Flood Defense Activity

The flood defense activity is another important factor in the non-physical measures. In fact, Municipality of Phnom Penh, under coordination with Ministry of Public Works and other ministries concerned, forms an ad hoc committee for flood defense during high water stage of the Tonle Mekong river system, and makes great effort to protect Phnom Penh City from being flooded.

The Master Plan considers such effort still essential to reinforce and ensure the function of facilities to be provided under the plan, particularly along the Riverfront (Tonle Sap and Tonle Bassac), Kop Srov Dike and Tompun Dike. Following are the recommendations to the present system.

(1) Concerned Agencies and Responsibility

Present flow of the flood defense activity is basically well functioning and it will be continuously applied (for detail of the present activities and condition, refer to the Interim Report). Organization and flow of the activities are illustrated in Figure D3-34.

Observation of River Water Level

The Ministry of Water Resources (former GDIMH of MAFF) carries out observation of river water stage and announces them to the related agencies and to the public. Observation is presently at one station, Chaktomuk on the Tonle Mekong. It is recommended that observation at the mouth of the Prek Phnov on the Tonle Sap and at the NR 3 crossing of the Prek Thnot is added.

Flood Warning

When river water stage comes up to the warning level, Ministry of Water Resources announces flood warning. Presently one flood warning level is determined at Chaktomuk Station on the Tonle Mekong. Application of two stages, namely Level 1 and Level 2, is recommended as explained in the article of proposed flood defense activities.

Government Decision to Prepare and Protective to Disaster

Committee in charge of Disaster under the Council of Ministers decides when to prepare and protective to the disaster, and Minister of Interior informs it to all the related agencies.

Flood Defense Activities

The Municipality of Phnom Penh appoints the personnel for Committee and Sub-Committees for Flood Protection. General organizations and tasks assigned to the Committee and Sub-Committees for Flood Protection presently applied during flooding period will be continuously applied.

Namely, under the Committee for Flood Protection, there are four Sub-Committees:

- Technique to protect flood;
- Rescue and transport;
- Finding funds, supply and social affairs; and
- Security.

Recommendation to the present system is as follows:

(a) Flood Protection Division proposed to be newly created as an institutional improvement will act as the working group for the Sub-Committee in charge of technique to protect flood. Concrete activities are explained hereafter.

(b) Organization, tasks assigned, activities for District, Sangkat, and Commune should be more clearly described.

(2) Related Laws and Regulations

Actual activities are presently well functioning, but some activities have no legal background. Necessary laws and regulations should accordingly be prepared. The following would be taken into consideration for the preparation of laws and regulations:

- A basic law on disaster measures;
- An act for flood fighting;
- A law on fire defense system (the fire defense group could work for flood fighting);
- An act for the disaster relief (for the Ministry of Health);
- Review of disaster prevention related article for the police laws; and
- Review of disaster prevention related article for the national defense related laws.

(3) Flood Defense Activities and Necessary Facilities/Equipment

The concrete procedures for the flood defense activities will be as follows:

River water stage observation

(a) Station

- Chaktomuk on the Tonle Mekong (existing station)
- River mouth of the Prek Phnov on the Tonle Sap (newly proposed)
- NR 3 Crossing of the Prek Thnot (newly proposed)

(b) Observation Frequency: Twice a day

(c) Method of Data Transmission: Radio (wireless circuit)

Warning

(a) Flood Warning Level

- Level 1: prepare for flood defense activities
- Level 2: start operation of flood defense activities

(b) To the Public General: The Minister of Water Resources gives warning using:

- TV broadcast; and
- Radio broadcast.

(c) To the Critical Area: Public announcement by patrol/warning cars and boats by Flood Protection Division

Defense Activities

Technical skills for defense activities should be trained through actual practices and drills to the personnel of concerned agencies that include; Flood Defense Division, flood defense organizations in District, Sangkat, Commune, and MPWT, MAFF, police, military, NGOs and other related agencies.

- Protection of dikes from break by floodwater
- Evacuation of residents (determination of place for evacuation, evacuation method, support to the evacuee, etc.)
- Rescue (rescue works using equipment, assurance of hospitals, etc.)

Necessary Facilities/Equipment for Flood Defense Activities

The following are the major ones of the facilities and equipment for flood defense activities. It is recommended that the Flood Protection Division under the Municipality of Phnom Penh maintains the facilities and equipment in good condition.

- Warehouse for facilities and equipment
- Patrol/sound vehicle (4-wheel drive): 5-unit
- Patrol/sound motor boat: 3-unit
- Supplies for urgent works (including, sand sacks, plastic sheet, shovels, etc.)

3.6.3 Project Cost and O/M Cost

Project Cost

Eight components, as presented in the previous Subsection 3.6.1, compose the physical measures in the Master Plan for the flood protection and drainage improvement in the Municipality of Phnom Penh. The whole project cost over the Master Plan amounts approximately US$ 261.6 million (refer to Table D3-12). The project cost of each component is estimated in the following table at the price level as of July 1, 1998:

Project Costs of Eight Components in the Master Plan

Component	Project Cost (US$ million)	Reference Table
1: Riverfront Protection in Sap Downstream Middle Section	2.3	Table D3-13
2: Reinforcement of Kop Srov and Tompun Dikes	17.8	Table D3-14
3: Tompun Watershed Drainage Improvement	88.6	Table D3-15
4: Trabek Basin Drainage Improvement	94.5	Table D3-16
5: City Core North Area Drainage Improvement	32.0	Table D3-17
6: Pochentong East Basin Drainage Improvement	11.9	Table D3-18
7: Northeast and Northwest Areas Drainage Improvement	12.1	Table D3-19
8: Environmental Enhancement	1.9	Table D3-20
Total	261.6	

O/M Cost

The operation and maintenance (O/M) cost should be taken into account for the economic evaluation of the Master Plan. Operation and maintenance for the Master Plan facilities will be done in line with the principle on the organization and institution described in Sector E. According to the principle, the annual O/M cost can be estimated by using a constant rate of 0.5 % to the total project cost of completed works at the time.

3.6.4 Implementation Schedule

The total project cost of the physical measures in the Master Plan reaches as high as US$ 261.6 million, so that the implementation must be achieved on a reasonable scheduling. Table D3-21 is an implementation schedule therefor prepared in the following considerations:

(a) Components with higher economy, commonly expressed in the economic internal rate of return (EIRR), should be implemented earlier than others. The individual EIRR of each component is as follows:

Individual EIRR and the Rank of Each Component

Component	EIRR (%)	Rank
1: Riverfront Protection in Sap Downstream Middle Section	- 0.5	6
2: Reinforcement of Kop Srov and Tompun Dikes	24.8	1
3: Tompun Watershed Drainage Improvement	11.0	2
4: Trabek Basin Drainage Improvement *	9.1	3
5: City Core North Area Drainage Improvement	5.3	4
6: Pochentong East Basin Drainage Improvement	4.8	5
7: Northeast and Northwest Areas Drainage Improvement	- 2.1	7
8: Environmental Enhancement	No tangible benefit	8
Total	12.9	-

* The construction of major facilities, Trabek pumping station and Trabek and Toul Sen drainage mains, will start in 1999 under the loan from ADB.

Note: Refer to Sector F.

(b) Disbursement amounts in each year are assumed to be around US$ 15 million in accordance with the study result on financial affordability in Sector F.

(c) In Components 3, 4 and 5, the major drainage works such as construction of pumping stations, regulation ponds and drainage mains should be followed by the sewer rehabilitation works which entail considerably high costs. This is because most drainage benefit can be realized by the construction of the major drainage works, and without furnishing such major works sewer rehabilitation could technically be meaningless. In this context, it is premised that the major drainage works be completed by year 2010 while the sewer rehabilitation by year 2020.

3.6.5 Technical Evaluation

The construction of the Master Plan projects comprises the following work items:

(a) Dikes and Revetments : Embankment, asphalt pavement, stone pitching, stone filling, etc.

(b) Pumping Stations and Sluiceways : RC structure, foundation piles, electrical and mechanical works, etc.

(c) Regulation Ponds and Open Drainage Mains : Excavation, dredging, etc.

(d) Underground Drainage Mains : Temporary works (earth retaining), excavation, RC structure, etc.

(e) Sewers : Excavation and backfilling, fabrication and furnishing of PC pipes, etc.

Cambodia has experienced construction of dikes, revetments, pumping stations, open channels and sewers by himself or under foreign assistance. No difficulty would thus be encountered in the actual construction of Master Plan projects, except for (a) the electrical and mechanical works in pumping stations and sluiceways, (b) temporary works such as earth retaining in underground drainage mains, and (c) PC pipe fabrication in sewers.

Pumps, gates and the appurtenance in Item (a) above shall be imported from a developed country, and the installation, operation and maintenance shall be supervised by engineers from such a country. Moreover, there might not be practices to date in earth retaining, with high sheet pile walls and H-beam struts, in Item (b), and fabrication of PC pipes in Item (c). Advanced technology therefor shall be introduced from neighboring countries.

In conclusion, the Master Plan can technically be justified though requiring some advanced technology.

3.7 Identification of Priority Projects

The total Master Plan, either physical or non-physical measures, has been confirmed to be economically viable (EIRR 12.9 %), financially affordable, environmentally sound and technically possible in the relevant sectors. All projects proposed in the Master Plan can be materialized by year 2020 without serious constraints. Based on such overall understanding, this Section, as the final stage of the Master Plan study, attempts to identify one or some priority project(s) to be subject to the succeeding feasibility study.

The identification of priority projects, or components in the Master Plan, will be made in line with nearly same considerations as applied to the delineation of the implementation schedule in Subsection 3.6.4. The logic for the identification is as follows:

(a) Three components, Reinforcement of Kop Srov and Tompun Dikes, Tompun Watershed Drainage Improvement, and Trabek Basin Drainage Improvement, are of higher economic viability, namely 24.8 %, 11.0 % and 9.1 % of EIRR, respectively. The others are rather low in EIRR, say less than 6 %, which can naturally be out of the priority projects.

(b) As for Trabek Basin Drainage Improvement among the three, the construction of a new pumping station and drainage mains is on schedule starting in mid-1999 under the loan from ADB. This is also omitted from the priority projects.

(c) On the other hand, Kop Srov and Tompun dikes play an important role in protecting the Municipality of Phnom Penh from floods of the Mekong river system. Once these should breach, most part of the city would go under floodwater. Taking into account its high economy as well, Reinforcement of Kop Srov and Tompun Dikes must be a component of the priority projects. Moreover, Svay Pak Drainage Sluiceway with the same nature as the dikes shall be reconstructed under this component although it was included in Component 7 in the Master Plan.

(d) The eastern half of the urbanized area of Phnom Penh is being safe from inundation through the Trabek Project financed by ADB, however the western half will yet suffer from repeated inundation. To solve this, Tompun Watershed Drainage Improvement targeting said area shall be promoted as another component of the priority projects.

In the same consideration as mentioned in Item (c) in Subsection 3.6.4, sewer rehabilitation in the drainage improvement is excluded from this component.

Summarizing the above, the priority projects to be examined in the succeeding feasibility studies are identified as follows:

- Component 2: Reinforcement of Kop Srov and Tompun Dikes
  (including reconstruction of Svay Pak Drainage Sluiceway)

- Component 3: Tompun Watershed Drainage Improvement
  (excluding sewer rehabilitation)

D4. Feasibility Study on Reinforcement of Kop Srov and Tompun Dikes

4.1 General

4.1.1 Premises and Conditions

The Project, Reinforcement of Kop Srov and Tompun Dikes (correspondent to Component 2 and a part of Component 7 in the Master Plan), aims at flood protection for a major part of Phnom Penh City against a 30-year probability of floodwater level in the Tonle Mekong river system. All the premises and major conditions established in the Master Plan are still valid in this feasibility study.

4.1.2 Sub-components of the Project

The Project, called Project A hereinafter, consists of the following four sub-components:

(a) Sub-component A1: Reinforcement of Kop Srov Dike with a length of 7.65 km

(b) Sub-component A2: Reinforcement of Tompun Dike with a length of 4.44 km

(c) Sub-component A3: Reconstruction of Svay Pak Drainage Sluiceway with a 3-lane box culvert of 1.5 m wide and 2.0 m high per each lane

(d) Sub-component A4: Preparation of Relocation Site and Spoil Area with a total area of 25 ha

Study will be made sub-component by sub-component. Facility layout for the Project is prepared in Figure D4-1.

4.2 Preliminary Design

4.2.1 Kop Srov Dike

<u>Preconditions</u>

Preconditions for the preliminary design for the reinforcement of the Kop Srov Dike are described hereunder.

(1) Design High Water Level

The design high water level along Kop Srov Dike has been set in the Master Plan at EL. 10.4 m. This value is derived from the 30-year return period floodwater level at Chaktomuk Station, EL. 10 m, adding the water level difference of 0.4 m between Chaktomuk and Kop Srov in the 1996 flood. This design high water level still hold in the present feasibility study.

(2) Design Dike Height

In the Master Plan, the design crest elevation of the dike is EL. 11.2 m constantly along the whole stretches (the design high water level, EL. 10.4 m, plus freeboard of 0.8 m to cope with wave setup). This is also valid in the succeeding study.

(3) Necessary Measures

From the standpoint of flood protection, measures necessary for the existing Kop Srov Dike are as follows:

(a) Heightening of the existing dike, whose crest elevation is EL. 10.1 m at the lowest portion, to confine the design high water level, EL. 10.4 m, throughout the dike stretch;

(b) Strengthening of the existing dike body that is damaged in many places by seepage, heavy traffic, etc.; and

(c) Pavement of the existing road surface for smooth operation of flood defense activity and easy maintenance of the dike.

Stretch to be Reinforced

The Master Plan suggested that Kop Srov Dike be reinforced in the extent of 9.0 km from the junction with NR-5. On the other hand, in-depth survey in the feasibility study stage revealed detailed topography, elevations and conditions of the existing dike. As a result, the reinforcement, comprising measures for either dike or road, is decided to be done by stretch in the manner shown in the following table:

Measures Applicable by Stretch

Section	Crest Height of Existing Dike	Possibility of Wave Setup (Necessity of Freeboard)	Condition of Existing Dike Body	Measures	
				For Dike	For Road
0+000 to 0+900 (900 m long)	EL. 10.5 to 10.7 m (higher than the design HWL EL. 10.4 m)	Not possible (another road in front of the stretch with a lot of houses and trees), then no freeboard required.	Few damaged portions exist.	Not to be constructed.	To be paved to connect the following section with NR-5.
0+900 to 7+650 (6,750 m long)	EL. 10.1 to 10.9 m (partly lower than the design HWL 10.4 m)	Possible (directly facing on a swamp area along the Prek Phnov), then a freeboard necessary.	Serious damage, such as piping holes, gullies, etc. found in many places.	To be constructed with a crest elevation of 11.2 m.	To be paved.
South from 7+650 (9,350 m long)	Above EL. 10.5 (higher than the design HWL EL. 10.4 m)	Not possible (new embankments for a temple and factories, in addition to old villages, located in front), requiring no freeboard.	No damage observed along the stretch.	Not to be constructed.	To be paved to connect the above section with NR-4.

Structure

(1) Dike Reinforcement

A dike will be provided on the outer side of the existing dike road in the section between Station 0+900 and 7+650 (6,750 m in length). This construction method of dike can achieve an about 10 % of cost reduction compared to full-width heightening of the existing dike road (refer to Subsection 3.3.4), and moreover has the following advantages:

(a) To ensure seepage prevention by filling non-permeable soil on the riverside of the existing dike;

(b) To secure smooth construction by keeping dike construction area from the existing roadway; and

(c) To minimize evacuation of houses that are much more built on the inner side of the dike *.

* Number of existing houses along Kop Srov Dike is as follows:

Section	Number of Houses	
	Outer Side	Inner Side
0+000 to 0+900	66	36
0+900 to 2+000	30	26
2+000 to 4+000	3	178
4+000 to 6+000	2	7
6+000 to 7+650	19	42
7+650 to 9+000	0	0
Total	120	289
	409	

The dike is 3 m wide on its crest, and slopes down at 1:2 on both sides with sod facing. The material of diking will be of laterite, which is suitable to control seepage so that a land side berm proposed in the Master Plan can be left out.

(2) Road Pavement

The existing road surface will be paved between the junctions with NR-5 and NR-4 (17,000 m in length). The pavement is for the following purpose:

- Easy operation of flood defense and maintenance of the dike;
- Prevention of piping holes made by seepage of rainfall on the dike crest; and
- Protection of the dike body from heavy traffic.

Considering that the road may constitute in future a part of the proposed Outer Ring Road, cross-sectional design of the road should follow Cambodian National Road Standard, namely a carriageway of 7.0 m with 1.5 m shoulders on both sides.

As for the type of pavement, three alternatives are examined: (1) Light traffic asphalt pavement, (2) High quality asphalt pavement, and (3) concrete pavement. Structure and cost of each are shown in Figure D4-2 and Tables D4-1 to D4-3. As can be seen

in the following table summarizing the study results on pavement type, most recommendable is the high quality asphalt in view of durability (in wide meaning), cost, easiness of construction and maintenance, then selected for the road pavement on Kop Srov and Tompun dikes:

Comparison on Pavement Type

Alternative	Construction Cost (US$ per m^2)	Assessment
(1) Light Traffic Asphalt Pavement	30	Most economical, but cannot bear heavy traffic expected in future. Not recommended.
(2) High Quality Asphalt Pavement	49	Reasonable cost, easy for construction and maintenance. Recommended.
(3) Concrete Pavement	70	Expensive, and difficult for construction and repairing work. Not recommended.

(3) Structural Features

The plan, profile, standard cross-sections, and cross-sections at certain intervals are shown in Figures D4-3, D4-4, D4-5 and D4-6, respectively.

4.2.2 Tompun Dike

Preconditions

Preconditions for the preliminary design for the reinforcement of the Tompun Dike are described hereunder.

(1) Design High Water Level

The design high water level along Tompun Dike has been set in the Master Plan at EL. 9.0 m. This value is derived from the 30-year return period floodwater level at Chaktomuk Station, EL. 10 m, deducting the water level difference of 1.0 m between Chaktomuk and Tompun in the 1996 flood. This design high water level hold in the present feasibility study.

(2) Design Dike Height

In the Master Plan, the design crest elevation of the dike is EL. 10.1 m constantly along the whole stretches (the design high water level, EL. 9.0 m, plus freeboard of 1.1 m to cope with wave setup). This is also valid in the succeeding study.

(3) Necessary Measures

The crown elevation of Tompun Dike ranges from EL. 10.0 m to 10.4 m, while the design dike elevation being EL. 10.1 m. No heightening is hence required and necessary measures for the 4.44 km stretch of Tompun Dike are as follows:

(a) Strengthening of the existing dike that is damaged in some places by seepage and traffic; and

(b) Pavement of the existing road surface for easy operation of flood defense and maintenance of the dike.

Structure

(1) Dike Reinforcement

Field reconnaissance in the feasibility study stage has identified existing conditions of Tompun Dike and damage incurred by the 1996 flood. The results are summarized as follows:

(a) The existing dike is 20 m and 40 m wide on its crest and foundation, respectively. The maximal water head difference between the outer and inner sides of the dike at 5 m (design high water level EL. 9 m minus the inner ground level EL. 4 m). Accordingly, the gradient of seepage water surface is 1:8, which is no steeper than even the design values applying to large rivers' dikes in foreign countries, e.g. Red River in Vietnam, Mississippi in USA, etc. This infers that piping through the dike body due to floodwater may hardly occur even at the high water stage.

(b) Seepage damage during the 1996 flood was reported in some places along Tompun Dike, however all are at the upper portion of the dike slope. Such damage may hence be attributed by rainfall leaking from the dike crest.

These considerations lead to the conclusion that:

(a) Provision of a land side berm proposed in the Master Plan is not so effective, and moreover this should bring about a huge number of house evacuation (more than 260 houses *); and

(b) Instead, pavement on the dike crest is recommended to prevent seepage from the crest to the slope surface.

* Number of existing houses along Tompun Dike is as follows:

Section	Number of Houses	
	Outer Side	Inner Side
0+900 to 2+000	159	133
2+000 to 3+000	92	60
3+000 to 4+000	92	54
4+000 to 5+300	91	16
Total	434	263
	697	

(2) Road Pavement

The existing road surface will be paved for the whole stretch of Tompun Dike with a length of 4.44 km. The pavement is for the following purpose:

- Easy operation of flood defense and maintenance of the dike;
- Prevention of piping holes made by seepage of rainfall on the dike crest; and
- Protection of the dike body from heavy traffic.

Likewise with Kop Srov Dike road, considering that Tompun Dike road may constitute in future a part of the proposed Outer Ring Road, cross-sectional design of the road should follow Cambodian National Road Standard, namely a carriageway of 7.0 m with 1.5 m shoulders on both sides. The pavement is of the high quality asphalt type.

(3) Structural Features

The plan, profile, standard cross-sections, and cross-sections at certain intervals are shown in Figures D4-7, D4-8, D4-9 and D4-10, respectively.

4.2.3 Svay Pak Drainage Sluiceway

Preconditions

Preconditions for the preliminary design for the reconstruction of Svay Pak Drainage Sluiceway are described hereunder.

(1) Purpose of Reconstruction

There exists a sluiceway passing under NR-5 about 2 km southward from the intersection to Kop Srov Dike. The sluiceway was constructed and managed by Department of Agriculture, Forestry and Fishery, MPP with function of:

- To avoid floodwater from entering into the Northeast Area, causing serious inundation over the area; and
- To control the water stage of Boeng Poungpeay area for agricultural purpose.

The sluiceway is provided with wooden gates, which however has lost water-tightness because of lack of maintenance and repair. Moreover, the civil structure itself is heavily damaged in places. Once the gate structure should breach, the Northeast Area would be under floodwater. Taking into account such importance and the existing status, the sluiceway will be re-constructed under the Project.

