accordance with the Manning's formula. Interceptor quantities are peak flows that the collection system has to sustain.

(4) Priority Projects and Project Components

The locations of project areas in this study are shown in Figure 2.2.4. The Basic Design Study divided the study area into two (2) major areas. The north area projects, particularly, the construction of new pumping stations, are required based on geographical characteristics. Based on the technical know-how in Cambodia, it will be difficult for them to install mechanical and electrical equipment of pumping stations and to construct underground reservoirs, which is a large structure. Therefore, it is necessary for projects of the north area to be implemented under Japan's Grant Aid.

On the other, the projects of south area consist of improvement of drainage system, rehabilitation of road pavement and installation of side ditch. These projects do not need special technology from Japan or a foreign country and, conventionally, the Cambodian Government has carried out such projects in the past. In this basic design, the layout and design of drainage pipes required for the drainage improvement in this area was clarified. Therefore, if funds are obtainable, the Cambodian Government will be able to undertake these projects by itself.

As mentioned above, when the projects of the north and south areas are compared, the north area projects have a higher priority. All projects were evaluated as to the existence of important installations, relevance with other projects, and beneficial and adverse effects. The results of evaluation are summarized in Table 2.2.6.

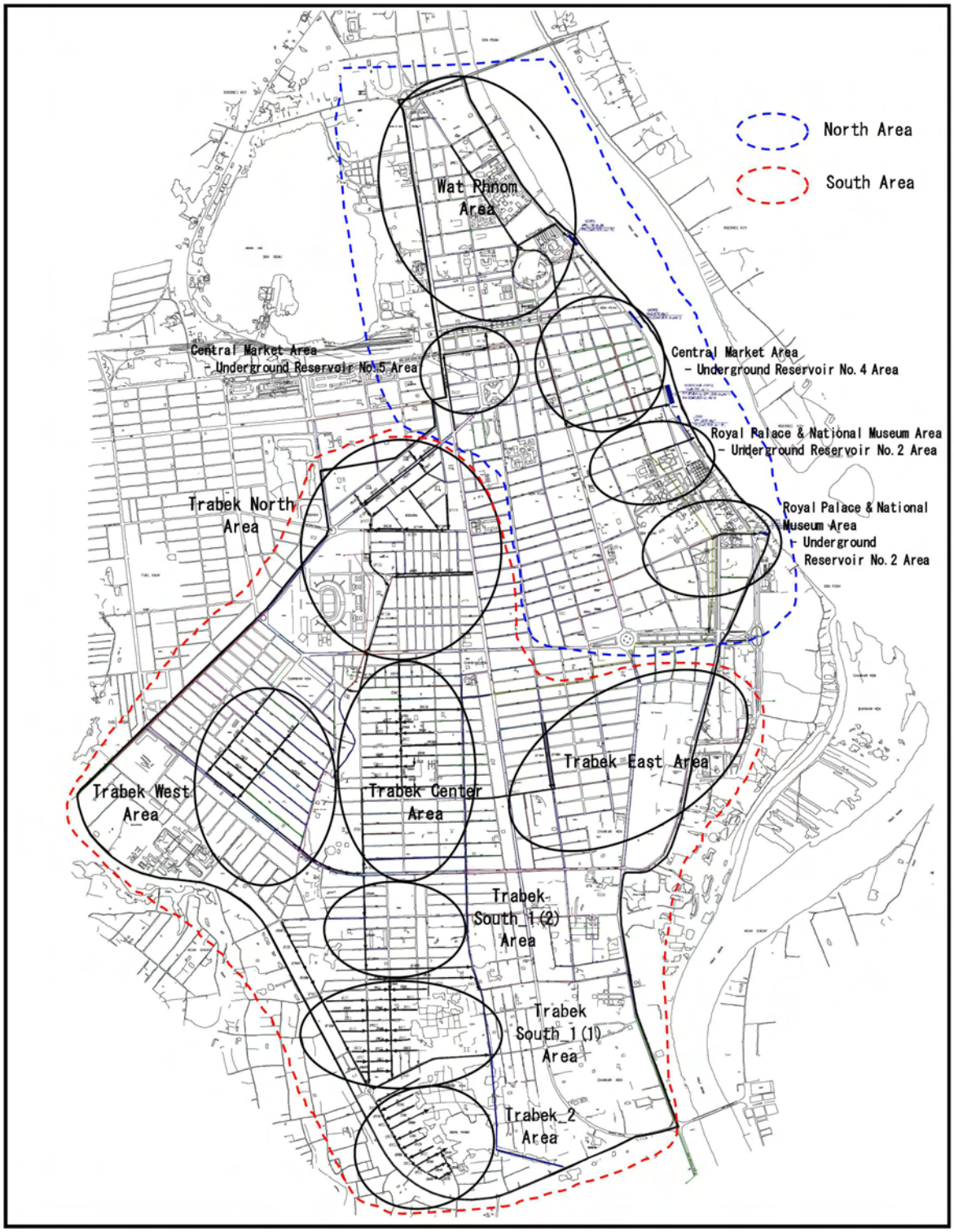


Figure 2.2.4 Location of Project Areas

Table2.2.6 Project Priority

Target Area		Present Condition	Important Facilities in the Area	Benefits and Effects	Relation with Other Projects	Comprehensive Evaluation	Priority
North Area	**Chakto Mukh Theater Revetment** (Underground Reservoir No. 1 Area)	A part of the revetment in this section collapsed in June 2006 due to circular slip caused by water rising at the beginning of rainy season, although only partial cavings were found during the site survey of Basic Design Study.	Chakto Mukh Theater and UGR1	Shore protection maintenance will prevent collapse of bank, and Phnom Penh City will be protected from floods of Tonle Sap River. UGR1 and Pumping Station will also be protected.	The revetment works is necessary to protect UGR1.	This project is required because serious influence on UGR1 will occur when shore protection repair is not carried out. Moreover, its implementation is strongly demanded by the Cambodian Government.	1
	Old Market East Revetment (Underground Reservoir No. 5 Area)	The strength of revetment was not enough against the slide force hence the concrete free frame and foundation pile were destroyed.	Restaurants, shops and parks along Tonle Sap River and UGR5	Shore protection maintenance will prevent collapse of bank, and Phnom Penh City will be protected from floods of Tonle Sap River. UGR5 and Pumping Station will also be protected.	The revetment works is necessary to protect UGR2.	It is a required enterprise when UGR5 is constructed. Moreover, its implementation is strongly demanded by the Cambodian Government.	4
	Wat Phnom Area	Inundation spreads to around Wat Phnom and it lasts for 5 to 6 hours. This area has the lowest land elevation so that damage is particularly worse.	Wat Phnom, American Embassy, MPWT and CDC*	Frequent traffic interruption in the rainy season will be minimized, and traffic will become smooth. Environmental conditions such as foul odor by rotten flood and contamination will improve.	Since the project is independent, it is possible not to undertake this project.	Not only substantial flood damage mitigation effect but public relations effect is expected from this component, because the improvement location is a notorious flood damage zone and it is where many tourists gather.	8
	Central Market Area	Inundation spreads to around the Central Market, Kandal Market, Road No. 13 and Road No. 154.					
	Underground Reservoir No. 5 Area	Central Market is the largest market in Phnom Penh City. Inundation and damage occur in the western part of the Central Market.	Central Market	Paralysis of marketing activities by floods will be eradicated and the negative economical effect will be lost. Living conditions of inhabitants and people living by the Central Market will improve, and many visiting tourists will also benefit.	Unless this project is undertaken simultaneously with UGR4 area, flood damage on the Central Market circumference will not be minimized. The plan scale of UGR4 and UGR2 will be affected.	Beneficial next to the component below.	4
