Table I3-1 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 I3-2 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 I3-3 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).

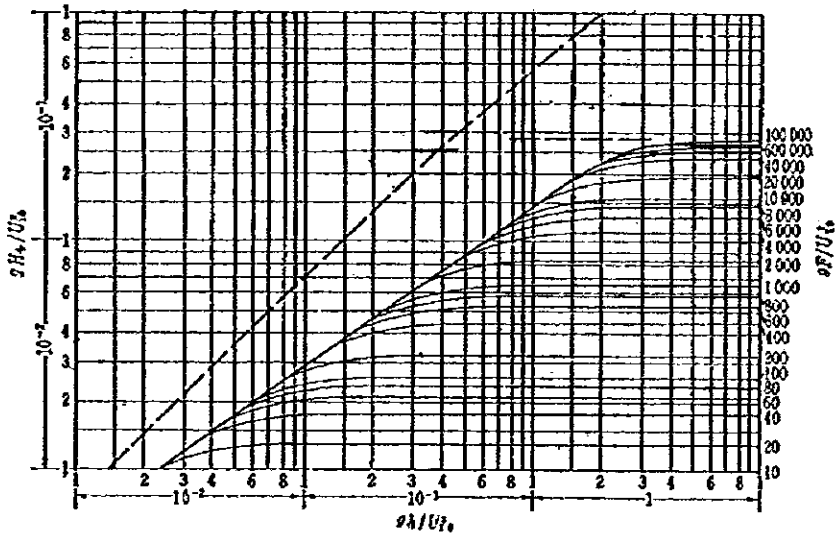

Table I3-4 Alternatives for Flood Protection

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 I3-5 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/m^3	71,000 m^3	106.5	39,000 m^3	58.5
	Embank-ment	12.3/m^3	492,000 m^3	6,051.6	286,000 m^3	3,517.8
	Sodding	3.9/m^2	127,000 m^2	495.3	70,000 m^2	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 I3-6 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 I3-7 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 km²)	**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 km²)	**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 km²)	**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 km²)	**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 km²)	**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 km²)	**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 km²)	**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 m³/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 km²)	**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 km²)	**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 km²)	**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 km²)	**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 km²)	**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 km²)	**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 km²)	**To the Tonle Sap River:** The same strategy as mentioned in C6, Bassac Riverside is taken.
NORTHWEST AREA (50.79 km²)	**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
<u>MIDDLE AREA</u>	
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.
<u>SOUTH AREA</u>	
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 I3-8 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 I3-9 Implementation Schedule for the Master Plan

