E.5 DRAINAGE IMPROVEMENT PLAN

E.5.1 BASIC CONCEPT AND CONDITIONS FOR FORMULATING DRAINAGE IMPROVEMENT PLAN

(1) Target of Drainage Improvement

The targets of the drainage improvement plan are:

- ***To recover and sustain the original and potential functions of the existing drainage channels and drainage pumping stations; and***
- ***To improve inundation conditions in severe regional inundation areas in which channel network of the present system is insufficient.***

The drainage improvement master plan is formulated basically based on the existing drainage networks and drainage facilities in the core area, in which 11 drainage blocks are identified. *Table E.5.1* shows the objective drainage channels and facilities, which include large pumping stations, esteros/creeks, drainage mains and major outfalls. Although there are numerous laterals and 8 small pumping stations, they are not included in the master plan and are to be rehabilitated separately through the ordinary maintenance activities.

Table E.5.1 Objective Drainage Channels and Facilities

North Manila: 5 drainage blocks (28.8 km^2)	*South Manila: 6 drainage blocks (43.8 km^2)*
7 Large pumping stations *20 Esteros/Creeks: 27.8 km* *19 Drainage mains: 17.8 km* *Related major laterals*	*8 Large pumping stations* *22 Esteros/Creeks: 45.7 km* *18 Drainage mains: 17.0 km* *Related major laterals*

(2) Measures of Drainage Improvement

In order to achieve drainage improvement in the core area of Metropolitan Manila, it is necessary to carry out integrated measures that include structural, non-structural and supporting measures.

1) Structural Measures

The structural measures aim to mitigate the inundation by rehabilitation works of drainage pumping stations, dredging of drainage channels, additional works including construction of interceptors, etc.

2) Non-structural Measures

The non-structural measures aim to reduce flood damage indirectly. It includes recommendation for countermeasures against rapid urbanization and usage of existing flood forecasting and warning system.

3) Supporting Measures

The supporting measures aim to support and sustain the above two measures by improving and developing organizational aspects of O&M system including community involvement, and by installing several O&M related equipment and facilities. Solid waste management along drainage channels to reduce accumulation of bottom deposits are proposed. Guideline for resettlement will be also prepared.

Figure E.5.1 shows the relationship among the three measures in the drainage improvement plan.

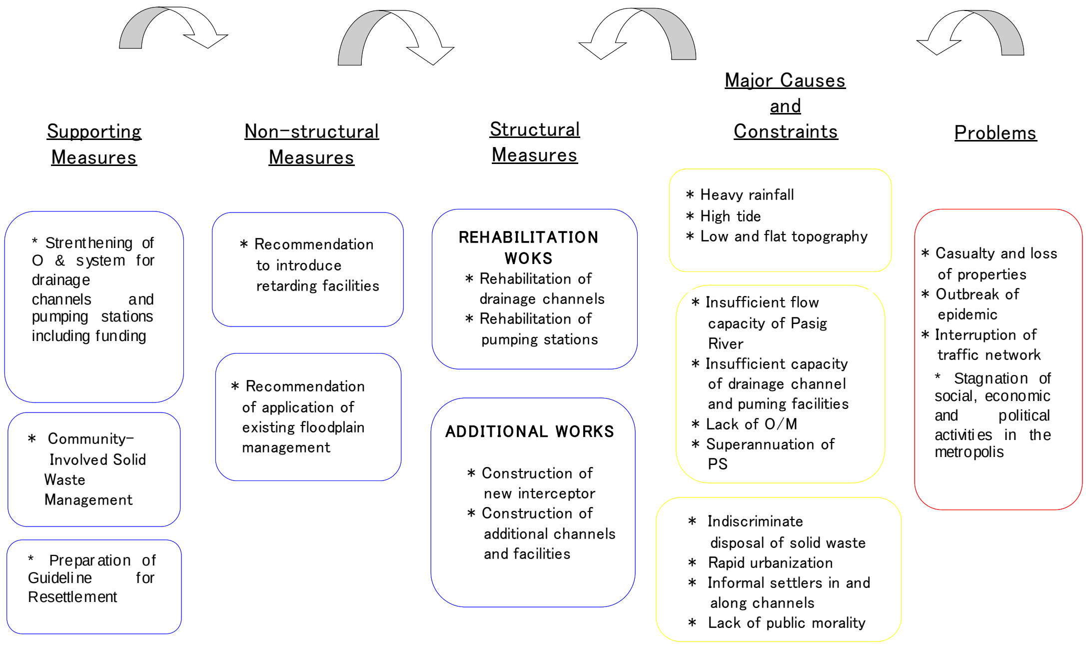


Figure E.5.1 Measures of Drainage Improvement

(3) Categorization of Drainage Channels

The existing drainage channels: esteros/creeks, drainage mains, outfalls and laterals, are categorized due to their drainage functions or roles. The 15 large drainage pumping stations drain storm water from about 70% of the core area. The esteros, which are directly connected to the pumping stations, are essential for the pump drainage system. These channels act not only as channels for discharging stormwater to pumping stations but also as regulating ponds of pumping stations. Therefore, they should be categorized as the trunk channels. The open and closed channels connecting to trunk channels are also important and categorized as the secondary channels. The rest of drainage channels except laterals are categorized as the tertiary channels. *Table E.5.2* summarizes the definition of the category of drainage channels, and the categorized channels are shown in *Figure E.5.2*.

Table E.5.2 Definition of Category of Drainage Channels

Trunk Channel	*Esteros/Creeks which are directly connected to large drainage pumping stations and jointly functions as common retarding pond for smooth pump operation*
Secondary Channel	*Other minor Esteros/Creeks and drainage mains/outfalls/interceptors which are connected to trunk channel*
Tertiary Channel	*Other channels except for above trunk and secondary channels and laterals*
Lateral	*Drainage pipes and gutters*

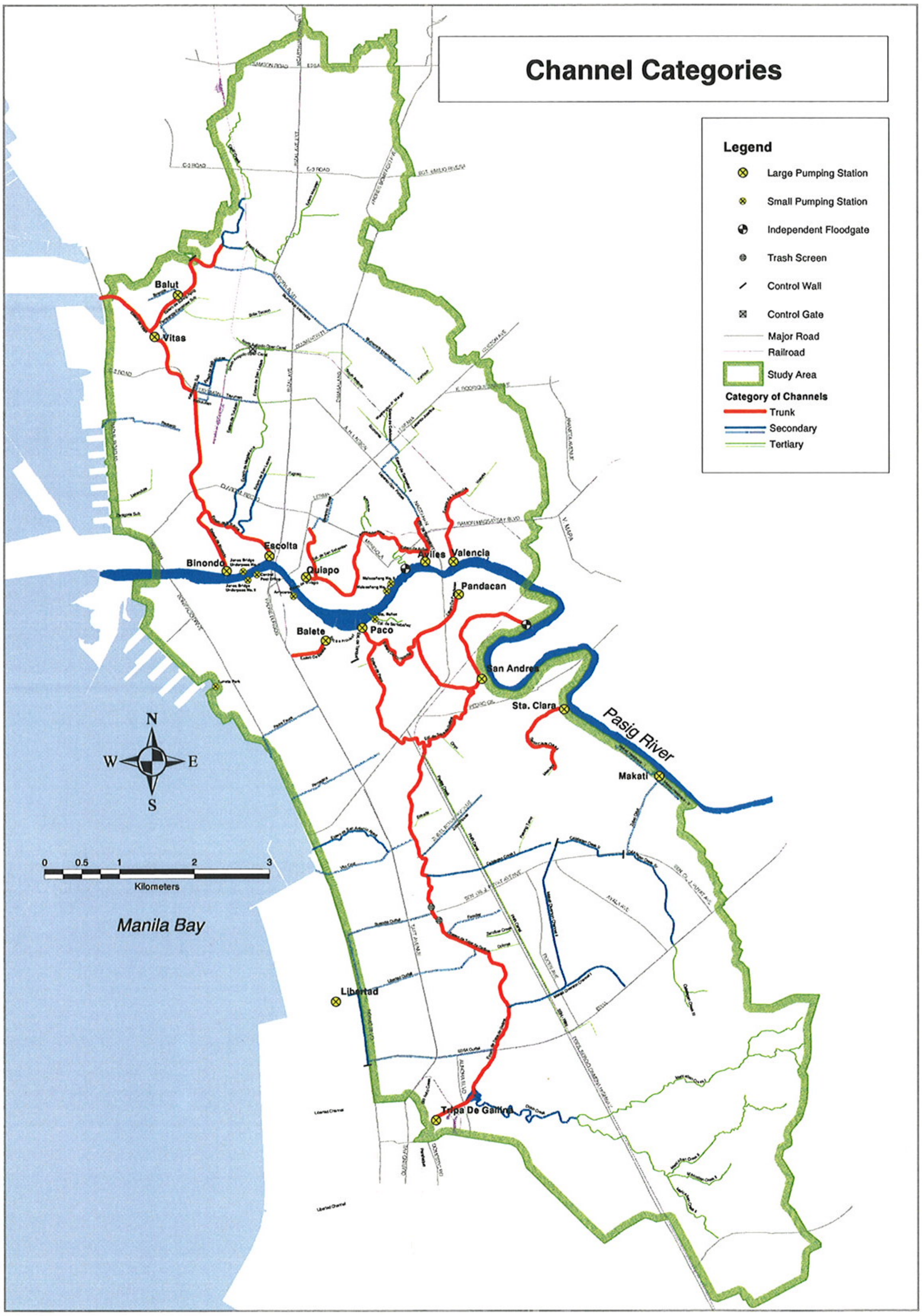


Figure E.5.2 Channel Categories

(4) Target of Rehabilitation and Design Scale for Additional Works

According to the 1952 Plan for the Drainage of Manila and Suburbs, major drainage channels were designed for a 10-year return period, whereas local channels had no prepared action. On the other hand, the 1984 Metro Manila Integrated Urban Drainage and Flood Control Plan proposed a 10-year return period for design discharge for major channels and drainage pumping stations, and a 2-year return period for local channels. It should be noted that drainage capacities of the pumping stations have been designed for a 10-year return period with a 20-cm allowable inundation depth in the catchments.

The present channels and facilities have been basically constructed and improved according to the above-mentioned design scales. However, those original functions and safety level have been considerably decreased due to illegal social activities of encroachment of informal settlers and accumulated bottom deposits, but in some drainage basin runoff is increasing due to the rapid urbanization, etc.

Ideally, it is supposed in the core area of Metropolitan Manila that drastic drainage improvement be desired in view of maintaining and improving the capital city's functions and the citizen's social and public welfare. However, it is not practical considering the present and potential drainage capacities of the existing channels, various constraints of limited channel easement, encroachment of numerous informal settlers in the channels, financial capacity for improvement works, etc.

Objective works in the drainage improvement consist of rehabilitation works and additional works for the drainage channels including box culverts and pumping stations.

Main purpose of the rehabilitation works is to revive the original cross-sectional area of drainage channels and box culverts, and to sustain the original functions of drainage pumping stations so as to operate properly. Accordingly, the rehabilitation target is to remove the accumulated bottom deposits in the channels and culverts by means of dredging or declogging including related remedial works of construction of stop logs and improvement of covered maintenance holes (or manholes) and to repair and replace damaged pump equipment and appurtenant facilities of the pumping stations.

Aside from the above, that of the additional works is to construct new box culverts for further improvement of the present poor drainage situation. For Blumentritt interceptor, construction of inlets for road surface flow and widening of narrow sections are planned as remedial works. The design scale for additional works is a safety level against a certain rainfall amount evaluated by occurrence probability to design and construct new drainage channels, generally called as "design scale".

The design scale for additional works is summarized in *Table E.5.3*.

Table E.5.3 Design Scale for Additional Works

Drainage pumping Stations (15 large pumping stations)	*10 years return period (269 mm/24 hours)*
Trunk Channel	*10 years return period (80 mm/hour)*
Secondary Channel Interceptor to be proposed	*3 years return period (60 mm/hour)*
Tertiary Channel, Lateral Small Pumping Station	*To recover original capacity, not specified*

(5) Other Conditions for Formulating Drainage Improvement Plan

1) Topography

- The most recent available topographic information based on 1:5,000 topographic map prepared in 2004, with low-lying areas modified using the result of manhole survey in 2000, is utilized for formulation of the Master Plan.
- Primary benchmark is BM-ML3 located in Quezon City.
- Elevation above DPWH datum of 10.475 m is equivalent to Mean Sea Level (MSL).
- Cross-sectional and longitudinal shape of the channels surveyed in the present study and in SEDLMM (2000) is used as basis to evaluate the existing condition.

2) Design Rainfall

- The probable rainfall intensity for Port Area station evaluated in the Study is employed. The average rainfall intensity for one hour against a 10-year return period is 81 mm/ hour.
- The design hyetograph has been proposed considering mass-curves, and it is applied in the Study. The detail is described in *Supporting Report B.*

3) Design High Water Levels at Surroundings

- Mean Spring High Tide Level (El. 11.34 m) is applied for design high water level on Manila Bay.
- As for design high water level along the Pasig River and the Paranaque River, water level for a 30-year return period event is applied. For the detail, please refer to *Chapter 2.1 of Main Report* or *Supporting Report B.*

4) Improvement of the Pasig River

- Completion of on-going Pasig-Marikina River Improvement Project is assumed.
- The design high water level along the Pasig River is thereby determined using that in the said project.
- Also, it is assumed that outlet of drainage along the Pasig River will be improved so that reverse flow from the Pasig River into the study area will be minimum, even if the water level along the Pasig River rises. The concept of improvement plan of drainage along the Pasig River, which is proposed in the on-going Pasig-Marikina River Improvement Project, is described in *Supporting Report E.*

5) Hydrologic and Hydraulic Analysis

- For the design purpose, the rational method to estimate probable peak discharge is applied.
- Discharge capacity is then estimated using conventional uniform or non-uniform calculation
- Manning’s coefficient for channel roughness is assumed at 0.025 for esteros/creeks

and 0.015 for drainage mains.

