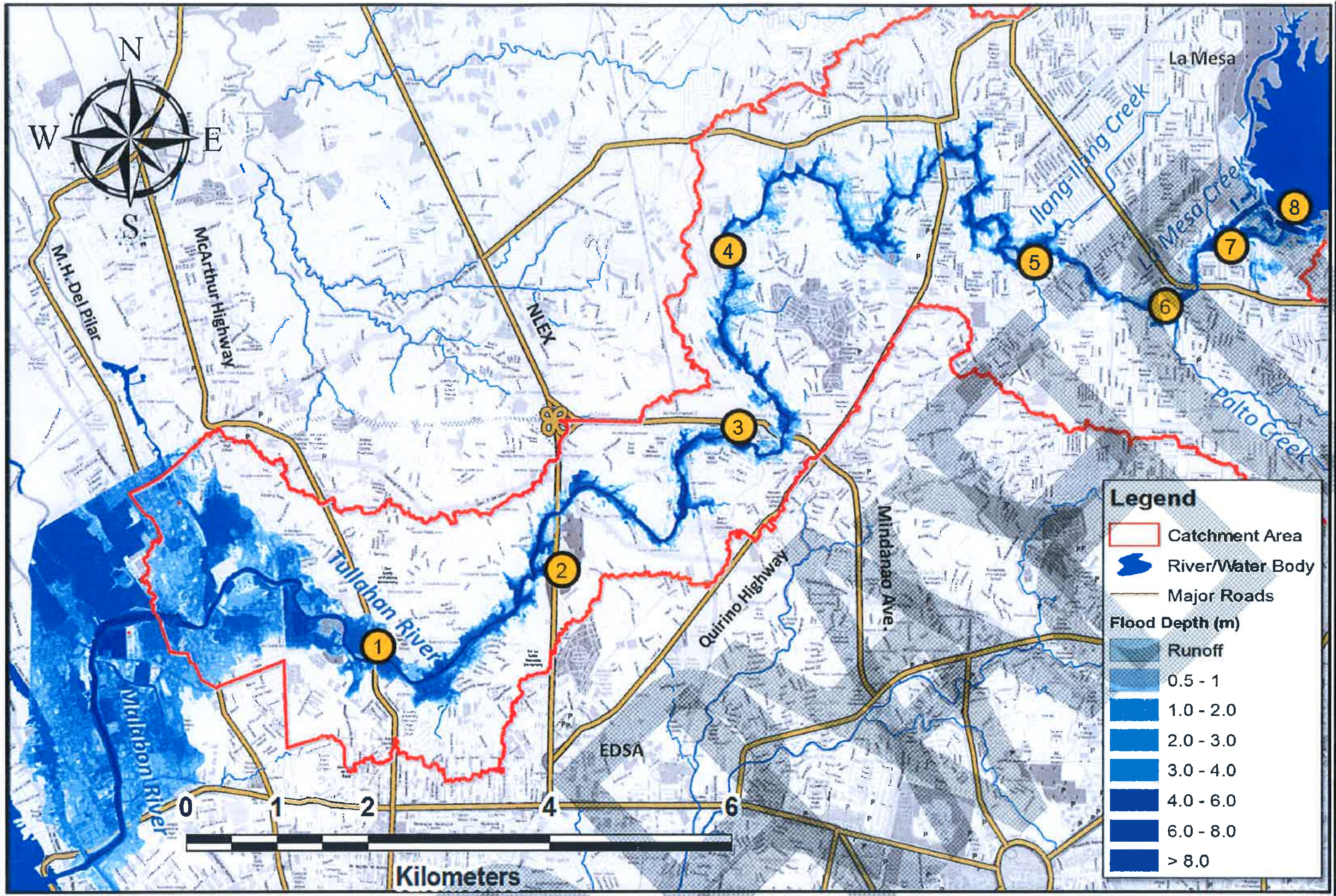
Tullahan River Improvement Works

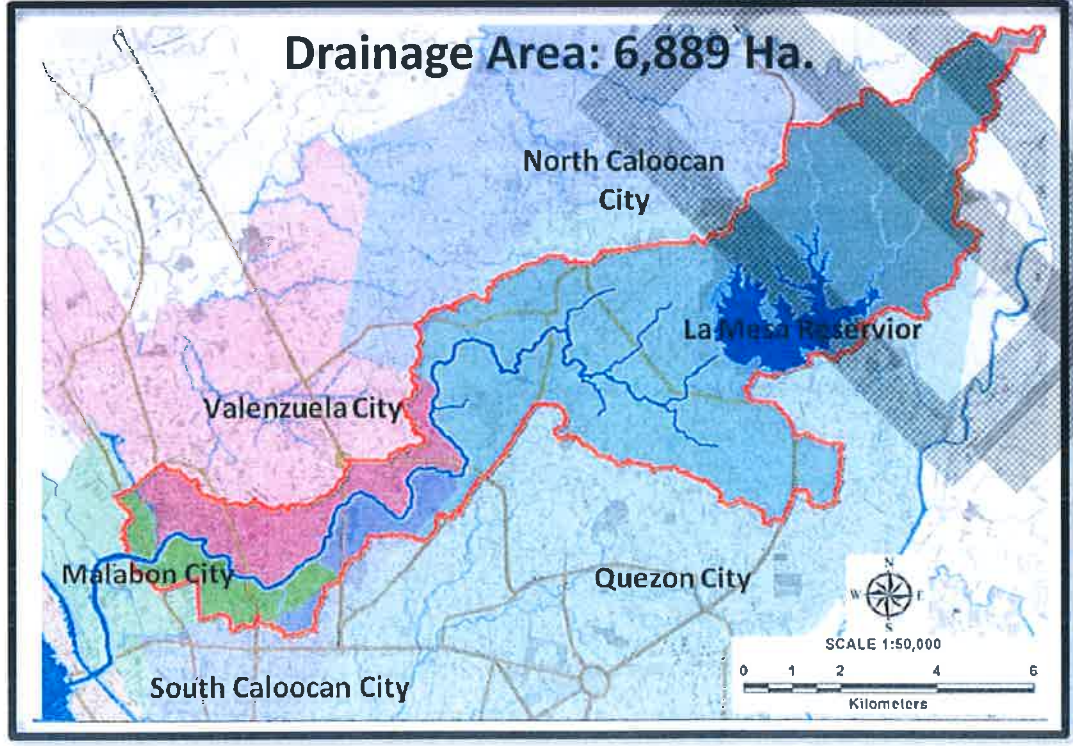
Various Flood Control Projects

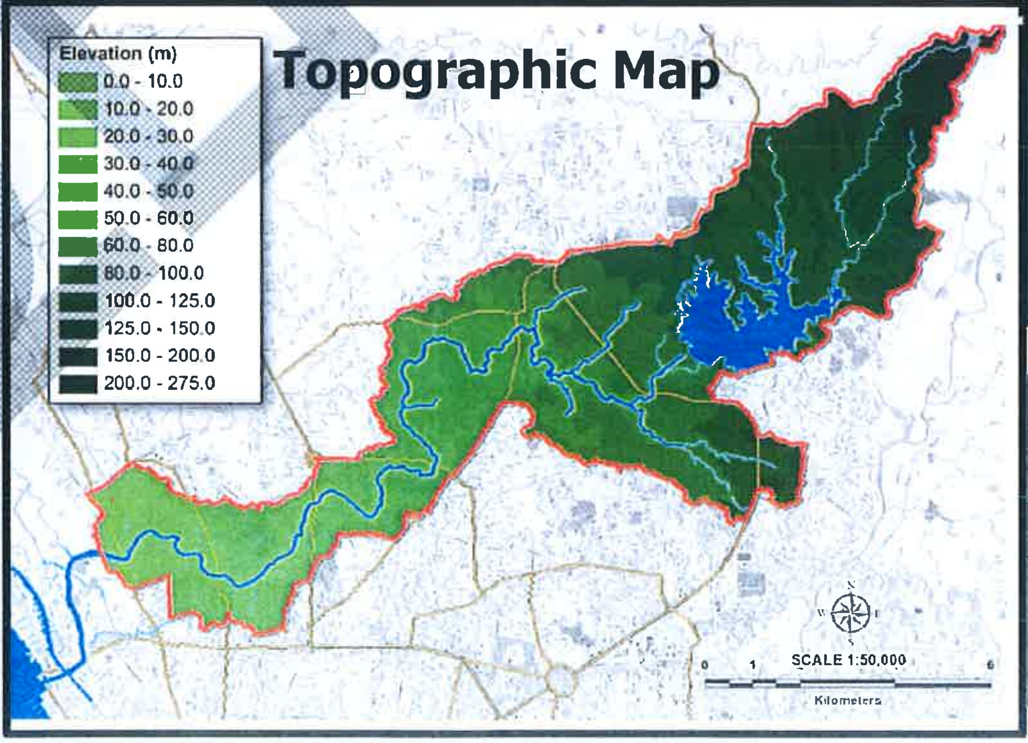
FLOOD CONDITION



CAUSES OF FLOOD







VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
Tullahan River Improvements Works

Inundation Map (100 year return period)

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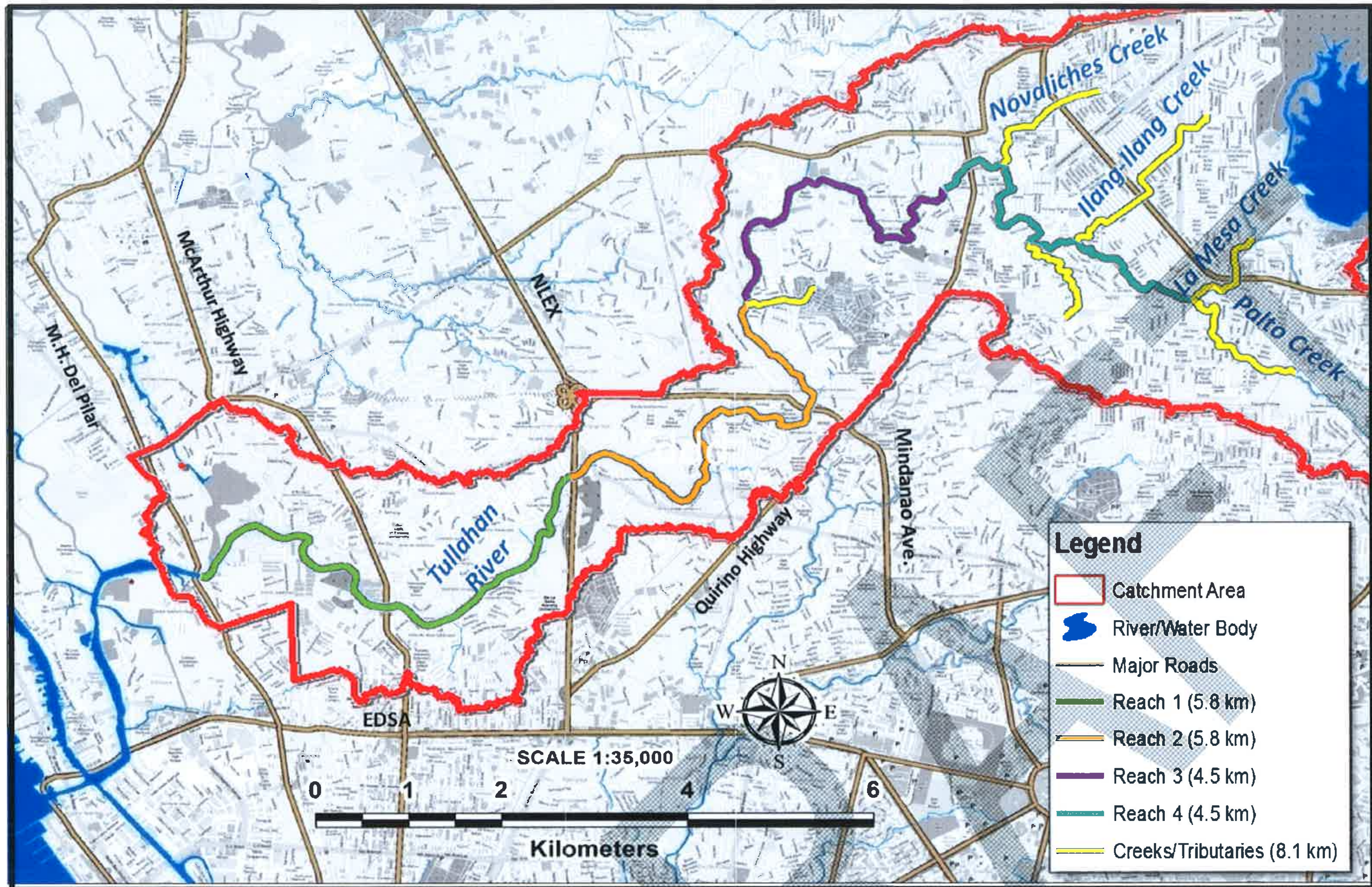
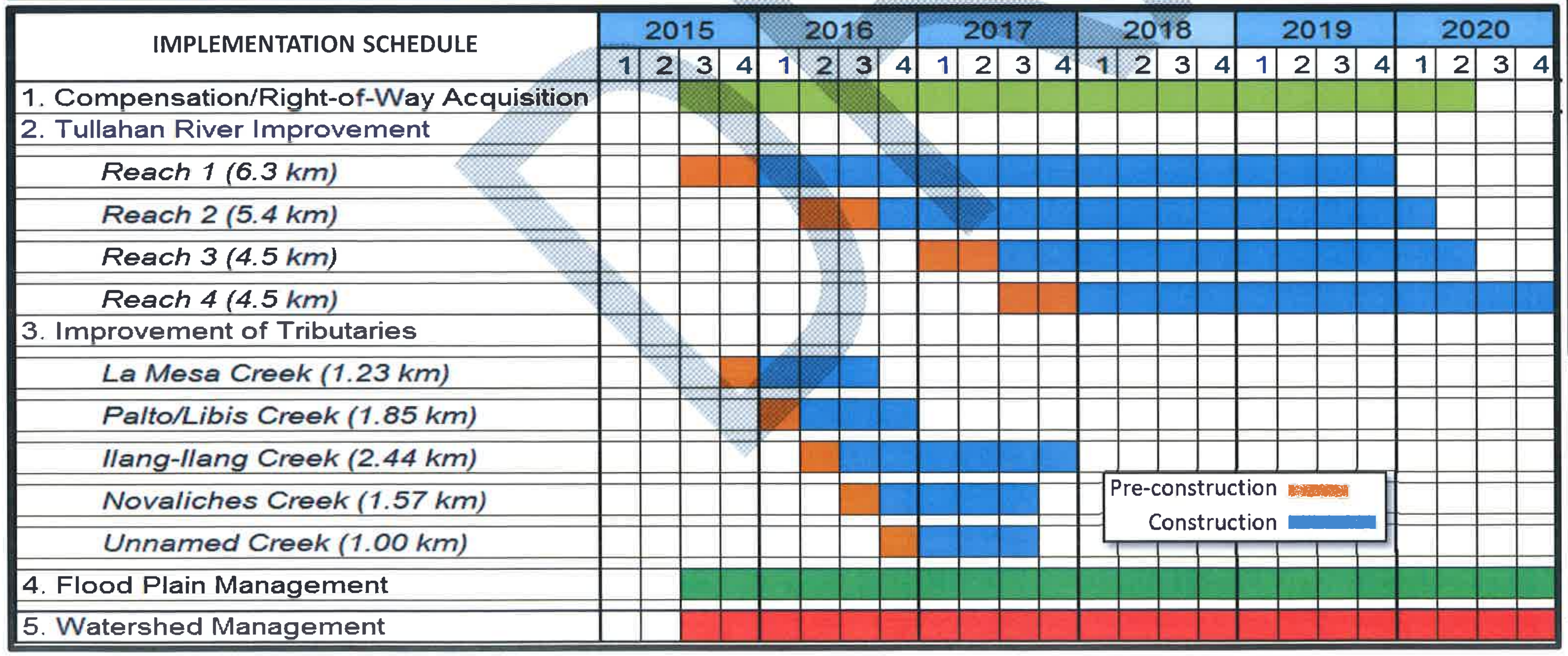




RIVER IMPROVEMENT WORKS

Reach 1 (6.3 km)	Tenejeros Bridge to NLEX
	a. dredging
	b. revetment
	c. bridge reconstruction
Reach 2 (5.4 km)	NLEX to San Pedro Subd. Bagbag, Novaliches
	a. dredging
	b. revetment
Reach 3 (4.5 km)	San Pedro Subd. Bagbag, Novaliches to Quirino Highway
	a. dredging
	b. revetment
	c. bridge reconstruction
Reach 4 (4.5 km)	San Pedro Subd. Bagbag, Novaliches to Quirino Highway
	a. dredging
	b. revetment
Tributaries (8.1 km)	
	a. dredging
	b. revetment
	c. bridge reconstruction

PROJECT COST

	Reach 1	Reach 2	Reach 3	Reach 4	Tributaries
LENGTH (km)	6.3	5.4	4.5	4.5	8.1
RIVER IMPROVEMENT COST					
A. Dredging and Excavation	336	288	240	240	433
B. Revetment Works	3,764	3,222	2,686	2,686	1,660
C. Bridge Reconstruction	153	-	103	220	160
Compensation/Land Acquisition Cost	551	529	443	415	583
PROJECT COST (Php Mil)	4,804	4,039	3,472	3,561	2,836
GRAND TOTAL					18,712