	Underground Reservoir No. 4 Area	Inundation and damage occur in the eastern part of the Central Market, Kandal Market, Road No. 13 and Road No. 154.	Central Market, Kandal Market, and a number of shops and restaurants along Road Nos. 13 and 154.	Paralysis of marketing activities by floods will be eradicated and the negative economical effect will be lost. Living conditions of inhabitants and people living by the markets will improve, and many visiting tourists will also benefit.	Unless this project is undertaken simultaneously with UGR5 area, flood damage around the Central Market will not be minimized. Moreover, the plan scale of UGR2 will be affected.	The project is specifically beneficial because it will protect the Central Market, which is one of the most representative commercial areas in Cambodia.	3
	Royal Palace & National Museum Area	Inundation and damage occur around the Royal Palace and the National Museum.					
	Underground Reservoir No. 2 Area	Inundation and damage occur around the National Museum.	National Museum	Residents and visiting administration officials and tourists will benefit. The many international organizations in the area will also benefit.	If this project is not undertaken, the plan scale of UGR1 will be affected.	The National Museum is an important place in Cambodia.	6
	Underground Reservoir No. 1 Area	Flood damage occurs in the area around the Royal Palace and the Diet Building which are landmarks of Cambodia. This area is the most famous flood damage area in Phnom Penh City.	Royal Palace, Diet Building, Chakto Mukh Theater, and the Ministry of Foreign Affairs	Inundation and damage will be minimized around the Royal Palace.	Unless this project is undertaken, flood damage around the Royal Palace and the Diet Building will not be minimized.	The Royal Palace is the most important place in Cambodia. Top priority is considered to minimize flood damage in the surrounding area.	1
	Interceptor System	Currently there is no wastewater treatment plant in Phnom Penh; therefore, Tonle Sap River would be polluted by wastewater directly discharged into it.	Intake tower of PPWSA	The water pollution of Tonle Sap River will be reduced and the adverse impact to residents and fishermen along the river will be reduced. This will also be effective in the future sewer plan.	In terms of environmental consciousness in the north area, the component is indispensable.	In terms of environmental consciousness in the north area, the component is indispensable.	7
South Area	**Trabek North**	Ou Ruessei Market and adjacent area suffer from frequent flooding.	Shops and food stalls in Ou Ruessei Market and adjacent area.	Ou Ruessei Market and surrounding shops/food stalls, and many people that gather there will benefit.	Even if only this component is undertaken, there will be no influence on other projects.	The project effect is the highest in the study area on the south.	9
	Trabek West	Inundation occurs frequently on roads in the residential area.	Residential area with several schools	Floods affect the residential area minimally.	Ditto	It is a residential area and priority is low compared to areas with markets or shops.	13
	Trabek Center	Flood damage occurs along Road No. 143.	Shops along Road No. 143	Beneficial to the shops and inhabitants along Road No. 143.	Ditto	Less beneficial than the preceding component.	12
	Trabek East	Flood damage occurs along Road No. 163 and Road No. 380. Boeng Keng Kang Market is along Road No. 380.	A number of shops, offices and restaurants along Road No. 63, and Boeng Keng Kang Market	Beneficial to a number of shops, offices and restaurants along Road No. 63, as well as the workers and customers in Boeng Keng Kang Market.	Ditto	The beneficial effect is high like the Ou Ruessei Market area.	10
	Trabek South-1 (1)	Inundations occur frequently in the residential area where drainage pipe is not installed.	None	Floods affect the residential area minimally.	Ditto	It is a residential area and priority is low compared to areas with markets or shops.	14
	Trabek South-1 (2)	Inundations occur frequently in Toul Tumpung Market (Russian Market) and adjacent area due to no drainage system.	Russian Market	Many people gathering at the Russian Market and the surrounding shop/food stalls will benefit.	Ditto	Priority is lower than Ou Ruessei Market and both areas of Road No. 163.	11
	Trabek South-2	Inundations occur frequently in the residential area where drainage pipe is not installed.	New residential area	It is a developing new residential area and there are few residents so that the effect is small.	Ditto	It is residential area and the beneficial effect is the lowest in the Study Area.	15

Note *: CDC: Council for the Development of Cambodia

It has been decided to carry out only the north area project that requires special technology from Japan and where high beneficial and adverse effects are acquired based on the above evaluation. The contents of the proposed project are given in the following table.

