CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Objective

The topography makes Phnom Penh Capital City prone to flooding and inundation. Besides, flood protection and urban drainage facilities have not been functioning well because of old age and insufficient maintenance. Although the drainage condition in some parts of the city had improved gradually in the past decade, the other areas such as Trabek Basin and its vicinity still suffer from inundation in the rainy season. As a result, the city is beset with poor environmental conditions caused by stagnant wastewater in the lowland areas causing deterioration of the residents' living environment and posing a serious constraint to social and economic development.

To find a solution to these issues, the Government of Cambodia and the Phnom Penh Capital Hall (hereinafter referred as "PPCH") have been conducting various studies on flood protection and drainage improvement to achieve the following goal:

Overall Goal

- Stabilization of the livelihood of people in the Phnom Penh City;
- Development of the city through the mitigation of flood damage; and
- Improvement of sanitary and environmental conditions in the city.

Based on the overall goals given above, THE PROJECT FOR FLOOD PROTECTION AND DRAINAGE IMPROVEMENT IN THE PHNOM PENH CAPITAL CITY (PHASE III) (hereinafter referred as "the Project") has the following objective:

Project Objective

- To minimize the inundation and damage caused by local rainfall by improving the drainage system and providing equipment for the cleaning of drainage facilities.

2.1.2 Basic Concept of the Project

To achieve the objective of the Project, drainage facilities in the surveyed area, as well as drainage pipes and a sediment chamber, shall be installed or improved at the planning scale of 2-year probability, and cleaning equipment such as high water jet cleaner and sludge sucker vacuum truck shall be procured as described in Table R 2.1.1. In addition, technical assistance by the soft component shall be implemented for effective and appropriate maintenance and utilization of the facilities constructed or procured in the Project.

The Project will be implemented as a part of the "Master Plan for Drainage Improvement and Flood Control in the Municipality of Phnom Penh" (hereinafter referred to as "the Master Plan"),

which was formulated in "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh" conducted by the Japan International Cooperation Agency (JICA) in 1999. The Project will succeed the previous Japan's Grant Aid projects, namely; "The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh" (hereinafter referred to as "the Phase 1") and "The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)" (hereinafter referred to as "the Phase 2").

Table R 2.1.1 Contents of Japan's Grant Aid for the Project

Covered by the Japan's Grant Aid			Covered by the Recipient Country
Items	Description	Quantity	
Improvement of Drainage Network (Drainage Pipe Installation)			
Installation of drainage pipe at locations conforming to the following conditions in Trabek Basin and adjacent area: - Seriously suffers from inundation - Main trunk - Particular construction technique required	Ou Russei Area	3.93 km	- Improvement of branch line of drainage pipe - Operation and maintenance of drainage network
	Boeng Reang Area	2.43 km	
	Monireth Area	2.05 km	
	Tuol Svay Prey Area	2.52 km	
	Tuol Sleng Area	2.47 km	
	Boeng Keng Kang Area	3.04 km	
	Tuol Tumpung North Area	1.15 km	
	Tuol Tumpung South Area	3.06 km	
	Total Length	20.65 km	
Reconstruction of Sediment Chamber at R240	Existing big chamber shall be replaced by a new sediment chamber.	1 site	- Operation and maintenance of chamber - Clearing/removal/disposal of solid waste/sludge/sediment
Procurement of Cleaning Equipment for Drainage Pipe	- High Water-Jet Machine - Sludge Sucker	2 sets	- Operation and maintenance of equipment - Cleaning work of drainage facilities utilizing equipment procured by the Japan's grant aid
Technical Assistance by Soft Component	For the effective management and utilization of the facilities constructed and procured in the Project, technical assistance by soft component shall be implemented.		- Sustainable implementation of scheduled management based on the technical assistance

2.2 Outline Design of the Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Design Policy

The following facilities and equipment have been requested by the Cambodian side for the Project:

- Reinforcement and improvement of drainage network (Drainage Pipe Installation);
- Reconstruction of the sediment chamber at R240; and
- Procurement of cleaning equipment for drainage pipe.

The Preparatory Survey confirmed the background, objective and benefits of the Project, as well as the institutional capacity and budget availability of the agencies concerned of the Cambodian side. The contents of Japan's Grant Aid for the Project are demarcated as the basic design policy, as shown in the following table.

Table R 2.2.1 Contents of Japan's Grant Aid for the Project

Project Item	Covered by the Japan's Grant Aid	Covered by the Recipient Country
Improvement of Drainage Network (Drainage Pipe Installation)	Improvement/installation of drainage at locations conforming to the following conditions in Trabek Basin and adjacent area: - Seriously suffers from inundation - Main trunk - Particular construction technique required	- Improvement of branch line of drainage pipes - Operation and maintenance of drainage network
Reconstruction of Sediment Chamber at R240	- To demolish and remove the existing big chamber - To construct new sediment chamber	- Operation and maintenance of chamber - Clearing/removal/disposal of solid waste/sludge/sediment
Procurement of Cleaning Equipment for Drainage Pipe	Procurement of the following equipment: - High Water-Jet Machine - Sludge Sucker	- Operation and maintenance of equipment - Cleaning work of drainage facilities utilizing equipment procured under the Japan's Grant Aid

The locations, dimensions and so on of the objective facilities/equipment are to be optimized based on the present inundation condition and the result of the hydraulic analysis in the Preparatory Survey. However, Japan's Grant Aid shall be extended for projects where grant aid is urgently necessary in the present situation. Therefore, the requested facilities and equipment should be reviewed based on the policy of the Japan's Grant Aid Scheme and the results of appraisal by the Government of Japan will be submitted later to the Japanese Cabinet for final approval.

(1) Improvement of Drainage Network (Drainage Pipe Installation)

Due to the natural topographic characteristics of the Trabek Basin and the adjacent area, surface runoff at the site drains into the drainage open channels directly, such as Trabek Main Channel, Meanchey Drainage Channel and Salang Drainage Channel, and then pump stations drain them out of the city. Since there is no well-defined drainage network connected to an open drainage channel at the site at present, inundation damage occurs during and after heavy rainfall frequently.

The main objective of the works is to mitigate inundation damage caused by inland storm runoff in the project site. To attain this objective, an efficient drainage pipe network shall be established by the Project.

The project area to be improved shall be studied through interview survey on the present inundation condition. The optimum drainage network has to be confirmed by hydraulic analysis based on the results of topographic survey, manhole survey and interview survey. Then, specifications of the optimum drainage network will be proposed based on the results of drainage simulation by software "MOUSE".

In addition, the following conditions shall be considered as the design criteria:

- The drainage network shall be connected to the open drainage channel to drain storm water.

- Retention ponds around the Olympic Stadium shall be reclaimed by the Cambodian Government considering the environmental point of view, and the retention capacity of these ponds shall be eliminated from the drainage function of the ponds.
- The present condition of the Trabek Pond shall be preserved to maintain its storage capacity, and the pond shall never be reclaimed in the future to ensure the function as regulation pond for the Trabek Pump Station.

(2) Reconstruction of Sediment Chamber at R240

The "Big Chamber at R240" as requested by the Cambodian side is renamed in this Preparatory Survey as "Sediment Chamber at R240" because of its intended purpose. The interceptor system was introduced in the Phase 2 to collect wastewater discharged from the north-east part of the city core. In the dry season, wastewater flows into the Trabek Main Channel through the Sediment Chamber at R240. In the rainy season, storm water is drained out to the Tonle Sap by the pump stations constructed in the Phase 2.

The Sediment Chamber at R240 plays the role as a sediment trap facility protecting drainage pipes in the upstream and downstream of the chamber from clogging, and also as control box to change the flow direction in the rainy and dry seasons. It shall be reconstructed at the present location, taking easiness of operation and maintenance work into consideration. Structural details such as dimensions, foundations and accessories will be designed in this Preparatory Survey.

The basic design policies for the reconstruction are as follows:

- The structure of Sediment Chamber at R240 shall be stable and durable.
- The Sediment Chamber at R240 shall connect the interceptor system with the Trabek drainage system, and maintain the effectiveness of the interceptor system.
- The Sediment Chamber at R240 shall connect to the drainage pipes in the upstream and downstream of the chamber to keep free drainage flow.
- Workability of maintenance work shall be well considered into the structural design.

(3) Procurement of High Water Jet Cleaner Equipment (Cleaning Unit for Drainage Pipe)

The PPCH had delegated the execution of cleaning work on drainage pipes and manholes in Phnom Penh Capital City to the DPWT, and the executing agency is the DSD which is a division under the DPWT. The DSD has some difficulties with their present pipe cleaning work. The outstanding issues on cleaning work for drainage pipes and manholes are as summarized below:

- Combination trucks, which are equipped with a combined water jet and sludge suction function, have outlived their expected useful life and their functional

capabilities have become weak due to old age. Since the water pressure from the existing combination trucks are too weak to crumble sludge/sediment, they have to be crumbled manually. Besides, the suction power of the existing combination trucks is low and the vacuum suction system is not efficient to suck up sludge/sediment from the drainage pipes or manholes.

- The two (2) sludge suckers owned by DSD have also outlived their useful life. Work efficiency by the equipment is low. One of them has been utilized for 27 years, the other for 13 years, and the self-propelled function has been damaged.
- There is a high risk of accident or disease contamination by poisonous gas or virus with the present drainage cleaning method because the workers work in the drainage pipe for a long number of hours. The present pipe cleaning work system could not assure the safety and health of workers.
- All suction equipment owned by DSD is of the "Vacuum Type" which is suitable to suck liquid waste without air but not suitable to suck solids with air. To suck up the sludge and deposits including solids at drainage pipes, manholes and side ditches in Phnom Penh Capital City, the "Brower Type" sludge sucker is suitable.

Procurement of cleaning equipment for drainage pipes shall aim to improve work efficiency and endurance and to assure the safety of pipe cleaning work. Through the procurement of cleaning equipment by the Project, it is expected that work efficiency and working conditions will improve.

Quantities and specifications will be decided based on the results of the Preparatory Survey, taking institutional capacity and budget availability into account.

2.2.1.2 Policy on Natural Conditions

(1) Protection Level of Drainage Facilities

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

Table R 2.2.2 Protection Level of Drainage Facilities

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

The Phase 1 and the Phase 2 had also adopted the protection level shown in the table above.

(2) Rainfall Intensity Curve

The maximum annual rainfalls for durations between 1981 and 2009 at Pochentong Meteorological Station were used for the rainfall analysis. The values of probable rainfall by the Gumbel Method in return periods of 2-year are given in the following table.

Table R 2.2.3 Probable Rainfall

Return Period (years)	Hourly Rainfall (mm/hr)	Daily Rainfall (mm/hr)	Rainfall Intensity Curve
2	44.8	87.8	$I=2,566.07x(T+25.48)^{-0.93}$

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

(3) Rainfall Duration

The duration of design rainfall was defined in the Master Plan as six (6) hours based on single rainfall patterns of recent heavy rains causing severe inundation in the study area.

2.2.1.3 Policy on Socio-Economic Condition

The acquisition of private land and house relocation attendant to 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. Underground facilities shall be given particular attention in the determination of alignment of drainage pipes. The location of the sediment chamber shall be in a public land to avoid any land issue.

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

2.2.1.4 Policy on Construction/Procurement

(1) Design Standard

The Ministry of Public Works and Transport established design standards for bridges and national roads in 2003. Since the other structural design standards in Cambodia have not yet been established, well known standards of advanced nations such as Japan, the European Union, Australia and the USA are adopted.

Since previous Japan's Grant Aid projects have adopted Japanese design standards, this Preparatory Survey also adopted the Japanese design standards.

(2) Procurement Situation

Main construction materials such as cement, reinforcing bars, aggregates and so on, and basic construction equipment are available in Cambodia, but the local availability of particular construction components like steel sheet pile, drainage pump, silent piler and so on is difficult. Therefore, locally available materials and construction equipment shall be used as much as possible for the construction work to minimize the construction cost. The Preparatory Survey also considered the future improvement plan to avoid the duplication of investment.

Cleaning equipment for drainage pipes will be procured in Japan or another country and disembarkation point will be the port in Sihanouk Ville.

(3) Related Law/Regulation

The Phnom Penh Capital Hall (PPCH) is vested with the right to approve the execution of various construction works in public spaces including road works in the city. Since the superintendence organization of this Project is PPCH, there will be no obstacle to project execution.

There are some possibilities that construction work will cause negative impact to the environment, such as air pollution (dust generation), vibration and noise disturbance. Since Cambodia has environmental regulations about air pollution and noise disturbance, construction planning shall take these regulations and traffic control into consideration.

2.2.1.5 Policy on the Applicability of Cambodian Company

There are local contractors in Cambodia who have some experience in construction work related to Japan's Grant Aid projects and adequate skill on general construction works such as roads, drainage channels and simple concrete structures. Therefore, local contractors can be employed as subcontractors for the general construction components to reduce the construction cost.

Some local engineers capable of supervising general construction work are also available in Phnom Penh Capital City. These local engineers also could be employed as site managers of the contractor or site inspectors of the consultant for the general construction components to reduce the construction cost.

2.2.1.6 Policy on Operation and Maintenance Condition of the Implementing Agency

To set up adequate specifications for the objective facilities, the capability and budget for operation and maintenance of the implementing agency shall be considered in the Preparatory Survey. To enable the appropriate management and maintenance in present budget, structure and staff of the implementing agency, technical assistance by soft component shall be implemented.

2.2.1.7 Policy on Determination of Planning Scale of the Objective Facilities

(1) Improvement of Drainage Network (Drainage Pipe Installation)

In determining the planning scale of objective facilities, it is necessary to consider that Japan's Grant Aid is extended only for projects where grant aid is urgently necessary as in the present situation. There are some constraints on the planning for improvement of the drainage networks as follows:

- Most of the drainage facilities discharge into the Trabek drainage system. Therefore, the present condition of the Trabek drainage system such as flow capacity of the main channel and discharge capacity of the pump station shall be considered as prerequisite conditions.
- Considering the characteristics/intensity of rainfall in Phnom Penh and the lack of detention pond as well as the limited space for drainage facilities underground, some allowance for inundation in terms of depth and duration shall be considered in the planning.

Based on the constraints mentioned above and in order to achieve the objectives of the Project, the drainage network shall be improved to the planning scale of 2-year probability of rainfall to be able to drain the storm water within 2 hours with 20 cm of allowable inundation depth. This planning scale was also adopted in the Phase 2. These considerations will contribute to the cost reduction of the whole project.

(2) Reconstruction of Sediment Chamber at R240

The new sediment chamber at R240 shall be designed with appropriate functions, as follows:

- Sand, sludge and solid wastes contained in sewage water shall be deposited properly on the new sediment chamber, which shall have enough deposit capacity;
- The new sediment chamber shall be constructed at the same location as the existing chamber;
- The new sediment chamber shall connect with the drainage pipes in the upstream and downstream to secure free flow of wastewater and effectiveness of the interceptor system;
- The new sediment chamber shall provide operators with a means of access to the interior part (sedimentation pit) for sediment cleaning and removal work;
- Location of openings as entrance to the interior of chamber shall be designed considering easier maintenance; and
- Openings shall always be closed with suitable manhole covers except during maintenance work to prevent bad odour from diffusing into the park.

(3) Procurement of Cleaning Equipment for Drainage Pipe

Based on the results of site investigation and study on collected data, the functions required of the cleaning equipment for drainage pipes shall be as shown in the table below.

Table R 2.2.4 Required Functions of Cleaning Equipment for Drainage Pipes

Equipment	Required Function / Use / Purpose
Sludge Sucker/ Truck	- To suck up sludge/sediment from drainage pipes and manhole - To transport sludge/sediment to disposal area - Left-hand drive
Water-jet Machine	- To break solidified sludge/sediment and flush garbage out of drainage pipes - To move crumbled sludge/sediment in drainage pipes to manholes - Left-hand drive

The equipment procurement in the Project aims to provide the proper tools for the cleaning of drainage pipes and manholes efficiently and safely. The following prerequisite conditions for the procurement of equipment shall be considered:

(a) The executing agency should have enough manpower to operate and maintain the procured equipment;

(b) The executing agency should have enough space and facility to accommodate the procured equipment; and

(c) The executing agency should allocate enough funds for the operation and maintenance of procured equipment.

Equipment procured by the Project shall have high work efficiency and durability, and operation shall be easy. Quantity of equipment shall be decided as the number urgently necessary to accomplish the present maintenance work.

2.2.1.8 Policy on the Procurement Plan

The country of origin of procured equipment should be selected considering the following conditions:

(a) There is an agency in Cambodia or in neighbouring country to procure the main parts of truck body;

(b) There is less possibility for equipment breakdown and it is easy to procure spare parts; and

(c) Japanese products are more reliable than those of other countries based on the experience of DSD with its existing equipment.

From the above reasons, Japan shall be the country of origin of equipment to be procured in the Project.

2.2.1.9 Policy on the Construction Plan

(a) Improvement of Drainage Network (Drainage Pipe Installation)

- New drainage pipes shall be laid underneath of existing road. Test excavations at each construction site of the proposed drainage pipeline shall be carried out prior to implementation in order to locate the exact position of existing underground facilities.
- The whole objective area of drainage network improvement in the Project shall be divided into eight (8) drainage areas, and each drainage area shall have a different and independent drainage function. The construction work at one drainage area shall be completed basically to make its drainage function effective before the construction team moves to another drainage area.
- Construction areas are located in the urban area. From the environmental and safety points of view, construction equipment to be used in the Project shall be the low-noise and low-vibration types to minimize the negative impact to houses and buildings.
- The working hours in this Project site are basically from 8:00AM to 5:00PM for safety reasons. However, night -time work shall be also planned to minimize the influence against the present traffic and the residents' living conditions.
- The jacking method may be adopted at sites where traffic volume is rather heavy to avoid the negative impact of traffic control.

(b) Reconstruction of Sediment Chamber at R240

- The new sediment chamber will replace the existing chamber located to the north of Wat Botum Park. Therefore, construction work could be carried out by the open-cut method without temporary retaining wall, because the working space is enough.
- The foundation pile of the new sediment chamber is designed as the PC pile. The hydraulic hammer shall be adopted for driving the PC piles considering the prevention of noise and the problem on oil or soot.

2.2.1.10 Policy on the Implementation Schedule

The Project includes the improvement of drainage network and the reconstruction of sediment chamber, and the construction work could be affected easily by rain. 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 formulation of the implementation plan. The construction of sediment chamber and box culvert as parts of the drainage pipeline shall be executed mainly in the dry season. To establish the implementation schedule, the conditions mentioned above shall be considered.

2.2.2 Basic Plan (Facility Plan/Equipment Plan)

The following three project components have been requested for the Japan's Grant Aid project:

- Improvement of Drainage Network (Drainage Pipe Installation)
- Reconstruction of Sediment Chamber at R240
- Procurement of Cleaning Equipment for Drainage Pipes

Study results and the basic plan for each project component are as described hereinafter.

2.2.2.1 Improvement of Drainage Network (Drainage Pipe Installation)

The target area has been set in accordance with the actual situation of inundation damage based on the result of interview survey. The improvement plan for the drainage network has been analysed and the required specifications of drainage pipes are to be provided to improve the inundation situation.

(1) Condition of Retention/Regulation Pond (Prerequisite Condition for Inundation/Drainage Analysis)

(a) Retention Ponds around the Olympic Stadium

As previously mentioned, the Cambodian Government has already decided to reclaim the retention ponds located in the surroundings of the Olympic Stadium. These ponds have been functioning as temporary storage for rainwater from the upstream area to reduce the peak flow to the drainage pipes in the downstream. After reclamation of these ponds, the inundation situation around the Olympic Stadium and the area upstream may become worse. Therefore, the drainage improvement plan shall be formulated through inundation/drainage analysis without considering the retention capacity of these ponds.

(b) Trabek Regulation Pond

The present storage capacity of the Trabek Pond is considered to be maintained because the pond is indispensable as the regulation reservoir of the Trabek Pump Station and the present storage capacity is essential for the drainage system of Phnom Penh Capital City.

(2) Actual Inundation Situation and Selection of Target Area

For the selection of target areas for the Project, the following indications have been set in consideration of influence to civil life by the inundation and the areas where flood damage is serious are extracted based on the results of investigation of flood inundation damage:

- All of the interviewees replied that flood inundation frequency is 4 times or more in a year. (70% of interviewees who experienced flood damage)

- Half or more interviewees replied that inundation depth is higher than the shin. (80% of interviewees who experienced flood damage)
- Half or more interviewees replied that inundation duration is longer than 3 hours. (36% of interviewees who experienced flood damage)

Based on these indexes, the target areas where inundation is serious are as indicated in Fig. R 2.2.1.

To categorize each target area and drainage system, eight (8) drainage areas have been defined as indicated in Fig. R 2.2.1 and the design and cost estimation shall be executed for the categorized drainage areas of the Project. The drainage areas have been determined primarily on the basis of topographic feature, existing drainage network, results of site survey and interview survey regarding inundation state, and drainage destination to existing drainage open channel.

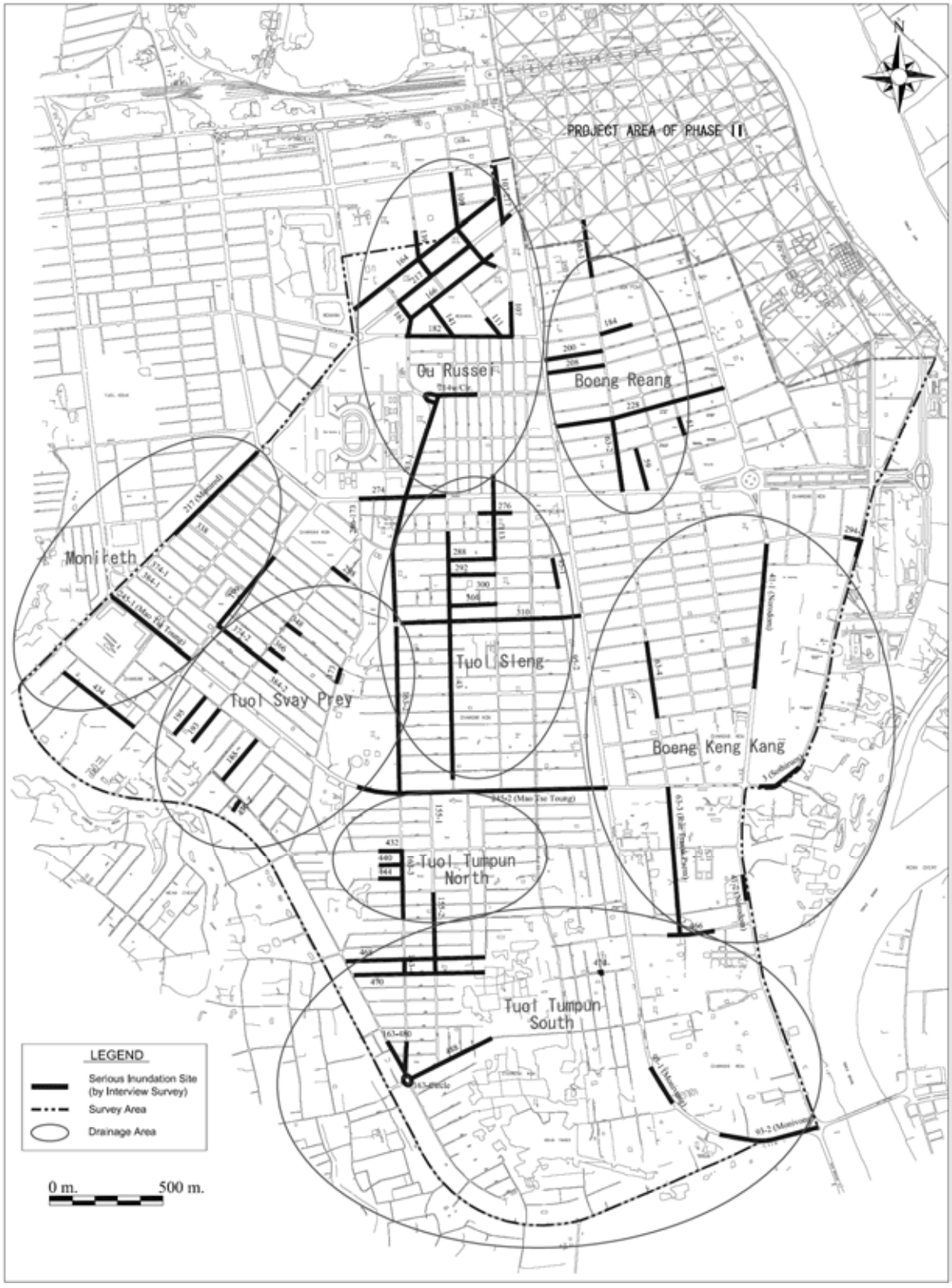


Fig. R 2.2.1 Serious Inundation Sites based on Interview Survey and Drainage Area

The situation of inundation in each drainage area is as described hereinafter.

(a) Ou Russei Area

The frequency and duration of inundation in this area are not so serious, but the inundation depth exceeds the allowable depth of 0.2m more than once a year. Street No. 107 and Street No. 111 have long-time inundation, especially Street No. 107, which inundates frequently even if rainfall is not so heavy, as shown in Photo R 2.2.1. The stretch near the intersection of Street No. 217 (Charles de Gaulle Boulevard) and Street No. 182 is obviously inundated due to the low ground level.