	2015	2016	2017	2018	2019	2020	TOTAL (Php Mil)
1. Tullahan River Improvement							
Reach 1 (6.3 km)	80	1,040	1,636	1,426	622	0	**4,804**
Reach 2 (5.3 km)	0	365	1,154	1,154	1,116	250	**4,039**
Reach 3 (4.5 km)	0	0	687	1,175	1,122	488	**3,472**
Reach 4 (4.5 km)	0	0	126	1,213	1,177	1,045	**3,561**
2. Improvement of Tributaries							
La Mesa Creek (1.23 km)	68	1,097	0	0	0	0	**1,165**
Palto/Libis Creek (1.85 km)	0	436	0	0	0	0	**436**
Ilang-Ilang Creek (2.44 km)	0	205	410	0	0	0	**615**
Novaliches Creek (1.57 km)	0	93	274	0	0	0	**367**
Unnamed Creek (1.00 km)	0	0	253	0	0	0	**253**
							18,712

VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA

Tullahan River Improvements Works

Recommended River Improvement Plan

Woodfields Engineers Company

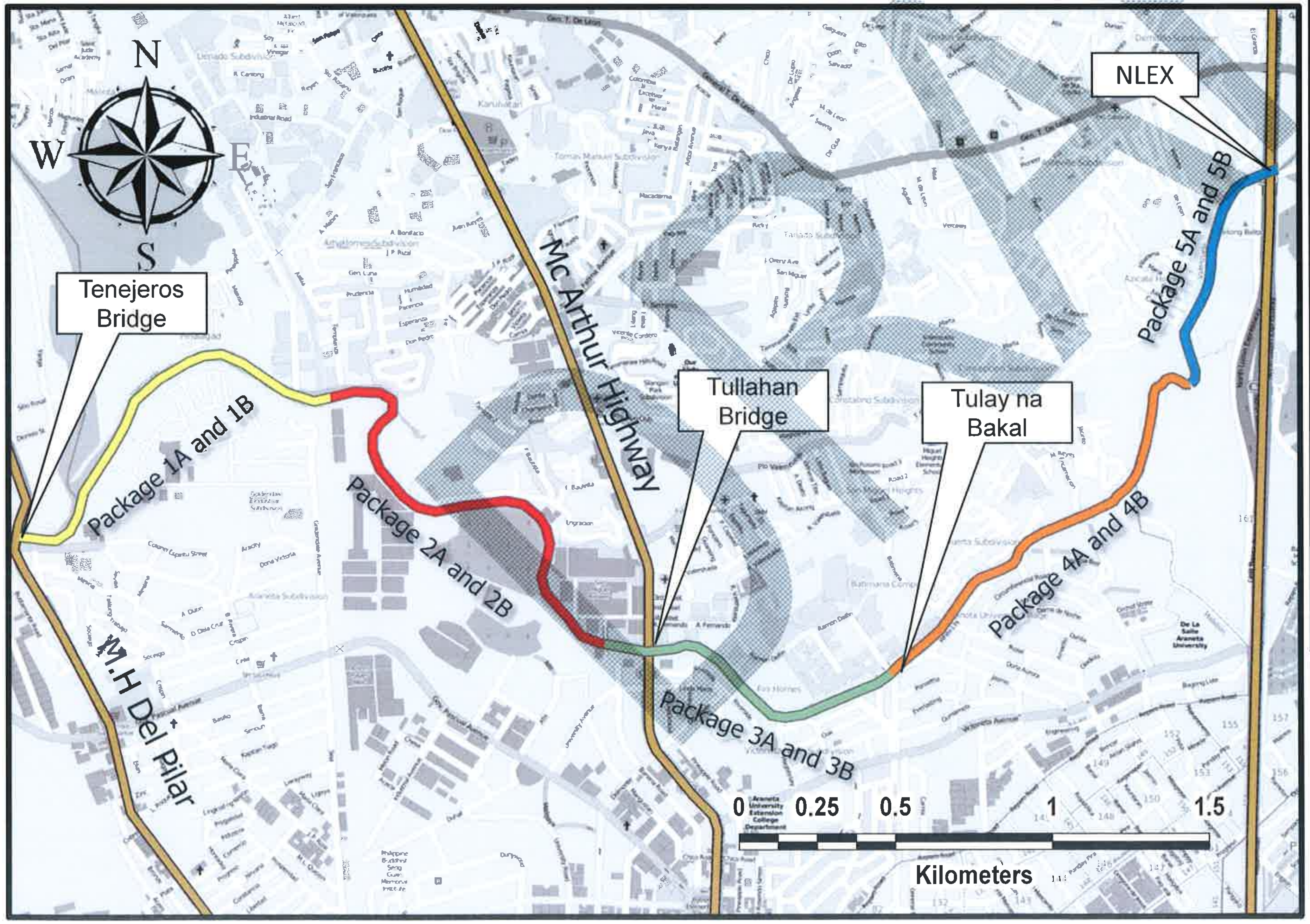
DPWH UPMO FCMC

REACH 1 ESTIMATED COST

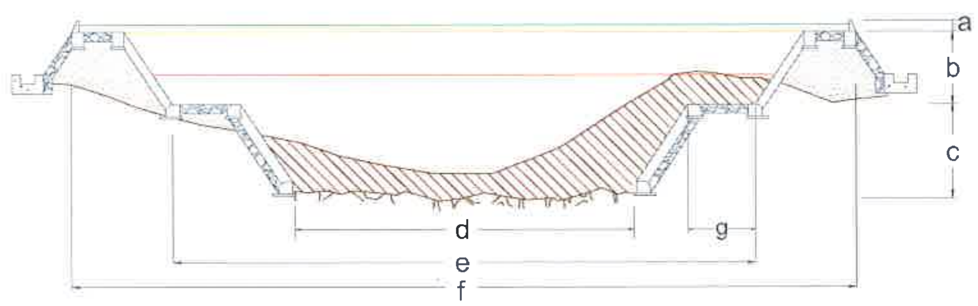
REACH 1	2015				2016				2017				2018				2019				TOTAL
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	(Php Mil)
1. Dredging and Excavation					21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	336
2. Revetment Works																					
Package 1A Left Bank (1.3 km)					49	49	49	49	49	49	49	49									388
Package 1B Right Bank (1.3 km)					49	49	49	49	49	49	49	49									388
Package 2A Left Bank (1.6 km)					40	40	40	40	40	40	40	40	40	40	40	40					478
Package 2B Right Bank (1.6 km)					40	40	40	40	40	40	40	40	40	40	40	40					478
Package 3A Left Bank (1.1 km)									41	41	41	41	41	41	41	41					329
Package 3B Right Bank (1.1 km)									41	41	41	41	41	41	41	41					329
Package 4A Left Bank (1.5 km)									37	37	37	37	37	37	37	37	38	38	38	38	448
Package 4B Right Bank (1.5 km)									37	37	37	37	37	37	37	37	38	38	38	38	448
Package 5A Left Bank (0.8 km)													30	30	30	30	30	30	30	30	239
Package 5B Right Bank (0.8 km)													30	30	30	30	30	30	30	30	239
3. Bridge Reconstruction																					
Tullahan Bridge (McArthur Highway)						30	30	30													91
Tulay na Bakal Bridge									31	31											62
4. Compensation/Land Acquisition Cost			40	40	40	40	40	40	39	39	39	39	39	39	39	39					551
PROJECT COST (Php Mil)																					4,804

REACH 1 IMPLEMENTATION SCHEDULE

WORK ITEMS	2015	2016	2017	2018	2019	2020	TOTAL (Php Mil)
1. Dredging and Excavation		84	84	84	84		336
2. Revetment Works							
Package 1A Left Bank (1.3 km)		194	194				388
Package 1B Right Bank (1.3 km)		194	194				388
Package 2A Left Bank (1.6 km)		159	159	160			478
Package 2B Right Bank (1.6 km)		159	159	160			478
Package 3A Left Bank (1.1 km)			165	164			329
Package 3B Right Bank (1.1 km)			165	164			329
Package 4A Left Bank (1.5 km)			149	149	150		448
Package 4B Right Bank (1.5 km)			149	149	150		448
Package 5A Left Bank (0.8 km)				120	119		239
Package 5B Right Bank (0.8 km)				120	119		239
3. Bridge Reconstruction							
Tullahan Bridge (McArthur Highway)		91					91
Tulay na Bakal			62				62
4. Compensation/Land Acquisition Cost	80	159	156	156			551
TOTAL COST FOR REACH 1 (Php Mil)							4,804



TYPICAL CROSS-SECTION



	Dimensions (m)		
a	1.0	e	45.0
b	3.0	f	55.0
c	3.5	g	3.0
d	35.0		

Flood Level
- 30 year
- 50 year
- 100 year
- Existing River Channel

Earth Works
- Fill
- Cut

VARIOUS FLOOD CONTROL PROJECTS IN METRO MANILA
Tullahan River Improvements Works

Urgent Works

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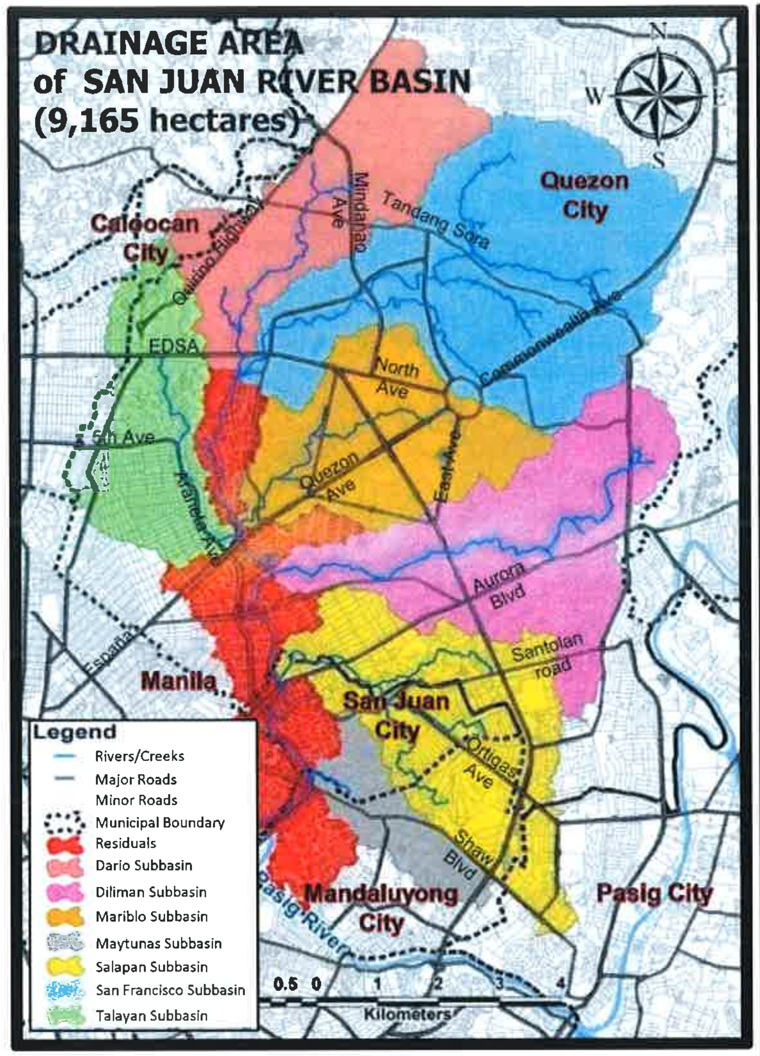
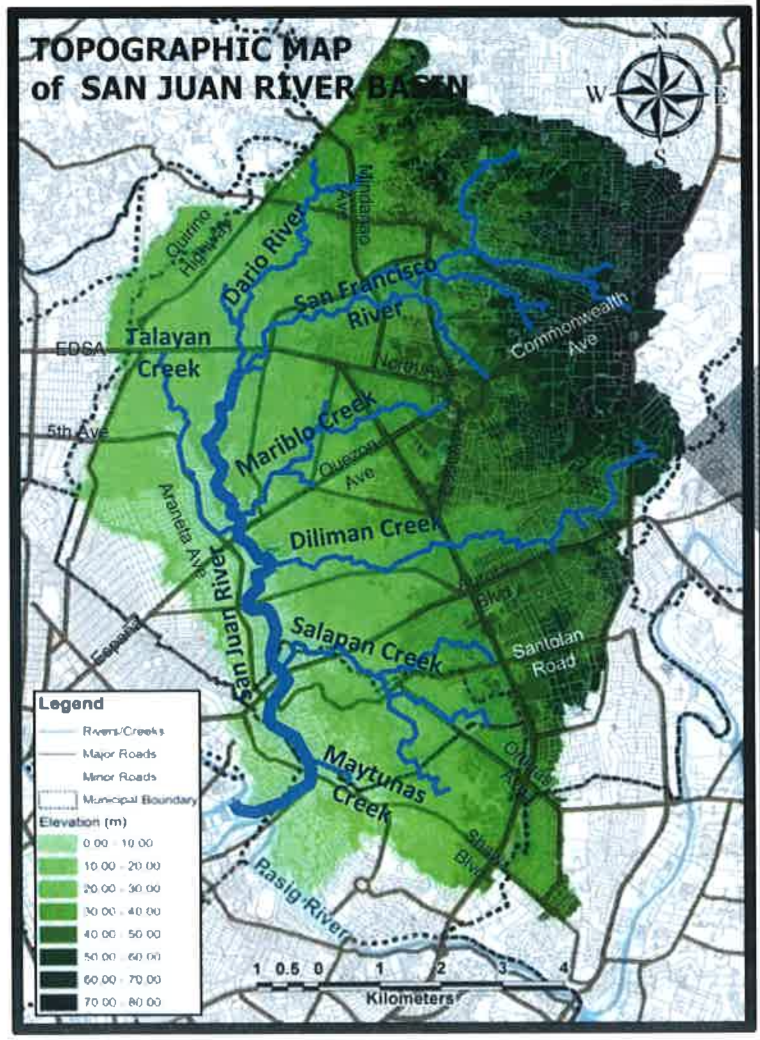
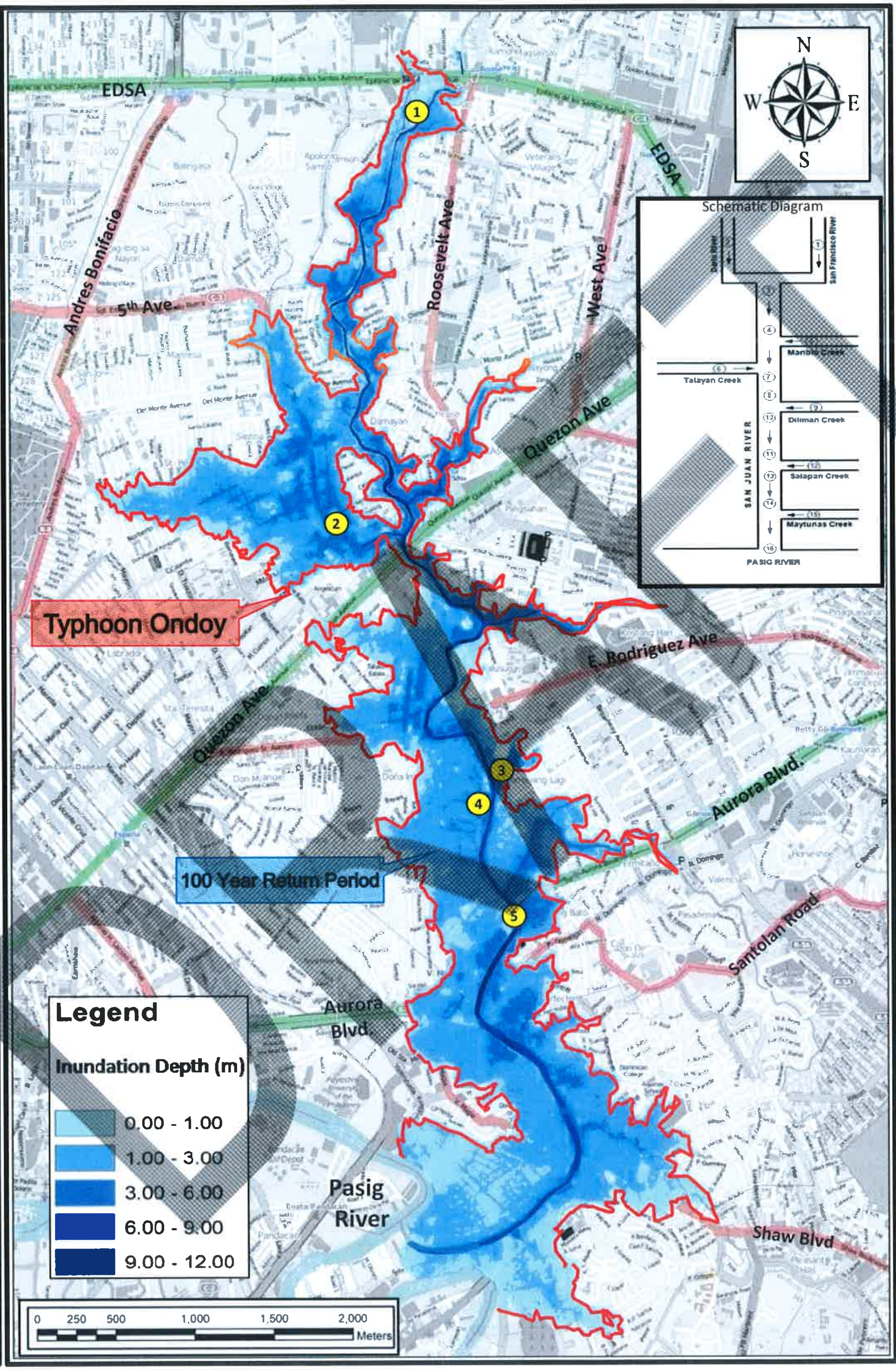
San Juan River Improvement Works