Table 2.2.7 The Contents of the Proposed Project

Priority	Project Area	Components	Quantity	Specification
1	Royal Palace & National Museum Area - Underground Reservoir No.1 Area	Drainage Pipe	305 m	ϕ 1,800 mm (R240)
		Pumping Station	1 station	5,000 m^3/h (1.4 m^3/s) (P1)
		Underground Reservoir	1 location	870 m^3 (UGR1)
1	Chakto Mukh Theater Revetment (Underground Reservoir No. 1 Area)	Revetment Woks	70 m	
3	Central Market Area - Underground Reservoir No.4 Area	Drainage Pipe	1,394 m	539 m, ϕ 1,000 mm (Norodom) 644 m, ϕ 1,500 mm (R154) 211 m, ϕ 1,500 mm (R148)
		Pumping Station	1 station	5,000 m^3/h (1.4 m^3/s) (P4)
		Underground Reservoir	1 location	6,480 m^3 (UGR3&UGR4)
4	Central Market Area - Underground Reservoir No. 5	Drainage Pipe	822 m	454 m, ϕ 1,000 mm (Monivong) 358 m, ϕ 1,200 mm (R110) 10 m, ϕ 1,800 mm (R108)
		Pumping Station	1 station	5,00 m^3/h (1.4 m^3/s) (P5)
		Underground Reservoir	1 location	2,475 m^3 (UGR5)
4	Old Market East Revetment (Underground Reservoir No. 5 Area)	Revetment Works	260 m	
6	Royal Palace & National Museum Area - Underground Reservoir No. 2	Drainage Pipe	421 m	ϕ 1,500 mm (R178)
		Pumping Station	1 station	2,500 m^3/h (0.7 m^3/s) (P2)
		Underground Reservoir	1 location	1,200 m^3 (UGR2)
7	Interceptor Plan	Interceptor	1,818 m	251 m, B500 x H500 mm 40 m, B700 x H500 mm 363 m, ϕ 500 mm 68 m, ϕ 600 mm 1,096 m, ϕ 700 mm
8	Wat Phnom Area	Drainage Pipe	1,115 m	371 m, ϕ 1,200 mm (R51) 190 m, ϕ 1,000 mm (R19) 554 m, ϕ 1,500 mm (R19)
		Side Ditch	320 m	160 m, B500 mm x H50 mm 160 m, B500 mm x H750 mm

2.2.3 Basic Design

2.2.3.1 Improvement of Revetment

Improvement of revetment in the sections of "Old Market East Revetment" and "Chakto Mukh National Theater Revetment" shall be implemented as the following conditions.

(1) Old Market East Revetment

In consideration of the destruction reason of existing revetment, soil materials of the existing dike shall be replaced with good soil and steel sheet piles shall be installed under the base concrete of the revetment as the countermeasure of scouring. In addition, stairway shall be constructed to keep access to the landing place of local small ships and cruise ships.

(a) Crown Elevation of Base Concrete

The crown elevation of the base concrete shall be set as EL. 2.0m, higher than the low water level, and steel sheet piles shall be installed under the base concrete for the prevention of suction of the foundation soil and the scouring by the river flow.

(b) Cross Sectional Shape of Revetment

For the stability of bank slope, foundation soil shall be replaced with fine sandy soil (with the internal friction angle of 30 degrees, and unit weight of 19.0 kN/m^3). Replaced area was computed by the result of stability analysis of bank slope. Safety factor of stability analysis was set to not less than 1.20. The following three types of slope gradient of revetment were compared.

- Plan-A: Gradient = 1:2.0, set the berm at 5 m high from the base concrete
- **Plan-B: Gradient = 1:2.5, set the berm at 3 m and 6 m high from the base concrete**
- Plan- C: Gradient = 1:3.0, set no berm

As a result of comparison, Plan-B (slope gradient=1:2.5, 2 berms at 2 m wide per berm) is adopted. Detail of comparison is shown in Table 2.2.8.

Table 2.2.8 Comparison of Cross Sectional Shape of Old Market East Revetment

Item	Plan-A (Slope=1:2.0, with berm)	Plan-B (Slope=1:2.5, with berm)	Plan-C (Slope=1:3.0, no berm)
Improvement Method	Both of soil replacement and soil stabilization shall be carried out for slope stability.	Remove the broken revetment and replace existing foundation soil with fine sandy soil for slope stability.	Remove the broken revetment and replace existing foundation soil with fine sandy soil for slope stability.
Alignment	Horizontal distance from top of slope to basement is 20.0 m. Shape of slope is almost same as existing one.	Horizontal distance from top of slope to basement is 26.0 m Length of slope is 5 m longer than existing one.	Horizontal distance from top of slope to basement is 27.0 m Length of slope is 6 m longer than existing one.
Convenience	Some troubles may happen when boarding a boat because of the berm (for 4 to 5 days, 4 times in a year).	Some troubles may happen when boarding a boat because of the berm (for 4 to 5 days, 4 times in a year).	Enable smooth boarding of boat, same as present, because of no berm
Constraints of Construction	Vibration and shock by soil stabilization may give negative influence to the vicinity. Soil stabilization shall be implemented in dry season.	Coffering shall be implemented for soil replacement in elevations lower than the low water level.	Coffering shall be implemented for soil replacement in elevations lower than the low water level. Concrete placement is not easy because of long length of slope.
Maintenance	Revetment structure is divided in some parts by berm. Damage area and repairing area will be small.	Revetment structure is divided in some parts by berm. Damage area and repairing area will be small.	The damage area by differential settlement, etc. may be wide and serious because of the continuous long slope.
Economical Efficiency	Special construction equipment shall be imported for the soil stabilization. The size of coffering may be large if construction period becomes long.	Soil replacement does not require special construction equipment, hence this plan will be highly efficient and economical.	Soil replacement does not require special construction equipment, hence this plan will be highly efficient and economical.
Evaluation	The size of slope protection will be small, but soil stabilization might give negative influence to the vicinity during construction period and construction period will be long so that construction could not be completed in a dry season. Third Option	The length of slope will be longer than the existing and slope shall be gentle. Berms shall be set for slope stability. This plan will be highly efficient and economical. Considering all items to be evaluated, this plan will be best for the revetment work. Best Option	The length of slope will be almost the same as Plan-B. Access to boat will be easy because of no berm, but maintenance risk will be large when slope protection is damaged. Second Option