Project Component	Cost in US$ mil	Year: 2000	01	02	03	04	2005	06	07	08	09	2010	11	12	13	14	2015	16	17	18	19	2020
Component 1: Riverfront Protection in Sap Downstream Middle Section (1.0km)	2.3									■												
Component 2: Reinforcement of Kop Srov and Tompun Dikes	17.8	▒	▒																			
a. Reinforcement of Kop Srov Dike (9.0km)	16.2	■	■																			
b. Reinforcement of Tompun Dike (4.4km)	1.6		■																			
Component 3: Tompun Watershed Drainage Improvement	88.6	▒	▒	▒	▒	▒	▒	▒	▒	53.7			▒	▒	▒	▒	▒	▒	▒	▒	▒	34.9
a. Tompun Pumping Station (15m³/s) and Regulation Pond	15.7	■	■	■																		
b. Meanchey Drainage Main, Downstream Stretch (2.76km long)	5.0			■	■																	
c. Meanchey Drainage Main, Upstream Stretch (2.135km long)	1.9			■	■																	
d. Tum Nup Tock Drainage Sluiceway (2mx2mx1 lane)	0.4								■													
e. Samdachi Monireth Drainage Main (2.36km long)	24.8				■	■	■	■	■													
f. Jawaharlal Nehru Drainage Main (1.16km long)	3.6								■	■												
g. Salang Drainage Main (1.89km long)	2.3								■	■												
h. Sewer Rehabilitation excluding Tum Nup Tock Basin (931ha)	32.8												■	■	■	■	■	■	■	■	■	
i. Sewer Construction, Tum Nup Tock Basin (68ha)	2.1																				■	
Component 4: Trabek Basin Drainage Improvement	94.5	▒	▒	▒	▒	▒	▒	▒	42.0				▒	▒	▒	▒	▒	▒	▒	▒	▒	52.5
a. Trabek Pumping Station (8m³/s) and Regulation Pond	18.2	■	■	■																		
b. Trabek Drainage Main (1.604km long)	13.7				■	■	■															
c. Toul Seo Drainage Main (2.05km long)	4.0					■	■															
d. Norodom Drainage Main (1.768km long)	6.1							■														
e. Sewer Rehabilitation (1,083ha)	52.5												■	■	■	■	■	■	■	■	■	
Component 5: City Core North Area Drainage Improvement	32.0								▒	▒	12.5		▒	▒	▒	▒	▒	▒	▒	▒	▒	19.5
a. C1: Wat Phnom Basin, Sewer Rehabilitation (89ha)	4.3												■	■	■							
b. C2: Kak Lakeshore Basin, Sewer Rehabilitation (51ha)	0.4																				■	
c. C3: Boeng Kak Basin, Kak Drainage Sluiceway	0.4									■												
d. C4: Tuol Kork Basin, Major Drainage Facilities	11.5								■	■												
e. C4: Tuol Kork Basin, Sewer Rehabilitation (332ha)	14.8														■	■	■	■	■	■	■	
f. C5: University Basin, Drainage Sluiceways (2 locations)	0.7									■												
Component 6: Pochentong East Basin Drainage Improvement	11.9									■	■											
Component 7: Northeast and Northwest Areas Drainage Improvement	12.1										▒	▒										
a. Poungpeay Drainage Main (11.92km)	10.4										■	■										
b. Svay Pak Drainage Sluiceway (2mx2mx2 lanes)	0.7											■										
c. Drainage Sluiceways in Poungpeay East Basin (12 locations)	1.1											■										
Component 8: Environmental Enhancement	1.9											▒										
a. Environmental Canal (1.75km long)	1.7											■										
b. Kak Interceptor (0.85km long)	0.2											■										
Total	261.1	154.2											106.9									

Table I4-1 Densities by Land Use Type

(Unit : number per mesh)

Land use type		Household	Factories	Shops	Offices	Warehouse	School	Hospital
(1998)								
0	Out of study area	-	-	-	-	-	-	-
1	Dense activities	3.2	2.0	2.0	0.2	0.08	0.002	0
2	Dense urban center	500.0	0.5	11.9	2.6	0.80	0.368	0.079
3	Dense residential	160.0	1.0	3.2	0.1	0.02	0.118	0.043
4	Loose residential	16.0	0	0.4	0	0	0.012	0
5	Loose activities	3.2	0	0.9	0	0	0.002	0
6	Agriculture land, unused land	3.0	0	0.1	0	0	0.002	0
7	Green space, park	0.0	0	0	0	0	0	0
8	Fish pond	3.0	0	0	0	0	0	0
9	Lakes, pond, river	0.0	0	0	0	0	0	0
(2010)								
0	Out of study area	-	-	-	-	-	-	-
1	Dense activities	3.5	2.2	2.1	0.3	0.09	0.003	0.000
2	Dense urban center	546.0	0.5	12.5	3.1	0.95	0.400	0.096
3	Dense residential	174.7	1.1	3.4	0.1	0.03	0.128	0.038
4	Loose residential	17.5	0.0	0.5	0.0	0.00	0.013	0.000
5	Loose activities	3.5	0.0	1.0	0.0	0.00	0.003	0.000
6	Agriculture land, unused land	3.3	0.0	0.1	0.0	0.00	0.002	0.000
7	Green space, park	0.0	0.0	0.0	0.0	0.00	0.000	0.000
8	Fish pond	3.3	0.0	0.0	0.0	0.00	0.000	0.000
9	Lakes, pond, river	0.0	0.0	0.0	0.0	0.00	0.000	0.000

Table I4-2 Damage Ratio by 0.5 Meter Depth Range

Type	Level of inundation					
		above floor level				
	below floor	less than 50 cm	50-99 cm	100-199 cm	200-299cm	300 cm -
House building *	0.032	0.092	0.119	0.266	0.580	0.834
Household goods *	0.021	0.145	0.326	0.508	0.928	0.991
Business organizations						
Building and goods*	0.032	0.092	0.119	0.266	0.580	0.834
Inventory	0.056	0.128	0.267	0.586	0.897	0.982
Farmers and fishermen						
Building and goods	0.000	0.156	0.237	0.297	0.651	0.698
Inventory	0.000	0.199	0.370	0.491	0.767	0.831

Source : Ministry of Construction, Japan

Note : Only those damage ratios with * are applied to the present analysis. The other ratios are shown for reference.

