CHAPTER 2

CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Objective

Phnom Penh City tends to suffer from flooding because of its topography. In addition, flood protection and urban drainage facilities are not functioning well because of old age and poor maintenance. As a result, the city is always at the risk of flooding in the rainy season and it habitually suffers from inundation and poor environmental conditions caused by stagnant wastewater in lowland areas. These cause deterioration of the residents' living environment and pose a serious constraint to social and economic development.

To find a solution to these issues, the Government of Cambodia and the Municipality of Phnom Penh (hereinafter referred to as "MPP") have been conducting various studies on flood protection and drainage improvement in line with the following overall goal:

(1) To stabilize the living conditions of people in the MPP;

(2) To improve the water environment in the MPP; and,

(3) To contribute to the development of the Municipality of Phnom Penh as well as the nation as a whole.

"The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II) (hereinafter referred to as "the Project")" aims at the following objectives under the overall goal mentioned above:

(1) To provide the Municipality of Phnom Penh with high safety against flooding from the Mekong River system and to minimize flood damage by repairing revetment; and,

(2) To minimize inundation and its damage caused by local rainfall by improving the drainage system.

2.1.2 Basic Concept of the Project

To achieve the objectives mentioned above, the Project shall consist of construction of revetment along Tonle Sap River and improvement of drainage system in northeast and southeast part of Phnom Penh City. It is expected to (1) provide the Municipality of Phnom Penh with high safety against the effect of the recorded highest water level of the Mekong and Tonle Sap rivers, which corresponds to about 30-year probability of planning scale, and (2) to minimize inundation and its damage cause by local rainfall (2-year return period of rainfall). The following will be implemented under Japan's Grant Aid:

(1) Revetment Works for Tonle Sap River (Longitudinal Length: 0.33 km)

(1)-a: Chakto Mukh Theater Revetment: 70 m

(1)-b: Old Market East Revetment: 260 m

(2) Improvement of Wat Phnom Basin;

(2)-a: Drainage Pipe – length: 1.44 km

(3) Improvement of Central Market Area

(3)-a: Drainage Pipe – length: 2.22 km

(3)-b: Pumping Station – 2 stations, Total discharge capacity: 10,000 m^3/h

(3)-c: Underground Reservoir – 2 locations, Total retention capacity: 8,955 m^3

(4) Improvement of Royal Palace & National Museum Area

(4)-a: Drainage Pipe – length: 0.73 km

(4)-b: Pumping Station – 2 stations, Total discharge capacity: 7,500 m^3/h

(4)-c: Underground Reservoir – 2 locations, Total retention capacity: 2,070 m^3

(5) Construction of Interceptor Pipe

(5)-a: Interceptor Pipe – length: 1.82 km

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

(1) Basic Design Policy

This project was requested by the Government of Cambodia based on the development plan proposed in the Final Report of "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh", which was conducted by the Study Team dispatched by the Japan International Cooperation Agency (JICA) for the period of February 1998 to August 1999. The Government of Cambodia had requested assistance for the improvement / rehabilitation of revetment along the Tonle Sap River as flood protection works and for improving the drainage system in the urban area of Phnom Penh City. The Municipality of Phnom Penh further requested assistance for the supply of maintenance equipment for the drainage system and expansion of the project area through discussions with the Basic Design Study Team during the field survey period of the Basic Design Study.

The locations, dimensions and so on of the objective works/facilities in those requests should be followed, in principle. However, Japan's Grant Aid is supposed to be extended for projects where grant aid is urgently necessary in the present situation. Therefore, the requested facilities are to be reviewed based on the policy for Japan's Grant Aid.

(a) Basic Design Policy for Flood Protection Plan

Necessity of reinforcement, improvement and rehabilitation of revetment shall be studied as the flood protection works. Most of the existing revetments in the study area have kept their functions even if some portions had become decrepit. However, there are some damaged revetments in the study area. Although improvement of 1.5 km of revetment had been requested, only high priority locations of revetment are to be improved under the Project.

(b) Basic Design Policy for Drainage Improvement Plan

The main objective of the works is to mitigate damage due to inland storm runoff in the project site. To realize this objective, an efficient drainage system (drainage pipe network, pumping station and underground reservoir) is necessary. The Basic Design Study has divided the study area into four (4) major drainage catchments, as follows:

North Area: Wat Phnom Area, Central Market Area and Royal Palace & National Museum Area

South Area: Trabek Basin & Adjacent Area

For the north area, there are several drainage mains discharging directly into the Tonle Sap River. These areas are affected by backwater through the drainage mains during high water stages of the river and this situation results in the piling up of the water surface thereby hindering free outflow of inland runoff. Inundation is thus caused by the combination of slow evacuation of storm runoff from the catchment and the backwater effect of Tonle Sap River, that it is necessary to install a new drainage network, pumping station and underground reservoir.

As described above, wastewater flows directly into the Tonle Sap River and the river is much polluted by untreated wastewater. Therefore, the interceptor system is to be proposed in this project and the wastewater collected through the drainage network is to be transported to the Trabek Main Canal through the interceptor.

With regard to the natural drainage pattern in the south area, surface runoff in the site drain directly towards the Trabek Main Canal. Since there is no well-defined drainage system in the site at present, there are inundation damage during/after heavy rains. Therefore, it is necessary to install a new drainage network.