After the reclamation of retention ponds around the Olympic Stadium, the inundation state in the Ou Russei area could be more serious. Therefore, it is necessary to prepare the improvement plan for this area in consideration of the negative impacts.

Street No. 107 (taken on 26 March 2010)

Charles de Gaulle Blvd. (taken on 20 April 2010)

Source: Preparatory Survey Team, JICA

Photo R 2.2.1 Inundation at Ou Russei Drainage Area

(b) Boeng Reang Area

This area was not included in the request for the Project, but it turned out that drainage improvement is required based on the results of the flood damage interview survey. Inundation along Street No. 200 and No. 208 is frequent and deep, and continues for a long time. Some areas along Street No. 63 are flooded due to broken drainage pipes.

Street No. 200 (taken on 20 April 2010)

Street No. 51 (taken on 20 April 2010)

Source: Preparatory Survey Team, JICA

Photo R 2.2.2 Inundation at Boeng Reang Drainage Area

(c) Monireth Area

Floods are experienced along the Monireth Blvd. (Street No. 217), which is one of the main roads in Phnom Penh Capital City. Urgent drainage improvement is necessary because inundation is serious in view of frequency, depth and duration.

Monireth Blvd. (taken on 20 April 2010)

Photo R 2.2.3 Inundation at Monireth Drainage Area

(d) Tuol Svay Prey Area

Floods frequently occur in this area. Street No. 348, No. 366, No. 195 and No. 430 are particularly serious. Floods along Street No. 434 continue for half a day. The cause of such long-time floods is not only the insufficient hydraulic capacity but also the clogging of drainage pipes.

Street No. 199 (taken on 31 May 2004)

Photo R 2.2.4 Inundation at Tuol Svay Prey Drainage Area

(e) Tuol Sleng Area

Street No. 143 and No. 163 which run through this area from north to south suffer from perpetual inundation and the inundation continues for a long time in some areas. Inundation along Street No. 288 and No. 304 is also frequent, deep and continues for many hours. Floods in this area should be mitigated by draining to Trabek Main Channel and/or Tuol Sen East Channel.

(f) Boeng Keng Kang Area

The ground level around Street No. 63 and No. 466 is higher than these streets so that storm water gathers following the topography and floods often occur in this area. The Cambodian side had requested the improvement of the drainage system along Street No. 63, which is famous as inundation point where inundation reaches knee-deep and continues for 2 or 3 hours. Floods in this area are planned to be drained into the Trabek Main Channel.

Intersection between Street No. 63 and No. 352
(taken on 11 Sep 2009)

Intersection between Street No. 63 and No. 294
(taken on 11 Sep 2009)

Photo R 2.2.5 Inundation at Boeng Keng Kang Drainage Area

(g) Tuol Tumpung North Area

Found here is one of the longest inundation areas among the target areas of the interview survey. Floods continue for a few hours or half a day in some areas. Especially, floods along Street No. 155 and No. 163 are deep and occur frequently. There is a high necessity of drainage capacity improvement along Street No. 163.

Street No. 163, in front of Russian Market
(taken on 31 Aug 2009)

Street No. 163, in front of Russian Market
(taken on 1 Sep 2009)

Photo R 2.2.6 Inundation at Tuol Tumpung North Drainage Area

(h) Tuol Tumpung South Area

Also here is one of the longest inundation areas among the target areas of the interview survey. The drainage main is to be installed under Street No. 488, to drain floodwaters

into the Trabek Main Channel. There are many constraints to the design, such as the slope and depth of pipe installation due to the low ground level.

(3) Work Flow of Formulation of Drainage Improvement Plan and Hydraulic Simulation

Hydraulic simulation by the software called MOUSE was adopted for the inundation/drainage analysis and the preparation of drainage improvement plan. Survey for around 600 manholes and about 26 km of roads (longitudinal profile and cross section survey of the roads) were conducted by the JICA Preparatory Study Team to provide data in addition to the existing survey results of about 300 manholes in the Trabek area. The MOUSE simulation model was developed based on the field survey and the existing data in order to carry out the hydraulic simulation.

The protection level for drainage facilities in the study area was set at 2-year return period with not more than 0.2m of inundation depth and 1 to 2 hours duration based on the design policy for drainage facility. The flowchart to prepare the drainage improvement plan is presented in Fig. R 2.2.2.

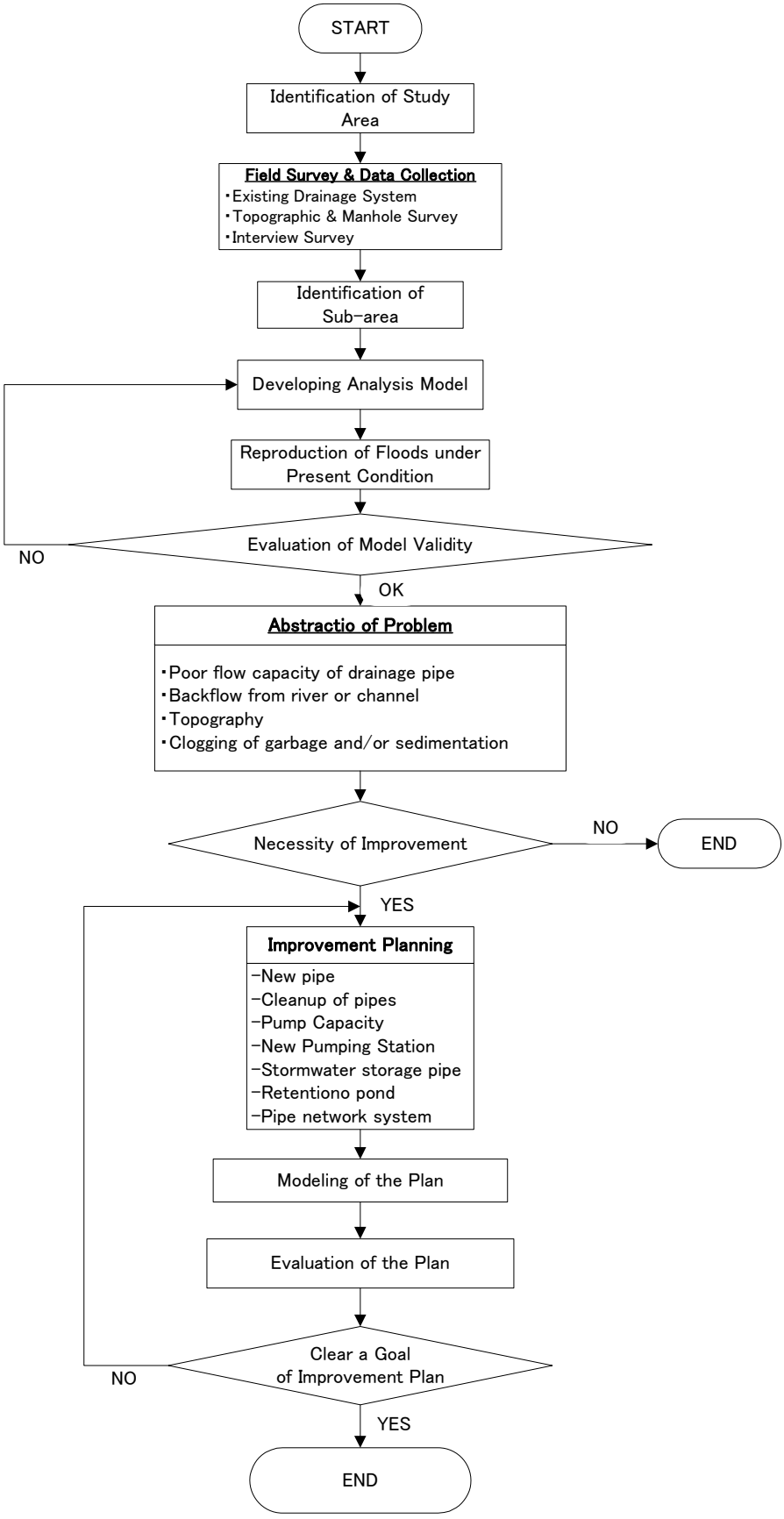


Fig. R 2.2.2 Flowchart to Formulate the Drainage Improvement Plan

(4) Prediction of Inundation State by Simulation

As mentioned below, the drainage simulation model for the software called MOUSE on the basis of site investigation is constituted for the proper design of the drainage network in the Project.

(a) Restaging of Inundation State based on Present Drainage Network

Drainage simulation by MOUSE under the present drainage network by the simulation model restages the present inundation area and inundation depth to be about the same as the results of the interview survey on inundation state [refer to Fig. R 2.2.3 (1)]. Hence, it is assured that drainage simulation by MOUSE can restage the present inundation state and predict the prospective state after the Project.

(b) Prediction of Influence by the Reclamation of Ponds around the Olympic Stadium

To clarify the negative impacts of inundation with the reclamation of ponds around the Olympic Stadium, restaging calculation using the drainage simulation model is executed. The calculation results are shown in Fig. R 2.2.3 (2).

In accordance with the comparison between Fig. R 2.2.3 (1) and Fig. R 2.2.3 (2), degradations of inundation state at Street No. 214 and No. 163 in the vicinity of the Olympic Stadium and Ou Russei Market will be particularly significant if the ponds around the Olympic Stadium are reclaimed.

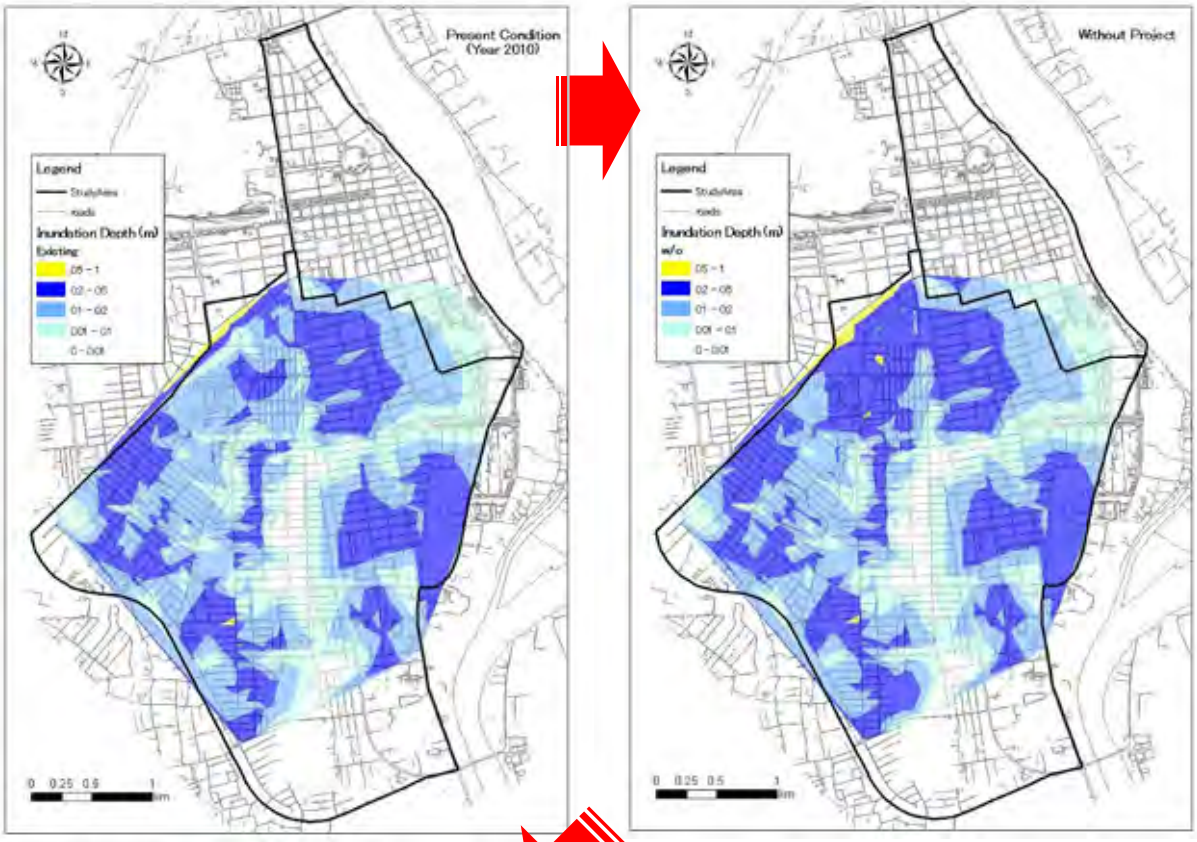
(c) Prediction of Inundation State after Completion of the Project

Restaging calculation results of the inundation result after the completion of installation work of drainage system by the proposed project as described below are as shown in Fig. R 2.2.3 (3). In this case, the inundation depth in all survey areas is improved by not more than 20cm although the condition that ponds around the Olympic Stadium are reclaimed is applied.

(d) Prediction of Influence by the Storage Volume Decrease of Trabek Pond

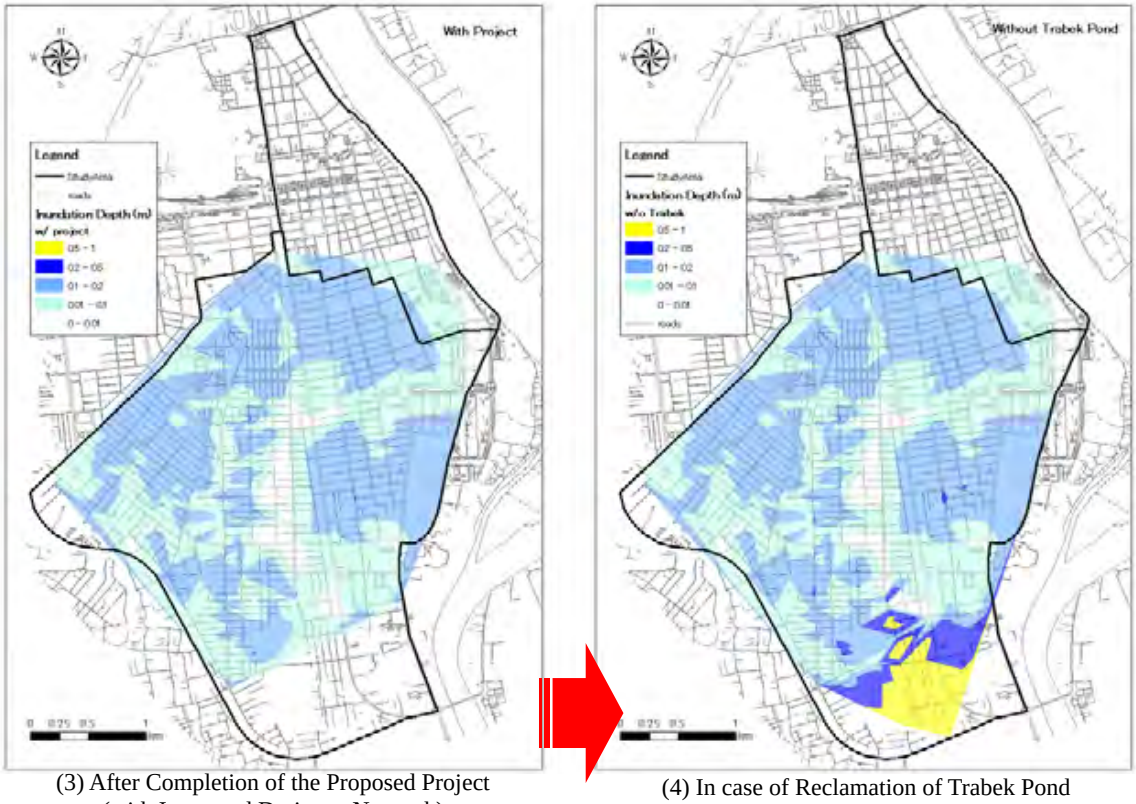
The execution condition of the Project is that the current storage volume of Trabek Pond will not be decreased (reclamation of the pond will never be implemented) in order to keep the facility as a regulation pond of the Trabek Pump Station.

Restaging calculation results in the bare possibility case that the pond will be reclaimed after the completion of the Project is as shown in Fig. R 2.2.3 (4). Inundation state in the southern area of Phnom Penh Capital City will obviously deteriorate by spilling from the channel to the Trabek Pump Station because the flood control and retention volume of the pond will be lost.



(1) Present Condition
with Present Drainage Network

(2) After Reclamation of the Ponds around
Olympic Stadium with Present Drainage Network



(3) After Completion of the Proposed Project
(with Improved Drainage Network)

(4) In case of Reclamation of Trabek Pond
(with Improved Drainage Network)

Fig. R 2.2.3 Prediction of Inundation Condition by MOUSE Simulation

(5) Design Condition

The design conditions applied for the MOUSE simulation, preparation of basic plan and drainage facility plan are as described below.

(i) Design Condition on Natural Environment

The conditions shown in the following table were adopted according to the design policy on natural conditions.

Table R 2.2.5 Probable Rainfall

Return Period	Hourly Rainfall (mm/hr)	Daily Rainfall (mm/day)	Rainfall Intensity Formula	Duration
2-year	44.8	87.8	$I = 2{,}566.07 \times (T+25.48)^{-0.93}$	6 hours

Source: Final Report "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh", 1999, JICA

(ii) Runoff Coefficient

The runoff coefficients shown in the following and applied in the Master Plan in the Phase 1 and the Phase 2 that changed according to land use were adopted.

Table R 2.2.6 Runoff Coefficients adopted for the Study

Land use	Runoff Coefficient
High density Urban Area	0.80
High density Residential Area	0.65
Low density Residential Area	0.50
Commercial Area	0.35
Agricultural Area	0.05
Park/Greenery	0.10
Water area	1.00

Source: Final Report "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh", 1999, JICA

According to the ADB study report on the Trabek Main Channel, the runoff coefficient is "0.7" uniformly. However the coefficients mentioned above were applied to improve the simulation accuracy in this preparatory study.

(iii) Roughness Coefficient

The material of the proposed drainage pipes will be reinforced concrete. The roughness coefficient of concrete is generally n = 0.011 – 0.016. The roughness coefficient of n = 0.015 was applied in the design stage to consider the pipe condition such as garbage and soil and sand sedimentation. Based on the sedimentation volume as a result of the manhole survey, the roughness coefficient of the existing pipes for MOUSE simulation is set higher than that of the new pipes.

(iv) Covering of Pipes

The covering of pipes empirically applies 1 m for below roadways and 0.75 m for collecting pipes in Cambodia. This agrees with the Japanese guideline which is 1.0 m for main drainage and 0.6 m for others.

(v) Joint Method

There are four (4) kinds of joint method, namely; (1) the water surface connection, (2) the crown joint method, (3) the pipe centre connection, and (4) the pipe bottom connection. The crown joint method, which is hydraulically safer, was applied, in principle.

(vi) Manhole Arrangement

Manhole arrangement follows the Japanese guideline prepared by the Japan Sewage Works Associations, and manholes are arranged at points necessary for O&M, starting point of pipe, changing point of direction and/or gradient, diameter changing point, confluence of each pipe and so on.

The intervals of manhole shown in the table below are the standard for the straight part of drainage pipe.

Table R 2.2.7 Maximum Interval of Manhole on each Diameter of Drainage Pipe

Pipe diameter(mm)	D600 or smaller	D1,000 or smaller	D1,500 or smaller	D1,650 or bigger
Maximum Interval (m)	75	100	150	200

Source: Guideline and Description for Planning and Design of Sewerage Facility, Japan Sewage Works Associations

(6) Basic Plan of Drainage Network Improvement

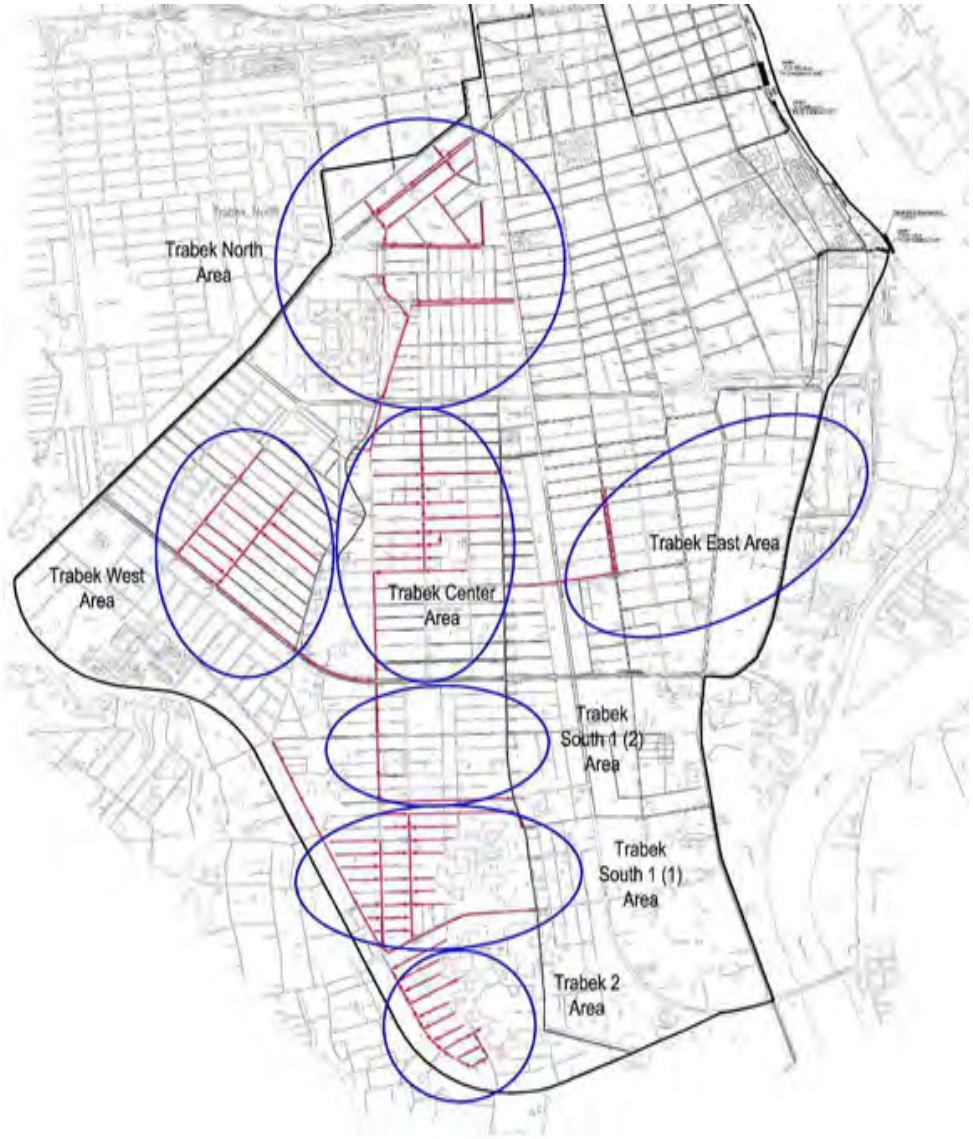
The proposed drainage improvement plan based on the result of MOUSE simulation analysis is shown in Table R 2.2.4. The reasons why the names of drainage area and the quantities of drainage pipe in the proposed plan are different from those requested are as follows:

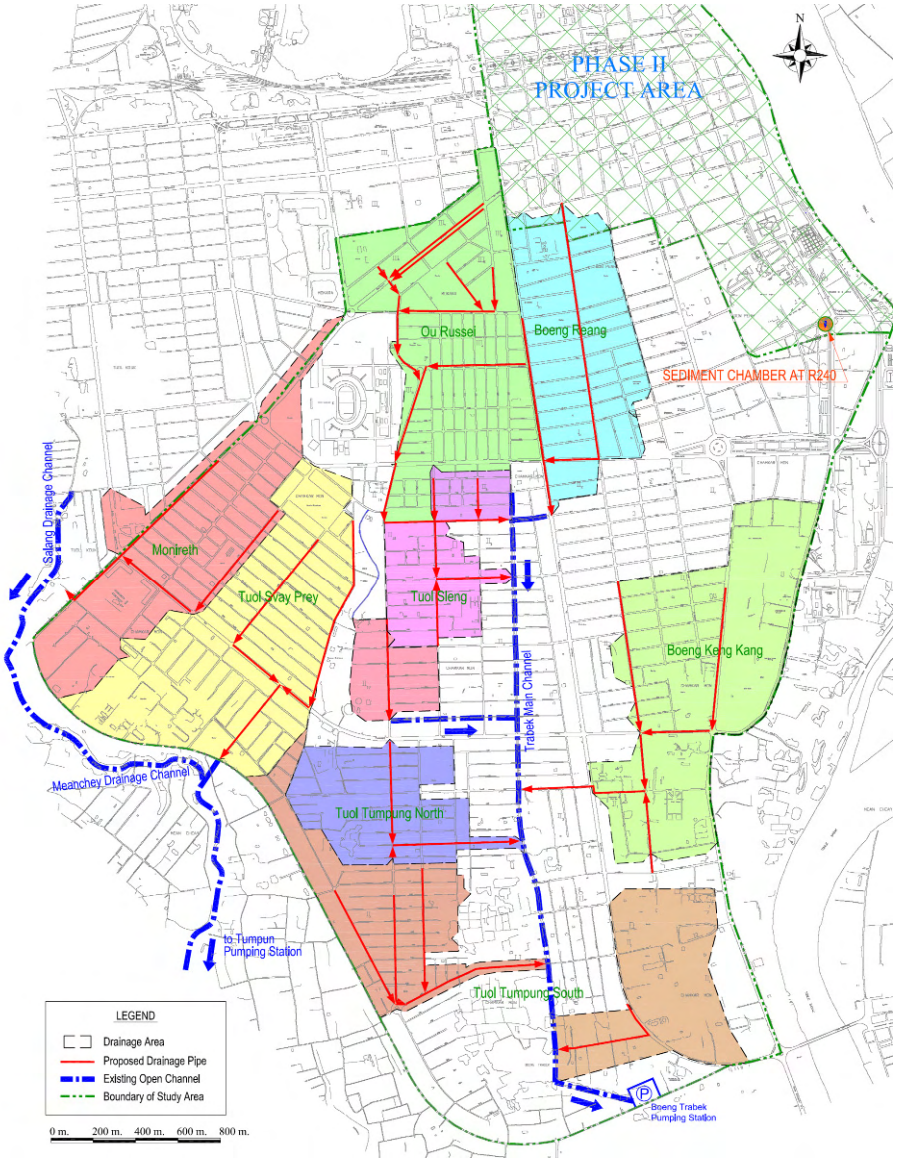
- The name of drainage area is revised based on the name of *"Sangkat"* in/around the drainage area for easier recognition of location of each drainage area.
- Proposed length of drainage pipe installation in each drainage area is not the same as the requested length. Proposed length is decided based on the result of MOUSE simulation analysis considering present inundation condition and effectiveness of improvement work.
- Proposed plan prioritizes to install large-sized drainage pipes at main streets in terms of effectiveness of improvement. Therefore, the total length of small-sized drainage pipes is reduced from the request to balance the total cost of pipe installation.
- Although Boeng Reang drainage area and Monireth drainage area have not been included in the request, it was confirmed through the interview survey with the residents that there is habitual inundation and damage in these areas. Therefore, Boeng Reang and Monireth drainage areas are added to the proposed drainage areas.