(c) Driving Length of Steel Sheet Pile

The driving length of steel sheet pile under base concrete shall be 8.0 m to secure the stability of steel sheet pile.

(d) Foot Protection Works

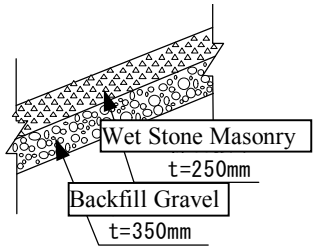
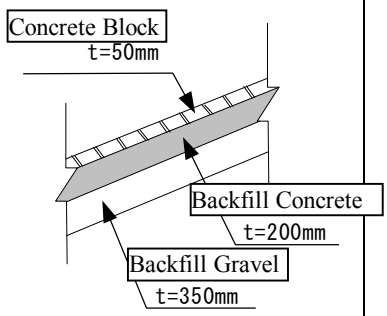
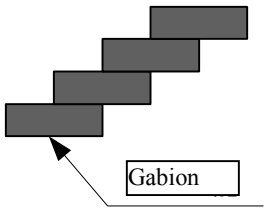
Foot protection works are installed in front of the revetment foundation to prevent riverbed scouring around the revetment foundation. Armour concrete block such as hexapod is selected for the protection works because of its good stability. The design criteria for the foot protection works are as described below.

- Armour concrete block shall have 1-ton weight considering work efficiency.
- The top elevation of foot protection works shall be the same as the top of revetment foundation. Flat zone with 2 m in width shall be designed in front of revetment foundation.
- Slope gradient of foot protection works shall be 1:1.5.
- According to the result of dynamic stability analysis, it is confirmed that armour concrete block is stable in a river under the condition of 2 m/s flow velocity.

(e) Slope Protection Works

Slope protection works shall be “Concrete Block” type, as shown in Table 2.2.9.

Table 2.2.9 Comparison of Type of Slope Protection Work

Item	Type-A: Wet Stone Masonry	Type-B: Concrete Block	Type-C: Gabion
Structure			 t=500 mm
Appearance	Deferent appearance from the protection style of upstream and downstream	Same as the protection style of upstream and downstream	Trash will be caught by wire. Appearance and sanitary conditions are bad.
Construction Time	Medium (shorter than Type-B)	Longest	Shortest
Maintenance	Easy cleaning Repairable	Easy cleaning Repairable	Trash removal and wire maintenance is necessary frequently.
Unit price	US$ 22/m^2	US$ 31/m^2	US$ 27/m^2
Evaluation	Second Option	Best Option	Second Option

(2) Chakto Mukh National Theater Revetment

In consideration of the destruction reason of existing revetment, steel sheet pile shall be installed under the base concrete of the revetment as the countermeasure of scouring.

(a) Crown Elevation of Base Concrete

The crown elevation of the base concrete shall be set as EL. 2.0 m, higher than the low water level, and steel sheet piles shall be installed under the base concrete for the prevention of suction of the foundation soil and the scouring by river flow.

(b) Cross Sectional Shape of Revetment

The present condition of existing foundation and dike in this section is much better than the condition in the section of Old Market East Revetment. According to the result of stability analysis, the present slope gradient 1:2.0 is stable (safety ratio is more than 1.2).

Design slope gradient of the revetment in Chakto Mukh National Theater shall be set as 1:2.0, and the berm shall not be set as same as the existing revetment.

(c) Driving Length of Steel Sheet Pile

The driving length of steel sheet pile under base concrete shall be 8.0 m to secure the stability of steel sheet pile.

(d) Foot Protection Works

Foot protection works are installed in front of the revetment foundation to prevent riverbed scouring around the revetment foundation. Armour concrete block such as hexapod is selected for the protection works because of its good stability. The design criteria for the foot protection works are as described below.

- Armour concrete block shall have 1-ton and 2-ton weight considering reduction of construction term because of its enormous installation amount.
- The top elevation of foot protection work shall be the same as the top of revetment foundation. Flat zone with 2 m in width shall be designed in front of revetment foundation.
- Slope gradient of foot protection works shall be 1:1.5.

(e) Slope Protection Works

Slope protection works shall be "Concrete Block" type for the same reason as the Old Market East Revetment. However, in consideration of good soil condition in this section, wet stone masonry is adopted in place of backfill concrete to reduce construction cost.

2.2.3.2 Pumping Station and Underground Reservoir

Four (4) pumping stations, namely; No. 1, No. 2, No. 4 and No. 5, and four (4) underground reservoirs, namely; No. 1, No. 2, No. 4 and No. 5, are to be constructed under the Japan's Grant Aid.

(1) Necessity of Pumping Station

During periods when river water level is low, rainwater is drained out into the river by gravity flow.

During periods when river water level is high, river water level rises up to almost the same level as the ground surface elevation. Drainage of rainwater by gravity flow becomes impossible in the latter period, so that compulsory drainage by pump is needed. Therefore, rainwater shall be

stored temporarily in the underground reservoir, then drained out into the river by pump during the period when the river water level is high.

(2) Basic Design Criteria of Pumping Station and Underground Reservoir

Rainwater is discharged through the drainage pipe network, passed through trash screen, stored in underground reservoir, and drained out into the river. The basic design criteria for pumping station and underground reservoir, such as layout, size and structure, are as described below.