- After necessary dimension of the drainage channel is determined, a more sophisticated, unsteady, hydrodynamic simulation by MOUSE is executed to confirm its validity.

E.5.2 BASIC CONSIDERATION OF DRAINAGE IMPROVEMENT PLAN

(1) Original and/or Potential Capacity of Existing Drainage Channels

As have been discussed in *ChapterE.4*, dredging and declogging of drainage channels are remarkably effective to increase the discharge capacity. It is indicated by the conventional hydrological and hydraulic analysis that original and/or potential capacity of many drainage channels is large enough to drain stormwater for design rainfall, except some channels in the severe inundation area. This has been clarified by the hydrodynamic simulation by MOUSE. The detail of the simulation by MOUSE is described in *Supporting Report D*. *Figure E.5.3* shows the simulated inundation conditions for the existing channels and for the dredged and declogged channels. The rainfall given here is the design rainfall for a 10-year return period. The dredging and declogging reduce the inundation depth and duration remarkably, especially for the area along trunk channels. However, for the severe inundation areas in North and South Manila, the inundation condition is not improved. Some additional works will be required.

(2) Disposal of Dredged and Declogged Material

Total volumes to be dredged and declogged from esteros/creeks and drainage mains are estimated at about 840,000 m^3 and about 80,000 m^3, respectively. Based on the results on the sampling survey of sediment and waste from estero bed during the Study, the concentration of toxic material in the sediment and waste was lower than the one for hazardous waste specified in DAO No. 22-29, as shown in *Chapter 2.1 of Main Report*. Therefore, it can be deposited by ordinary landfill method. However, because the number of samples taken during the Study is limited and there is always uncertainty, it is strongly recommended that detailed investigation on harmful chemical parameters be conducted before implementation of the project.

Dredged and declogged material from esteros and drainage mains should be appropriately transported and disposed at appropriate sites.

(3) Encroachment of Structures within Esteros

Encroachment of structures has been observed in many esteros. It is estimated that about 6,000 families are living in such structures in the study area. If the structures nearby esteros are included, the number of families who live along esteros is expected to be much larger. When the bottom deposits will be dredged to recover the original cross-sectional area of esteros, such structures within esteros should be removed and those who live in the structure within esteros should be basically relocated first.

In general, as a principle of river management, not only such encroachment within esteros but also encroachment in maintenance roads along esteros must be prevented. On the other hand, negative impact upon those who have already lived in such structures, due to the project implementation, should be minimum. Considering both views, the following compromised plan would be preferable. That is to say, to recover the original cross-sectional area of esteros and consequently original discharge capacity, dredging work would be implemented after the structures within esteros are removed without touching the structures outside of esteros tentatively.

There are three main reasons for necessity of removal of the structure within esteros. First, both overhanged structures from bank and self-standing structures within esteros will be obstacles for dredging work itself. Second, the lowered estero bed by dredging will threaten the stability of self-standing structures within esteros. Third, the structures themselves may become obstacles against water flow during storm although it is difficult to estimate its quantitative effect due to limited information.

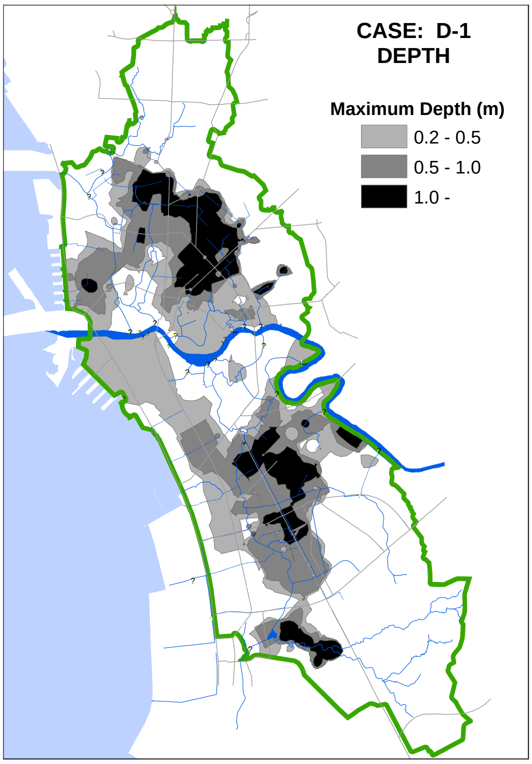
The removal of the structures within esteros requires relocation of those who are living in there. To mitigate negative impact upon them, a well-considered and socially acceptable relocation plan and procedure is crucial to implement dredging work of esteros.

(4) Maintenance Hole of Drainage Main

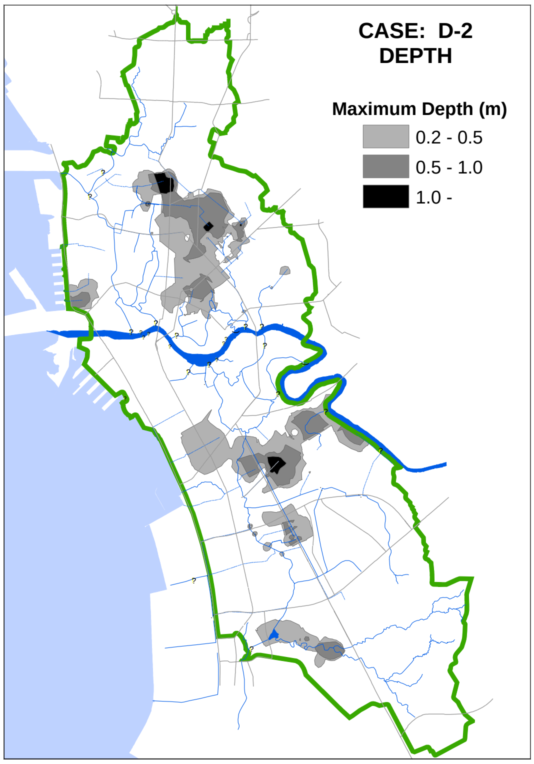
Many of maintenance holes of drainage main have been improperly maintained. Some of them have been covered by road pavement or structures and no longer utilized for maintenance. Such maintenance holes should be improved in order to recover their proper functions. Otherwise, it is really difficult to conduct ordinary O&M works.

(5) Necessity of Pumping Stations

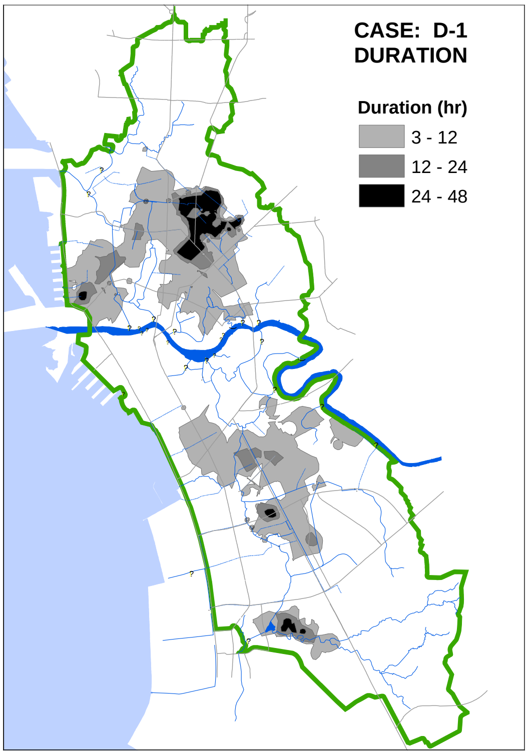
About 70% of the study area is drained by drainage pumping stations in the core area. The pumping stations, especially 12 stations constructed in the ‘70s and ‘80s, are aging and losing their service lives. All of the stations will lose their function completely, if any rehabilitation works would not be executed. This condition is equivalent to the condition before the pumping stations were constructed. *Figure E.5.4* demonstrates the simulated inundation condition without pump and gate operation. The gate was assumed to be kept fully opened. The rainfall given is the design rainfall for a 10-year return period. As seen in the figure, deep inundation area extends to the entire low-lying area, which brings about much more severe damage in the capital of the Philippines. This proves the necessity of pumping stations. To keep the pump drainage system forever is costly. However, it is indispensable for the existing core area to rely on the pump drainage system. Coexistence with the pumping stations will be required. Therefore, the rehabilitation works for the pumping stations will be fundamental for the drainage improvement master plan.



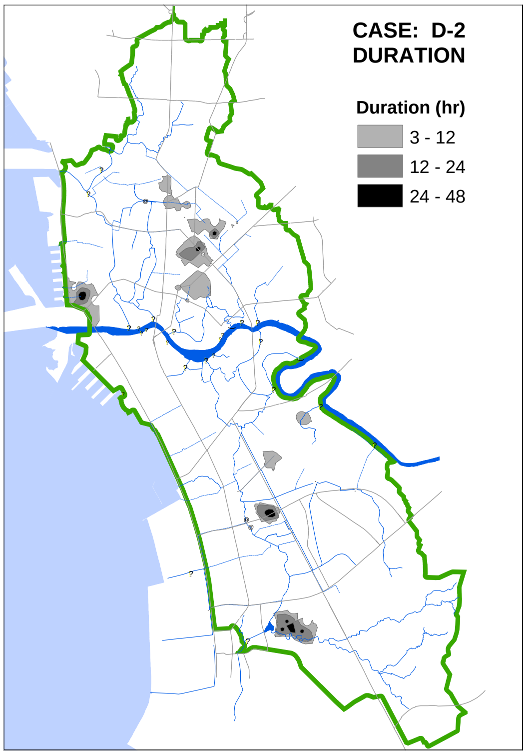
Maximum Inundation Depth
(Existing condition)



Maximum Inundation Depth
(Conditon after dredging and declogging)

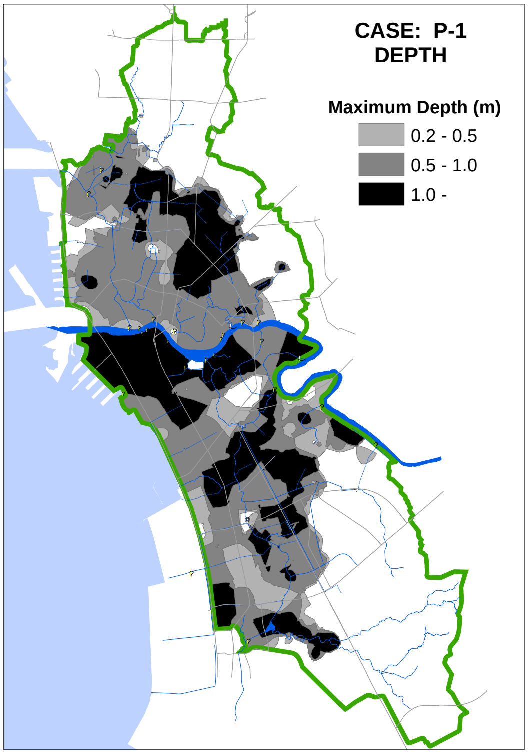


Inundation Duration
(Existing condition)

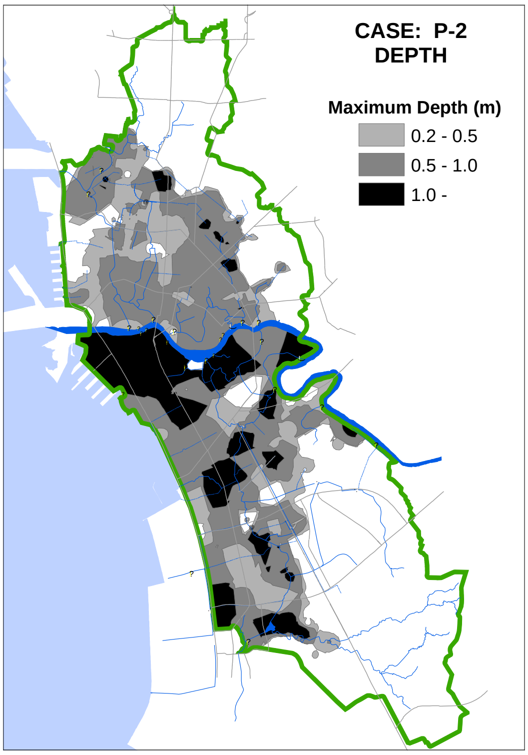


Inundation Duration
(Condition after dredging and declogging)

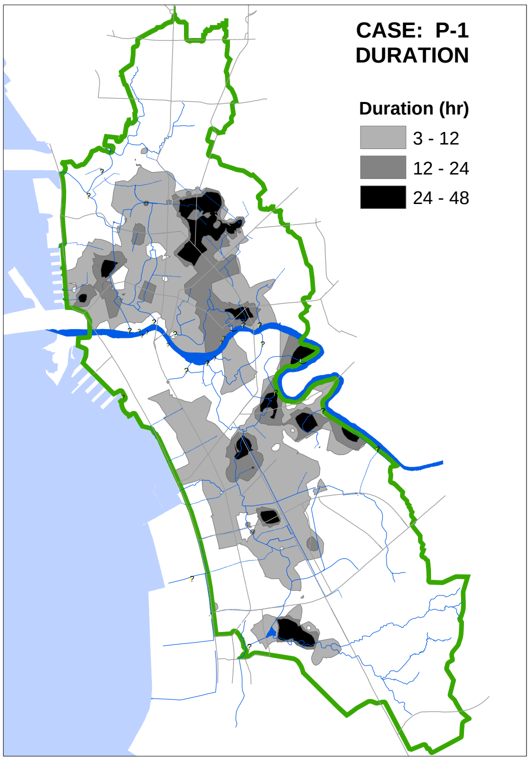
Figure E.5.3 Simulated Inundation Conditions - Effect of Dredging and Declogging



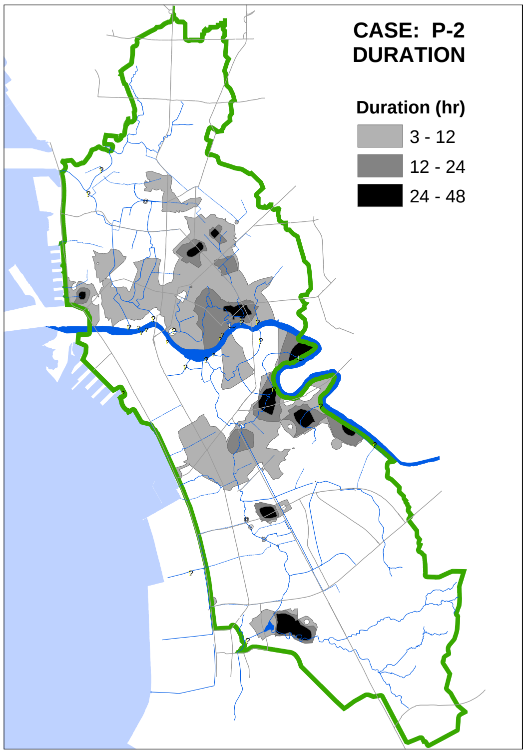
Maximum Inundation Depth
(Without pump and gate operation for existing condition)



Maximum Inundation Depth (Without pump and gate operation for condition after dredging and declogging)



Inundation Duration
(Without pump and gate operation for existing condition)



Inundation Duration (Without pump and gate operation for condition after dredging and declogging)

Figure E.5.4 Simulated Inundation Conditions - Effect of Pumping Stations

(6) Contents of Structural Measures

Based on the above discussion, it is concluded that the necessary structural measures for improving existing drainage system are as follows.