(2) Policy on Natural Conditions

(a) Design High Water Level of Tonle Sap River

The design high water level of Tonle Sap River for revetment design and pumping design is set at EL. 10.20 m based on the recorded highest water level of EL. 10.18 m at Chakto Mukh water level gauge on 20 September 2000.

(b) Protection Level of Drainage Facilities

The protection level for drainage facilities in the study area, which corresponds to a minor drainage facility with less than 1 km^2 of catchment area, is defined at 2-year return period in accordance with the Master Plan (JICA 1999). The following table shows the protection levels for each scale of facilities defined in the Master Plan.

Table 2.2.1 Protection Level for Each Facility

Structure or Facility	Protection Level
Flood protection facilities such as dikes, river walls, road heightening, etc.	30-year return period of water level (EL.+10.0 m), which is a little higher than the maximum water level at Chaktomuk Station since 1960 (EL.+9.96 m in 1961).
Major drainage facilities such as pumping stations, floodgates/sluiceways, reservoirs and drainage mains, with a catchment area more than 1 km^2 (approximately).	5-year return period of rainfall
Minor drainage facilities and sewer systems with a catchment area less than 1 km^2 (approximately).	2-year return period of rainfall

(c) Rainfall Duration

The duration of design rainfall is defined at 6 hours based on single rainfall patterns of recent heavy rains causing severe inundation in the study area in the Master Plan.

(d) Rainfall Intensity Curve

The maximum annual rainfalls for durations between 1981 and 1997 at Pochentong Meteorological Station are used for the rainfall analysis. The value of probable rainfalls by the Gumbel Method in return periods of 2-year is summarized in the following table.

Table 2.2.2 Probable Rainfall

Return Period (years)	Hourly Rainfall (mm/hr)	Daily Rainfall (mm/hr)
2	44.8	87.8

The rainfall intensity curve based on Horner Type equation, which matches best among four equations examined in the Master Plan, is adopted to represent the actual relation between probable rainfall intensity and the duration.

(3) Policy on Socio-Economic Conditions

Acquisition of private land and house relocation attendant on the project implementation often cause social conflicts. To avoid such conflicts, the Right-of-Way for the improvement of drainage pipes shall be set within the area of road and pavement. The determination of alignment of drainage pipes shall be given particular attention for the underground facilities. The locations of pumping stations and underground reservoirs shall be set in public lands.

The project area is located in a densely populated area, economic center and tourist zone. Design of facilities shall give attention on landscape. The implementation plan of construction works shall give particular attention on noise and vibration pollution and the minimization of negative impact on economic activities.

(4) Policy on Construction/Procurement

(a) Design Standard

The Ministry of Public Works and Transport established design standards for bridges and national roads in 2003. The other structural design standards in Cambodia have not been established yet, hence well-known standards of advanced nations such as Japan, the European Union, Australia and the USA have been adopted. Since previous Japan's Grant Aid projects have adopted Japanese design standards, this Basic Design Study has also adopted the Japanese design standards.

(b) Procurement Situation

Main construction materials like cement, reinforcing bars, aggregates and so on are available in Cambodia, but the local availability of particular construction components like steel gate, drainage pump, electric facilities and so on is difficult. Locally available materials shall be used for the construction as much as possible to minimize the construction cost. The Basic Design Study has also considered the future improvement plan to avoid the duplication of investment.

(c) Related Law/Regulation

The Municipality of Phnom Penh (MPP) sets limitation of height for new buildings in the area along the Tonle Sap River to preserve the landscape. This usually restricts height to the building of four stories or more, and MPP has the right to give approval. The approval of MPP is required also for the execution of various constructions in public spaces including road works in the city. Since the superintendence organization of this Project is MPP, there is no obstacle in project execution.

Though the construction site in the Chakto Mukh National Theater is exceptionally under the jurisdiction of the Ministry of Culture and Fine Arts, there is no obstacle to the execution of the Project because MPP has already received an informal consent concerning the construction execution from the Ministry of Culture and Fine Arts.

(d) Construction Supervisor for Installation of Pump, Machinery and Electric Equipment

Some local engineers capable of supervising general construction work are available in the Phnom Penh City, but local engineers knowledgeable in the installation of the pump, machine and the electrical equipment procured under the Project are not available.

Therefore, construction supervisors for such special installation work shall be dispatched separately from Japan.

(5) Policy on the Applicability of Cambodian Company

There are some local contractors in Cambodia, and they have experience in construction works involving Japan's Grant Aid Project and adequate skills on general construction works such as roads, drainage channels and simple concrete structures. Therefore, local contractors could be used for the general construction components to reduce the construction cost.

(6) Policy on the Operation and Maintenance Condition of Implementing Agency

To determine the adequate specifications of the objective facilities, the capabilities and budget for operation and maintenance of the implementing agency shall be considered in the Basic Design Study.

(7) Policy on the Determination of Planning Scale of the Objective Facilities

To determine the planning scale of the objective facilities, it shall be considered that Japan's Grant Aid is extended only for projects where grant aid is urgently necessary as in the present situation.

Based on the design policies mentioned above and in order to achieve the objectives of the Project, the existing revetment shall be reinforced to make it safe from the recorded highest water level of the Mekong and Sap rivers, which corresponds to about 30-year probability of planning scale. Drainage facilities, such as drainage pipe, underground reservoir and pumping station, shall also be improved with the planning scale of 2-year probability to be able to drain the storm water within 1 to 2 hours with 20 cm of allowable inundation depth.