(a) Major Features of Site of Pumping Station and Plan/Design Criteria

All of the pumping stations will be located mainly at the urban area of Phnom Penh City. This area has many tourist attractions such as the Chakto Mukh National Theater, the Royal Palace and the National Museum, and many residents and tourists visit here throughout the year.

Pumping stations are to be planned and designed in accordance with the following criteria:

- Plan/design of facilities/equipment shall be suitable for the surrounding landscape, etc.
  - Minimize height of building, electric substation, etc., projected above the ground level.
  - Minimize area of facilities as much as possible, since the site areas are very limited.
- Minimize construction cost of the Project, utilizing standardized civil/architectural structures and electric/mechanical equipment.
- Discharge rainwater by gravity flow as much as possible, which must result in reduction and/or minimization of electric power consumption by pumping up operation.
  - It is noted that gravity flow discharge is expected whenever water level of Tonle Sap River locates below pumping outlet. This means that gravity flow discharge will be possible during 6 months in a year between January and June.
- A pair of drainage pump having the same capacity shall be mounted on the gate of each pumping station on account of risk management, etc.

- Main power source of pumping station shall be commercial electric power, which is easily obtainable. In consideration of pump operation in case of power failure, an Emergency Diesel-Engine Drive Generator Set (EGS) shall be provided for each pumping station.

- Trash/Garbage shall be caught and removed by trash screen at entrance of the Underground Reservoir (UGR) and not to dispose them directly into the Tonle Sap River.

(b) Layout Plan/Design Criteria

- The Layout Plan of pumping station, trash screen and underground reservoir shall take the location of existing drainage outlet to Tonle Sap River into consideration.

- Trash screen is installed before entrance of underground reservoir.

- Since transfer/removal of existing facilities (house, Buddhist Temple, pumping station, electric distribution line, phone wire, water supply pipe, etc.) within the project area causes extension of construction term and increase of construction cost, those transfer/removal shall be avoided as much as possible.

- Since old/large trees are often related to a religious belief in Cambodia, they shall be preserved as much as possible.

- Since traffic/pedestrians volume in Sisowath Boulevard is large, this road shall be excluded from the construction area of the pumping station and underground reservoir. Underground reservoir shall be constructed under the greenbelt along Tonle Sap River. It is preferable that the construction space secures 10 m in width between the greenbelt and the Tonle Sap River. Minimum construction space on the ground level shall be not less than 5 m in width.

(c) Structural Plan/Design Criteria of Underground Reservoir

- The soil thickness at the underground reservoir shall be secured in consideration of the promotion of vegetation.

- Height of inside of underground reservoir shall be 10 cm higher than the maximum water level in underground reservoir (Surcharge water level: SWL), which is calculated by hydraulic analysis.

- Bottom elevation of underground reservoir shall be set at bottom elevation of connected drainpipe.

The layout plan of pumping station, trash screen and underground reservoir is as illustrated in following figure.

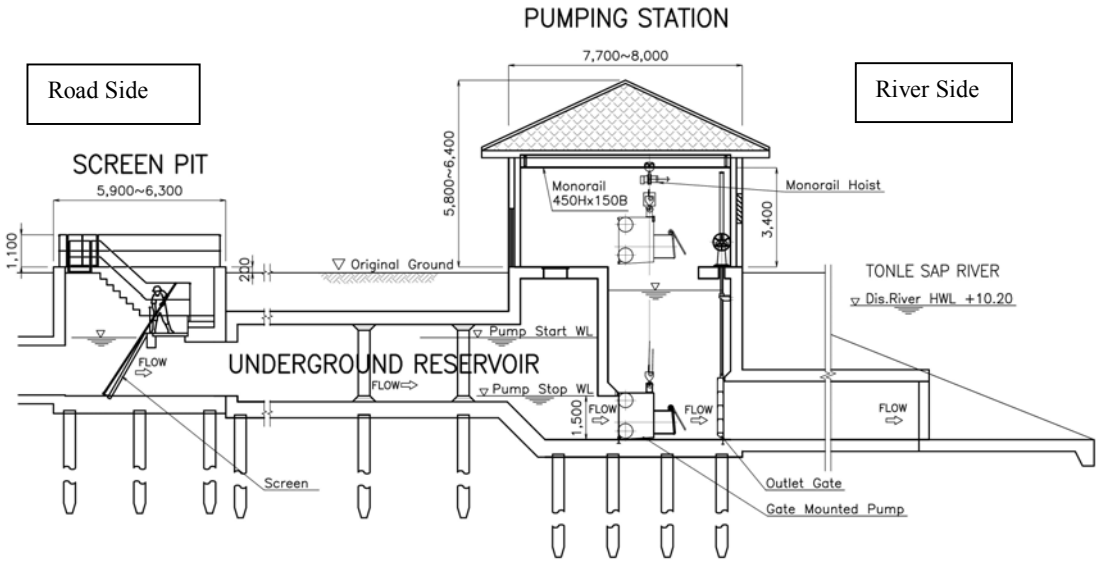


Figure2.2.5 Layout Image of Pumping Station and Underground Reservoir

(3) Major Specification of Pumping Station and Underground Reservoir

The major specification and composition of drainage facilities constructed by the Project such as pumping station and underground reservoir are as shown in the following table.