Table I4-3 Damage Values for Mesh by Land Use Type and Inundation Level in 2010

(Unit : $)

Land use type	Inundation below floor level	Inundation above floor level				
		Less than 50 cm	50-99 cm	100-199 cm	200-299cm	300 cm -
1 Dense activities	16,890	48,854	63,676	141,563	308,042	441,742
2 Dense urban center	79,677	275,277	431,656	844,373	1,743,014	2,318,837
3 Dense residential	25,370	87,723	137,654	269,140	555,458	738,718
4 Loose residential	2,448	8,518	13,440	26,180	53,941	71,554
5 Loose activities	727	2,386	3,571	7,211	15,094	20,502
6 Agriculture land, unused land	461	1,606	2,534	4,936	10,171	13,491
7 Green space, park	0	0	0	0	0	0
8 Fish pond	428	1,511	2,411	4,661	9,570	12,628
9 Lakes, pond, river	0	0	0	0	0	0

Table I 4-4 Preliminary Estimate of Damages by Degraded Urban Function

Phnom Pehn's GRDP

Industry	271	billion Riel in 1996 in current price
Service	910	billion Riel in 1996 in current price
Total	1,181	billion Riel in 1996 in current price

Length of inundation (AFDS)

(Unit : days)

	1995	1996	Average
Household	22.3	20.1	21.2
Shop	17.6	14.0	15.8
Office	2.8	2.8	2.8
Factory	13.9	8.2	11.1
Warehouse	9.6	9.6	9.6
School	12.6	5.9	9.3
Total	13.1	10.1	11.6

Level of degradation of urban function

	Normal inundation	Severe inundation	Average
Maximum	30%	90%	
Minimum	0%	10%	
Average	10%	43%	26%

Derivation of Damage

GRDP	1,181	billion Riel in 1996 in current price
Length	11	days
	3.0%	of 365 days
Level of degradation	26%	
Damage	9.4	billion Riel in 1996 in current price
	2.5	million $ per year
Adjustment to 1998 level	none due to little gorwth in 1997 and 1998	

Direct economic benefit	30.2	million $ per year
	8.2%	

Note : $= 3,800 Riel

Table I4-5 Direct Flood and Inundation Damage and Economic Benefit by Component

Unit: US$

Component	Direct Damage in Without-project Case			
	2-year	5-year	10-year	30-year
1	50,000 of maintenance cost			
2	0	0	44,717,000	53,736,000
3	3,747,000	4,308,000	4,867,000	5,316,000
4	4,486,000	6,697,000	7,535,000	8,701,000
5	1,361,000	1,845,000	2,075,000	2,488,000
6	1,187,000	1,428,000	1,588,000	1,716,000
7	3,899,000	4,303,000	4,458,000	5,039,000
8	No damage			

Component	Direct Damage in With-project Case			
	2-year	5-year	10-year	30-year
1	Nil			
2	0	0	4,458,000	5,039,000
3	749,000	809,000	1,051,000	1,166,000
4	1,867,000	2,599,000	3,168,000	3,535,000
5	820,000	1,076,000	1,107,000	1,174,000
6	978,000	1,268,000	1,286,000	1,599,000
7	3,832,000	4,220,000	4,673,000	5,299,000
8	No damage			

Component	Direct Benefit			
	2-year	5-year	10-year	30-year
1	50,000			
2	0	0	40,259,000	48,697,000
3	2,998,000	3,499,000	3,816,000	4,150,000
4	2,619,000	4,098,000	4,367,000	5,166,000
5	541,000	769,000	968,000	1,314,000
6	209,000	160,000	302,000	117,000
7	67,000	83,000	(215,000)	(260,000)
8	Nil			