- Drainage area “Trabek South-2” indicated in the request is excluded from the proposed plan because inundation damage in this area was not confirmed in the interview survey.

Table R 2.2.8 Requested and Proposed Improvement Plan of Drainage Network

Request		From Request to Proposal	Proposal	
Drainage Area	Quantity		Drainage Area	Quantity
Trabek North Area	5.60km	Renamed by name of place	Ou Russei Area	3.93km
No request	—	Added due to present condition	Boeng Reang Area	2.43km
No request	—	Added due to present condition	Monireth Area	2.05km
Trabek West Area	4.00km	Renamed by name of place	Tuol Svay Prey Area	2.52km
Trabek Center Area	4.36km	Renamed by name of place	Tuol Sleng Area	2.47km
Trabek East Area	1.34km	Renamed by name of place	Boeng Keng Kang Area	3.04km
Trabek South-1 (1) Area	6.61km	Renamed by name of place	Tuol Tumpung South Area	1.15km
Trabek South-1 (2) Area	1.20km	Renamed by name of place	Tuol Tumpung North Area	3.06km
Trabek South-2 Area	2.73km	Excluded due to no inundation	—	—
Total Length	25.84km	➔	Total Length	20.65km





(1) Requested Drainage Improvement Plan (2) Proposed Drainage Improvement Plan

Fig. R 2.2.4 Comparison of Improvement Plan of Drainage Network, Request and Proposal

(7) Drainage Improvement Plan

Based on the updated existing pipe network data and the MOUSE simulation analysis, the total length of pipe network to be improved is 20.654 km.

The project area is divided into eight (8) drainage areas. Floods in the Monireth Area shall drain into the Salang Drainage Channel located in the west of Monireth Blvd., close to this area. According to the Master Plan and the Phase 1, a part of the flood in the Tuol Svay Prey area is planned to drain into the Meanchey Drainage Channel. Hence, the plan proposed in the Project will adopt the said plan. As for the remaining six (6) drainage areas, the floods are discharged by pumping drainage at Trabek Pump Station through the Trabek Main Channel installed by ADB and the Trabek Pond.

For each drainage area, a brief description of the provisionally proposal drainage pipe such as diameter and length of proposed pipes, reason for improvement and underground facilities are as described below. Additionally, detail type and length of proposed pipes at each drainage area are as shown in the following table.

Table R 2.2.9 Type and Length of Proposed Drainage Pipes at Each Drainage Area

unit: m

Type	Drainage Area								Total
	Ou Russei	Boeng Reang	Monireth	Tuol Svay Prey	Tuol Sleng	Boeng Keng Kang	Tuol Tumpung North	Tuol Tumpung South	
Dia. 600mm	236	-	-	-	-	-	-	124	360
Dia. 800mm	680	-	-	645	1,012	-	-	708	3,045
Dia. 1,000mm	1,673	811	657	347	489	1,777	54	854	6,662
Dia. 1,200mm	-	1,077	438	349	370	364	483	602	3,683
Dia. 1,500mm	81	392	952	746	604	904	610	769	5,058
Dia. 1,800mm	78	-	-	82	-	-	-	-	160
Dia. 2,000mm	675	-	-	355	-	-	-	-	1,030
Box Culvert 2m×2.5m	411	-	-	-	-	-	-	-	411
Box Culvert 1m×1.5m	13	153	-	-	-	-	-	-	166
Box Culvert 1m×1.25m	79	-	-	-	-	-	-	-	79
Total	3,926	2,433	2,047	2,524	2,475	3,045	1,147	3,057	20,654

(a) Ou Russei Area

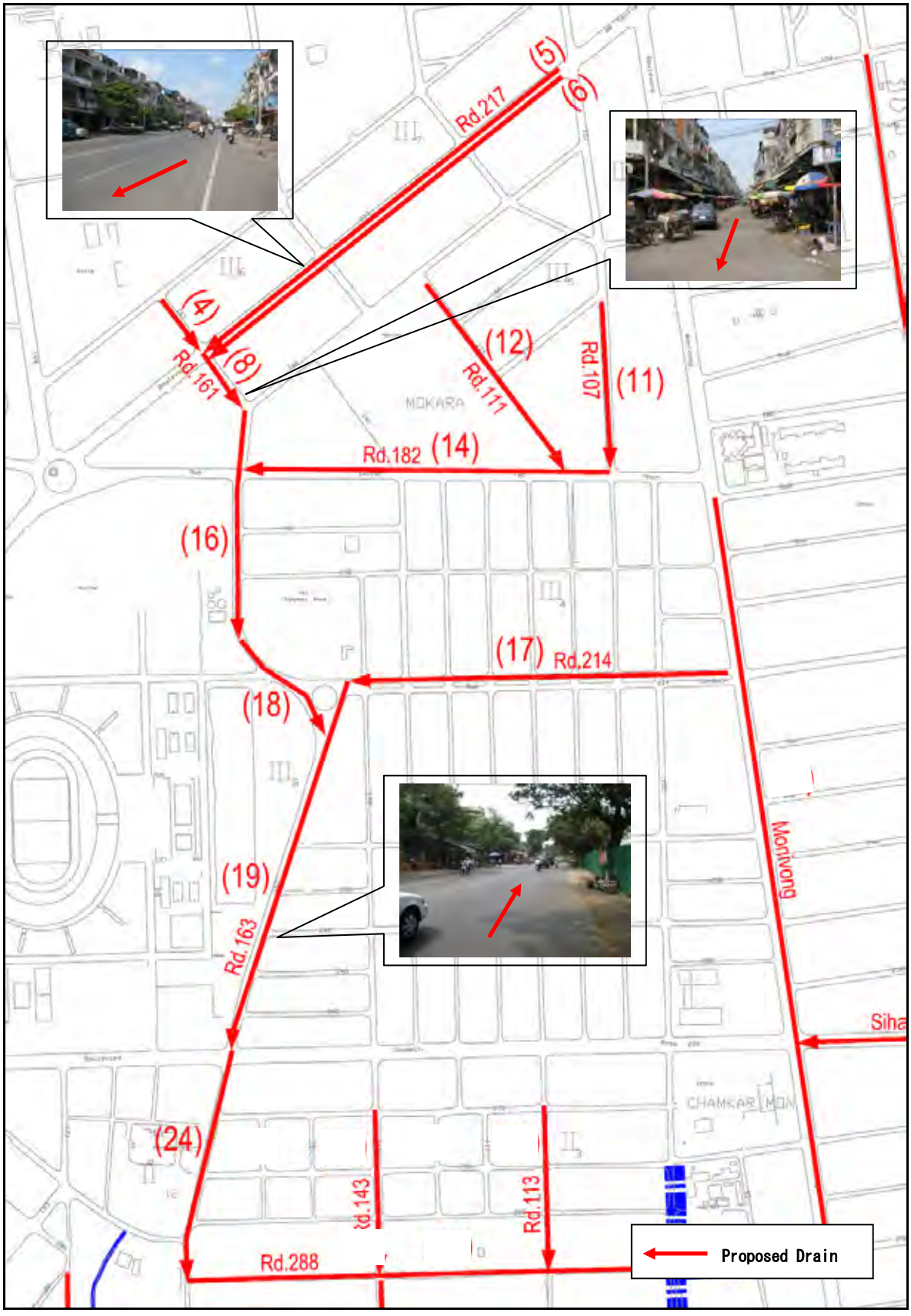


Fig. R 2.2.5 Alignment of Proposed Drainage Pipes (Ou Russei Area)

Table R 2.2.10 Proposed Drainage Pipes (Ou Russei Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Consideration
(4)	Box Culvert 1,000 x 1,250	79	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Radio cable, Telephone cable; A lot of private shops
(5)	1,000	580	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; Street No. 217 is a heavy traffic road.
(6)	1,000	560	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; Street No. 217 is a heavy traffic road.
(8)	Box Culvert 1,000 x 1,500 and 1,500	94	Existing drainage pipes do not have sufficient hydraulic capacity	Water supply, Electric cable; Heavy traffic road
(11)	600	236	Existing drainage pipe are already full of garbage and silt and are not in proper working condition.	Water supply, Electric cable, Telephone cable; There is big market along this road.
(12)	800	301	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; There is big market along this road.
(14)	1,000	464	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; This is a heavy traffic road.
(16)	1,800 ~ 2,000	255	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; Street No. 163 is a main and heavy traffic road.
(17)	800 ~ 1,000	448	Existing drainage pipes do not have sufficient hydraulic capacity	Water supply, Telephone cable, TV cable
(18)	2,000	200	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; Street No. 163 is a main and heavy traffic road.
(19)	Box Culvert 2,000 x 2,500	411	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; Street No. 163 is a main and heavy traffic road.
(19)	2,000	298	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; Street No. 163 is a main and heavy traffic road.
Total		3,926	Note: Flood damage will be more serious after the reclamation of retention ponds around the Olympic Stadium.	

Source: Preparatory Survey Team, JICA

(b) Boeng Reang Area

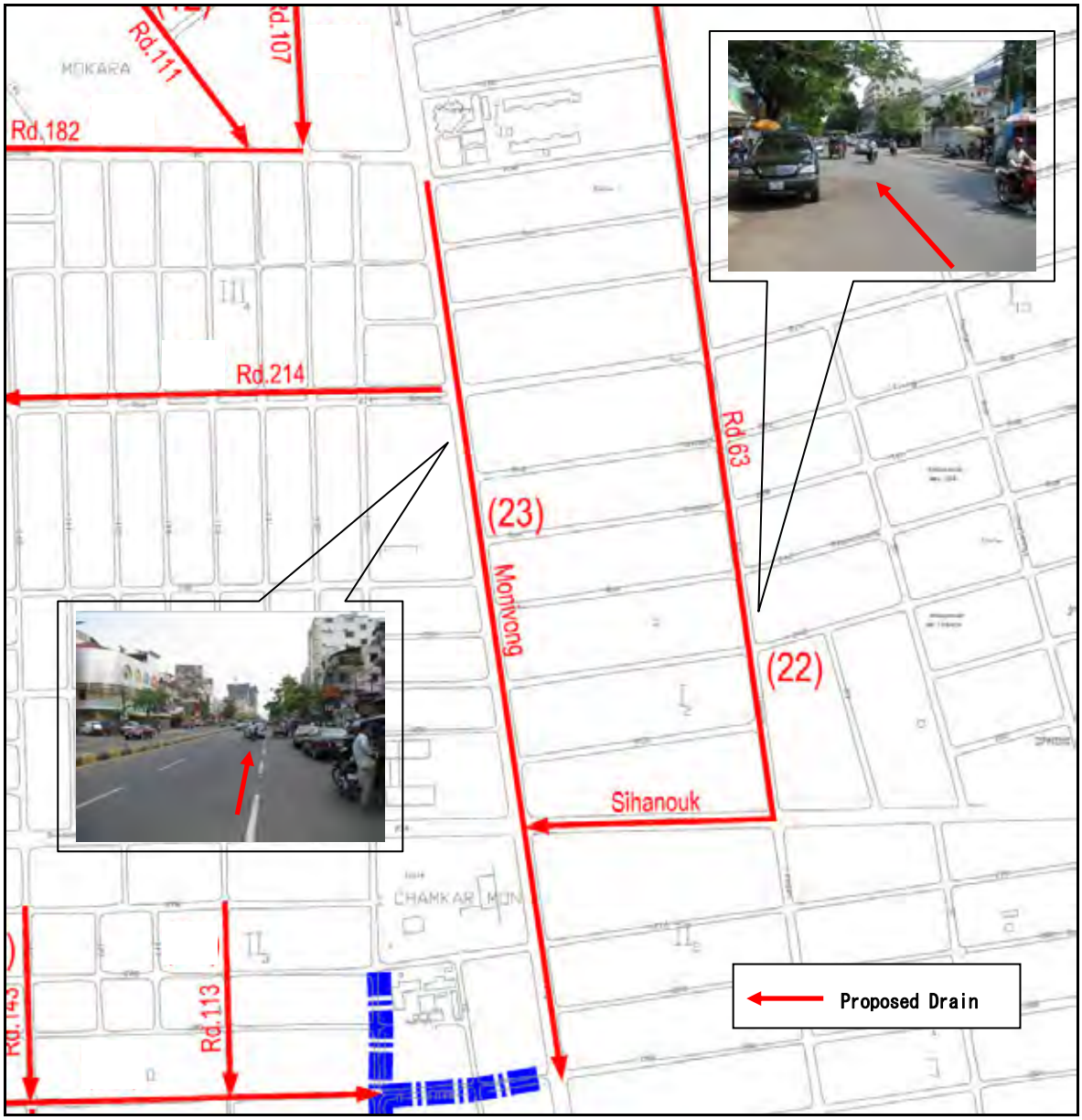


Fig. R 2.2.6 Alignment of Proposed Drainage Pipes (Boeng Reang Area)

Table R 2.2.11 Proposed Drainage Pipes (Boeng Reang Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Consideration
(22)	1,000 ~ 1,500	1,613	Improvement of drain condition of surrounding area. Existing drainage pipe are already full of garbage and silt and are not in proper working condition.	Water supply, Telephone cable; Sihanouk Road is a main and heavy traffic road.
(22)	Box Culvert 1,000 x 1,500	153	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable, TV cable; Monivong Road is a main and heavy traffic road.
(23)	1,000 ~ 1,200	667	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable, TV cable. Monivong Road is a main and heavy traffic road.
Total		2,433	Note: This area was not included in the request for the Project, but it turned out through the preparatory survey that drainage improvement is required.	

Source: Preparatory Survey Team, JICA

(c) Monireth Area

Fig. R 2.2.7 Alignment of Proposed Drainage Pipes (Monireth Area)

Table R 2.2.12 Proposed Drainage Pipes (Monireth Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Underground Facilities (Crossing) Remarks
(36)	1,000 (two lines) and 1,500	968	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable, TV cable; Monireth Road is a big and heavy traffic road.
(37)	1,000	641	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable, TV cable
(38)	1,200	438	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Radio cable, Electric cable, Telephone cable; Mao Tse Toung Road is a main and heavy traffic road.
Total		2,047		

Source: Preparatory Survey Team, JICA

(d) Tuol Svay Prey Area

Fig. R 2.2.8 Alignment of Proposed Drainage Pipes (Tuol Svay Prey Area)

Table R 2.2.13 Proposed Drainage Pipes (Tuol Svay Prey Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Underground Facilities (Crossing) Remarks
(44)	800	645	Existing drainage pipes do not have sufficient hydraulic capacity	Water supply, Telephone cable
(45)	1,200 ~ 1,500	302	Existing drainage pipes do not have sufficient hydraulic capacity	Water supply, Telephone cable; Mao Tse Toung Road is a main and heavy traffic road.
(50)	1,800 ~ 2,000	437	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; Need to connect to existing Tum Nup Toek Sluiceway constructed by the Phase 1; Crossing Mao Tse Toung Road
(51)	1,000 ~ 1,500	957	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable
(72)	1,500	183	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable, TV cable; Mao Tse Toung Road is a main and heavy traffic road.
Total		2,746		

Source: Preparatory Survey Team, JICA

(e) Tuol Sleng Area

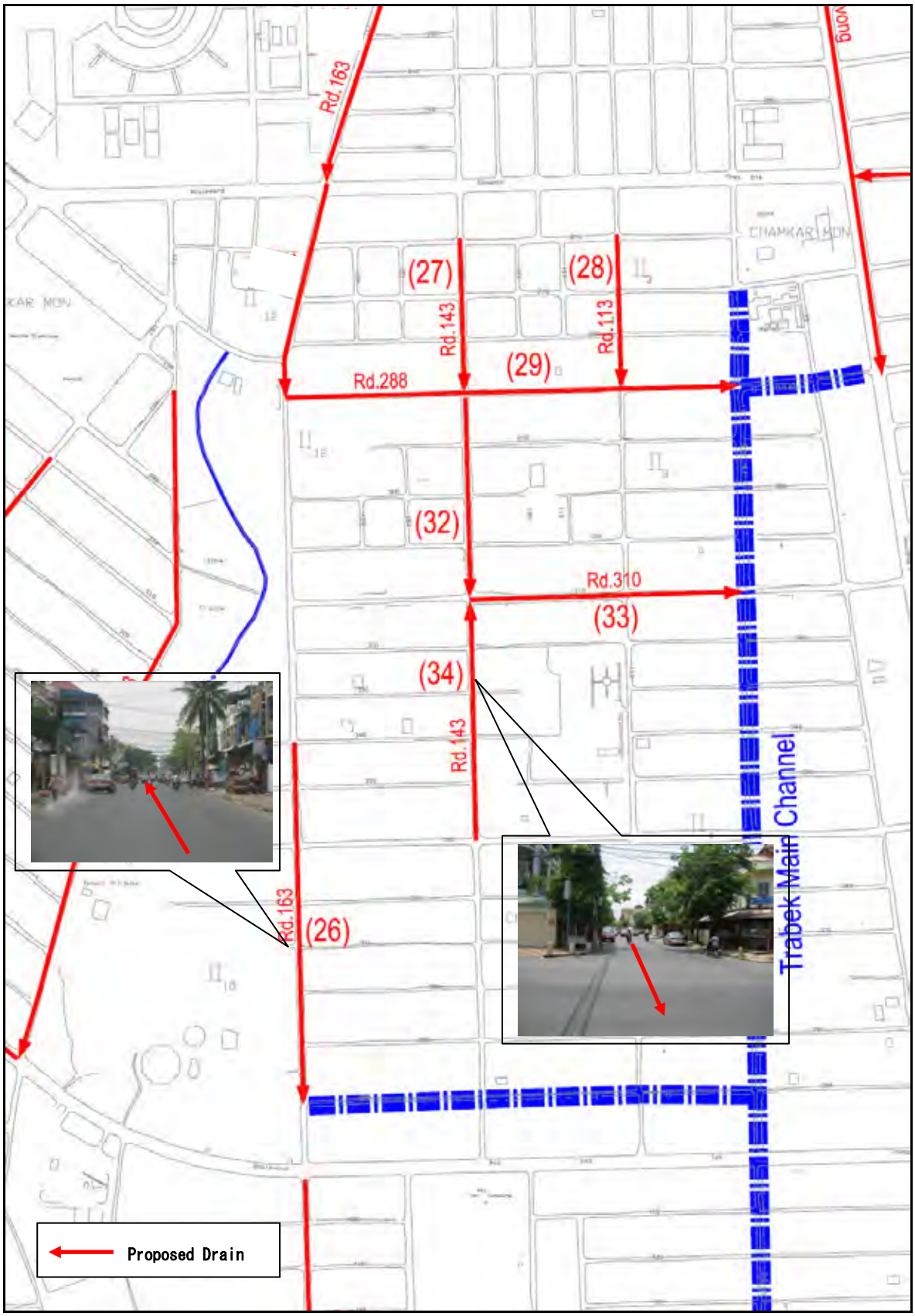


Fig. R 2.2.9 Alignment of Proposed Drainage Pipes (Tuol Sleng Area)

Table R 2.2.14 Proposed Drainage Pipes (Tuol Sleng Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Consideration
(26)	1,000	489	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; Street No. 163 is a main and heavy traffic road.
(27)	800	212	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; There are so many shops along Street No. 143.
(28)	800	210	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable
(29)	1,500 (two lines)	604	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; Need to connect to Trabek Main Channel
(32)	800	275	Existing drainage pipes do not have sufficient hydraulic capacity	Water supply, Telephone cable
(33)	1,200	370	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; Need to connect to Trabek Main Channel
(34)	800	315	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; There are so many shops along Street No. 143.
Total		2,475		

Source: Preparatory Survey Team, JICA

(f) Boeng Keng Kang Area

Fig. R 2.2.10 Alignment of Proposed Drainage Pipes (Boeng Keng Kang Area)

Table R 2.2.15 Proposed Drainage Pipes (Boeng Keng Kang Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Underground Facilities (crossing) Remarks
(54)	1,000	664	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply; Norodom Road is a main and heavy traffic road.
(56)	1,500 (two lines)	269	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable; Two lines pipe due to sewer covering
(57)	1,000	382	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply
(71)	1,000 (two lines)	731	Existing drainage pipes do not have sufficient hydraulic capacity	Water supply, Telephone cable
(73)	1,200	364	Existing drainage pipes do not have sufficient hydraulic capacity	Mao Tse Toung Road is a main and heavy traffic road.
(74)	1,500 (two lines)	635	Only the line that can cross Monivong Road. Drain end of the sub-area	Water supply; Two lines pipe to be able to pass the water supply pipe; Connection to Trabek Main Channel
Total		3,045		

Source: Preparatory Survey Team, JICA

(g) Tuol Tumpung North Area

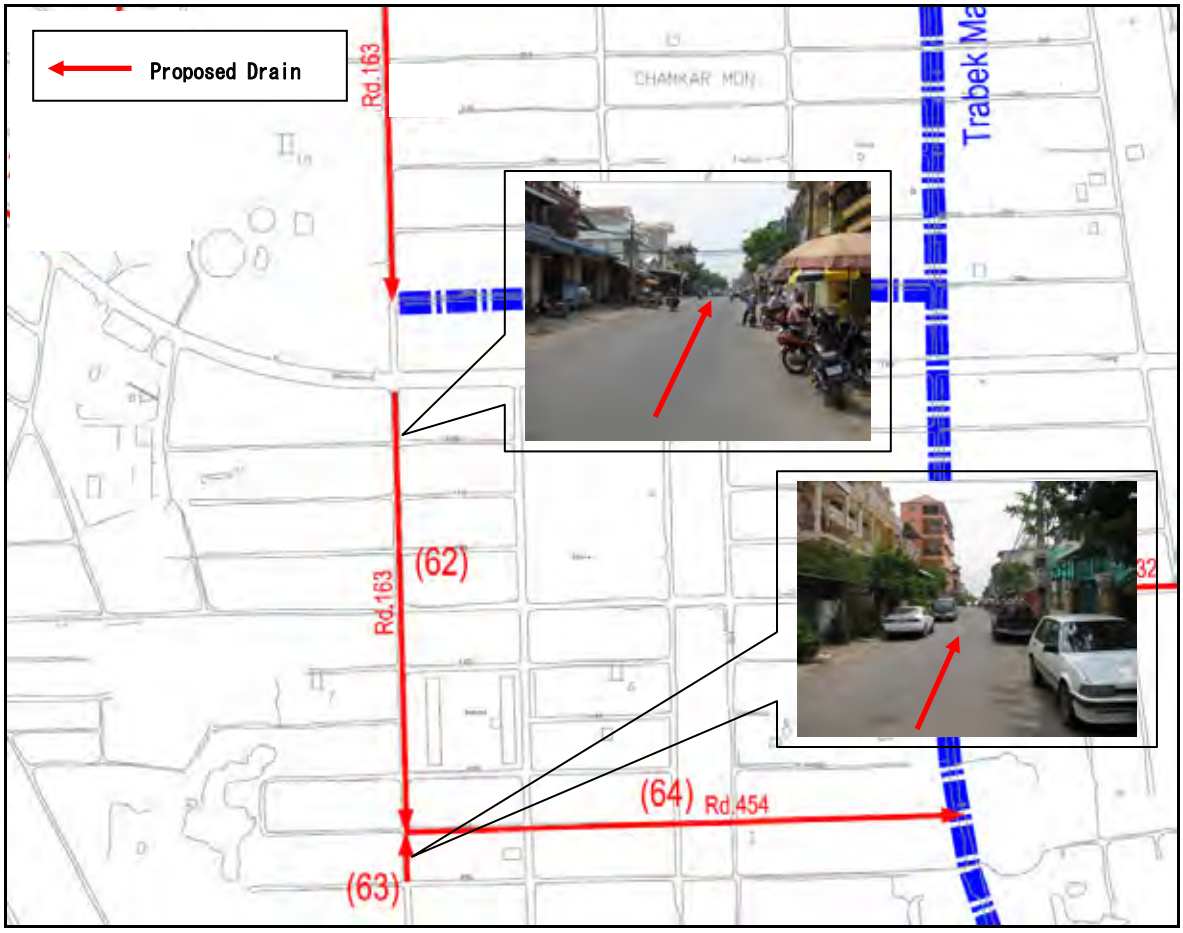


Fig. R 2.2.11 Alignment of Proposed Drainage Pipes (Tuol Tumpung North Area)