Table 2.2.10 Major Specification of Pumping Station and Underground Reservoir

Pumping Station (Discharge Capacity)	Underground Reservoir (Storage Capacity)	Nos. of Trash Screen	Nos. of Connected Drainage Pipe	Remarks
No.1 Pumping Station (1.4 m^3/s) (0.70×2 pumps)	Underground Reservoir No. 1 (870 m^3)	1	1 line	Site is in lot of Chakto Mukh National Theater.
No.2 Pumping Station (0.7 m^3/s) (0.35×2 pumps)	Underground Reservoir No. 2 (1,200 m^3)	1	1 line	-
No.4 Pumping Station (1.4 m^3/s) (0.70×2 pumps)	Underground Reservoir No. 4 (6,480 m^3)	1	2 lines	Existing Pumping Station No. 3 is also connected to Underground Reservoir No. 4.
No.5 Pumping Station (1.4 m^3/s) (0.70×2 pumps)	Underground Reservoir No. 5 (2,475 m^3)	1	1 line	-

Note: The official name of existing Pumping Station No. 3 is Preah Kumlung Pumping Station. Capacity=0.28 m^3/s (0.28×1 pump)

(4) Design of Trash Screen

The site inspection on existing drainage facilities in Phnom Penh City during the site survey in the Basic Design Study found many urban trash/waste, sewage, aquatic plants, etc., and these obstructions can easily damage the pump. Therefore, trash screen shall be set at the entrance of underground reservoir to protect pump completely from such materials.

(a) Expected Incoming Volume of Urban Trash, etc.

According to the experiential formula described in the Japanese design standard on drainage pumping station, incoming volumes of urban trash, etc., are expected as follows.

$Vg = K \times Q$

Where; Vg = Incoming volumes of urban trashes, etc. (m^3/hr)
K = Coefficient (0.2 to 0.25)
Q = Drain water volume (m^3/s)

$Q = 1.4\ m^3/s$: $Vg = (0.2 \text{ to } 0.25) \times 2 \text{ pumps} \times 0.7 = 0.28 \text{ to } 0.35\ m^3/hr$

$Q = 0.7\ m^3/s$: $Vg = (0.2 \text{ to } 0.25) \times 2 \text{ pumps} \times 0.35 = 0.14 \text{ to } 0.175\ m^3/hr$

When the operation time of the pump is assumed to be 8 hours/day, the amount of urban trash that flows in is expected to be 2.2 to 2.8 m^3 for Q=1.4 m^3/s. When the catching rate with the trash screen is assumed to be about 50%, the amount of urban trash that should be removed in a day becomes about 1.4 m^3. (The amount of urban trash that should be removed in a day becomes about 0.7 m^3 for Q=0.7 m^3/s.)

(b) Screen Pit and Trash Screen

Since there will be considerable incoming volumes of urban trashes, etc., as mentioned above, a screen pit having the slant/horizontal type trash screen must be provided at the entrance part of each underground reservoir.

Slant type screens have an angle of about 60 degrees to the horizontal plane. The screen surfaces are cleaned by one-man operated hand-rake. Those collected by such hand-rake are put into locally-made bamboo baskets and must be brought to a disposal area frequently during heavy rainfall, or periodically. The design criteria for screens are as follows:

- Hand-rake floor EL. is set as SWL -0.2 m, so that raking operation can be done even during SWL;

- The screen is provided double such as slant and horizontal type, to give ample water entrance areas for operation of the drainage pumps;
- Net clearance between screen flat bars is kept at 20 mm;
- Maximum water-head difference occurring at the rear of screen is 1.0 m; and
- The screens are of removable type for future maintenance, etc.

The main configurations of screen are shown in the table below.

Table 2.2.11 Main Configuration of Trash Screen

Pumping Stations (P.S.)	No.1 P.S.	No.2 P.S.	No.4 P.S.	No.5 P.S.	Remarks
SWL (EL. m)	8.0	8.5	9.1	9.45	
Floor (EL. m)	7.8	8.3	8.9	9.25	SWL -0.2 m
Pump Start WL (EL. m)	7.1	8.1	7.9	9.1	
Screen Pit Sill (EL. m)	5.1	6.1	6.4	7.1	
Clear Height (m)	2.7	2.2	2.5	2.15	
Slant Length (m)	3.118	2.540	2.887	2.483	60 degrees
Horizontal Screen (L.m)	1.0	1.0	1.0	1.0	
Screen Width (m)	2.0	1.5	2.4	2.7	
Quantity (set)	1	1	1	1	

(5) Design of Underground Reservoirs (UGR)

The UGR is provided at each entrance point of pumping station, so as to cut peak discharge flow and, subsequently, to reduce pump capacity. The design criteria for the UGR are as follows:

- The basic structure of UGR is the flat slab structure, which is a rigid structure consisting of slab, wall and pillar;
- Dimension of UGR is designed to secure required storage capacity calculated by the hydraulic analysis, and scale of UGR shall be minimized because of the limitation of available area;
- Height of inside of UGR is set 10 cm higher than the maximum water level (SWL) in UGR;
- Structure of UGR is designed in consideration of the buoyancy with residual underground water;

- Since bearing capacity of ground is small, foundation type of UGR shall be the pile foundation;
- In each UGR, small channel of interceptor is installed; and
- The trash screen is arranged before the entrance of UGR.

(a) Underground Reservoirs No. 1 (UGR1)

UGR1 will be located under the access road and parking lot in the Chakto Mukh National Theatre. A new line of box culvert will be installed under Road No. 240 by the Project. Rainwater will flow into UGR1 through this box culvert, and then Pumping Station No. 1 (P1) will discharge the rainwater out into the Tonle Sap River. Since there are many kinds of old and large trees in the proposed site, the layout of facilities shall take preservation of these trees into consideration. Layout and the proposed locations of P1 and UGR1 are shown in the following figure.