Table I4-6 Annual Average Benefits (1/3)

a. Component 2: Kop Srov and Tompun Dikes

Return Period	Flood Damage (US$1,000)		Benefit (US$1,000)	Mean (US$1,000)	Frequency per Year	Annual Average Benefit (US$1,000)
	Without-Project	With-Project				
0.2-year	0	0	0			
				0	4.500	0
2-year	0	0	0			
				0	0.300	0
5-year	0	0	0			
				26,168	0.100	2,617
10-year	58,132	5,795	52,337			
				57,821	0.067	3,851
30-year	69,857	6,551	63,306			
Total	-	-	-	-	-	6,468

b. Component 3: Tompun Watershed

Return Period	Flood Damage (US$1,000)		Benefit (US$1,000)	Mean (US$1,000)	Frequency per Year	Annual Average Benefit (US$1,000)
	Without-Project	With-Project				
0.2-year	0	0	0			
				1,949	4.500	8,769
2-year	4,871	974	3,897			
				4,223	0.300	1,267
5-year	5,600	1,052	4,549			
				4,755	0.100	475
10-year	6,327	1,366	4,961			
				5,178	0.067	345
30-year	6,911	1,516	5,395			
Total	-	-	-	-	-	10,856

Note: 30 % of indirect damage has been included in the values above.

Table I4-6 Annual Average Benefits (2/3)

c. Component 4: Trabek Basin

Return Period	Flood Damage (US$1,000)		Benefit (US$1,000)	Mean (US$1,000)	Frequency per Year	Annual Average Benefit (US$1,000)
	Without-Project	With-Project				
0.2-year	0	0	0			
				1,702	4.500	7,661
2-year	5,832	2,427	3,405			
				4,366	0.300	1,310
5-year	8,706	3,379	5,327			
				5,502	0.100	550
10-year	9,796	4,118	5,677			
				6,196	0.067	413
30-year	11,311	4,596	6,716			
Total	-	-	-	-	-	9,933

d. Component 5: City Core North Area

Return Period	Flood Damage (US$1,000)		Benefit (US$1,000)	Mean (US$1,000)	Frequency per Year	Annual Average Benefit (US$1,000)
	Without-Project	With-Project				
0.2-year	0	0	0			
				352	4.500	1,582
2-year	1,769	1,066	703			
				852	0.300	255
5-year	2,399	1,399	1,000			
				1,129	0.100	113
10-year	2,698	1,439	1,258			
				1,483	0.067	99
30-year	3,234	1,526	1,708			
Total	-	-	-	-	-	2,050

Note: 30 % of indirect damage has been included in the values above.

Table I4-6 Annual Average Benefits (3/3)

e. Component 6: Pochentong East Basin

Return Period	Flood Damage (US$1,000)		Benefit (US$1,000)	Mean (US$1,000)	Frequency per Year	Annual Average Benefit (US$1,000)
	Without-Project	With-Project				
0.2-year	0	0	0			
				136	4.500	611
2-year	1,543	1,271	272			
				240	0.300	72
5-year	1,856	1,648	208			
				300	0.100	30
10-year	2,064	1,672	393			
				272	0.067	18
30-year	2,231	2,079	152			
Total	-	-	-	-	-	731

f. Component 7: Northeast and Northwest Areas

Return Period	Flood Damage (US$1,000)		Benefit (US$1,000)	Mean (US$1,000)	Frequency per Year	Annual Average Benefit (US$1,000)
	Without-Project	With-Project				
0.2-year	0	0	0			
				44	4.500	196
2-year	5,069	4,982	87			
				98	0.300	29
5-year	5,594	5,486	108			
				-86	0.100	-9
10-year	5,795	6,075	-280			
				-309	0.067	-21
30-year	6,551	6,889	-338			
Total	-	-	-	-	-	196

Note: 30 % of indirect damage has been included in the values above.