(2) Design High Water Levels

The design high water levels outside and inside the sluiceway site are as follows:

- Outer side (Tonle Sap River side) : EL. 10.0 m
- Inner side (Boeng Poungpeay side) : EL. 7.0 m

Structure

(1) Cross-sectional Area

In the following considerations, the total cross-sectional area of the sluiceway is determined 1.5 m wide, 2.0 m high, 3 cells equaling 9.0 m^2 in total:

Study on the Cross-sectional Area of Svay Pak Drainage Sluiceway

Consideration	Total Cross-sectional Area Required
(a) To better the drainage function, the cross-sectional area is preferable to be 2 to 3 times the existing one *.	6.8 to 10.2 m^2
(b) To drain stored water in Boeng Poungpeay area in the rainy season when the gates are closed within 2 to 3 months, the total cross-sectional area is: 45,000,000 m^3 **/ (2 to 3 month) / 0.8 m/sec.	7.2 to 10.9 m^2
(c) To easily operate a gate in manual, the size should be less than 3 m^2 and to avoid land acquisition a 3-cell culvert is the limit.	Less than 9 m^2

* 1.2 m diameter, 3 cells, equal to 3.4 m^2 in total.
** Refer to Subsection 3.4.6.

(2) Structural Features

The sluiceway is of the general type of RC gate structure with manually-operated steel slice gates. For details, refer to Figures D4-11 and D4-12.

(3) Construction Method

Cofferdams shall be provided upstream and downstream of the construction site with temporary drains. Further, relocation of NR-5 is necessary during the work, which may be shifted on the upstream cofferdam temporarily.

4.2.4 Relocation Site and Spoil Area

Land acquisition and house evacuation probably required for the implementation of the Project, estimated in this stage, are presented in Table D4-4 where those in alternative plans are also indicated for reference. No land acquisition is necessary for the construction of Sub-components A1 to A3, while house evacuation of 54 houses in the section from 0+900 to 7+650 of Kop Srov Dike. Suggested as one of the relocation sites for them is the narrow housing zone (25 ha) along a part of Kop Srov Dike which was once constructed under the assistance of UNBRO (refer to Figure D4-3).

The UNBRO area is on a low-lying land with elevations of around 6.0 m. The area has repeatedly been affected by local inundation because of the breakdown of the pump facility, so that less housing now remains in the area. The construction of Kop Srov Dike, on the other hand, will produce approximately 200,000 m^3 of excess soil. That soil can be used for raising the formation of the UNBRO area by about 1 m, then making the area free from inundation. In this regard, the UNBRO area, very close to Tompun Dike, is recommended as the spoil area for the construction.

Moreover, the raised UNBRO area can serve as the relocation site (entailing 5,400 m^2) for the 54 houses to be evacuated for the Project construction. The relocation site will be furnished with necessary infrastructures, such as roads, electricity, wells and sanitary facilities.

Finally, it is noted that right-of-way preparation and establishment of a reasonable relocation plan is an essential task of the Cambodian Government, which shall be settled prior to the actual implementation when the Government will request a foreign assistance for the Project.

4.3 Project Formulation

4.3.1 Features of Facilities

(1) Sub-component A1: Reinforcement of Kop Srov Dike

(a) Stretch : 7.65 km section southwestwards from the junction with NR-5 plus 9.35 km connecting road (see Figure D4-3)

(b) Design High Water Level : EL. 10.4 m (30-year return period)

(c) Design Dike Height : EL. 11.2 m (adding 0.8 m of freeboard)

(d) Dike Structure : Earthfill dike with a 7 m wide asphalt-paved road (see Figures D4-4 to D4-6)

(2) Sub-component A2: Reinforcement of Tompun Dike

(a) Stretch : 4.44 km section between the junctions with the Inner Ring Dike and NR-303 (see Figure D4-7)

(b) Design High Water Level : EL. 9.0 m (30-year return period)

(c) Design Dike Height : EL. 10.1 m (adding 1.1 m of freeboard)

(d) Dike Structure : 7 m wide asphalt-paved road (see Figures D4-8 to D4-10)

(3) Sub-component A3: Svay Pak Drainage Sluiceway

(a) Location : Existing Svay Pak Drainage Sluiceway (PK #9) site (see Figure D4-11)

(b) Structure : 3-lane box culvert, each 1.5 m wide and 2 m high with a steel-made slide gate (see Figure D4-12)

(4) Sub-component A4: Relocation Site and Spoil Area

(a) Location : Existing UNBRO scheme beside Kop Srov Dike (see Figure D4-3)

(b) Area : 25 ha for spoil area within which 5,400 m^2 is used as the relocation site for the Project

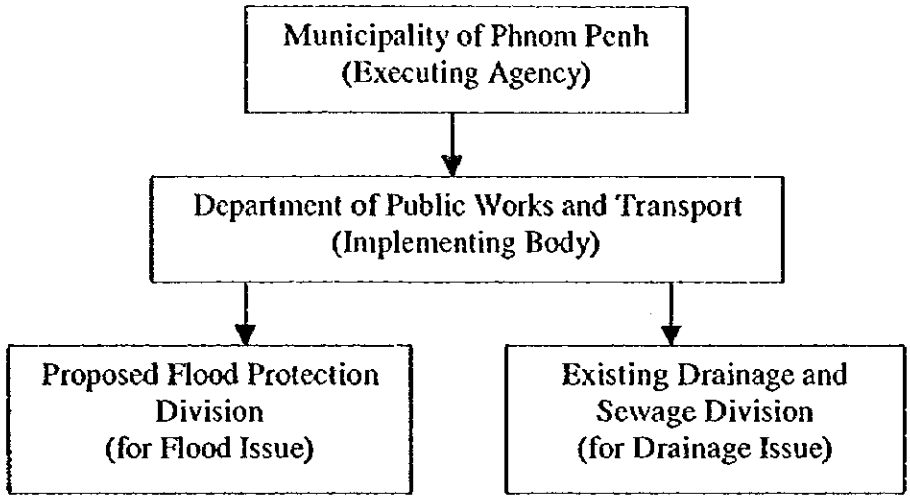
4.3.2 Procurement of Equipment and Materials

Major equipment and materials necessary for the construction of the Project "Reinforcement of Kop Srov and Tompun Dikes", along with places where they are available, are presented in Tables D4-5 and D4-6, respectively.

4.3.3 O/M Plan

Organization

The study on organization and institution compiled in Sector E has advised an organizational hierarchy (system) for the implementation of flood protection and drainage improvement projects in the Master Plan as follows:



The above system will also apply to the operation and maintenance stage. Specifically, the proposed Flood Protection Division will directly undertake the operation and maintenance of flood protection structures/facilities provided by the Project, Reinforcement of Kop Srov and Tompun Dikes as listed below:

- Earth dikes with sod facing;
- Asphalt-paved roads with laterite shoulders; and
- Three sluiceways including Svay Pak Drainage Sluiceway.

The operation and maintenance work can also be achieved by the number of staff proposed in Sector E for the newly established Flood Protection Division, whereas they must be subject to capacity building program now going on and even to be enriched in future.

Activities

The activities of Flood Protection Division should incorporate the following items:

(1) Periodical Activity

(a) Daily patrol by staffs to confirm the condition of structures, facilities and the vicinities, just visually;

(b) Biweekly inspection by engineers and staffs to investigate the function, quality and shape of each structure or facility, deeply but still qualitatively; and

(c) Seasonal checkup (twice a year before and after the rainy season) by most members of Flood Protection Division to quantitatively measure the dimensions, quality, capacity and so on of each of the structures and facilities.

(2) Emergency Activity

(a) Flood defense activity in corporation with the headquarters and district offices of the Municipality of Phnom Penh and concerned ministries, including operation of the gate structures; and

(b) Other emergency activities in case of earthquake, fire and other accidents probably affecting flood protection structures and facilities.

Necessary Equipment and Materials

The operation and maintenance work for flood protection structures and facilities will require a variety of equipment and materials. However, the Department of Public Works and Transport has owned a number of equipment listed in Table D2-4, which may be sufficient for this purpose. The equipment shall be stored in two stockyards to be provided near Kop Srov and Tompun dikes, respectively. Minor materials, like cement, gravel, sand, sand bags, timbers, logs, ropes, etc., shall be kept in warehouses to be built at intervals of about 2 km along both dikes.

4.3.4 Project Cost and O/M Cost

Project Cost

The project cost for the Reinforcement of Kop Srov and Tompun Dikes amounts at approximately US$ 20.8 million as shown in Table D4-7. The breakdown by sub-component is presented in the following table:

Project Cost for the Reinforcement of Kop Srov and Tompun Dikes

Sub-component	Project Cost (US$ million)	Reference Table
A1: Reinforcement of Kop Srov Dike	15.9	Table D4-8
A2: Reinforcement of Tompun Dike	3.2	Table D4-9
A3: Reconstruction of Svay Pak Drainage Sluiceway	1.0	Table D4-10
A4: Relocation Site and Spoil Area	0.7	Table D4-11
Total	20.8	

O/M Cost

The annual O/M cost for the Project is estimated as 0.3 % of the project cost taking account of the facilities installed.

4.3.5 Implementation Schedule

Table D4-12 shows the implementation schedule for the Reinforcement of Kop Srov and Tompun Dikes. The actual construction will initiate in 2001 and terminate in 2003 with a total construction period of 3 years. The year 2000 will be allocated for the basic and detailed design of the structures/facilities by a proper consulting firm, and land acquisition and house evacuation necessary for securing right-of-way for the construction which are a crucial task of the Municipality of Phnom Penh.

4.3.6 Technical Evaluation

The construction for the Reinforcement of Kop Srov and Tompun Dikes requires the following structures:

- Earth dikes with small heights, say 3 to 4 m, covered only with sod;
- Asphalt pavement with laterite shoulders; and
- Sluiceway composed of a 3-lane box culvert, each 1.5 m wide and 2.0 m high with a slide gate.

These structures are so simple that no technical difficulty can be encountered in designing, construction and even operation and maintenance of them. Noted here are only the following items:

(a) Soil for diking shall be transported from an adequate borrow area which can supply low permeability and high strength soil, e.g. Udon borrow area;

(b) Cofferdams and detouring of NR-5 for the construction of Svay Pak Drainage Sluiceway shall carefully be planned and operated; and

(c) Steel slide gates for the sluiceway shall be ones made in an advanced country in view of their importance.

D5. Feasibility Study on Tompun Watershed Drainage Improvement

5.1 General

5.1.1 Premises and Conditions

The Project, Tompun Watershed Drainage Improvement (corresponding to Component 3 in the Master Plan), is for the drainage improvement of Tompun Watershed (17.47 km^2), the western half of the populated area of Phnom Penh City, with a scale of a 5-year return period rainfall. All the premises and major conditions set forth in the Master Plan can hold even for this feasibility study.

5.1.2 Sub-components of the Project

The Project, called Project B hereinafter, comprises the following 13 sub-components:

(a) Sub-component B1 : Construction of Tompun New Pumping Station and Inlet Channel with a capacity of 15 m^3/sec

(b) Sub-component B2 : Construction of Tompun Regulation Pond with a total area of 47.5 ha

(c) Sub-component B3 : Improvement of Meanchey Drainage Main, Downstream Stretch, from Tompun Regulation Pond to Meanchey Bridge with a length of 2.635 km

(d) Sub-component B4 : Improvement of Meanchey Drainage Main, Middle Stretch, from Meanchey Bridge to the junction with a branch with a length of 1.285 km

(e) Sub-component B5 : Improvement of Meanchey Drainage Main, Upstream Stretch, upstream from the junction with a length of 0.535 km

(f) Sub-component B6 : Construction of Tum Nup Took Drainage Sluiceway with a capacity of 10 m^3/sec

(g) Sub-component B7 : Construction of Samdach Monireth Drainage Main, Downstream Stretch, between the junctions with Meanchey and Jawaharlal Nehru drainage mains with a length of 1.676 km

(h) Sub-component B8 : Construction of Samdach Monireth Drainage Main, Upstream Stretch, upstream from the junction with Jawaharlal Nehru Drainage Main with a length of 0.714 km

(i) Sub-component B9 : Construction of Jawaharlal Nehru Drainage Main with a length of 1.152 km

(j) Sub-component B10: Improvement of Salang Drainage Main, Downstream Stretch, from the junction with Meanchey Drainage Main to a bridge with a length of 0.887 km

(k) Sub-component B11: Improvement of Salang Drainage Main, Upstream Stretch, upstream from the bridge with a length of 0.488 km

(l) Sub-component B12: Conservation of the north lake of Boeng Salang with dredging (5.1 ha) and providing a walkway around the lake

(m) Sub-component B13: Preparation of Relocation Site and Spoil Area with a total area of 26 ha

The following study is conducted sub-component by sub-component and the facility layout of the Project is depicted in Figure D5-1.

5.2 Preliminary Design

5.2.1 Tompun Pumping Station, Inlet Channel and Regulation Pond

Preconditions

Preconditions considered for the preliminary design of the Tompun new pumping station, inlet channel and regulation pond are set as follows:

(1) Design Discharge

The design discharge with a 5-year probability of rainfall at the downstream end of Tompun Watershed, where the above structures are proposed, is 75 m^3/sec as obtained in Sector B.

(2) Capacity Allocation between Pumping Station and Regulation Pond

The combination of a pump capacity of Tompun Pumping Station and the corresponding regulation volume of Tompun Regulation Pond determined in the Master Plan is as follows:

- Pump capacity : 15 m^3/sec
- Regulation pond volume : 560,000 m^3

(3) Design Water Levels

The design water levels necessary for designing the Tompun new pumping station, inlet channel, regulation pond are listed in the following table, together with reasons why they are applied:

Water Levels Concerning Tompun Pumping Station and Related Structures

Water Level	Elevation (EL. m)	Reasons
(1) Outer Side (a) Design High Water Level (HWL)	9.00	Derived from the 30-year return period floodwater level at Chaktomuk Station, EL. 10 m, deducting the water level difference of 1 m between Chaktomuk and Tompun Dike in the 1996 flood.
(b) Normal Water Level (NWL) in the Dry Season	4.00 to 4.50	According to water level surveys.
(2) Inner Side (Regulation Pond) (a) Design Surcharge Water Level (SWL)	4.50	On account of ground elevations in vicinity.
(b) Design High Water Level (HWL)	3.70	On account of ground elevations along Meanchey Drainage Main
(c) Design Low Water Level (LWL)	3.30	To be Maintained in the rainy season
(d) Normal Water Level (NWL) in the Dry Season	About 3.30 in future (4.00 at present)	Considering the convenience for water body utilization.

Shown in Figure D5-2 is the seasonal variation of water level outside Tompun Dike estimated with several assumptions on the basis of the data at Chaktomuk Station, compared to the design water levels mentioned in the above table. Figure D5-2 indicated that the outer water level is, throughout the year even in the dry season, higher than the inner one. There is hence less possibility of gravity flow from the inner side to the outer, even in the most dry season, and no construction of a natural drainage sluiceway is recommended in the feasibility study.

Structure of Pumping Station

(1) Design Pump Head

The design pump head is determined in accordance with the following criteria:

H = (The larger of Ha or Hb) + Hl

where,

H: Design pump head (m)

Ha: (HWL on the outer side) - (SWL on the inner side)

= 9.00 m - 4.50 m = 4.50 m

HWL on the outer side: Design high water level equivalent to a 30-year recurrence floodwater level at Chaktomuk Station (EL. 9.00 m)

SWL on the inner side: Design surcharge water level of Tompun Regulation Pond (EL. 4.50 m)

Hb: ((HWL on the outer side) - (LWL on the inner side)) × 0.75

= (9.00 m -2.70 m) × 0.75 = 4.73 m

LWL on the inner side: Design low water level of Tompun Regulation Pond (EL. 2.70 m)

Hl: Pipe loss in pump facilities = 0.5 m (assumed)

Consequently, the design pump head is determined at 5.23 m (4.73 m + 0.5 m).

(2) Pump Type

Determination of the type of pumps is an essential issue on designing a pumping station. Generally, this issue governs the structure of the civil and building works of the station. Prior to detailed discussions concerning pump type selection, basic conditions and assumptions for the Project are as follows:

(a) The axial flow type of pump is suitable for design heads less than 6 m (the design pump head is actually 5.23 m) compared to the mix flow and centrifugal types of pump.

(b) Commercial electricity is applicable for the power source of Tompun New Pumping Station because a main power transmission line will soon be constructed along Tompun Dike connecting power stations with grid substations. However, backup generators against power failure should be required. The capacity of backup generators is planned at 60 % of the required total power, which can operate 3 units of 3 m^3/sec pumps. (In case of power failure when only 3 pumps work, the water stage in Tompun Regulation Pond will rise by 0.3 m over the design high water level for the design flood with a rainfall probability of 5-year.)

The following three types of pump are examined in accordance with the above conditions and assumptions:

- Axial flow vertical-shaft motor driven traditional type;
- Axial flow horizontal-shaft motor driven traditional type; and
- Submersible type.

A comparison of the three types is described in Table D5-1. As can be seen in the table, the submersible type of pump is recommended for Tompun New Pumping Station as it is economical and easy for maintenance, and further construction thereof is relatively simple and quick.

(3) Structural Features

The structural features of Tompun Pumping Station are shown in Figures D5-3 and D5-4, while the layout with the inlet channel and regulation pond in Figure D5-5. Main points of the structure of the pumping station are as follows:

(a) The capacity of the existing Tompun pumping station is ignored in planning, and Tompun New Pumping Station will be constructed on the west side with a total capacity of 15 m^3/sec, consisting of 5 pump units of 3 m^3/sec per each (submergible type).

(b) The main civil structure of the pumping station is designed without superstructure because submersible pumps can be installed outdoor. The main structure is about 24.6 m wide and 16.9 m long.

(c) An operation building yard is planned to be constructed beside the main structure, having a dimension of 12.3 m wide and 39.1 m long, to house an operating room, electric room, backup generator room, substation yard and store room.

(d) Five outlets, each made of a steel pipe, from the respective pump units will be constructed beneath Tompun Dike. A flap gate will be installed at each exit.

(e) No automatic trash removal equipment is installed at the initial stage although spaces for future installation of such equipment will be secured in the design. This is because debris would scarcely flow down to the pumping station for the time being due not only to less debris but to water hyacinth vigorously growing in the upstream channel that can considerably check flowing articles.

Structure of Inlet Channel

The inlet channel connecting to Tompun New Pumping Station is designed with the same capacity of 15 m^3/sec as the pumping station. Major features of the channel are presented hereunder.

(1) Plan

The alignment of the designed channel generally follows the existing Meanchey stream. The length of the channel is 1,020 m from Tompun New Pumping Station to the upstream end of Tompun Regulation Pond. (Refer to Figure D5-5.)

(2) Profile

Most of the channel is within the area of Tompun Regulation Pond. The bed gradient of the designed channel is set at 1/10,000. The design bed elevation varies from EL. 0.6 m at Tompun Pumping Station and EL. 0.7 m at the upstream end. (Refer to Figure D5-6.)

(3) Cross-sections

Cross-sections of the inlet channel are trapezoid-shaped with side slopes of 1:2 of earth channel. For the purposes of inspection and maintenance, roads and sidewalks are provided on both banks of the channel. On the other hand, the bank elevations in the stretch of Tompun Regulation Pond are the same as the original ground along the pond. Major features of the cross-sections resulting from hydraulic calculations are shown in Figures D5-7 and D5-8 and summarized below:

Major Features of Inlet Channel

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Freeboard (m)	Channel Width (m)
Inlet Channel	Earth channel	15	3.8	0.3	29.2

Structure of Regulation Pond

Tompun Regulation Pond is located on the existing Boeng Tompun just upstream of the new pumping station. The area is 47.5 ha, consisting of the east and west lakes sandwiching Inlet Channel (refer to Figure D5-5). The bed elevation is 3.0 m with design water levels tabulated in Item (3) of Clause "Preconditions" in this Subsection. The regulation pond will be constructed simply of small dikes and earth banks both with a slope gradient of 1:2 on which sodding will be made (refer to Figure D5-9).

5.2.2 Meanchey Drainage Main

Preconditions

Preconditions for the preliminary design of Meanchey Drainage Main is set as follows:

(1) Purpose of Improvement

Improvement of the existing Meanchey channel is an essential factor in the Project. In particular, the downstream stretch of Meanchey Drainage Main is the trunk line gathering storm water not only from its own upper reaches but from Salang and Tum Nup Toek basins (the western half of City Core). It finally leads water to the complex of a pumping station and a regulation pond at the Tompun site. Without improving the stretch, no effect can be anticipated on the drainage over Tompun Watershed.

(2) Design Discharges

The design discharges along Meanchey Drainage Main, with a return period of 5-year, calculated in Sector B are as follows:

- Meanchey Drainage Main, Downstream Stretch (0+000 to 2+635):75 m^3/sec
- Meanchey Drainage Main, Middle Stretch (2+635 to 3+920) :15 m^3/sec
- Meanchey Drainage Main, Upstream Stretch (3+920 to 4+455) :11 m^3/sec

Structure of Meanchey Drainage Main

The plan, profile and cross-sections of Meanchey Drainage Main are as follows.

(1) Plan

The alignment of the designed channel generally follows the existing Meanchey stream. The length of the channel is 4,455 m in total comprising the downstream

stretch of 2,635 m, middle stretch of 1,285 m, and upstream stretch of 535 m. (Refer to Figure D5-10.)

(2) Profile

The bed gradient of the designed channel in each stretch generally corresponds with the average bed gradient of the existing Meanchey stream which has been clarified by the topographic survey carried out from November, 1998 to February, 1999. The results are shown in Figure D5-11, which are summarized as follows:

- 1/2,500 in the downstream stretch;
- 1/2,000 in the middle stretch; and
- 1/1,000 in the upstream stretch.

To enable gravity drainage to Tompun Regulation Pond, the design bed elevation varies from EL. 0.7 m at the downstream end to EL. 3.4 m at the upstream end.