- Rehabilitation works to recover its original function, and
- Additional works to improve present condition toward higher safety level against inundation.

1) Rehabilitation Works

The existing trunk, secondary and tertiary channels will be dredged and declogged to recover cross-sectional flow area assigned in the original design stage, while drainage pump equipment and appurtenant facilities will be repaired or replaced complying with the extent of superannuation. The following are basic lines for rehabilitation works.

Dredging of Trunk Channels directly connected with Pumping Stations

The functions of the trunk channel are not only leading stormwater to pumping station but also retarding stormwater for smooth pump operation. In this sense, trunk channels are cleaned and dredged to recover basically original cross-sectional area assigned in those design stages. In addition, relocation of informal settlers within channels will be required for retrieving present drainage systems.

Dredging and Declogging of Secondary and Tertiary Channels

Dredging or declogging will be carried out for secondary and tertiary channels. Minor channels of laterals are principally declogged separately through ordinary maintenance activity.

Related Works

1) Rehabilitation of maintenance holes

Maintenance holes covered by road pavement are raised to recover those functions.

2) Installation of stop log gate for drainage mains

Stop log gate is installed depending on water level at the box culvert that is rehabilitated. The criterion of installation of stop log gate is as follows. .

- For box culvert discharging through pumping stations:

  Culvert with more than 50 cm water depth of box culvert when water level of outlet is pump operation stop level
- For box culvert discharging directly to Manila Bay:

  All culverts

Repair and Replacement of Pump Equipment and Appurtenant Facilities

In combination with the dredging and declogging of drainage channels, rehabilitation works of pump equipment and appurtenant facilities will be examined. Complying with respective extents of superannuation based on technical checking of mechanical and electrical aspects, rehabilitation works will cover repair, replacement and other required remedial works for existing pump equipment and appurtenant facilities including adjustment of design drainage capacity.

2) Additional Works

Even after rehabilitation works of drainage channels and pumping stations are completed, regional inundation areas still remain due to lack of drainage channels and facilities therein. For severe regional inundation areas of Aviles-Sampaloc area in North Manila and San Isidro-San Antonio-Pio-del Pilar area in South Manila and other problem areas, some additional works will be proposed.

(7) Drainage Block with Multiple Pumping Stations

In North Manila, Vitas, Binondo and Escolta stations are jointly operating through Esteros de Vitas, Binondo and Reina. Also, Quiapo and Aviles are jointly working through Esteros de San Miguel and Aviles. Similarly, in South Manila, Libertad-Tripa de Gallina and Paco-Pandacan-San Andres drainage blocks, there exist 5 large drainage pumping stations jointly draining stormwater through Estero de Tripa de Gallina. The other 3 drainage pumping stations are working independently for own drainage basin. In the system of Tripa de Gallina, the drainage block is largely divided into 2 blocks of Libertad-Tripa de Gallina and Paco-Pandacan-San Andres by an existing hump located around an outlet to Vito Cruz outfall in the Estero de Tripa de Gallina. During heavy rainfall event, these 2 blocks are combined and stormwater therein is drained by joint operation of 5 pumping stations. In this sense, retarding space of connected esteros of Tripa de Gallina and others are working effectively as a common regulating pond or reservoir for all pumping stations.

For this joint pump operation system existing at present, the following are considered referring to Libertad-Tripa de Gallina drainage block in South Manila.

Pump operation system with high flexibility

Aerial rainfall distributions are actually not uniform in the whole basin with various aerial distribution patterns, e.g. heavy rainfall in Makati area, light rain in Paco area. In this case, Libertad and Tripa de Gallina pumping stations covering a heavy rainfall zone are operated as core stations and other stations play a supplementary role. If each drainage basin for pumping station is separated by a control gate, such flexibility will not be demonstrated and troublesome gate operation will be needed even in the time of heavy rainfall. Likewise, the present joint or combined pump operation system is more flexible and effective than an independent operation.

Pump operation system with emergency measures

In case one or two pumping stations are shut down due to mechanical and electrical troubles, other pumping stations can take up the function to drain storm water in those problem areas. The worst case, in which much stormwater stays in drainage basin even after heavy rainfall event finishes, can be avoided by the multiple pumping stations. Likewise, the present system is well taken care of to handle an emergency.

Accordingly, there is no particular reason to delineate or separate a drainage block and/or basin by installing a control gate in the esteros for each pumping station. Therefore, the installation of control gates will not be proposed in the master plan.

(8) Severe Inundation Area in North Manila

1) Cause of Severe Inundation

Aviles-Sampaloc area has been suffering from frequent and severe regional inundation. This regional inundation is caused by not only local stormwater in Quiapo-Aviles drainage block but also excess stormwater flowing from the hilly area of existing Blumentritt interceptor. The problems recognized so far are as follows.

- The flow capacity of existing Blumentritt interceptor is quite small compared to its catchment size. Taking into account the topographic condition of the uppermost sub-basin of the Blumentritt interceptor (indicated as Region 1 in *Figure E.5.5: Area =0.6 km*^{2}), it will be difficult to intercept stormwater from there. Accordingly, the stormwater from there can be easily overflowed toward Quaipo-Aviles drainage block.
- The stormwater from sub-basin of middle reach of the existing Blumentritt interceptor (indicated as Region 2 in *Figure E.5.5: Area =1.0 km*^{2}), cannot be collected by the existing Blumentritt interceptor. The overflowed stormwater enters into the uppermost sub-basin of Vitas-Binondo-Escolta drainage block (indicated as Region 3 in *Figure E.5.5: Area =0.6 km*^{2}).
- The drainage line connecting Kabulusan outfall, Estero de Kabulusan, South Antipolo Canal, North Antipolo Canal and South Antipolo drainage main is a main drainage that drains the stormwater in Region 3. However, because of heavily accumulated bottom deposits in the drainage, the flow capacity is quite small. Also, there exists the region that has higher ground elevation than the surroundings along the west of Region 3. The overflowed stormwater into Region 3 cannot be easily moved toward the west even as overland flow. The overflowed stormwater thereby tends to intrude toward the south, that is, Quiapo- Aviles drainage block.
- Therefore, almost all of the overflowed stormwater from the middle and uppermost sub-basins of the existing Blumentritt interceptor is finally drained into the Pasig River through Aviles and/or Quiapo pumping stations. Actual drainage area for Quiapo-Aviles drainage block is thereby increased with 2.2 km^2 (summation of Region 1 to 3), which means the actual drainage area is almost 1.4 times as large as the assumed drainage area (Assumed area = 5.6 km^2, Actual area = 7.8 km^2).
- To make the situation worse, the capacity of Severino Reyes drainage main, a secondary channel connecting to Quiapo pumping station, is not enough. Especially, its inlet is quite small. This makes for the long duration of inundation on and around Espana Street.

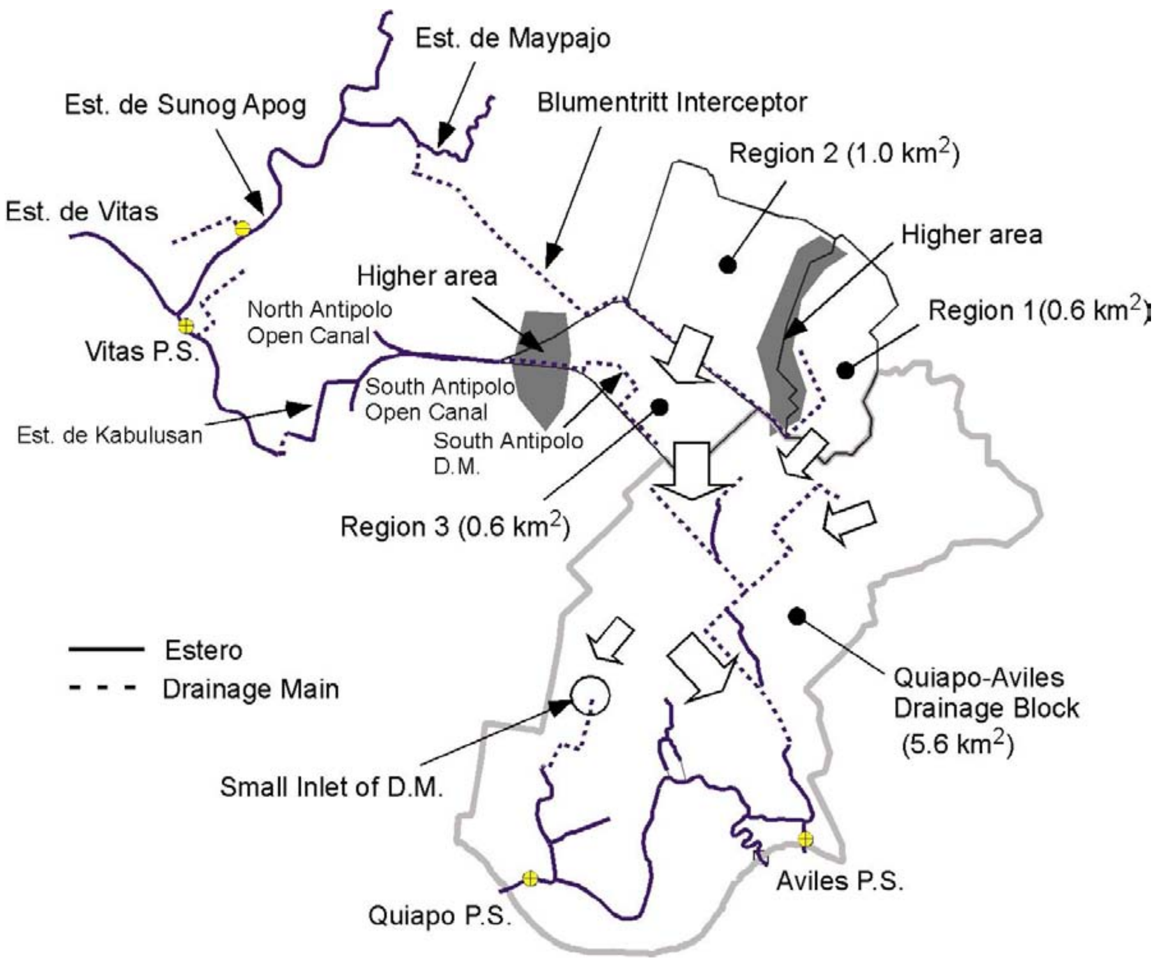


Figure E.5.5 Causes of Severe Inundation in North Manila

2) Reconsideration of Drainage Scheme

The stormwater from Regions 1 and 2, depicted in *Figure E.5.5*, is originally planned to be drained by the existing Blumentritt interceptor. However, considering the actual topographic condition, it is almost impossible for the Blumentritt interceptor to collect the stormwater from Region 1. This region should be separated from the sub-basin of the Blumentritt interceptor, and should be considered as one of sub-basins of Quiapo-Aviles drainage block.

As for Region 2, the stormwater will be collected by the Blumentritt interceptor. Improvement of the existing Blumentritt interceptor and construction of new channels will be necessary.

The stormwater in Region 3 can be drained through Vitas pumping station by declogging of south Antipolo drainage main and improvement of Kabulusan outfall, Estero de Kabulusan, South Antipolo Canal and North Antipolo Canal.

In this case, total drainage area of Quiapo-Aviles drainage block becomes 6.2 km^2. According to the original design for Aviles and Quiapo pumping stations in 1978, the total design drainage area was 5.8 km^2. Considering this, some additional measures should be applied within Quiapo-Aviles drainage block to compensate for the increase of the drainage area from the original scheme.

One solution is to increase pump and channel capacities of Quiapo-Aviles drainage block (*Alternative 1*). On the other hand, in the 1986 plan, construction of Sampaloc interceptor to drain the stormwater from the uppermost sub-basin of Aviles drainage basin to the Pasig River by gravity was proposed. This is another solution to compensate for the increase of the drainage area of Quiapo-Aviles drainage block (*Alternative 2*).