The sites of new pumping stations in the northern part of the Project areas (Wat Phnom Area, Central Market Area and Royal Palace/National Museum Area) are limited and located in scenic areas so that the size of pumping stations shall be minimized as much as possible. With the situation taken into consideration, an underground reservoir is planned next to a pumping station as a retarding pond of a pumping station to reduce the pumping capacity as much as possible and to minimize cost of the pumping equipment.

These considerations will contribute to the cost reduction of the whole project.

(8) Policy on the Implementation/Procurement Plan and Implementation Schedule

The Project includes construction of a new pumping station, improvement of drainage network, reinforcement of revetment and so on, and the construction works are easily affected by rain and flooding. During the rainy season, work efficiency certainly becomes low and work progress will decline as a result. Therefore, it is important to consider the rainy season in the establishment of the implementation plan as well as the procurement plan. The construction of revetment and underground reservoir that faces the river and adjoining areas shall be executed mainly in the dry season.

To establish the implementation schedule, the conditions mentioned above shall be considered. In consideration of construction scale and work efficiency in the rainy season, it is estimated that the term of construction would require three (3) dry seasons.

2.2.2 Basic Plan

The Government of Cambodia has requested assistance from Japan's Grant Aid for projects with the following components:

- Procurement of Maintenance Equipment,
- Flood Protection, and
- Drainage Improvement.

(1) Maintenance Equipment of Drainage System

Maintenance equipment of drainage pipe plays an important role in demonstrating the adequate function of a drainage system composed of drainage pipes and pumping stations. Though the maintenance equipment that DPWT presently possess are old and work efficiency is bad, it is considered that those maintenance equipment are in the state that can be used if it is maintained well. Therefore, it is judged that there is no necessity to supply new maintenance equipment urgently by Japan's Grant Aid.

However, even if excellent maintenance of the existing equipment is continued, interference in the maintenance work on the drainage network should be expected in the next five years because the existing equipment are very old and some of them have already exceeded their service life.

(2) Flood Protection Plan

As the Flood Protection Plan, rehabilitation and improvement of revetment shall be implemented. The study area for revetment improvement is the stretch of Chroy Changvar Bridge (Cambodia-Japan Friendship Bridge) up to the Chakto Mukh National Theater.

(a) Objective Section of Revetment Improvement

The present condition of revetment in the requested area is shown in Photo 2.2.1. Some sections of the revetment in the requested area are decrepit and damaged, but almost all sections are considered to be functioning well at present.

There are two (2) sections of revetment that are seriously damaged and MPP have strongly requested the improvement of these sections. Therefore, the following two (2) sections of revetment are selected as the objective sections of the Project.

(i) Old Market East Revetment

This section is located at the eastern side of the old market in the downstream side of Road No. 108 along the Tonle Sap River. The dike in this section had slid and 100 m of the existing revetment had collapsed.

(ii) Chakto Mukh National Theater Revetment

This section of 70m in length is located in the upstream from the boundary of Chakto Mukh National Theater and Himawari Hotel. Some portions of the revetment in this section have been damaged or had collapsed.