Table R 2.2.16 Proposed Drainage Pipes (Tuol Tumpung North Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Underground Facilities (Crossing) Remarks
(62)	1,200	483	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, TV cable; Street No.163 is a main and heavy traffic road.
(63)	1,000	54	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply; Street No.163 is a main and heavy traffic road.
(64)	1,500	610	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; Connection to Trabek Main Channel
Total		1,147		

Source: Preparatory Survey Team, JICA

(h) Tuol Tumpung South Area

Fig. R 2.2.12 Alignment of Proposed Drainage Pipes (Tuol Tumpung South Area)

Table R 2.2.17 Proposed Drainage Pipes (Tuol Tumpung South Area)

No.	Diameter (mm)	Length (m)	Reasons for Improvement	Underground Facilities (Crossing) Remarks
(67)	800 ~ 1,000	580	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Electric cable, Telephone cable; Some parts of this street do not have drainage pipes.
(68)	800 ~ 1,000	514	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply
(69)	600 ~ 1,000	592	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply, Telephone cable
(70)	1,500	769	Existing drainage pipes do not have sufficient hydraulic capacity.	Water supply; Connection to Trabek Main Channel
(75)	1,200	602	Existing drainage pipes do not have sufficient hydraulic capacity.	Monivong Road is a main and heavy traffic road; Connection to Trabek Main Channel.
Total		3,057		

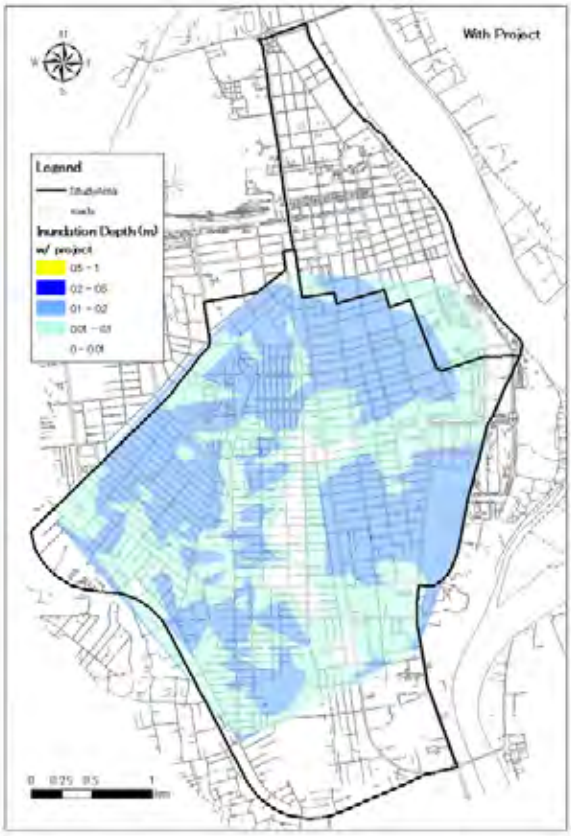
Source: Preparatory Survey Team, JICA

(8) Effectiveness of Trabek Regulation Pond on Flood Control

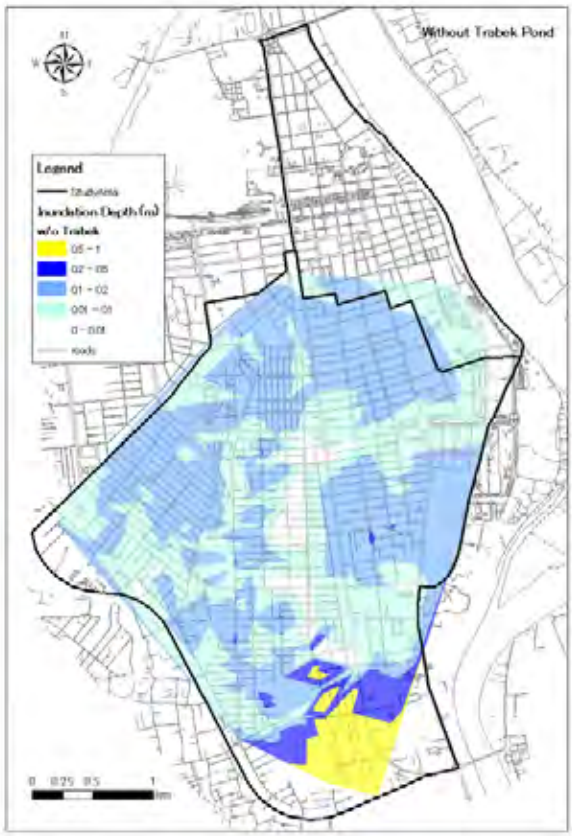
According to the rough topographic survey in the preparatory survey, the storage volume of Trabek Regulation Pond is estimated at 330,000m^3 and reduces significantly from the planning conditions of the Master Plan (JICA, 1999) and the ADB project as 740,000m^3 with water level of EL. 5.30m because of the reclamation of north pond. The maximum

water level in the proposed plan is computed as EL. 5.54m as the result of drainage simulation. This water level is approaching the high flood level of EL. 5.60m set by the ADB project.

In other words, preservation of the present area and volume of the Trabek Regulation Pond is an indispensable requisite to secure the effective performance of drainage network improved by the Project (refer to Fig. R 2.2.13). Furthermore, the Cambodian side shall preserve the present storage volume of the pond and prohibit the reclamation of the pond.



(1) After Completion of the Proposed Project
(with Improved Drainage Network)



(2) In case of Reclamation of Trabek Pond
(with Improved Drainage Network)

Fig. R 2.2.13 MOUSE Simulation Result
(Influence of Reclamation of Trabek Regulation Pond)

On the other hand, if it is necessary to increase the drainage capacity of the Trabek drainage system due to climate change or growth of population, etc., at the present condition of the Trabek Pump Station, the storage volume of the Trabek regulation pond needs to be expanded to retain floodwaters temporarily.

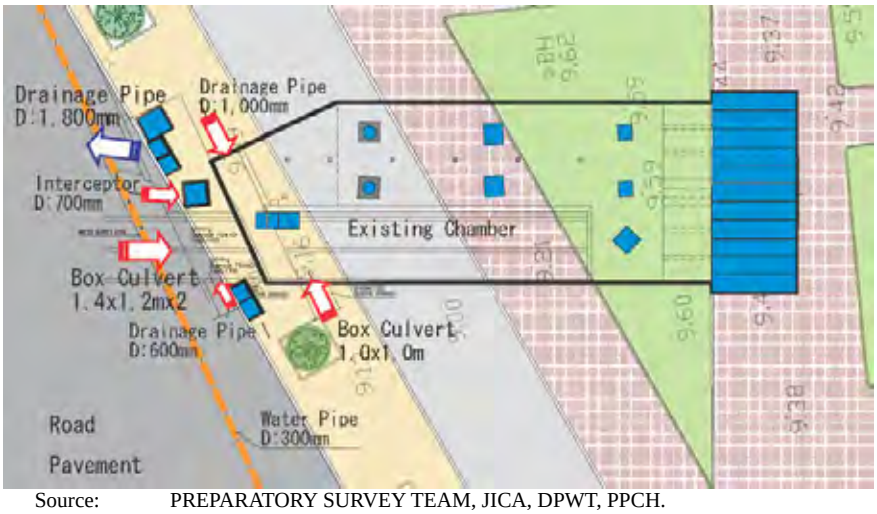
If the storage volume of the Trabek regulation pond could not be expanded, the discharge capacity of the Trabek Pump Station shall be enhanced so as not to deteriorate the inundation state in Phnom Penh Capital City.

2.2.2.2 Reconstruction of Sediment Chamber at R240

Based on the design policy described in section 2.2.1, reconstruction plan of sediment chamber at R240 is studied as below.

(1) Location of New Sediment Chamber

The new sediment chamber will be constructed at/around the existing chamber in the park. Consequently, the area where the new chamber will be constructed shall have sufficient space for temporary facilities and temporary material stockyard, etc. In view thereof, the new sediment chamber should be constructed nearby the existing chamber in terms of workability, because the foundation piles of the old chamber might impede the reconstruction work. Besides, the drainage network system at the immediate upstream of the old chamber is complicated. As shown in the following figure, five (5) drainage systems flow into the existing chamber and one (1) outlet flows out of it.



Source: PREPARATORY SURVEY TEAM, JICA, DPWT, PPCH.

Fig. R 2.2.14 Complicated Drainage Network System near the Old Chamber

In case that the new chamber location is shifted nearby the existing chamber, all of the existing network systems should be modified to fit the new chamber system, and additional work and cost will be necessary. Considering the circumstances, it is recommended that the new sediment chamber is constructed on the same spot as the existing chamber after demolition work.

(2) Dimensions of Sediment Pit of New Sediment Chamber

One of the objectives of the new sediment chamber is to deposit sand, sludge and solid waste in the pit so that they will not spread into the downstream manholes. Therefore, the dimensions of the new chamber shall be obtained based on the relation between the volume of sediment and the frequency of maintenance removal work. In addition, the length and width of the new chamber should be confirmed as to whether or not sand and sludge to be

captured in the pit would settle properly. In this connection, the dimensions of the new chamber shall be decided taking the following concepts into consideration:

- Basically, the volume capacity of the sediment pit of the new chamber should be more than or equivalent to the pit volume of the existing chamber.
- The new chamber shall be designed so as not to interrupt foot paths for people walking in/enjoying on the paths in the park, in particular.

Volume of the sediment pit of the new chamber shall be more than 140m^3 under the considerations described below.

(a) Assumption of Amount of Sewage Water and Sediment Volume flowing into the Chamber

The existing Chamber at R240 has been accepting sewage water from six (6) sub-basins as indicated in Fig. R 2.2.15. Based on the demographic data predicting the population in 2010, total daily inflows are estimated at 10,880 m^3/day (daily mean), 13,800 m^3/day (daily max.) and 20,090 m^3/day (hourly max.), as tabulated in Table R 2.2.19.

Source: PREPARATORY SURVEY TEAM, JICA, DPWT, PPCH

Fig. R 2.2.15 Sub-Basins of Drainage Network in Upstream Area of Chamber at R240

Table R 2.2.18 Unit Wastewater Amount

Item	Contents	Unit Wastewater Amount (litre/day)	Note
Daily Mean	Water demand per Person	99	
	Groundwater	20	
	Total	119	
Daily Max.	Water demand per Person	*1) 131	A
	Groundwater	20	B = A x 0.15
	Total	151	C = A + B
Hourly Max.	Water demand per Person	197	D = A x 1.5
	Groundwater	20	
	Total	217→(round up)→220	

*1) Source: JICA "The Study on the Master Plan of Greater Phnom Penh Water Supply (Phase 2) in the Kingdom of Cambodia" 2005

Table R 2.2.19 Designed Sewage Water Volume of Big Chamber at R240

Sub-Basin	Planned Population in 2010 (person)	Sewage Water Volume (m^3/day)		
		Daily Mean (119 ltr/person/day)	Daily Max. (151 ltr/person/day)	Hourly Max. (220 ltr/person/day)
1	18,477	2,200	2,790	4,060
2	7,518	890	1,140	1,650
3	29,913	3,560	4,520	6,580
4	7,043	840	1,060	1,550
5	10,748	1,280	1,620	2,360
6	15,516	1,850	2,340	3,410
(1')	2,160	260	330	480
Total	91,375	10,880	13,800	20,090

According to the "Manual and Guideline of Plan and Design for Sewerage Works" in Japan, sediment volume contained in sewage water can be estimated at 0.005~0.05 m^3 per 1,000m^3 of sewage water in case of the combined type. Based on the calculation of sewage water volume shown in Table R 2.2.19, it is expected that the maximum of 21,000 m^3/day of sewage water will flow into the chamber. Accordingly, the generated volume of sediment could be estimated at between 0.11 m^3/day at the minimum and 1.05 m^3/day at the maximum. The results are as summarized below.

Table R 2.2.20 Assumed Sediment Volume of Big Chamber at R240

Item	Sediment Volume/Sewage Water		Sediment Volume	Remarks
Daily	Minimum	0.005m^3/1,000m^3	0.11 m^3	Daily Inflow of Sewage Water = 21,000 m^3/day
	Maximum	0.05m^3/1,000m^3	1.05 m^3	
Annual	Minimum	0.005m^3/1,000m^3	38.33 m^3	
	Maximum	0.05m^3/1,000m^3	383.25 m^3	

Note : Sediment Volume: 0.005~0.05m^3 per 1,000m^3 of Sewage Water,
Source :"Manual and Guideline of Plan and Design for Sewerage Works" in Japan

(b) Estimation of Sediment Volume Flowing into Existing Big Chamber at R240

Sediment volume accumulated in the existing chamber has also been estimated in a practical manner. This actual estimation was conducted on December 28, 2009. The following table shows the results of actual sediment volume estimation.

Table R 2.2.21 Survey Results of Actual Sediment Depth of Existing Big Chamber at R240

Date	Sediment Depth	Thickness of Floating Garbage	Water Level	Remarks
February, 2009	0 cm	0 cm	—	Immediately after removal works
December 28, 2009	60 cm	10 cm	EL+6.54m	11 months after removal
April 5, 2010	50~70cm	10~30 cm	EL+6.58m	14 months after removal

Note: Sediment depths were estimated through the manual driving of FRP pipe. Hence, the estimated value might contain some errors.

Judging from the actual survey results and drawings prepared in the Phase 2, annual sediment in the existing chamber is estimated at 130~140 m^3/year in volume corresponding to 60 cm/year in depth.

In addition, the capacity of the sediment pit in the existing chamber is already fully occupied by sediment, since the depth between the elevation of bottom slab and inlet bed of siphon is only 60 cm. In other words, the conveyed sediment contained in the sewage water is at the full capacity level of the sediment pit of the existing chamber, and its actual volume is the intermediate value of calculated volume range based on the "Manual and Guideline of Plan and Design for Sewerage Works" in Japan.

(c) Sediment Capacity Required in New Sediment Chamber at R240

The DSD normally conducts cleaning work of drainage pipes and manholes at a 5-year interval. On the other hand, the DSD has taken special care in the cleaning works for the drainage main and other important pipes of the drainage system before the rainy season every year.

The cleaning and removal of sediment in the New Sediment Chamber shall be undertaken every year. In this connection, the design volume of the sediment pit of the new sediment chamber shall be more than 140m^3.

(3) Required Area of New Chamber

The dimensions of the new sediment chamber are designed with fair length and width for settling out the targeted grain sizes of sand or other inorganic materials based on the existing chamber's dimensions.

The following table shows the calculation results of required length to settle targeted material and not to settle organic material as a reference for consideration of dimensions of the new sediment chamber.

Table R 2.2.22 Consideration of Dimensions of New Sediment Chamber at R240

Item	Unit	Targeted Sewage Water		
		Daily Mean	Daily Max	Hourly Max
Discharge	m^3/day	10,880	13,800	20,090
	m^3/s	0.13	0.16	0.24
Estimation 1: Required Length **to settle Inorganic Materials and Sand** (Eligible Sediment)				
Targeted Grain Size	Diameter	0.20 mm		
	Density	2.65 g/cm^3		
	Settle Speed	21.0 mm/s		
Effective Width	m	3.0m (Width of Chamber Outlet)		
Effective Depth	m	0.5m (Water Depth at Chamber Outlet)		
Settling Time	s	23→30 seconds		
Flow Velocity	m/s	0.09	0.11	0.16
Required Length	m	3 or longer	4 or longer	5 or longer
Estimation 2-2: Required Length **not to settle Organic Materials, etc.** (Non-eligible Sediment)				
Targeted Grain Size	Diameter	0.20 mm		
	Density	1.20 g/cm^3		
	Settle Speed	2.2 mm/s		
Effective Width	m	5.4m (Width of Existing Chamber)		
Effective Depth	m	1.4m (Water Depth in Existing Chamber)		
Settling Time	s	227→250 seconds		
Flow Velocity	m/s	0.02	0.02	0.03
Required Length	m	5 or shorter	5 or shorter	8 or shorter

The length of the existing chamber (17m) is sufficient for the settlement of inorganic materials and sand. However, special care shall be taken against odour because it is expected that organic materials will also settle in the chamber.

The new chamber should be designed to have a fair length and width considering the following policy and methods:

- The cleaning and removal of sediment in the Chamber shall be undertaken every year. In this connection, the design volume of the sediment pit of the new chamber shall be more than 140m^3.
- Width of the new sediment chamber shall be the same as the existing chamber; length shall be designed by taking settlement length and sediment volume into consideration. The dimensions of the new chamber shall be as small as possible.

(4) Bottom Elevation of New Sediment Chamber

Ground elevation around the existing big chamber ranges from EL+9.0m to EL+9.6m. Surrounding area of the chamber is utilized as a public park, greenbelt, tile pavement, and access road to the parking lot of the park. Bottom elevation of new sediment chamber shall be set taking the following conditions into consideration:

- Shallower bottom elevation requires smaller temporary works.
- Shallower bottom elevation makes piling work easy and economical.
- Shallower bottom elevation makes operation and maintenance work easier.

On the other hand, the new sediment chamber needs to have enough sediment capacity. Therefore, the following conditions shall be considered:

- Bottom elevation of new sediment chamber shall be lower than EL +5.23m, which is the bottom elevation of interceptor pipe at inlet of chamber.
- Bottom elevation of existing chamber is EL +4.5m. New sediment chamber will be constructed after demolition of the existing chamber.

Based on the criteria described above, the bottom elevation of the new sediment chamber shall be EL +4.5m, which is the same as the bottom elevation of the existing chamber, considering easiness of construction work, economical advantage, and easiness of operation and maintenance work after the Project.

(5) Countermeasure against Organic Sediment

If the length of the new sediment chamber would be decided on the premise of securing the retention capacity for sediment, the organic materials included in the wastewater will settle in the chamber. These organic materials will generate hydrogen sulphide in the dry season and become the cause of bad smell.

Therefore, the following issues shall be considered in the plan of the new chamber:

- Since the chamber will be reconstructed in the public park, manholes and openings shall be covered with caps so that the bad smell would not diffuse as much as possible to the park.
- The inner surface of walls, beams, columns and roof slab of the new chamber shall be painted with acrylic or epoxy resin to protect the concrete from corrosion generated by hydrogen sulphide gas.

(6) Design for Countermeasure against Floating Garbage

It is anticipated that a great deal of floating garbage also flows into the chamber, as shown in the photographs below.

View from Manhole-1

View from Manhole-2

Source: Preparatory Survey Team, JICA

Photo R 2.2.7 Floating Garbage in the Existing Chamber

There are some alternatives that could be selected for the treatment and capture method of floating garbage, as follows:

- Siphon Type (floating garbage captured by siphon);
- Screen Type (floating garbage captured by fixed screen);
- Screen with Chain Block Type (floating garbage captured by movable screen); and
- Free-Passing Type (no capture of floating garbage).

Table R 2.2.23 gives a comparison among the alternative types of capturing floating garbage. As a result of the comparison, the following items were confirmed and are recommended:

(1) Floating garbage should be collected at one place to reduce and minimize maintenance cost. Collection points will be at the chamber or inlet channel of the Trabek Pump Station.

(2) Siphon type has some disadvantages as follows:

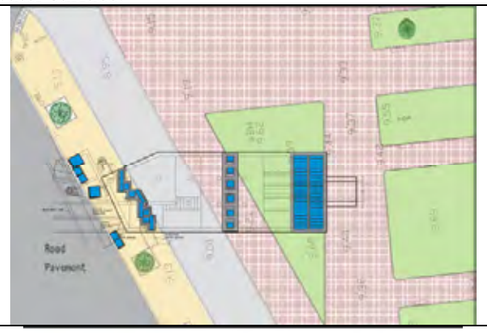
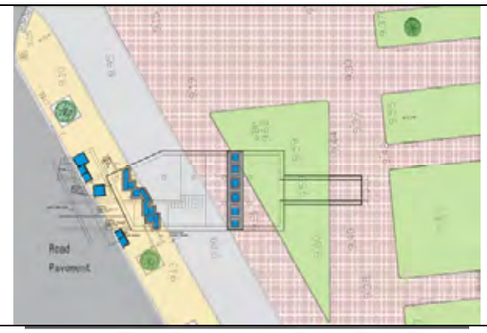
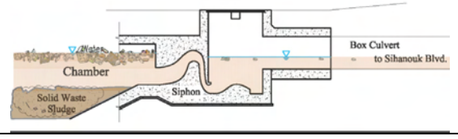
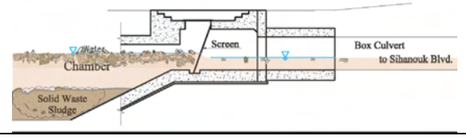
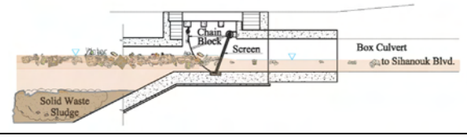
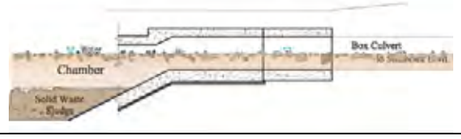
- Siphon structure cannot be checked by easy methods such as visual inspection;
- Water level in the chamber of siphon type is the highest among the alternatives under the same hydraulic conditions. It will cause stagnation of water in the upstream stretch; and
- Initial cost (construction cost) of siphon type is the most expensive compared to the other alternatives.

(3) Screen type has the following characteristics:

- It is difficult to remove gumming garbage on the screen under water pressure; and
- The screen type is liable to raise water level in the chamber due to closing of water area by gumming garbage on the screen. Therefore, it is recommended that cleaning work for floating garbage should be conducted daily.

In consideration of the above and through the discussion among PPCH, DPWT and the Survey Team, the “Free-Passing Type” is selected as the most suitable manner for the New Sediment Chamber at R240.

Table R 2.2.23 Comparative Table of Countermeasures against Floating Garbage

Item	Siphon Type	Screen Type	Screen with Chain Block Type	**Free-Passing Type**
Concept	Most of the floating garbage would be trapped in the chamber since inlet of siphon is placed below the water surface.	Most of the garbage would be trapped in the Chamber by fixed screen.	Most of the Garbage would be trapped in the Chamber by movable screen.	All garbage will pass through the chamber and scatter into the city.
Plan Drawing				
Longitudinal Profile				
Advantage	Hard to be clogged; Flow inside chamber is gentle and moderate; Sewage water can rotate.	Hard to be clogged in dry season; Easy to be cleaned in dry season	Hard to be clogged. Easy to be cleaned. In case of clogging, the screen can be hoisted by chain block to remove the garbage gumming on the screen due to water pressure.	No negative factor for clogging in the chamber; Not necessary to take away garbage in the chamber.
Disadvantage	Once air is contained in the siphon, it is difficult to drain sewage water to the downstream pipes; Free flow of sewage water is impeded; Among the alternatives, water level in the upstream pipes is the highest.	Proper periodical cleaning work is required for floating garbage frequently.	Proper periodical cleaning work is required for floating garbage frequently.	Floating garbage may spread over the downstream section and choke up manholes and drainage pipes. Cleaning work for garbage will be spread and increased more frequently in a wide area.
Economic Efficiency	Initial cost is the highest among the four alternatives.	Initial cost is higher than the “Free-Passing Type.” Additional costs consist of the costs for screen and manhole cover.	Initial cost is higher than the “Free-Passing Type”. Additional costs consist of the costs for screen, manhole cover and chain block.	Initial cost is the lowest among the alternatives. However, the running costs including cleaning works for manholes and pipes may be the highest due to floating garbage scattered in manholes and pipes in the city.
Evaluation	Fair Alternative. This is one of the fair alternatives and adoptable methods. However, water level in the chamber is the highest among the alternatives and wastewater stagnate in the drainage pipe at the upstream.	Fair Alternative. Most of the large–sized garbage will be trapped by the screen. Cleaning costs for manholes and pipes will be reduced due to intensive effectiveness of maintenance works.	Superior Alternative in terms of garbage collection. Most of large-sized-garbage will be trapped by the screen. This type is simple and effective to remove garbage gumming on the screen and reduces cleaning costs for manholes and pipes by intensive effectiveness of maintenance work.	Superior alternative in terms of maintenance work of the chamber. Floating garbage may scatter in manholes and drainage pipes in the downstream stretch. **<Adopted>**
Integrated Evaluation and Decision	With the comparison of alternatives shown in this table, the “Screen with Chain Block Type” seems to be the recommendable alternative. However, through the discussion with the Phnom Penh Capital Hall (PPCH), DPWT, and the Survey Team, the “Free-Passing Type” was adopted as the final plan for the New Sediment Chamber from the following points of view: • It is expected that the quantity of illegal dumping of garbage tends to decrease in the future, because PPCH has kept working to reduce the illegal dumping of garbage into the drainage facilities and started to penalize violators of the regulation about illegal garbage dumping on May 1, 2010 to tighten its control over garbage dumping. • There is no fear about clogging in the chamber. Work volume of operation and maintenance will be the minimum among the alternatives. • PPCH wants to collect all floating garbage at inlet channel of the Trabek Pump Station.			