(3) Cross-sections

The cross-sections of Meanchey Drainage Main are trapezoid-shaped with side slopes of 1:2 of earth channel and 1:0.3 of masonry-reveted channel. For the purposes of inspection and maintenance, roads and sidewalks are provided on both banks of the channel. Major features of the channel resulting from hydraulic calculations are shown in Figures D5-12 and D5-13 and summarized below:

Major Features of Meanchey Drainage Main

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Freeboard (m)	Channel Width (m)
Downstream	Earth channel	75 (at DHWL) 15 (at DSWL)	3.8	0	32.4
Middle	Earth channel	15	2.5	0	13.2
Upstream	Masonry-reveted channel	11	2.0	0	4.4

Note: DHWL and DSWL mean the design high water level (EL. 3.7 m) and design surcharge water level (EL. 4.5 m) of Tompun Regulation Pond, respectively.

Structure of Tum Nup Toel Drainage Sluiceway

Tum Nup Toel Drainage Sluiceway is the facility provided beneath the Inner Ring Dike to drain storm water in the corresponding drainage basin to Meanchey Drainage Main by gravity. The detailed structure is shown in Figure D5-14.

5.2.3 Samdach Monireth and Jawaharlal Nehru Drainage Mains

Preconditions

(1) Purpose of Construction

The City Core portion of the Tompun Watershed (631 ha) consists of the following three areas:

- Boeng Salang Area : 275 ha
- Tum Nup Toek Area : 68 ha
- Remaining Area : 288 ha

Storm water in the Boeng Salang area is once stored in the existing Salang Lake and drained to Meanchey Drainage Main through Salang Drainage Main. Drainage in the Tum Nup Toek area is achieved by a sluiceway provided across the Inner Dike directly to Meanchey Drainage Main. On the other hand, there is no major drainage facilities furnished in the remaining area, which condition repeatedly causes serious inundation over the area, one of the most vigorous zones in Phnom Penh. In this case, recommended in the Master Plan is the construction of underground drainage mains along Samdach Monireth and Jawaharlal Nehru streets because of no space for providing open channels in the house-congested area. This idea still holds in the present feasibility study.

(2) Design Discharges

The design discharges of Samdach Monireth and Jawaharlal Nehru drainage mains are determined through hydrological analysis as follows:

- Samdach Monireth Drainage Main, Downstream Stretch : 44 m^3/sec
- Samdach Monireth Drainage Main, Upstream Stretch : 20 m^3/sec
- Jawaharlal Nehru Drainage Main : 8 m^3/sec

Structure of Samdach Monireth and Jawaharlal Nehru Drainage Mains

The plan, profile and cross-sections of Samdach Monireth and Jawaharlal Nehru drainage mains are as follows.

(1) Plan

The alignments of the designed drainage mains follow Samdach Monireth and Jawaharlal Nehru streets. Most part of the drainage mains is of the underground box culvert except an open channel portion joining Meanchey Drainage Main 50 m downstream of Meanchey Bridge. The total length of Samdach Monireth Drainage Main is 2,390 m comprising the downstream stretch of 1,676 m and upstream stretch of 714 m. The length of Jawaharlal Nehru Drainage Main is 1,152 m. (Refer to Figures D5-15, D5-19 and D5-20.)

(2) Profile

The longitudinal gradient of the drainage mains is constantly 1/2,000 which generally corresponds with the average gradient of the existing road surface. The design bottom elevation varies from EL. 1.7 m at the confluence with Meanchey Drainage Main to EL. 2.9 m at the upstream end of Samdach Monireth and EL. 3.6 m at that of Jawaharlal Nehru. (Refer to Figures D5-16 and D5-21.)

(3) Cross-sections

The cross-sections of the underground culverts are rectangular-shaped with one or two lane(s) depending on the design discharges. The cross-sections of the open channel are trapezoid-shaped with side slopes of 1:2 of earth channel, and for the purposes of inspection and maintenance, roads and sidewalks are provided on both banks of the channel. Major features of the channels are shown in Figures D5-17 to D5-19 and D5-22, and summarized as below:

Major Features of Samdach Monireth and Jawaharlal Nehru Drainage Mains

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Freeboard (m)	Channel Width (m)
Samdach Monireth, Outlet	Earth channel	44	3.0	0.0	20.2
Samdach Monireth, Downstream	Underground box culvert	44	3.0	0.6	4.25 (2-lane)
Samdach Monireth, Upstream	Underground box culvert	20	3.0	0.6	4.00 (1-lane)
Jawaharlal Nehru	Underground box culvert	8	2.5	0.6	2.50 (1-lane)

5.2.4 Salang Drainage Main

Preconditions

(1) Purpose of Improvement

Boeng Salang plays an important role in the retention of storm water gathering from the City Core portion of the Tompun Watershed. However, the south lake of Boeng Salang has been reclaimed in most area and encroached on by housing, resulting in diminution of its retention function although the north lake comparatively remains as it was. To compensate and control such deterioration in terms of drainage, Salang Drainage Main will be provided along the centerline of the south lake, and moreover some conservation measures are recommended to be taken in the north lake (5.1 ha). The measures comprise dredging on the lake bottom and building a walkway (the pier type of structure) along the perimeter of the lake to control house encroachment into the lake area.

(2) Design Discharge

The design discharge of Salang Drainage Main is 21 m^3/sec both for the upstream and downstream stretch.

Structure of Salang Drainage Main

The plan, profile and cross-sections of Salang Drainage Main are as follows.

(1) Plan

The alignment of the designed channel generally follows the existing Boeng Salang south lake, and joins Meanchey Drainage Main 50 m upstream of Meanchey Bridge. The total length of the channel is 1,375 m composed of the downstream stretch of 887 m and upstream stretch of 488 m. (Refer to Figures D5-23 and D5-27.)

(2) Profile

The bed gradient of the designed channel in each stretch is 1/3,000 which generally corresponds with the average bed gradient of the existing lake bottom. The design bed elevation varies from EL. 1.8 m at the confluence with Meanchey Drainage Main to EL. 2.2 m at the upstream end (Boeng Salang north lake) as shown in Figure D5-24.

(3) Cross-sections

The cross-sections of Salang Drainage Main are trapezoid-shaped with side slopes of 1:2 of earth channel and 1:0.3 of masonry-reveted channel. For the purposes of inspection and maintenance, roads and sidewalks are provided on both banks of the channel. (Refer to Figures D5-25 to D5-27.) Major features of the channel is as follows:

Major Features of Salang Drainage Main

Stretch	Type of Channel	Design Discharge (m^3/sec)	Design Water Depth (m)	Freeboard (m)	Channel Width (m)
Downstream Stretch	Earth channel	21	3.0	0	15.7
Upstream Stretch	Masonry-reveted channel	21	3.0	0	7.0

5.2.5 Relocation Site and Spoil Area

Land acquisition and house evacuation probably required for the implementation of the Project are presented in Table D5-2 where those in alternative plans are also indicated for reference. The total land acquisition and house evacuation for Sub-components B1 to B12 are 58,400 m^2 and 460 houses. As for the relocation site, one suggested by the Study Team is the proposed spoil area (26 ha) near Tompun New Pumping Station (refer to Figure D5-5). The proposed spoil area will be provided in two stages with the following respective dimensions:

Dimensions of Proposed Spoil Area

Stage	Corresponding Sub-component *	Excess Soil Volume Approximate (m^3)	Area (ha)	Formation Height (EL. m)	Embankment Height (m)
I	B1, B3, B6 and B10	250,000	10.5	6.0	2.5
II	B2, B4, B5, B7, B8, B9, B11 and B12	550,000	15.5	7.0	3.5
Total	-	800,000	26.0	-	-

Note: The existing ground elevation is around 3.5 m.
* Refer to Chapter D6.

A part of the spoil area, Stage I, will be used for the relocation site of the evacuated peoples, 480 households in total (above 460 plus 20 in the spoil area). The relocation site will require 48,000 m^2 of land complete with necessary infrastructures, such as roads, electricity, wells and sanitary facilities.

Finally, it is noted that right-of-way preparation and establishment of a reasonable relocation plan is an essential task of the Cambodian Government, which shall be settled prior to the actual implementation when the Government will request a foreign assistance for the Project.

5.3 Project Formulation

5.3.1 Features of Facilities

(1) Sub-component B1: Tompun New Pumping Station and Inlet Channel

(a) Location : On Tompun Dike, adjoining the existing pumping station to the east (see Figures D5-3 & 5-5)

(b) Pump capacity : 15 m^3/sec (3 m^3/sec x 5 units)

(c) Type of Pumps : Submergible pump

(d) Structure : Pumping station of RC structure with foundation piles, outlets with flap gates, a control house and the inlet channel (see Figures D5-4 & D5-6 to D5-8)

(2) Sub-component B2: Tompun Regulation Pond

(a) Location : Existing Boeng Tompun (see Figure D5-5)

(b) Area : 47.5 ha (total of East and West ponds)

(c) Design Surcharge Water Level : EL. 4.5 m (at the maximum storage)

(d) Design High Water Level : EL. 3.7 m (at the peak discharge of Meanchey Drainage Main)

(e) Design Low Water Level : EL. 3.3 m (to be maintained through the year)

(f) Design Bottom Height : EL. 3.0 m (see Figure D5-9)

(g) Regulation Volume : 560,000 m^3 by which 60 m^3/sec of the peak discharge can be regulated.

(3) Sub-component B3: Meanchey Drainage Main, Downstream Stretch

(a) Stretch : From Tompun Regulation Pond to Meanchey Bridge with a length of 2.635 km (see Figure D5-10)

(b) Design Discharge : 75 m^3/sec

(c) Channel Bed Gradient : 1/2,500 (see Figure D5-11)

(d) Structure : Earth channel with a side slope of 1:2 (see Figures D5-12 & D5-13)

(4) Sub-component B4: Meanchey Drainage Main, Middle Stretch

(a) Stretch : From Meanchey Bridge to the junction with a branch with a length of 1.285 km (see Figure D5-10)

(b) Design Discharge : 15 m^3/sec

(c) Channel Bed Gradient : 1/2,000 (see Figure D5-11)

(d) Structure : Earth channel with a side slope of 1: 2 (see Figures D5-12 & 13)

(5) Sub-component B5: Meanchey Drainage Main, Upstream Stretch

(a) Stretch : Upstream from the junction with a length of 0.535 km (see Figure D5-10)

(b) Design Discharge : 11 m^3/sec

(c) Channel Bed Gradient : 1/1,000 (see Figure D5-11)

(d) Structure : Masonry-riveted channel with a side slope of 1: 0.3 (see Figures D5-12 & 13)

(6) Sub-component B6: Tum Nup Toek Drainage Sluiceway

(a) Location : On the Inner Ring Dike near the existing Tum Nup Toul Pumping Station

(b) Structure : 3.0 m wide & 3.6 m high box culvert with stoplogs (see Figure D5-14)

(7) Sub-component B7: Samdach Monireth Drainage Main, Downstream Stretch

(a) Stretch : Under Samdach Monireth Street between the junctions with Meanchey and Jawaharlal Nehru drainage mains with a length of 1.676 km, at the downmost of which an outlet structure, with stoplogs, will be provided (see Figures D5-15 & D5-19)

(b) Design Discharge : 44 m^3/sec

(c) Channel Bed Gradient : 1/2,000 (see Figure D5-16)

(d) Structure : 4.25 m wide, 3.6 m high & 2 lanes (see Figures D5-17 to D5-19)

(8) Sub-component B8: Samdach Monireth Drainage Main, Upstream Stretch

(a) Stretch : Under Samdach Monireth Street upstream from the junction with Jawaharlal Nehru Drainage Main with a length of 0.714 km (see Figure D5-15)

(b) Design Discharge : 20 m^3/sec

(c) Channel Bed Gradient : 1/2,000 (see Figure D5-16)

(d) Structure : 4.0 m wide & 3.6 m high (see Figures D5-17 & 18)

(9) Sub-component B9: Jawaharlal Nehru Drainage Main

(a) Stretch : Under Jawaharlal Nehru Street with a length of 1.152 km (see Figure D5-20)

(b) Design Discharge : 8 m^3/sec

(c) Channel Bed Gradient : 1/2,000 (see Figure D5-21)

(d) Structure : Box culvert, 2.5 m wide & 3.1 m high (see Figures D5-17 & 5-22)

(10) Sub-component B10: Salang Drainage Main, Downstream Stretch

(a) Stretch : Along the existing Boeng Salang south lake from the junction with Meanchey Drainage Main to a bridge with a length of 0.887 km, at the downmost of which an outlet structure, with stoplogs, will be constructed (see Figures D5-23 &D5-27)

(b) Design Discharge : 21 m^3/sec

(c) Channel Bed Gradient : 1/3,000 (see Figure D5-24)

(d) Structure : Earth channel with 1:2 of side slopes (see Figures D5-25 to D5-27)

(11) Sub-component B11: Salang Drainage Main, Upstream Stretch

(a) Stretch : From the bridge to the existing Boeng Salang north lake with a length of 0.488 km (see Figure D5-23)

(b) Design Discharge : 21 m^3 /sec

(c) Channel Bed Gradient : 1/3,000 (see Figure D5-24)

(d) Structure : Masonry-reveted channel with 1:0.3 of side slopes (see Figures D5-25 & D5-26)

(12) Sub-component B12: North Lake of Boeng Salang

(a) Location : Existing Boeng Salang north lake (see Figure D5-

23)

(b) Structure : Dredging of 5.1 ha and provision of a walkway around the lake

(13) Sub-component B13: Relocation Site and Spoil Area

(a) Location : West side of the Tompun New Pumping Station (see Figure D5-5)

(b) Area : 26 ha for spoil area within which 48,000 m^2 is used as the relocation site for the Project

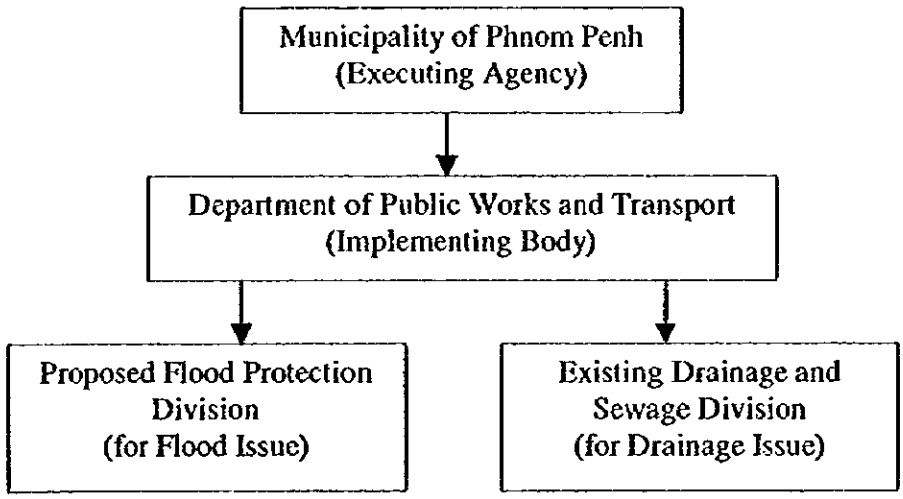
5.3.2 Procurement of Equipment and Materials

Major equipment and materials necessary for the construction of the Project "Tompun Watershed Drainage Improvement", along with places where they are available, are presented in Tables D5-3 and D5-4, respectively.

5.3.3 O/M Plan

Organization

The study on organization and institution compiled in Sector E has advised an organizational hierarchy (system) for the implementation of flood protection and drainage improvement projects in the Master Plan as follows:



The above system will also apply to the operation and maintenance stage. Specifically, the existing Drainage and Sewage Division will directly be in charge of the operation and maintenance of drainage structures/facilities provided under the Tompun Watershed Drainage Improvement Project as listed below:

- Pumping station with 5 units of 3 m^3/sec submergible pumps;
- Open drainage mains and regulation ponds;
- Underground drainage mains of box culvert type; and
- Three sluiceways with stop logs.

The operation and maintenance work can be fulfilled by the present number of staff in Drainage and Sewage Division presented in Sector E, although some additional engineers shall be assigned for the operation and maintenance of Tompun Pumping Station, say one civil and two mechanical/electrical engineers.

Activities

The activities of Drainage and Sewage Division should incorporate the following items:

(1) Periodical Activity

(a) Daily patrol by staffs to confirm the condition of structures, facilities and the vicinities, just visually;

(b) Biweekly inspection by engineers and staffs to investigate the function, quality and shape of each structure or facility, deeply but still qualitatively; and

(c) Seasonal checkup (twice a year before and after the rainy season) by most members of Drainage and Sewage Division to quantitatively measure the dimensions, quality, capacity and so on of each of the structures and facilities.

(2) Emergency Activity

(a) Flood defense activity in corporation with the headquarters and district offices of the Municipality of Phnom Penh and concerned ministries, including operation of the pumps and stoplogs; and

(b) Other emergency activities in case of earthquake, fire and other accidents probably affecting drainage structures and facilities.

Necessary Equipment and Materials

The operation and maintenance work for drainage structures and facilities will require a variety of equipment and materials. However, the Department of Public Works and Transport has owned a number of equipment listed in Table D2-4, which may be sufficient for this purpose. The equipment shall be stored in a stockyard to be provided near Tompun Pumping Station. Minor materials, like cement, gravel, sand, sand bags, timbers, logs, ropes, etc., shall be kept in warehouses to be built at intervals of about 2 km along the drainage mains.

5.3.4 Project Cost and O/M Cost

Project Cost

The project cost for the Tompun Watershed Drainage Improvement amounts at approximately US$ 50.8 million as shown in Table D5-5. The breakdown by sub-component is presented in the following table:

Project Cost for the Tompun Watershed Drainage Improvement

Sub-component	Project Cost (US$ million)	Reference Table
B1: Tompun New Pumping Station and Inlet Channel	11.5	Table D5-6
B2: Tompun Regulation Pond	3.6	Table D5-7
B3: Meanchey Drainage Main, Downstream Stretch	3.8	Table D5-8
B4: Meanchey Drainage Main, Middle Stretch	0.5	Table D5-9
B5: Meanchey Drainage Main, Upstream Stretch	0.5	Table D5-10
B6: Tum Nup Toek Drainage Sluiceway	0.7	Table D5-11
B7: Samdach Monireth Drainage Main, Downstream Stretch	16.3	Table D5-12
B8: Samdach Monireth Drainage Main, Upstream Stretch	3.7	Table D5-13
B9: Jawaharlal Nehru Drainage Main	4.1	Table D5-14
B10: Salang Drainage Main, Downstream Stretch	1.3	Table D5-15
B11: Salang Drainage Main, Upstream Stretch	0.6	Table D5-16
B12: North Lake of Boeng Salang	0.7	Table D5-17
B13: Relocation Site and Spoil Area	3.5	Table D5-18
Total	50.8	

O/M Cost

The annual O/M cost for the Project is estimated as 0.5 % of the project cost taking account of the facilities installed.

5.3.5 Implementation Schedule

The implementation schedule for the Tompun Watershed Drainage Improvement is shown in Table D4-12, where that for the Reinforcement of Kop Srov and Tompun Dikes is also presented. The actual construction of the Project will initiate in 2001 and end in 2007 with a total construction period of 7 years. The year of 2000 will be shared for the basic and detailed design of the structures/facilities in the Project, and the land acquisition and house evacuation by the Municipality of Phnom Penh.

5.3.6 Technical Evaluation

The project of the Tompun Watershed Drainage Improvement entails the following structures and construction:

(a) Pumping station, of 5 units of 3 m^3/sec submergible pumps, at the Tompun site, associated with outlet pipes and an operation house;

(b) Lake excavation and dredging on existing lakes, i.e. Boeng Tompun and Boeng Salang;

(c) Existing open channel improvement, comprising widening and deepening, some with stone-masonry revetments; and

(d) Underground box culverts, one- or two-lanes, beneath existing major roads.

The construction of a pumping station, among the above, might be rather complicated, and necessitate some advanced technology. In particular, submergible pumps, valves and the

appurtenance shall be imported from a developed country, and the installation, operation and maintenance of them shall be supervised by engineers from such a country. Moreover, with regard Item (d) above, since there are no practices in Cambodia pertaining to earth retaining in a part of the temporary works, requiring high sheet pile walls and H-beam struts, advanced technology therefor shall be introduced from neighboring countries. However, as a whole, the construction of the Project can go well without no definite technical problems.

D6. Possible Urgent Projects

The feasibility study on each of the two projects, A: Reinforcement of Kop Srov and Tompun Dikes, and B: Tompun Watershed Drainage Improvement, has been achieved and completed as presented in Chapters D4 and D5. The study gives a cost estimation: that is $ 20.8 million for the former and $ 50.8 million for the latter, totaling as huge as $ 71.6 million. In such case, it is natural to schedule a stepwise implementation of the entire projects. The next table shows the evaluation results of the urgency of each sub-component using "High", "Medium" and "Low", along with its construction cost and compensation required, under the following considerations:

- Project A has an economic return as high as 25.2 % of EIRR, and each sub-component therein is indispensable to protect the major part of Phnom Penh from flooding caused by the Mekong river system. All four sub-components in Project A are hence ranked "High" in urgency.
- As for Project B, sub-components located downstream should be implemented ahead in general consideration. Sub-components B1 and B3 are hence assessed "High", while Sub-component B2, also situated downstream, "Medium" since the existing Boeng Tompun has about 70 % of regulation capacity compared with the proposed regulation pond.
- The preparation of a relocation site/spoil area (Sub-component B13) must be "High" to secure the succeeding construction works.
- Sub-components B6 and B10 can achieve drainage in the City Core portion of Tompun Watershed to a fair extent at minimal cost, so that the two sub-components are evaluated also "High".
- Sub-components B7 to B9 will play an important role in the drainage of the City Core portion, however they entail a cost as large as US$ 24.1 million (nearly half of the total cost of Project B) and are classified "Medium".
- The other sub-components located in upstream reaches with less beneficiary, Sub-components B4, B5, B11 and B12, are rated "Low" in urgency.