Table I4-7 Annual Average Benefit for Rice Production (1/2)

a. Component 2 : Kop Srov and Tompun Dikes

Return Period	Flood Damage (US$)		Benefit (US$)	Mean (US$)	Frequency per Year	Annual Average Benefit (US$)
	Without-Project	With-Project				
0.2-year	0	0	0			
				0	4.500	0
2-year	0	0	0			
				0	0.300	0
5-year	0	0	0			
				158,593	0.100	15,859
10-year	317,185	0	317,185			
				336,938	0.067	22,440
30-year	356,690	0	356,690			
Total	-	-	-	-	-	38,299

b. Component 3 : Tompun Watershed

Return Period	Flood Damage (US$)		Benefit (US$)	Mean (US$)	Frequency per Year	Annual Average Benefit (US$)
	Without-Project	With-Project				
0.2-year	0	0	0			
				1,344	4.500	6,046
2-year	3,280	593	2,687			
				2,445	0.300	734
5-year	3,367	1,164	2,203			
				2,285	0.100	228
10-year	3,775	1,409	2,366			
				2,353	0.067	157
30-year	3,879	1,540	2,339			
Total	-	-	-	-	-	7,164

Table I4-7 Annual Average Benefit for Rice Production (2/2)

c. Component 6 : Pochenton East Basin

Return Period	Flood Damage (US$)		Benefit (US$)	Mean (US$)	Frequency per Year	Annual Average Benefit (US$)
	Without-Project	With-Project				
0.2-year	0	0	0			
				637	4.500	2,864
2-year	4,586	3,313	1,273			
				1,118	0.300	335
5-year	5,532	4,570	962			
				1,542	0.100	154
10-year	6,805	4,684	2,121			
				1,812	0.067	121
30-year	7,116	5,614	1,502			
Total	-	-	-	-	-	3,474

d. Component 7 : Northeast and Northwest Areas

Return Period	Flood Damage (US$)		Benefit (US$)	Mean (US$)	Frequency per Year	Annual Average Benefit (US$)
	Without-Project	With-Project				
0.2-year	0	0	0			
				204	4.500	918
2-year	44,331	43,923	408			
				963	0.300	289
5-year	51,544	50,026	1,518			
				147	0.100	15
10-year	54,384	55,608	-1,224			
				-1,608	0.067	-107
30-year	60,830	62,821	-1,991			
Total	-	-	-	-	-	1,115

Table I4-8 Cost Benefit Stream for Master Plan Projects (1/3)

(US$1,000)

No.	Year	Construction Cost								
		Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8	Total
1	2000	0	8,462	6,297	5,629	0	0	0	0	20,388
2	2001	0	8,462	6,297	5,629	0	0	0	0	20,388
3	2002	0	0	6,297	5,629	0	0	0	0	11,926
4	2003	0	0	6,297	5,629	0	0	0	0	11,926
5	2004	0	0	6,297	5,629	0	0	0	0	11,926
6	2005	0	0	6,297	5,629	0	0	0	0	11,926
7	2006	0	0	6,297	5,629	0	0	0	0	11,926
8	2007	0	0	6,297	0	5,862	0	0	0	12,158
9	2008	2,094	0	0	0	5,862	5,646	0	0	13,603
10	2009	0	0	0	0	0	5,646	5,703	0	11,349
11	2010	0	0	0	0	0	0	5,703	1,747	7,450
12	2011	0	0	3,325	5,002	1,848	0	0	0	10,176
13	2012	0	0	3,325	5,002	1,848	0	0	0	10,176
14	2013	0	0	3,325	5,002	1,848	0	0	0	10,176
15	2014	0	0	3,325	5,002	1,848	0	0	0	10,176
16	2015	0	0	3,325	5,002	1,848	0	0	0	10,176
17	2016	0	0	3,325	5,002	1,848	0	0	0	10,176
18	2017	0	0	3,325	5,002	1,848	0	0	0	10,176
19	2018	0	0	3,325	5,002	1,848	0	0	0	10,176
20	2019	0	0	3,325	5,002	1,848	0	0	0	10,176
21	2020	0	0	3,325	5,002	1,848	0	0	0	10,176
22	2021	0	0	0	0	0	0	0	0	0
23	2022	0	0	0	0	0	0	0	0	0
24	2023	0	0	0	0	0	0	0	0	0
25	2024	0	0	0	0	0	0	0	0	0
26	2025	0	0	0	0	0	0	0	0	0
27	2026	0	0	0	0	0	0	0	0	0
28	2027	0	0	0	0	0	0	0	0	0
29	2028	0	0	0	0	0	0	0	0	0
30	2029	0	0	0	0	0	0	0	0	0
31	2030	0	0	0	0	0	0	0	0	0
32	2031	0	0	0	0	0	0	0	0	0
33	2032	0	0	0	0	0	0	0	0	0
34	2033	0	0	0	0	0	0	0	0	0
35	2034	0	0	0	0	0	0	0	0	0
36	2035	0	0	0	0	0	0	0	0	0
37	2036	0	0	0	0	0	0	0	0	0
38	2037	0	0	0	0	0	0	0	0	0
39	2038	0	0	0	0	0	0	0	0	0
40	2039	0	0	0	0	0	0	0	0	0
41	2040	0	0	0	0	0	0	0	0	0
42	2041	0	0	0	0	0	0	0	0	0
43	2042	0	0	0	0	0	0	0	0	0
44	2043	0	0	0	0	0	0	0	0	0
45	2044	0	0	0	0	0	0	0	0	0
46	2045	0	0	0	0	0	0	0	0	0
47	2046	0	0	0	0	0	0	0	0	0
48	2047	0	0	0	0	0	0	0	0	0
49	2048	0	0	0	0	0	0	0	0	0
50	2049	0	0	0	0	0	0	0	0	0
Total		2,094	16,925	83,628	89,423	30,206	11,293	11,406	1,747	246,721