Based on the preliminary design results for respective alternatives, *Alternative 1*, which utilizes the present system effectively and is technically sound, is selected as the appropriate plan in view of less social negative impact and less project total cycle cost under the condition that benefit accrued from the both alternatives is almost the same. (Please refer to *Annex E.5* for the detail.)

(9) Severe Inundation Area in South Manila

1) Additional Works for San Isidro-San Antonio-Pio del Pilar Area

The San Isidro-San Antonio-Pio del Pilar area, covered by drainage channels of Zobel-Roxas, PNR Canal, Calatagan creek I, Faraday drainage main, Makati Diversion Channel, etc. in Libertad-Tripa de Gallina drainage block, has been suffering from frequent inundation. Causes of such chronic inundation are simply lack of drainage capacity. For this regional problem, additional and remedial works will be considered in combination with dredging and declogging of drainage channels such as Estero de Tripa de Gallina.

2) Libertad Regulating Pond

The retarding function of original Libertad pond jointly constructed with the pumping station was lost due to ongoing reclamation project of Manila Bay. According to the original plan in 1978, the area of the retarding pond was supposed to be 100m x 1700m. In view of smooth and effective pump operation, restoration or additional works on original Libertad pond will be needed.

3) Possible Further Urbanization of Upper Maricaban Creek

Urban development in the upper sub-basin of Maricaban Creek is on going and further development is expected. Potential functions of retarding of stormwater and infiltration in the catchment will be decreased according to the progress of the urbanization. Such urbanization results in increase of run-off volume directly discharging into Maricaban creek and eventually, riparian areas of lower Dilain creek are subject to damage by more frequent and severe inundation. The increased discharge to Tripa de Gallina pumping station may also affect the inundation condition in San Isidro-San Antonio-Pio del Pilar area because of possible rise of water level at the pumping station. For this problem, the following alternatives have been examined:

- *Alternative 1*: Improvement of Dilain creek and installation of additional drainage pump at Tripa de Gallina pumping station
- *Alternative 2*: Construction of new Maricaban interceptor with improvement of Dilain Pond

Based on the preliminary design results for respective alternatives, *Alternative 2*, which is technically sound with less project total cycle cost, is selected as an appropriate plan under the condition that benefit accrued from the both alternatives is almost the same. Please see *Annex E.5* for the detail.

4) On-going Road and Drainage Construction in Upper Area of Zobel-Roxas

According to the South Manila District Office of DPWH, there is an on-going road and drainage construction project in upper area of Zobel-Roxas. The drainage along the new road in upper area of Zobel-Roxas is going to be connected to Sta.Clara Creek, although the original drainage scheme in 1978 did not consider the said area as drainage area. It will bring additional load to Sta.Clara drainage block. According to the explanation by the office, the additional drainage area due to the new construction is still unknown.

Although there is the new construction project, in the Master plan, the upper area of Zobel-Roxas is considered to be included in Libertad-Tripa de Gallina drainage block based on the original drainage scheme.

The existing discharge capacity of Sta. Clara pumping station for the existing drainage area may not be enough according to the numerical simulation by MOUSE. If the additional drainage area will be added to the Sta.Clara drainage block, the situation will become worse. On the other hand, the existng Sta.Clara Creek is very narrow and shallow. Because there are many houses along the channel, widening of the channel seems almost impossible. Therefore, even if the capacity of the Sta.Clara pumping station will be increased, the channel improvement will be very difficult. The channel improvement is indispensable to improve inundation condition.

To solve this problem, it will be proposed that some portion of the existing drainage basin of Sta. Clara will be separated from the existing Sta. Clara drainage basin. The area is tentatively set as 0.3 km^2, and storm water from there is assumed to be drained to the Pasig River directly. Installation of pump gates for the area will be also proposed.

The present study strongly suggests that the additional drainage area to Sta.Clara drainage should be minimal so that the additional load to Sta.Clara drainage basin will be minimum degree.

(10) Proposed Drainage Scheme

It is proposed that the uppermost sub-basin of the existing Blumentritt interceptor is to be transferred to Quiapo-Aviles drainage block. Furthermore, some additional works for drainage channels are to be proposed in the master plan. Accordingly, some adjustments of sub-basin and block in North Manila are necessary. *Table E.5.4* shows the areas for the proposed drainage blocks. The adjusted drainage block and sub-basin are also shown in *Figure E.5.6* and *Table E.5.5*.

Table E.5.4 Proposed Drainage Blocks

ID	*Name of Drainage Block*	*Existing Area (km^2)*	*Proposed Area (km^2)*	*Remarks*
N01	*Vitas-Binondo-Escolta*	*8.55*	*8.26*	*-0.29 km^2*
N02	*Quiapo-Aviles*	*5.58*	*6.19*	*+0.61 km^2*
N03	*Valencia*	*2.37*	*2.37*	*No change*
N04	*Maypajo-Blumentritt-Balut*	*9.91*	*9.59*	*-0.32 km^2*
N05	*North Harbor*	*2.37*	*2.37*	*No change*
S01	*Libertad-Tripa de Gallina*	*25.96*	*25.96*	*No change*
S02	*Balete*	*0.94*	*0.94*	*No change*
S03	*Paco-Pandacan-San Andres*	*6.12*	*6.12*	*No change*
S04	*Sta. Clara*	*1.57*	*1.57*	*No change*
S05	*Makati*	*4.31*	*4.31*	*No change*
S06	*South Harbor and Others*	*4.90*	*4.90*	*No change*

Figure E.5.6 Drainage Block and Sub-Basin for Proposed Drainage Scheme (1/2)

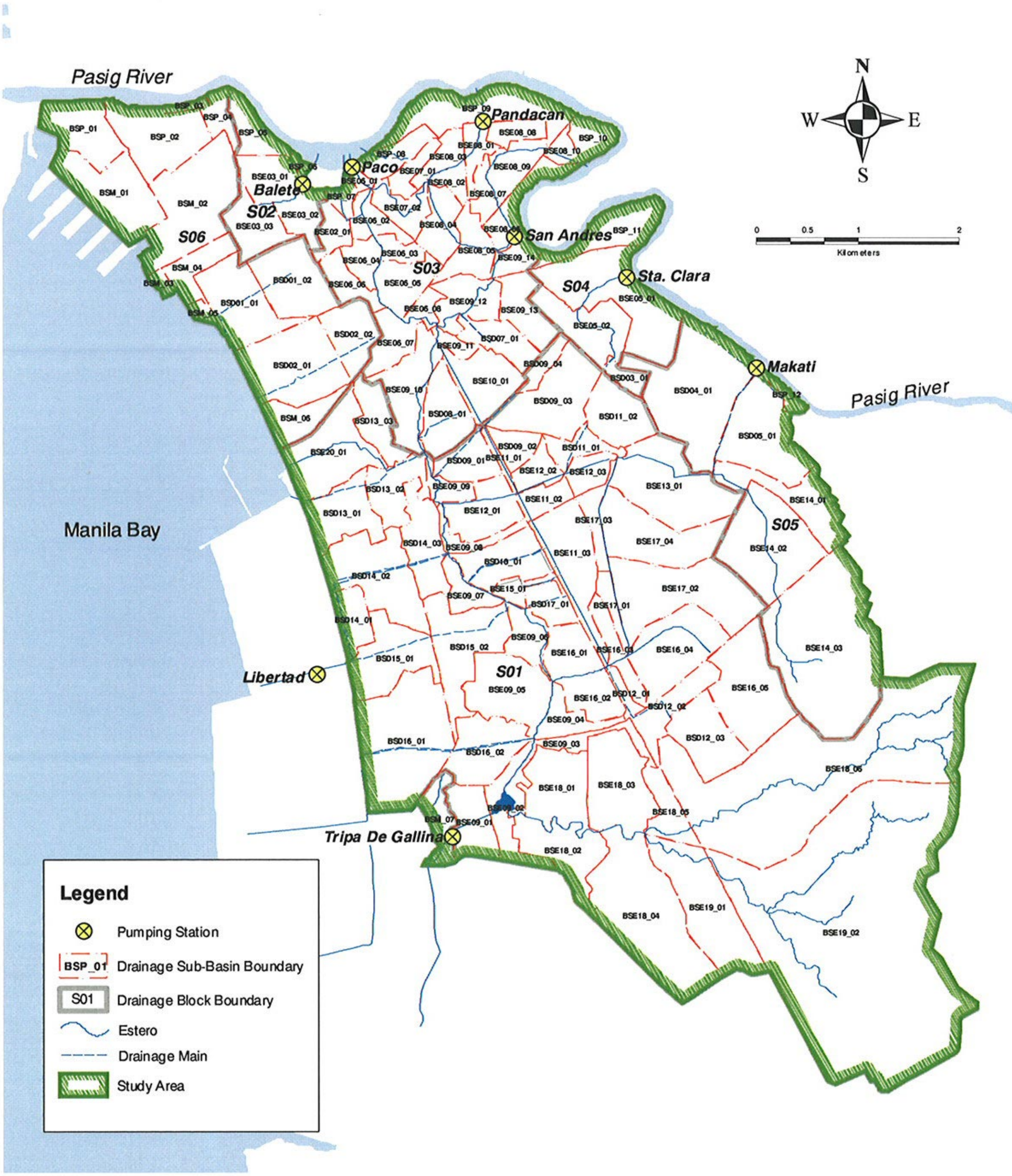


Figure E.5.6 Drainage Block and Sub-Basin for Proposed Drainage Scheme (2/2)

Table E.5.5 Sub-Basin for Proposed Drainage Scheme (1/2)

Drainage Block				Drainage Basin				Drainage Reach Basin			Drainage Sub-Basin	
Name	ID	Area (km^2)	RO Coeff. C	Name	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)
Vitas-Binondo-Escolta	N01	8.26	0.76	Vitas (P.S.)	N01_01	5.27	0.74	RND07_01	0.22	0.76	BND07_01	0.22
								RND07_02	*0.20*	*0.79*	*BND07_02*	*0.20*
								RND08_01	0.44	0.73	BND08_01	0.01
											BND08_02	0.43
								RND08_02	0.71	0.74	BND08_03	0.71
								RND09_01	0.59	0.74	BND09_01	0.16
											BND09_02	0.43
								RND12_01	0.47	0.75	BND12_01	0.31
											BND12_02	0.16
								RND12_02	0.65	0.64	BND12_03	0.65
								RNE01_02	0.32	0.82	BNE01_02	0.32
								RNE04_03	0.70	0.79	BNE04_05	0.70
								RNE07_02	0.07	0.70	BNE07_03	0.07
								RNE07_03	0.19	0.74	BNE07_04	0.19
								RNE08_01	0.27	0.74	BNE08_01	0.27
								RNE09_01	0.25	0.75	BNE09_01	0.17
											BNE09_02	0.08
								RNE10_01	0.18	0.78	BNE10_01	0.18
								RNE11_01	0.04	0.70	BNE11_01	0.04
				Binondo (P.S.)	N01_02	2.69	0.78	RND13_01	0.86	0.77	BND13_01	0.86
								RNE04_02	0.31	0.78	BNE04_02	0.08
											BNE04_03	0.10
											BNE04_04	0.13
								RNE05_01	0.80	0.80	BNE05_01	0.51
											BNP_01	0.26
											BNP_02	0.03
								RNE06_01	0.39	0.74	BNE06_01	0.39
								RNE07_01	0.33	0.76	BNE07_01	0.18
											BNE07_02	0.15
				Escolta (P.S.)	N01_03	0.30	0.79	RNE04_01	0.30	0.79	BNE04_01	0.30
Quiapo-Aviles	N02	6.19	0.71	Quiapo (P.S.)	N02_01	2.29	0.74	RND14_01	0.93	0.74	BND14_01	0.93
								RNE12_01	0.76	0.75	BNE12_01	0.11
											BNE12_02	0.19
											BNP_03	0.26
											BNP_04	0.19
								RNE13_01	0.10	0.71	BNE13_01	0.10
								RNE14_02	0.51	0.72	BNE14_03	0.51
				Aviles (P.S.)	N02_02	3.90	0.69	RND15_01	0.51	0.61	BND15_01	0.29
											BND15_02	0.19
											BND15_03	0.04
								RND16_01	0.37	0.69	BND16_01	0.37
								RND16_02	0.94	0.69	BND16_02	0.94
								RND17_01	0.38	0.74	BND17_01	0.19
											BND17_02	0.19
								RND18_01	0.24	0.74	BND18_01	0.24
								RND06_01	*0.62*	*0.66*	*BND06_01*	*0.62*
								RNE14_01	0.35	0.74	BNE14_01	0.08
											BNE14_02	0.28
								RNE15_01	0.06	0.66	BNE15_01	0.06
								RNE16_01	0.04	0.76	BNE16_01	0.04
								RNE17_01	0.28	0.73	BNE17_01	0.04
											BNE17_02	0.24
								RNE18_01	0.07	0.74	BNE18_01	0.07
								RNE19_01	0.04	0.71	BNE19_01	0.04
Valencia	N03	2.37	0.68	Valencia (P.S.)	N03_01	2.37	0.68	RND19_01	1.21	0.65	BND19_01	1.21
								RNE20_01	1.16	0.71	BNE20_01	0.56
											BNE20_02	0.41
											BNP_05	0.20
Maypajo-Blumentrit-Balut	N04	9.59	0.70	Maypajo-Blumentrit	N04_01	9.10	0.69	*RND05N_01*	*0.15*	*0.79*	*BND05N_01*	*0.15*
								RND05_01	*1.05*	*0.47*	*BND05_01*	*1.05*
								RND05_02	*0.95*	*0.70*	*BND05_02*	*0.95*
								RNE01_01	0.14	0.60	BNE01_01	0.14
								RNE02_01	0.16	0.98	BNE02_01	0.16
								RNE02_02	*0.19*	*0.82*	*BNE02_02*	*0.19*
								RNE02_03	3.44	0.68	BNE02_03	0.45
											BNE02_04	1.99
											BNE02_05	1.01
								RNE03_01	3.02	0.75	BNE03_01	1.57
											BNE03_02	1.45
				Balut (P.S.)	N04_02	0.49	0.79	RND04_01	0.49	0.79	BND04_01	0.49
North Harbor	N05	2.37	0.80	North Harbor	N05_01	2.37	0.83	RND01_01	1.13	0.83	BND01_01	1.13
								RND02_01	0.62	0.85	BND02_01	0.62
								RND03_01	0.23	0.85	BND03_01	0.23
								RNM_01	0.39	0.77	BNM_01	0.39
Total		28.78	0.72			28.78	0.73		28.78	0.73		28.78