Urgency of Each Sub-component in Project A: Reinforcement of Kop Srov and Tompun Dikes, and Project B: Tompun Watershed Drainage Improvement

Sub-component	Rank of Urgency	Construc-tion Cost ($ mill.)	Compensation Required	
			Land Acquisition (m^2)	House Evacuation (house)
Project A: Reinforcement of Kop Srov and Tompun Dikes (EIRR = 25.2 %)				
A1: Kop Srov Dike	High	15.9	0	54
A2: Tompun Dike	High	3.2	0	0
A3: Svay Pak Drainage Sluiceway	High	1.0	0	0
A4: Relocation Site/Spoil Area	High	0.7	250,000	0
Total	-	20.8	250,000	54
Project B: Tompun Watershed Drainage Improvement (EIRR = 11.7 %)				
B1: Tompun New Pumping Station and Inlet/Outlet Channels	High	11.5	5,000	30
B2: Tompun Regulation Pond	Medium	3.6	20,000	20
B3: Meanchey Downstream	High	3.8	28,000	90
B4: Meanchey Middle	Low	0.5	0	120
B5: Meanchey Upstream	Low	0.5	0	10
B6: Tum Nup Toek Drainage Sluiceway	High	0.7	3,000	10
B7: Samdach Monireth Downstream	Medium	16.3	2,400	30
B8: Samdach Monireth Upstream	Medium	3.7	0	0
B9: Jawaharlal Nehru	Medium	4.1	0	0
B10: Salang Downstream	High	1.3	0	60
B11: Salang Upstream	Low	0.6	0	90
B12: Boeng Salang	Low	0.7	0	0
B13: Relocation Site/Spoil Area	High	3.5	260,000	20
Total	-	50.8	318,400	480

Note: The overall EIRR is 16.7 %.

From the table above, suggested as sub-components that should be realized in the earlier stage of the two projects are the following:

(1) In Project A: Reinforcement of Kop Srov and Tompun Dikes

(a) Sub-component A1: Reinforcement of Kop Srov Dike;
(b) Sub-component A2: Reinforcement of Tompun Dike;
(c) Sub-component A3: Reconstruction of Svay Pak Drainage Sluiceway; and
(d) Sub-component A4: Preparation of Relocation Site/Spoil Area.

(2) In Project B: Tompun Watershed Drainage Improvement

(a) Sub-component B1: Construction of Tompun New Pumping Station and Inlet Channel;
(b) Sub-component B3: Improvement of Meanchey Drainage Main, Downstream Stretch;
(c) Sub-component B6: Construction of Tum Nup Toek Drainage Sluiceway;
(d) Sub-component B10: Improvement of Salang Drainage Main, Downstream Stretch; and
(e) Sub-component B13: Preparation of Relocation Site/Spoil Area.

Table D2-1 Characteristics of Each Basin (1/3)

Name of Basin	Area (km^2)	Characteristics
CITY CORE	(25.29)	
C1: Wat Phnom Basin	0.89	- Offices, hotels, houses, etc. densely located. - This area is the highest portion (over EL. 10.5 m) and local runoff drained to the Tonle Sap River by gravity.
C2: Kak Lakeshore Basin	0.51	- Offices, a hospital, French embassy, houses, etc. situated. - Local runoff drained to Boeng Kak.
C3: Boeng Kak Basin	1.14	- Lake area which will be a recreational zone in the city. - Water discharges northwards to E1 area.
C4: Tuol Kork Basin	3.32	- New housing area with high to medium density. - Runoff drained out by 2 pumping stations and by gravity.
C5: University Basin	0.71	- University zone and ponds/swamps of a slender shape. - Runoff reserved therein due to its low topography.
C6: Bassac Riverside Basin	1.58	- Hotels, offices, embassies, factories, etc. located and a lot of squatters spread in the river front. - Local runoff drained directly to the Tonle Bassac River.
C7: Trabek Basin	10.83	- Urban center shares its upstream reaches and dense residential area its downstream ones. - Local runoff drained out through open channels and by Trabek pumping station to Boeng Cheung Ek. A major watershed in the City Core.
C8: Salang Basin	5.53	- Urban center located upstream and dense residential area downstream with a new urban scheme in Salang area. - Local runoff drained by pumps and by gravity outside Inner Ring Dike, led to Tompun pumping station. Another important watershed in the City Core.
C9: Tum Nup Toek Basin	0.68	- Small but dense residential area inclusive. - Local runoff drained by pumps outside Inner Ring Dike.
C10: Toek Laak Basin	0.10	- ditto-

Table D2-1 Characteristics of Each Basin (2/3)

Name of Basin	Area (km^2)	Characteristics
NORTHEAST AREA	(40.23)	
E1: Poungpeay East Basin	13.53	- Many developments (mainly factories) found in the southern part, while fishponds still in the north. - This area divided into some ten portions by road/railway embankments with drain pipes. Runoff drained out to E2.
E2: Boeng Poungpeay Basin	24.18	- Lake/swamp area whose perimeter is already intruded by developments (factories, sand mining, etc.) in places. - All runoff from Northeast and Northwest areas gathers herein, discharging to the Tonle Sap River through a sluiceway at Syay Pek.
E3: Krom Sala Basin	1.25	- Farmland and fishponds occupy with some housing. - Local runoff directly led to the Tonle Sap River through a pipe culvert.
E4: Sap Riverside Basin	1.27	- Narrow strip facing the Tonle Sap River with factories, workshops, schools, shops, shanties, etc. located. - Local runoff drained directly to the Tonle Sap River.
NORTHWEST AREA	50.79	- Farmland with small villages scattering. - Rainfall mostly reserved in the paddy fields and storage ponds for irrigation, then less flow down into the Northeast Area.
MIDDLE AREA	(38.80)	
M1: Tompun Basin	11.16	- Many houses found on the highland and they encroach on the ex-swamp area around Boeng Tompun. - Flood prevented by Tompun dike and runoff from C8, C9, C10, M1, M2 & M3 areas drained here by pumps.
M2: Pochentong East Basin	15.35	- This is a newly developed area. The airport, factories, warehouses, offices, schools, shops and houses located with decreasing farmland left in the center. - Local runoff drained by gravity towards the east (to Tompun Basin) and by pumps towards the south.
M3: Pochentong West Basin	11.59	- Villages still scatter on farmland, however large-scale constructions (e.g. for a dry port) start in places. - Local runoff drained to the Pochentong Airport direction and to Northwest Area.
M4: Prey Pring Basin	0.70	- Village with farmland occupies. - Local runoff naturally drained outside the Study Area

Table D2-1 Characteristics of Each Basin (3/3)

Name of Basin	Area (km^2)	Characteristics
SOUTH AREA	(40.60)	
S1: BOT Road South Basin	6.46	- Factories rapidly develops with reclamation works. Along the southern border of this area, a road bypass planned (named Tompun extension). - Runoff drained to the south.
S2: Prey Sar Basin	34.14	- Farmland and villages spread with less development. - Flood enters through 3 openings from the outside of the Study Area (from the Prek Thnot River), and runoff drained through the openings.
Total	195.71	-

Table D2-2 Major Crossings (1/2)

No.	Structures	Dimension	Road/Railway Surface EL (m)	Invert/Bottom EL (m)	Description/Note
1.National Road No.303(NR303)					
NR303-1	Bridge	L=100m,B=7.5m	12.6	5.0	R.C girder bridge
NR303-2	Gate Slot	B=2mx6			
	Bridge	L=15m,B=5m,6-span	9.9	6.8	Steel girder bridge
NR303-3	Pipe Culvert	ϕ 800x3,L=17m	9.5	7.9	Concrete pipes
2.Prey Sar Road(PS)					
PS-1	Bridge	L=23m,B=3.7m,5-span	10.1	6.8	R.C girder
PS-2	Pipe Culvert	ϕ 1000,L=8m	9.3	7.1	Concrete pipe. Gate slot at downstream side.
PS-3	Box Culvert	H=1.7m,B=1.4m,L=7m	12.0	10.0	Constructed diagonally to road
PS-4	Box Culvert	H=1.5m,B=1.4m,L=5m	12.0	10.2	Gate slot at upstream side
PS-5	Pipe Culvert	ϕ 1000,L=7m	12.5	10.8	Concrete pipe
3.National Road No.3(NR3)					
NR3-1	Pipe Culvert	ϕ 400x2,L=8m	13.6	11.6	Concrete pipe
NR3-2	Bridge	L=6.8m,B=7.5m,3-span			Concrete bridge
	Gate Slot	H=2.6m,B=1.5mx3	13.5	10.9	For drainage purpose
NR3-3	Pipe Culvert	ϕ 800,L=12m	13.5	11.5	Concrete pipe
NR3-4	Pipe Culvert	ϕ 1000,L=10.5m	13.4	11.1	Concrete pipe
NR3-5	Pipe Culvert	ϕ 1000,L=10m	13.4	11.0	Concrete pipe
NR3-6	Pipe Culvert	ϕ 1000x2,L=11m	13.4	11.4	Concrete pipe
NR3-7	Pipe Culvert	ϕ 1000x2,L=10m	11.9	10.1	Concrete pipe installed under NR3
	Pipe Culvert	ϕ 800,L=14.1m	12.1	10.5	Concrete pipe connecting to the airport
NR3-8	Pipe Culvert	ϕ 600	-	-	Not found at site
4.Kop Srov Road(KS)					
KS-1	Pipe Culvert	ϕ 600x2,L=12m	14.2	12.8	Concrete pipes
KS-2	Pipe Culvert	ϕ 600x2,L=12m	13.6	12.0	Concrete pipes
KS-3	Pipe Culvert	ϕ 600x2,L=12m	14.0	12.4	Concrete pipes
KS-4	Pipe Culvert	ϕ 600x2,L=12m	13.8	12.2	Concrete pipes
KS-5	Pipe Culvert	ϕ 600x2,L=12m	-	-	Concrete pipes
KS-6	Box Culvert	H=1.0m,B=1.0m,L=10m	-	-	Gate installed at upstream side for irrigation intake
KS-7	Pipe Culvert	L=16m, ϕ unknown	-	-	Completely buried
KS-8	Box Culvert	H=1.2m,B=1.2m,L=30m	10.7	7.5	Gate installed at upstream side for irrigation intake, inverted siphon crosses under the culvert
KS-9	Box Culvert	H=1.0m,B=1.0m,L=11m	10.7	7.4	Gate installed at upstream side for irrigation intake
5.National Road No.5(NR5)					
NR5-1	Pipe Culvert	ϕ 1200,L=120.2m	10.4	4.2	3 manholes are provided, of which 1 manhole has gate.
NR5-2	Pipe Culvert	ϕ 1200x3,L=22.2m	11.1	2.7	Wooden gates are installed at both upstream and downstream sides
6.BOT Road(BOT)					
BOT-1	Pipe Culvert	ϕ 800,L=20.9m	10.1	8.6	Concrete pipe broken
BOT-2	Pipe Culvert	ϕ 700x2,L=12.9m	10.2	8.8	Concrete pipes
BOT-3	Pipe Culvert	ϕ 800x5,L=23m	10.6	7.4	Concrete pipes, gates installed at upstream side
7.Railway(RW)					
RW-1	Box Culvert	H=1.2m,B=1.2mx2,L=10m	11.1	8.7	R.C structure
RW-2	Pipe Culvert	ϕ 1000,L=9m	10.2	7.8	Concrete pipe
RW-3	Box Culvert	H=1.6m,B=1.4mx2,L=11m	10.6	7.9	R.C structure
RW-4	Pipe Culvert	ϕ 1000,L=9m	10.8	8.4	Concrete pipe
RW-5	Pipe Culvert	ϕ 1000,L=11m	10.7	8.5	Concrete pipe, buried in half
RW-6	Box Culvert	H=1.0m,B=1.0m,L=20m	10.4	8.4	Covered by bush

Note: Road/Railway surface and Invert/Bottom elevations shown on this table are assumed based on the 1/2,000 topographic maps and the results of site reconnaissance.

Table D2-2 Major Crossings (2/2)

No.	Structures	Dimension	Road/Railway Surface EL.(m)	Invert/Bottom EL.(m)	Description/Note
8.Khmuomb Road(KH)					
KH-1	Pipe Culvert	ϕ1600,L=20m	8.8	5.2	Concrete pipe
KH-2	Box Culvert	H=1.0m,B=1.0m,L=10m	9.9	8.6	For irrigation channel abandoned. 2gates installed at upstream side
KH-3	Pipe Culvert	ϕ600,L=14m	8.1	7.2	Concrete pipe (installed under old road)
	Pipe Culvert	ϕ1600,L=13m	8.3	7.2	Corrugated pipe (installed under new road)
KH-4	Pipe Culvert	ϕ600,L=8m	8.5	7.6	Concrete pipe
KH-5	Pipe Culvert	ϕ1500,L=16m	8.5	5.9	Concrete pipe for intake of irrigation pumping station
KH-6	Pipe Culvert	ϕ800,L=12m	8.4	7.1	Concrete pipe
KH-7	Pipe Culvert	ϕ600,L=11m	8.8	7.6	Concrete pipe
KH-8	Gate Structure	H=3.5m,B=1.4m×3	10.0	6.5	Gates installed at downstream side
9.North East Area(NE)					
NE-1	Pipe Culvert	ϕ1500,L=14m	7.3?	5.9	Concrete pipe broken
NE-2	Pipe Culvert	ϕ1100,L=11m	8.2	5.2	Concrete pipe
NE-3	Pipe Culvert	ϕ600,L=6m	7.3	5.9	Concrete pipe
NE-4	Box Culvert	H=1m,B=1m,L=13.5m	7.9	6.4	adjacent to Poung Peay P/S, gate slot at downstream side
	Box Culvert	H=0.8m,B=0.8m,L=13.5m	7.9	6.4	adjacent to Poung Peay P/S, gate slot at downstream side
NE-5	Pipe Culvert	ϕ800,L=6m	8.0	4.7	Concrete pipe
NE-6	Pipe Culvert	ϕ800,L=8m	7.6	5.3	Concrete pipe
NE-7	Pipe Culvert	ϕ1200,L=9m	7.1	5.6	Concrete pipe
NE-8	Pipe Culvert	ϕ1000×2,L=7m	9.7	6.2	Concrete pipe for abandoned railway crossing
NE-9	Pipe Culvert	-	-	-	Not found at site
NE-10	Pipe Culvert	-	7.4	-	Broken completely
NE-11	Bridge	L=6m,B=5m	9.0	6.5	R.C structure
	Pipe Culvert	ϕ800×5,L=5m		6.0	Concrete pipes through the bridge
10.Pochentong West Area(PW)					
PW-1	Pipe Culvert	ϕ600×3,L=12m	11.2	9.5	Steel pipes
11.Pochentong East Area(PE)					
PE-1	Pipe Culvert	ϕ1200,L=9.3m			Concrete pipes
	Gate	H=1.8m,B=1.35m×2	8.8	6.1	Gates installed at upstream side
12.North West Area(NW)					
NW-1	Pipe Culvert	ϕ1000×2,L=10m	9.5	7.0	Concrete Pipes

Note: Road/Railway surface and Invert/Bottom elevations shown on this table are assumed based on the 1/2,000 topographic maps and the results of site reconnaissance.

Table D2-3 Features of Existing Pumping Stations (1/2)

Pumping Station	1. Trabek	2. Tompun		3. Tum Nup Toek
Construction Year	1960	1972		1995
Motor Driven Pump				
Pump Type	horizontal-shaft centrifugal	vertical-shaft axial-flow	vertical-shaft centrifugal	horizontal-shaft centrifugal
Year Installed	1960	1972	1995	1995
No. of Unit	8	4	2	2
Power per Unit	80kW or 108HP	92.5kW or 125HP	25.8kW or 32HP	28.6kW or 38.6HP
Pumping Capacity per Unit (m^3/h)	2,350 (1,900)	2,500 (2,300)	720 (720)	900 (900)
Pumping Capacity (m^3/h)	18,800 (15,200)	11,440 (10,640)		1,800 (1,800)
Diesel Engine Driven Pump				
Pump Type		vertical-shaft axial-flow		
Year Installed		1998		
No. of Unit		5		
Power per Unit		90 kW or 120 HP		
Pumping Capacity per Unit (m^3/h)		2,100 (2,100)		
Pumping Capacity (m^3/h)		10,500 (10,500)		
Total				
No. of Unit	8	11		2
Pumping Capacity (m3/h)	18,800 (15,200)	21,940 (21,140)		1,800 (1,800)

Pumping Station	4. Salang	5. Toek Laak	6. Olympic	7. Toul Kork I
Construction Year	1970	1962	1965	1970
Motor Driven Pump				
Pump Type	vertical-shaft *1 centrifugal		vertical-shaft axial-flow	
Year Installed	1995		1965	
No. of Unit	2		3	
Power per Unit	25.8kW or 32HP		29.5kW or 40HP	
Pumping Capacity per Unit (m^3/h)	720 (720)		1,700 (0)	
Pumping Capacity (m^3/h)	1,440 (1,440)		5,100 (0)	
Diesel Engine Driven Pump				
Pump Type	vertical-shaft axial-flow	vertical-shaft axial-flow		vertical-shaft axial-flow
Year Installed	1970	1962		1970
No. of Unit	3	2		1
Power per Unit	90kW or 120HP	17.8kW or 24HP		92.5kW or 125HP
Pumping Capacity per Unit (m^3/h)	2,500 (2,100)	300 (300)		2,500 (2,100)
Pumping Capacity (m^3/h)	7,500 (6,300)	600 (600)		2,500 (2,100)
Total				
No. of Unit	5	2	3	1
Pumping Capacity (m3/h)	8,940 (7,740)	600 (600)	5,100 (0)	2,500 (2,100)

Table D2-3 Features of Existing Pumping Stations (2/2)

Pumping Station	8. Toul Kork II	9. Toul Kork III	10. Poung Peay *3	Grand Total
Construction Year	1970	1970		
Motor Driven Pump				
Pump Type				
Year Installed				
No. of Unit				21
Power per Unit				
Pumping Capacity per Unit (m^3/h)				
Pumping Capacity (m^3/h)				38,580 (29,080)
Diesel Engine Driven Pump				
Pump Type	vertical-shaft axial-flow	vertical-shaft *2 axial-flow		
Year Installed				
No. of Unit	1	1		13
Power per Unit	92.5kW or 125HP	92.5kW or 125HP		
Pumping Capacity per Unit (m^3/h)	2,500 (2,100)	2,500 (0)		
Pumping Capacity (m^3/h)	2,500 (2,100)	2,500 (0)		26,100 (21,600)
Total				
No. of Unit	1	1		34
Pumping Capacity (m3/h)	2,500 (2,100)	2,500 (0)		64,680 (50,680)

Note: Pumping capacities without ( ) show the condition when provided, while with ( ) the present conditions.

Remarks:

*1 This pump can be driven by motor (25.6kW or 32HP) and diesel engine (90kW or121HP).

*2 The pump was destroyed and no pump equipment is housed in Tuol Kork II.

*3 Information on Poung Peay pumping station is not available.

Table D2-4 Equipment Owned by DPWT

No.	Equipment	Quantity (unit)	Capacity	Donor Country/ Agency	Manufacturer	Present Conditions/ Remarks
Drainage and Sewerage Section						
1.	Vacuum truck with water jet cleaner	3	6m3	France	Renault	All units are in use.
2.	Vacuum truck	1	2m3	PADEK (NGO)	-	in use
3.	Vacuum truck with water jet cleaner	1	6m3	France	Ford	in use
4.	Vacuum truck with water jet cleaner	1	6m3	France	Fiat	out of order
5.	Vacuum Truck	1	6m3	France	Saviem	out of order
6.	Vacuum Truck	1	6m3	Russia	Zil	out of order
7.	Water tank lorry	1	12m3	Russia	Kamaz	out of order
8.	Dumptruck	1	4m3	China	-	in use
9.	Dumptruck	1	6m3	France	Ford	out of order
10.	Loader with backhoe	1	0.30m3	UK	Maseey F.	in use
11.	Grab bucket	1	0.50m3	Russia	-	in use
12.	Light lorry	1	-	Germany	Deutz	in use
13.	Dredger	1	-	-	-	no information
14.	Vacuum truck with water jet cleaner	3	6m3	Norway (NORAD)	IVECO (Italy)	brand-new donated in 1998
15.	Water tank lorry	1	8m3	Norway (NORAD)	HINO (Japan)	brand-new donated in 1998
16.	Caterpillar excavator	1	0.7m3	Norway (NORAD)	SAMSUNG (Korea)	brand-new donated in 1998
17.	Wheel excavator	1	-	Norway (NORAD)	SAMSUNG (Korea)	brand-new donated in 1998
18.	Dump truck	5	6.5m3 or 6t	Norway (NORAD)	TOYOTA (Japan)	brand-new donated in 1998
19.	Excavator loader (backhoe)	1	0.25 m3 & 0.88m3	Norway (NORAD)	New Holland (Netherlands)	brand-new donated in 1998
20.	Cargo crane (for pipe transportation)	1	load>5t, lift>2t	Norway (NORAD)	ISUZU (Japan)	brand-new donated in 1998
Road and Bridge Section						
1.	Dump truck	4	7m3	Russia	Kamaz	3 units are in use,1 unit is out of order
2.	Dump truck	1	4m3	Russia	Maz	out of order, not in use
3.	Truck crane	2	7m3	Russia	Kamaz	in use
4.	Water tank lorry	1	4m3	Russia	Maz	not in use
5.	Low loader	1	7m3	Russia	Kamaz	in use
6.	Grader	3	-	Russia	-	2 units are in use, 1 unit is out of order
7.	Loader	3	-	Russia	-	2 units are in use, 1 unit is out of order
8.	Roller	5	-	Russia	-	2 units are in use, 3 units are out of order
9.	Excavator	2	-	Russia	-	all units are out of order
10.	Excavator	1	-	Russia	-	in use
11.	Paint spraying machine	1	-	-	-	not in use
12.	Air compressor	2	-	Russia	-	not in use
13.	Bulldozer T130	2	-	Russia	-	1 unit is in use, the other is out of order

Table D3-1 Protection Levels in Capitals of Southeast Asian Countries

Name of Capital	Flood Protection	Drainage Improvement	
		Major Facilities (such as rivers, drainage channels and associated facilities)	Minor Facilities (such as sewer systems)
Bangkok	100-year for the Chao Phraya River (with high dikes in places)	A<0.2 km^2 : 1-year A=0.2-1.0 km^2 : 2-year A>1.0 km^2 : 5-year	A<1.0 km^2 : 1-year A>1.0 km^2 : 2-year
Hanoi	100-year for the Red River (with high diking)	10-year	5-year
Vientiane	25-year for the Mekong River	10-year	2-year
Jakarta	-	A < 0.1 km^2 : 1- to 2-year A = 0.1 - 1.0 km^2 : 2- to 5-year A > 1.0 km^2 : 5- to 10-year	
Manila	50-year for the Pasig-Marikina River System (with river walls)	A < 5 km^2 : 3-year A > 5 km^2 : 5-year	
Dhaka	All-time high water level (approx. 30-year) for the Ganges River	2-year	

Table D3-2 Major Design Conditions

Description	Planning Condition	Remarks
(1) Target Year	2010	According to S/W
(2) Protection Levels		
(a) Flood Protection Facilities	30-year return period of water level (EL.10m) a little higher than the maximum water level since 1960 at Chaktomuk Station (EL.9.96 m in 1961)	Dikes, river walls, road heightening, etc. (Refer to Sector B, Subsection 3.2.2)
(b) Major Drainage Facilities (with catchments over approx. 1 km^2)	5-year return period of rainfall	Pumping stations, floodgates /sluiceways, regulation ponds, drainage mains, etc.
(c) Minor Drainage Facilities (with catchments under approx. 1 km^2)	2-year return period of rainfall	Sewer systems
(3) Freeboard		
(a) Dikes and River Walls	Height to cope with wave setup	See Table D3-3.
(b) Box Culverts and Bridges	0.6 m to avoid clogging due to debris	
(c) Others	No freeboard considered	Riverbanks (roads), open channels, regulation ponds, sewer pipes, etc.
(4) Roughness Coefficients in Manning's Formula		
(a) Earth Channels	0.030	Large-scale natural channels with some meandering and vegetation on the slopes
(b) Reveted Channels	0.020	Small-scale artificial channels with a straight alignment and revetments
(c) Concrete-lined Channels	0.015	Box culverts, flumes, sewer pipes, etc.