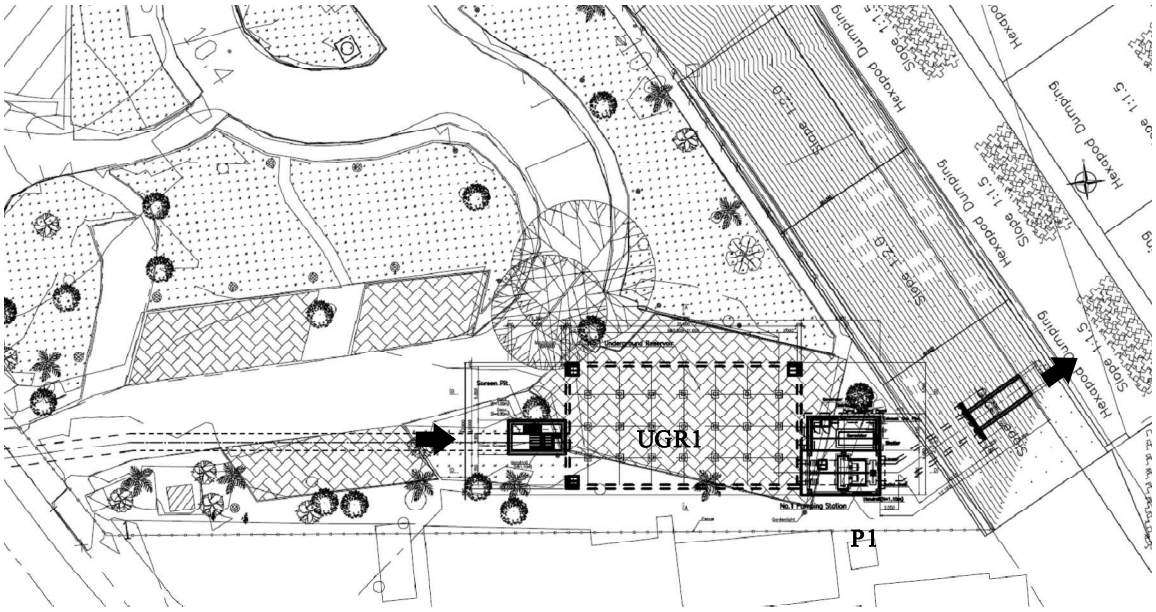


Figure 2.2.6 Layout of Underground Reservoir No. 1 and Pumping Station No. 1

(b) Underground Reservoir No. 2 (UGR2)

UGR2 will be located under a greenbelt along the riverfront of the Tonle Sap River. A drainage pipeline will be constructed under Road No. 178 and connected to UGR2 by the Project. Rainwater will flow into UGR2 through this drainage pipe, and then Pumping Station No. 2 (P2) will discharge the rainwater out into the Tonle Sap River. Screen pit shall be installed before the inlet of UGR2.

Since there is not enough space to construct the underground reservoir in the riverfront of the Tonle Sap River at the end of Road No. 178, UGR2 shall be constructed at south of small temple where width of space becomes wider, and drainage pipe shall be laid to the proposed location of UGR2. Layout and the proposed location of P2 and UGR2 are shown in the following figure.

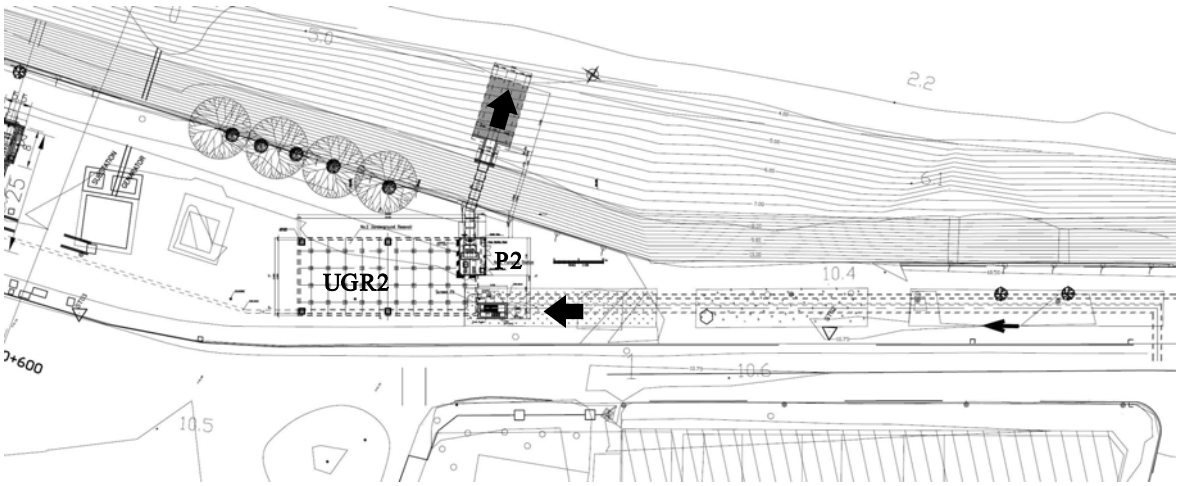


Figure 2.2.7 Layout of Underground Reservoir No. 2 and Pumping Station No. 2

(c) Underground Reservoir No. 4 (UGR4)

There are 2 lines of drainage pipe, under Road No. 148 and No. 154, near the proposed site of UGR4. The drainage pipe under Road No. 148 discharges wastewater and rainwater into the river through the existing outlet by gravity flow. The drainage pipe under Road No. 154 is connected to the existing Pumping Station No. 3 (P3), and P3 discharges the wastewater and rainwater into the river. P3 is the pumping station constructed in 2004. Gate-mounted type pump is installed in P3.

The proposed location of UGR4 is under a greenbelt along the riverfront of the Tonle Sap River between Road No. 148 and No. 154. The two lines of drainage pipe under Road No. 148 and No. 154 will be reconstructed and connected to UGR4 by the Project. Water discharged from the drainage pipe under Road No. 148 will be led toward the outlet of the drainage pipe under Road No. 154 by a water conveyance channel in the underground reservoir. The drainage pipe under Road No. 154 will be connected to the underground reservoir before the Screen Pit, which will be located just after the outlet of the drainage pipe. Rainwater stored in UGR4 will then be drained by P3 and P4 to the Tonle Sap River. Layout and the proposed location of P4 and UGR4 are shown in the following figure.