Source: 1/5,000 scale GIS map *Italic character: Modified portion*

Table E.5.5 Sub-Basin for Proposed Drainage Scheme (2/2)

Drainage Block				Drainage Basin				Drainage Reach Basin			Drainage Sub-Basin	
Name	ID	Area (km^2)	RO Coeff. C	Name	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)	RO Coeff. C	ID	Area (km^2)
Libertad-Tripa de Gallina	S01	25.96	0.69	Tripa de Gallina (P.S.)	S01_01	17.05	0.66	RSD12_01	0.72	0.73	BSD12_01	0.06
											BSD12_02	0.26
											BSD12_03	0.39
								RSE09_01	0.28	0.68	BSE09_01	0.28
								RSE09_02	0.44	0.72	BSE09_02	0.31
											BSE09_03	0.13
								RSE09_03	0.66	0.77	BSE09_04	0.18
											BSE09_05	0.48
								RSE13_01	0.72	0.73	BSE13_01	0.72
								RSE16_01	0.64	0.79	BSE16_01	0.24
											BSE16_02	0.23
											BSE16_03	0.18
								RSE16_02	1.21	0.69	BSE16_04	0.54
											BSE16_05	0.66
								RSE17_01	1.55	0.75	BSE17_01	0.09
											BSE17_02	0.77
											BSE17_03	0.13
											BSE17_04	0.55
								RSE18_01	2.50	0.68	BSE18_01	0.44
											BSE18_02	0.41
											BSE18_03	0.55
											BSE18_04	1.09
								RSE18_02	2.94	0.65	BSE18_05	0.21
											BSE18_06	2.72
								RSE19_01	5.40	0.56	BSE19_01	0.69
											BSE19_02	4.71
				Libertad (P.S.)	S01_02	7.48	0.75	RSD09_01	0.22	0.71	BSD09_01	0.22
								RSD09_02	0.79	0.72	BSD09_02	0.14
											BSD09_03	0.55
											BSD09_04	0.10
								RSD10_01	*0.35*	*0.72*	*BSD10_01*	*0.35*
								RSD11_01	0.49	0.69	BSD11_01	0.15
											BSD11_02	0.34
								RSD14_01	1.14	0.76	BSD14_01	0.19
											BSD14_02	0.61
											BSD14_03	0.34
								RSD15_01	1.01	0.78	BSD15_01	0.45
											BSD15_02	0.56
								RSD16_01	1.38	0.76	BSD16_01	0.98
											BSD16_02	0.40
								RSD17_01	0.16	0.79	BSD17_01	0.16
								RSE09_04	0.19	0.78	BSE09_06	0.19
								RSE09_05	*0.16*	*0.77*	*BSE09_07*	*0.16*
								RSE09_06	0.11	0.69	BSE09_08	0.11
								RSE09_07	0.11	0.71	BSE09_09	0.11
								RSE11_01	0.04	0.85	BSE11_01	0.04
								RSE11_02	0.14	0.80	BSE11_02	0.14
								RSE11_03	0.50	0.80	BSE11_03	0.50
								RSE12_01	0.32	0.70	BSE12_01	0.32
								RSE12_02	0.28	0.74	BSE12_02	0.14
											BSE12_03	0.14
								RSE15_01	0.09	0.76	BSE15_01	0.09
				VitoCruz	S01_03	1.43	0.69	RSD13_01	0.36	0.75	BSD13_01	0.36
								RSD13_02	0.53	0.71	BSD13_02	0.28
											BSD13_03	0.25
								RSE20_01	0.55	0.64	BSE20_01	0.55
Balete	S02	0.94	0.64	Balete (P.S.)	S02_01	0.94	0.64	RSE03_01	0.94	0.64	BSE03_01	0.25
											BSE03_02	0.19
											BSE03_03	0.29
											BSP_05	0.19
											BSP_06	0.03
Paco-Pandacan-San Andres	S03	6.12	0.72	Paco (P.S.)	S03_01	1.74	0.73	RSE02_01	0.21	0.69	BSE02_01	0.13
											BSP_07	0.08
								RSE04_01	0.19	0.58	BSP_08	0.19
								RSE06_01	0.04	0.73	BSE06_01	0.04
								RSE06_02	1.01	0.78	BSE06_02	0.16
											BSE06_03	0.10
											BSE06_04	0.13
											BSE06_05	0.25
											BSE06_06	0.16
											BSE06_07	0.21
								RSE07_01	0.30	0.69	BSE07_01	0.11
											BSE07_02	0.19
				Pandacan (P.S.)	S03_02	1.15	0.68	RSE08_01	0.91	0.67	BSE08_01	0.13
											BSE08_02	0.09
											BSE08_03	0.13
											BSP_09	0.56
								RSE08_02	0.23	0.74	BSE08_04	0.23
				San Andres (P.S.)	S03_03	3.23	0.72	RSD07_01	0.23	0.72	BSD07_01	0.23
								RSD08_01	0.32	0.71	BSD08_01	0.32
								RSE06_03	0.08	0.83	BSE06_08	0.08
								RSE08_03	0.24	0.75	BSE08_05	0.24
								RSE08_04	0.87	0.70	BSE08_06	0.21
											BSE08_07	0.10
											BSE08_08	0.12
											BSE08_09	0.21
											BSE08_10	0.08
											BSP_10	0.14
								RSE09_08	0.47	0.75	BSE09_10	0.40
											BSE09_11	0.07
								RSE09_09	0.67	0.71	BSE09_12	0.28
											BSE09_13	0.26
											BSE09_14	0.13
								RSE10_01	0.35	0.70	BSE10_01	0.35
Sta. Clara	S04	1.57	0.63	Sta. Clara (P.S.)	S04_01	1.57	0.63	RSD03_01	0.09	0.70	BSD03_01	0.09
								RSE05_01	1.48	0.63	BSE05_01	0.77
											BSE05_02	0.39
											BSP_11	0.33
Makati	S05	4.31	0.63	Makati (P.S.)	S05_01	1.65	0.68	RSD04_01	1.00	0.66	BSD04_01	1.00
								RSD05_01	0.65	0.72	BSD05_01	0.59
											BSP_12	0.06
				Upper Calatagan	S05_02	2.66	0.60	RSE14_01	2.66	0.60	BSE14_01	0.40
											BSE14_02	0.74
											BSE14_03	1.52
South Harbor and Others	S06	4.90	0.67	South Harbor	S06_01	3.66	0.69	RSD01_01	0.93	0.81	BSD01_01	0.48
											BSD01_02	0.46
								RSD02_01	0.92	0.79	BSD02_01	0.64
											BSD02_02	0.28
								RSM_01	0.53	0.65	BSM_01	0.53
								RSM_02	0.75	0.47	BSM_02	0.75
								RSM_03	0.03	0.33	BSM_03	0.03
								RSM_04	0.21	0.41	BSM_04	0.21
								RSM_05	0.05	0.71	BSM_05	0.05
								RSM_06	0.23	0.85	BSM_06	0.23
				Pasig South	S06_02	1.03	0.61	RSP_01	0.36	0.69	BSP_01	0.36
								RSP_02	0.51	0.60	BSP_02	0.51
								RSP_03	0.03	0.66	BSP_03	0.03
								RSP_04	0.12	0.38	BSP_04	0.12
				Paranaque	S06_03	0.20	0.78	RSM_07	0.20	0.78	BSM_07	0.20
Total		43.79	0.66			43.79	0.68		43.79	0.68		43.79

Source: 1/5,000 scale GIS map *Italic character: Modified portion*

(11) Other Concerns for Structural Measures

1) Estero de Vitas

According to the survey result conducted by the Study Team, it is indicated that top elevation of both banks of the lower Estero de Vitas, which is about EL.12.2 m, may be insufficient as a tide wall. If top elevation of a gate for gravity discharge at Vitas pumping station was set based on the bank elevation, the elevation may also be low as a tide wall. Such existing condition might cause overtopping of seawater into the nearby urban areas. In order to prevent such phenomenon, required remedial works, i.e. increasing the height, will be considered in the master plan.

2) Estero de Balete

Within Estero de Balete, there are some places where discharge capacity is limited by constricted sections owing to installation of small box culverts under bridges. These constrictions should be relieved.

3) Perlita Creek

The drainage sub-basin covered by Perlita Creek is also frequently inundated. To mitigate such inundation condition, countermeasures will be required.

4) Laterals and Small Pumping Stations

The existing countless number of drainage laterals and the existing 8 small pumping stations are basically to be rehabilitated separately through ordinary maintenance activities.

(12) Non-structural and Supporting Measures

With only implementation of structural measures against disasters, mitigation of flooding and inundation damage will be limited. The following non-structural and supporting measures are necessary to support and sustain structural measures in the master plan.

<u>Non-structural measures</u>

- Recommendation of Countermeasures for Rapid Urbanization
- Recommendation of Application of Existing Floodplain Management System

<u>Supporting measures</u>

- Improvement of operation and maintenance organization including funding system
- Installation of equipment and facilities for effective O&M
- Community-involved O&M
- Control of Illegal Social Activities through community involvement activity and information, communication and education campaign
- Recommendation on Resettlement Plan and Procedure

In order to recover potential system functions, resettlement of informal settlers is indispensable. For recovering potential drainage system, recommendation of resettlement plan and procedure will be made. An appropriate approach to illegal solid waste disposal into drainage channels will be separately examined.

E.5.3 IMPROVEMENT PLAN FOR DRAINAGE CHANNELS

(1) Probable Peak Discharge for Proposed Drainage Scheme

The probable peak discharges would be changed according to the change of the drainage scheme. *Figure E.5.7*and *Table E.5.6* shows the probable peak discharges at observation points based on the proposed drainage scheme. The preliminary design dimensions for necessary additional works are basically determined according to the probable peak discharges shown in *Table E.5.6*.

Figure E.5.8 shows the relationship between specific discharge and drainage area for several probable design rainfalls based on runoff analysis. These relationships can be referred for design of drainage in the core area.

(2) Rehabilitation Works for Drainage Channels

The present drainage channels have been mostly losing those original cross-section areas provided in the construction stage. In order to recover the original cross-sectional areas, the following are proposed:

- Dredging of trunk channels:
  Dredging will be done for the channels to recover the estimated original bed elevations/cross-sections.
- Dredging and Declogging of secondary and tertiary channels:
  Secondary and tertiary channels are dredged and declogged to recover the estimated original bed elevations/cross-sections.
- Installation of stop log gate for Drainage Mains
  Stop log gate is installed depending on water level at the box culvert that is rehabilitated. The criterion of installation of stop log gate is as follows.

  - For box culvert discharging through pumping stations:

    Culvert with more than 50 cm water depth of box culvert when water level of outlet is pump operation stop level
  - For box culvert discharging directly to Manila Bay:
    All culverts

Table E.5.7 presents a summary of dredging and declogging volume of the drainage channels.

Table E.5.7 Summary of Dredging and Declogging Volumes

Unit of volume: 1,000 m^3

Location	Works	Trunk channel		Secondary channel		Tertiary channel		Total volume
		No.of channels	Volume	No. of channels	Volume	No. of channels	Volume	
North Manila	Dredging	9	314	5	71	7	31	416
	Declogging	-	-	9	28	13	21	49
	Sub total	9	314	14	99	20	52	465
South Manila	Dredging	6	316	4	98	2	10	424
	Declogging	-	-	11	30	4	2	32
	Sub total	6	316	15	128	6	12	456
Total	-	18	630	29	227	26	64	921

Before implementing the dredging and declogging works, the informal settlers in esteros will have to be relocated. Affected by these measures are families living in about 1,900 buildings. When it is assumed that the conversion rate from number of buildings to number of families that live there is 2.8, the number of the families to be resettled is about 5,500.

The drainage mains in which the stop log gate should be installed are shown in *Table E.5.8.* Please refer to *Annex E.3* for preliminary examination for dimension of the stop log gate.

(3) Additional Works for Drainage Channels

According to the basic consideration in *Chapter E.5.2*, the additional works for drainage channels shown in *Table E.5.9* are proposed. For the detail dimensions of some additional works, please refer to *Annex E.4*.