Note: For all alternatives, proper and periodic cleaning work (at least, once a year) to remove sludge and sunken garbage are indispensable.

(7) Foundation of New Sediment Chamber

According to the boring survey results, the soil immediately under the chamber structure is covered with fine sand (SC) layer (3m in depth) with N-value of 4 to 1, which has a very loose feature and hence, does not have a sufficient bearing capacity as direct foundation of the new sediment chamber.

Therefore, pile foundation shall be adopted as the foundation of the new chamber to avoid residual settlement and deformation, and the bearing layer of pile should be set on consolidated clay (CH) layer with the N-value of 30 and over.

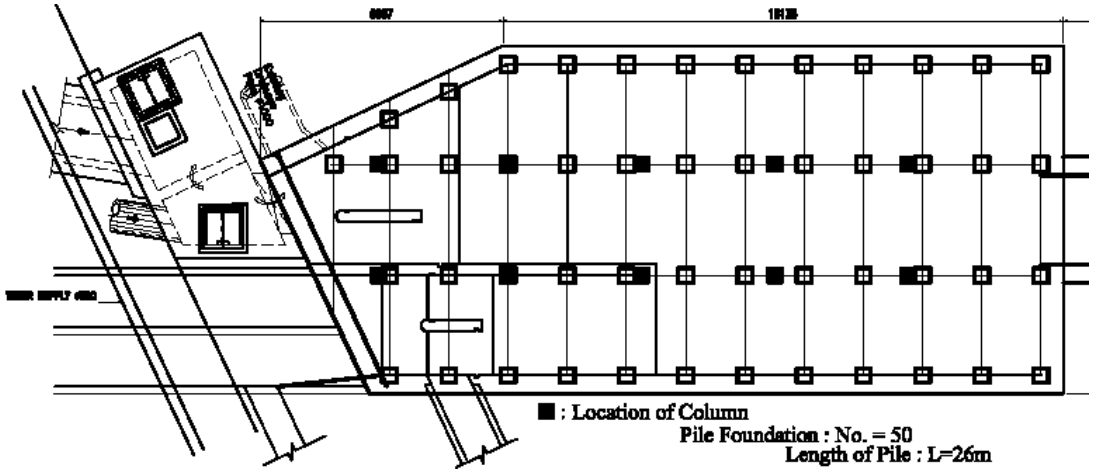


Fig. R 2.2.16 Plan of Foundation Pile Arrangement of New Sediment Chamber

Considering the following conditions, piles shall be rectangular-shaped PC piles (400mm x 400mm) and shall be driven by hydraulic hammer considering the following reasons:

- No horizontal force work on the piles;
- Easy and low cost of procurement of piles; and construction equipment; and
- Shorter working period.

(8) Consideration of Opening and Manhole on the Chamber Structure

The new sediment chamber should provide several openings and manholes on the top slab to access the sediment pit and inlet/outlet for cleaning work, inspection and maintenance inside the chamber. In addition, openings for the installation of stop-log with recesses shall be provided.

Taking into consideration social environmental issues such as odour, security and the existing park plan, all of the openings shall be closed by manhole covers of which materials are reasonably good-looking, easily-operated, easy-opening, long-durability, safe and inexpensive. All openings shall be covered to avoid odour scattering, as shown below.

Table R 2.2.24 Openings and Manholes Provided on the Chamber (Tentative)

Position	Intended Use	Specifications	No. of Units	Material of Manhole Cover
Inlet	Entrance	ϕ 600 mm	4	FRP
Inlet	Operation of Stop-Log	300mm x 500~1,200mm	5	FRP
Sediment Pit	Entrance	ϕ 900 mm	2	FRP
		ϕ 600 mm	4	FRP
Sediment Pit	Cleaning Hole	ϕ 600 mm	2	Cast Iron
Outlet	Entrance	ϕ 900 mm	2	FRP

Source: JICA Preparatory Study Team

Source: Maker's Web Sites

Photo R 2.2.8 Sample Photos of Manhole Cover (FRP)

(9) Layout Plan of New Sediment Chamber

Based on the considerations and setting up of policy for the new sediment chamber described above, the proposed layout plan is as shown in the following figure.

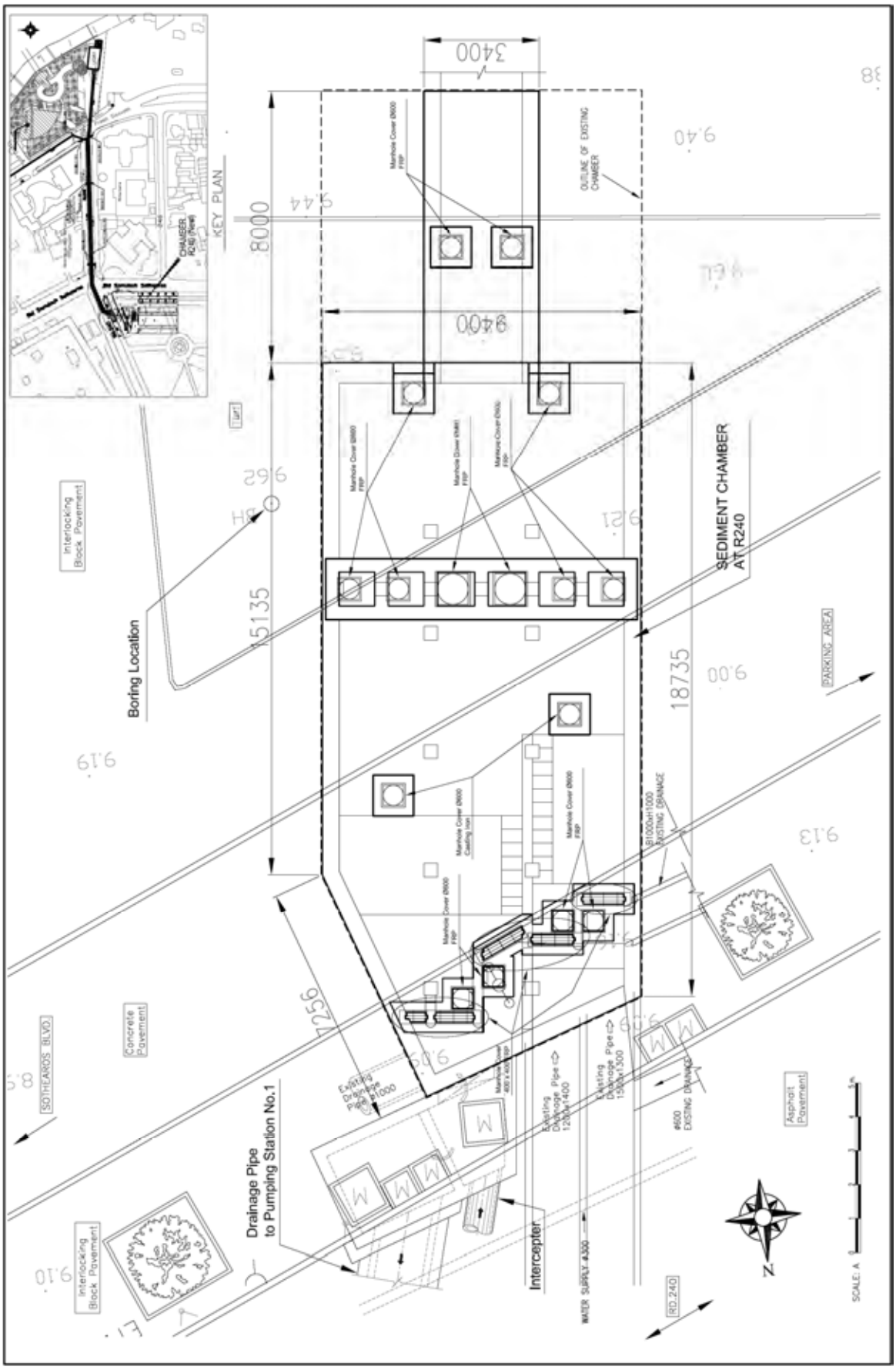


Fig. R 2.2.17 General Plan of New Sediment Chamber

2.2.2.3 Procurement of Cleaning Equipment for Drainage Pipe

(1) Selection of Procured Equipment

Based on the design policy described in section 2.2.1 and the current condition of cleaning equipment for drainage pipes and manholes of the DSD as an executing division, the following options are conceived for the procurement of equipment for cleaning drainage pipes and manholes:

Table R 2.2.25 Options on Type and Variety of Cleaning Equipment

Option	Type	Concept
Option 1	**Sludge Sucker & Water-Jet Machine**	Adopted
Option 2	Combination Truck	Same condition as existing equipment
Option 3	Water-Jet Machine	Same as the request by the Cambodian Government
Option 4	No Procurement	-

The capability of the existing equipment for cleaning the drainage pipes and manholes owned by DSD is insufficient, causing problems in terms of work efficiency, safety, and mobility. Therefore, Option 4 is not recommendable.

In accordance with the request by PPCH, only the water-jet machine is required as Option 3. However, it may be difficult to improve the work efficiency of DSD with the procurement of only the water-jet machine, due to the insufficient suction capacity and unsuitable specification of the existing combination truck. Since a combination of suction function and jetting function is important for the cleaning work on drainage pipes and manholes, Option 3 is not recommendable.

Comparing Option 1 and Option 2, Option 1 (Sludge Sucker & Water-Jet Machine) stands longer than Option 2 (Combination Truck), in general. Furthermore, even in case that one truck of Option 1 is out of order, the other one can operate with the other cleaning equipment presently owned by DSD. Since this is a big advantage against Option 2 from the point of work efficiency, Option 1 is recommendable.

(2) Number of Equipment Procured

(a) Necessary Number of Equipment for Cleaning Drainage Pipe and Manhole in the Future

Currently, DSD is carrying out the cleaning work under the following general policy:

- 1st priority pipes, as shown with continuous bold lines (Mao Tse Toung, Norodom, Monivong) in Fig. R 2.2.18, are cleaned every year.
- 2nd priority pipes as shown with broken bold lines (Monireth, Kampuchea Krom, Sihanouk, Street No. 63) in Fig. R 2.2.18, are cleaned every three years.

- Other pipelines are cleaned depending on the request of Phnom Penh Capital City (PPCC) and the budget allocated by Phnom Penh Capital Hall (PPCH).

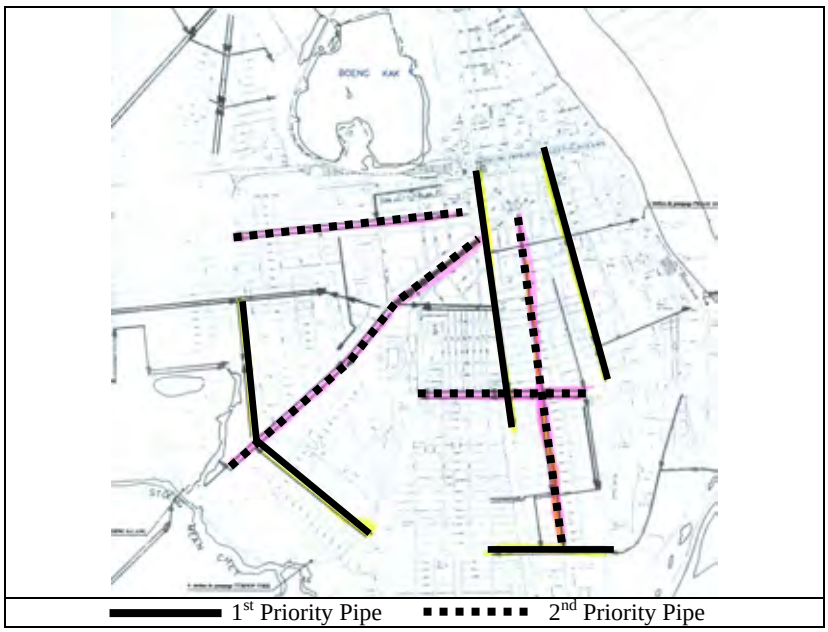


Fig. R 2.2.18 Priority Drainage Pipes in Phnom Penh Capital City

There may be a possibility that drainage pipes and manholes except the 1st and 2nd priority pipes are not cleaned for a long time. It is therefore recommended that all main pipes should be cleaned in every 5 years, at least.

Main drainage pipes in Phnom Penh Capital City under the management of DSD extend to 288km in total length of the 421km in the whole city of Phnom Penh. If the cleaning work for half of the above pipes is delegated to a private cleaning company as recently done, the remaining pipe length to be cleaned by DSD is 144km.

The calculation table to specify the number of equipment for cleaning pipes in the future is shown in Table R 2.2.26, assuming that sludge volume in the existing drainage pipes (L=144km) is 20,000m^3. For convenience of the calculation, one water-jet machine (tank capacity 3.0m^3) and one sludge-sucker (tank capacity 4.5m^3) are specified as “one set of cleaning equipment.”

Table R 2.2.26 Future Work Plan of Cleaning Drainage Pipe and Manhole

Item	Sludge[*1] (m^3)	Pressured Water[*2] (m^3)	Volume to be Sucked (m^3)	Sludge Volume by Sucker per Day (m^3/day)[*3]	Total Volume of Sludge to be sucked in Five Years (m^3/year)[*4]	Necessary Number of Sludge Sucker and Water-Jet Machine (set)
Formula	A	B =A x 50%	C=A+B	D	E = D x 210 days x 5 yrs	F=C/E
Calculation	20,000	10,000	30,000	4.5	4,725	6.4

Source: JICA Preparatory Survey Team
[*1] Sediment of sludge is assumed to be 30% of section area of pipe
[*2] Pressured water volume is assumed to be 50% of sludge volume
[*3] Assumed sucked volume using sludge sucker (10t) and jetting machine ($5m^3$)
[*4] Working days by DSD are assumed to be 210days/year

In accordance with the above calculation, "seven (7) sets of cleaning equipment" will be necessary to carry out the cleaning work on drainage pipes of 144km in a five-year cycle.

(b) Number of Equipment to be Procured by the Japan's Grant Aid

As described in the subsection above, at least "seven sets of cleaning equipment" will be necessary in the future. Since DSD has some educated engineers, experienced workers and know-how to maintain cleaning equipment for drainage pipes and manholes, it should also have the capacity to operate and maintain the procured cleaning equipment for drainage pipes and manholes.

However, there are issues to be improved, as follows:

1) Urgency of Improvement of Safety and Effectiveness of Cleaning Work

Most important issues to be improved through the procurement of equipment are work efficiency and safety of cleaning work.

2) Lack of Long-Term Work Schedule

The DSD has not prepared any work schedule for the cleaning of drainage pipes and manholes on the long-term in detail. Long-term scheduling and executing proper maintenance is important to keep the lifecycle of existing drainage pipes and manholes in Phnom Penh Capital City longer. Daily cleaning work is often executed based on the instructions of PPCH without following any strategy.

3) Insufficient Records Management

The DSD prepares weekly records of actual work volumes. However, since the management of these records is not suitable, the following terms are not clear:

- Comparison of work volume between the plan and the actual result;
- Outstanding issue at site; and

- Information on existing drainage pipes and manholes (a ledger of drainage pipes and manholes should be made with drawings, including detailed information).

Judging from the current situation of the DSD as the executing agency, it is considered that improvement of present cleaning work condition without drastic change of organization and budget is urgent and realistic. Therefore, urgently necessary number of equipment shall be procured in the Project to make the present cleaning work effective and safe by mechanizing the present manpower work.

The DSD presently operates two units of cleaning work team (1 team consists of 7~8 workers using 1 combination truck). The work of these two teams shall be mechanized by the procured cleaning equipment. It is, therefore, recommended to procure **two (2) sets of cleaning equipment (two Sludge Suckers and two Water-Jet Machines)** in this Project.

(3) Country of Origin

The proposed cleaning equipment for drainage pipes and manholes are not available in Cambodia, because they are specialized vehicles. There are some factories which may be able to assemble specialized vehicles from imported parts in Thailand; however, those specialized vehicles made in Thailand are considered to be inferior in reliability as to quality and performance. Therefore, the country of origin of the equipment shall be Japan or Europe.

Procured equipment for drainage pipe cleaning shall be **procured from Japan** through a Japanese maker/supplier who has an agent in Cambodia or in a neighbouring country, taking the following conditions into account:

(a) Maker/supplier of equipment must have an agent in Cambodia or in a neighbouring country to procure the main parts of equipment.

(b) There is less possibility to have trouble with the equipment and it is easier to procure spare parts from Japan than from Europe.

(c) DSD is confident on the quality and performance of Japanese equipment, and it has requested for Japanese equipment rather than European equipment relying on their experience with the existing equipment.

Procured equipment will be handed over to the recipient country at the Sihanoukville Port after disembarkation and Customs clearance.

(4) Specifications of Proposed Equipment for Drainage Pipe Cleaning

Based on the results of the site investigation and analysis of collected data, the equipment for drainage pipe cleaning listed in the following table are selected and proposed.

Table R 2.2.27 List of Drainage Cleaning Equipment to be procured by the Project

Name of Equipment	Use	Set Composition	Quantity to be Procured
Sludge Sucker	Suction and transport of sludge in drainage pipes and manholes	1 unit	2 sets
Water-Jet Machine	Crumbling of solid sludge, flushing of garbage in drainage pipes, transport of sludge in drainage pipes to manholes	1 unit	

The conditions for setting the specifications of procured equipment are as given below:

(a) Work efficiency and endurance shall be high and operation should be easy.

(b) Specifications shall be that DSD is able to maintain equipment by itself.

(c) Size of garage of the DSD and road width shall be considered to decide equipment size.

(d) Base truck of equipment shall be left-hand drive.

(a) Specifications of Sludge Sucker

There is no problem with work space for the present cleaning work. During the cleaning work, the existing combination truck owned by DSD (almost the same size as a 10t Truck) parks on the carriageway or sidewalk.

The following figure shows a typical daily work schedule for drainage pipe and manhole cleaning work of DSD.

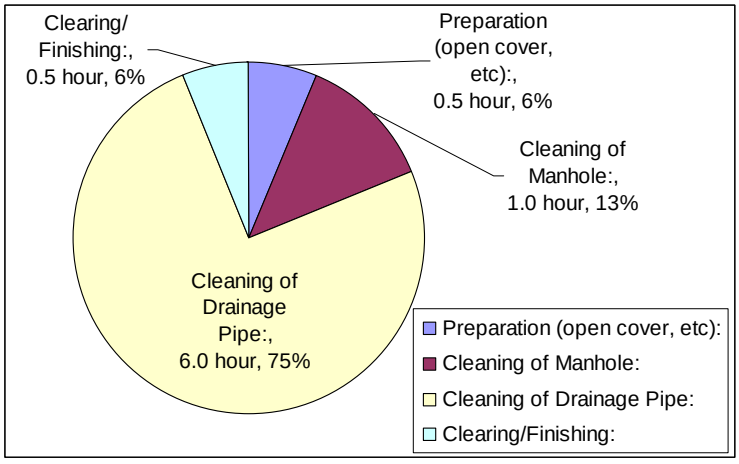


Fig. R 2.2.19 Daily Work Schedule of Cleaning for Drainage Pipe and Manhole

Working hour is assumed at 8.0 hours per day. Based on the experience of DSD, cleaning efficiency is 0.75 m^3/hour and 4.5 m^3/day in average. This daily amount of sludge sucked from drainage pipe and manhole is adopted as the minimum requirement of tank capacity of new sludge sucker to be procured. Considering the carrying capacity of new sludge sucker and weight of base truck, GVW (Gross Vehicle Weight) shall be not less than 15,000kg.

Normally, during the sucking of sludge from the drainage pipes and manholes, air also comes with the sludge. In such a condition, the blower type is preferable to the rotary vane type in terms of vacuum system.

The proposed specification of the sludge sucker is as given below.

Table R 2.2.28 Proposed Specifications of Sludge Sucker

Type of Equipment	Specification
Sludge Sucker	1) Left-hand Drive 2) Sludge Tank Capacity: Not less than 4.5 m^3 3) Vacuum system: Blower type; Maximum Vacuum Pressure: Not less than -93 kPa (-700 mmhg)

(b) Specifications of Water-Jet Machine

Combination trucks usually use 5m^3 of water per day for cleaning the drainage pipes. The water tank volume of the existing combination truck is 4.4m^3, and if necessary, other water tank trucks (9m^3) supply water.

Judging from the sludge tank capacity of new sludge suckers (4.5 m^3) and water consumption rate of cleaning work with new water-jet machines, water volume needed for cleaning work with a new machine is estimated at 60% of present water consumption volume. Therefore, the water tank capacity of the new water-jet machine shall be not less than 3.0m^3.

There are some locations where the existing combination truck (10t) could not be operated due to the limitation of road width in the urban area of Phnom Penh Capital City, as shown below.

(1) Narrow Street in Phnom Penh

(2) Narrow Street in Phnom Penh

Photo R 2.2.9 Narrow Streets in Phnom Penh Capital City

In general, the diameter of drainage pipes lain beneath narrow roads is smaller than 500 mm and since the small-diameter pipes cannot be cleaned by manpower because workers cannot enter the pipes, the water-jet machine will be utilized. Therefore, the new water-jet machine shall be small enough to enter the narrow streets and have its nozzle reach the cleaning point of small-diameter pipes.

A comparison table of truck dimensions of water-jet machine is given below.

Table R 2.2.29 Comparison of Water-Jet Machine Size by Base Truck

Item	4t Truck Base	**5t Truck Base**	10t Truck Base
Width	2.2m	2.3m	2.5m
Length	6.5m	8.5m	10.2m
Capacity of Water Tank	$2.5m^3$	$3.0m^3$	$6.0m^3$
Evaluation	Too small tank volume	**Adopted**	Too large body

Source: Preparatory Survey Team, JICA

It is, therefore, recommendable to procure a water-jet machine with a water tank capacity of $3.0m^3$ mounted on a 5-ton class base-truck, so that the existing water tank truck ($9m^3$) could still be utilized to refill its water tank. Judging from the current condition and objectives of cleaning work, the jetting capacity should be 180liters/min.

The proposed specification of the water-jet machine is shown below.

Table R 2.2.30 Proposed Specification of Water -Jet Machine (Tentative)

Type of Equipment	Specification
Water-Jet Machine	1) Left-hand Drive, GVW not less than 10,000kg (5-ton Size Truck) 2) Water Tank Capacity: Not less than $3.0\ m^3$ 3) High Pressure Pump: Discharging Capacity: Not less than 180 litres/min Maximum Discharge Pressure: Not less than 19MPa ($194kgf/cm^2$)

(5) Procurement of Spare Parts

Spare parts, which are selected to be procured in the Project with the equipment in consideration of (1) necessity for management of the equipment, (2) frequently consumed and difficulty to purchase in Cambodia presently, are shown in Table R 2.2.31. One (1) set of these parts shall be procured in the Project as minimum requirement for repair.

Table R 2.2.31 Proposed Specifications of Spare Parts for Cleaning Equipment

Equipment	Specification of Spare Parts		
Spare Parts for Water-Jet Machine	1. Universal Joint	:	1 set
	2. Main High Pressure Hose (L=100m)	:	1 set
	3. Sub High Pressure Hose (L=40m)	:	1 set
	4. Each Type of Nozzle	:	1 set
	5. Line Filter	:	1 set
	6. Suction Filter by Oil Pressure	:	1 set
	7. Element for Water Filter	:	1 set
	8. V-belt	:	1 set
Spare Parts for Sludge Sucker	1. V-belt	:	1 set
	2. Ball Valve Inner Kit	:	1 set
	3. Ball Valve	:	1 set
	4. Packing for Hatch	:	1 set
	5. Suction Hose (L=10m, convex/concave)	:	1 set
	6. Suction Hose (L=10m, concave)	:	1 set
	7. Suction Filter	:	1 set
	8. Universal Joint	:	1 set

It is difficult to procure spare parts for drainage pipe cleaning equipment in Phnom Penh Capital City. As an instance, it was difficult to procure the spare parts for the existing combination truck made by Renault in France. Since it takes a long time to procure

original spare parts from France, similar spare parts produced by other makers are usually used to fix the existing equipment.