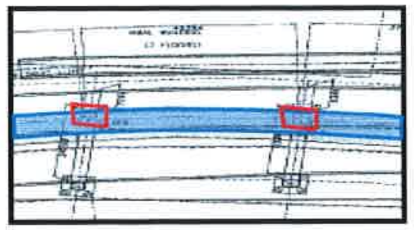


San Juan River Discharge Distributions

Node/ Reach	River/Creek	Existing Capacity (m³/s)	Design Discharge (m³/s)			Discharge Difference (m³/s)		
			30-yr	50-yr	100-yr	30-yr	50-yr	100-yr
(1)	San Francisco	73.4	181.9	193.3	223.2	108.5	119.9	149.8
(2)	Dario	53.4	90.3	96.0	110.8	36.9	42.6	57.4
(3)-(4)	San Juan	165.0	288.2	306.3	354.2	123.2	141.3	189.2
(5)	Mariblo	80.4	84.7	90.1	104.3	4.3	9.7	23.9
(6)	Talayan	43.6	66.0	70.2	81.0	22.4	26.6	37.4
(7)-(8)	San Juan	308.0	461.3	490.3	551.1	153.3	182.3	243.1
(9)	Diliman	101.8	120.1	127.8	147.7	18.3	26.0	45.9
(10)-(11)	San Juan	351.0	594.5	631.6	732.8	243.5	280.6	381.8
(12)	Salapan	88.0	115.4	122.9	141.6	27.4	34.9	53.6
(13)-(14)	San Juan	514.0	725.1	774.3	894.4	211.1	260.3	380.4
(15)	Maytunas		30.0	31.9	36.8			
(16)	San Juan	628.0	773.8	822.6	950.0	145.8	194.6	322.0

Existing Condition

1. Encroachment of informal settlers, subdivision houses, condominium and big establishments into river banks.



4. Intrusion of proposed Skyway 3's pedestal and bored pile into Talayan Creek.

3. Apparent reclamation of riverbank. On-going rip-rap construction at left bank of San Juan River downstream of Mariblo Bridge on private lot claimed to be DPWH project.

4. Low existing bank elevation and encroachment of informal settlers. Uncollected dredged materials on the side of rivers further hamper the flow of water.

5. Insufficient vertical clearance between the proposed new bridge (Lambingan) and existing structure (LRT 2).

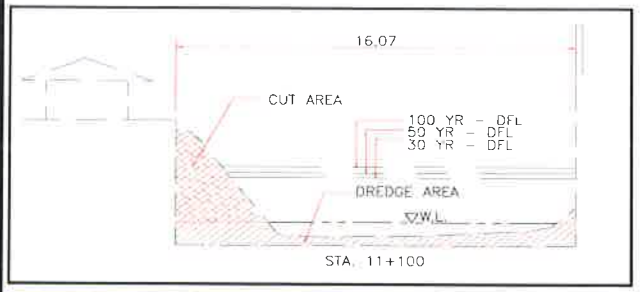
SAN JUAN RIVER IMPROVEMENT WORKS

100-Year Return Period Inundation Map

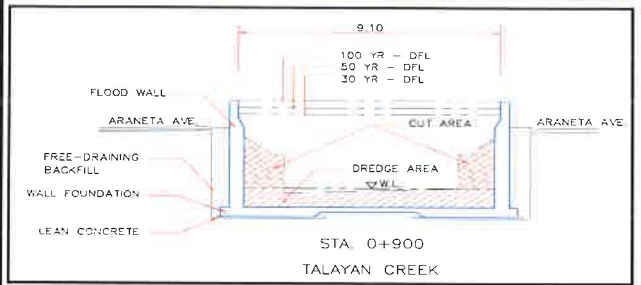
wec Woodfields Engineers Company	DPWH UPMO FCMC	1/3

LEGEND:

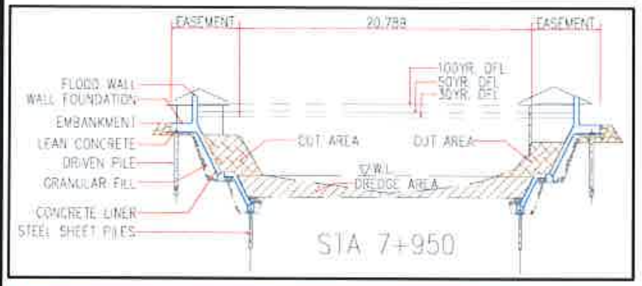
SAN JUAN RIVER CROSS SECTIONS



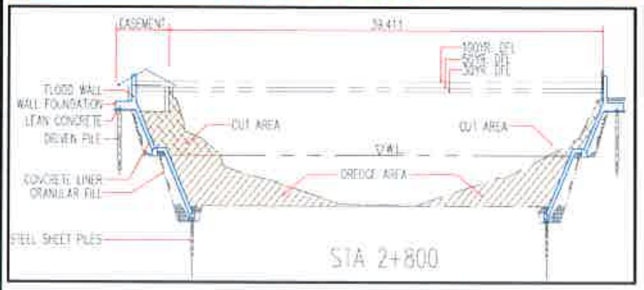
Type 1 (Package III)



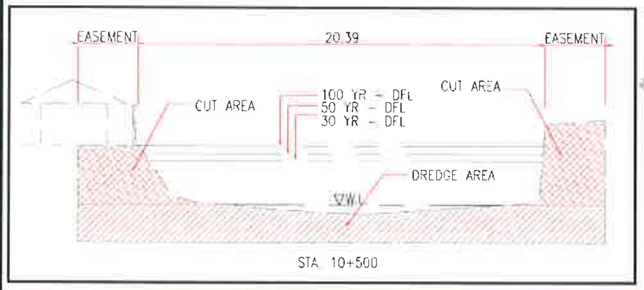
Type 1-A (Talayan - Package II)



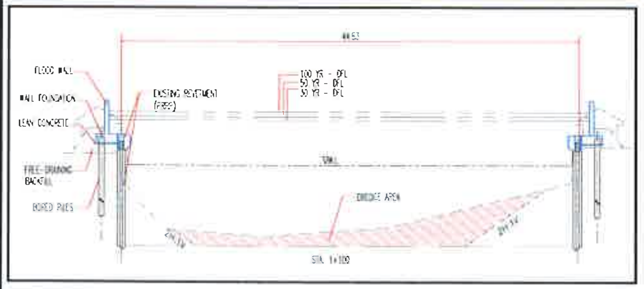
Type 2 (Package II)



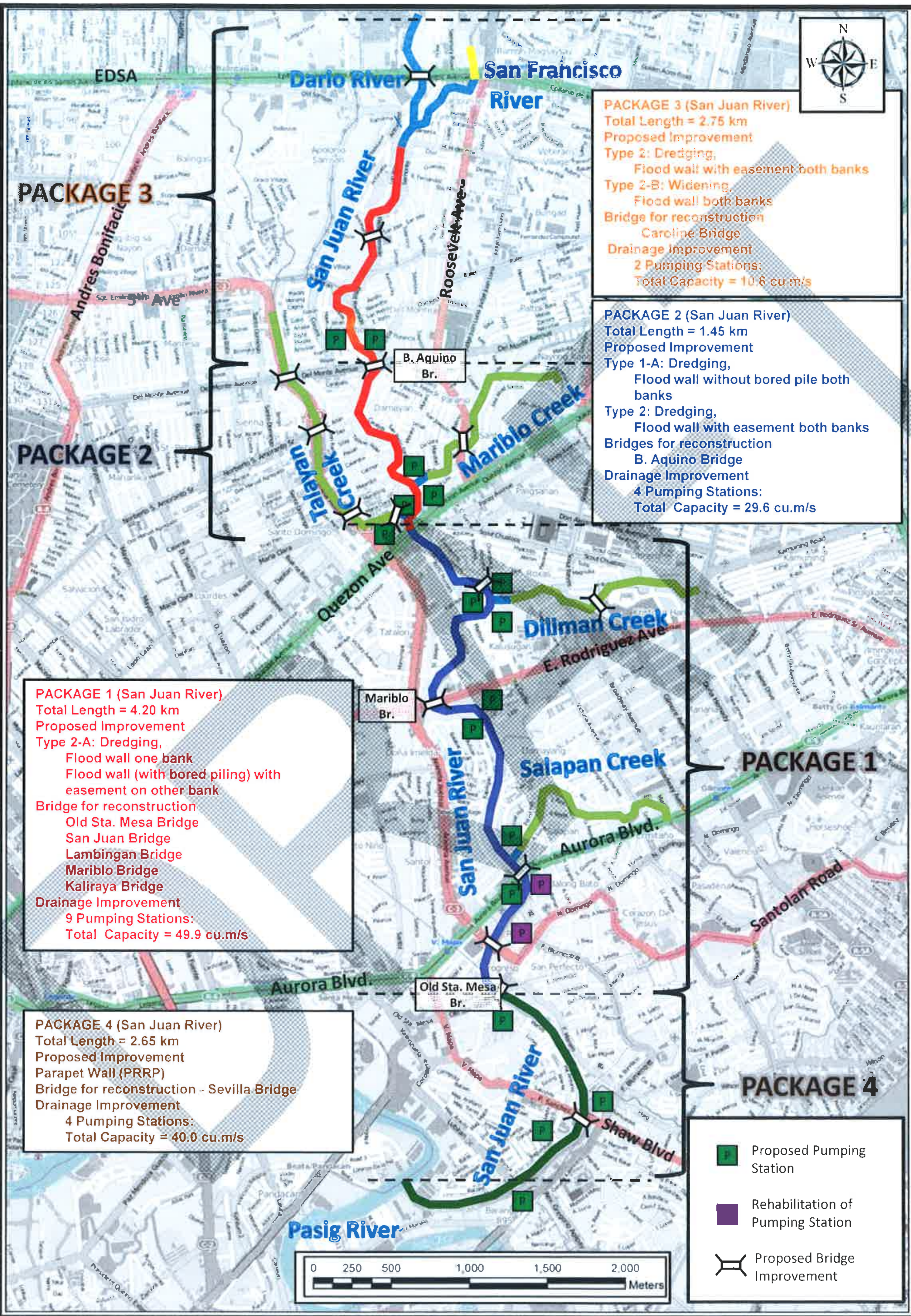
Type 2-A (Package I)



Type 2-B (Package III)



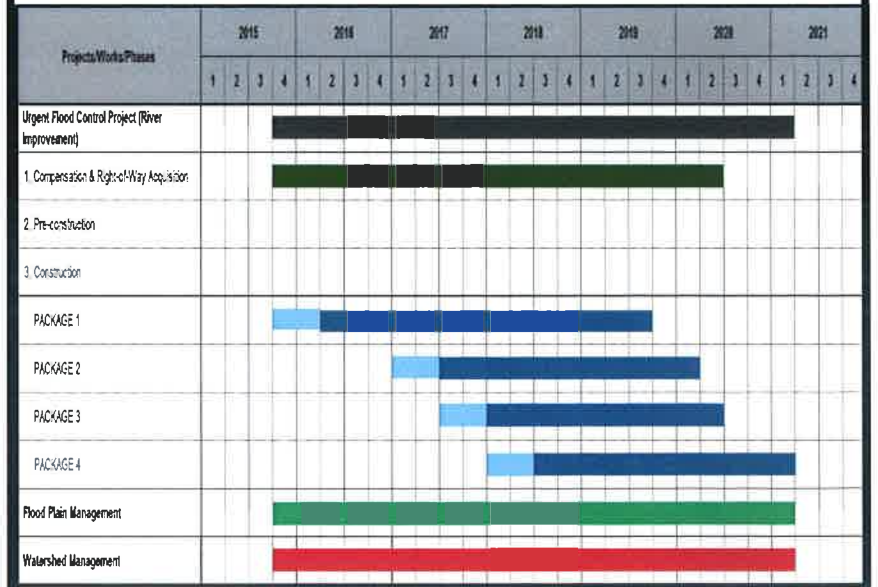
PRRP (Package IV)



Project Cost Estimates

WORK ITEM	Package 1	Package 2	Package 3	Package 4	TOTAL
Compensation Cost		1,919	1,378		
Dredging and Excavation	268	77	146	140	631
Revetment Works	4,968	992	1,878	875	8,713
Bridge Reconstruction	579	104	57	103	842
a. Old Sta. Mesa	83				83
b. San Juan	167				167
c. Lambingan	123				123
d. Mariblo	138				138
e. Kaliraya	68				68
f. Aquino		104			104
g. Caroline			57		57
h. Sevilla				103	103
Pumped Systems for Local Drainage	3,495	1,766	633	2,802	8,695
a. 9 Pumping Stations: Total Q = 49.9 cu.m/s	3,495				3,495
b. 4Pumping Stations: Total Q = 29.6 cu.m/s		1,766			1,766
c. 2 Pumping Stations: Total Q = 10.6 cu.m/s			633		633
d. 4 Pumping Stations: Total Q = 44.0 cu.m/s				2,802	2,802
Tributary Improvements	1,418	1,336	327		3,081
GRAND TOTAL	10,728	6,194	4,418	3,920	25,260

Project Implementation



SAN JUAN RIVER IMPROVEMENT WORKS

Recommended River and Drainage Improvement Plan

Woodfields Engineers Company

DPWH UPMO FCMC

2/3

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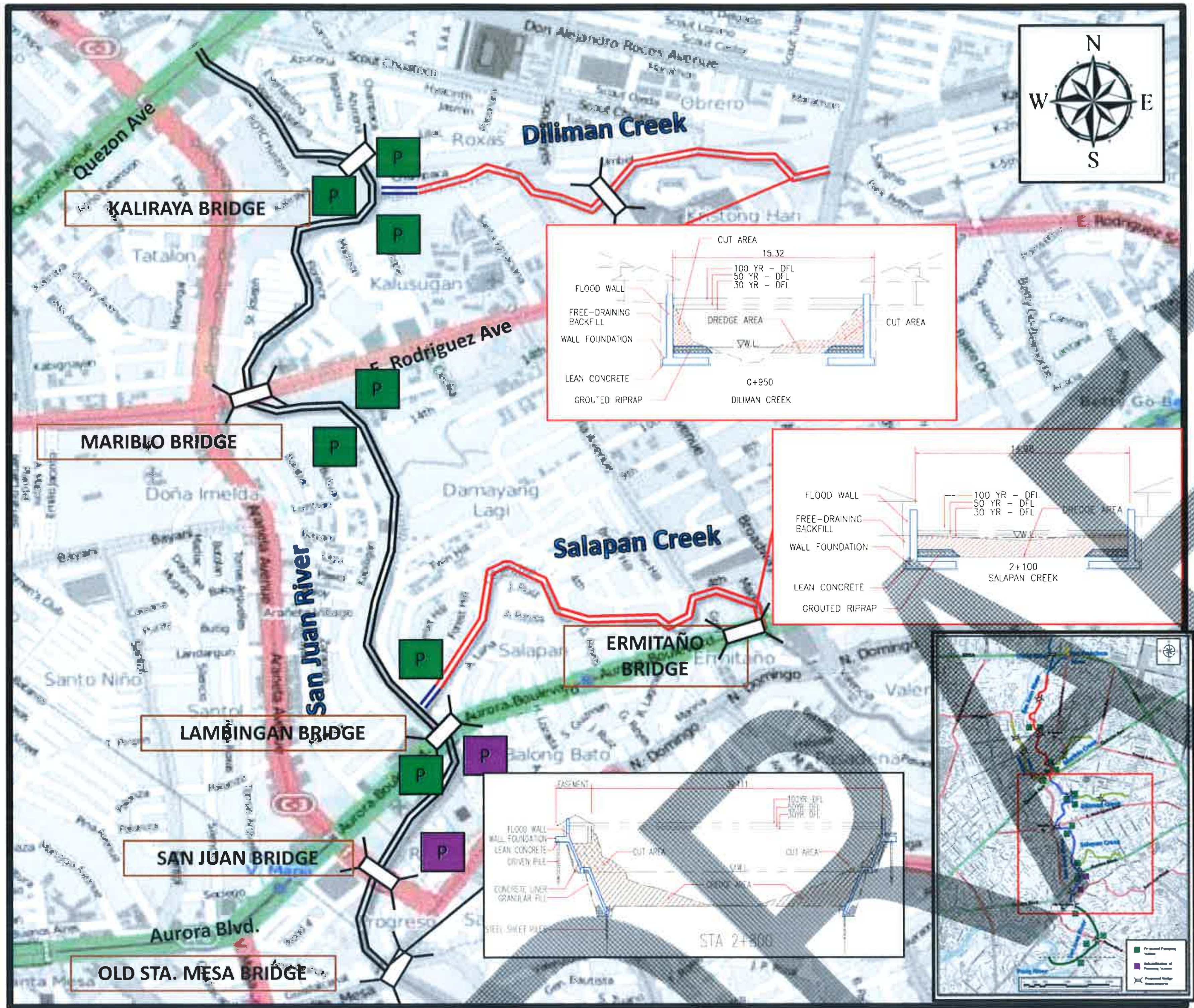