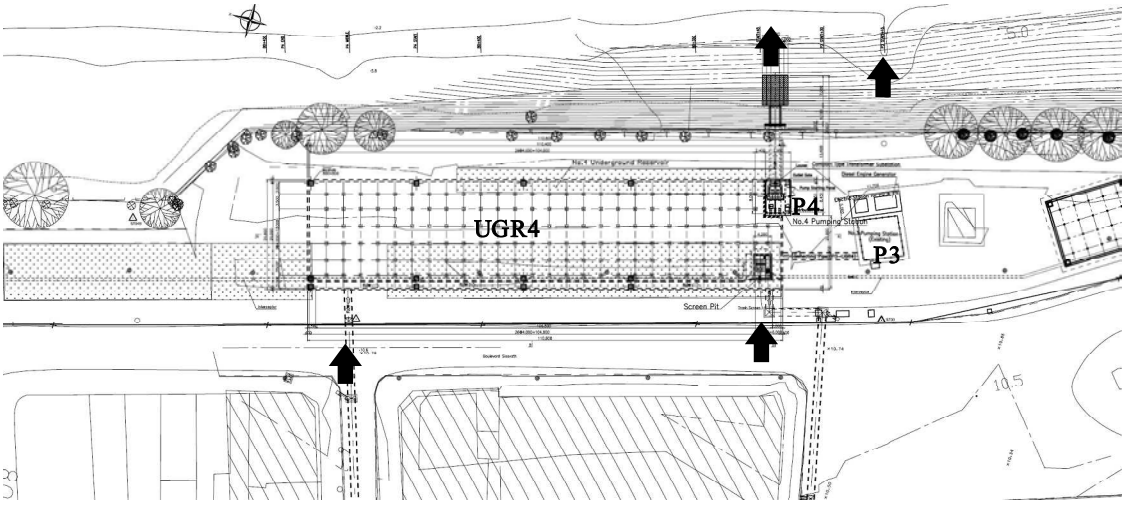


Figure 2.2.8 Layout of Underground Reservoir No. 4 and Pumping Station No. 4

(d) Underground Reservoir No. 5 (UGR5)

There is a line of drainage pipe under Road No. 108 near the proposed site of UGR5. Wastewater and rainwater in the drainage pipe are discharged into the river through the existing outlet by gravity flow.

UGR5 will be located under a greenbelt along the riverfront of the Tonle Sap River between Road No. 108 and No. 110. The drainage pipeline under Road No. 108 will be improved and connected to UGR5 by the Project. Rainwater will flow into UGR5 through this drainage pipe, and then Pumping Station No. 5 (P5) will discharge the rainwater out into the Tonle Sap River. Screen pit shall be installed just before the inlet of UGR5. Layout and the proposed location of P5 and UGR5 are shown in the following figure.

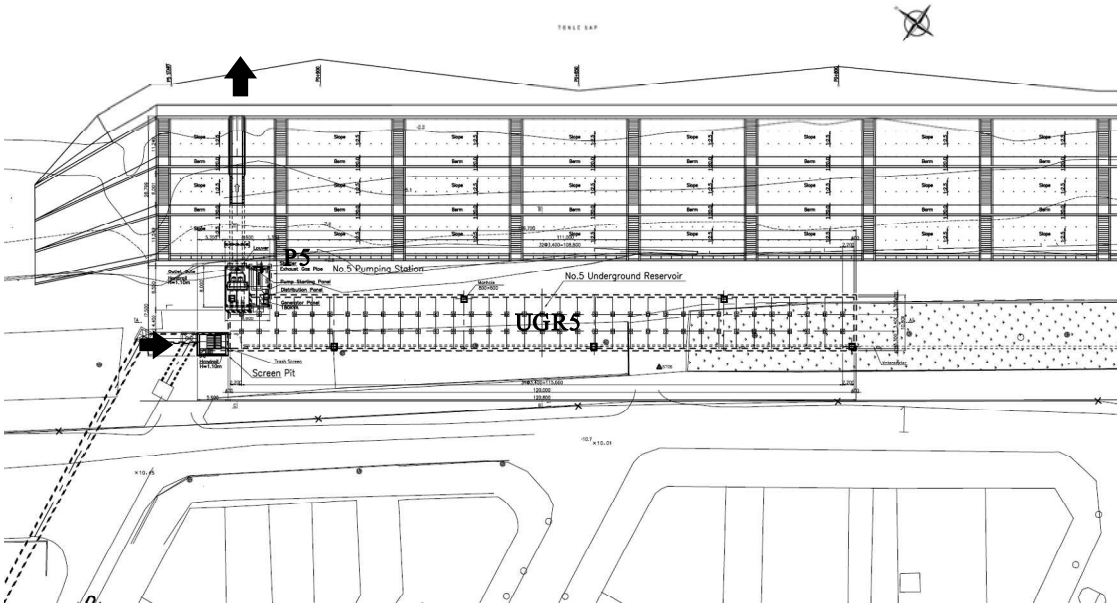


Figure 2.2.9 Layout of Underground Reservoir No. 5 and Pumping Station No. 5

(6) Outlet and Outlet Gate

Outlet gate shall be installed at the entrance of outlet to prevent influx of river water into the underground reservoir. This gate shall be closed in the case of emergency or maintenance operation of pump. Normally, an outlet gate of sluiceway is installed outside of the dike (riverside). However, the outlet gate of this project shall be installed at the entrance of outlet in pump pit (inside of the dike, landside) in consideration of structure of existing revetment and landscape. Basic design criteria for outlet and outlet gate are enumerated as follows:

- Dimension of the outlet of Pumping Station No. 2 shall be concrete pipe with diameter of 1.5 m;
- Dimension of the outlets of Pumping Station No. 1, No. 4 and No. 5 shall be concrete box culvert of 2.0 m×2.0 m;
- Outlet gate shall be the steel-made slide gate, and have 4-sealing edges; and
- Hoisting equipment of outlet gate shall be manual spindle type. Gate shall be operated by manpower.