Table D3-3 Estimation of Wave Setup

Description	Kop Srov Dike	Tompun Dike	Sap/Bassac Riverbank	Remarks
High Water Level	EL. 10.4 m*	EL. 9.0 m*	EL. 10.0 m	
Water Depth: h	3.4 m	5.0 m	15.0 m	
Wind Velocity: U_{10}	10 m/s from Northwest	10 m/s from South	10 m/s from East	Refer to Sector B, Subsection 2.2.2
Fetch: F	3,500 m	7,000 m	4,000 m	
gh/U_{10}^2	0.33	0.49	1.47	
gF/U_{10}^2	340	690	390	
$gH_{1/3}/U_{10}^2$	0.039	0.053	0.042	See the graph below
$H_{1/3}$	0.40 m	0.54 m	0.43 m	
Wave Setup	0.80 m	1.08 m	0.86 m	2 x $H_{1/3}$ in case of 1:2 of dike slope
Necessary Freeboard	0.8 m	1.1 m	0.9 m	
Design Dike Height	EL. 11.2 m	EL. 10.1 m	EL. 10.9 m	
Existing Dike Height	EL. 10.1 m - 10.7 m	EL. 10.0 m - EL. 10.4 m	-	

* Determined based on the 30-year return period floodwater level at Chaktomuk Station, EL.10m, adding and deducting the actual water level balances in the 1996 flood, respectively (refer to Sector B, Figure B2-9).

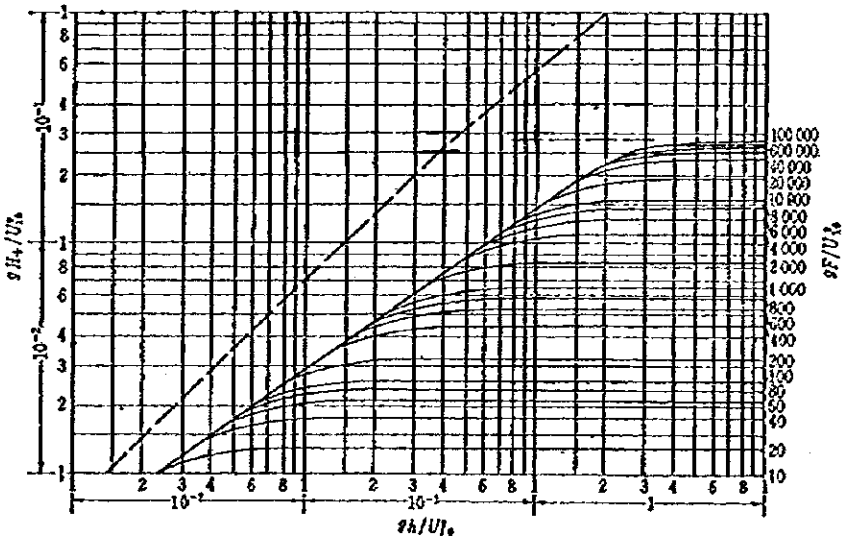


Table D3-4 Unit Prices for Cost Estimation

Items	Unit	Unit Price (US$)		
		L.C	F.C	Total
Earthworks				
Open excavation	m^3	0.4	1.1	1.5
Disposal of excavated material	m^3	1.1	3.2	4.3
Filling/backfilling with excavated material	m^3	0.8	1.7	2.5
Excavation for river improvement	m^3	0.6	1.5	2.1
Dredging for river improvement	m^3	1.7	2.9	4.6
Excavation under existing road	m^3	0.7	1.5	2.2
Asphalt Pavement	m^2	2.0	4.6	6.6
Embankment for dike	m^3	3.1	9.2	12.3
Sodding	m^2	3.6	0.3	3.9
Toe drain	m^3	4.3	12.9	17.2
Stone filling	m^3	6.9	20.3	27.2
Stone pitching	m^2	8.7	3.8	12.5
Excavation for river protection	m^3	0.7	1.8	2.5
Trench excavation	m^3	0.6	1.5	2.1
Backfilling in sewer trench/under road	m^3	4.2	10.4	14.6
Lake dredging	m^3	2.5	3.5	6.0
Lake excavation	m^3	0.7	1.8	2.5
Concrete Works				
Concrete	m^3	71.7	56.7	128.4
Form	m^2	16.5	3.8	20.3
Reinforcing bars	ton	471.8	541.8	1,013.6
Other Works				
Masonry revetment wall	m^2	36.4	33.2	69.6
Piling 200x200mm, L=3m	no.	113.8	191.8	305.6
Piling 305x305mm, L=10m	no.	228.6	449.1	677.7
Piling 406x406mm, L=10m	no.	268.5	568.8	837.3
Sewer pipe, dia. 375mm	m	17.6	27.4	45.1
Sewer pipe, dia. 450mm	m	19.3	31.8	51.1
Sewer pipe, dia. 600mm	m	26.7	50.1	76.9
Sewer pipe, dia. 750mm	m	32.9	65.5	98.4
Sewer pipe, dia. 900mm	m	47.0	105.8	152.9
Sewer pipe, dia. 1,050mm	m	55.4	126.8	182.3
Sewer pipe, dia. 1,200mm	m	73.2	177.9	251.2
Sewer pipe, dia. 1,350mm	m	86.5	214.5	301.0
Sewer pipe, dia. 1,500mm	m	88.9	217.6	306.5
Sewer pipe, dia. 1,650mm	m	102.5	254.4	356.9
Sewer pipe, dia. 1,800mm	m	115.6	290.1	405.7
Steel sheet piling	m^2	33.6	95.2	128.8
Tree planting	no.	51.8	145.6	197.4
Bridge, excluding earthworks	m^2	390.0	910.0	1,300.0
Steel gate, metal works	m^2	2,800.0	11,200.0	14,000.0

Table D3-5 Alternatives for Flood Protection

Section	Protection Line	Basic Measures
1. Riverfront (1) Sap Upstream (11.0 km) & Bassac (3.5 km) Sections	Alt. 1: Riverbank shoulder	Dike embankments along the riverbank shoulder to protect not only the area inside the road but the riverside strip outside the road.
	Alt. 2: Road alignment	Flood defense activity just in case (the road surface is basically higher than EL. 10 m of the high water level), and the riverside strip is left intact.
(2) Sap Downstream Section (3.8 km)	Along the bank shoulder whose elevation is EL. 10.5 m at lowest and higher than 10 m of the high water level.	North Section (Chruoy Changvar Bridge to Street 108, 1.7 km): The bank is well maintained with important facilities such as Phnom Penh port, landing places and an intake, so no measure is suggested.
		Middle Section (Street 108 to Street 184, 1.0 km): The existing revetments are collapsed in places, jeopardizing the bank safety and damaging the aesthetics of the riverfront. The following two revetment types are suggested: Alt. 1: Stone Pitching; and Alt. 2: Concrete Facing.
		South Section (Street 184 to Hotel Sofitel, 1.1 km): The condition of the existing revetments is sound. No measure is required.
2. Existing Dikes (1) Kop Srov Dike (9.0 km)	Along the existing dike alignment	The dike height and width are both insufficient. The following two types of section for the reinforcement of the dike are conceived: Alt. 1: Triple Section Alt. 2: Single Section
(2) Tompun Dike (4.4 km)	Along the existing dike alignment	The existing dike height is basically sufficient (see Table D3-3). The width is also enough judging from the fact that the hydraulic gradient through the dike section is approx. 1/8 even at the high water level.
3. South Section	Alt. 1: Prey Sar Road Alignment (19.6 km)	Construction of a pumping station, drainage sluiceways and a regulation pond.
	Alt. 2: Tompun Extension Road Alignment (7.3 km)	No cost for the construction is required since the area between the BOT and the Tompun Extension roads will be reclaimed by the private sector with the elevation of 9.5 m at least.
4. West Section (9.2 km)	Along the existing road alignment	No measure.

Table D3-6 Costs and Benefits when Alternative 1 is Applied to Sap Upstream and Bassac Sections

Description		Unit Cost (US $)	Sap Upstream Section (Total length: 11.0 km)		Bassac Section (Total length: 3.5 km)	
			Quantity	Amount (US $ 1,000)	Quantity	Amount (US $ 1,000)
Dike Length		-	5,800 m	-	2,900 m	-
Const-ruction Cost	Excavation	1.5/m³	71,000 m³	106.5	39,000 m³	58.5
	Embank-ment	12.3/m³	492,000 m³	6,051.6	286,000 m³	3,517.8
	Sodding	3.9/m²	127,000 m²	495.3	70,000 m²	273.0
	Miscell-aneous	-	L.S.	1,330.7	L.S.	769.9
	Total	-	-	7,984.1	-	4,619.2
Land Use in the Riverside Strip			- Factories : 55 ha - Housing : 22 ha - Open space : 50 ha - Total : 127 ha		- Hotels, etc. : 61 ha - Housing : 18 ha - Open space : 79 ha - Total : 158 ha	
Number of Households below HWL			720 households		1,150 households	
Cost / Household Ratio			US$ 11,100 / household		US$ 4,000 / household	

Note: The cost/household ratio in Tompun Watershed is approximately US$ 900/household.

Table D3-7 Costs of Alternatives for Riverfront Protection in Sap Downstream Middle Section

No.	Items	Unit	Alternative 1: Stone Pitching Type					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
1.	Excavation including disposal of excavated material	m^3	38,000	1.8	5.0	68	190	258
2.	Stone filling	m^3	10,400	6.9	20.3	72	211	283
3.	Concrete frame	m^3	1,300	71.7	56.7	93	74	167
4.	Reinforcing bars	ton	195	471.8	541.8	92	106	198
5.	Foundation concrete	m^3	100	71.3	49.8	7	5	12
6.	Form	m^2	23,100	16.5	3.8	381	88	469
7.	Stone pitching	m^2	7,700	8.7	3.8	67	29	96
8.	Miscellaneous	L.S				156	141	297
	Total					937	843	1,780

No.	Items	Unit	Alternative 2: Concrete Facing Type					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
1.	Excavation including disposal of excavated material	m^3	43,000	1.8	5.0	77	215	292
2.	Stone filling	m^3	10,400	6.9	20.3	72	211	283
3.	Concrete frame	m^3	1,300	71.7	56.7	93	74	167
4.	Reinforcing bars	ton	210	471.8	541.8	99	114	213
5.	Sand & gravel bedding	m^3	3,000	4.3	12.9	13	39	52
6.	Foundation concrete	m^3	400	71.3	49.8	29	20	48
7.	Form	m^2	19,200	16.5	3.8	317	73	390
8.	Concrete surfacing	m^3	900	71.7	56.7	65	51	116
9.	Miscellaneous	L.S				153	159	312
	Total					917	955	1,872

Table D3-8 Costs of Alternatives for Reinforcement of Kop Srov Dike

No	Items	Unit	Alternative 1: Triple Section					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
1.	Excavation	m^3	153,000	0.4	1.1	61	168	230
2.	Embankment	m^3	396,000	3.1	9.2	1,228	3,643	4,871
3.	Disposal of excavated material	m^3	153,000	1.1	3.2	168	490	658
4.	Toe drain	m^3	126,000	4.3	12.9	542	1,625	2,167
5.	Sodding	m^2	135,000	3.6	0.3	486	41	527
6.	Asphalt pavement	m^2	90,000	2.0	4.6	180	414	594
7.	Filling for road	m^3	90,000	4.2	10.4	378	936	1,314
8.	Miscellaneous	L.S				609	1,463	2,072
	Total of I.					3,651	8,780	12,432
II.	**Land Acquisition**	m^2	153,000	2.0	-	306	-	306
	Total of II.					306	-	306
	Grand Total					3,957	8,780	12,738

No	Items	Unit	Alternative 2: Single Section					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
1.	Excavation	m^3	162,000	0.4	1.1	65	178	243
2.	Embankment	m^3	450,000	3.1	9.2	1,395	4,140	5,535
3.	Disposal of excavated material	m^3	162,000	1.1	3.2	178	518	697
4.	Toe drain	m^3	126,000	4.3	12.9	542	1,625	2,167
5.	Sodding	m^2	135,000	3.6	0.3	486	41	527
6.	Asphalt pavement	m^2	90,000	2.0	4.6	180	414	594
7.	Filling for road	m^3	90,000	4.2	10.4	378	936	1,314
8.	Miscellaneous	L.S				645	1,571	2,215
	Total of I.					3,869	9,423	13,292
II.	**Land Acquisition**	m^2	166,500	2.0	-	333	-	333
	Total of II.					333	-	333
	Grand Total					4,202	9,423	13,625

Table D3-9 Costs and Benefits when Alternative 1 is Applied to Prey Sar Basin

Description		Specifications	Amount (US $ 1,000)
Construction Cost	Pumping Station	Submergible pump, 5 m^3/sec	5,100
	Floodgate	10 m wide x 4 m high, 3 places	3,600
	Diking	11.3 km	15,600
	Total	-	24,300
Land Use	At Present	- Agricultural Land : 31.98 km^2 - Loose Residential Area : 2.13 km^2 - Dense Activities : 0.03 km^2 - Total : 34.14 km^2	
	In Future	- Agricultural Land : 29.29 km^2 - Loose Residential Area : 4.40 km^2 - Dense Activities : 0.03 km^2 - Loose Activities : 0.42 km^2 - Total : 34.14 km^2	
Households in Prey Sar Basin		5,000 households	
Cost / Household Ratio		US $ 4,900/household	

Note: The cost/household ratio in Tompun Watershed is approximately US$ 900/household.

Table D3-10 Drainage Direction and Basic Measures in Each Basin (1/3)

Name of Basin	Drainage Direction and Basic Measures
CITY CORE	
C1: Wat Phnom Basin (0.89 km^2)	**To the Tonle Sap River:** The area is as high as over EL. 10.5 m, so that all the runoff can be discharged to the Tonle Sap River, as it is, by gravity even at the design high water stage of the Mekong river system. Basic measures in the basin is rehabilitation of the existing sewers.
C2: Kak Lakeshore Basin (0.51 km^2)	**To Boeng Kak (C3):** This small area develops along the eastern shoreline of Boeng Kak. Local runoff flows into the lake. This condition is to be left intact rehabilitating the existing sewer system.
C3: Boeng Kak Basin (1.14 km^2)	**To E1 of Northeast Area:** This is a lake area, receiving storm water from C3, and a sluiceway drains the lake water to E1 of Northeast Area. No works will be made except rehabilitation of the existing sluiceway at the lake outlet.
C4: Tuol Kork Basin (3.32 km^2)	**To E1 & E2 of Northeast Area without using Existing Pumps:** Local runoff in this area is drained to E1 and E2 of Northeast Area by pumps and by gravity. The flow direction is still valid in the Master Plan. However, pump drainage won't be applied for the area whose ground elevation is higher than EL. 8 m, while the outside water level is EL. 7 m at highest. Major works in the area are construction of drainage mains and rehabilitation of the existing sewer network.
C5: University Basin (0.71 km^2)	**To E2 of Northeast Area:** No outlet is presently provided for this area. However, the Master Plan suggests the construction of two drainage sluiceway toward E2 of Northeast Area for smooth drainage and sanitation betterment in the area.
C6: Bassac Riverside Basin (1.58 km^2)	**To the Tonle Bassac River:** Storm water in the area is naturally drained to the Tonle Bassac River at present. This condition will be left intact (no work being made).
C7: Trabek Basin (10.83 km^2)	**To Boeng Cheung Ek by Trabek Pumping Station :** This is a major basin covering the eastern half of the City Core. All runoff in the basin is collected by Trabek and Toul Sen channels, led to Boeng Trabek and finally drained by a pumping station. On the other hand, at present, a drainage project has been launched in the basin as a part of Phnom Penh Water Supply and Drainage Project, ADB Loan No. 1468. The project has confirmed the existing catchment and system, aiming at construction of an additional pumping station (8 m^3/sec) and improvement of Trabek/Toul Sen channels. That is now under detailed design stage, the detailed features of which are still vague. Further, to keep plan and design standard consistent with other basins in the Master Plan, we will delineate our own plan and estimate its cost for the basin. The works will be an additional pumping station, a regulation pond, drainage mains and sewer rehabilitation. It is however noted that such plan and cost would be overall and not govern the ADB project at all.

Table D3-10 Drainage Direction and Basic Measures in Each Basin (2/3)

Name of Basin	Drainage Direction and Basic Measures
C8: Salang Basin (5.53 km^2)	**To Tompun Basin (M1) without using Existing Pumps:** This is another important watershed sharing the west part of the City Core. All runoff in the area is collected by the sewer system, once stored in Boeng Salang, then discharged outside the Inner Ring Dike, namely to Tompun Basin, either by pumps or through existing two sluiceways. The drainage direction remains in the Master Plan according to the topography. However, use of drainage pumps is given up as a result of the examination on the possible water levels in- and outside the Inner Ring Dike. The existing pump facilities will be kept just in case. The works should comprise construction of drainage mains, rehabilitation of sewer network and so on.
C9: Tum Nup Toek Basin (0.68 km^2)	**To Tompun Basin (M1) without using Existing Pumps:** This is a small basin furnished with sewer system, which will be rehabilitated, and a pumping station, whose effect is ignored in the Master Plan.
C10: Toek Laak Basin (0.10 km^2)	**To Salang Basin (C8) without using Existing Pumps:** In the same consideration above, pumps are not used for draining this catchment. The flow direction is accordingly to shift toward Salang Basin (C8). Sewer rehabilitation only is incorporated in the Master Plan.
NORTHEAST AREA E1: Poungpeay East Basin (13.53 km^2)	**To Boeng Poungpeay (E2):** The Tonle Sap River forms an elevated strip (natural levee) with a width of several hundred meters on its west bank, so that the drainage direction of the basin should be controlled to the west, namely to Boeng Poungpeay (E2). Examined here is only installation of sluiceways under embankments separating the basin into some ten sub-basins.
E2: Boeng Poungpeay Basin (24.18 km^2)	**To the Tonle Sap River with or without Pump Facility:** This basin gathers all storm water generated in the northern half of the Study Area. The water is at present drained, through a sluiceway provided under NR-5, to the Tonle Sap River when the water stage of the river is not so high, while in the reverse case water is just stored in this large lake area. As for the drainage direction, no other selection can be found. However, necessity of a pump facility and rehabilitation of the existing sluiceway will be examined. No works other than the above will basically be made.
E3: Krom Sala Basin (1.25 km^2)	**To the Tonle Sap River:** The condition is similar to the above E2, however the area is very small and the outlet sluiceway is quite new and functions well. No work is therefore recommended in this basin.
E4: Sap Riverside Basin (1.27 km^2)	**To the Tonle Sap River:** The same strategy as mentioned in C6, Bassac Riverside is taken.
NORTHWEST AREA (50.79 km^2)	**To E2 of Northeast Area:** Most rainfall is reserved in paddy fields and storage ponds for irrigation, and thus less outflow goes into E2 of Northeast Area. No significant change is expected in the land use of year 2010, so that the present condition can remain even in the future without causing problems. No work is basically suggested.

Table D3-10 Drainage Direction and Basic Measures in Each Basin (3/3)

Name of Basin	Drainage Direction and Basic Measures
MIDDLE AREA	
M1: Tompun Basin (11.16 km^2)	**To Boeng Cheung Ek by Tompun Pumping Station:** This basin plays an important role in the drainage of the western half of the City Core and a part of the suburban area. There exist a pumping station, a reservoir and a main drainage channel, called Meanchey Channel, to collect storm water from various catchments. All collected water is pumped out from the Study Area to Boeng Cheung Ek. This existing system is considered quite efficient, and valid even in the Master Plan. The works should comprise construction of an additional pumping station beside the existing one, digging of the reservoir, improvement of Meanchey Channel and so on.
M2: Pochentong East Basin (15.35 km^2)	**Alt. 1: To South Area, or Alt. 2: To Tompun Basin (M1), or Alt. 3: To E2 of Northeast Area:** The drainage direction of this area is to the south and east at present, however proposed ideas are to the south, to the Tompun Basin and to the north. Under such a circumstance, the above three alternatives are subject to further examination. The works should be similar to the above.
M3: Pochentong West Basin (11.59 km^2)	**To Northwest Area:** The present flow direction is to the Northwest Area and to Pochentong East Basin (M2). Drainage of the latter area may require pumping at the final stage, so that from the economic standpoint, the drainage direction of this basin (M3) should be limited to the Northwest Area. In this case, a new drainage main shall be constructed to ensure thorough drainage.
M4: Prey Pring Basin (0.70 km^2)	**To the Outside of the Study Area:** In accordance with the present drainage direction, the storm water in this area is independently drained out from the Study Area by gravity. No work is necessary.
SOUTH AREA	
S1: BOT Road South Basin (6.46 km^2)	**To S2 of South Area:** This basin will completely be reclaimed in the near future as a commercial zone. Naturally, the runoff in the area is discharged to the south direction (to S2). No work is suggested.
S2: Prey Sar Basin (34.14 km^2)	**To Prek Thnot River Basin:** The storm water in this area, together with some inflow from outside the Study Area, is drained to the Prek Thnot river basin through the existing two openings as it is. No work is required.