PACKAGE 1 URGENT WORKS

SAN JUAN RIVER

Total Length = 4.20 km

River Improvement

Type 2-A: Dredging, Floodwall on one bank, Floodwall (with bored piling) with easement on other bank

Drainage Improvement

9 Pumping Stations

Total Capacity = 49.9 m3/s

Bridge reconstruction

Old Sta. Mesa Bridge

San Juan Bridge

Lambingan Bridge

Mariblo Bridge

Kaliraya Bridge

SALAPAN CREEK

Total Length = 2.30 km

River Improvement

Type 2-B: Widening, Floodwall on both banks

Type 1: Dredging, Floodwall on both banks

Bridge Reconstruction

Ermitaño Bridge

DILIMAN CREEK

Total Length = 1.80 km

River Improvement

Type 2-B: Widening, Floodwall on both banks

Type 1: Dredging, Floodwall on both banks

Bridge Reconstruction

Lagarian Bridge 1

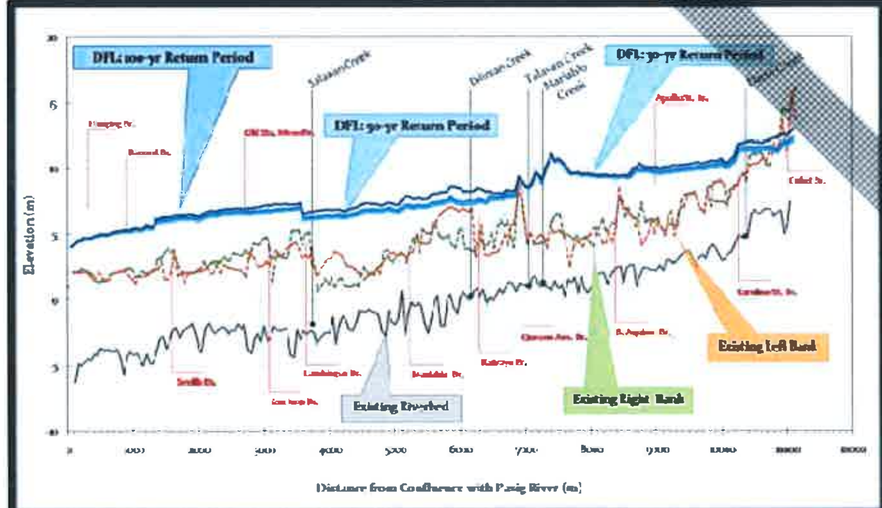
JUSTIFICATIONS

(for Urgent Implementation)

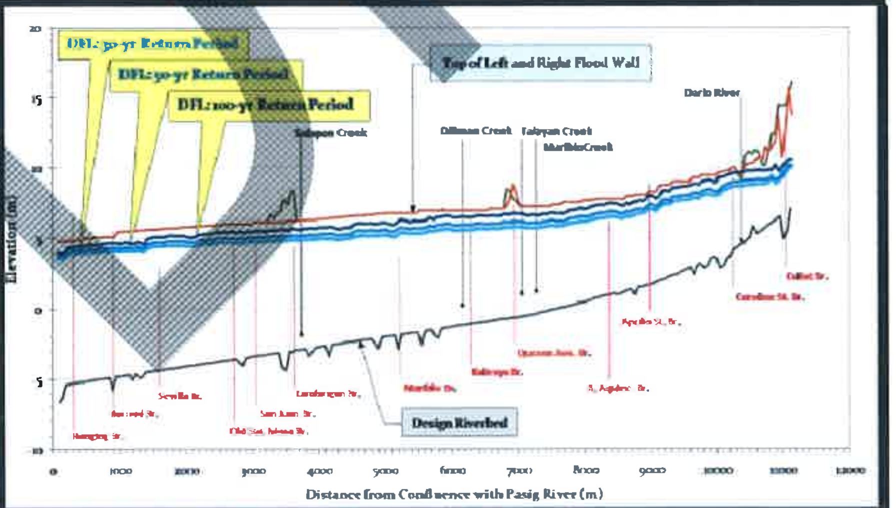
- The 4.2 km stretch along San Juan River has the lowest elevations on both banks. Within the proximity San Juan River comprising of low-lying barangays: five (6) in Quezon City, seven (7) in San Juan City, one (1) in the City of Manila and two (2) in Mandaluyong, has the most serious flooding conditions within San Juan River Basin.
- Quezon Avenue's high elevation (serves as ridgeline) prevents upstream flood to spill over and inundate the downstream areas, thereby, approximately 250 ha would be spared from flooding during storm events. The 250 ha (right bank = 147 ha, left bank = 100 ha) flood hazard area corresponds to 36% of the total 700 ha inundated area within the basin.

PACKAGE 1 ESTIMATED COST AND IMPLEMENTATION SCHEDULE

WORK ITEM	2016				2017				2018				2019				TOTAL (PHP Mil)	TOTAL/Sub-Package (PhP
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
RIVER IMPROVEMENT WORKS																		
SUB-PACKAGE 1-A																		268
Dredging and Excavation		19	19	19	19	19	19	19	19	19	19	19	19	19	23		268	
SUB-PACKAGE 1-B																		993
Revetment Works (Old Sta. Mesa to San Juan Bridge)		354	354	285													993	
SUB-PACKAGE 1-C																		994
Revetment Works (San Juan to Lambingan Bridge)					286	354	354										994	
SUB-PACKAGE 1-D																		994
Revetment Works (Lambingan to Mariblo Bridge)								286	354	354							994	
SUB-PACKAGE 1-E																		994
Revetment Works (Mariblo to Kaliraya Bridge)											286	354	354				994	
SUB-PACKAGE 1-F																		994
Revetment Works (Kaliraya to Quezon Ave Bridge)														354	354	286	994	
SUB-PACKAGE 1-G																		579
Bridge Reconstruction																		
a. Old Sta. Mesa Bridge									28	28	28						83	
b. San Juan River Bridge										55	55	57					167	
c. Mariblo Bridge											41	41	42				123	
d. Lambingan Bridge													46	46	45		138	
e. Kaliraya Bridge														23	23	22	68	
SUB-PACKAGE 1-H																		963
Tributary Improvement																		
Salapan Creek: a. Dredging and Excavation									49	49	48						146	
Salapan Creek: b. Revetment Works									251	251	251						753	
Salapan Creek: c. Bridge Reconstruction										22	22	20					64	
SUB-PACKAGE 1-I																		455
Tributary Improvement																		
Diliman Creek: a. Dredging and Excavation													38	38	39		115	
Diliman Creek: b. Revetment Works													93	93	91		277	
Diliman Creek: c. Bridge Reconstruction														22	22	20	64	
DRAINAGE IMPROVEMENT WORKS																		
SUB-PACKAGE 1-J																		944
1 Pumping Sta: Damayang Lagi							315	315	315								944	
SUB-PACKAGE 1-K																		772
3 Pumping Sta: Progreso, Doña Imelda, Sobrepena										386	386						772	
SUB-PACKAGE 1-L																		993
4 Pumping Sta: Kalusugan, Tatalon, Balong- Bato, Rivera												331	331	331			993	
SUB-PACKAGE 1-M																		786
1 Pumping Sta: Roxas															393	393	786	
PROJECT COST (PHP Mil)																		10,727



San Juan River Flood Water Surface Profile for Different Return Periods at Existing River Condition



San Juan River Flood Water Surface Profile for Different Return Periods with Channel Improvements

SAN JUAN RIVER IMPROVEMENT WORKS

Woodfields Engineers Company	DPWH UPMO FCMC	Urgent Works Package 1	3/3

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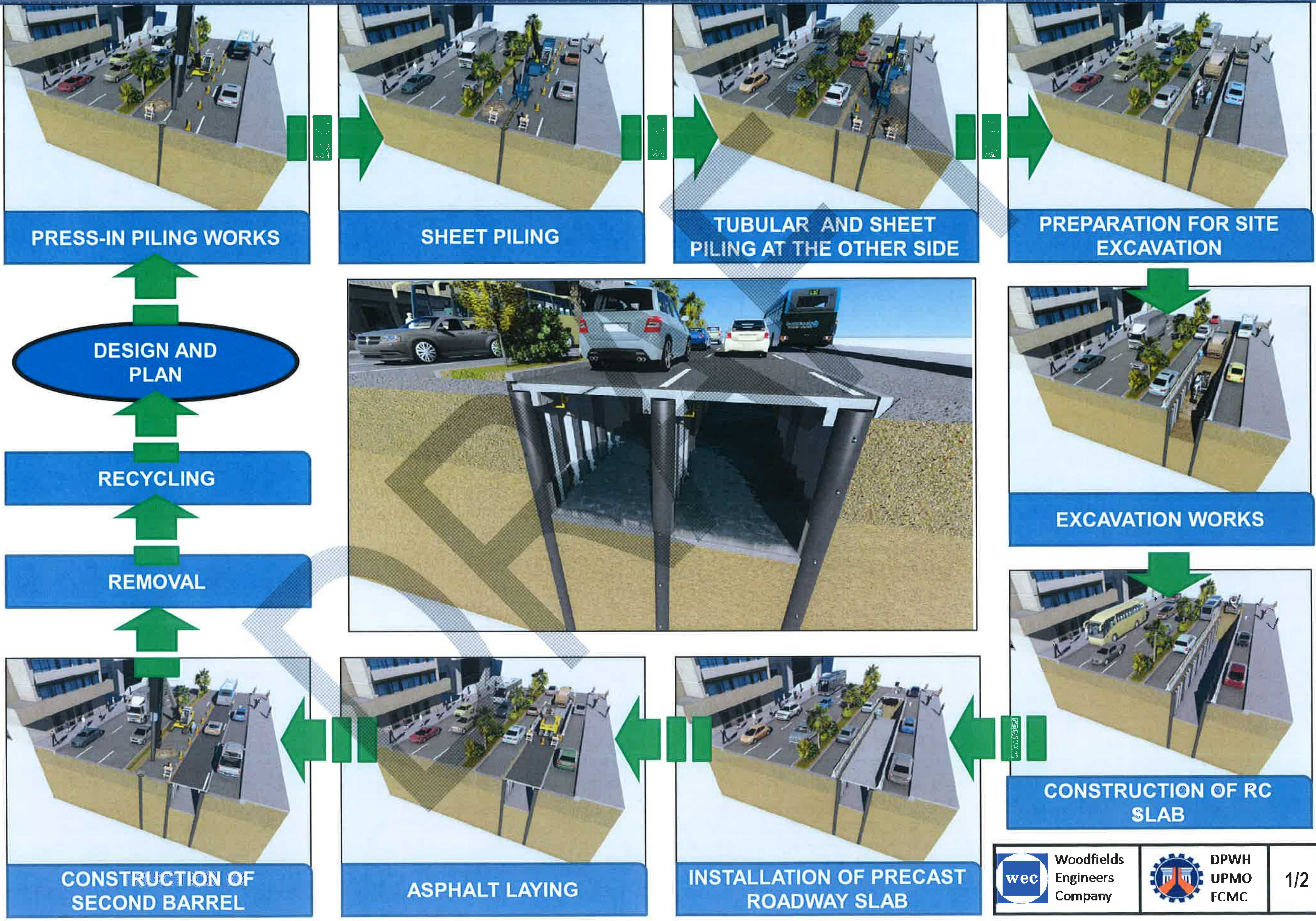
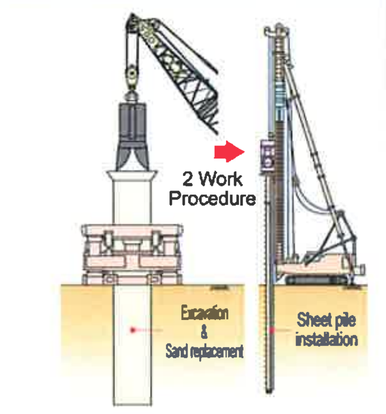
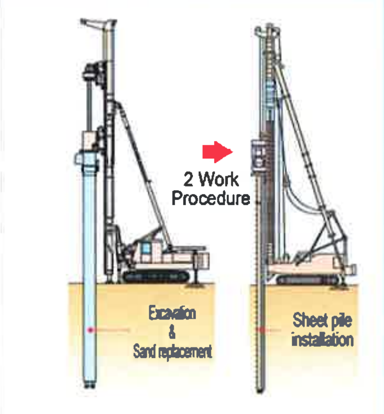
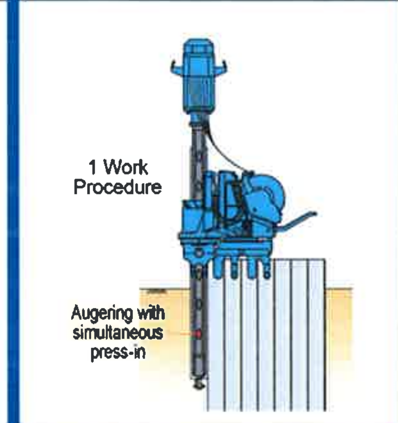
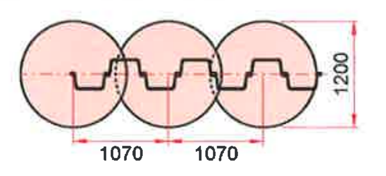
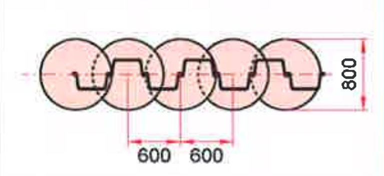
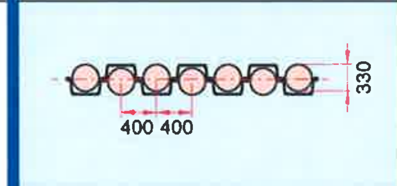
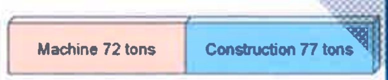
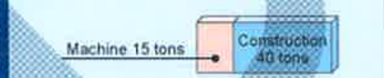
Annex I
Proposed Construction Methodology for Diversion Channel

CLOSED – DIVERSION CHANNEL/INTERCEPTOR METHODOLOGY



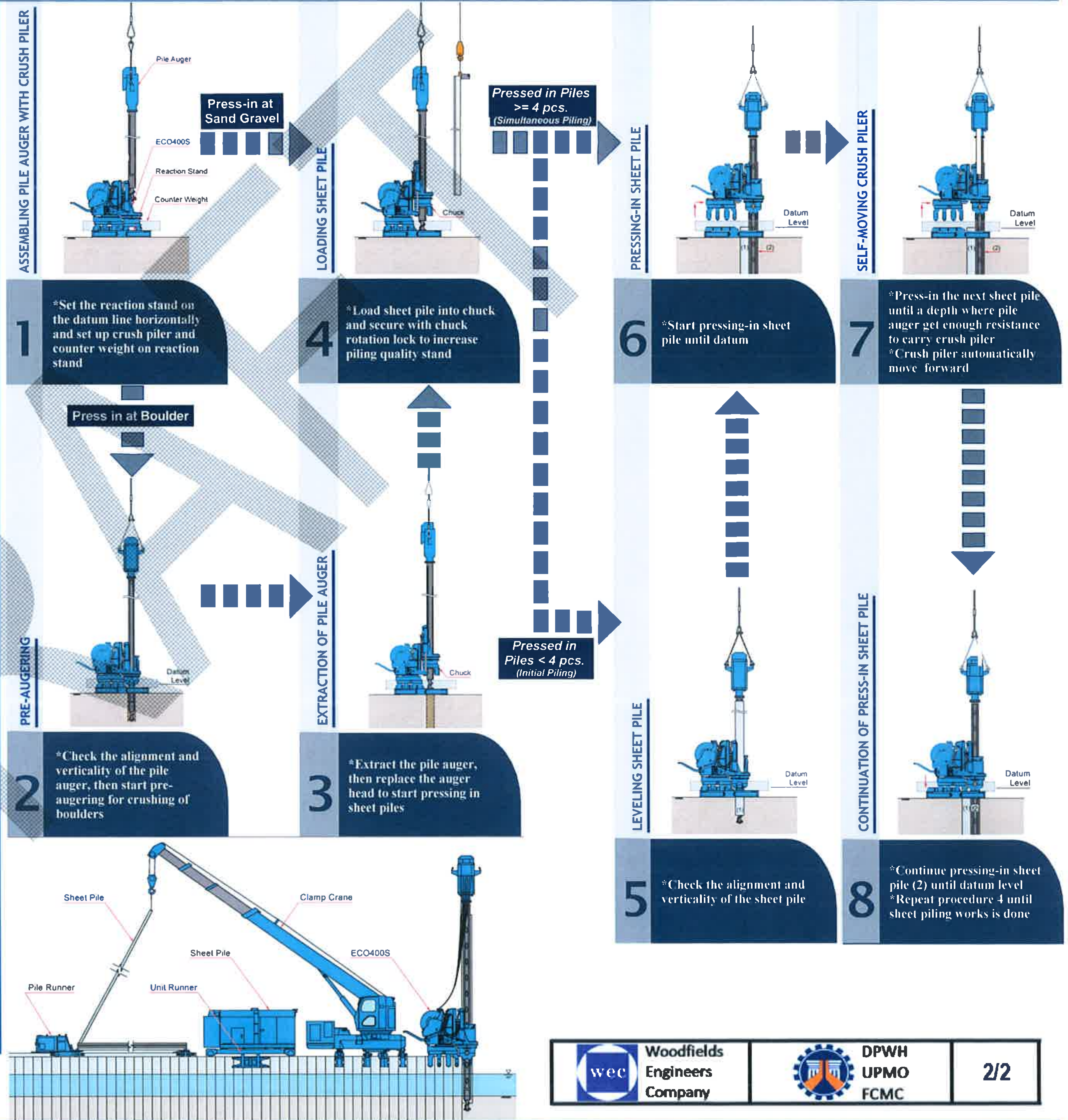
wec Woodfields Engineers Company	DPWH UPMO FCMC	1/2