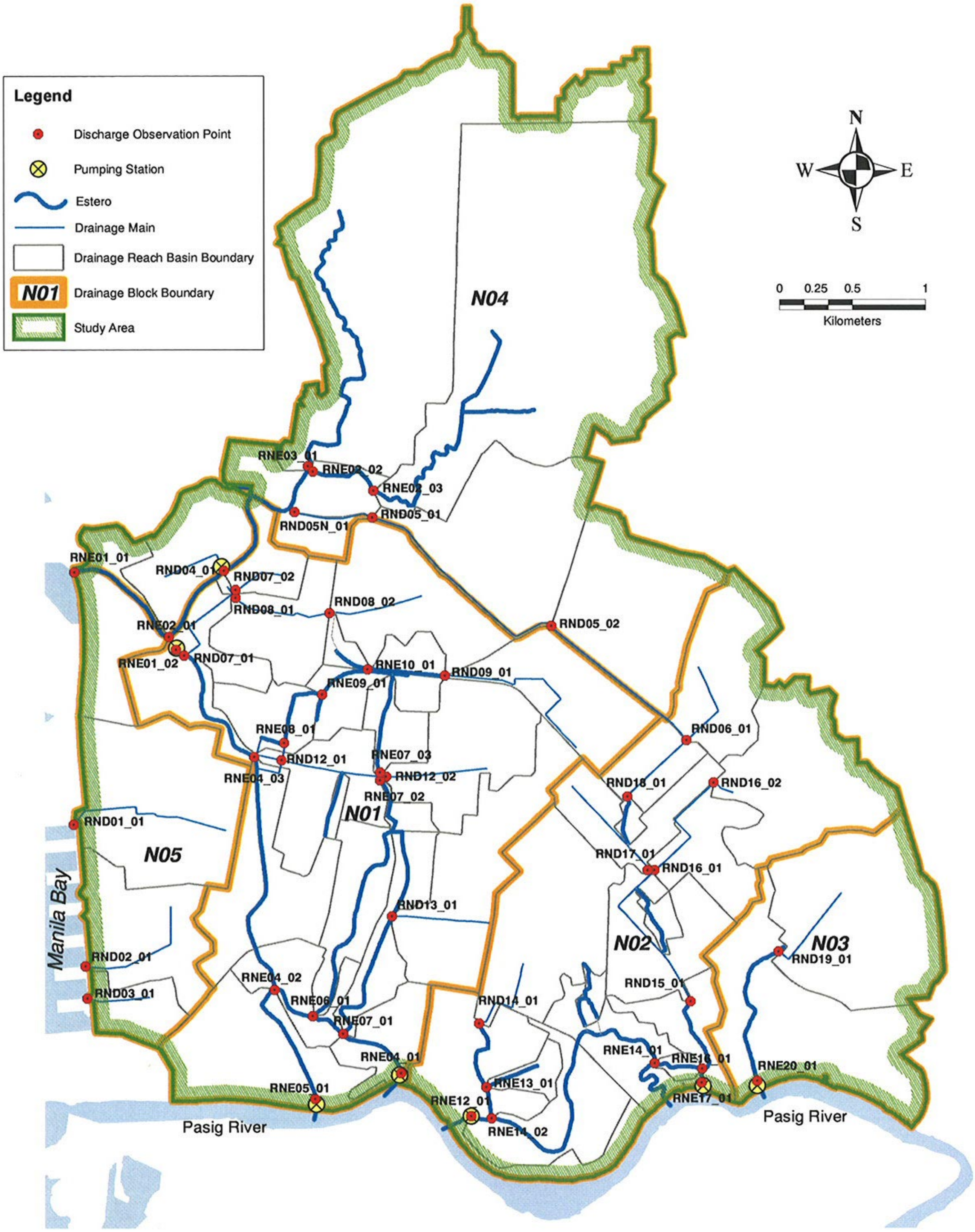


Figure E.5.7 Location of Discharge Observation Points in the Proposed Drainage Scheme (1/2)

Figure E.5.7 Location of Discharge Observation Points in the Proposed Drainage Scheme (2/2)

Table E.5.6 Estimated Probable Peak Discharge for Proposed Drainage Scheme(1/2)

Block_ID	Basin_ID	WaterWay ID	Observation Point (Reach_ID)	Drainage Area A (km2)	Runoff Coef. C	Time of Concentration T_c (hour)	Areal Reduction Factor	Q10 (m^3/s)	Q5 (m^3/s)	Q3 (m^3/s)	Q2 (m^3/s)	Remarks
N01	N01_01	NE01	RNE01_02	5.403	0.744	1.46	0.98	73.6	63.9	55.2	47.4	Vitas P.S.
N01	N01_01	ND07	RND07_01	1.559	0.746	0.81	0.99	29.6	25.8	22.3	19.4	
N01	N01_01	ND07	RND07_02	0.203	0.785	0.34	1.00	6.1	5.4	4.6	4.0	
N01	N01_01	ND08	RND08_01	1.141	0.737	0.70	0.99	23.0	20.1	17.4	15.2	
N01	N01_01	ND08	RND08_02	0.705	0.744	0.55	0.99	16.1	14.1	12.2	10.6	
N01	N01_01	NE08	RNE08_01	1.282	0.746	1.22	1.00	19.7	17.2	14.8	12.8	
N01	N01_01	NE09	RNE09_01	1.014	0.748	1.10	1.00	16.6	14.4	12.5	10.8	
N01	N01_01	NE10	RNE10_01	0.768	0.747	0.99	1.00	13.3	11.6	10.0	8.7	
N01	N01_01	ND09	RND09_01	0.592	0.739	0.85	1.00	11.0	9.6	8.3	7.2	
N01	N01_01	ND12	RND12_01	1.410	0.695	0.55	1.00	30.6	26.8	23.2	20.2	
N01	N01_01	ND12	RND12_02	0.647	0.641	0.40	1.00	14.9	13.1	11.3	9.8	
N01	N01_01	NE07	RNE07_03	0.189	0.742	0.32	1.00	5.5	4.9	4.2	3.7	
N01	N01_01	NE07	RNE07_02	0.069	0.705	0.26	1.00	2.1	1.8	1.6	1.4	
N01	N01_01	NE04	RNE04_03	3.522	0.736	1.23	1.00	53.4	46.4	40.1	34.6	
N01	N01_02	NE05	RNE05_01	2.562	0.774	1.65	0.99	34.3	29.7	25.7	22.0	Binondo P.S.
N01	N01_02	NE04	RNE04_02	1.766	0.762	1.44	0.99	25.1	21.8	18.9	16.2	
N01	N01_02	NE06	RNE06_01	0.392	0.745	0.41	1.00	10.4	9.1	7.9	6.9	
N01	N01_02	NE07	RNE07_01	1.197	0.765	1.34	1.00	18.0	15.6	13.5	11.6	
N01	N01_02	ND13	RND13_01	0.863	0.768	0.93	1.00	15.8	13.8	11.9	10.3	
N01	N01_03	NE04	RNE04_01	0.296	0.795	0.41	1.00	8.4	7.4	6.3	5.5	Escolta P.S.
N02	N02_01	NE12	RNE12_01	2.293	0.737	1.00	0.99	38.6	33.6	29.1	25.2	Quiapo P.S.
N02	N02_01	NE14	RNE14_02	0.505	0.716	0.38	1.00	13.3	11.6	10.0	8.8	
N02	N02_01	NE13	RNE13_01	0.100	0.709	0.26	1.00	3.0	2.7	2.3	2.0	
N02	N02_01	ND14	RND14_01	0.926	0.741	0.81	1.00	17.6	15.4	13.3	11.6	
N02	N02_02	NE17	RNE17_01	3.901	0.707	1.34	0.99	53.6	46.6	40.2	34.6	Aviles P.S.
N02	N02_02	NE16	RNE16_01	0.451	0.743	0.58	1.00	10.2	8.9	7.7	6.7	
N02	N02_02	NE14	RNE14_01	0.410	0.741	0.48	1.00	10.1	8.9	7.6	6.7	
N02	N02_02	ND15	RND15_01	3.167	0.700	1.21	0.99	45.5	39.6	34.2	29.5	
N02	N02_02	ND16	RND16_01	1.312	0.688	0.91	1.00	21.9	19.1	16.5	14.3	
N02	N02_02	ND16	RND16_02	0.943	0.688	0.70	1.00	17.9	15.7	13.5	11.8	
N02	N02_02	ND17	RND17_01	1.272	0.702	0.87	1.00	22.2	19.3	16.7	14.5	
N02	N02_02	ND18	RND18_01	0.855	0.686	0.66	1.00	16.8	14.7	12.7	11.0	
N03	N03_01	NE20	RNE20_01	2.370	0.678	0.66	0.99	45.3	39.5	34.2	29.8	Valencia
N03	N03_01	ND19	RND19_01	1.208	0.646	0.50	1.00	25.4	22.2	19.2	16.8	
N04	N04_01	NE01	RNE01_01	14.848	0.711	2.40	0.95	141.4	122.2	105.3	89.4	Est Vitas
N04	N04_01	NE02	RNE02_01	9.309	0.694	1.82	0.96	102.6	88.9	76.7	65.6	
N04	N04_01	NE03	RNE03_01	3.019	0.751	1.44	0.99	42.3	36.7	31.7	27.2	
N04	N04_01	NE02	RNE02_02	3.634	0.688	1.39	0.97	46.6	40.5	35.0	30.1	
N04	N04_01	NE02	RNE02_03	3.444	0.681	1.35	0.99	45.5	39.6	34.2	29.4	
N04	N04_01	ND05	RND05_01	1.997	0.583	1.09	0.99	25.4	22.1	19.1	16.5	
N04	N04_01	ND05	RND05_02	0.946	0.704	0.70	0.99	18.2	15.9	13.8	12.0	
N02	N02_02	ND06	RND06_01	0.617	0.664	0.50	1.00	13.3	11.7	10.1	8.8	
N04	N04_02	ND04	RND04_01	0.494	0.789	0.31	1.00	15.6	13.7	11.8	10.3	Balut P.S.
N05	N05_01	ND01	RND01_01	1.127	0.831	0.60	1.00	28.0	24.5	21.2	18.5	
N05	N05_01	ND02	RND02_01	0.618	0.850	0.31	1.00	20.9	18.4	15.8	13.8	
N05	N05_01	ND03	RND03_01	0.229	0.850	0.30	1.00	7.9	6.9	6.0	5.2	
N04	N04_01	ND05N	RND05N_01	2.143	0.597	1.25	1.00	26.1	22.7	19.6	16.9	New oulet of Blumentritt

Note: Observation points are basically located at downstream end of each reach basin.

Table E.5.6 Estimated Probable Peak Discharge for Proposed Drainage Scheme (2/2)

Block_ID	Basin_ID	WaterWay ID	Observation Point (Reach_ID)	Drainage Area A (km2)	Runoff Coef. C	Time of Concentration T_c (hour)	Areal Reduction Factor	Q10 (m^3/s)	Q5 (m^3/s)	Q3 (m^3/s)	Q2 (m^3/s)	Remarks
S01	S01_01	SE09	RSE09_01 (*1)	11.561	0.619	1.24	0.95	99.1	80.9	64.5	50.2	Tripa P.S.
S01	S01_01	SE18	RSE18_01 (*1)	10.839	0.614	1.13	0.96	98.0	80.1	63.8	49.7	
S01	S01_01	SE18	RSE18_02	2.935	0.646	0.85	0.98	46.8	40.8	35.3	30.6	
S01	S01_01	SE19	RSE19_01 (*1)	5.401	0.565	0.82	0.97	35.5	25.8	16.9	9.5	
S01	S01_01	SE09	RSE09_02	0.439	0.716	0.57	1.00	9.6	8.4	7.3	6.4	
S01	S01_01	SE09	RSE09_03 (*2)	5.489	0.740	1.81	0.98	65.9	57.1	49.3	42.1	
S01	S01_01	SE16	RSE16_01 (*2)	4.829	0.735	1.61	0.98	61.6	53.5	46.2	39.6	
S01	S01_01	SD12	RSD12_01 (*2)	0.715	0.726	0.59	1.00	15.6	13.7	11.8	10.3	
S01	S01_01	SE16	RSE16_02 (*2)	1.207	0.694	1.21	0.99	17.2	15.0	12.9	11.2	
S01	S01_01	SE17	RSE17_01 (*2)	2.266	0.746	1.54	0.99	30.4	26.4	22.8	19.6	
S01	S01_01	SE13	RSE13_01 (*2)	0.724	0.727	0.35	1.00	20.1	17.6	15.2	13.3	
S01	S01_02	SD14	RSD14_01	4.740	0.740	1.78	0.98	57.5	49.8	43.0	36.8	Buendia
S01	S01_02	SE09	RSE09_06	2.506	0.718	1.41	0.99	34.0	29.5	25.5	22.0	
S01	S01_02	SE09	RSE09_07	1.120	0.720	1.21	1.00	16.8	14.6	12.6	10.9	
S01	S01_02	SD09	RSD09_01	1.007	0.722	0.92	1.00	17.5	15.2	13.2	11.4	
S01	S01_02	SD09	RSD09_02	0.786	0.726	0.77	1.00	15.0	13.1	11.3	9.9	
S01	S01_02	SE12	RSE12_01	1.272	0.719	1.21	1.00	19.0	16.5	14.3	12.3	
S01	S01_02	SE11	RSE11_01	0.042	0.850	0.40	1.00	1.3	1.1	1.0	0.8	
S01	S01_02	SE11	RSE11_02	0.136	0.799	0.32	1.00	4.3	3.7	3.2	2.8	
S01	S01_02	SE12	RSE12_02	0.772	0.704	1.07	1.00	12.1	10.5	9.1	7.8	
S01	S01_02	SD11	RSD11_01	0.488	0.683	0.73	1.00	9.1	7.9	6.8	6.0	
S01	S01_02	SE09	RSE09_05	1.094	0.767	0.87	1.00	20.8	18.2	15.7	13.6	
S01	S01_02	SD10	RSD10_01	0.849	0.766	0.74	1.00	17.6	15.3	13.2	11.5	
S01	S01_02	SE11	RSE11_03	0.499	0.797	0.54	1.00	12.5	10.9	9.4	8.3	
S01	S01_02	SD15	RSD15_01	1.357	0.777	0.77	0.99	27.6	24.1	20.8	18.1	Libertad
S01	S01_02	SE09	RSE09_04	0.351	0.785	0.41	1.00	9.8	8.6	7.4	6.5	
S01	S01_02	SD16	RSD16_01 (*2)	6.869	0.743	2.35	0.97	70.7	61.1	52.7	44.7	EDSA
S01	S01_03	SD13	RSD13_01	0.885	0.724	0.99	1.00	14.8	12.9	11.2	9.7	
S01	S01_03	SD13	RSD13_02	0.528	0.706	0.76	1.00	9.9	8.6	7.5	6.5	
S01	S01_03	SE20	RSE20_01	0.549	0.639	0.58	1.00	10.7	9.4	8.1	7.1	
S02	S02_01	SE03	RSE03_01	0.939	0.668	1.03	1.00	14.2	12.4	10.7	9.3	Balete P.S.
S03	S03_01	SE06	RSE06_01	1.740	0.738	0.72	0.98	34.5	30.1	26.0	22.7	Paco P.S.
S03	S03_01	SE07	RSE07_01	0.299	0.725	0.35	1.00	8.2	7.2	6.2	5.4	
S03	S03_01	SE06	RSE06_02	1.218	0.766	0.68	0.99	25.9	22.6	19.5	17.0	
S03	S03_02	SE08	RSE08_01	1.147	0.628	0.42	0.99	25.2	22.1	19.0	16.6	Pandacan P.S.
S03	S03_02	SE08	RSE08_02	0.233	0.736	0.29	1.00	7.0	6.2	5.3	4.7	
S03	S03_03	SE08	RSE08_04	3.232	0.720	1.61	0.99	40.8	35.4	30.6	26.2	SanAndres P.S.
S03	S03_03	SE08	RSE08_03	0.239	0.747	0.49	1.00	5.9	5.1	4.4	3.9	
S03	S03_03	SE09	RSE09_09	2.124	0.725	1.51	1.00	28.3	24.5	21.2	18.2	
S03	S03_03	SD07	RSD07_01	0.226	0.732	0.54	1.00	5.2	4.5	3.9	3.4	
S03	S03_03	SE06	RSE06_03	0.084	0.830	0.26	1.00	3.0	2.6	2.3	2.0	
S03	S03_03	SE09	RSE09_08	1.146	0.725	1.18	0.99	17.3	15.0	13.0	11.2	
S03	S03_03	SE10	RSE10_01	0.352	0.702	0.71	1.00	6.8	5.9	5.1	4.5	
S03	S03_03	SD08	RSD08_01	0.323	0.715	0.57	1.00	7.1	6.2	5.3	4.7	
S04	S04_01	SE05	RSE05_01	1.569	0.632	0.54	1.00	31.2	27.3	23.6	20.6	Sta. Clara P.S.
S05	S05_01	SD04	RSD04_01	1.002	0.657	0.70	1.00	18.3	15.9	13.8	12.0	Makati P.S.
S05	S05_01	SD05	RSD05_01	0.649	0.715	0.54	1.00	14.6	12.8	11.0	9.6	Makati P.S.
S05	S05_02	SD06	RSD06_01	2.657	0.604	0.93	0.99	38.1	33.2	28.7	24.9	
S05	S05_02	SE14	RSE14_01	2.657	0.604	0.80	0.99	41.2	35.9	31.0	27.0	
S06	S06_01	SD01	RSD01_01	0.932	0.806	0.47	0.99	24.9	21.8	18.8	16.4	
S06	S06_01	SD02	RSD02_01	0.924	0.792	0.52	0.99	23.2	20.4	17.6	15.4	