Table I4-8 Cost Benefit Stream for Master Plan Projects (2/3)

(US$1,000)

No.	Year	O/M/R Cost								
		Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8	Total
1	2000	0	0	0	0	0	0	0	0	0
2	2001	0	42	31	28	0	0	0	0	102
3	2002	0	85	63	56	0	0	0	0	204
4	2003	0	85	94	84	0	0	0	0	264
5	2004	0	85	126	113	0	0	0	0	323
6	2005	0	85	157	141	0	0	0	0	383
7	2006	0	85	189	169	0	0	0	0	442
8	2007	0	85	220	197	0	0	0	0	502
9	2008	0	85	252	197	29	0	0	0	563
10	2009	10	85	252	197	59	28	0	0	631
11	2010	10	85	252	197	59	56	29	0	688
12	2011	10	85	252	197	59	56	57	9	725
13	2012	10	85	268	222	68	56	57	9	776
14	2013	10	85	285	247	77	56	57	9	827
15	2014	10	85	302	272	86	56	57	9	877
16	2015	10	85	318	297	96	56	57	9	928
17	2016	10	85	335	322	105	56	57	9	979
18	2017	10	85	352	347	114	56	57	9	1,030
19	2018	10	85	368	372	123	56	57	9	1,081
20	2019	10	85	385	397	133	56	57	9	1,132
21	2020	10	85	402	422	142	56	57	9	1,183
22	2021	10	85	418	447	151	56	57	9	1,234
23	2022	10	85	418	447	151	56	57	9	1,234
24	2023	10	85	418	447	151	56	57	9	1,234
25	2024	10	85	418	447	151	56	57	9	1,234
26	2025	10	85	418	447	151	56	57	9	1,234
27	2026	10	85	418	447	151	56	57	9	1,234
28	2027	10	85	418	447	151	56	57	9	1,234
29	2028	10	85	418	447	151	56	57	9	1,234
30	2029	10	85	418	447	151	56	57	9	1,234
31	2030	10	85	418	447	151	56	57	9	1,234
32	2031	10	85	418	447	151	56	57	9	1,234
33	2032	10	85	418	447	151	56	57	9	1,234
34	2033	10	85	418	447	151	56	57	9	1,234
35	2034	10	85	418	447	151	56	57	9	1,234
36	2035	10	85	418	447	151	56	57	9	1,234
37	2036	10	85	418	447	151	56	57	9	1,234
38	2037	10	85	418	447	151	56	57	9	1,234
39	2038	10	85	418	447	151	56	57	9	1,234
40	2039	10	85	418	447	151	56	57	9	1,234
41	2040	10	85	418	447	151	56	57	9	1,234
42	2041	10	85	418	447	151	56	57	9	1,234
43	2042	10	85	418	447	151	56	57	9	1,234
44	2043	10	85	418	447	151	56	57	9	1,234
45	2044	10	85	418	447	151	56	57	9	1,234
46	2045	10	85	418	447	151	56	57	9	1,234
47	2046	10	85	418	447	151	56	57	9	1,234
48	2047	10	85	418	447	151	56	57	9	1,234
49	2048	10	85	418	447	151	56	57	9	1,234
50	2049	10	85	418	447	151	56	57	9	1,234
Total		429	4,104	17,030	17,441	5,528	2,287	2,253	341	49,413