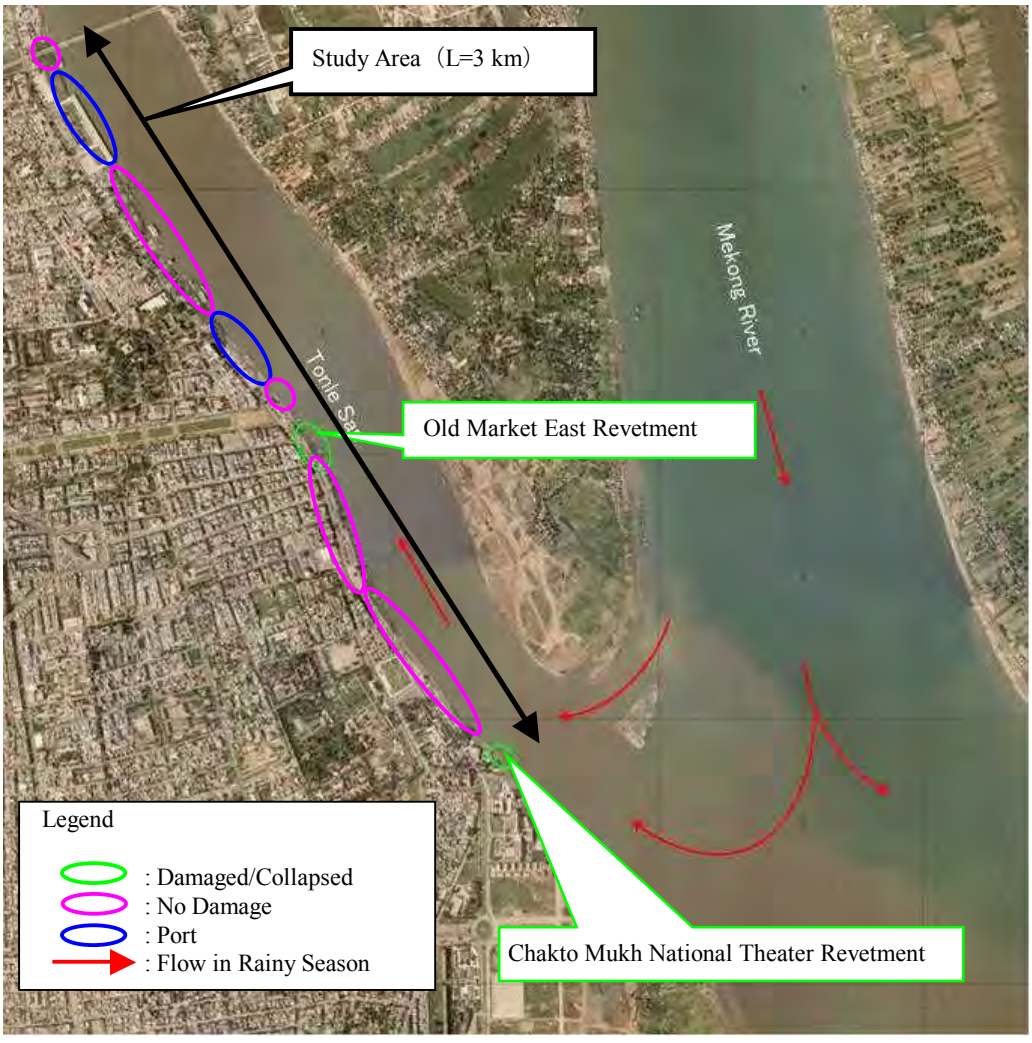

Photo 2.2.1 Study Area of the Revetment Improvement Work

(b) Improvement Length of Revetment

(i) Old Market East Revetment

The length of revetment improvement shall be 260 m. The damage of the existing revetment was caused by landslide of the dike. The collapsed section of 100 m in length from the end of Road No. 108 to the downstream shall be urgently rehabilitated and improved. The downstream section of the existing revetment with the same structure which continues up to the collapsed section, shall likewise be improved for the following reasons:

- This section has the high probability to be damaged/collapsed, because it has the same revetment structure as the collapsed section; and
- Downstream from the end of this section will not be damaged by river flow because of shift of river alignment.

Photo 2.2.2 Collapse in the Old Market East Revetment (1)

At the toe of revetment:
Strength of revetment was not enough against slide force, so that the concrete free frame and foundation pile was destroyed. (Photo taken in February 8,

Photo 2.2.3 Collapse in the Old Market East Revetment (2)

At the toe of revetment:
Gabion mattress was not also effective against the slide force. (Photo taken in February 18, 2006)

(ii) Chakto Mukh National Theater Revetment

Requested section of revetment of 70 m in length is located in the upstream from the boundary of Chakto Mukh National Theater and Himawari Hotel. A part of the revetment in this section collapsed in June 2006 by circular slip caused by

water rising at the beginning of rainy season, although only partial caving was found in the site survey of the Basic Design Study.

Photo 2.2.4 Chakto Mukh National Theater Revetment

Date
Left above: March 3, 2004
Above: January 31, 2006
Left: June 2006

In January 2006, damage level was not so serious and almost same condition as in 2004.
In June 2006, revetment collapsed and damage is expanding.

Through the comparison of the results of the sounding survey between 1997 and 1998, and the cross-sectional survey in this Basic Design Study, the riverbed in front of this section tends to be corroded, and the water route tends to move toward the right bank. Furthermore, the river width around the confluence between the Tonle Sap River and the Mekong River tends to be narrow, and it was confirmed by hearing investigation that the flow rate around the right bank of Tonle Sap River became much faster than before. Main reasons of collapse of the existing revetment are as follows:

- Riverbed scouring lost toe weights of slopes;
- The soil strength of foundation and dike are not enough; and
- This section is susceptible to river flow.

There are many cases where partial revetment improvement had worsened the condition of the upstream and downstream riverbanks, so that revetment improvement in the Project might also give adverse impacts to the vicinity.

However, the MPP had strongly requested the implementation of this improvement under the Japanese Grant Aid Project on the following assumptions:

- MPP will respond to any effect on another revetment caused by this revetment improvement; and
- MPP will implement the revetment improvement at the downstream of these portions.

Therefore, in this Project, improvement of all part of Chakto Mukh National Theater Revetment (L=70 m) shall be implemented with foot protection works.

(iii) Location and Length of Revetment Improvement

As a conclusion, the following two sections of revetment shall be improved and the improvement lengths shall be as follows:

- Old Market East Revetment : L=260 m
- Chakto Mukh National Theater Revetment: L=70 m