PROCEDURES IN USING SILENT PILER ECO 400S

	All Casing Sand Replacement Piling Method	Uniaxial Double Earth Auger Pre-boring Sand Replacement Piling Method	Hard Ground Press-in Method
Cross Section			
Augering area			
Method Outline	A casing with cemented carbide tips on the edge is driven by gyration jack-in, and the soil inside the casing are excavated by a hammer grab. The casing is then driven farther in, and this process is repeated as required. While the casing is being extracted, sand is poured inside the casing to construct a sand pile. Sheet pile is then installed by a jack-in piling rig equipped with auger.	A boring shaft is driven by double gyration. Special cutting edges are mounted on the casing edge and auger head. The casing and auger head revolves in different directions one another. After completing excavation, sand is poured inside the casing to construct a sand pile. Sheet pile is then installed by a jack-in piling rig equipped with auger.	A sheet pile is pitched to the Crush Piler. The Pile Auger penetrates together with the sheet pile into the ground.
Features	• There are 2 work procedures required prior to sheet piling work I. Casing jack-in with gyration, excavation, backfilling II. Sheet pile installation by a jack-in piling rig equipped with auger. • The great torque enables to penetrate into rock, boulder and reinforced concrete materials. • During excavation work, the hammer grab generates noise and vibration. • This method requires a large working area, because it requires massive construction equipments such as casing gyration jack-in machine, crawler crane and excavator.	• There are 2 work procedures required prior to sheet piling work. • The penetration capability into boulder is lower than "All Casing Sand Replacement Piling Method". • This method requires a large working area, because it requires massive construction equipments such as casing gyration jack-in machine, crawler crane and excavator.	• This method doesn't cause construction pollutions such as noise and vibration, because sheet piles are installed by static load. • This method requires less work procedures than other methods, because it doesn't require sand replacement work. • The piling rig hardly overturns, because it clamps previously installed piles so that the rig is fixed with those reaction piles. • The piling rig is so compact that it can be used at narrow site conditions and on slope. • This method can install sheet piles with high accuracy.
Duration	104 days (226 %)	92 days (200 %)	46 days (100 %)
Budget *1	Excavation & Sand replacement = JPY 68 million Sheet pile jack-in = JPY 5.5 million Total = JPY 73.5 million (273 %)	Excavation & Sand replacement = JPY 50 million Sheet pile jack-in = JPY 5.5 million Total = JPY 55.5 million (206 %)	Sheet pile press-in = JPY 27 million Total = JPY 27 million (100 %)
Environmental Burden *2 (CO2 Emission)	 Σ = 145 t (264 %) (Add 130 tons for temporary work platform work.)	 Σ = 149 t (271 %) (Add 130 tons for temporary work platform work.)	 Σ = 55 t (100 %)
Evaluation	△	△	◎

Comparison Conditions	
	• Sheet Pile: FSP IV, L = 15.0 m • Alignment: 100 Linermeter • No of Piles: 250 nos • Soil condition: Sand Nmax < 50 (GL to 12.0 m) 12 - 15m: Soft rock (uniaxial compressive strength 4 N/mm²)

*1: Installation budget only.
(Excluding erection charge, transportation charge and material charge)
*2: The above estimations are based on Japanese standard costing of each construction method.



Woodfields Engineers Company	DPWH UPMO FCMC	2/2

Appendix 2-2

Outline of DPWH Survey

Additional Collecting Data

1. Design Rainfall

The design rainfall used was based on available rainfall intensity-duration-frequency (RIDF) from PAGASA shown in Figure 1 across three (3) rainfall stations in Metro Manila.

Return Period	Duration in hours: 1	3	6	12	24
2	55.5	90.3	117.4	136.3	156.0
5	81.8	135.7	185.1	216.1	243.1
10	99.3	165.8	229.9	268.9	300.7
15	109.1	182.7	255.2	298.8	333.3
20	116.0	194.6	272.9	319.6	356.0
25	121.3	203.8	286.5	335.7	373.6
30	125.4	210.8	297.1	348.2	387.1
50	137.6	231.9	328.5	385.2	427.6
100	153.8	259.9	370.2	434.4	481.2

a. Science Garden

Return Period	Duration in hours: 1	3	6	12	24
2	55.5	86.3	111.2	134.6	153.3
5	75.2	121.4	160.0	195.9	223.5
10	88.1	144.6	192.3	236.6	270.0
15	95.5	157.7	210.5	259.5	296.3
20	100.6	166.9	223.2	275.6	314.6
25	104.5	174.0	233.1	288.0	328.8
50	116.7	195.7	263.3	326.1	372.4
100	128.8	217.3	293.4	363.9	415.8

b. Port Area

Return Period	Duration in hours: 1	3	6	12	24
2	49.4	77.6	101.1	125.5	143.8
5	82.1	132.9	173.6	215.3	246.9
10	103.7	169.5	221.5	274.7	315.2
20	124.4	204.6	267.5	331.7	380.7
25	131.0	215.8	282.1	349.8	401.5
50	151.2	250.1	327.1	405.6	465.5
100	171.3	284.2	371.7	460.9	529.1

c. NAIA

Figure 1. RIDF tables used in the study.

Then, flood discharges were based on Probable Maximum Precipitation (PMP). However, site specific PMP estimates are not available for the Philippines. In this case, Order of magnitude PMP estimates was therefore developed. These estimates were determined using generalized procedures which were originally developed in the United States and then adapted by the Australian Bureau of Meteorology for use in tropical areas of Australia. It is assumed that the storm mechanisms for a PMP event occurring in the Philippines area would be similar to those occurring in the tropical regions of northern Australia, given that various areas of tropical northern Australia are about the same distance from the equator as Metro Manila for example and have similar annual average rainfall totals. The amount of extreme rainfall was based on developed RIDF curves available and the temporal distribution of rainfall was based on the distribution in Figure 2.

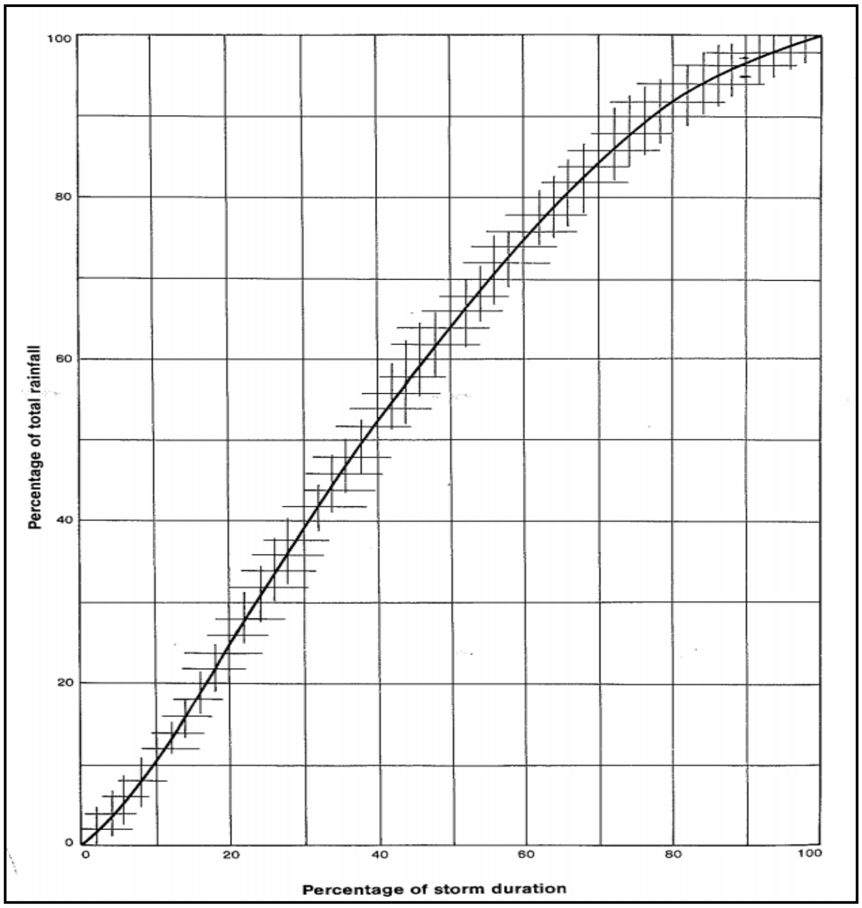


Figure 2. Rainfall distribution for extreme rainfall adopted for design flood discharges (Bureau of Meteorology, 2003).

2. Design Discharges

Using the RIDF and temporal distribution, the following peak discharges were generated for each composite catchment and project sites. The adopted rainfall duration is closest to the time of concentration. In project areas where volume of flood water is significant, longer storm duration was adopted. The corresponding tables summarized the peak design discharges used for each flood control project sites.

Table 1. Design Discharges for Buendia, Maricaban, NAIA, and Parañaque.

Project Site	Rainfall Station	Duration	Catchment Area (m^2)	Peak Discharge (m^3/s)
BUENDIA				
Tripa de Gallina	Port Area	60 mins	833,220	14.49
Calatagan Creek I	Port Area	60 mins	1,172,262	44.04
Calatagan Creek II	Port Area	60 mins	2,455,889	79.02
Zobel DM	Port Area	60 mins	2,257,670	49.36
Makati Diversion I	Port Area	60 mins	3,626,985	59.08
Makati Diversion II	Port Area	60 mins	1,169,453	48.81
Makati Div-Tripa	Port Area	60 mins	322,367	5.04
Calatagan Creek	Port Area	60 mins	646,632	14.69
Paco	Port Area	60 mins	1,421,229	14.04
Pandacan	Port Area	60 mins	1,909,232	15.49
Provisor	Port Area	60 mins	2,299,079	18.49
Libertad Pumping Station	Port Area	60 mins	6,508,563	58.99
EDSA Outfall	Port Area	60 mins	1,265,780	55.68
Libertad Outfall	Port Area	60 mins	992,459	10.06
Buendia Outfall	Port Area	60 mins	2,268,004	22.14
Vito Cruz Outfall	Port Area	60 mins	418,900	6.01
MARICABAN				
Maricaban Creek I	NAIA	60 mins	6,452,411	217.36
Maricaban Creek II	NAIA	60 mins	1,559,394	77.56
Maricaban Creek III	NAIA	60 mins	3,336,983	164.21
NAIA				
Parañaque Channel 1	NAIA	60 mins	11,019,835	266.26
Rivera	NAIA	60 mins	440,793	23.07
Parañaque Channel 2	NAIA	60 mins	10,579,042	171.97
Airport Road	NAIA	60 mins	1,057,904	49.92
Parañaque Channel 3	NAIA	60 mins	12,075,867	186.57
Librada	NAIA	60 mins	1,207,587	20.24
Parañaque Channel 4	NAIA	60 mins	12,882,021	160.76
Seaside	NAIA	60 mins	1,487,280	10.30
Parañaque Channel 5	NAIA	60 mins	15,741,590	192.21
Inland Channel	NAIA	60 mins	1,736,539	101.35
Redemptorist Channel	NAIA	60 mins	2,683,733	105.00
Seaside Channel	NAIA	60 mins	4,725,641	126.99
Banana Island Creek	NAIA	60 mins	1,468,857	31.97
Ibayo Creek	NAIA	60 mins	268,113	13.46
Cut-cut Creek	NAIA	60 mins	1,940,485	48.38
PARAÑAQUE				
Baliwag River	NAIA	60 mins	9,085,982	276.31
Don Galo River	NAIA	60 mins	15,394,645	510.57
San Dionisio River	NAIA	60 mins	10,222,761	90.62
San Isidro River	NAIA	60 mins	13,541,773	521.25
Las Piñas River	NAIA	60 mins	1,237,975	122.85
South Parañaque River	NAIA	60 mins	42,362,463	863.92
Parañaque River (Manila Bay)	NAIA	60 mins	57,227,663	1024.68

Table 2. Design Discharges for Tullahan River.

Project Site	Rainfall Station	Duration	Catchment Area	Peak Discharge m^3/s
1. Tenejeros Bridge	Science Garden	24-hrs	70.00 km^2	588.4
2. PNR	Science Garden	24-hrs	68.44 km^2	582.0
3. McArthur highway	Science Garden	24-hrs	62.12 km^2	564.4
4. NLEX	Science Garden	24-hrs	52.50 km^2	553.2

Table 3. Design Discharges for Zapote-Las Piñas River.

Project Site	Rainfall Station	Duration	Catchment Area	Peak Discharge m^3/s
1. Zapote River	NAIA	24-hrs	67.00 km^2	703
2. Las Piñas River	NAIA	24-hrs	21.44 km^2	197

Table 4. Design Discharges UST-España Areas.

Project Site	Rainfall Station	Duration	Catchment Area (ha)	Peak Discharge m^3/s
1.Constancia Interceptor	Port Area	1 hr	155.075	17.247
2.Antipolo Interceptor	Port Area	1 hr	150.299	21.924
3.Pureza Interceptor	Port Area	1 hr	325.330	51.548
4.Casanas-Margal-Quijote DM	Port Area	1 hr	197.923	19.680
5.Earnshaw DM	Port Area	1 hr	23.225	5.805
6.Lepanto-Forbes DM (Existing)	Port Area	1 hr	242.502	20.096
7.Estero de Valencia	Port Area	1 hr	184.107	29.080
8.Estero de Sampaloc I	Port Area	1 hr	273.494	20.172
9.Estero de San Miguel-Uli-Uli	Port Area	1 hr	47.289	7.085

Table 5. Design Discharges for San Juan River.

Project Site	Rainfall Station	Duration	Catchment Area km^2	Peak Discharge m^3/s
1. STA 1+100	Science Garden	24 hrs	91.60	822.50
2. STA 3+350	Science Garden	24 hrs	82.58	728.46
3. STA 7+250	Science Garden	24 hrs	51.49	436.95
4. STA 11+100	Science Garden	24 hrs	14.40	283.60

3. Design Sections

The typical cross-sections are in ANNEX A to E.