Note: Observation points are basically located at downstream end of each reach basin.

*Note: *1 Diversion by Maricaban Interceptor is considered.*

*Note: *2 Stormwater from these reaches is assumed to be drained through EDSA outfall, considering the existing condition.*

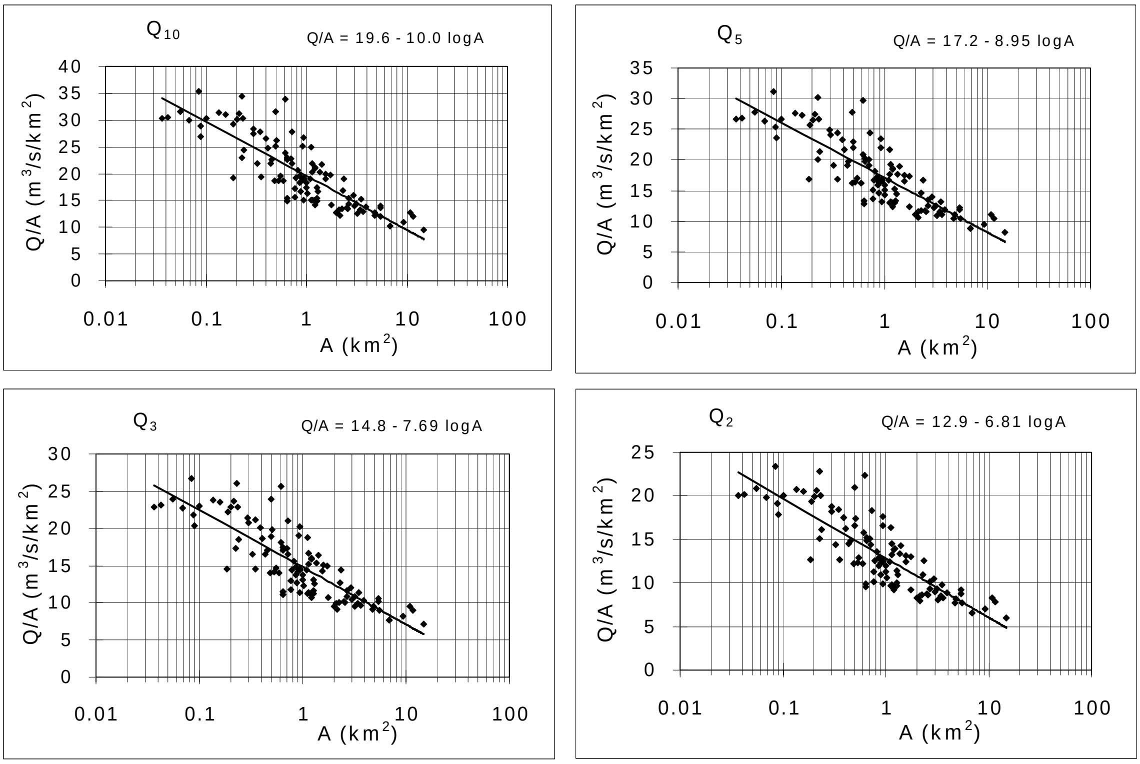


Figure E.5.8　Specific Discharge in the Core Area

Table E.5.8 Stop Log Gate

Block_ID	Code	Name	Length (m)	Number of Cell	Stop Log Gate
N01	ND07	Pampanga-Earnshaw Sub	1040	2	○
	ND08	Solis-Tecson	1430	2	○
	ND09	South Antipolo	1370	1	○
	ND10	Kabulusan Sub	140	1	○
	ND11	Kabulusan	370	1	○
	ND12	Tayuman	1600	1	○
	ND13	Fugoso	670	2	○
N02	ND14	Severino Reyes	650	1	○
	ND15	Lepanto-Gov. Forbes	1160	3	○
	ND16	Lepanto-Josefina	1060	2	○
	ND17	Economia	820	3	○
	ND18	Washington-P. Margal	210	1	○
N03	ND19	Visayas	670	2	○
N04	ND05	Blumentritt Interceptor	2980	2	○
	ND06	Kanlaon	640	1	
	ND04	Buendia	510	1	○
N05	ND01	Pacheco	1160	1	○
	ND02	Lakandula	870	1	○
	ND03	Zaragosa Sub	430	1	
S01	SD12	SSH-Way	1110	1	
	SD09	Zobel Roxas	1160	1	
	SD10	Faraday	820	2	
	SD11	Pasong Tamo	540	1	
	SD14	Buendia Outfall	1990	2	○
	SD15	Libertad Outfall	1800	1	○
	SD16	EDSA Outfall	1720	2	○
	SD17	Dolores	430	1	
	SD13	Vito Cruz	1450	1	○
S03	SD18	United Nations Interceptor	170	1	
	SD07	Onyx	410	1	
	SD08	Estrada	520	1	
S04	SD03	Masukol	130	1	
S05	SD04	Makati Headrace-I	630	1	○
	SD05	Makati Headrace-II	390	1	○
	SD06	Zobel Orbit	1220	1	
S06	SD01	Padre Faura	1160	1	○
	SD02	Remedios	1350	1	○

Table E.5.9 Proposed Additional Works for Drainage Channels (1/2)

Drainage Block	Drainage Block	Item	Sub-Item	Purpose	Location	Length	Dimension	Remarks
N01	**Vitas-Binondo-Escolta**	**Additional works of South Antipolo area**	Replacement of existing Kubulusan Sub Outfall	To drain stormwater in the uppermost area of Vitas-Binondo-Esclota drainage block	Kabulusan Sub D.M.	140m	W3.8mxH2.7m	
			Additional B.C. along South Antipolo Open Canal	To drain stormwater in the uppermost area of Vitas-Binondo-Esclota drainage block	Beside the existing South Antipolo Canal	400m	W3.3mxH2.7m	The dimension is determined by assuming that the dredging of South and North Antipolo Open Canals are not possible considering the existing condition of encroachment of informal settelers. If dredgings are possible, the dimension will be able to be downsized.
					Beside the existing South Antipolo Canal	500m	W2.6mxH2.7m	
			Additional B.C. along Solis Tescon D.M.	To prevent local inundation along Solis Tecson D.M.	Beside the existing Soilis Tescon D.M.	1400m	W3.0mxH1.5m	
N02	**Quiapo-Aviles**	**Additional works of channel to Quiapo Pumping Station**	Additional B.C. of Severino Reyes D.M.	To introduce more stormwater to Quiapo P.S.	Beside the existing Severino Reyes D.M.	700m	W2.8mxH2.5m	
			Extension of B.C.along Espana Street	To introduce more stormwater to Quiapo P.S.	Along Espana Street	800m	W2.8mxH2.5m	
		Additional works for Aviles drainage area	Additional B.C. along Margal	To drain the stromwater in the uppermost area of the existing Blumentritt Interceptor through Quiapo-Aviles drainage block efficiently	P.Margal to Kanloan	630m	W3.8mxH2.1m	
					P.Margal to Economia	700m	W3.8mxH2.1m	
			Imrpovement of a Bridge along Estero de Sampaloc I	To improve flow capacity of the channels to Aviles P.S.	Est. de Sampaloc I			
			Improvement of Est. de Samaploc II and Lepanto-Gov.Forbes D.M.	To increase flow capacity of the channels to Aviles P.S. to cope with increase of drainage area of Quiapo-Aviles drainage block	Est. de Sampaloc II and Lepanto-Gov.Forbes D.M.			It is assumed that Est. de Samaploc II is available to utilize. Improvement of inlet & outlet of the Est. de Sampaloc II to Lepanto-Gov.Forbes D.M., improvement of culverts are included. If Est. de Samaploc II is not available, additional box culvert is necessary.
N04	**Maypajo-Blumentritt-Balut**	**Additional works of Estero de Vitas**	Hightenning of river wall in the lower estro de Vitas	To prevent possible overtopping of seawater into the nearby urban area	Estero de Vitas	Rightbank 700m Leftbank 900m	DL+13.0m	
					Estero de Sunog Apog/Maypajo	Rightbank 1200m Leftbank 800m	DL+13.0m	
		Additional works of Blumentritt Interceptor	Remedial works of existing Blumentritt Interceptor	To prevent overflow from hilliy area to Quiapo-Aviles drainage block	Blumentritt Interceptor			
			Construction of Additional Interceptor	To prevent overflow from hilliy area to Quiapo-Aviles drainage block	Extension of the existing Blumentritt Interceptor	560m	2xW2.5mxH3.3m	The route of the additional interceptor is tentatively set besides the existing Blumentritt interceptor. More detailed study will be required for setting more technically, economically and enviornmentally sound route.
					Beside the existing Blumentritt Interceptor	1100m	W3.2mxH3.3m	
					Beside the existing Blumentritt Interceptor	1600m	W2.3mxH2.4m	

Table E.5.9 Proposed Additional Works for Drainage Channels (2/2)

Drainage Block	Drainage Block	Item	Sub-Item	Purpose	Location	Length	Dimension	Remarks
S01	Libertad-Tripa de Gallina	**Additional works for severe inundation area in South Manila**	Additional B.C. along Zobel Roxas D.M.	To improve flow capacity along Zobel Roxas D.M. To improve flow capacity of crossing point with South Super Highway in Zobel Roxas D.M.	Zobel Roxas D.M. (upper area of South Super Highway)	650m	2xW1.8mxH1.4m	
					Zobel Roxas D.M. (under the South Super Highway)	65m	3xW1.5mxH1.4m	
			Additional B.C. along Faraday D.M.	To improve flow capacity along Faraday D.M. To improve flow capacity of crossing point with South Super Highway in Faraday D.M.	Finlandia Street (Tripa to Faraday D.M.)	800m	2xW2.2mxH1.7m	
					Faraday D.M. (Under the South Super Highway)	65m	2xW1.5mxH1.4m	
			Additional B.C. along Makati Diversion Channel	To improve flow capacity along Makati Diversion Channel I	Beside the Makati diversion Channel I	550m	2xW2.2mxH2.1m	The dimension is determined by assuming that widening of the existing Makati Diversion Channel I is not possible considering the existing condition of river banks with many residents.
		Additional works of Libertad pond	Expansion of the exsiting Libertad pond	To regain the original capacity of retarding pond of Libertad-Tripa de Gallina systsem	Libertad channel		100mx1700m	The original capacity of 100m x 1700m or its equivalent should be regained.
		Additional works of Dilain/Maricaban Creek area	Construction of Maricaban Interceptor	To reduce flood risk caused by future urbanization in upper Maricaban Creek Basin	Libertad Channel to Paranaque River	500m	2xW3.5mxH3.3m	
					Maricaban Creek II to Paranaque River	2350m	W3.7mxH3.3m	
					Maricaban Creek II to Paranaque River	1800m	W4.0mxH4.0m	
			Improvement of Dilain Pond	To prevent reverse flow from Est. de Tripa de Gallina to the surroundings	Left Bank of Dilain Pond			
S02	Balete	**Additional works in Estero de Balete**	Improvement of Padre Burgos B.C.	To improve a bottleneck point	Padre Burgos			
			Improvement of bridge cross San Maecelino St.	To improve a bottleneck point	San Maecelino St.			