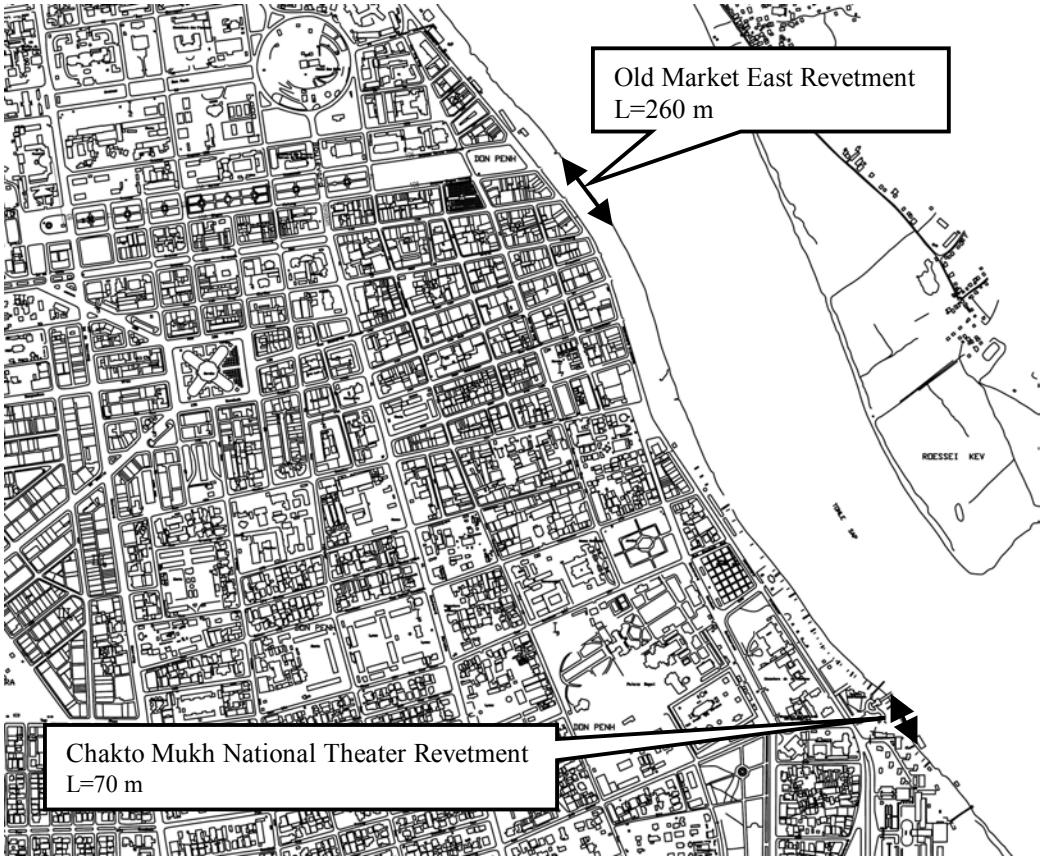

Figure 2.2.1 Implementation Section of Revetment Improvement

(3) Drainage Improvement Plan

The flowchart to prepare a drainage improvement plan is presented in Figure 2.2.2. The inundation/drainage analysis was computed using the software called MOUSE presented by DHI (Danish Hydraulic Institute).

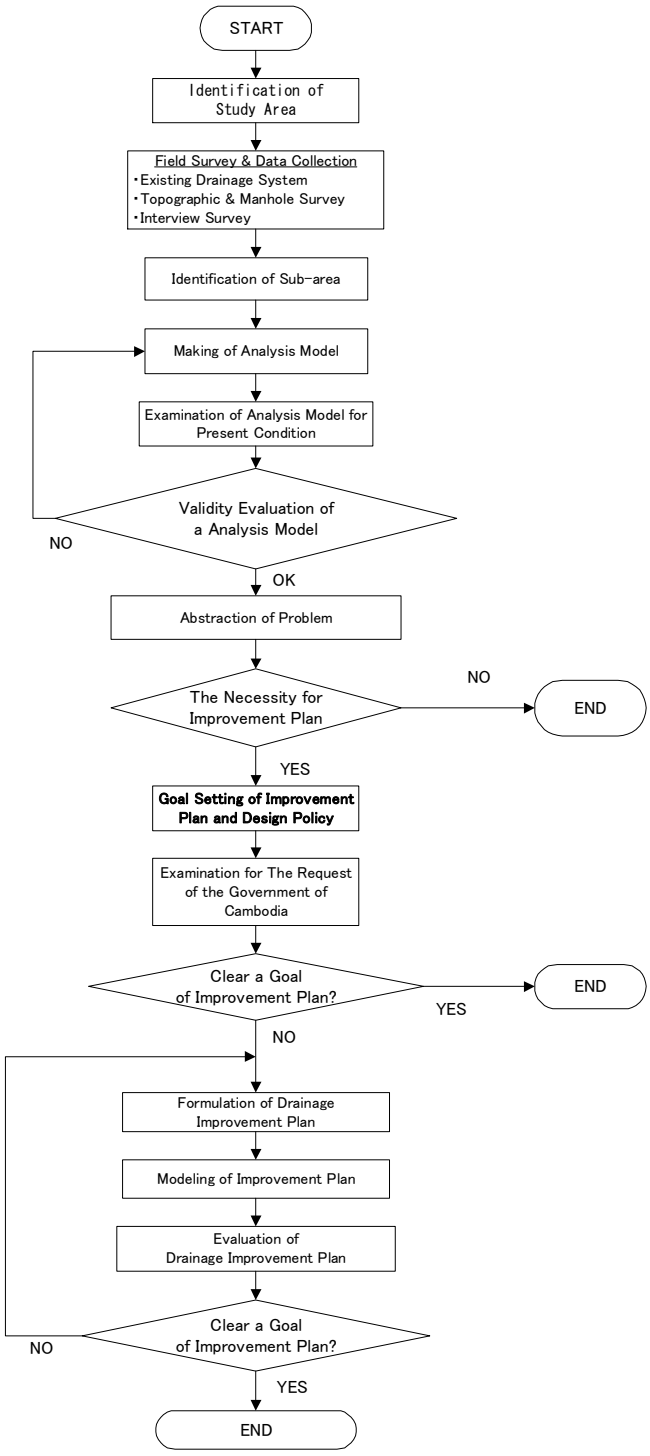

Figure 2.2.2 Flowchart to Formulate Drainage Improvement Plan

(a) Identification of Study Area

The Study Area of approximately 12.78 km^2 covers the Phnom Penh city center and the eastside of the Municipality of Phnom Penh comprising the Central Market Area, the Royal Palace and National Museum Area, Wat Phnom Basin, and the Trabek Basin and Adjacent Area. The Study Area is divided into 10 sub-drainage areas on account of the existing drainage pipe networks and topography. (See Figure 2.2.3).