Table D3-11 Costs of Alternatives for Combination of Pump Capacityand and Regulation Pond Volume in Tompun Watershed (1/5)

No.	Items	Unit	Alternative 1: Pumping capacity: 9 m^3/sec					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Regulation Pond							
(1)	Lake excavation	m^3	65,500	0.7	1.8	46	118	164
(2)	Lake dredging	m^3	589,500	2.5	3.5	1,474	2,063	3,537
(3)	Disposal of excavated material	m^3	655,000	1.1	3.2	721	2,096	2,817
(4)	Miscellaneous	L.S				448	855	1,303
	Total of 1.					2,688	5,133	7,821
2.	Inlet Channel							
(1)	Excavation for river improvemet	m^3	13,000	0.6	1.5	8	20	27
(2)	Dredging for river improvement	m^3	13,000	1.7	2.9	22	38	60
(3)	Disposal of excavated material	m^3	26,000	1.1	3.2	29	83	112
(4)	Miscellaneous	L.S				12	28	40
	Total of 2.					70	168	239
3.	Pumping Station							
(1)	Open excavation	m^3	22,200	0.4	1.1	9	24	33
(2)	Disposal of excavated material	m^3	15,600	1.1	3.2	17	50	67
(3)	Piling 406x406mm, L=10m	no.	60	268.5	568.8	16	34	50
(4)	Piling 305x305mm, L=10m	no.	140	228.6	449.1	32	63	95
(5)	Piling 200x200mm, L=4m	no.	130	113.8	191.8	15	25	40
(6)	Steel sheet piling	m^2	490	33.6	95.2	16	47	63
(7)	Filling with excavated material	m^3	6,600	0.8	1.7	5	11	17
(8)	Embankment for dike	m^3	10,900	3.1	9.2	34	100	134
(9)	Concrete	m^3	2,900	71.7	56.7	208	164	372
(10)	Form	m^2	6,100	16.5	3.8	101	23	124
(11)	Reinforcing bars	ton	250	471.8	541.8	118	135	253
(12)	Sodding	m^2	4,100	3.6	0.3	15	1	16
(13)	Steel gate	m^2	14	2,800.0	11,200.0	39	157	196
(14)	Miscellaneous	L.S				125	167	292
	Total of 3.					750	1,003	1,753
4.	Outlet Channel							
(1)	Excavation for river improvemet	m^3	9,200	0.6	1.5	6	14	19
(2)	Dredging for river improvement	m^3	7,600	1.7	2.9	13	22	35
(3)	Disposal of excavated material	m^3	15,800	1.1	3.2	17	51	68
(4)	Miscellaneous	L.S				7	17	24
	Total of 4.					43	104	147
5.	Mechanical & Electrical Works							
(1)	Intake equipment	L.S				0	491	491
(2)	Pumping equipment	L.S				0	826	826
(3)	Power supply equipment	L.S				0	1,044	1,044
(4)	Others	L.S				0	284	284
	Total of 5.					0	2,645	2,645
	Total of I.					3,551	9,052	12,603

Table D3-11 Costs of Alternatives for Combination of Pump Capacityand and Regulation Pond Volume in Tompun Watershed (2/5)

No.	Items	Unit	Alternative 2: Pumping capacity: 15 m^3/sec					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Regulation Pond							
(1)	Lake excavation	m^3	158,400	0.7	1.8	111	285	396
(2)	Lake dredging	m^3	369,600	2.5	3.5	924	1,294	2,218
(3)	Disposal of excavated material	m^3	528,000	1.1	3.2	581	1,690	2,270
(4)	Miscellaneous	L.S				323	654	977
	Total of 1.					1,939	3,922	5,861
2.	Inlet Channel							
(1)	Excavation for river improveme	m^3	15,000	0.6	1.5	9	23	32
(2)	Dredging for river improvement	m^3	16,000	1.7	2.9	27	46	74
(3)	Disposal of excavated material	m^3	31,000	1.1	3.2	34	99	133
(4)	Miscellaneous	L.S				14	34	48
	Total of 2.					84	202	286
3.	Pumping Station							
(1)	Open excavation	m^3	22,500	0.4	1.1	9	25	34
(2)	Disposal of excavated material	m^3	17,300	1.1	3.2	19	55	74
(3)	Piling 406x406mm, L=10m	no.	95	268.5	568.8	26	54	80
(4)	Piling 305x305mm, L=10m	no.	120	228.6	449.1	27	54	81
(5)	Piling 200x200mm, L=4m	no.	110	113.8	191.8	13	21	34
(6)	Steel sheet piling	m^2	690	33.6	95.2	23	66	89
(7)	Filling with excavated material	m^3	5,200	0.8	1.7	4	9	13
(8)	Embankment for dike	m^3	9,900	3.1	9.2	31	91	122
(9)	Concrete	m^3	3,400	71.7	56.7	244	193	437
(10)	Form	m^2	6,600	16.5	3.8	109	25	134
(11)	Reinforcing bars	ton	310	471.8	541.8	146	168	314
(12)	Sodding	m^2	3,400	3.6	0.3	12	1	13
(13)	Steel gate	m^2	16	2,800.0	11,200.0	45	179	224
(14)	Miscellaneous	L.S				141	188	330
	Total of 3.					849	1,129	1,978
4.	Outlet Channel							
(1)	Excavation for river improveme	m^3	10,500	0.6	1.5	6	16	22
(2)	Dredging for river improvement	m^3	7,600	1.7	2.9	13	22	35
(3)	Disposal of excavated material	m^3	18,100	1.1	3.2	20	58	78
(4)	Miscellaneous	L.S				8	19	27
	Total of 4.					47	115	162
5.	Mechanical & Electrical Works							
(1)	Intake equipment	L.S				0	624	624
(2)	Pumping equipment	L.S				0	1,413	1,413
(3)	Power supply equipment	L.S				0	1,558	1,558
(4)	Others	L.S				0	369	369
	Total of 5.					0	3,963	3,963
	Total of I.					2,919	9,331	12,250

Table D3-11 Costs of Alternatives for Combination of Pump Capacityand and Regulation Pond Volume in Tompun Watershed (3/5)

No.	Items	Unit	Alternative 3: Pumping capacity: 21 m^3/sec					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Regulation Pond							
(1)	Lake excavation	m^3	168,800	0.7	1.8	118	304	422
(2)	Lake dredging	m^3	253,200	2.5	3.5	633	886	1,519
(3)	Disposal of excavated material	m^3	422,000	1.1	3.2	464	1,350	1,815
(4)	Miscellaneous	L.S				243	508	751
	Total of 1.					1,458	3,049	4,507
2.	Inlet Channel							
(1)	Excavation for river improveme	m^3	26,000	0.6	1.5	16	39	55
(2)	Dredging for river improvement	m^3	17,000	1.7	2.9	29	49	78
(3)	Disposal of excavated material	m^3	43,000	1.1	3.2	47	138	185
(4)	Miscellaneous	L.S				18	45	64
	Total of 2.					110	271	381
3.	Pumping Station							
(1)	Open excavation	m^3	32,200	0.4	1.1	13	35	48
(2)	Disposal of excavated material	m^3	26,300	1.1	3.2	29	84	113
(3)	Piling 406x406mm, L=10m	no.	170	268.5	568.8	46	97	142
(4)	Piling 305x305mm, L=10m	no.	170	228.6	449.1	39	76	115
(5)	Piling 200x200mm, L=4m	no.	130	113.8	191.8	15	25	40
(6)	Steel sheet piling	m^2	810	33.6	95.2	27	77	104
(7)	Filling with excavated material	m^3	5,900	0.8	1.7	5	10	15
(8)	Embankment for dike	m^3	13,100	3.1	9.2	41	121	161
(9)	Concrete	m^3	5,400	71.7	56.7	387	306	693
(10)	Form	m^2	9,400	16.5	3.8	155	36	191
(11)	Reinforcing bars	ton	490	471.8	541.8	231	265	497
(12)	Sodding	m^2	4,100	3.6	0.3	15	1	16
(13)	Steel gate	m^2	24	2,800.0	11,200.0	67	269	336
(14)	Miscellaneous	L.S				214	281	494
	Total of 3.					1,283	1,683	2,966
4.	Outlet Channel							
(1)	Excavation for river improveme	m^3	11,400	0.6	1.5	7	17	24
(2)	Dredging for river improvement	m^3	7,600	1.7	2.9	13	22	35
(3)	Disposal of excavated material	m^3	19,000	1.1	3.2	21	61	82
(4)	Miscellaneous	L.S				8	20	28
	Total of 4.					49	120	169
5.	Mechanical & Electrical Works							
(1)	Intake equipment	L.S				0	698	698
(2)	Pumping equipment	L.S				0	2,020	2,020
(3)	Power supply equipment	L.S				0	1,754	1,754
(4)	Others	L.S				0	466	466
	Total of 5.					0	4,938	4,938
	Total of I.					2,900	10,061	12,961

Table D3-11 Costs of Alternatives for Combination of Pump Capacityand and Regulation Pond Volume in Tompun Watershed (4/5)

No.	Items	Unit	Alternative 4: Pumping capacity: 27 m^3/sec					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Regulation Pond							
(1)	Lake excavation	m^3	169,000	0.7	1.8	118	304	423
(2)	Lake dredging	m^3	169,000	2.5	3.5	423	592	1,014
(3)	Disposal of excavated material	m^3	338,000	1.1	3.2	372	1,082	1,453
(4)	Miscellaneous	L.S				183	395	578
	Total of 1.					1,095	2,373	3,468
2.	Inlet Channel							
(1)	Excavation for river improveme	m^3	37,000	0.6	1.5	22	56	78
(2)	Dredging for river improvement	m^3	18,000	1.7	2.9	31	52	83
(3)	Disposal of excavated material	m^3	55,000	1.1	3.2	61	176	237
(4)	Miscellaneous	L.S				23	57	79
	Total of 2.					136	340	476
3.	Pumping Station							
(1)	Open excavation	m^3	37,300	0.4	1.1	15	41	56
(2)	Disposal of excavated material	m^3	29,900	1.1	3.2	33	96	129
(3)	Piling 406x406mm, L=10m	no.	220	268.5	568.8	59	125	184
(4)	Piling 305x305mm, L=10m	no.	175	228.6	449.1	40	79	119
(5)	Piling 200x200mm, L=4m	no.	155	113.8	191.8	18	30	47
(6)	Steel sheet piling	m^2	1,500	33.6	95.2	50	143	193
(7)	Filling with excavated material	m^3	7,400	0.8	1.7	6	13	19
(8)	Embankment for dike	m^3	14,200	3.1	9.2	44	131	175
(9)	Concrete	m^3	7,100	71.7	56.7	509	403	912
(10)	Form	m^2	11,300	16.5	3.8	186	43	229
(11)	Reinforcing bars	ton	650	471.8	541.8	307	352	659
(12)	Sodding	m^2	4,100	3.6	0.3	15	1	16
(13)	Steel gate	m^2	29	2,800.0	11,200.0	81	325	406
(14)	Miscellaneous	L.S				273	356	629
	Total of 3.					1,636	2,136	3,771
4.	Outlet Channel							
(1)	Excavation for river improveme	m^3	11,900	0.6	1.5	7	18	25
(2)	Dredging for river improvement	m^3	7,600	1.7	2.9	13	22	35
(3)	Disposal of excavated material	m^3	19,500	1.1	3.2	21	62	84
(4)	Miscellaneous	L.S				8	20	29
	Total of 4.					50	123	173
5.	Mechanical & Electrical Works							
(1)	Intake equipment	L.S				0	821	821
(2)	Pumping equipment	L.S				0	2,615	2,615
(3)	Power supply equipment	L.S				0	2,429	2,429
(4)	Others	L.S				0	544	544
	Total of 5.					0	6,409	6,409
	Total of I.					2,917	11,381	14,297

Table D3-11 Costs of Alternatives for Combination of Pump Capacityand and Regulation Pond Volume in Tompun Watershed (5/5)

No.	Items	Unit	Alternative 5: Pumping capacity: 33 m^3/sec					
			Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Regulation Pond							
(1)	Lake excavation	m^3	139,800	0.7	1.8	98	252	350
(2)	Lake dredging	m^3	93,200	2.5	3.5	233	326	559
(3)	Disposal of excavated material	m^3	233,000	1.1	3.2	256	746	1,002
(4)	Miscellaneous	L.S				117	265	382
	Total of 1.					705	1,588	2,293
2.	Inlet Channel							
(1)	Excavation for river improveme	m^3	45,000	0.6	1.5	27	68	95
(2)	Dredging for river improvement	m^3	23,000	1.7	2.9	39	67	106
(3)	Disposal of excavated material	m^3	68,000	1.1	3.2	75	218	292
(4)	Miscellaneous	L.S				28	70	99
	Total of 2.					169	422	591
3.	Pumping Station							
(1)	Open excavation	m^3	39,400	0.4	1.1	16	43	59
(2)	Disposal of excavated material	m^3	33,400	1.1	3.2	37	107	144
(3)	Piling 406x406mm, L=10m	no.	250	268.5	568.8	67	142	209
(4)	Piling 305x305mm, L=10m	no.	190	228.6	449.1	43	85	129
(5)	Piling 200x200mm, L=4m	no.	140	113.8	191.8	16	27	43
(6)	Steel sheet piling	m^2	1,690	33.6	95.2	57	161	218
(7)	Filling with excavated material	m^3	5,900	0.8	1.7	5	10	15
(8)	Embankment for dike	m^3	14,400	3.1	9.2	45	132	177
(9)	Concrete	m^3	7,900	71.7	56.7	566	448	1,014
(10)	Form	m^2	11,700	16.5	3.8	193	44	238
(11)	Reinforcing bars	ton	740	471.8	541.8	349	401	750
(12)	Sodding	m^2	3,700	3.6	0.3	13	1	14
(13)	Steel gate	m^2	31	2,800.0	11,200.0	87	347	434
(14)	Miscellaneous	L.S				299	390	689
	Total of 3.					1,793	2,340	4,132
4.	Outlet Channel							
(1)	Excavation for river improveme	m^3	12,300	0.6	1.5	7	18	26
(2)	Dredging for river improvement	m^3	7,600	1.7	2.9	13	22	35
(3)	Disposal of excavated material	m^3	19,900	1.1	3.2	22	64	86
(4)	Miscellaneous	L.S				8	21	29
	Total of 4.					51	125	176
5.	Mechanical & Electrical Works							
(1)	Intake equipment	L.S				0	894	894
(2)	Pumping equipment	L.S				0	3,208	3,208
(3)	Power supply equipment	L.S				0	2,575	2,575
(4)	Others	L.S				0	632	632
	Total of 5.					0	7,309	7,309
	Total of I.					2,717	11,784	14,501

Table D3-12 Project Cost for the Master Plan

Unit :US$1,000

Project Component	I. Construction Cost	II. Land Acquisition	III.Administration Cost	IV. Engineering Service	V. Physical Contingency	Total
Component 1:Riverfront Protection in Sap Downstream Middle Section(1km)	1,780	0	53	267	178	2,278
Component 2: Reinforcement of Kop Srov and Tompun Dikes	13,609	360	408	2,041	1,361	17,780
a. Reinforcement of Kop Srov Dike (9.0km)	12,432	306	373	1,865	1,243	16,219
b. Reinforcement of Tompun Dike (4.4km)	1,177	54	35	177	118	1,561
Component 3: Tompun Watershed Drainage Improvement	69,120	109	2,074	10,368	6,912	88,582
a. Tompun Pumping Station ($15m^3/s$) and Regulation Pond	12,250	27	367	1,837	1,225	15,706
b. Meanchey Drainage Main, Downstream Stretch (2.76km)	3,839	58	115	576	384	4,972
c. Meanchey Drainage Main, Upstream Stretch (2.135km)	1,502	0	45	225	150	1,923
d. Tum Nup Toek Drainage Sluiceway (2mx2mx1lane)	330	0	10	49	33	422
e. Samdachi Monireth Drainage Main (2.36km)	19,387	0	582	2,908	1,939	24,815
f. Jawaharlal Nehru Drainage Main (1.16km)	2,771	0	83	416	277	3,546
g. Salang Drainage Main (1.89km)	1,764	24	53	265	176	2,282
h. Sewer Rehabilitation excluding Tum Nup Toek Basin (563 ha)	25,602	0	768	3,840	2,560	32,771
i. Sewer Rehabilitation, Tum Nup Toek Basin (68ha)	1,675	0	50	251	168	2,144
Component 4: Trabek Basin Drainage Improvement	73,806	32	2,214	11,071	7,381	94,504
a. Trabek Pumping Station ($8m^3/s$) and Regulation Pond	14,214	32	426	2,132	1,421	18,225
b. Trabek Drainage Main (1.604km)	10,663	0	320	1,599	1,066	13,648
c. Toul Sen Drainage Main (2.05km)	3,149	0	94	472	315	4,031
d. Norodom Drainage Main (1.768km)	4,750	0	143	713	475	6,080
e. Sewer Rehabilitation (1,083 ha)	41,031	0	1,231	6,155	4,103	52,519
Component 5: City Core North Area Drainage Improvement	24,916	83	747	3,737	2,492	31,975
a. C1: Wat Phnom Basin, Sewer Rehabilitation (89ha)	3,329	0	100	499	333	4,261
b. C2: Kak Lakeshore Basin, Sewer Rehabilitation (51ha)	274	0	8	41	27	351
c. C3: Boeng Kak Basin, Kak Drainage Sluiceway	283	0	8	42	28	363
d. C4: Tuol Kork Basin, Major Drainage Facilities	8,953	75	269	1,343	895	11,535
e. C4: Tuol Kork Basin, Sewewr Rehabilitation (332ha)	11,561	0	347	1,734	1,156	14,798
f. C5: University Basin, Drainage Sluiceways (2 locations)	515	8	15	77	52	667
Component 6: Pochentong East Basin Drainage Improvement	9,309	24	279	1,396	931	11,939
Component 7: Northeast and Northwest Areas Drainage Improvement	8,965	0	269	1,345	897	12,098
a. Poungpeay Drainage Main (11.92km)	7,627	0	229	1,144	763	10,385
b. Svay Pak Drainage Sluiceway (2mx2mx2 lanes)	518	0	16	78	52	664
c. Drainage Sluiceways in Poungpeay East Basin (12 locations)	820	0	25	123	82	1,050
Component 8: Environmental Enhancement	1,482	0	44	222	148	1,897
a. Environmental Canal (1.75km)	1,352	0	41	203	135	1,730
b. Kak Interceptor (0.85km)	131	0	4	20	13	167
Grand Total	202,988	607	6,090	30,448	20,299	261,053

Table D3-13 Cost for Component 1: Riverfront Protection in Sap Downstream Middle Section

(1.0 km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation including disposal of excavated material	m^3	38,000	1.8	5.0	68.40	190.00	258.40
2.	Stone filling	m^3	10,400	6.9	20.3	71.76	211.12	282.88
3.	Concrete frame	m^3	1,300	71.7	56.7	93.21	73.71	166.92
4.	Reinforcing bars	ton	195	471.8	541.8	92.00	105.65	197.65
5.	Foundation concrete	m^3	100	71.3	49.8	7.13	4.98	12.11
6.	Form	m^2	23,100	16.5	3.8	381.15	87.78	468.93
7.	Stone pitching	m^2	7,700	8.7	3.8	66.99	29.26	96.25
8.	Miscellaneous	L.S				156.13	140.50	296.63
	Total of I.					936.77	843.00	1,779.77
II.	**Land Acquisition**	L.S	0	2.0	0.0	0.00	0.00	0.00
III.	**Administration Cost**	L.S				53.39	0.00	53.39
IV.	**Engineering Service**	L.S				140.52	126.45	266.97
V.	**Physical Contingency**	L.S				93.68	84.30	177.98
	Grand Total					1,224.35	1,053.75	2,278.11

Table D3-14 Cost for Component 2: Reinforcement of Kop Srov and Tompun Dikes

a. Reinforcement of Kop Srov Dike (9.0km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
1.	Excavation	m^3	153,000	0.4	1.1	61.20	168.30	229.50
2.	Embankment	m^3	396,000	3.1	9.2	1,227.60	3,643.20	4,870.80
3.	Disposal of excavated material	m^3	153,000	1.1	3.2	168.30	489.60	657.90
4.	Toe drain	m^3	126,000	4.3	12.9	541.80	1,625.40	2,167.20
5.	Sodding	m^2	135,000	3.6	0.3	486.00	40.50	526.50
6.	Asphalt pavement	m^2	90,000	2.0	4.6	180.00	414.00	594.00
7.	Filling for road	m^3	90,000	4.2	10.4	378.00	936.00	1,314.00
8.	Miscellaneous	L.S				608.58	1,463.40	2,071.98
	Total of I.					3,651.48	8,780.40	12,431.88
II.	**Land Acquisition**	m^2	153,000	2.0	0.0	306.00	0.00	306.00
III.	**Administration Cost**	L.S				372.96	0.00	372.96
IV.	**Engineering Service**	L.S				547.72	1,317.06	1,864.78
V.	**Physical Contingency**	L.S				365.15	878.04	1,243.19
	Grand Total					5,243.31	10,975.50	16,218.81

b. Reinforcement of Tompun Dike (4.4km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
1.	Excavation	m^3	11,400	0.4	1.1	4.56	12.54	17.10
2.	Disposal of excavated material	m^3	11,400	1.1	3.2	12.54	36.48	49.02
3.	Toe drain	m^3	53,200	4.3	12.9	228.76	686.28	915.04
4.	Miscellaneous	L.S				49.17	147.06	196.23
	Total of I.					295.03	882.36	1,177.39
II.	**Land Acquisition**	m^2	27,000	2.0	0.0	54.00	0.00	54.00
III.	**Administration Cost**	L.S				35.32	0.00	35.32
IV.	**Engineering Service**	L.S				44.25	132.35	176.61
V.	**Physical Contingency**	L.S				29.50	88.24	117.74
	Grand Total					458.11	1,102.95	1,561.06