ANNEX A. UST España Areas

Table 1. Indicative Dimensions of Proposed RCBC within España-UST Vicinity Area

Proposed Box Culverts	Indicative Dimensions		
	Number of Barrels	Width (meters)	Depth (meters)
1.Constancia Interceptor	3	3	2
2.Antipolo Interceptor	2	3	4
3.Pureza Interceptor	2	3.2	4.5
4.Casanas-Margal-Quijote DM	2	3.5	2.4
5.Earnshaw DM	2	2.4	2.4

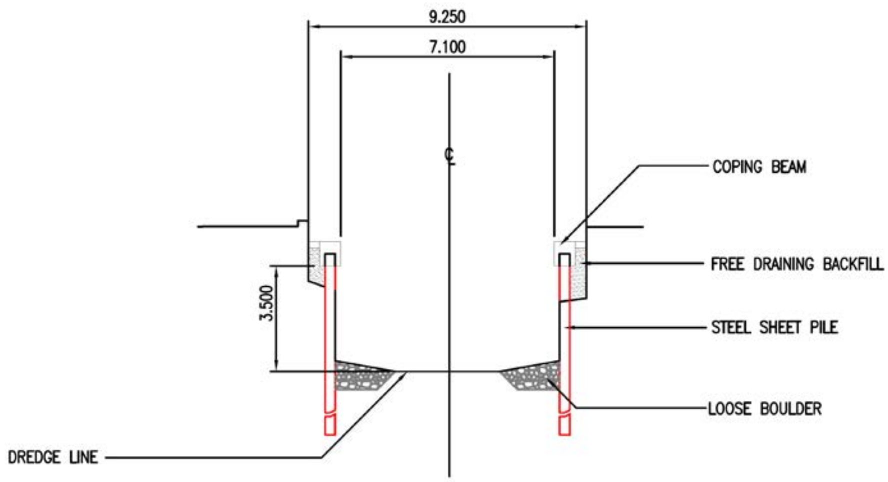


Figure 1. Typical Section for the Improvement of Estero de Valencia

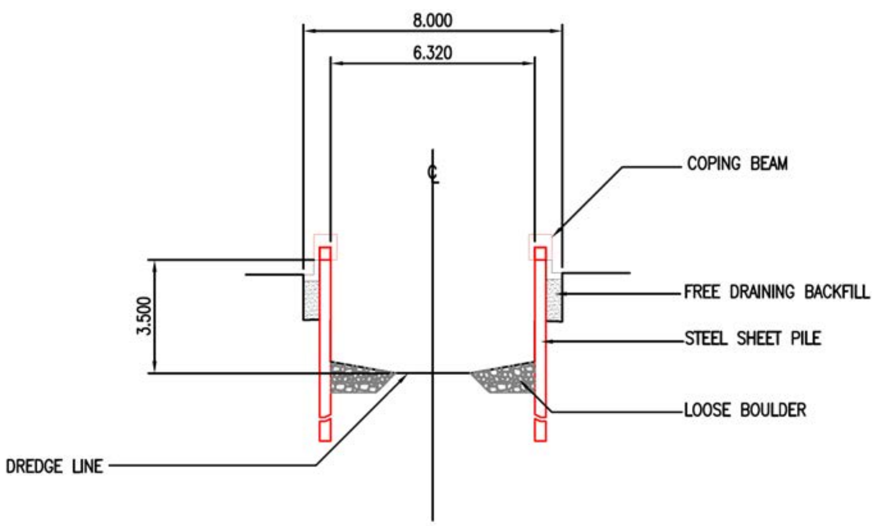


Figure 2. Typical Section for the Improvement of Estero de San Miguel – Uli-Uli

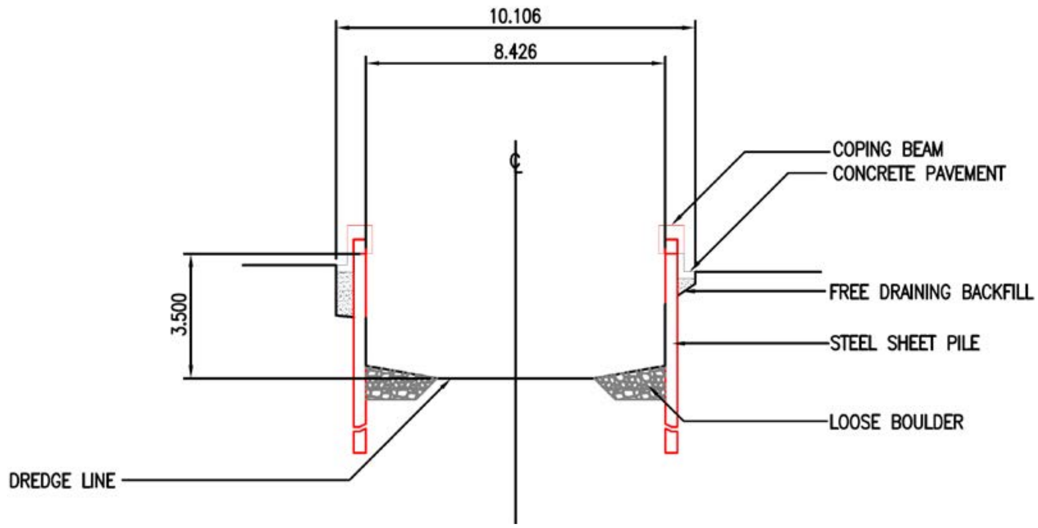
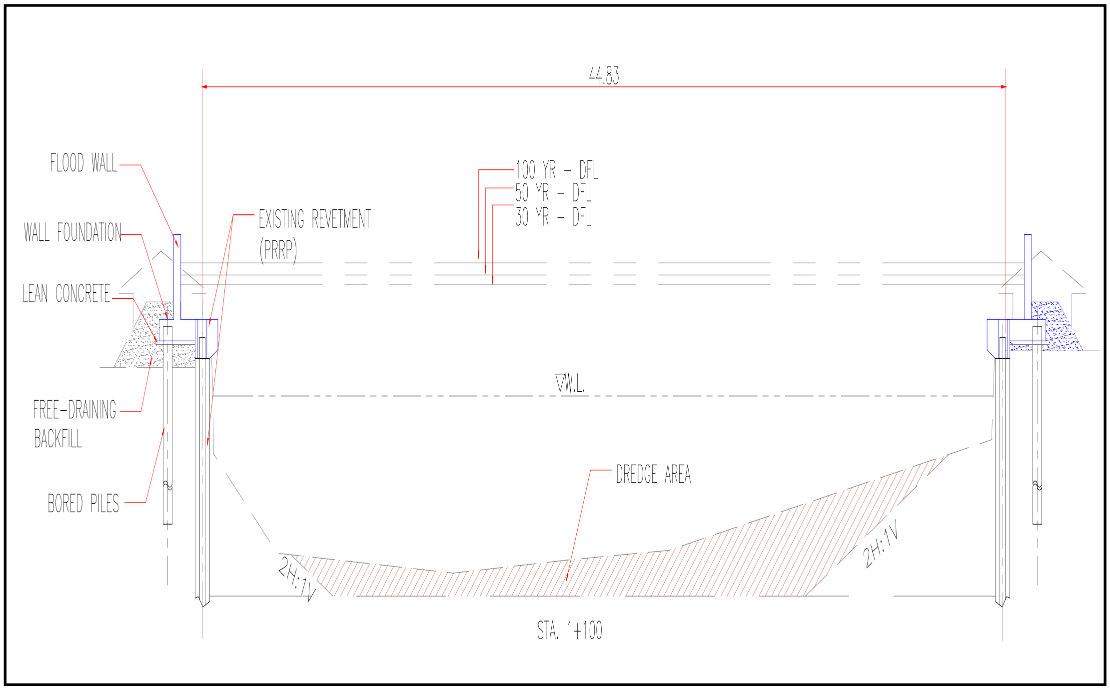
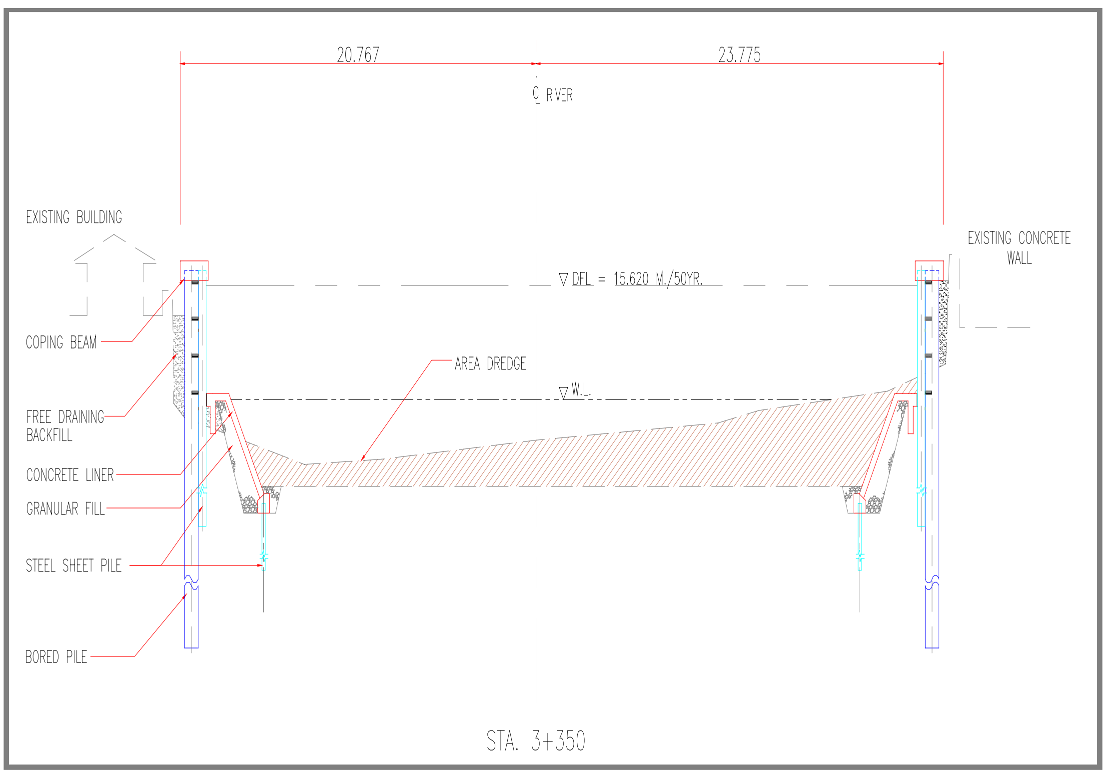


Figure 3. Typical Section for the Improvement of Estero de Sampaloc I

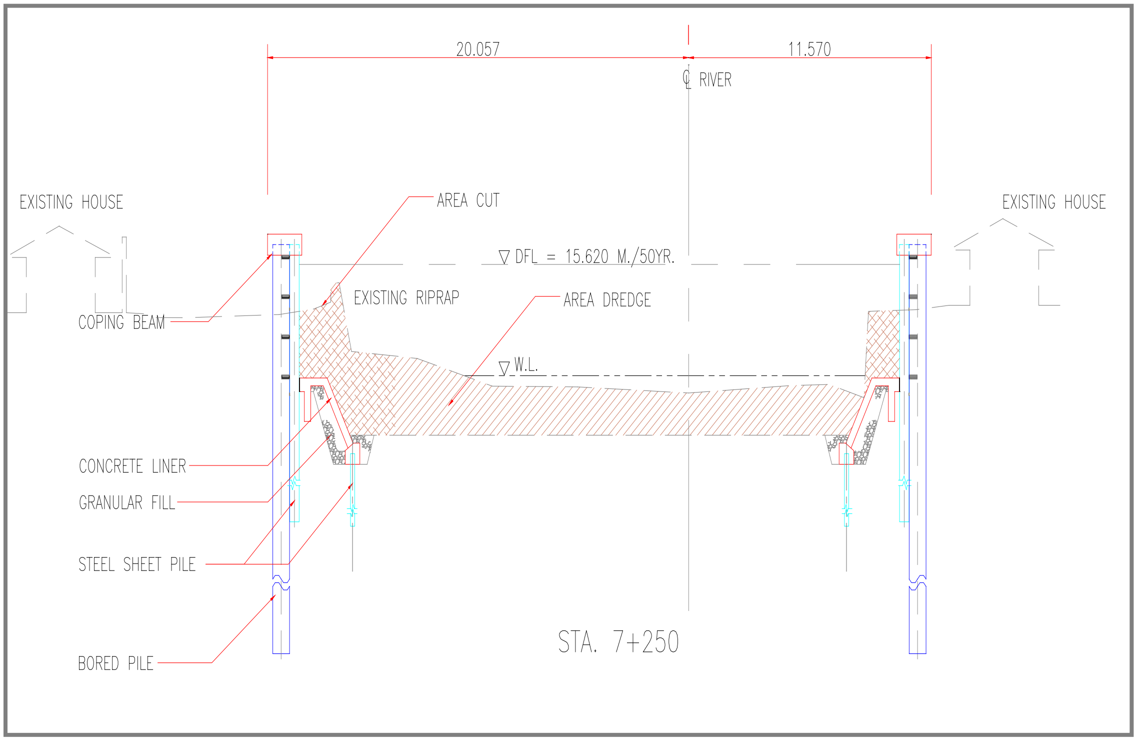
ANNEX B. San Juan River



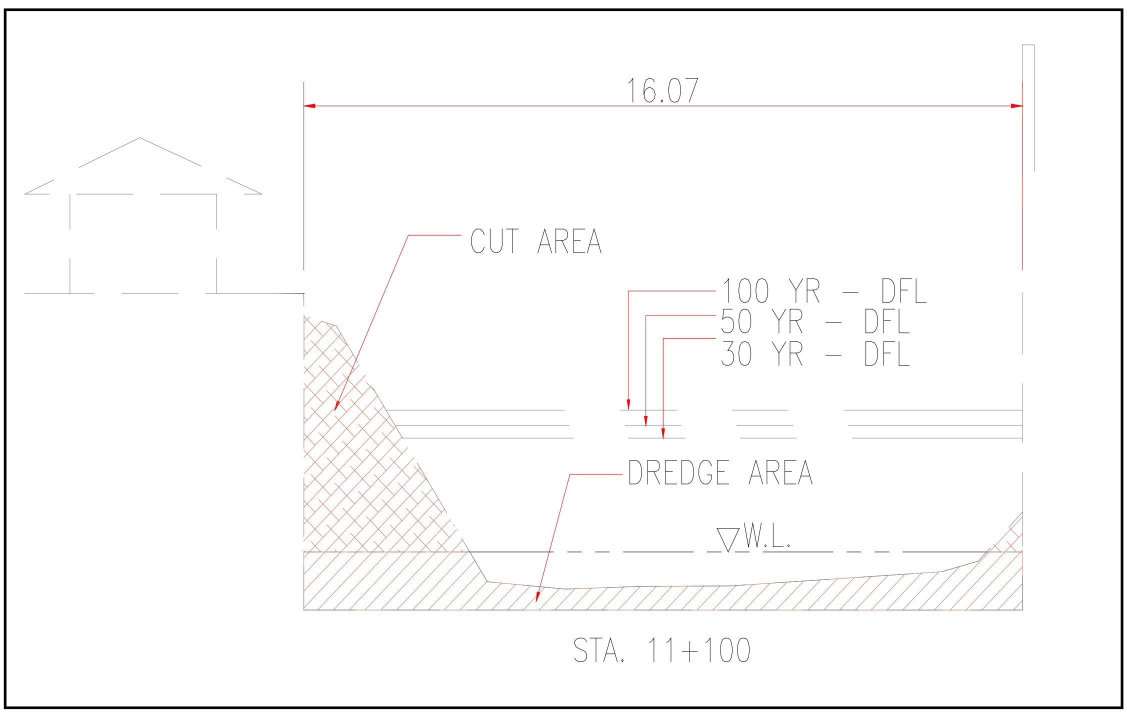
Package 4



Package 1

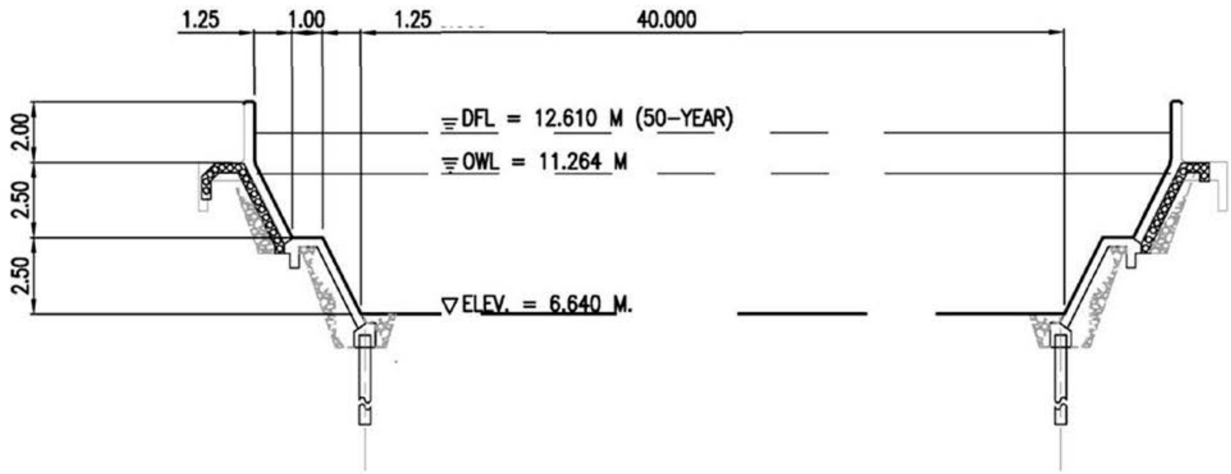


Package 2

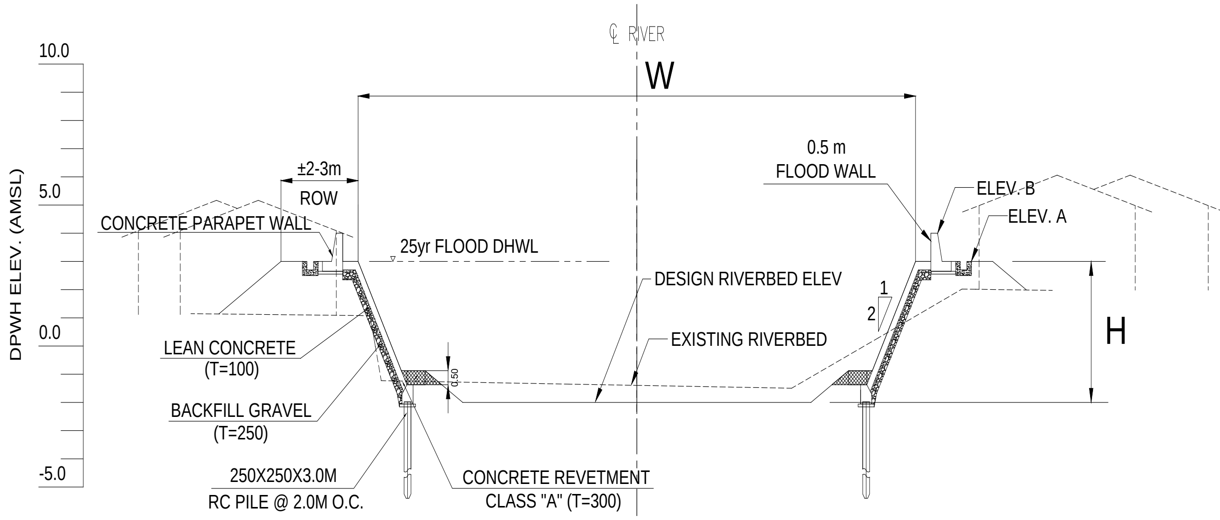


Package 3

ANNEX C. Tullahan River



ANNEX D. Zapote-Las Piñas River



Notes:

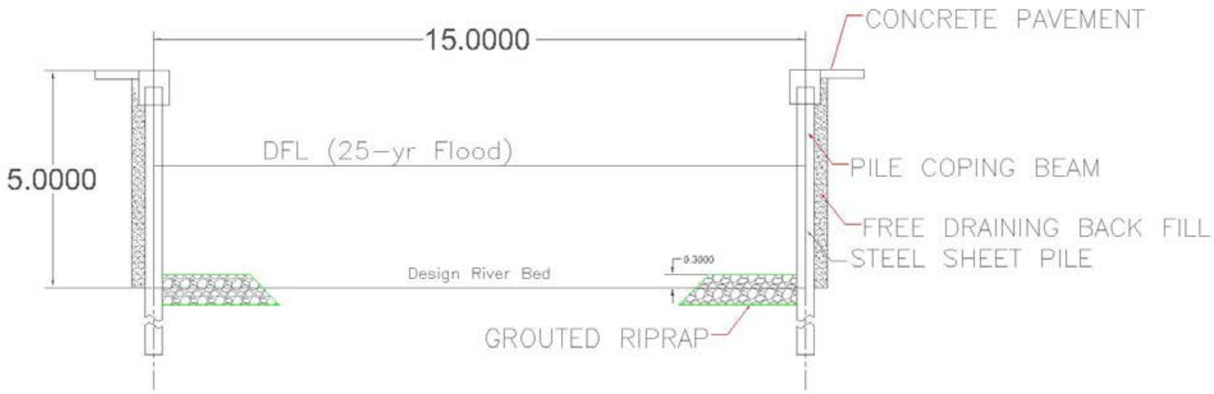
Zapote River 25-yr

Reach	W	H	Existing Width	Landmark
5	50	6	20	
4	57	6	21	
3	68	5	22	
2	80	5	25	
1	99	4	38	Mouth

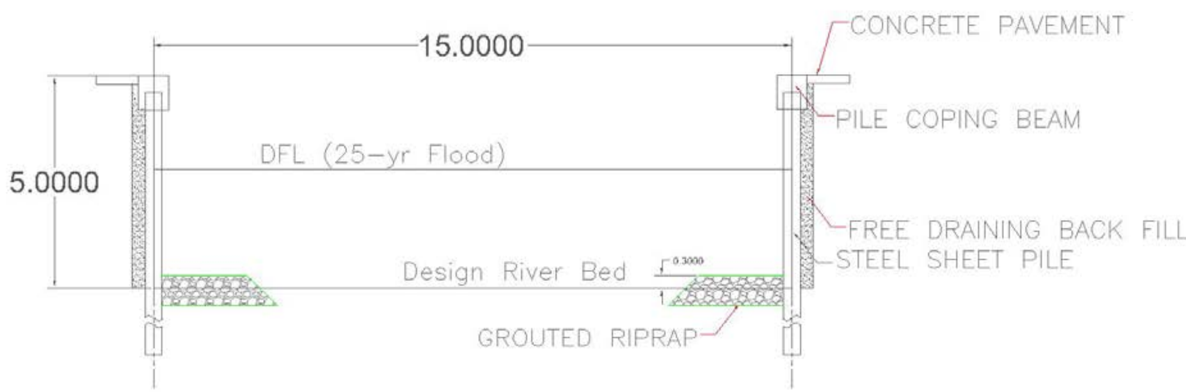
Las Piñas River 25-yr

Reach	W	H	Existing Width	Landmark
4	21	5	12	
3	24	4.5	14	
2	30	4	15	
1	36	3.5	18	Mouth

ANNEX E. Buendia-Maricaban-NAIA-Parañaque

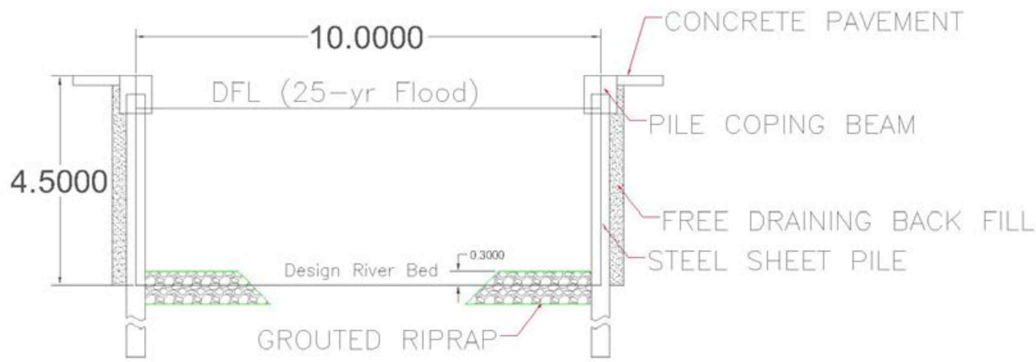


Calatagan Creek

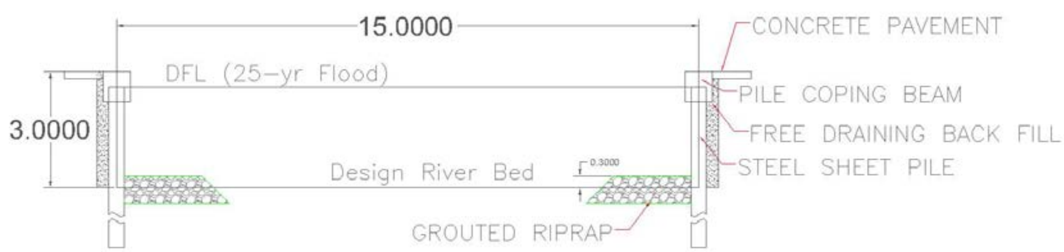


Makati Diversion Channel

Maricaban I

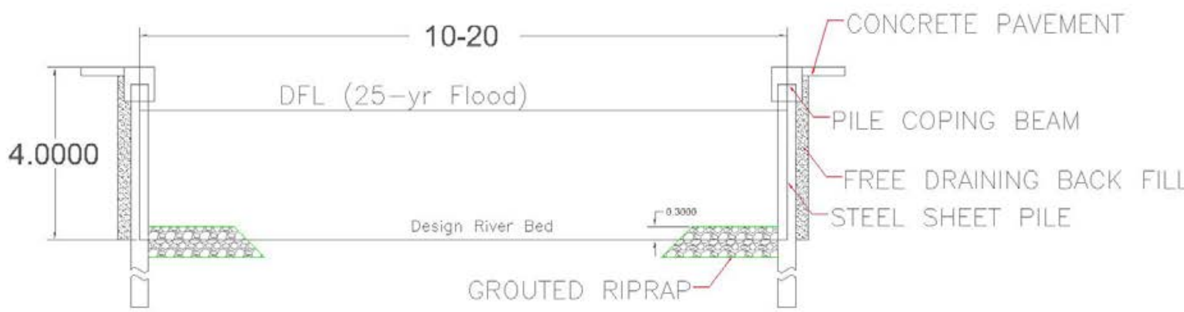


Maricaban II



Maricaban III

Paranaque Channel



Estero de Tripa de Gallina

(1) **Design Discharge for Buendia, Maricaban, NAIA, and Parañaque.**

Project Site	Rainfall Station	Duration	Catchment Area (km^2)	Peak Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
BUENDIA					
Tripa de Gallina	Port Area	60 mins	0.83	14.49	17.39
Calatagan Creek I	Port Area	60 mins	1.17	44.04	37.57
Calatagan Creek II	Port Area	60 mins	2.46	79.02	32.18
Zobel DM	Port Area	60 mins	2.26	49.36	21.86
Makati Diversion I	Port Area	60 mins	3.63	59.08	16.29
Makati Diversion II	Port Area	60 mins	1.17	48.81	41.74
Makati Div-Tripa	Port Area	60 mins	0.32	5.04	15.63
Calatagan Creek	Port Area	60 mins	0.65	14.69	22.72
Paco	Port Area	60 mins	1.42	14.04	9.88
Pandacan	Port Area	60 mins	1.91	15.49	8.11
Provisor	Port Area	60 mins	2.30	18.49	8.04
Libertad pumping Station	Port Area	60 mins	6.51	58.99	9.06
Edsa Outfall	Port Area	60 mins	1.27	55.68	43.99
Libertad Outfall	Port Area	60 mins	0.99	10.06	10.14
Buendia Outfall	Port Area	60 mins	2.27	22.14	9.76
Vito Cruz Outfall	Port Area	60 mins	0.42	6.01	14.35
Project Site	**Rainfall Station**	**Duration**	**Catchment Area (km^2)**	**Peak Discharge (m^3/s)**	**Specific Discharge ($m^3/s/km^2$)**
MARICABAN					
Maricaban Creek I	NAIA	60 mins	6.45	217.36	33.69
Maricaban Creek II	NAIA	60 mins	1.56	77.56	49.74
Maricaban Creek III	NAIA	60 mins	3.34	164.21	49.21
Project Site	**Rainfall Station**	**Duration**	**Catchment Area (km^2)**	**Peak Discharge (m^3/s)**	**Specific Discharge ($m^3/s/km^2$)**
NAIA					
Parañaque Channel 1	NAIA	60 mins	11.02	266.26	24.16
Rivera	NAIA	60 mins	0.44	23.07	52.34
Parañaque Channel 2	NAIA	60 mins	10.58	171.97	16.26
Airport Road	NAIA	60 mins	1.06	49.92	47.19
Parañaque Channel 3	NAIA	60 mins	12.08	186.57	15.45
Librada	NAIA	60 mins	1.21	20.24	16.76
Parañaque Channel 4	NAIA	60 mins	12.88	160.76	12.48
Seaside	NAIA	60 mins	1.49	10.30	6.93
Parañaque Channel 5	NAIA	60 mins	15.74	192.21	12.21
Inland Channel	NAIA	60 mins	1.74	101.35	58.36
Redemptorist Channel	NAIA	60 mins	2.68	105.00	39.12
Seaside Channel	NAIA	60 mins	4.73	126.99	26.87
Banana Island Creek	NAIA	60 mins	1.47	31.97	21.77
Ibayo Creek	NAIA	60 mins	0.27	13.46	50.20
Cut-cut Creek	NAIA	60 mins	1.94	48.38	24.93
Project Site	**Rainfall Station**	**Duration**	**Catchment Area (km^2)**	**Peak Discharge (m^3/s)**	**Specific Discharge ($m^3/s/km^2$)**
PARAÑAQUE					
Baliwag River	NAIA	60 mins	9.09	276.31	30.41
Don Galo River	NAIA	60 mins	15.39	510.57	33.17 *
San Dionisio River	NAIA	60 mins	10.22	90.62	8.86
San Isidro River	NAIA	60 mins	13.54	521.25	38.49
Las Piñas River	NAIA	60 mins	12.38	122.85	9.92
South Parañaque River	NAIA	60 mins	42.36	863.92	20.39
Parañaque River (Manila Bay)	NAIA	60 mins	57.23	1024.68	17.91

Source: DPWH-UPMO-FCMC- and Woodfields Consultants Inc.
Specific discharges are computed by JICA Survey Team based on the data source.
*: Catchment are was modified

Requested Data Summary for JICA Study on Flood Control

(2) Design Discharge for Tullahan River

Project Site	Rainfall Station	Duration	Catchment Area (km^2)	Peak Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
1. Tenejeros Bridge	Science Garden	24-hrs	70.00	588.40	8.41
2. PNR	Science Garden	24-hrs	68.44	582.00	8.50
3. McArthur highway	Science Garden	24-hrs	62.12	564.40	9.09
4. NLEX	Science Garden	24-hrs	52.50	553.20	10.54

(3) Design Discharge for Zapote-Las Piñas River

Project Site	Rainfall Station	Duration	Catchment Area (km^2)	Peak Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
1. Zapote River	NAIA	24-hrs	67.00	703.00	10.49
2. Las Piñas River	NAIA	24-hrs	21.44	197.00	9.19

(4) Design Discharge for UST-España Areas

Project Site	Rainfall Station	Duration	Catchment Area (km^2)	Peak Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
1. Constancia Interceptor	Port Area	1 hr	1.55	17.25	11.12
2. Antipolo Interceptor	Port Area	1 hr	1.50	21.92	14.59
3. Pureza Interceptor	Port Area	1 hr	3.25	51.55	15.84
4. Casanas-Margal-Quijote DM	Port Area	1 hr	1.98	19.68	9.94
5.Earnshaw DM	Port Area	1 hr	0.23	5.81	24.99
6.Lepanto-Forbes DM (Existing)	Port Area	1 hr	2.43	20.10	8.29
7. Estero de Valencia	Port Area	1 hr	1.84	29.08	15.80
8.Estero de Sampaloc I	Port Area	1 hr	2.73	20.17	7.38
9. Estero de San Miguel- Uli-Uli	Port Area	1 hr	0.47	7.09	14.98

(5) Design Discharge for San Juan River

Project Site	Rainfall Station	Duration	Catchment Area (km^2)	Peak Discharge (m^3/s)	Specific Discharge ($m^3/s/km^2$)
1. STA 1+100	Science Garden	24-hrs	91.60	822.50	8.98
2. STA 3+350	Science Garden	24-hrs	82.58	728.46	8.82
3. STA 7+250	Science Garden	24-hrs	51.49	436.95	8.49
4. STA 11+100	Science Garden	24-hrs	14.40	283.60	19.69

Source: DPWH-UPMO-FCMC- and Woodfields Consultants Inc.
Specific discharges are computed by JICA Survey Team based on the data source.

a. Science Garden

Duration in hours

Return Period	1	3	6	12	24
2	55.5	90.3	117.4	136.3	156.0
5	81.8	135.7	185.1	216.1	243.1
10	99.3	165.8	229.9	268.9	300.7
15	109.1	182.7	255.2	298.8	333.3
20	116.0	194.6	272.9	319.6	356.0
25	121.3	203.8	286.5	335.7	373.6
30	125.4	210.8	297.1	348.2	387.1
50	137.6	231.9	328.5	385.2	427.6
100	153.8	259.9	370.2	343.4	481.2

b. Port Area

Duration in hours

Return Period	1	3	6	12	24
2	55.5	86.3	111.2	134.6	153.3
5	75.2	121.4	160.0	195.9	223.5
10	88.1	144.6	192.3	236.6	270.0
15	95.5	157.7	210.5	259.5	296.3
20	100.6	166.9	223.2	275.6	314.6
25	104.5	174.0	233.1	288.0	328.8
50	116.7	195.7	263.3	326.1	372.4
100	128.8	217.3	293.4	363.9	415.8

c. NAIA

Duration in hours

Return Period	1	3	6	12	24
2	49.4	77.6	101.1	125.5	143.8
5	82.1	132.9	173.6	215.3	246.9
10	103.7	169.5	221.5	274.7	315.2
20	124.4	204.6	267.5	331.7	380.7
25	131.0	215.8	282.1	349.8	401.5
50	151.2	250.1	327.1	405.6	465.5
100	171.3	284.2	371.7	460.9	529.1

Appendix 3-1

Cost of Damages

of Tropical Storm "Ondoy"

(OCD Situation Report)