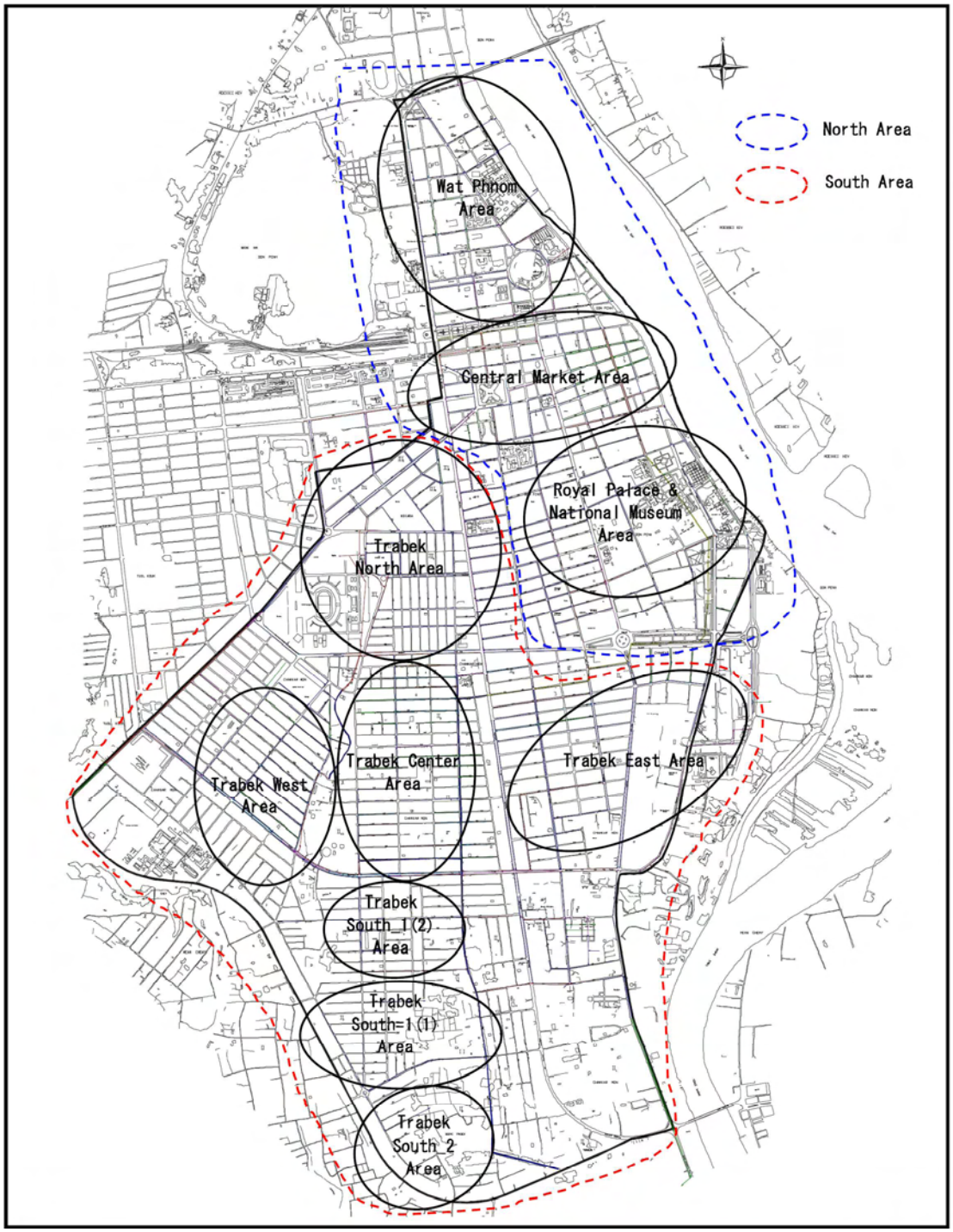

Figure 2.2.3 Study Area

(b) Validity Evaluation of Analysis Model

According to the study result of the existing model, the inundation spreads to all over the Study Area and it lasts for 3 to 12 hours for a rain corresponding to a 2-year return period. Damage in lowland areas such as the areas around Wat Phnom, Central Market and the Royal Palace is particularly severe. This result well represents the existing condition. Therefore, this analysis model can be used to carry out the detailed analysis.

(c) Abstraction of Problem

In order to formulate the Drainage Improvement Plan, it is important to understand the causes for inundation. Based on field investigation and hydraulic analysis, the main reasons are described as follows:

- Undersized and/or irregular pipe cross-section,
- Backwater through the drainage pipe during high water stage of river,
- Topographic feature,
- Clogged with debris and sediments, and
- Irregular longitudinal slope.