Table I4-8 Cost Benefit Stream for Master Plan Projects (3/3)

(US$1,000)

No.	Year	Total Cost	Benefit									B-C
			Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8	Total	
1	2000	20,388	0	0	0	0	0	0	0	0	0	-20,388
2	2001	20,490	0	0	436	455	0	0	0	0	891	-19,599
3	2002	12,130	0	3,730	934	976	0	0	0	0	5,641	-6,489
4	2003	12,189	0	3,999	1,502	1,570	0	0	0	0	7,071	-5,118
5	2004	12,249	0	4,287	2,147	2,244	0	0	0	0	8,678	-3,571
6	2005	12,309	0	4,596	2,877	3,007	0	0	0	0	10,480	-1,829
7	2006	12,368	0	4,926	3,702	3,868	0	0	0	0	12,496	128
8	2007	12,660	0	5,281	4,629	4,838	0	0	0	0	14,748	2,088
9	2008	14,165	0	5,661	5,672	5,186	535	0	0	0	17,054	2,889
10	2009	11,980	47	6,069	6,080	5,560	1,147	342	0	0	19,245	7,265
11	2010	8,138	50	6,506	6,518	5,960	1,230	734	100	0	21,097	12,959
12	2011	10,900	50	6,506	6,518	5,960	1,230	734	199	0	21,197	10,296
13	2012	10,951	50	6,506	6,952	6,357	1,312	734	199	0	22,110	11,159
14	2013	11,002	50	6,506	7,387	6,754	1,394	734	199	0	23,024	12,022
15	2014	11,053	50	6,506	7,821	7,152	1,476	734	199	0	23,938	12,885
16	2015	11,104	50	6,506	8,256	7,549	1,558	734	199	0	24,852	13,748
17	2016	11,155	50	6,506	8,690	7,946	1,640	734	199	0	25,766	14,611
18	2017	11,206	50	6,506	9,125	8,344	1,722	734	199	0	26,680	15,474
19	2018	11,256	50	6,506	9,559	8,741	1,804	734	199	0	27,593	16,337
20	2019	11,307	50	6,506	9,994	9,138	1,886	734	199	0	28,507	17,200
21	2020	11,358	50	6,506	10,428	9,536	1,968	734	199	0	29,421	18,063
22	2021	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
23	2022	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
24	2023	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
25	2024	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
26	2025	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
27	2026	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
28	2027	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
29	2028	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
30	2029	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
31	2030	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
32	2031	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
33	2032	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
34	2033	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
35	2034	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
36	2035	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
37	2036	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
38	2037	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
39	2038	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
40	2039	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
41	2040	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
42	2041	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
43	2042	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
44	2043	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
45	2044	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
46	2045	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
47	2046	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
48	2047	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
49	2048	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
50	2049	1,234	50	6,506	10,863	9,933	2,050	734	199	0	30,335	29,101
Total		296,134	2,047	298,790	434,256	399,198	78,353	29,702	7,861	0	1,250,207	954,072

Note : (1) Rate of annual growth of economic benefit until 2010 : 7.20% /year

(2) A discount rate at 10% per year is applied for deriving B/C ratio and net present value (NPV).