However, these spare parts usually do not fit with the original equipment so that DSD has to modify some parts by itself. After using the equipment fitted with modified spare parts for some time, the equipment bogs down and becomes idle until it is repaired again. Since the DSD usually has no spare parts in its workshop, if any equipment gets in trouble, it starts to take the procedure for the procurement of spare parts and, usually, the equipment lies idle for more than one month.

Considering the above condition, it is important to establish a certain system to order spare parts for the new cleaning equipment (sludge sucker and water-jet machine). In this connection, contracting with an agent in Phnom Penh Capital City for the procurement of spare parts is proposed.

Actually, many spare parts of Japanese products such as generators, telephone exchangers, rice polishing machines, pumps, etc., could be procured in Phnom Penh Capital City using this method. The procedure to obtain spare parts is given below.

i) DSD places an order for the necessary spare parts through the contracted agent.

ii) The contracted agent forwards the order to the maker in a neighbouring country (Vietnam, Thailand) or in Japan.

iii) The maker ships the spare parts to DSD.

iv) DSD receives the spare parts and repairs the related equipment.

To perform the supply of spare part smoothly, contracting with an agent in Phnom Penh Capital City for **ten years** for the procurement of spare parts shall be one of the conditions of the contract for the Project.

2.2.3 Outline Design Drawings

(1) List of Outline Design Drawings

Table R 2.2.32 List of Outline Design Drawings (1/2)

No	TITLE	DRAWING No.
	General Map	
1	General Map of Construction Area	GM-001
	DRAINAGE MAIN	
	General	
2	General Plan of Drainage Facilities (1/2)	DM-GN-001
3	General Plan of Drainage Facilities (2/2)	DM-GN-002
4	Detail of Manhole & Drainage Pipe (1/2)	DM-GN-003
5	Detail of Manhole & Drainage Pipe (2/2)	DM-GN-004
	1. Ou Russei Area	
6	Plan & Profile R161 Drainage Main (1/2)	DM-OR-001
7	Plan & Profile R161 Drainage Main (2/2)	DM-OR-002
8	Plan & Profile R163 (from R161 to R288) (1/2)	DM-OR-003
9	Plan & Profile R163 (from R161 to R288) (2/2)	DM-OR-004
10	Plan & Profile R217 Drainage Main (1/2)	DM-OR-005
11	Plan & Profile R217 Drainage Main (2/2)	DM-OR-006
12	Plan & Profile R182 Drainage Main	DM-OR-007
13	Plan & Profile R107 Drainage Main	DM-OR-008
14	Plan & Profile R111 Drainage Main	DM-OR-009
15	Plan & Profile R214 & R163 Drainage Main	DM-OR-010
	2. Boeng Reang Area	
16	Plan & Profile R63 (from R154 to R274) Drainage Main (1/3)	DM-BR-001
17	Plan & Profile R63 (from R154 to R274) Drainage Main (2/3)	DM-BR-002
18	Plan & Profile R63 (from R154 to R274) Drainage Main (3/3)	DM-BR-003
19	Plan & Profile R274 Drainage Main	DM-BR-004
20	Plan & Profile Monivong Drainage Main (1/3)	DM-BR-005
21	Plan & Profile Monivong Drainage Main (2/3)	DM-BR-006
22	Plan & Profile Monivong Drainage Main (3/3)	DM-BR-007
	3. Monireth Area	
23	Plan & Profile Monireth Drainage Main (1/2)	DM-MN-001
24	Plan & Profile Monireth Drainage Main (2/2)	DM-MN-002
25	Plan & Profile R199 Drainage Main (1/2)	DM-MN-003
26	Plan & Profile R199 Drainage Main (2/2)	DM-MN-004
27	Plan & Profile MaoTseToung (from R199 to Monireth) Drainage Main	DM-MN-005
	4. Tuol Svay Prey Area	
28	Plan & Profile R173 Drainage Main (1/2)	DM-SP-001
29	Plan & Profile R173 Drainage Main (2/2)	DM-SP-002
30	Plan & Profile MaoTseToung (from R173 to R183) Drainage Main	DM-SP-003
31	Plan & Profile R183 Drainage Main	DM-SP-004
32	Plan & Profile MaoTseToung (from R199 to R183) Drainage Main	DM-SP-005
33	Plan & Profile R193 Drainage Main (1/2)	DM-SP-006
34	Plan & Profile R193 Drainage Main (2/2)	DM-SP-007
	5. Tuol Sleng Area	
35	Plan & Profile R288 Drainage Main (1/2)	DM-SL-001
36	Plan & Profile R288 Drainage Main (2/2)	DM-SL-002
37	Plan & Profile R143 (from R276 to R288) Drainage Main	DM-SL-003
38	Plan & Profile R113 Drainage Main	DM-SL-004
39	Plan & Profile R143 (from R288 to R310) Drainage Main	DM-SL-005
40	Plan & Profile R310 Drainage Main	DM-SL-006
41	Plan & Profile R143 (from R360 to R310) Drainage Main	DM-SL-007
42	Plan & Profile R163 (from R348 to R396) Drainage Main	DM-SL-008

Table R 2.2.33 List of Outline Design Drawings (2/2)

No	TITLE	DRAWING No.
	6. Boeng Keng Kang Area	
43	Plan & Profile Norodom Drainage Main (1/2)	DM-BK-001
44	Plan & Profile Norodom Drainage Main (2/2)	DM-BK-002
45	Plan & Profile MaoTseToung (from Norodom to R63) Drainage Main	DM-BK-003
46	Plan & Profile R63 (from MaoTseToung to R436) Drainage Main	DM-BK-004
47	Plan & Profile R436 Drainage Main	DM-BK-005
48	Plan & Profile Monivong & R432 Drainage Main	DM-BK-006
49	Plan & Profile R63 (from R322 to MaoTseToung) Drainage Main (1/2)	DM-BK-007
50	Plan & Profile R63 (from R322 to MaoTseToung) Drainage Main (2/2)	DM-BK-008
51	Plan & Profile R63 (from R466 to R436) Drainage Main	DM-BK-009
	7. Tuol Tumpung North Area	
52	Plan & Profile R163 (from MaoTseToung to R454) Drainage Main	DM-TN-001
53	Plan & Profile R163 (from R456 to R454) & R454 Drainage Main (1/2)	DM-TN-002
54	Plan & Profile R163 (from R456 to R454) & R454 Drainage Main (2/2)	DM-TN-003
	8. Tuol Tumpung South Area	
55	Plan & Profile R430 Drainage Main (1/2)	DM-TS-001
56	Plan & Profile R430 Drainage Main (2/2)	DM-TS-002
57	Plan & Profile R488 Drainage Main (1/2)	DM-TS-003
58	Plan & Profile R488 Drainage Main (2/2)	DM-TS-004
59	Plan & Profile R163 (from R468 to R488) Drainage Main	DM-TS-005
60	Plan & Profile R155 Drainage Main (1/2)	DM-TS-006
61	Plan & Profile R155 Drainage Main (2/2)	DM-TS-007
62	Plan & Profile Monivong (to R508) Drainage Main	DM-TS-008
63	Plan & Profile R508 Drainage Main	DM-TS-009
	SEDIMENT CHAMBER AT R240	
64	General Plan	SC-001
65	Layout of Foundation Piles	SC-002
66	Longitudinal Profiles	SC-003
67	Typical Sections	SC-004

(2) Outline Design Drawings

The Outline Design Drawings are attached as the “Annex”.

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

The basic implementation policy for the Project is as described below.

(1) Basic Policy of Project Implementation

- The Project is to be implemented under the Japan’s Grant Aid Scheme. Japan‘s Grant-Aid is provided through the following procedures:
  - Preparatory Survey conducted by JICA.
  - Appraisal by the Government of Japan (hereinafter referred to as “the GOJ”) and JICA, and Approval by the Japanese Cabinet.

- Exchange of Notes ((hereinafter referred to as “the E/N”) between the GOJ and the Government of Cambodia (hereinafter referred to as “the GOC”).
- Grant Agreement (hereinafter referred to as “the G/A”) between JICA and the GOC.
- Implementation of the Project on the basis of the G/A.

- The implementation agency of the Project is the Department of Public Works and Transport (DPWT) of Phnom Penh Capital City. With regard to the operation and maintenance of facilities, the Drainage and Sewerage Division (DSD) of DPWT will be in charge after the construction and procurement.
- The GOC will enter into contract with the Consultant for consulting services with regard to designing, tendering, cost estimating and supervising the procurement and construction works for the Project. The Consultant shall be a Japanese consulting firm, which shall be selected by JICA and recommended to the GOC for the Project in order to maintain technical consistency.
- The GOC will enter into contract with the Contractor who shall be selected through competitive tendering, and the contract shall be verified by JICA to fulfil accountability to Japanese taxpayers. The Contractor shall be a Japanese firm who is capable of procuring the products and of construction in proper manner under Japan’s Grant Aid.

(2) Construction and Procurement Policy

- To establish a smooth and safe construction method and schedule, the following conditions shall be considered:
  - Natural Environment: meteorology, topography and geology.
  - Social Environment: traffic control, underground facilities and other negative impacts against residents.
- The products necessary for the project implementation shall be those produced in eligible source countries. Eligible source countries are Cambodia or Japan for procurement under the Grant Aid. Procurement from countries other than Cambodia or Japan can be made in accordance with the G/A, with the prior consent of JICA.
- Construction method applied for the Project shall be simple and common method without special technology or equipment as much as possible.
- Specifications and standards applied for the Project shall meet the international standards.

2.2.4.2 Implementation Conditions

(1) Conditions for Construction

Conditions to be considered in establishing the construction plan of the Project are as described hereinafter.

(a) Improvement of Drainage Network (Drainage Pipe Installation)

- Total length of drainage pipes installed by the Project is more than 20km. Construction site of drainage pipes is spread widely in the urban area of Phnom Penh Capital City. Whole construction area of the drainage system in this Project is divided into eight (8) sub-areas based on the catchment area to establish efficient construction plan.
- Construction shall be started basically from northern sub-area and proceed to southern sub-area. Drainage pipes in each sub-area shall be essentially installed from downstream to upstream. Completed section of drainage network in each sub-area shall be inspected and placed in service.
- Explanation meetings with local residents shall be held by the DPWT before the commencement of the Project. Objective of the Project, contents of construction works and implementation schedule shall be explained to the local residents to facilitate their understanding and cooperation on project implementation. These explanation meetings shall be held for every “Khan” or “Sangkat” concerned.
- Most of the construction works of the Project is to be executed in the urban area of Phnom Penh Capital City. Since some portions of the drainage pipeline are adjacent to houses, shops and restaurants, construction planning shall take into consideration safety control, traffic control and environmental negative impact, such as noise disturbance and vibration. Countermeasures against negative impacts arising from construction work are as follows:
  - Drainage works at intersections of heavy traffic road shall be carried out at night.
  - Some parts of drainage work at market area, business area and restaurant area shall be carried out at night according to site situation.
  - Construction of new drainage pipeline is basically daytime work. During daytime work, construction site shall be secured by means of road closure or limitation of traffic lane. Detour shall be indicated on direction board and traffic shall be controlled by guardsmen.
  - To minimize the noise and vibration generated by construction work, light steel sheet piles shall be driven by hydraulic vibro-hammer (LHV) mounted on the

excavator, and other types of steel sheet pile shall be driven by hydraulic pressure injection type pile driver (Silent Piler).

(b) Reconstruction of Sediment Chamber at R240

- The existing sediment chamber will be demolished and a new one will be constructed at the same location. Five (5) drainage lines flow into the existing chamber. To divert the inflows and maintain the present sewage flow during construction, a rectangular-sectioned diversion channel will be temporarily constructed with steel sheet piles in the west side of the existing chamber. The temporary channel shall be covered with deck plates so as not to release strong odour.
- The foundation pile of the new sediment chamber is designed as the PC pile. In the selection of driving method for PC piles, the hydraulic hammer is adopted to mitigate noise.
- Construction site is located near the Royal Palace and the tourist zone. Construction site shall be surrounded with temporary fence considering the safety and security of construction work.

(2) Conditions for Procurement

Based on the contents of the Minutes of Discussions (M/D) signed on 11 March 2010 during the Preparatory Survey, equipment for drainage pipe cleaning, which will be 2 sets of Sludge Sucker and Water-Jet Machine procured in the Project, will be handed over to the Cambodian side at the Sihanoukville port after disembarkation. Therefore, the cost for manufacturing and marine transportation until the Sihanoukville port shall be borne by the Government of Japan and the cost for Customs clearance and transportation from the Sihanoukville port to Phnom Penh shall be borne by the Government of Cambodia.

2.2.4.3 Scope of Work

The scope of work for the Japanese and Cambodian sides needs to be clarified before the implementation of the Project. Each side shall assume responsibility for the work set forth in accordance with the policy of Japan's Grant Aid. The undertakings or responsibilities of both sides are as shown in the table below.

Table R 2.2.34 Major Undertakings for Construction and Procurement by Each Government

Item	Contents		Responsibility	
			Japanese Side	Cambodian Side
Procurement of Materials and Equipment	Procurement and transportation of construction materials		O	-
	Shipping of procured cleaning equipment		O	-
	Customs clearance of the procured cleaning equipment	- Sludge Sucker: 2 units - Water-Jet Machine: 2 units	-	O
	Land transportation of the procured cleaning equipment		-	O
	Land transportation of construction materials		O	
Preparation Work	Land acquisition for construction, site office, stockyard, workshop and disposal site		-	O
	Other preparation works		O	-
Relocation/ Removal	Relocation/removal of underground facilities, such as water supply pipes, communication lines, electric cables and so on		O	-
Construction Work	- Reconstruction of Sediment Chamber at R240 - Installation of drainage pipes		O	-

Note: "O" Responsible; "-" Not Responsible

2.2.4.4 Consultant's Supervision of Construction and Procurement

The Consultant shall provide services to the GOC with regard to detailed design, cost estimation, tendering and supervision of the procurement and construction works for the Project in accordance with a contract with the GOC.

(1) Detailed Design

The Consultant will conduct the detailed design study for the project, including the following:

- Kick-off meeting with executing agency and site investigation
- Confirmation of details of existing drainage network and additional manhole survey
- Detailed design study, preparation of detail design drawings
- Cost estimation

(2) Tendering Management

The Consultant will assist the GOC in conducting the procurement tendering in fair and proper manner, as follows:

- Preparation of tender documents
- Notice for Prequalification
- Evaluation of Prequalification Documents
- Tender Notice
- Execution of tendering and Evaluation of tendering

- Facilitation of contract between the Client and the Contractor

(3) Construction Supervision

The Consultant will provide appropriate supervision and guidance to the Contractor, on behalf of the GOC, as follows:

- Confirmation and approval of survey results of the Contractor
- Confirmation and approval of construction plan of the Contractor
- Quality and quantity control
- Construction schedule control
- Work progress control
- Safety control
- Discussion and negotiation with organizations concerned
- Inspection and hand-over of completed facilities in the course of project implementation

The whole construction period is estimated to be 44 months. Construction work will consist of the construction of the new sediment chamber at R240 and the installation of drainage pipes with 20 km in total length. Sixteen (16) parties will work in parallel at maximum.

To supervise the construction work properly, a Japanese qualified representative (1 person) and local inspectors (4 persons) shall be assigned regularly throughout the construction period, and experts shall be dispatched to the project site from time to time according to the schedule of spot engineering services to handle and solve technical issues.

(4) Procurement Supervision

The Consultant will supervise the manufacturing schedule and quality of equipment for drainage pipe cleaning to be procured. The Consultant will also confirm the function and condition of equipment at site, and provide appropriate guidance for the operation and maintenance of the procured equipment.

For the proper procurement service, the Consultant will carry out the following:

- Negotiate with manufacturer about design, manufacturing schedule and quality control of the equipment
- Participate and observe factory inspections and pre-shipment inspections
- Communicate with DSD and agencies concerned
- Supervise procurement status

- Confirm and follow-up Customs clearance
- Participate and observe initial operation guidance
- Inspect and hand-over products in the course of project implementation
- Issue inspection results and certificate of completion
- Submit completion report

The Consultant will dispatch a procurement supervisor for the factory inspection and pre-shipment inspection (in Japan), and to the initial operation guidance and technical assistance for operation and maintenance (in Cambodia) to ensure smooth and certain implementation of procurement for the Project.

On the other hand, the equipment manufacturer shall dispatch a mechanical engineer(s) to provide guidance/instructions on how to operate, manage and maintain the equipment to DSD staff in the initial operation guidance services.

2.2.4.5 Quality Control Plan

(1) Quality Control Plan of Construction Materials and Works

The quality control of main construction materials and construction works shall be performed under the conditions set below. The tests shall be decided based on the "Civil Work Quality Control Standard" of the Ministry of Land, Infrastructure and Transport, Japan.

Table R 2.2.35 Quality Control Tests

Work Item	Test Item	Standard(*)	Test Frequency
Concrete	Compressive strength test	JIS A 1108	Twice a day: in the morning and in the afternoon.
	Slump test	JIS A 1101	Once every agitator for site mixed and ready mixed
	Salt content test	JIS A 5308	Once a week
	Air content	JIS A 1116	Twice a day: in the morning and in the afternoon.
	Cement material	JIS R 5210	Before construction work and material change
Aggregate	Sieve analysis	JIS A 1102	Once a day
Embankment/ Backfill	Compaction test	JIS A 1210	Before construction work and material change
	Grain size analysis	JIS A 1204	
	Field density test	JIS A 1214	3 places x once in every 3,000 m^3.
Sub-base Course	Modified CBR Test	AASHTO T193	Before construction work and material change
	Sieve analysis	JIS A 1102	
	Field density test	AASHTO T99	3 places x once in every 1,000 $m^{2.}$
Base Course	Revised CBR Test	AASHTO T193	Before construction work and material change
	Sieve analysis	JIS A 1102	
	Field density test	AASHTO T180	3 places x once in every 1,000 m^2.
Asphalt Pavement	Sieve analysis	JIS A 1102	Before construction work and material change
	Density and water absorption test	JIS A 1109, 1110	
	Filler moisture test	JIS A 5008	
	Marshall stability test	ASTM D 1559	
	Asphalt extraction test	AASHTO T194	Once a day
	Field density test	JIS K 2207	1 place x once in every 1,000 m^2.

Note: (*) Other equivalent international standards could be applied.

Construction materials and construction work shall be controlled under the following conditions:

(a) Concrete

Concrete shall have the specified strength, durability and water-tightness, and dispersion of quality of concrete shall be small. The standard strength of concrete shall be based on 28-day Compressive Strength. The method of compressive strength test shall satisfy JIS A1108 and 1132. A sample of mixed concrete shall be picked up twice a day, and the strength tests of 7 days and 28 days shall be carried out for every sample. At the time of concrete-placing, slump test shall be carried out in site and the slump value shall be confirmed against the specified value. Since the concrete placing work is performed in the tropics, temperature control of concrete shall be performed adequately and temperature of pouring concrete at the time of placing shall be lower than the provided temperature ($35^{o}C$).

(b) Placing and Curing of Concrete

Concrete shall be placed using the method that can possibly avoid the separation of materials, and adequately compacted with a vibrator at placing and immediately after placing. After the placing of concrete, the surface of concrete shall be kept wet for at least five (5) days.

(c) Cement

Portland cement shall be used for the construction and its quality shall conform to JIS R5210.

(d) Aggregate

Aggregates shall be clean, strong and durable, and shall have adequate grain sizes. Aggregates shall be confirmed not to include contaminations such as dust, sludge, organic substance, salinity and so on. Especially, fine aggregates shall not include thin or slender pieces of stone. Unit weight of oven dried aggregate shall be not less than 2.5 g/cm^3.

(e) Reinforcing Bar

Reinforcing bar shall have the specified strength. Deformed bar may be used as reinforcing bar in case of not specified. The material test of reinforcing bar shall be carried out according to instructions of the Consultant of the Engineer before use.

(f) Storage of Reinforced Concrete Material

In case of storing the materials of reinforced concrete, the storage method shall follow the Japanese Concrete Standard Specification.

(2) Quality Control Plan of Procurement of Equipment

The quality of equipment shall be controlled under the following conditions:

- Specifications and quality control method of the equipment shall be confirmed between the Consultant and the manufacturer before manufacturing.
- Number, quality, function and performance of the equipment and spare parts shall be confirmed by factory inspection.
- Pre-shipment inspection shall be done by independent organization at embarkation port.
- Storage of the equipment after disembarkation at the Sihanoukville port shall be controlled by the execution agency of Cambodia.
- Inspection at disembarkation port shall be done by the Cambodian side, and then the equipment will be handed over to the Cambodian side. Engineer of the manufacturer shall join the inspection.
- Initial operation guidance is implemented after transportation to DSD workshop.

2.2.4.6 Procurement Plan

(1) Procurement in Cambodia

(a) Cement

Cement products of Thailand circulate freely in the local market. The cement has a good reputation on both quality and quantity to satisfy the demands in Phnom Penh.

(b) Concrete

There are some ready-mixed concrete suppliers in the capital city, all of which were established with foreign investment or joint venture of foreign and local investment. Ready-mixed concrete is commonly used for construction in Phnom Penh. Under these circumstances, ready-mixed concrete shall be used for construction in this project. Quality of ready-mixed concrete shall strictly conform to the specification stipulated by this project.

(c) Steel Materials

With regard to reinforcing bars and other steel materials, products of Thai origin are widely used in the country. Vietnamese iron bars are also available but used to be not guaranteed products for their quality. However, the quality has been improved in recent years since the Japan-Vietnam Joint Corporation was established. Despite these facts, Thai-made products are still predominant over the country.

(d) Construction Equipment

The construction equipments, which are available in the recipient country, are Backhoe, Dump Truck, Rough Terrain Crane and PC Pile Driver.

(2) Import Item

In case the construction materials and equipment are not available locally, their quality is not reliable or their supply amount is insufficient in Cambodia, those construction materials and equipment shall be imported from Japan or other countries, such as Thailand, Singapore and Vietnam.

Transportation route from Japan is from Japanese port to Sihanoukville port via Singapore by marine transport. Transportation route from Sihanoukville port to Phnom Penh Capital City shall be national road No. 4 by trailer. The materials from Thailand shall be transported by land.

2.2.4.7 Operational Guidance Plan

The DSD of DPWT has operated their existing cleaning equipment and maintained the existing drainage system. The DSD has basic knowledge and skills about operation and maintenance of equipment for drainage pipe cleaning.

However, the DSD does not have any experience to operate equipment made in Japan, such as Sludge Sucker and Water-Jet Machine. It is necessary to attempt technology transfer to operating staff through the initial operation guidance carried out by the supplier/manufacturer of equipment newly introduced.

Practically, the engineer/specialist of the supplier/manufacturer shall be dispatched for a week around the same time as arrival of the equipment at the DSD's workshop to carry out the initial operation and maintenance guidance services. Contents of the guidance are shown in Table R 2.2.36.

Table R 2.2.36 Contents of Initial Operation and Maintenance Guidance

Item		Contents of Guidance
Adjustment, Test Drive	Sludge Sucker	Check of grease and throttlehold of bolts & nuts Confirmation of motion of PTO, vacuum pump and discharge function of sludge Confirmation of operationality of operation panel
	High-Water Jet Machine	Check of grease and throttlehold of bolts & nuts Confirmation of motion of PTO, high-pressure pump and hose reel Confirmation of operationality of operation panel
Initial Operation Guidance		Explanation of basic structure How to check each function How to maintain equipment
Management Guidance		Preparation work before usage Actual operation training of the equipment at site Site cleaning around equipment after completion of site training Cleaning of sludge tank at workshop Daily and periodical maintenance to keep good condition Explanation of manual, question and answer

2.2.4.8 Soft Component (Technical Assistance) Plan

The DSD of DPWT will be responsible to operate and maintain the cleaning equipment procured by the Project and drainage facilities constructed by the Project. The DSD has maintained the existing drainage system by using its existing cleaning equipment, and the DSD has basic knowledge and skills about operation and maintenance (O&M) of the cleaning equipment.

The DSD's present maintenance works are mainly carried out upon request of the local authority or cleaning work of drainage pipe after clogging at the location where inundation frequently occurs.

In consideration of this circumstance, technical assistance by soft component shall be implemented to encourage the O&M capability of DSD staff. The soft component (technical assistance) aims to enable the DSD carry out the systematic and scheduled maintenance work introducing the PDCA cycle and to utilize drainage facilities/equipment constructed/procured by Phase 2 and the Project.

Activities and targets by the soft component (technical assistance) are as follows:

- <Act> to study how to compose proper records of cleaning activities through the actual O&M works of drainage facilities constructed by the Project.
- <Plan> to establish a practical, safe and certain O&M action plan based on the activities recorded.
- <Do> to execute the actual O&M work under the action plan.
- <Check> to check and revise the action plan in consideration of the actual circumstance.