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (1/9)

a. Tompun Pumping Station (15 m^3/s) and Regulation Pond

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
1.	Regulation Pond							
(1)	Lake excavation	m^3	158,400	0.7	1.8	110.88	285.12	396.00
(2)	Lake dredging	m^3	369,600	2.5	3.5	924.00	1,293.60	2,217.60
(3)	Disposal of excavated material	m^3	528,000	1.1	3.2	580.80	1,689.60	2,270.40
(4)	Miscellaneous	L.S				323.14	653.66	976.80
	Total of 1.					1,938.82	3,921.98	5,860.80
2.	Inlet Channel							
(1)	Excavation for river improveme	m^3	15,000	0.6	1.5	9.00	22.50	31.50
(2)	Dredging for river improvement	m^3	16,000	1.7	2.9	27.20	46.40	73.60
(3)	Disposal of excavated material	m^3	31,000	1.1	3.2	34.10	99.20	133.30
(4)	Miscellaneous	L.S				14.06	33.62	47.68
	Total of 2.					84.36	201.72	286.08
3.	Pumping Station							
(1)	Open excavation	m^3	22,500	0.4	1.1	9.00	24.75	33.75
(2)	Disposal of excavated material	m^3	17,300	1.1	3.2	19.03	55.36	74.39
(3)	Piling 406x406mm, L=10m	no.	95	268.5	568.8	25.51	54.04	79.54
(4)	Piling 305x305mm, L=10m	no.	120	228.6	449.1	27.43	53.89	81.32
(5)	Piling 200x200mm, L=4m	no.	110	113.8	191.8	12.52	21.10	33.62
(6)	Steel sheet piling	m^2	690	33.6	95.2	23.18	65.69	88.87
(7)	Filling with excavated material	m^3	5,200	0.8	1.7	4.16	8.84	13.00
(8)	Embankment for dike	m^3	9,900	3.1	9.2	30.69	91.08	121.77
(9)	Concrete	m^3	3,400	71.7	56.7	243.78	192.78	436.56
(10)	Form	m^2	6,600	16.5	3.8	108.90	25.08	133.98
(11)	Reinforcing bars	ton	310	471.8	541.8	146.26	167.96	314.22
(12)	Sodding	m^2	3,400	3.6	0.3	12.24	1.02	13.26
(13)	Steel gate	m^2	16	2,800.0	11,200.0	44.80	179.20	224.00
(14)	Miscellaneous	L.S				141.50	188.16	329.66
	Total of 3.					849.00	1,128.94	1,977.94
4.	Outlet Channel							
(1)	Excavation for river improveme	m^3	10,500	0.6	1.5	6.30	15.75	22.05
(2)	Dredging for river improvement	m^3	7,600	1.7	2.9	12.92	22.04	34.96
(3)	Disposal of excavated material	m^3	18,100	1.1	3.2	19.91	57.92	77.83
(4)	Miscellaneous	L.S				7.83	19.14	26.97
	Total of 4.					46.96	114.85	161.81
5.	Mechanical & Electrical Works							
(1)	Intake equipment	L.S				0.00	623.57	623.57
(2)	Pumping equipment	L.S				0.00	1,413.14	1,413.14
(3)	Power supply equipment	L.S				0.00	1,557.86	1,557.86
(4)	Others	L.S				0.00	368.57	368.57
	Total of 5.					0.00	3,963.14	3,963.14
	Total of I.					2,919.13	9,330.64	12,249.77
II.	**Land Acquisition**	m^2	5,300	5.0	0.0	26.50	0.00	26.50
III.	**Administration Cost**	L.S				367.49	0.00	367.49
IV.	**Engineering Service**	L.S				437.87	1,399.60	1,837.47
V.	**Physical Contingency**	L.S				291.91	933.06	1,224.98
	Grand Total					4,042.91	11,663.30	15,706.20

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (2/9)

b. Meanchey Drainage Main, Downstream (2.76km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation	m^3	156,000	0.6	1.5	93.60	234.00	327.60
2.	Dredging	m^3	81,000	1.7	2.9	137.70	234.90	372.60
3.	Disposal of excavated material	m^3	236,000	1.1	3.2	259.60	755.20	1,014.80
4.	Embankment for dike	m^3	1,000	3.1	9.2	3.10	9.20	12.30
5.	Masonry revetment	m^2	4,500	36.4	33.2	163.80	149.40	313.20
6.	Tree planting	no.	600	51.8	145.6	31.08	87.36	118.44
7.	Bridge	m^2	800	390.0	910.0	312.00	728.00	1,040.00
8.	Miscellaneous	L.S				200.18	439.61	639.79
	Total of I.					1,201.06	2,637.67	3,838.73
II.	Land Acquisition	L.S	29,000	2.0	0.0	58.00	0.00	58.00
III.	Administration Cost	L.S				115.16	0.00	115.16
IV.	Engineering Service	L.S				180.16	395.65	575.81
V.	Physical Contingency	L.S				120.11	263.77	383.87
	Grand Total					1,674.48	3,297.09	4,971.57

c. Meanchey Drainage Main, Upstream (2.135km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation	m^3	44,000	0.6	1.5	26.40	66.00	92.40
2.	Disposal of excavated material	m^3	33,000	1.1	3.2	36.30	105.60	141.90
3.	Filling with excavated material	m^3	11,000	0.8	1.7	8.80	18.70	27.50
4.	Masonry revetment	m^2	8,200	36.4	33.2	298.48	272.24	570.72
5.	Tree planting	no.	240	51.8	145.6	12.43	34.94	47.38
6.	Concrete for culverts	m^3	700	71.7	56.7	50.19	39.69	89.88
7.	Reinforcing bars for culverts	ton	60	471.8	541.8	28.31	32.51	60.82
8.	Form for culverts	m^2	1,300	16.5	3.8	21.45	4.94	26.39
9.	Bridge	m^2	150	390.0	910.0	58.50	136.50	195.00
10.	Miscellaneous	L.S				108.17	142.22	250.40
	Total of I.					649.03	853.35	1,502.38
II.	Land Acquisition	L.S	0	2.0	0.0	0.00	0.00	0.00
III.	Administration Cost	L.S				45.07	0.00	45.07
IV.	Engineering Service	L.S				97.35	128.00	225.36
V.	Physical Contingency	L.S				64.90	85.33	150.24
	Grand Total					856.36	1,066.68	1,923.04

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (3/9)

d. Tum Nup Toek Drainage Sluiceway (B: 2.0m x H: 2.0m x 1 lane)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation under existing road	m^3	3,900	0.7	1.5	2.73	5.85	8.58
2.	Embankment for dike	m^3	2,200	3.1	9.2	6.82	20.24	27.06
3.	Backfilling under road	m^3	60	4.2	10.4	0.25	0.62	0.88
4.	Backfilling with excavated mate	m^3	820	0.8	1.7	0.66	1.39	2.05
5.	Disposal of excavated material	m^3	3,000	1.1	3.2	3.30	9.60	12.90
6.	Asphalt pavement	m^2	30	2.0	4.6	0.06	0.14	0.20
7.	Concrete	m^3	450	71.7	56.7	32.27	25.52	57.78
8.	Reinforcing bars	ton	40	471.8	541.8	18.87	21.67	40.54
9.	Form	m^2	1,200	16.5	3.8	19.80	4.56	24.36
10.	Piling 200x200mm, L=3m	no.	100	113.8	191.8	11.38	19.18	30.56
11.	Steel gate	m^2	5	2,800.0	11,200.0	14.00	56.00	70.00
12.	Miscellaneous	L.S				22.03	32.95	54.98
	Total of I.					132.16	197.73	329.89
II.	Land Acquisition	m^2	0	5.0	0.0	0.00	0.00	0.00
III.	Administration Cost	L.S				9.90	0.00	9.90
IV.	Engineering Service	L.S				19.82	29.66	49.48
V.	Physical Contingency	L.S				13.22	19.77	32.99
	Grand Total					175.10	247.16	422.26

e. Samdachi Monireth Drainage Main (2.36km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation under existing road	m^3	274,500	0.7	1.5	192.15	411.75	603.90
2.	Embankment for dike	m^3	5,490	3.1	9.2	17.02	50.51	67.53
3.	Backfilling under road	m^3	76,500	4.2	10.4	321.30	795.60	1,116.90
4.	Backfilling with excavated mate	m^3	71,100	0.8	1.7	56.88	120.87	177.75
5.	Disposal of excavated material	m^3	204,300	1.1	3.2	224.73	653.76	878.49
6.	Asphalt pavement	m^2	38,250	2.0	4.6	76.50	175.95	252.45
7.	Concrete	m^3	43,830	71.7	56.7	3,142.61	2,485.16	5,627.77
8.	Reinforcing bars	ton	4,185	471.8	541.8	1,974.48	2,267.43	4,241.92
9.	Form	m^2	96,480	16.5	3.8	1,591.92	366.62	1,958.54
10.	Piling 200x200mm, L=3m	no.	2,790	113.8	191.8	317.50	535.12	852.62
11.	Steel gate	m^2	27	2,800.0	11,200.0	75.60	302.40	378.00
12.	Miscellaneous	L.S				1,598.14	1,633.04	3,231.17
	Total of I.					9,588.83	9,798.21	19,387.05
II.	Land Acquisition	m^2	0	5.0	0.0	0.00	0.00	0.00
III.	Administration Cost	L.S				581.61	0.00	581.61
IV.	Engineering Service	L.S				1,438.33	1,469.73	2,908.06
V.	Physical Contingency	L.S				958.88	979.82	1,938.70
	Grand Total					12,567.65	12,247.77	24,815.42

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (4/9)

f. Jawaharial Nehru Drainage Main (1.16km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation under existing road	m^3	41,000	0.7	1.5	28.70	61.50	90.20
2.	Backfilling under road	m^3	12,600	4.2	10.4	52.92	131.04	183.96
3.	Backfilling with excavated mate	m^3	13,800	0.8	1.7	11.04	23.46	34.50
4.	Disposal of excavated material	m^3	26,600	1.1	3.2	29.26	85.12	114.38
5.	Asphalt pavement	m^2	7,000	2.0	4.6	14.00	32.20	46.20
6.	Concrete	m^3	5,900	71.7	56.7	423.03	334.53	757.56
7.	Reinforcing bars	ton	500	471.8	541.8	235.90	270.90	506.80
8.	Form	m^2	19,000	16.5	3.8	313.50	72.20	385.70
9.	Piling 200x200mm, L=3m	no.	620	113.8	191.8	70.56	118.92	189.47
10.	Miscellaneous	L.S				235.78	225.97	461.75
	Total of I.					1,414.69	1,355.84	2,770.53
II.	Land Acquisition	m^2	0	5.0	0.0	0.00	0.00	0.00
III.	Administration Cost	L.S				83.12	0.00	83.12
IV.	Engineering Service	L.S				212.20	203.38	415.58
V.	Physical Contingency	L.S				141.47	135.58	277.05
	Grand Total					1,851.47	1,694.80	3,546.27

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (5/9)

g. Salang Drainage Main (1.89km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Drainage Sluiceway (B: 4.25m x H: 3.6m x 2 lanes)							
(1)	Excavation	m^3	2,000	0.6	1.5	1.20	3.00	4.20
(2)	Embankment for dike	m^3	1,900	3.1	9.2	5.89	17.48	23.37
(3)	Excavation under existing road	m^3	3,800	0.7	1.5	2.66	5.70	8.36
(4)	Backfilling under road	m^3	130	4.2	10.4	0.55	1.35	1.90
(5)	Backfilling with excavated mate	m^3	300	0.8	1.7	0.24	0.51	0.75
(6)	Disposal of excavated material	m^3	5,500	1.1	3.2	6.05	17.60	23.65
(7)	Asphalt pavement	m^2	70	2.0	4.6	0.14	0.32	0.46
(8)	Concrete	m^3	1,000	71.7	56.7	71.70	56.70	128.40
(9)	Reinforcing bars	ton	90	471.8	541.8	42.46	48.76	91.22
(10)	Form	m^2	2,000	16.5	3.8	33.00	7.60	40.60
(11)	Piling 200x200mm, L=3m	no.	60	113.8	191.8	6.83	11.51	18.34
(12)	Masonry revetment	m^2	300	36.4	33.2	10.92	9.96	20.88
(13)	Steel gate	m^2	31	2,800.0	11,200.0	86.80	347.20	434.00
(14)	Miscellaneous	L.S				53.69	105.54	159.23
	Total of 1.					322.12	633.23	955.36
2.	Open Channel (L=1.83km)							
(1)	Excavation	m^3	36,500	0.6	1.5	21.90	54.75	76.65
(2)	Dredging	m^3	17,500	1.7	2.9	29.75	50.75	80.50
(3)	Disposal of excavated material	m^3	54,000	1.1	3.2	59.40	172.80	232.20
(4)	Masonry revetment	m^2	350	36.4	33.2	12.74	11.62	24.36
(5)	Bridge	m^2	200	390.0	910.0	78.00	182.00	260.00
(6)	Miscellaneous	L.S				40.36	94.38	134.74
	Total of 2.					242.15	566.30	808.45
	Total of I.					564.27	1,199.54	1,763.81
II.	Land Acquisition	L.S	12,000	2.0	0.0	24.00	0.00	24.00
III.	Administration Cost	L.S				52.91	0.00	52.91
IV.	Engineering Service	L.S				84.64	179.93	264.57
V.	Physical Contingency	L.S				56.43	119.95	176.38
	Grand Total					782.25	1,499.42	2,281.67

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (6/9)

h. Sewer Rehabilitation excluding Tuni Nup Toek Basin (563ha)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
I.1	Dia 375mm							
1.	Trench excavation	m^3	9,060	0.6	1.5	5.44	13.59	19.03
2.	Sewer installation	m	3,342	17.6	27.4	58.82	91.57	150.39
3.	Backfilling in trench	m^3	8,520	4.2	10.4	35.78	88.61	124.39
4.	Disposal of excavated material	m^3	4,740	1.1	3.2	5.21	15.17	20.38
5.	Asphalt pavement	m^2	3,342	2.0	4.6	6.68	15.37	22.06
6.	Manhole, connecting pipes, etc.	L.S				31.58	62.68	94.26
	Total of I.1					143.51	286.99	430.50
I.2	Dia 450mm							
1.	Trench excavation	m^3	74,940	0.6	1.5	44.96	112.41	157.37
2.	Sewer installation	m	23,370	19.3	31.8	451.04	743.17	1,194.21
3.	Backfilling in trench	m^3	69,780	4.2	10.4	293.08	725.71	1,018.79
4.	Disposal of excavated material	m^3	38,340	1.1	3.2	42.17	122.69	164.86
5.	Asphalt pavement	m^2	25,710	2.0	4.6	51.42	118.27	169.69
6.	Manhole, connecting pipes, etc.	L.S				249.38	511.19	760.57
	Total of I.2					1,132.05	2,333.43	3,465.49
I.3	Dia 600mm							
1.	Trench excavation	m^3	92,460	0.6	1.5	55.48	138.69	194.17
2.	Sewer installation	m	20,952	26.7	50.1	559.42	1,049.70	1,609.11
3.	Backfilling in trench	m^3	84,360	4.2	10.4	354.31	877.34	1,231.66
4.	Disposal of excavated material	m^3	46,380	1.1	3.2	51.02	148.42	199.43
5.	Asphalt pavement	m^2	27,252	2.0	4.6	54.50	125.36	179.86
6.	Manhole, connecting pipes, etc.	L.S				306.07	664.24	970.31
	Total of I.3					1,380.80	3,003.75	4,384.54
I.4	Dia 750mm							
1.	Trench excavation	m^3	60,180	0.6	1.5	36.11	90.27	126.38
2.	Sewer installation	m	8,640	32.9	65.5	284.26	565.92	850.18
3.	Backfilling in trench	m^3	55,140	4.2	10.4	231.59	573.46	805.04
4.	Disposal of excavated material	m^3	30,360	1.1	3.2	33.40	97.15	130.55
5.	Asphalt pavement	m^2	15,984	2.0	4.6	31.97	73.53	105.49
6.	Manhole, connecting pipes, etc.	L.S				175.60	398.04	573.64
	Total of I.4					792.92	1,798.36	2,591.28
I.5	Dia 900mm							
1.	Trench excavation	m^3	28,320	0.6	1.5	16.99	42.48	59.47
2.	Sewer installation	m	3,654	47.0	105.8	171.74	386.59	558.33
3.	Backfilling in trench	m^3	25,260	4.2	10.4	106.09	262.70	368.80
4.	Disposal of excavated material	m^3	13,920	1.1	3.2	15.31	44.54	59.86
5.	Asphalt pavement	m^2	7,302	2.0	4.6	14.60	33.59	48.19
6.	Manhole, connecting pipes, etc.	L.S				93.04	220.90	313.94
	Total of I.5					417.78	990.81	1,408.58
I.6	Dia 1,050mm							
1.	Trench excavation	m^3	38,340	0.6	1.5	23.00	57.51	80.51
2.	Sewer installation	m	4,152	55.4	126.8	230.02	526.47	756.49
3.	Backfilling in trench	m^3	33,600	4.2	10.4	141.12	349.44	490.56
4.	Disposal of excavated material	m^3	18,480	1.1	3.2	20.33	59.14	79.46
5.	Asphalt pavement	m^2	9,132	2.0	4.6	18.26	42.01	60.27
6.	Manhole, connecting pipes, etc.	L.S				124.34	297.77	422.11
	Total of I.6					557.08	1,332.33	1,889.41

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (7/9)

No.	Items	Unit	Q'ty	Unit Price (US$) L.C	Unit Price (US$) F.C	Amount (US$1,000) L.C	Amount (US$1,000) F.C	Amount (US$1,000) Total
I.7	Dia 1,200mm							
1.	Trench excavation	m^3	45,480	0.6	1.5	27.29	68.22	95.51
2.	Sewer installation	m	3,744	73.2	177.9	274.06	666.06	940.12
3.	Backfilling in trench	m^3	40,020	4.2	10.4	168.08	416.21	584.29
4.	Disposal of excavated material	m^3	22,020	1.1	3.2	24.22	70.46	94.69
5.	Asphalt pavement	m^2	8,988	2.0	4.6	17.98	41.34	59.32
6.	Manhole, connecting pipes, etc.	L.S				148.10	366.28	514.38
	Total of I.7					659.73	1,628.58	2,288.31
I.8	Dia 1,350mm							
1.	Trench excavation	m^3	41,040	0.6	1.5	24.62	61.56	86.18
2.	Sewer installation	m	3,066	86.5	214.5	265.21	657.66	922.87
3.	Backfilling in trench	m^3	35,400	4.2	10.4	148.68	368.16	516.84
4.	Disposal of excavated material	m^3	19,440	1.1	3.2	21.38	62.21	83.59
5.	Asphalt pavement	m^2	7,980	2.0	4.6	15.96	36.71	52.67
6.	Manhole, connecting pipes, etc.	L.S				137.97	344.88	482.84
	Total of I.8					613.83	1,531.17	2,144.99
I.9	Dia 1,500mm							
1.	Trench excavation	m^3	34,980	0.6	1.5	20.99	52.47	73.46
2.	Sewer installation	m	2,340	88.9	217.6	208.03	509.18	717.21
3.	Backfilling in trench	m^3	29,640	4.2	10.4	124.49	308.26	432.74
4.	Disposal of excavated material	m^3	16,320	1.1	3.2	17.95	52.22	70.18
5.	Asphalt pavement	m^2	6,558	2.0	4.6	13.12	30.17	43.28
6.	Manhole, connecting pipes, etc.	L.S				111.44	276.64	388.08
	Total of I.9					496.01	1,228.94	1,724.95
I.10	Dia 1,650mm							
1.	Trench excavation	m^3	44,220	0.6	1.5	26.53	66.33	92.86
2.	Sewer installation	m	2,718	102.5	254.4	278.60	691.46	970.05
3.	Backfilling in trench	m^3	36,600	4.2	10.4	153.72	380.64	534.36
4.	Disposal of excavated material	m^3	20,160	1.1	3.2	22.18	64.51	86.69
5.	Asphalt pavement	m^2	8,148	2.0	4.6	16.30	37.48	53.78
6.	Manhole, connecting pipes, etc.	L.S				144.31	360.88	505.19
	Total of I.10					641.63	1,601.30	2,242.93
I.11	Dia 1,800mm							
1.	Trench excavation	m^3	59,280	0.6	1.5	35.57	88.92	124.49
2.	Sewer installation	m	3,282	115.6	290.1	379.40	952.11	1,331.51
3.	Backfilling in trench	m^3	48,480	4.2	10.4	203.62	504.19	707.81
4.	Disposal of excavated material	m^3	26,700	1.1	3.2	29.37	85.44	114.81
5.	Asphalt pavement	m^2	10,500	2.0	4.6	21.00	48.30	69.30
6.	Manhole, connecting pipes, etc.	L.S				194.39	489.20	683.58
	Total of I.11					863.34	2,168.16	3,031.50
	Total of I.					7,698.66	17,903.83	25,602.49
II.	**Land Acquisition**	L.S						0.00
III.	**Administration Cost**	L.S				768.07	0.00	768.07
IV.	**Engineering Service**	L.S				1,154.80	2,685.57	3,840.37
V.	**Physical Contingency**	L.S				769.87	1,790.38	2,560.25
	Grand Total					10,391.40	22,379.79	32,771.19