Table Damage Estimation in Each Area by City/Municiparity

City Area (m2) in each area					Damage		
Area Name	City/Municipality Name	Area	City Area	Ratio	Ondoy	in each Area	Total
		[1]	[2]	[3]=[1]/[2]	[4]	[5]=[4]*[3]	
Buendia	Makati City	8,529,800	31,973,600	0.27	195,000	52,650	
Buendia	Manila City	2,970,870	41,302,300	0.07	12,269,380	858,857	
Buendia	Pasay City	4,873,140	17,786,300	0.27	4,255,250	1,148,918	
Buendia	Pranaque City	54,778	45,625,500	0.00	32,207,679	0	2,060,424
Espana-UST	Manila City	7,715,000	41,302,300	0.19	12,269,380	2,331,182	
Espana-UST	Queson City	2,520,600	165,391,000	0.02	55,951,466	1,119,029	3,450,212
Las Pinas	Las Pinas City	15,498,600	32,279,400	0.48	10,591,150	5,083,752	
Las Pinas	Muntinlupa City	54,856	38,144,000	0.00	14,482,500	0	
Las Pinas	Pranaque City	991,375	45,625,500	0.02	32,207,679	644,154	5,727,906
Maricaban	Makati City	6,381,310	31,973,600	0.20	195,000	39,000	
Maricaban	Pasay City	3,390,520	17,786,300	0.19	4,255,250	808,498	
Maricaban	Pranaque City	50,575	45,625,500	0.00	32,207,679	0	
Maricaban	Taguig City	1,813,970	27,531,100	0.07	4,960,150	347,211	1,194,708
Naia	Pasay City	6,170,160	17,786,300	0.35	4,255,250	1,489,338	
Naia	Pranaque City	5,287,650	45,625,500	0.12	32,207,679	3,864,922	5,354,259
Paranaque	Las Pinas City	4,681,800	32,279,400	0.15	10,591,150	1,588,673	
Paranaque	Muntinlupa City	36,935	38,144,000	0.00	14,482,500	0	
Paranaque	Pasay City	2,076,160	17,786,300	0.12	4,255,250	510,630	
Paranaque	Pranaque City	33,919,900	45,625,500	0.74	32,207,679	23,833,683	
Paranaque	Taguig City	621,945	27,531,100	0.02	4,960,150	99,203	24,443,516
San Juan	Kalookan City	1,475,520	53,137,300	0.03	5,464,150	163,925	
San Juan	Malabon City	1,682	15,969,800	0.00	10,660,900	0	
San Juan	Mandaluyong City	6,577,600	11,073,100	0.59	4,174,421	2,462,908	
San Juan	Manila City	1,427,430	41,302,300	0.03	12,269,380	368,081	
San Juan	Pasig City	735,362	31,893,500	0.02	17,426,000	348,520	
San Juan	Queson City	72,542,000	165,391,000	0.44	55,951,466	24,618,645	
San Juan	San Juan Ctiy	5,881,880	5,881,880	1.00	15,660,000	15,660,000	43,622,079
Tullahan	Kalookan City	5,837,300	53,137,300	0.11	5,464,150	601,057	
Tullahan	Malabon City	14,890,100	15,969,800	0.93	10,660,900	9,914,637	
Tullahan	Manila City	207,765	41,302,300	0.01	12,269,380	122,694	
Tullahan	Navotas City	6,305,000	10,954,000	0.58	0	0	
Tullahan	Queson City	53,370,300	165,391,000	0.32	55,951,466	17,904,469	
Tullahan	Rodriguez City	609,465	263,142,000	0.00	0	0	
Tullahan	San Jose Del Monte City	448,003	104,855,000	0.00	0	0	
Tullahan	Valenzuela City	8,326,560	44,537,900	0.19	4,692,900	891,651	29,434,507
Zapote	Bacoor	26,536,800	46,961,800	0.57	2,810,142	1,601,781	
Zapote	Dasmarinas	11,694,700	88,209,200	0.13	5,278,340	686,184	
Zapote	Las Pinas City	11,450,900	32,279,400	0.35	10,591,150	3,706,903	
Zapote	Muntinlupa City	322,969	38,144,000	0.01	14,482,500	144,825	6,139,693

Area in each area	m2
Naia	11,460,208
Zapote	50,342,270
Las Pinas	16,580,130
Tullahan	90,064,825
Paranaque	41,361,833
Maricaban	11,636,372
Buendia	16,428,585
San Juan	88,641,444
Espana-UST	10,235,595
	336,751,261

City/Municipality Area	m2
Bacoor	46,961,800
Dasmarinas	88,209,200
Kalookan City	53,137,300
Las Pinas City	32,279,400
Makati City	31,973,600
Malabon City	15,969,800
Mandaluyong City	11,073,100
Manila City	41,302,300
Muntinlupa City	38,144,000
Navotas City	10,954,000
Pranaque City	45,625,500
Pasay City	17,786,300
Pasig City	31,893,500
Queson City	165,391,000
San Juan Ctiy	5,881,880
Taguig City	27,531,100
Valenzuela City	44,537,900
Rodriguez City	263,142,000
San Jose Del Monte City	104,855,000

Cavite Province	1,512,410,000
Bacoor	0.03
Dasmarinas	0.06

2009 Ondoy Damage	Php	
Bacoor	2,810,142	*
Dasmarinas	5,278,340	*
Kalookan City	5,464,150	
Las Pinas City	10,591,150	
Makati City	195,000	
Malabon City	10,660,900	
Mandaluyong City	4,174,421	
Manila City	12,269,380	
Muntinlupa City	14,482,500	
Navotas City		
Pranaque City	32,207,679	
Pasay City	4,255,250	
Pasig City	17,426,000	
Queson City	55,951,466	
San Juan Ctiy	15,660,000	
Taguig City	4,960,150	
Valenzuela City	4,692,900	
Rodriguez City		
San Jose Del Monte City		
Cavite Province	90,500,930	

*: computed based on Area Ratio
between province and the city/municipality
Source: Situation Report Efects of Tropical Storm "Ondoy"

EFFECTS OF TROPICAL STORM "ONDOY"
COST OF DAMAGES
September 24 - 27, 2009

Region/Province/City/Municipality	INFRASTRUCTURE					AGRICULTURE							Private Property	TOTAL COST (Infrastructure + Agriculture)
	ROADS/BRIDGES/ OTHER STRUCTURES	FLOOD CONTROL	HEALTH FACILITIES	SCHOOLS		CROPS (Rice and Corn)		LIVESTOCKS	HVCC (Mango, Banana, Papaya, Vegetables)	FISHERIES		FACILITIES/ INFRASTRUCTURE/ EQUIPMENT DAMAGED		
				No. of Schools Damaged	AMOUNT (Schools)	Type of Crops / Livestocks	Estimated Peso Value	Estimated Peso Value		Type of Project/ Species	Estimated Peso Value			
GRAND TOTAL	4,298,528,512.55					6,668,669,327.00								10,967,197,839.55
TOTAL	2,598,323,375.00	15,000,000.00	1,043,356,000.00	1,383	641,849,137.55		5,222,417,188.00	43,546,166.00	256,695,140.00	-	175,685,917.00	970,324,916.00	-	
DOH			735,156,000.00											735,156,000.00
Central Luzon LGUs			57,200,000.00											57,200,000.00
CALABARZON LGUs			17,000,000.00											17,000,000.00
CAR	41,050,000.00		-	80	40,355,000.00		-	-	17,000,000.00		-	51,350,000.00		149,755,000.00
Abra	770,000.00			16										770,000.00
Benguet	9,780,000.00											6,350,000.00		16,130,000.00
UCRIIS														-
Ifugao	20,000,000.00			7	3,800,000.00									23,800,000.00
Kalinga				13	7,305,000.00				2,200,000.00			15,000,000.00		24,505,000.00
Mt. Province	10,500,000.00			44	29,250,000.00				14,800,000.00			30,000,000.00		84,550,000.00
NCR	50,000,000.00		234,000,000.00	350	176,648,279.85		-	-	-		-	-		460,648,279.85
NCR LGUs	20,232,534.00		234,000,000.00		-									254,232,534.00
Caloocan City	-			25	5,464,150.00									5,464,150.00
Las Piñas City				27	10,591,150.00									10,591,150.00
Malabon City / Navotas				44	10,660,900.00									10,660,900.00
Mandaluyong City				14	4,174,420.50									4,174,420.50
Manila City				38	12,269,380.00									12,269,380.00
Makati City				5	195,000.00									195,000.00
Marikina City				29	13,524,800.00									13,524,800.00
Muntinlupa City				16	14,482,500.00									14,482,500.00
Paranaque City				28	32,207,679.35									32,207,679.35
Pasay City				27	4,255,250.00									4,255,250.00
Pasig City				31	17,426,000.00									17,426,000.00
Quezon City	29,767,466.00			20	26,184,000.00									55,951,466.00
San Juan City				5	15,660,000.00									15,660,000.00
Taguig / Pateros				24	4,960,150.00									4,960,150.00
Valenzuela City				17	4,592,900.00									4,592,900.00
Region I	23,600,000.00		-	2	1,100,000.00		132,784,000.00	-	11,697,500.00		-	-		169,181,500.00
Ilocos Norte	10,600,000.00													10,600,000.00
Ilocos Sur	4,300,000.00													4,300,000.00
La Union	5,000,000.00					Rice	1,802,000.00		-					6,802,000.00
Pangasinan	3,700,000.00			2	1,100,000.00	Rice	129,149,000.00		11,697,500.00					145,646,500.00
						Corn	1,833,000.00							1,833,000.00
Region II	64,791,000.00		-	72	28,811,250.00		81,143,023.00	-	23,175,570.00		-	270,240,000.00		468,160,843.00
Cagayan	391,000.00			31	10,600,000.00	Rice	44,047,000.00					55,640,000.00		110,678,000.00
						Corn	429,000.00							429,000.00
Isabela	7,000,000.00					Rice	1,530,000.00		3,592,000.00			4,500,000.00		16,622,000.00
						Corn	962,000.00							962,000.00
MARIIS												35,900,000.00		35,900,000.00
Nueva Vizcaya	56,300,000.00			34	14,611,250.00	Rice	15,354,023.00		19,583,570.00			167,600,000.00		273,448,843.00
						Corn	676,000.00							676,000.00
Quirino						Rice	7,888,000.00					6,600,000.00		14,488,000.00
						Corn	10,257,000.00							10,257,000.00
DEO	1,100,000.00													1,100,000.00
Tuguegarao City				7	3,600,000.00									3,600,000.00
Region III	1,423,137,375.00		-	356	163,801,181.70		3,872,791,315.00	1,010,450.00	133,200,000.00		127,532,260.00	436,594,936.00		6,158,067,517.70
Aurora						Rice	12,021,358.00		4,900,000.00					16,921,358.00
						Corn	4,620,469.00							4,620,469.00
Bataan				10	3,420,000.00	Rice	105,973,877.00		1,600,000.00	Milkfish, Prawn Fishpond	355,460.00	21,996,000.00		133,345,337.00
Bataan General Hospital						Livestock		732,300.00						732,300.00
Bulacan	63,000,000.00			135	18,883,181.70	Rice	890,545,368.00		40,500,000.00	Tilapia, Milkfish fishpond	78,897,075.00	49,325,000.00		1,141,150,624.70
San Jose Del Monte				4	14,000.00	Corn	435,775.00							449,775.00
Nueva Ecija	25,337,375.00			70	30,050,000.00	Rice	865,492,407.00		28,100,000.00			2,480,000.00		951,459,782.00

EFFECTS OF TROPICAL STORM "ONDOY"

COST OF DAMAGES

September 24 - 27, 2009

Region/Province/City/Municipality	INFRASTRUCTURE					AGRICULTURE							Private Property	TOTAL COST (Infrastructure + Agriculture)
	ROADS/BRIDGES/ OTHER STRUCTURES	FLOOD CONTROL	HEALTH FACILITIES	SCHOOLS		CROPS (Rice and Corn)		LIVESTOCKS	HVCC (Mango, Banana, Papaya, Vegetables)	FISHERIES		FACILITIES/ INFRASTRUCTURE/ EQUIPMENT DAMAGED		
				No. of Schools Damaged	AMOUNT (Schools)	Type of Crops / Livestocks	Estimated Peso Value	Estimated Peso Value		Type of Project/ Species	Estimated Peso Value			
Pampanga	1,302,000,000.00			52	44,587,000.00	Rice	1,320,912,092.00		52,400,000.00	Tilapia, Milkfish, Prawn fishpond	48,279,725.00	185,675,000.00		**2,953,853,817.00**
Angeles City				1	150,000.00	Corn	3,342,613.00							**3,492,613.00**
						Livestock		23,000.00						**23,000.00**
San Fernando City				5	950,000.00									**950,000.00**
UPRIIS												158,411,416.00		**158,411,416.00**
Tarlac	1,500,000.00			8	667,000.00	Rice	638,356,400.00		4,500,000.00			18,400,000.00		**663,423,400.00**
Tarlac City				25	9,120,000.00	Livestock		255,150.00						**9,375,150.00**
Zambales	31,300,000.00			29	42,600,000.00	Rice	31,035,956.00		1,200,000.00			307,520.00		**106,443,476.00**
						Corn	55,000.00							**55,000.00**
Olangapo City				17	13,360,000.00									**13,360,000.00**
Region IV-A	**836,635,000.00**	**15,000,000.00**	**-**	**502**	**227,918,426.00**		**928,661,263.00**	**42,535,716.00**	**53,570,000.00**		**48,153,657.00**	**102,362,980.00**		**2,239,837,042.00**
Batangas	35,300,000.00			44	35,070,000.00	Rice	39,525,000.00		2,660,000.00	Tilapia Fishcage/Fishpond	19,302,500.00			**131,857,500.00**
						Corn	6,131,500.00			Seaweeds	45,000.00			**6,176,500.00**
						Livestock		11,100,036.00						**11,100,036.00**
						Service Boat						80,000.00		**80,000.00**
						Poultry House, flying pens, pigpens						142,500.00		**142,500.00**
Cavite	20,000,000.00	12,000,000.00		107	39,495,000.00	Rice	14,824,000.00		2,610,000.00	Sugpo/Milkfish	3,358,830.00			**80,287,830.00**
						Corn	5,382,000.00			Fishpond				**5,382,000.00**
						Livestocks		88,500.00						**88,500.00**
						Motorized Banca						580,000.00		**580,000.00**
						Baklad/Fishpond						4,082,600.00		**4,082,600.00**
						Hook & Line/Gillnets						65,000.00		**65,000.00**
						Pigpens						15,000.00		**15,000.00**
Laguna	7,500,000.00			119	108,353,000.00	Rice	646,926,870.00		43,500,000.00	Tilapia		32,000,000.00		**844,343,870.00**
						Corn	11,635,450.00			Fishpond	6,064,000.00			**11,635,450.00**
						Livestock		10,336,800.00		Fishcage				**10,336,800.00**
						Gillnets/Fishtraps						2,000,000.00		**2,000,000.00**
						Fishnets/Bancas						300,000.00		**300,000.00**
Sta. Rosa City				8	2,875,900.00	Hatchery pond for Tilapia						6,820,000.00		**9,695,900.00**
San Pablo City				54	14,800,000.00	Fishcages/fishponds						2,482,880.00		**17,282,880.00**
Calamba City				57	928,000.00									**928,000.00**
Quezon	8,000,000.00	3,000,000.00		2	900,000.00	Rice	8,829,750.00		1,300,000.00	Tilapia				**20,157,750.00**
						Corn	1,092,000.00			Milkfish				**1,092,000.00**
						Livestock		153,600.00		Prawn	1,128,000.00	2,000,000.00		**2,153,600.00**
						Fishing/MBs				Fishpond		360,000.00		**360,000.00**
Quezon - Marinduque						Fsihnets/Bancas						200,000.00		**200,000.00**
Rizal	375,385,000.00			103	24,390,350.00	Rice	192,642,893.00		3,500,000.00	Seaweeds	18,255,327.00			**614,173,570.00**
						Corn	1,671,800.00							**1,671,800.00**
						Livestock		20,856,780.00						**20,856,780.00**
						P. House + Pigpens						1,235,000.00		**1,235,000.00**
Antipolo City	35,000,000.00			8	1,106,176.00	CIS						50,000,000.00		**86,106,176.00**
Baras	53,500,000.00													**53,500,000.00**
Tanay	301,950,000.00													**301,950,000.00**
Region IV-B	**62,700,000.00**		**-**	**21**	**3,215,000.00**		**132,439,000.00**	**-**	**9,032,500.00**		**-**	**189,000.00**		**207,575,500.00**
Marinduque				6	75,000.00	Corn	234,000.00		2,250,000.00					**2,559,000.00**
Occidental Mindoro	38,700,000.00			15	3,140,000.00	Rice	120,811,750.00		6,100,000.00					**168,751,750.00**
						Corn	8,010,250.00							**8,010,250.00**
						Motorized Banca						180,000.00		**180,000.00**
						Squid Jiggers						9,000.00		**9,000.00**
Oriental Mindoro							3,383,000.00							**3,383,000.00**
Palawan	3,000,000.00								682,500.00					**3,682,500.00**
Romblon	21,000,000.00													**21,000,000.00**
Region V	**96,410,000.00**		**-**	**0**	**-**		**74,224,587.00**	**-**	**9,019,570.00**		**-**	**109,588,000.00**		**289,242,157.00**
Albay	1,270,000.00					Rice	6,528,000.00		2,900,159.00					**10,698,159.00**
						Corn	190,168.00							**190,168.00**
Camarines Norte	54,000,000.00					Rice	3,536,000.00		530,563.00			80,700,000.00		**138,766,563.00**
Camarines Sur	35,000,000.00					Rice	62,476,129.00		5,362,072.00			2,638,000.00		**105,476,201.00**
						Corn	342,590.00							**342,590.00**
Catanduanes	6,140,000.00								38,571.00					**6,178,571.00**
Masbate						Rice	913,700.00		188,205.00			26,250,000.00		**27,351,905.00**
Sorsogon						Rice	238,000.00							**238,000.00**
Region IX	**-**		**-**	**0**	**-**		**374,000.00**	**-**	**-**		**-**	**-**		**374,000.00**
Zamboanga Sur						Rice	374,000.00							**374,000.00**