2.2.4.9 Implementation Schedule

The Project will be implemented under Japan's Grant Aid based on the Grant Agreement (G/A) between GOC and JICA after the Exchange of Notes (E/N) has been concluded between GOC and GOJ. The Project will begin with the detail design study immediately after the signing of contract for consultancy services. The consultancy services will require 7.5 months including engineering design services, preparation of tender documents and tender administration.

The total construction period will be 44 months including construction of facilities and procurement of cleaning equipment. The implementation schedule from the detail design study to completion of the construction works is shown in Fig. R 2.2.20.

Detailed Design and Tendering Stage

Month	1	2	3	4	5	6	7	8	9	10
Exchange of Notes (E/N)	▼									
Grant Agreement (G/A)	▼									
Agreement for Consulting Services		▼								
Site Survey and Study in Cambodia			■							
Design Study in Japan				□						
Preparation of Tender Documents						□				
Approval of Tender Documents							■			
PQ Notice								▼		
PQ Evaluation								□		
Tender Announcement & Preparation									□	
Tendering										▼
Tender Evaluation										■
Contract Signing		7.5 Months in Total								▼

■ Work in Cambodia □ Work in Japan

Construction, Procurement and Soft Component Stage

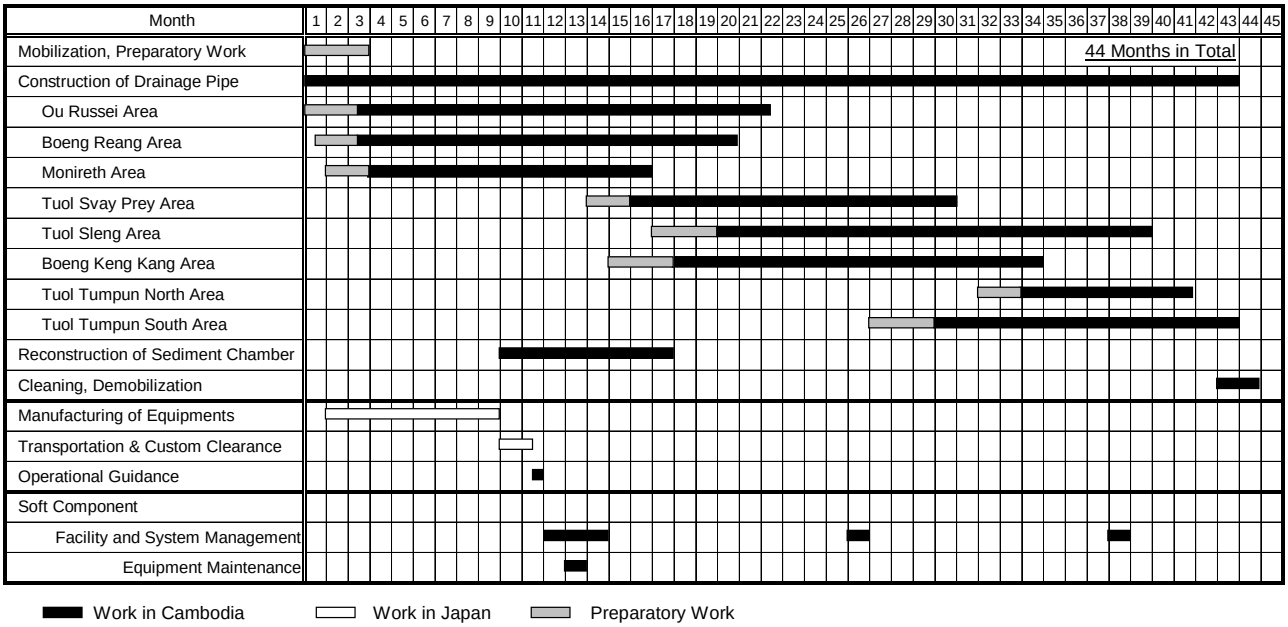


Fig. R 2.2.20 Implementation Schedule

2.3 Obligations of Recipient Country

2.3.1 General Undertakings of Cambodia

The Cambodian side shall undertake the following for the smooth implementation of the Project. Incidentally, these undertaking are acknowledged by Cambodian side and mentioned in Minutes of Discussions (M/D)

(1) To secure and clear the lands required for implementation of the Project such as construction site, stockyard, temporary working yard, disposal area and land for site office, and to get approval of land use from the agency concerned, if any.

(2) To provide the following facilities:

- The distribution power line to the site and site office,
- The city water distribution main to the site and site office, and
- The telephone trunk line to the main distribution panel of the site office.

(3) To ensure prompt unloading, tax exemption and Customs clearance of the products at the port/terminal of disembarkation in Cambodia and internal transportation of the cleaning equipment procured under Japan's Grant Aid

(4) To exempt Japanese nationals from Customs duties, internal taxes and other fiscal levies that may be imposed in Cambodia with respect to the procurement of products and services under the Project.

(5) To arrange the acquisition of visa and other formalities that may be necessary for the entry of Japanese nationals into Cambodia and stay therein for the performance of the work.

(6) To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project.

(7) To maintain and use the facilities and equipment properly and effectively with a suitable number of staff assigned for the operation and maintenance and to bear all expenses other than those covered under the Grant Aid.

(8) To bear the advising commission on the Authorization to Pay (A/P) and payment commission to the Japanese bank for banking services based upon the Banking Arrangement (B/A).

2.3.2 Specific Undertakings of Cambodia

The specific undertakings required of the Cambodian side for the smooth implementation of the Project are as described below.

(1) Internal Transportation of Cleaning Equipment for Drainage Pipes

Two (2) units of Sludge Sucker and two (2) units of High Water-Jet Machine will be procured by the Project as the cleaning equipment for drainage pipes.

Internal transportation cost of procured equipment from disembarkation port (Sihanoukville port) to Phnom Penh shall be borne by the Cambodian side.

(2) Preservation of the Trabek South Regulation Pond

The Cambodian side shall preserve the Trabek South Regulation Pond in its present condition. All expenses necessary for the preservation shall be borne by the Cambodian side.

(3) Periodical Environmental Monitoring

The Cambodian side shall execute periodical environmental monitoring during construction to check circumstances of negative impacts generated by the construction work, the implementation state and effectiveness of countermeasures for the negative impacts.

(4) Establishment of Monitoring System of Inundation Condition

The Cambodian side is required to establish the inundation monitoring system and to carry out inundation monitoring periodically. Inundation monitoring shall be carried out in some locations in the city area where inundation damage is relatively heavy, and data shall be recorded such as date, time, inundation depth, duration of inundation, rainfall data, and so on in each monitoring point. The monitoring locations proposed by the Preparatory Survey Team of JICA are as shown in Fig. R 2.3.1.

A sample sheet of inundation monitoring record is shown in the table below.

Table R 2.3.1 Sample Sheet of Inundation Monitoring Record

Location: _____

Date of Inundation [dd.mm.yy]	Inundation		Duration [h:m]	Max. Depth [cm]	Rain		Daily Rainfall Record (at Pochentong) [mm]
	Start [h:m]	End [h:m]			Start [h:m]	End [h:m]	
03.09.2010	16:30	18:10	1:40	40 cm	16:00	17:00	80 mm

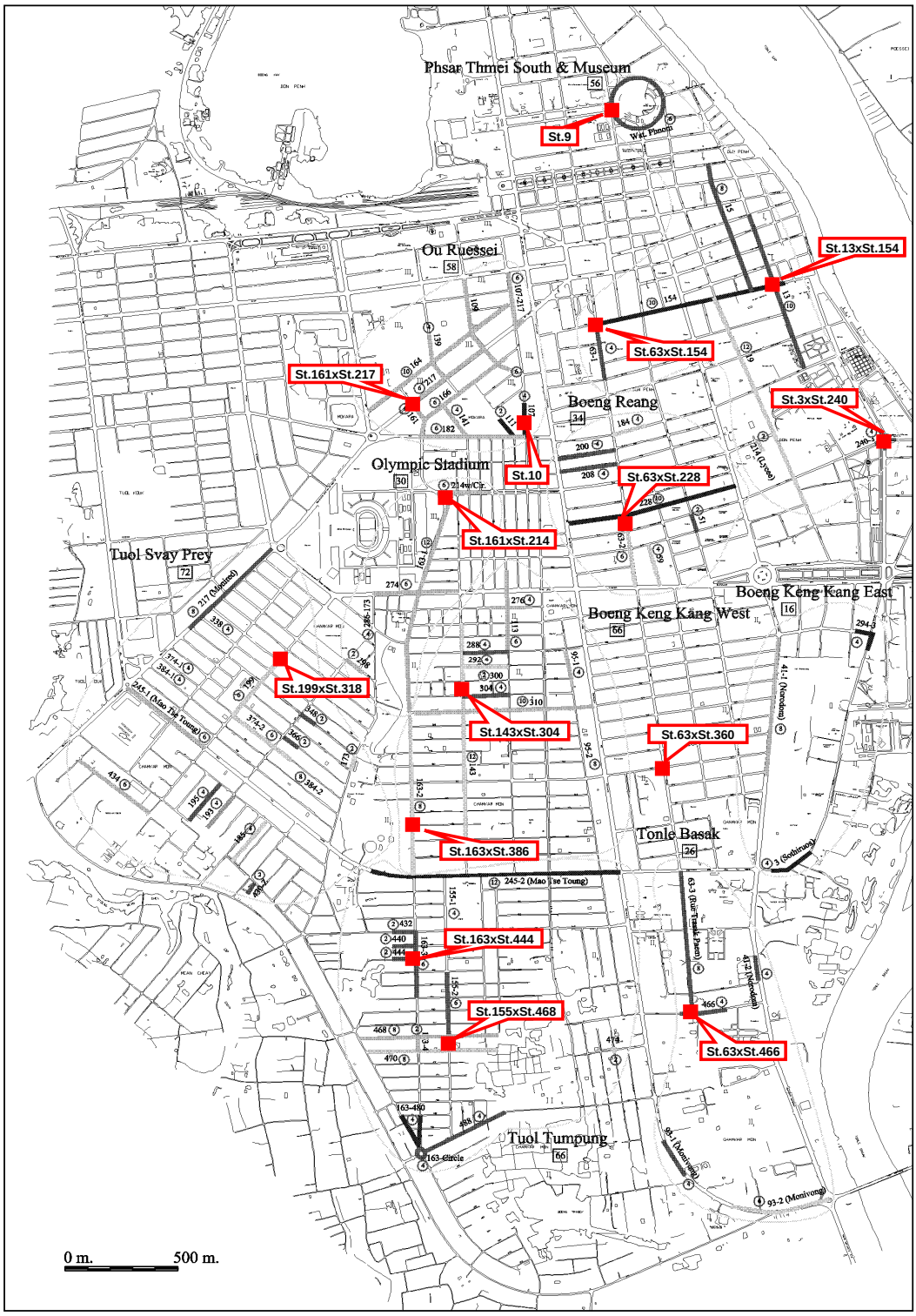


Fig. R 2.3.1 Location of Inundation Monitoring (15 points)

2.4 Project Operation Plan

2.4.1 Responsible Organization for Operation and Maintenance

2.4.1.1 Organization for Operation and Maintenance of Drainage Facilities and Cleaning Equipment

DSD (refer to Fig. R 2.4.1) of DPWT shall be the organization in charge of operation and maintenance work of the Sediment Chamber at R240 and the improved/constructed drainage pipes as well as equipment for the maintenance of drainage facilities procured by the Project.

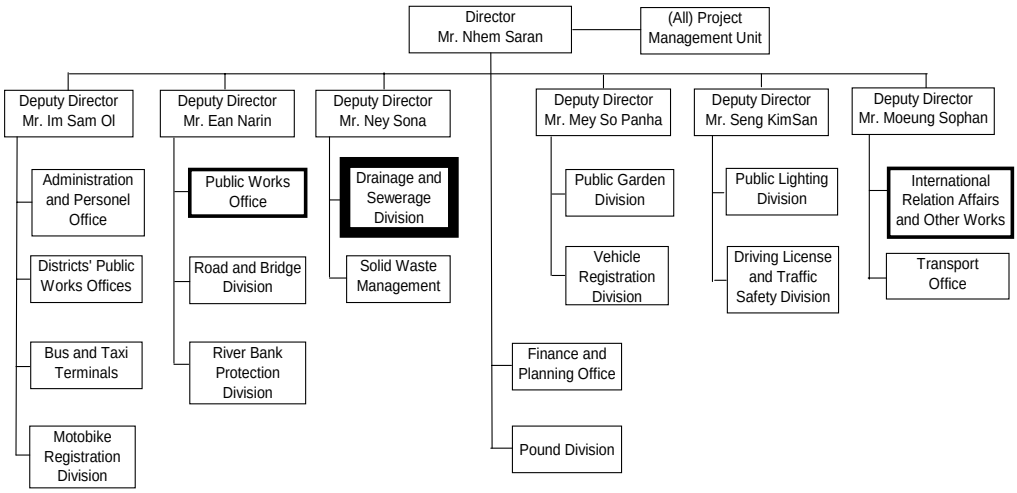


Fig. R 2.4.1 Organizational Chart of DPWT

DSD has a total of 211 personnel as shown in Table R 2.4.1. Among them, 17 regular personnel (Engineering Group) has the responsibility for maintenance of drainage facilities and equipment, design of sewage pipes and assistance in sewage pipe construction work, and four (4) regular staff and 36 contracted staff in charge of maintenance of the drainage pipes.

Table R 2.4.1 DPWT Staff

Department	Regular Staff	Contracted Staff	Total
1. Management Unit	7	-	7
2. Administration and Personnel Office	10	-	10
3. Finance and Planning Office	12	-	12
4. Public Works Office	29	-	29
5. Transport Office	21	-	21
6. Road and Bridge Division	48	39	87
7. Drainage and Sewerage Division	49	162	211
8. Public Lighting Division	17	20	37
9. Public Garden Division	35	272	307
10. Pound Division	9	7	16
11. River Bank Protection Division	7	-	7
12. Districts' Public Works Offices	19	-	19
13. Motorbike Registration Division	13	-	13
14. Vehicle Registration Division	40	-	40
15. Driving License and Traffic Safety Division	39	-	39
Total	355	500	855

2.4.1.2 Responsible Organization for Preservation of Trabek Pond

Preservation of Trabek Pond shall be implemented under the management and responsibility of PPCH. Actually, the local office at Khan Chamkarmon where the Pond is located is in charge of daily management and preservation works.

2.4.2 Operation and Maintenance Method

2.4.2.1 Drainage Network (including Drainage Pipe, Box Culvert and Manhole)

Since drainage pipes are laid underground, it is difficult to predict and detect any trouble and abnormality. On the other hand, if these abnormalities/troubles occur within the installed drainage pipes, accidents would be caused directly affecting city activities and civil life, such as leakage of sewer, road collapse, etc. Positive promotion of operation and maintenance works of drainage pipes would contribute to reduce accidents, maintain performance of drainage pipes and extend the practical service life of drainage pipes. Taking these effects into account, carrying out operation and maintenance works for the drainage pipes has economical advantages.

As mentioned above, DSD is in charge of the maintenance of existing pipes. Table R 2.4.2 shows the number of staff related to the maintenance work.

Table R 2.4.2 DSD Staff related to Pipe Maintenance Work

Description		Full-time worker	Contract worker
Driver	Back Hoe（2 units）	-	4
	Dump Truck（5 cars）	1	4
	Crane Truck	-	1
	Vacuum Truck	2	1
	Water Wagon	1	-
Driver's Assistant		-	5
Operator	Vacuum & Suction Hose	-	11
Worker	Cleaning of Pipe & Manhole	-	7
Total		4	36

Source：DPWT as of April, 2010

Adequate operation and maintenance work of drainage pipes shall involve following procedures:

1) Maintenance and inspection;

2) Cleaning and dredging; and

3) Renewal and repair.

(1) Maintenance and Inspection

In the "Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries (issued by the Infrastructure Development Institute, JAPAN, October 2001)", the inspection frequency is about once in every five (5) years for pipes

without any particular problem. According to the record, the inspection frequency in urban area in Japan is once in every three (3) to seven (7) years.

It has been confirmed in the site investigations that the drainage system in many parts are clogged with debris and sediment, which means that there are a lot of sections where maintenance work has not been done for a long time. On the other hand, DSD implements pipe cleaning work more than once a year for the main trunk of drainage system.

It is preferable to execute the inspection work at the frequency of about once in every three (3) to five (5) years for the drainage pipes constructed under the Project.

(a) Inspection Items

Principal inspection items shall be as follows:

[Drainage Pipe, Box Culvert]

- Flow condition and sediment build-up condition
- Settlement of the ground surface: Cracking in pavement due to differential settlement of the ground, etc.
- Damage situation: Damage, crack, penetration of root of tree
- Groundwater infiltration condition
- Illegal connection

[Manhole]

- Manhole cover and internal condition

(b) Inspection Method for Drainage Pipe, Box Culvert and Manhole

In addition to visual inspection inside the manhole with the cover removed, the inspection shall be made by viewing the inside part of manhole through pipes. Most abnormalities can be detected through visual manhole inspection.

(c) Record of Inspection Result

Inspection results shall be recorded in proper recording sheets, which shall be documented for future use in the elaboration of cleaning plans.

(2) Cleaning and Dredging

Sludge deposits in pipes reduce flow capacity. It also causes wastewater, and hydrogen disulfide and organic acids to accelerate corrosion of pipes. Therefore, it is essential to carry out regular inspections and remove deposits when observed.

(a) Guidelines for Pipe Cleaning and Dredging

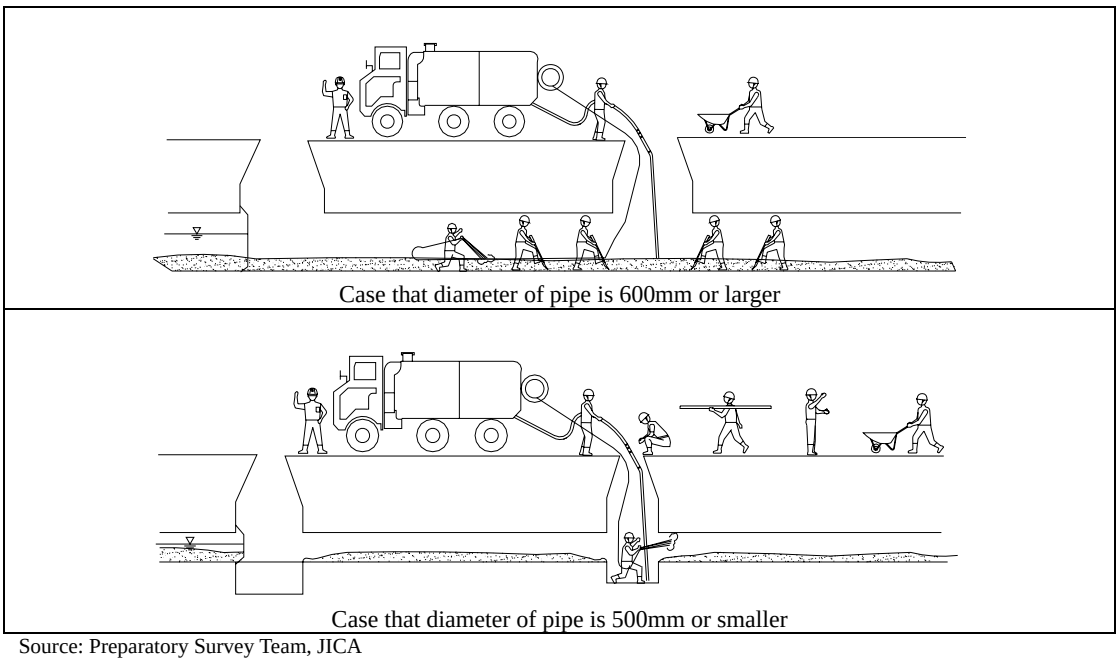
Generally, the clogging ratio required for cleaning, which is calculated by [(clogged sectional area) / (interior cross-sectional area) x 100(%)], is approximately 20% for drainage mains and 60% for house connections. Basically, cleaning does not need to be more frequent than the inspections. However, in commercial areas where eating and drinking establishments are concentrated, there may be the necessity to increase the maintenance frequency due to the excessive deposits that may accumulate rapidly in these areas.

(b) Pipe Cleaning and Dredging Method

The performance of cleaning equipment and machinery used by DSD has remarkably declined due to aging, so that sludge deposits are difficult to break by simply the water-jet function of the existing cleaning equipment. Therefore, the workers have to go inside the pipes to break and remove the deposits and garbage manually using shovels.

The manual removal work will be continued basically for the cleaning work in large diameter drainage pipes. On the other hand, the high water-jet machine procured by the project shall be used to break and remove the deposits and garbage from small diameter drainage pipes after the completion of the Project.

The deposits/garbage removed from drainage pipes are to be accumulated inside the manholes and sucked out using the sludge sucker, as illustrated in Fig. R 2.4.2.



Source: Preparatory Survey Team, JICA

Fig. R 2.4.2 Pipe Cleaning Method conducted by DSD (with Equipment)

(3) Renewal and Repair of Drainage Pipes

Deterioration of pipes proceeds over the surface as a whole, and renewal and repair will take a considerable time. Therefore, it is necessary to implement renewal and repair according to the plan established on the basis of the results of inspections and surveys to prevent accidents beforehand.

2.4.2.2 Sediment Chamber at R240

The Sediment Chamber at R240 reconstructed by the Project has the function to collect influent sand, soil and sludge and store them. The storage capacity of the new sediment chamber is designed in the manner to be cleaned in a more frequent time span than once a year, since organic materials accumulated for a long time emit a bad odour due to putrefaction and also cause corrosion of concrete. Therefore, the chamber should be cleaned more than once a year in order to keep the system capacities and to extend the service life together with the prevention of corrosion.

Based on the calculation of sewage water volume, it is expected that 130m^3 to 150m^3 of sewage sludge will be deposited in the chamber. Sludge sucker and about ten (10) cleaning workers can remove the volume of sludge, and DSD has the capacity to provide them. Alternatively, the work for chamber cleaning can be subcontracted to a private contractor based on the past cleaning results.

2.4.2.3 Equipment and Machinery for Drainage Pipes

Most of the equipment and machineries that DSD presently have are remarkably in advanced state of aging and the work efficiency is not high. However, the DSD personnel have maintained them well and used them for the daily cleaning activities. Therefore, the DSD personnel have accumulated experience and know-how on cleaning drainage facilities and maintaining cleaning equipment.

It is very possible for DSD to maintain and utilize the procured equipment and machinery through adequate training on the unique methods of operation and maintenance. Technology transfer to DSD personnel is aimed through the initial operation guidance by the supplier/manufacturer in order to transfer the method of operation and maintenance techniques for the special equipment (high water-jet machine and sludge sucker) newly procured. The technology transfer for DSD personnel also aims at the establishment of a system to receive appropriate maintenance services from the agent of the supplier/manufacturer.

To bring out the effect of installed drainage pipes under the Project and to improve the inundation state effectively in Phnom Penh Capital City with the effective use of procured equipment, it is necessary to record the activities of operation and maintenance and to carry out the maintenance works applying the PDCA cycle composed of “Plan”, “Do”, “Check” and “Action”. The specific

activities consist of upgrading the weekly record of maintenance works, preparation of action plan on operation and maintenance, comparison of plan and activity results, extraction and improvement of site problems and so on.

It would be difficult for DSD to accomplish a goal only by its own effort because the items and fields to be solved cover many topics and specific and technical expertise are required. It would thus be suitable to execute technical assistance by soft component to establish the operation and maintenance activities in a well-planned and organized manner. Through these soft component activities, the know-how on operation and maintenance can spread to not only DSD but also each "Sangkat" or "Khan" and it is expected that the entire drainage network in Phnom Penh Capital City can receive appropriate maintenance and management services in the future.

2.5 Project Cost Estimate

2.5.1 Initial Cost Estimate

(1) Cost Borne by Japan's Grant Aid

The cost to be borne by the Japan's Grant Aid is not shown in this report due to the confidentially.

(2) Cost Borne by Recipient Country

The cost to be borne by the Government of Cambodia is estimated to be about US$113,000 (10.3 million Japanese Yen). The breakdown is presented in the following table.

Table R 2.5.1 Project Cost Borne by Cambodian Government

Item	Cost (US$)	Cost (million Japanese Yen)
Advising Commission for Banking Arrangement (B/A) and Authorization to Pay (A/P), and Payment Commission	93,600	8.5
Periodical Environmental Monitoring Cost during the Construction Stage (14 times in total for 44 months)	15,400	1.4
Internal Transportation Cost for the Equipment for Drainage Pipe Cleaning Procured by the Project	4,000	0.4
TOTAL	113,000	10.3

Exchange Rate : US$1.00 = 91.2 Japanese Yen, and THB1 = 2.80 Japanese Yen (as of March 2010)

(3) Cost Estimation Conditions

1. Estimation Timing : April 2010

2. Foreign Exchange Rate : US$1.00 = JPY 91.20 US$: US Dollar
   THB1.00 = JPY 2.80 JPY: Japanese Yen
   THB: Thai Baht

   Foreign Exchange Rate applied is the average of Telegraphic Transfer Rate (TTS rate) for six (6) months from October 2009 to March 2010.

3. Construction Period : The implementation schedule of the detailed design, construction and procurement is shown in Subsection 2.4.9.