E.5.4 Improvement Plan for Drainage Pumping Stations

(1) Design Discharge Capacity of Pumping Stations

The drainage capacities of the existing pumping stations are principally kept by means of repair and/or replacement of pump equipment and appurtenant facilities complying with the extent of mechanical and electrical service life. The existing and proposed drainage capacities of the pumping stations are shown in *Table E.5.10.* As discussed in *Chapter E.5.2*, Some adjustment of the capacities will be made.

Table E.5.10 Discharge Capacity of Pumping Stations

Pumping station	*Existing discharge capacity*	*Proposed discharge capacity*	*Remarks*
Aviles	*15.6 m^3/s*	*18.6 m^3/s*	*+ 3 m^3/s*
(Pump Gates at existing Uli-Uli Independent Floodgate)	-	*2.0 m^3/s*	*New*
Quiapo	*10.8 m^3/s*	*10.8 m^3/s*	*No change*
Valencia	*11.8 m^3/s*	*11.8 m^3/s*	*No change*
Binondo	*11.6 m^3/s*	*11.6 m^3/s*	*No change*
Escolta	*1.5 m^3/s*	*1.5 m^3/s*	*No change*
Vitas	*32.0 m^3/s*	*32.0 m^3/s*	*No change*
Balut	*2.0 m^3/s*	*2.0 m^3/s*	*No change*
Pandacan	*4.4 m^3/s*	*4.4 m^3/s*	*No change*
Tripa de Gallina	*57.0 m^3/s*	*57.0 m^3/s*	*No change*
Sta. Clara	*5.3 m^3/s*	*5.3 m^3/s*	*No change*
(Pump Gates in existing Sta. Clara Drainage Basin)	-	*2.0 m^3/s*	*New*
Paco	*7.6 m^3/s*	*7.6 m^3/s*	*No change*
Libertad	*42.0 m^3/s*	*42.0 m^3/s*	*No change*
Makati	*7.0 m^3/s*	*7.0 m^3/s*	*No change*
Balete	*3.0 m^3/s*	*3.0 m^3/s*	*No change*
San Andres	*19.0 m^3/s*	*19.0 m^3/s*	*No change*
(Pump Gates at outlet of Perlita Creek)	-	*2.0 m^3/s*	*New*

(2) Rehabilitation Works for Drainage Pumping Stations

Detailed overall technical checking of the service lives for drainage pump equipment and appurtenant facilities has been made from the mechanical and electrical viewpoints, based on the survey by the Flood Control Management Services of MMDA in the period from May to June 2004. The technical checking and diagnosis have been made in accordance with the criteria that are applied in the irrigation pumping stations by the Ministry of Agriculture, Fisheries and Forest, Japan. The checking consists of the following two steps:

- 1st step is overall checking of mechanical and electrical parts, and
- 2nd step is repair or replacement of mechanical parts that received a score above 10 points during the 1st step checking.

In the Study, 1st step checking was made mainly by visual observation, trial pump operation and diagnosis without disassembly of the pump equipment. Checking results, and rehabilitation items and priorities are described below.

1) Criteria on Technical Checking and Diagnosis

It is generally reported that the lifespan for drainage pump equipment and appurtenant facilities and for electrical apparatus is around 20 and 10 years, respectively. It would be required for pump equipment and appurtenant facilities, used for more than 20 years, to be repaired or replaced in order to operate a pumping station in good condition from the mechanical, electrical and economic viewpoints. The electrical apparatus should also be replaced in general. The concept of degradation and timing of repair/replacement is shown in *Figure E.5.9.*

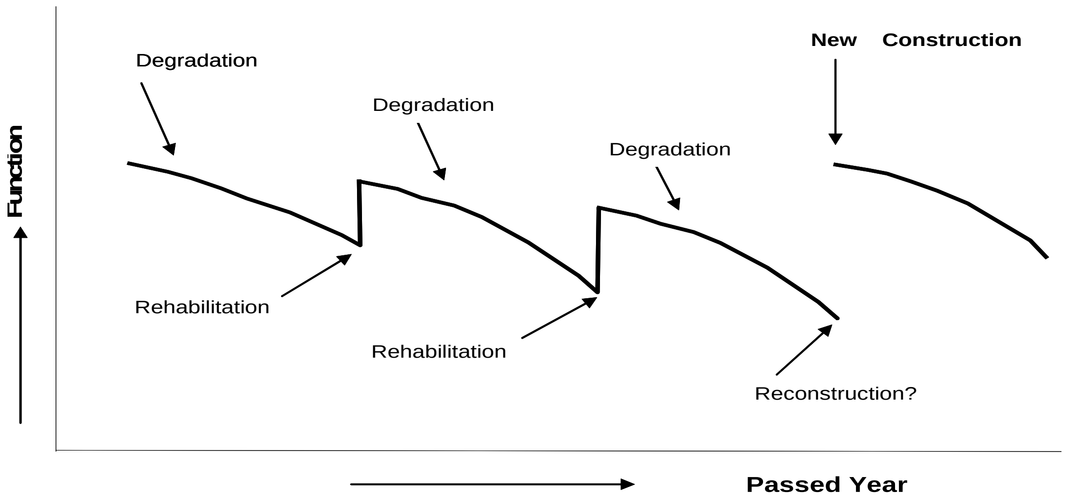


Figure E.5.9 Concept of Degradation of Pumping Equipment and Appurtenant Facilities

The criteria consist of two categories of mechanical and electrical aspects as shown in *Table E.5.11* and *Table E.5.12*. Mechanical checking by scoring is divided into two factors of aged ratio and fault ratio, while electrical checking is divided into age, maintenance history, etc. Higher scoring means higher degree in need of repair/replacement. For mechanical parts scored above 10 points, 2nd step checking will be needed for detailed programming of repair/replacement; for electrical parts scored above 10 points, replacement or renewal is recommended.

Table E.5.11 Criteria for Mechanical Checking and Diagnosis

Pump Equipment	Scoring for Aged Ratio				Scoring for Fault Ratio		
	2.5	2.0	1.5	1.0	2.0	1.5	1.0
Main Pump	Passed years; More than 35	Passed years; 35 to 25	Passed years; 20 to 10	Passed years; Less than 10	Fault times; More than 3	Fault times; 2 to 1	Fault times; No fault
Diesel Engine	More than 27	27 to 15	15 to 5	Less than 5	More than 3	2 to 1	No fault
Gear Box/ Butterfly Valve	More than 30	30 to 20	20 to 10	Less than 10	More than 3	2 to 1	No fault
Non-Return Valve/ Auto screen/ Conveyor/ Flap Valve	More than 25	25 to 20	20 to 10	Less than 10	More than 3	2 to 1	No fault
Auxiliary Pump	-	More than 15	15 to 10	Less than 10	More than 3	2 to 1	No fault

Table E.5.12 Criteria for Electrical Checking and Diagnosis

Item	Condition		Scoring
Aged	15 to 10 years		6
	20 to 15 years		12
	More than 20 years		20
Ordinary Condition	Daily average ambient temperature abovE.30º C		6
	Anuual average humidity above 85%		6
	Outdoor type		6
Maintenance Record	Trace of short circuit		9
	Water penetration or condensation		3
	Repair work on conductive part in the past		6
	Replacement of main equipment (less than 10%)		6
	Replacement of main equipment (more than 10%)		9
Deterioration	Enclosure	Peeling of paint, rust, damage	3
		Water penetration or condensation	3
		Damage of packing	3
		Losing of door, damage of handle	3
	Conductive part	Change in color due to overheating on busbar or termination	6
		Crack, damage or deformation of busbar support	3
		Change in color due to overheating on terminal block	3
		Crack, damage or deformation of terminal block	3

2) Results of Technical Checking and Diagnosis

In accordance with the above criteria, checking has been made as shown in *Table E.5.13.*

Table E.5.13 Technical Checking Results for Mechanical and Electrical Parts

Pumping Station	Completion Year	Operation Hours	Mechanical Parts								Total Scoring of Electrical Parts
			Main Pump	Engine	Gearbox	Discharge Valve	Flap Valve	Screen, Hori. and Inclined Conveyors	Auxi. Pump	Total Scoring	
Aviles	1976	14,650	80	72	48	55	70	196	118	639	40
Quiapo	1976	15,830	220	176	124	164	84	444	256	1,468	39
Valencia	1976	10,790	72	58	36	34	10	618	87	471	34
Pandacan	1976	10,890	30	23	16	10	18	116	30	243	43
Paco	1977	16,630	15	12	23	6	5	78	151	290	41
Sta. Clara	1977	7,420	29	55	22	8	6	54	34	208	41
Tripa de Gallina	1977	8,010	125	171	100	143	38	467	0	1,044	43
Libertad	1977	12,880	58	50	32	38	0	118	80	376	39
Makati	1984	4,030	11	12	6	6	10	52	41	138	38
Binondo	1985	8,220	33	38	11	25	40	95	49	291	43
Balete	1988	140	59	0	-	-	-	-	-	59	37
Escolta	1982	360	24	35	-	-	-	-	-	59	42
Vitas	1997	4,080	5	12	0	0	0	24	12	51	14
Balut	1997	3,700	4	11	-	0	0	30	11	56	15
San Andres	1997	1,150	0	2	0	2	0	20	14	38	14

Based on the results shown in *TableE.5.13* and the previous study report made by Japan Consulting Institute in 1999, the existing pumping stations are concluded as follows:

For mechanical parts

The pump equipment and appurtenant facilities of three pumping stations: Vitas, Balut and San Andres, are still in good condition and able to function for the coming 20 years with periodical inspection and maintenance works including overhauling.

However, the other 12 pumping stations are required further checking and overhauling for detailed programming of repair and replacement, and especially of 12 pumping stations, the four pumping stations of Aviles, Quiapo, Valencia and Tripa de Gallina, require urgent rehabilitation works.

The present pump equipment at Escolta (total capacity: 1.5 m^3/s) and Balete (total capacity: 3.0 m^3/s) are submergible type with discharge pipes installed over or nearby the existing gate and their operation efficiencies are assumed quite low, and proposed to be converted into ordinary fixed type pumps or gate pumps.

The present additional submergible pump installed over drainage gates is recommended to convert into ordinary fixed type in connection with rehabilitation works.

For electrical parts

The electrical parts of Vitas, Balut and San Andres stations are presently in good condition because they are still relatively new. It is proposed that performance characteristics of electrical apparatus be kept through the ordinary maintenance activities in the future.

For the other 12 pumping stations, scorings largely exceeded 20 points, which is a critical mark for repair or replacement. Evaluated scores clarify that it is required for all parts to be urgently replaced. It also can be said that tentative repair or partial replacement of a chain of electrical apparatus to improve its performance characteristics is costly and not recommendable. Therefore, it is concluded that electrical apparatus at the 12 pumping stations should be replaced urgently.

3) Rehabilitation Works

Based on the above technical checking and diagnosis results and detailed discussion and consultation with the Flood Control Management Services of MMDA, the following rehabilitation program is proposed in the Master Plan.

Overhauling is proposed principally for all pumping stations prior to rehabilitation works. Based on the overhauling results, detailed rehabilitation programs are to be formulated in the implementation stage. The rehabilitation program for the drainage pumping stations is proposed as follows:

For 4 stations of Quiapo, Aviles, Valencia and Tripa de Gallina

- List up supply of spare parts and consumables required
- Repair and replacement of pump equipment
- Replacement of electrical apparatus

For 6 stations of Pandacan, Binondo, Paco, Sta. Clara, Makati and Libertad

- List up supply of spare parts and consumables required
- Repair of damaged pump equipment
- Replacement of electrical apparatus

For 2 stations of Balete and Escolta

- Replacement of pump equipment by pump gate

For 3 stations of Vitas, Balut and San Andres

- List up supply of spare parts and consumables required

(3) Additional Works for Drainage Pumping Stations

As discussed in *Chapter E.5.2*, some additional pumps are required.

1) Aviles-Quiapo Drainage Block

- ***Increase of pump capacity at Aviles pumping station***

- ***Installation of pump gates at existing Uli-Uli floodgate***

The planned drainage area of Aviles pumping station is increased and it is proposed to increase the pump capacity (5 m^3/s). 3 m^3/s is added by increase of the capacity of the existing Aviles pumping station, by replacing mechanical parts of pump equipment through its rehabilitation, and 2 m^3/s is to be achieved by new installation of pump gates at the existing Uli-Uli independent floodgate.

2) Sta. Clara Drainage Block

- ***Installation of pump gates in Sta. Clara drainage basin***

The existing Sta. Clara pumping station does not have enough capacity for the drainage area. Also, additional drainage area is expected in the future due to the on-going road and drainage construction in the upper Zobel-Roxas area, although how big the area is still unknown. It is tentatively proposed that the drainage area of 0.3 km^2 within the drainage basin of Sta. Clara pumping station be drained by some newly installed pump gates at drainage outlet along the Pasig River. Although the location of the new pump gates needs to be investigated further, total capacity would be about 2 m^3/s considering specific discharge of the existing pumping stations in the core area.

3) Paco-Pandacan-San Andres Drainage Block

- ***Installation of pump gates on Perlita Creek***

The drainage sub-basin covered by Perlita Creek is also frequently inundated. To mitigate such inundation condition, installation of small pump gates is proposed to accelerate draining of storm water when the water level of Estero de Tripa de Gallina rises. The capacity is tentatively set at about 2 m^3/s. However, before implementing this, a detailed investigation should be conducted to maximize its efficiency.