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (8/9)

i. Sewer Construction in Tum Nap Toek Basin (68ha)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
I.1	Dia 450mm							
1.	Trench excavation	m^3	800	0.6	1.5	0.48	1.20	1.68
2.	Sewer installation	m	360	19.3	31.8	6.95	11.45	18.40
3.	Backfilling in trench	m^3	700	4.2	10.4	2.94	7.28	10.22
4.	Disposal of excavated material	m^3	400	1.1	3.2	0.44	1.28	1.72
5.	Asphalt pavement	m^2	390	2.0	4.6	0.78	1.79	2.57
6.	Manhole, connecting pipes, etc.	L.S				3.24	6.36	9.60
	Total of I.1					14.83	29.36	44.19
I.2	Dia 600mm							
1.	Trench excavation	m^3	2,700	0.6	1.5	1.62	4.05	5.67
2.	Sewer installation	m	860	26.7	50.1	22.96	43.09	66.05
3.	Backfilling in trench	m^3	2,400	4.2	10.4	10.08	24.96	35.04
4.	Disposal of excavated material	m^3	1,300	1.1	3.2	1.43	4.16	5.59
5.	Asphalt pavement	m^2	1,120	2.0	4.6	2.24	5.15	7.39
6.	Manhole, connecting pipes, etc.	L.S				10.83	22.88	33.70
	Total of I.2					49.16	104.28	153.44
I.3	Dia 750mm							
1.	Trench excavation	m^3	4,500	0.6	1.5	2.70	6.75	9.45
2.	Sewer installation	m	1,160	32.9	65.5	38.16	75.98	114.14
3.	Backfilling in trench	m^3	3,900	4.2	10.4	16.38	40.56	56.94
4.	Disposal of excavated material	m^3	2,100	1.1	3.2	2.31	6.72	9.03
5.	Asphalt pavement	m^2	2,150	2.0	4.6	4.30	9.89	14.19
6.	Manhole, connecting pipes, etc.	L.S				17.87	39.00	56.87
	Total of I.3					81.72	178.90	260.62
I.4	Dia 900mm							
1.	Trench excavation	m^3	4,000	0.6	1.5	2.40	6.00	8.40
2.	Sewer installation	m	910	47.0	105.8	42.77	96.28	139.05
3.	Backfilling in trench	m^3	3,300	4.2	10.4	13.86	34.32	48.18
4.	Disposal of excavated material	m^3	1,800	1.1	3.2	1.98	5.76	7.74
5.	Asphalt pavement	m^2	1,820	2.0	4.6	3.64	8.37	12.01
6.	Manhole, connecting pipes, etc.	L.S				18.30	42.71	61.01
	Total of I.4					82.95	193.44	276.39
I.5	Dia 1,050mm							
1.	Trench excavation	m^3	1,500	0.6	1.5	0.90	2.25	3.15
2.	Sewer installation	m	330	55.4	126.8	18.28	41.84	60.13
3.	Backfilling in trench	m^3	1,200	4.2	10.4	5.04	12.48	17.52
4.	Disposal of excavated material	m^3	630	1.1	3.2	0.69	2.02	2.71
5.	Asphalt pavement	m^2	720	2.0	4.6	1.44	3.31	4.75
6.	Manhole, connecting pipes, etc.	L.S				7.47	17.58	25.05
	Total of I.5					33.83	79.48	113.31

Table D3-15 Cost for Component 3: Tompun Watershed Drainage Improvement (9/9)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.6	Dia 1,200mm							
1.	Trench excavation	m^3	3,800	0.6	1.5	2.28	5.70	7.98
2.	Sewer installation	m	750	73.2	177.9	54.90	133.43	188.33
3.	Backfilling in trench	m^3	2,700	4.2	10.4	11.34	28.08	39.42
4.	Disposal of excavated material	m^3	1,500	1.1	3.2	1.65	4.80	6.45
5.	Asphalt pavement	m^2	1,800	2.0	4.6	3.60	8.28	11.88
6.	Manhole, connecting pipes, etc.	L.S				21.05	51.60	72.65
	Total of I.6					94.82	231.89	326.71
I.7	Dia 1,650mm							
1.	Trench excavation	m^3	4,000	0.6	1.5	2.40	6.00	8.40
2.	Sewer installation	m	580	102.5	254.4	59.45	147.55	207.00
3.	Backfilling in trench	m^3	2,400	4.2	10.4	10.08	24.96	35.04
4.	Disposal of excavated material	m^3	1,300	1.1	3.2	1.43	4.16	5.59
5.	Asphalt pavement	m^2	1,730	2.0	4.6	3.46	7.96	11.42
6.	Manhole, connecting pipes, etc.	L.S				22.01	54.80	76.81
	Total of I.7					98.83	245.43	344.26
I.8	Dia 1,800mm							
1.	Trench excavation	m^3	1,700	0.6	1.5	1.02	2.55	3.57
2.	Sewer installation	m	240	115.6	290.1	27.74	69.62	97.37
3.	Backfilling in trench	m^3	900	4.2	10.4	3.78	9.36	13.14
4.	Disposal of excavated material	m^3	500	1.1	3.2	0.55	1.60	2.15
5.	Asphalt pavement	m^2	770	2.0	4.6	1.54	3.54	5.08
6.	Manhole, connecting pipes, etc.	L.S				9.93	24.94	34.87
	Total of I.11					44.56	111.62	156.18
	Total of I.					500.70	1,174.40	1,675.11
II.	**Land Acquisition**	L.S						0.00
III.	**Administration Cost**	L.S				50.25	0.00	50.25
IV.	**Engineering Service**	L.S				75.11	176.16	251.27
V.	**Physical Contingency**	L.S				50.07	117.44	167.51
	Grand Total					676.13	1,468.00	2,144.14

Table D3-16 Cost for Component 4: Trabek Basin Drainage Improvement (1/5)

a. Trabek Pumping Station ($8m^3/s$) and Regulation Pond

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
1.	Regulation Pond							
(1)	Lake excavation	m^3	223,560	0.7	1.8	156.49	402.41	558.90
(2)	Lake dredging	m^3	521,760	2.5	3.5	1,304.40	1,826.16	3,130.56
(3)	Disposal of excavated material	m^3	745,320	1.1	3.2	819.85	2,385.02	3,204.88
(4)	Miscellaneous	L.S				456.15	922.72	1,378.87
	Total of 1.					2,736.89	5,536.31	8,273.20
2.	Inlet Channel							
(1)	Excavation for river improveme	m^3	38,600	0.6	1.5	23.16	57.90	81.06
(2)	Dredging for river improvement	m^3	38,600	1.7	2.9	65.62	111.94	177.56
(3)	Disposal of excavated material	m^3	77,200	1.1	3.2	84.92	247.01	331.96
(4)	Miscellaneous	L.S				34.74	83.38	118.12
	Total of 2.					208.44	500.26	708.70
3.	Pumping Station							
(1)	Open excavation	m^3	30,000	0.4	1.1	12.00	33.00	45.00
(2)	Disposal of excavated material	m^3	30,000	1.1	3.2	33.00	96.00	129.00
(3)	Piling 406x406mm, L=10m	no.	75	268.5	568.8	20.14	42.66	62.80
(4)	Piling 305x305mm, L=10m	no.	120	228.6	449.1	27.43	53.89	81.32
(5)	Piling 200x200mm, L=4m	no.	50	113.8	191.8	5.69	9.59	15.28
(6)	Steel sheet piling	m^2	600	33.6	95.2	20.16	57.12	77.28
(7)	Embankment for dike	m^3	9,500	3.1	9.2	29.45	87.40	116.85
(8)	Concrete	m^3	2,900	71.7	56.7	207.93	164.43	372.36
(9)	Form	m^2	5,700	16.5	3.8	94.05	21.66	115.71
(10)	Reinforcing bars	ton	270	471.8	541.8	127.39	146.29	273.67
(11)	Sodding	m^2	3,000	3.6	0.3	10.80	0.90	11.70
(12)	Steel gate	m^2	14	2,800.0	11,200.0	39.20	156.80	196.00
(13)	Miscellaneous	L.S				125.45	173.95	299.39
	Total of 3.					752.68	1,043.69	1,796.37
4.	Outlet Channel							
(1)	Excavation for river improveme	m^3	6,400	0.6	1.5	3.84	9.60	13.44
(2)	Disposal of excavated material	m^3	6,400	1.1	3.2	7.04	20.48	27.52
(3)	Miscellaneous	L.S				2.18	6.02	8.19
	Total of 4.					13.06	36.10	49.15
5.	Mechanical & Electrical Works							
(1)	Intake equipment	L.S				0.00	571.29	571.29
(2)	Pumping equipment	L.S				0.00	1,147.30	1,147.30
(3)	Power supply equipment	L.S				0.00	1,333.53	1,333.53
(4)	Others	L.S				0.00	334.30	334.30
	Total of 5.					0.00	3,386.42	3,386.42
	Total of I.					3,711.07	10,502.76	14,213.84
II.	**Land Acquisition**	m^2	6,300	5.0	0.0	31.50	0.00	31.50
III.	**Administration Cost**	L.S				426.42	0.00	426.42
IV.	**Engineering Service**	L.S				556.66	1,575.41	2,132.08
V.	**Physical Contingency**	L.S				371.11	1,050.28	1,421.38
	Grand Total					5,096.75	13,128.46	18,225.21

Table D3-16 Cost for Component 4: Trabek Basin Drainage Improvement (2/5)

b. Trabek Drainage Main (1.604 km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation	m^3	106,480	0.7	1.5	74.54	159.72	234.26
2.	Backfilling under road	m^3	34,210	4.2	10.4	143.68	355.78	499.47
3.	Backfilling with excavated mate	m^3	28,820	0.8	1.7	23.06	48.99	72.05
4.	Disposal of excavated material	m^3	77,660	1.1	3.2	85.43	248.51	333.94
5.	Asphalt pavement	m^2	22,660	2.0	4.6	45.32	104.24	149.56
6.	Concrete	m^3	23,320	71.7	56.7	1,672.04	1,322.24	2,994.29
7.	Reinforcing bars	ton	2,156	471.8	541.8	1,017.20	1,168.12	2,185.32
8.	Form	m^2	51,480	16.5	3.8	849.42	195.62	1,045.04
9.	Piling 305x305mm, L=10m	no.	2,024	228.6	449.1	462.69	908.98	1,371.66
10.	Miscellaneous	L.S				874.67	902.44	1,777.12
	Total of I.					5,248.05	5,414.66	10,662.70
II.	Land Acquisition	m^2	0	5.0	0.0	0.00	0.00	0.00
III.	Administration Cost	L.S				319.88	0.00	319.88
IV.	Engineering Service	L.S				787.21	812.20	1,599.41
V.	Physical Contingency	L.S				524.80	541.47	1,066.27
	Grand Total					6,879.94	6,768.32	13,648.26

c. Toul Sen Drainage Main (L=2.05km)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation	m^3	45,900	0.7	1.5	32.13	68.85	100.98
2.	Backfilling under road	m^3	9,500	4.2	10.4	39.90	98.80	138.70
3.	Backfilling with excavated mate	m^3	15,500	0.8	1.7	12.40	26.35	38.75
4.	Disposal of excavated material	m^3	30,400	1.1	3.2	33.44	97.28	130.72
5.	Asphalt pavement	m^2	6,300	2.0	4.6	12.60	28.98	41.58
6.	Concrete	m^3	5,400	71.7	56.7	387.18	306.18	693.36
7.	Reinforcing bars	ton	460	471.8	541.8	217.03	249.23	466.26
8.	Form	m^2	22,300	16.5	3.8	367.95	84.74	452.69
9.	Piling 305x305mm, L=10m	no.	280	228.6	449.1	64.01	125.75	189.76
10.	Piling 200x200mm, L=3m	no.	600	113.8	191.8	68.28	115.08	183.36
11.	Masonry revetment	m^2	2,700	36.4	33.2	98.28	89.64	187.92
12.	Miscellaneous	L.S				266.64	258.18	524.81
	Total of I.					1,599.84	1,549.05	3,148.89
II.	Land Acquisition	m^2	0	5.0	0.0	0.00	0.00	0.00
III.	Administration Cost	L.S				94.47	0.00	94.47
IV.	Engineering Service	L.S				239.98	232.36	472.33
V.	Physical Contingency	L.S				159.98	154.91	314.89
	Grand Total					2,094.26	1,936.31	4,030.57

Table D3-16 Cost for Component 4: Trabek Basin Drainage Improvement (3/5)

d. Norodom Drainage Main (1.768km long)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	Construction Cost							
1.	Excavation	m^3	86,600	0.7	1.5	60.62	129.90	190.52
2.	Backfilling under road	m^3	24,100	4.2	10.4	101.22	250.64	351.86
3.	Backfilling with excavated mate	m^3	35,600	0.8	1.7	28.48	60.52	89.00
4.	Disposal of excavated material	m^3	51,000	1.1	3.2	56.10	163.20	219.30
5.	Asphalt pavement	m^2	12,100	2.0	4.6	24.20	55.66	79.86
6.	Concrete	m^3	9,900	71.7	56.7	709.83	561.33	1,271.16
7.	Reinforcing bars	ton	840	471.8	541.8	396.31	455.11	851.42
8.	Form	m^2	30,300	16.5	3.8	499.95	115.14	615.09
9.	Piling 200x200mm, L=3m	no.	950	113.8	191.8	108.11	182.21	290.32
10.	Miscellaneous	L.S				396.96	394.74	791.71
	Total of I.					2,381.79	2,368.45	4,750.24
II.	Land Acquisition	m^2	0	5.0	0.0	0.00	0.00	0.00
III.	Administration Cost	L.S				142.51	0.00	142.51
IV.	Engineering Service	L.S				357.27	355.27	712.54
V.	Physical Contingency	L.S				238.18	236.85	475.02
	Grand Total					3,119.74	2,960.57	6,080.31

Table D3-16 Cost for Component 4: Trabek Basin Drainage Improvement (4/5)

e. Sewer Rehabilitation (1,083 ha)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.	**Construction Cost**							
I.1	Dia 375mm							
1.	Trench excavation	m^3	16,500	0.6	1.5	9.90	24.75	34.65
2.	Sewer installation	m	6,045	17.6	27.4	106.39	165.63	272.03
3.	Backfilling in trench	m^3	15,150	4.2	10.4	63.63	157.56	221.19
4.	Disposal of excavated material	m^3	8,400	1.1	3.2	9.24	26.88	36.12
5.	Asphalt pavement	m^2	6,045	2.0	4.6	12.09	27.81	39.90
6.	Manhole, connecting pipes, etc.	L.S				56.75	112.45	169.20
	Total of I.1					258.00	515.08	773.08
I.2	Dia 450mm							
1.	Trench excavation	m^3	66,000	0.6	1.5	39.60	99.00	138.60
2.	Sewer installation	m	20,475	19.3	31.8	395.17	651.11	1,046.27
3.	Backfilling in trench	m^3	61,350	4.2	10.4	257.67	638.04	895.71
4.	Disposal of excavated material	m^3	33,750	1.1	3.2	37.13	108.00	145.13
5.	Asphalt pavement	m^2	22,500	2.0	4.6	45.00	103.50	148.50
6.	Manhole, connecting pipes, etc.	L.S				218.87	448.84	667.71
	Total of I.2					993.43	2,048.49	3,041.92
I.3	Dia 600mm							
1.	Trench excavation	m^3	207,750	0.6	1.5	124.65	311.63	436.28
2.	Sewer installation	m	47,115	26.7	50.1	1,257.97	2,360.46	3,618.43
3.	Backfilling in trench	m^3	189,600	4.2	10.4	796.32	1,971.84	2,768.16
4.	Disposal of excavated material	m^3	104,400	1.1	3.2	114.84	334.08	448.92
5.	Asphalt pavement	m^2	61,350	2.0	4.6	122.70	282.21	404.91
6.	Manhole, connecting pipes, etc.	L.S				688.13	1,493.40	2,181.54
	Total of I.3					3,104.61	6,753.62	9,858.23
I.4	Dia 750mm							
1.	Trench excavation	m^3	121,200	0.6	1.5	72.72	181.80	254.52
2.	Sewer installation	m	16,830	32.9	65.5	553.71	1,102.37	1,656.07
3.	Backfilling in trench	m^3	111,450	4.2	10.4	468.09	1,159.08	1,627.17
4.	Disposal of excavated material	m^3	61,350	1.1	3.2	67.49	196.32	263.81
5.	Asphalt pavement	m^2	31,200	2.0	4.6	62.40	143.52	205.92
6.	Manhole, connecting pipes, etc.	L.S				348.60	791.87	1,140.47
	Total of I.4					1,573.00	3,574.95	5,147.96
I.5	Dia 900mm							
1.	Trench excavation	m^3	66,150	0.6	1.5	39.69	99.23	138.92
2.	Sewer installation	m	7,665	47.0	105.8	360.26	810.96	1,171.21
3.	Backfilling in trench	m^3	59,700	4.2	10.4	250.74	620.88	871.62
4.	Disposal of excavated material	m^3	32,850	1.1	3.2	36.14	105.12	141.26
5.	Asphalt pavement	m^2	15,330	2.0	4.6	30.66	70.52	101.18
6.	Manhole, connecting pipes, etc.	L.S				206.05	490.85	696.90
	Total of I.5					923.53	2,197.55	3,121.08
I.6	Dia 1,050mm							
1.	Trench excavation	m^3	80,700	0.6	1.5	48.42	121.05	169.47
2.	Sewer installation	m	8,385	55.4	126.8	464.53	1,063.22	1,527.75
3.	Backfilling in trench	m^3	71,100	4.2	10.4	298.62	739.44	1,038.06
4.	Disposal of excavated material	m^3	39,150	1.1	3.2	43.07	125.28	168.35
5.	Asphalt pavement	m^2	18,450	2.0	4.6	36.90	84.87	121.77
6.	Manhole, connecting pipes, etc.	L.S				256.39	614.70	871.09
	Total of I.6					1,147.92	2,748.55	3,896.48

Table D3-16 Cost for Component 4: Trabek Basin Drainage Improvement (5/5)

No.	Items	Unit	Q'ty	Unit Price (US$)		Amount (US$1,000)		
				L.C	F.C	L.C	F.C	Total
I.7	Dia 1,200mm							
1.	Trench excavation	m^3	84,600	0.6	1.5	50.76	126.90	177.66
2.	Sewer installation	m	6,945	73.2	177.9	508.37	1,235.52	1,743.89
3.	Backfilling in trench	m^3	74,400	4.2	10.4	312.48	773.76	1,086.24
4.	Disposal of excavated material	m^3	40,950	1.1	3.2	45.05	131.04	176.09
5.	Asphalt pavement	m^2	16,680	2.0	4.6	33.36	76.73	110.09
6.	Manhole, connecting pipes, etc.	L.S				275.00	680.16	955.16
	Total of I.7					1,225.02	3,024.11	4,249.12
I.8	Dia 1,350mm							
1.	Trench excavation	m^3	88,650	0.6	1.5	53.19	132.98	186.17
2.	Sewer installation	m	6,255	86.5	214.5	541.06	1,341.70	1,882.76
3.	Backfilling in trench	m^3	76,950	4.2	10.4	323.19	800.28	1,123.47
4.	Disposal of excavated material	m^3	42,450	1.1	3.2	46.70	135.84	182.54
5.	Asphalt pavement	m^2	16,245	2.0	4.6	32.49	74.73	107.22
6.	Manhole, connecting pipes, etc.	L.S				289.24	723.24	1,012.48
	Total of I.8					1,285.86	3,208.76	4,494.62
I.9	Dia 1,500mm							
1.	Trench excavation	m^3	63,600	0.6	1.5	38.16	95.40	133.56
2.	Sewer installation	m	3,885	88.9	217.6	345.38	845.38	1,190.75
3.	Backfilling in trench	m^3	54,600	4.2	10.4	229.32	567.84	797.16
4.	Disposal of excavated material	m^3	30,150	1.1	3.2	33.17	96.48	129.65
5.	Asphalt pavement	m^2	10,890	2.0	4.6	21.78	50.09	71.87
6.	Manhole, connecting pipes, etc.	L.S				193.81	481.53	675.34
	Total of I.9					861.61	2,136.72	2,998.33
I.10	Dia 1,650mm							
1.	Trench excavation	m^3	54,900	0.6	1.5	32.94	82.35	115.29
2.	Sewer installation	m	2,895	102.5	254.4	296.74	736.49	1,033.23
3.	Backfilling in trench	m^3	46,800	4.2	10.4	196.56	486.72	683.28
4.	Disposal of excavated material	m^3	25,800	1.1	3.2	28.38	82.56	110.94
5.	Asphalt pavement	m^2	8,670	2.0	4.6	17.34	39.88	57.22
6.	Manhole, connecting pipes, etc.	L.S				166.39	416.44	582.82
	Total of I.10					738.34	1,844.44	2,582.78
I.11	Dia 1,800mm							
1.	Trench excavation	m^3	17,700	0.6	1.5	10.62	26.55	37.17
2.	Sewer installation	m	900	115.6	290.1	104.04	261.09	365.13
3.	Backfilling in trench	m^3	14,745	4.2	10.4	61.93	153.35	215.28
4.	Disposal of excavated material	m^3	8,100	1.1	3.2	8.91	25.92	34.83
5.	Asphalt pavement	m^2	2,880	2.0	4.6	5.76	13.25	19.01
6.	Manhole, connecting pipes, etc.	L.S				55.65	140.07	195.72
	Total of I.11					246.91	620.23	867.14
	Total of I.					12,358.24	28,672.50	41,030.73
II.	**Land Acquisition**	L.S						0.00
III.	**Administration Cost**	L.S				1,230.92	0.00	1,230.92
IV.	**Engineering Service**	L.S				1,853.74	4,300.87	6,154.61
V.	**Physical Contingency**	L.S				1,235.82	2,867.25	4,103.07
	Grand Total					16,678.72	35,840.62	52,519.34