4. Remarks : This cost is estimated by taking Japan's Grant Aid scheme into account.

2.5.2 Operation and Maintenance Cost

The increased amount of annual operation and maintenance cost after the Project is estimated to be US$36,500 in total. This amount is about 13% of the average cleaning cost of drainage pipes, and about 5% of the average total amount of expenditure of DSD between 2006 and 2008.

On the other hand, PPCH may allow the maintenance cost of drainage and sewage system from 10% of income by water supply service, and irregular expenditures such as construction of new pumping station will be borne by PPCH's general accounting budget. In 2008, about US$730,000 was supplied by PPCH for the construction of a new pumping station beside the Svay Pak Drainage Sluiceway. According to Table R 2.5.2, the total amount of expenditures of DSD (except irregular expenditures) after project implementation is estimated to be lower than 10% of income by water supply services in the last three (3) years.

Table R 2.5.2 Expenditures of DSD and Income by Water Supply Services

Item	DSD (US$) Expenditures			Increased Amount after the Project
	2006	2007	2008	
Installation of New Drainage Pipes	175,420	241,575	406,182	36,500
Repair of Drainage Pipes	33,085	126,417	83,506	
Cleaning of Drainage Pipes	248,913	86,939	311,010	
Cleaning of Open Channel/Retention Pond	108,852	45,070	45,050	
Maintenance of Pumping Station	11,850	6,098	729,923 (support by PPCH)	
Total	578,119	706,099	1,575,671 (845,748)*	
10% of Income by Water Supply Service	907,143	1,173,810	1,321,429	

Note*: Value in ( ) is the total expenditure of DSD after construction cost of new pumping station has been deducted.
Source: Actual recent expense, DSD

(1) Operation and Maintenance Cost of Drainage Pipes

Sludge deposits in drainage pipes reduce flow capacity. It also causes wastewater, and hydrogen disulfide and organic acids to accelerate corrosion of pipes. Therefore, it is essential to carry out regular inspections and remove deposits when observed. In Phnom Penh Capital City, it has been confirmed in the site investigations that many portions of the drainage system are clogged with debris and sediment. Therefore, the frequency of cleaning work should be once in every five (5) years. According to the capital outlay plan in the DPWT budget, the unit cost of drainage pipe cleaning is US$5/m, and unit cost of manhole cleaning is US$50/piece. The annual cleaning cost as the operation and maintenance cost of drainage pipes installed by the Project is approximately **US$26,500**, as estimated below.

[Total O&M Cost] US$5/m x 22,909m + US$50/piece x 362 pieces = US$132,645

[Annual O&M Cost] US$132,645/5years = US$26,529/year

(2) Operation and Maintenance Cost of Sediment Chamber at R240

The Sediment Chamber at R240 has the function to accumulate sludge and sand from upstream and not to diffuse the sludge to downstream pipes and manholes. Therefore, it is desirable to take out sludge and sand from the chamber in every dry season (once per year) to keep the function required.

Cleaning cost of the chamber is approximately **US$2,000** based on actual cleaning work carried out on the existing chamber in February 2009, as estimated below.

(10days x 15 workers x US$10/day + US$500 (fuel and lighting fee) = US$2,000)

(3) Operation and Maintenance Cost of New Cleaning Equipment for Drainage Pipes

DSD has been utilizing the aged cleaning equipment for cleaning and maintenance work on drainage pipes. Expenditures, such as fuel and maintenance costs of equipment, are covered under the annual budget of DSD. New cleaning equipment procured under the Project will be managed instead of the present aged equipment for cleaning work; hence, the total amount of daily maintenance cost for equipment such as fuel cost and wages of personnel is assumed as almost the same as the present cost. Furthermore, additional cost to arrange the parking area of new equipment is not necessary because there are enough parking spaces for new equipment at the DSD workshop.

Necessary additional cost for the new cleaning equipment is estimated to be about **US$8,000** (maintenance parts and insurance fee: US$2,000/year x 4 vehicles).

According to the present situation of existing facilities and equipment managed by DSD, the aged equipment has been kept for more than 15 years through the grace and dedicated maintenance services of DSD personnel.

Service life of the cleaning equipment procured by the Project will be guaranteed for 5 years, in general. It is possible to make the service life of equipment longer than the expected economic life by proper management and maintenance work. With proper maintenance as the prerequisite condition, service life of the new cleaning equipment procured by the Project is expected to be 10 years.

2.6 Other Relevant Issues

Obligations of the recipient country necessary to be implemented for the smooth progress of the project are as listed below. Implementation state of the obligations shall be managed carefully although each obligation has been recognized as mentioned in Minutes of Discussions.

(1) Prompt unloading, tax exemption and Customs clearance of the products at the port/terminal of disembarkation in Cambodia shall be ensured.

(2) Japanese nationals shall be exempted from Customs duties, internal taxes and other fiscal levies which may be imposed in Cambodia with respect to the procurement of products and services under the Project.

(3) Internal transportation cost of procured equipment (Sludge Sucker and High Water-Jet Machine: 2 sets) from disembarkation port (Sihanoukville port) to Phnom Penh Capital City shall be borne by the Cambodian side.

(4) The Cambodian side shall preserve the Trabek South Regulation Pond in its present condition. All expenses necessary for the preservation shall be borne by the Cambodian side. Additionally, the Cambodian side shall explain the policy, purpose and contents of the Project appropriately and respectfully to residents around the Pond so as not to make them misunderstand the Project, and resettlement of the residents shall not be applied for the preservation of the Pond.

(5) The Cambodian side shall execute the periodical environmental monitoring during construction to check circumstances of negative impacts derived from construction work and implementation state and effectiveness of countermeasures for the negative impacts.

(6) It is necessary to establish the inundation monitoring system for the confirmation of drainage improvement effectiveness generated from the Project and sustainable data collection toward scheduled and prevenient management of drainage facilities. Planning and preparation work for the monitoring shall be executed gradually although actual monitoring will be implemented after completion of the Project.

CHAPTER 3 PROJECT EVALUATION

3.1 Recommendation

3.1.1 Necessary Procedure before the Commencement of Construction Work

(1) Explanation Meeting for Local Residents

Installation work of drainage pipes under "the Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III)" (hereinafter referred to as the Project) will be executed in the urban area of Phnom Penh City. Since the construction sites of drainage pipe installation are adjacent to houses, shops and restaurants, the Cambodian side is required to hold meetings with the local residents in/around the construction sites to explain the Project prior to the commencement of construction work. These explanation meetings shall be held for each *"Khan"* or *"Sangkat"* concerned.

It is very important and necessary to facilitate the understanding and cooperation of the residents on the Project for smooth implementation.

(2) Provision of Construction Sites and Working Areas

Necessary provisions to be completed prior to the commencement of construction work are:

(1) to obtain official permission or approval of construction at public roads for drainage pipe installation and at site of the Sediment Chamber at R240 to avoid any unnecessary conflict on its reconstruction; and

(2) to prepare and provide adequate lands for site office, stockyard, work shop, warehouse and disposal area.

Construction work of drainage pipe installation does not require land acquisition from private land because the new drainage pipes shall be installed under public roads and reconstruction of the Sediment Chamber at R240 at the public garden as present location.

3.1.2 Environmental Countermeasures during Construction Work

According to the results of Initial Environmental Examination (IEE), "Environmental Mitigation Measure" and "Environmental Monitoring Plan" shall be executed.

Since the construction work will be conducted in a dense residential area, near markets and restaurants, noise, vibration or traffic accident by construction equipment during the construction period shall be prevented. To prevent spilling out during transportation to disposal areas, excavated materials loaded on dump trucks shall be covered adequately with tarpaulin sheets. It is also

necessary to take measures to prevent dropping of excavated materials from carriers and the dispersal of soil adhering to the tires of transport vehicles during transportation.

3.1.3 Appropriate Operation, Maintenance and Management of Drainage Facilities

Appropriate operation, maintenance and management of the planned, designed and completed drainage facilities are indispensible to keep them functional. Enough number of staff and budget are thus important for the purpose.

Especially, cleaning works of drainage facilities by Drainage and Sewerage Division (DSD) of Department of Public Works and Transport (DPWT) of Phnom Penh City Hall (PPCH) are necessary to maintain the newly constructed drainage facilities and to mitigate the inundation damage. Management skill transferred through technical assistance by the soft component shall be utilized for scheduled and prevenient management of the drainage facilities and the appropriate activation and maintenance of cleaning equipment procured in the Project. Therefore, enough funds shall be allocated and made available for disbursement for the operation, maintenance and management with the assistance of equipment procured by DSD and DPWT.

Furthermore, DSD shall make efforts to human resources development in charge of scheduled maintenance of drainage facilities and to expand the management skill transferred by technical assistance.

3.1.4 Preservation of Trabek Regulation Pond

Trabek Regulation Pond plays an important role to regulate water discharge into Trabek Pumping Station. It is indispensable to preserve Trabek Regulation Pond at least with the present area and storage capacity without any reclamation to keep the function of drainage facilities constructed by the Project. On the other hand, basic policy of the Project, that any resettlement of residents around the pond shall not be required for the preservation work, is acknowledged in the meeting for explanation on draft report in Cambodia. PPCH shall explain the policy and outline of the Project appropriately not to cause misunderstanding about the Project

3.1.5 Monitoring of Inundation Condition

To sustain and develop the drainage improvement after completion of the Project, Cambodian side shall implement sustainable inundation monitoring at some designated monitoring points shown in Fig. R 3.1.1 to collect the data of inundation state and confirm the relation between rainfall, cleaning condition of drainage pipes, installation of drainage facilities and inundation state, and to review the cleaning schedule and drainage improvement plan.

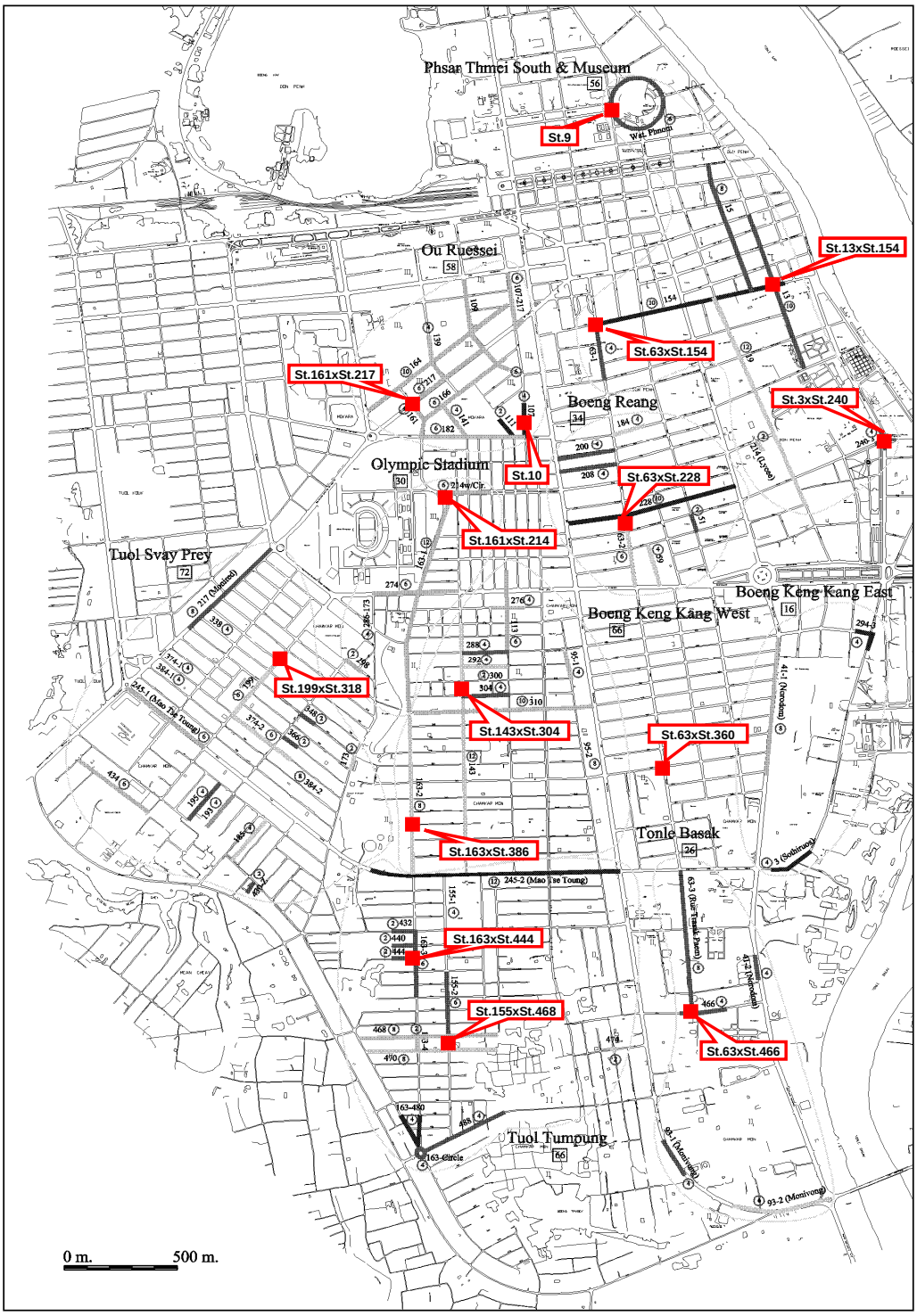


Fig. R 3.1.1 Location of Inundation Monitoring (15 points)

3.1.6 Gradual Improvement of Drainage System

A large amount of expense and time is required to implement the fundamental measures for solving a drainage problem, and realizing these measures immediately in a developing country is accompanied by difficulty from various restrictions. On the other hand, although the urgency and importance of solving the drainage problem in a city on a long-term target are increasing, the implementation of an effective project even if it is set on a short term becomes very important.

The drainage network consists of the drainage main and drainage laterals, and all of the proposed drainage pipes in the Project correspond to the drainage main. The fundamental measure for solving a drainage problem is to carry out all of the drainage plans including drainage mains and laterals, and an effective drainage plan is not realized in a partial plan.

The drainage problem could be solved only after the installation or improvement of drainage laterals, and all drainage laterals are connected to the drainage main. Although the objective of the Project can be attained where new drainage mains are to be installed, the target could not be attained throughout the city as a whole. Therefore, to be able to attain an impressive target in the whole city area, a suitable operation and maintenance plan and drainage lateral plan are required to be carried out gradually and intentionally.

3.2 Project Evaluation

3.2.1 Adequacy of the Project

Trabek Basin and adjacent area, which is located in the south-east part of Phnom Penh Capital City, frequently suffers from inundation damage by heavy rain. This inundation problem, which not only disturb inhabitant's life in Phnom Penh Capital City but also might paralyze the capital functions of Cambodia, shall be contended and solved urgently. Adequacy to execute the Project has been verified from the following viewpoints:

(1) Target Scale to be Benefited

The survey area to be benefited by the Project is the Trabek Basin and its adjacent area, southeast part of Phnom Penh Capital City, where there are approximately 230 thousand residences, 50 thousand households, 2,600 shops, 4 large markets, 400 merchandise facilities like factories and warehouses, and 60 public facilities like schools and hospitals.

In addition, all inhabitants in Phnom Penh Capital City will widely benefit through the procured cleaning equipment by making the maintenance and cleaning work of drainage pipes smooth, efficient and safe and thus mitigating the inundation damage.

(2) Human Security

As the positive effects of the Project, the mitigation of deterioration of sanitary environment including the decrease in value of houses and goods by inundation is expected. The positive effects would contribute to the preservation of people's health, conservation of living conditions and sustainment of work environment and hence, compatible with "Basic Human Needs." Especially, these positive effects contribute to poor residents because they often live at frequently inundated places, where are near drainage channel, lower than other places, and not installed drainage facilities enough.

(3) Operation and Maintenance of Facilities

DSD, which has taken charge of the maintenance of drainage facilities in Phnom Penh Capital City, needs to be improved on cleaning and maintenance capability of drainage facilities. To improve cleaning and maintenance capability of DSD for drainage facilities, and to enhance operation and management capability of DSD, technical assistance by soft component shall be implemented. After completion of the technical assistance of the Project, DSD will be able to carry out the operation and maintenance work in a planned and consistent way. Moreover, maintenance cost can be secured under PPCH's own budget.

(4) Consistency with Long -Term Development Programme

The Project is to be implemented based on the master plan established in the JICA Master Plan study in 1999. The Project will contribute to the achievement of some of the Cambodian Millennium Development Goals (CMDGs) such as the Cambodian long-term development target under "CMDGs 7: Ensure Environmental Sustainability" and "CMDGs: Forge a Global Partnership for Development". The Project also contributes the City Development Strategy (CDS) as the metropolitan development strategy of Phnom Penh Capital City under "Vision 2: Environment and Natural Resources" and "Vision 3: Infrastructure and Transportation."

(5) Impact to Environment

There is no significant or permanent negative impact to natural and social environments caused by the Project. In contrast, positive impact such as improved living and social environments by mitigation of inundation condition and enhancement of maintenance work of drainage facilities is expected.

(6) Necessity and Superiority of Japanese Technology

Japanese technology is required to execute the Project under Japan's Grant Aid Scheme because of the following reasons:

- Progressed knowledge and technology are required to simulate complicated drainage network and to formulate the appropriate drainage improvement plan with activation of the existing drainage system.
- Japanese construction technology is required to design appropriate drainage facilities and to implement construction work smoothly and accurately.
- Execution of drainage improvement project through the Japan's Grant Aid, there were two Japan's grant aid projects in the past, namely "the Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh" and "the Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)",

enables the establishment of a consistent drainage system in Phnom Penh Capital City based on the Master Plan formulated in 1999.

- Construction of a consistent drainage system in Phnom Penh Capital City through the three-staged Japan's Grant Aid Project contributes to the development of PPCH and Cambodia.
- Utilization of local human resources, who have experience and knowledge about construction works obtained through the implementation of foregoing two Japan's grant aid projects contributes to the smooth progress and cost reduction of the Project.

3.2.2 Effectiveness of the Project

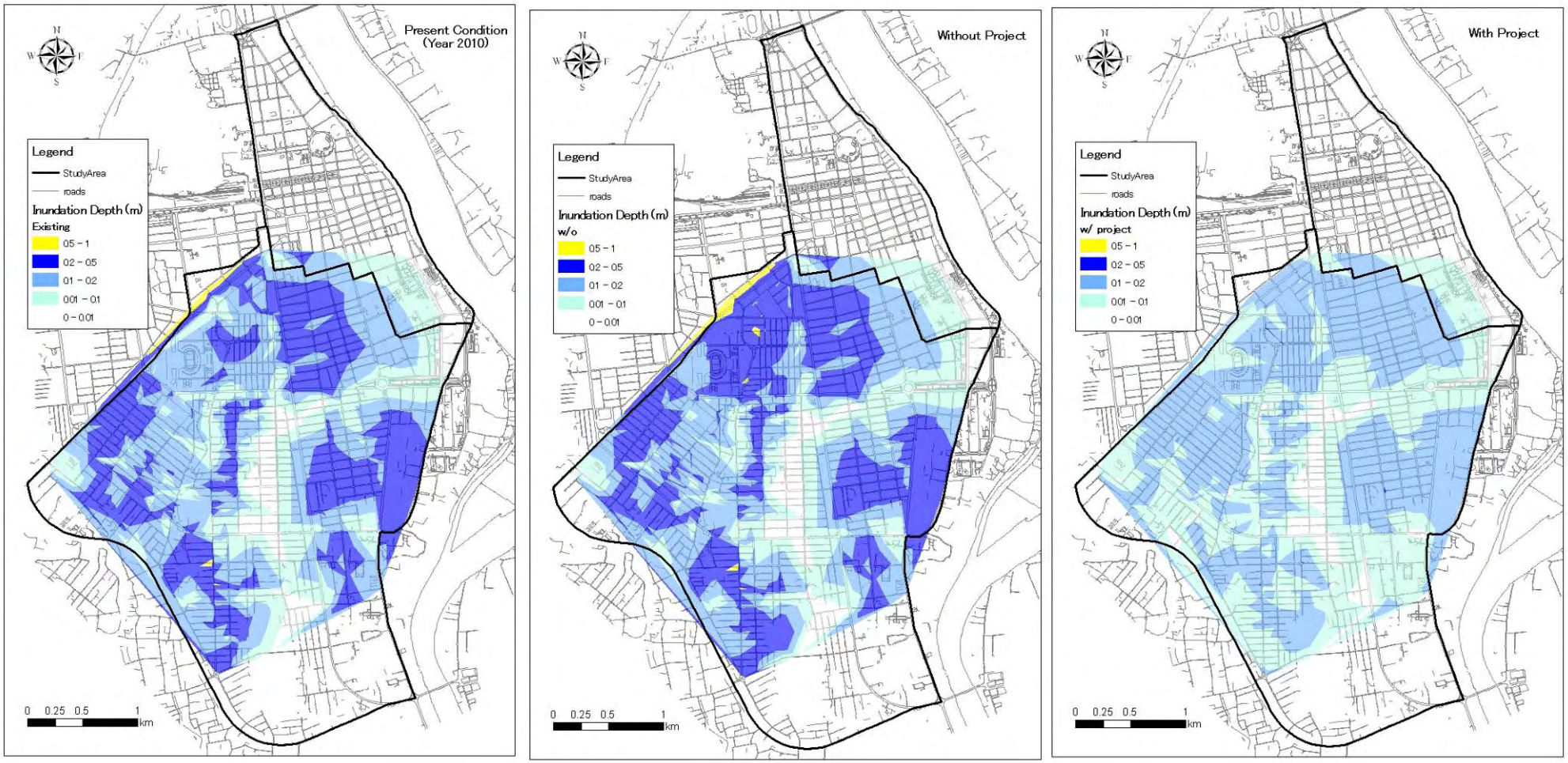
(1) Quantitative and Direct Effectiveness

The inundation depth under a 2-year rainfall is less than 0.2m, the duration is shorter than 2 hours, and the flood damage in Trabek area in the southeastern part of Phnom Penh Capital City is mitigated by the proposed drainage improvement in the Project. Moreover, the decrease of frequency of flood is also expected. The flood duration at the selected point of each drainage area and the inundation depth computed by MOUSE simulation are used as indexes to show the quantitative effect of the Project.

As a comparison, flood duration in the present condition, under reclamation of ponds around Olympic Stadium (without the Project) and after the proposed drainage improvement (with the Project), are summarized in Table R 3.2.1. The results show that the duration is shorter than 2 hours in all points. Especially in Ou Russei drainage area, the duration substantially increases under "without the Project" compared with the present condition, but it is drastically shortened until 1.5 hours by the proposed project. As for the inundation depth, the results are as shown in Fig. R 3.2.1. Even under the present condition, the inundation area of 0.2m or deeper (dark blue and yellow color in Fig. R 3.2.1) spreads widely. The results show that the flood situation becomes worse especially in and around the Olympic Stadium under "without the Project" condition and then the flood can be mitigated at shallower than 0.2m of inundation depth with the proposed project.

Table R 3.2.1 Improvement of Flood Duration

Drainage Area	Flood Duration (hr)		
	Present	w/o the Project	with the Project
(1) Ou Russei	1.0	10 or more	1.5
(2) Boeng Reang	3.5	3.5	2.0
(3) Monireth	3.0	3.0	1.5
(4) Tuol Svay Prey	2.5	3.0	1.5
(5) Tuol Sleng	2.0	2.5	1.0
(6) Boeng Keng Kang	2.0	2.0	0.8
(7) Tuol Tumpung North	5.0	4.8	1.5
(8) Tuol Tumpung South	6.5	7.0	1.5



(1) Present Condition (before the Project)

(2) Condition after Reclamation of Ponds around Olympic Stadium (without the Project)

(3) Condition after Construction of Proposed Drainage Facilities (with the Project)

Fig. R 3.2.1 Flood Depth by Two-Year Rainfall

(2) Indirect Effectiveness

(a) Economic Effectiveness

The Project will contribute to the avoidance of occurrence of economic damage because the project area encompasses commercial, tourist and public office areas.

(b) Hygienic Effectiveness

As the indirect effect of the improvement of urban drainage facilities in the Project, the prevention of occurrence and spread of epidemics due to long duration of inundation is expected.

(c) Improvement of Travel Condition

Frequent inundations block traffic in many places of Phnom Penh Capital City in the rainy season, and detours to non-inundated roads always causes traffic jams. There are many shops and government offices in the project area, and many residents commute in the morning and evening. Hence, when inundation occurs during these time zones, traffic jams become serious and the situation interferes with not only commercial operation but also administrative activities.

After the implementation and completion of the Project, inundation periods will become shorter and inundation depths will become shallower, making it easier for ordinary vehicles to pass the roads.

(d) Drainage Improvement in whole Phnom Penh

DSD’s capacity development of management and maintenance of drainage facilities will be expected after completion of the Project by equipment procurement and technical assistance by soft component. This development will contribute the improvement of drainage facilities in not only Trabek area but also whole Phnom Penh Capital City.

Hence, it is expected that positive effect by the Project will spread widely to whole Phnom Penh Capital City, and whole residents in Phnom Penh Capital City will be the recipient of the Project.