(d) Goal Setting of Drainage Improvement Plan

The goal of the drainage improvement plan is given in the following table.

Table 2.2.3 The Goal of Drainage Improvement Plan

Item	Present	Goal	Description
Frequency	4 times or more per year	1 time in two years	It is adopted and set as the master plan.
Inundation Depth	About 60 cm	20 cm or less	It is set up as the goal that inundation does not reach up to about 20 to 30 cm of the sidewalk curbstone and damage does not affect pedestrians and vehicular traffic.
Inundation Period	3 to 12 hours	1 to 2 hours	It is set up as the goal that inundation is lower than the present minimum inundation period of 3 hours.

(e) Evaluation of The Request

To examine and evaluate the requested drainage facilities, a hydrological model was set-up. This model consists of the existing drainage networks and the requested drainage

facilities, namely; 6 pumping stations and 6 underground reservoirs and their collector pipes. The summary is given in the following table.

Table 2.2.4 Contents of the Request and Summary for Evaluation

Components	Quantity	Specification	Evaluation
1. Wat Phnom Area			
Drainage Pipe	9.05 km	900 m, ϕ 1,500 mm (Road No.47) 200 m, ϕ 1,500 mm (Road No.90) 100 m, ϕ 1,000 mm 500 m, ϕ 800 mm (Road No.79) 300 m, ϕ 600 mm (Road No.86)	Inundation lasts for 1 to 2 hours at maximum (it lasts for 5 to 6 hours for existing). However, inundation depth is 30 cm or more. Therefore, further examination is required.
Pumping Station	1 station	2,500 m^3/h	
Underground Reservoir	1 location	6,000 m^3	
2. Central Market Area			
Drainage Pipe	3.4 km	North : 640 m, ϕ 800 mm (Monivong Bld.) 350 m, ϕ 1,000 mm (Road No.110) 860 m, ϕ 1,500 mm (Road No.108) Center : 250 m, ϕ 1,500 mm (Road No.148) South : 600 m, ϕ 1,000 mm (Norodom Bld.) 700 m, ϕ 1,500 mm (Road No.154)	North: Inundation depth is 30 cm or more. Therefore, further examination is required. Center: Inundation lasts for 1 to 2 hours at maximum and inundation depth is 20 cm or less, i.e., the requested facilities are appropriate as a project. South: The scale of the requested facilities may be excessive. Therefore, further examination is required.
Pumping Station	2 stations	North : 2,500 m^3/h, Center : 5,000 m^3/h	
Underground Reservoir	3 locations	North : 4,500 m^3, Center : 3,000 m^3, South : 4,500 m^3	
3. Royal Palace & National Museum Area			
Drainage Pipe	0.7 km	North : 300 m, 2,000×1,500 mm (Road No.184) South : 400 m, 2,000×1,500 mm (Road No.204)	Inundation lasts for 1 to 2 hours at maximum and inundation depth is 20 cm or less. However, the scale of the requested facilities may be excessive. Therefore, further examination is required.
Pumping Station	2 stations	North : 5,000 m^3/h, South : 2,500 m^3/h	
Underground Reservoir	2 locations	North : 7,400 m^3 South : 1,100 m^3	

It is clear from Table 2.2.4 that drainage facilities based on the Request will minimize inundation and its damage. However, since the effect of these facilities varies widely, further examination is required.

(f) Formulation of Final Drainage Improvement Plan

The final drainage improvement plan is formulated on the basis of evaluation of the Request. Several factors are considered in the plan of underground reservoir, pumping station and pipes, as discussed below.

(i) Underground Reservoir

The site of the riverbank in which underground reservoir is to be installed is a place in which many tourists gather. Therefore, it is unsuitable for the construction site of a large-scale structure. Moreover, since there is no large space available, the plan is to make the capacity of the underground reservoir as small as possible.

(ii) Pumping Station

A large space to install a large pump on the site of the underground reservoir is not available. Therefore, the plan considered is to annex the pump to the underground reservoir and to make the pumping capacity as small as possible. Moreover, for reasons of geographical characteristics that require pumped drainage, a large pumping capacity, which needs power, should not be greatly expected. Therefore, it is desirable to reduce the capacity of the pump.

(iii) Drainage Pipe

In the case of closed conduit, the cross-sectional types of drainage pipe are circular, rectangle, horseshoe shape, egg-shaped, etc. In Phnom Penh City, 90% percent of the existing closed conduits are the circular type and 10% are the rectangle type. In case of the rectangle type, there is no limit on covering; however, this type is constructed cast-in-place so that the construction period will be long and construction cost also will be high. On the other hand, in case of the circular pipe, factory products can be used so that the construction period is shorter. Moreover, since the circular type is cheaper than the rectangle type, the circular type is adopted in this project.

The plan formulation strategy for drainage is based on three (3) basic factors as mentioned above. The drainage/inundation analysis was computed on software called MOUSE. The analysis model consists of pipe network, pumping stations and underground reservoirs. The MOUSE can conduct drainage and flood analysis

and all of the specifications of facilities are determined at the same time. The specifications of the drainage facility of the Request and the Proposed Plan are as tabulated below.

Table 2.2.5 (1) The Specification for Drainage Facility of the Request and the Proposed Plan (North Area)

Components	Requested Plan		Proposed Plan	
	Quantity	Specification	Quantity	Specification
Wat Phnom Area				
Drainage Pipe	9.05 km	900 m, ϕ 1,500 mm (R47) 200 m, ϕ 1,500 mm (R47) 100 m, ϕ 1,000 mm (R51) 500 m, ϕ 800 mm (R19) 300 m, ϕ 600 mm (R86)	1.435 km	371 m, ϕ 1,200 mm (R51) 190 m, ϕ 1,000 mm (R19) 554 m, ϕ 1,500 mm (R19) 160 m, B500 mm x H650 mm (Side Ditch) 160 m, B500 mm x H750 mm (Side Ditch)
Pumping Station	1 station	2,500 m^3/h (P6)	—	—
Underground Reservoir	1 location	6,000 m^3 (UGR6)	—	—
Central Market Area				
Drainage Pipe	3.40 km	640 m, ϕ 800 mm (Monivong) 350 m, ϕ 1,000 mm (R110) 860 m, ϕ 1,500 mm (R108) 600 m, ϕ 1,000 mm (Norodom) 700 m, ϕ 1,500 mm (R154) 250 m, ϕ 1,500 mm (R148)	2.216 km	454 m, ϕ 1,000 mm (Monivong) 358 m, ϕ 1,200 mm (R110) 10 m, ϕ 1,800 mm (R108) 539 m, ϕ 1,000 mm (Norodom) 644 m, ϕ 1,500 mm (R154) 211 m, ϕ 1,500 mm (R148)
Pumping Station	2 stations	2,500 m^3/h (P5) 5,000 m^3/h (P4)	2 stations	5,000 m^3/h (P5) 5,000 m^3/h (P4)
Underground Reservoir	3 locations	4,500 m^3 (UGR5) 3,000 m^3 (UGR4) 4,500 m^3 (UGR3)	2 stations	2,475 m^3 (UGR5) 6,480 m^3 (UGR3&UGR4)
Royal Palace & National Museum Area				
Drainage Pipe	0.70 km	300 m, B2000 x H1500 mm(R184) 400 m, B2000 x H1500 mm(R240)	0.726 km	421 m, ϕ 1,500 mm (R178) 305 m, ϕ 1,800 mm (R240)
Pumping Station	2 stations	5,000 m^3/h (P2) 2,500 m^3/h (P1)	2 stations	2,500 m^3/h (P2) 5,000 m^3/h (P1)
Underground Reservoir	2 locations	7,400 m^3 (UGR2) 1,100 m^3 (UGR1)	2 stations	1,200 m^3 (UGR2) 870 m^3 (UGR1)
Interceptor Plan				
Interceptor	-	-	1.818 km	129 m, B500 x H500 mm (UGR5) 363 m, ϕ 500 mm (UGR5→ UGR3&4) 122 m, B500 x H500 mm (UGR3&4) 68 m, ϕ 600 mm (UGR3&4→ UGR2) 40 m, B700 x H500 mm (UGR2) 1,096 m, ϕ 700 mm (UGR2→ Chamber)
Total length of pipes	13.15 km		6.195 km	

Table 2.2.5(2) The Specification for Drainage Facility of the Request and the Proposed Plan (South Area)

Components	Requested Plan		Proposed Plan	
	Quantity	Specification	Quantity	Specification
Trabek Basin and Adjacent Area				
Drainage Pipe	19.0 km		25.84 km	
Rehabilitation of Road Pavement	200 ha		11 ha	
Trabek North Area				
Drainage Pipe			5.60 km	240 m, ϕ 600 mm 1,450 m, ϕ 800 mm 2,220 m, ϕ 1,000 mm 470 m, ϕ 1,200 mm 1,220 m, ϕ 1,500 mm
Trabek West Area				
Drainage Pipe			4.00 km	1,560 m, ϕ 600 mm 310 m, ϕ 1,000 mm 260 m, ϕ 1,200 mm 480 m, ϕ 1,300 mm 920 m, ϕ 1,500 mm 470 m, ϕ 1,700 mm
Trabek Center Area				
Drainage Pipe			4.36 km	2,060 m, ϕ 600 mm 370 m, ϕ 800 mm 750 m, ϕ 900 mm 800 m, ϕ 1,000 mm 380 m, ϕ 1,200 mm
Trabek East Area				
Drainage Pipe			1.34 km	820 m, ϕ 1,000 mm 520 m, ϕ 1,500 mm
Trabek South Area – 1 (1)				
Drainage Pipe			6.61 km	1,810 m, ϕ 600 mm 260 m, ϕ 700 mm 920 m, ϕ 800 mm 610 m, ϕ 900 mm 240 m, ϕ 1,000 mm 860 m, ϕ 1,200 mm 1,910 m, ϕ 1,500 mm
Trabek South Area – 1 (2)				
Drainage Pipe			1.20 km	240 m, ϕ 1,000 mm 960 m, ϕ 1,500 mm
Trabek South Area – 2				
Drainage Pipe			2.73 km	520 m, ϕ 500 mm 1,220 m, ϕ 600 mm 360 m, ϕ 700 mm 310 m, ϕ 800 mm 320 m, ϕ 900 mm

(g) Interceptor Plan

The interceptor system shall be proposed in this project and the wastewater collected through the drainage networks shall be transported to the Trabek Main Canal through the interceptor. The carrying capacities of the proposed interceptors have been computed in