Results : EIRR = 12.86% B/C = 1.25 NPV = 32,120 thousand US$

Table I4-9 Cost Benefit Stream for Each Component (1/4)

(US$1,000)

No.	Year	Construction Cost								
		Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8	Total
1	2000	2,094	8,463	9,281	9,936	7,552	5,647	5,703	1,747	50,421
2	2001	0	8,463	9,281	9,936	7,552	5,647	5,703	0	46,580
3	2002	0	0	9,281	9,936	7,552	0	0	0	26,768
4	2003	0	0	9,281	9,936	7,552	0	0	0	26,768
5	2004	0	0	9,281	9,936	0	0	0	0	19,217
6	2005	0	0	9,281	9,936	0	0	0	0	19,217
7	2006	0	0	9,281	9,936	0	0	0	0	19,217
8	2007	0	0	9,281	9,936	0	0	0	0	19,217
9	2008	0	0	9,281	9,936	0	0	0	0	19,217
10	2009	0	0	0	0	0	0	0	0	0
11	2010	0	0	0	0	0	0	0	0	0
12	2011	0	0	0	0	0	0	0	0	0
13	2012	0	0	0	0	0	0	0	0	0
14	2013	0	0	0	0	0	0	0	0	0
15	2014	0	0	0	0	0	0	0	0	0
16	2015	0	0	0	0	0	0	0	0	0
17	2016	0	0	0	0	0	0	0	0	0
18	2017	0	0	0	0	0	0	0	0	0
19	2018	0	0	0	0	0	0	0	0	0
20	2019	0	0	0	0	0	0	0	0	0
21	2020	0	0	0	0	0	0	0	0	0
22	2021	0	0	0	0	0	0	0	0	0
23	2022	0	0	0	0	0	0	0	0	0
24	2023	0	0	0	0	0	0	0	0	0
25	2024	0	0	0	0	0	0	0	0	0
26	2025	0	0	0	0	0	0	0	0	0
27	2026	0	0	0	0	0	0	0	0	0
28	2027	0	0	0	0	0	0	0	0	0
29	2028	0	0	0	0	0	0	0	0	0
30	2029	0	0	0	0	0	0	0	0	0
31	2030	0	0	0	0	0	0	0	0	0
32	2031	0	0	0	0	0	0	0	0	0
33	2032	0	0	0	0	0	0	0	0	0
34	2033	0	0	0	0	0	0	0	0	0
35	2034	0	0	0	0	0	0	0	0	0
36	2035	0	0	0	0	0	0	0	0	0
37	2036	0	0	0	0	0	0	0	0	0
38	2037	0	0	0	0	0	0	0	0	0
39	2038	0	0	0	0	0	0	0	0	0
40	2039	0	0	0	0	0	0	0	0	0
41	2040	0	0	0	0	0	0	0	0	0
42	2041	0	0	0	0	0	0	0	0	0
43	2042	0	0	0	0	0	0	0	0	0
44	2043	0	0	0	0	0	0	0	0	0
45	2044	0	0	0	0	0	0	0	0	0
46	2045	0	0	0	0	0	0	0	0	0
47	2046	0	0	0	0	0	0	0	0	0
48	2047	0	0	0	0	0	0	0	0	0
49	2048	0	0	0	0	0	0	0	0	0
50	2049	0	0	0	0	0	0	0	0	0
Total		2,094	16,925	83,528	89,423	30,206	11,293	11,406	1,747	246,622

Table I4-9 Cost Benefit Stream for Each Component (2/4)

(US$1,000)

No.	Year	O/M/R Cost								
		Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8	Total
1	2000	0	0	0	0	0	0	0	0	0
2	2001	10	42	46	50	38	28	29	9	252
3	2002	10	85	93	99	76	56	57	9	485
4	2003	10	85	139	149	113	56	57	9	619
5	2004	10	85	186	199	151	56	57	9	753
6	2005	10	85	232	248	151	56	57	9	849
7	2006	10	85	278	298	151	56	57	9	945
8	2007	10	85	325	348	151	56	57	9	1,041
9	2008	10	85	371	397	151	56	57	9	1,137
10	2009	10	85	418	447	151	56	57	9	1,233
11	2010	10	85	418	447	151	56	57	9	1,233
12	2011	10	85	418	447	151	56	57	9	1,233
13	2012	10	85	418	447	151	56	57	9	1,233
14	2013	10	85	418	447	151	56	57	9	1,233
15	2014	10	85	418	447	151	56	57	9	1,233
16	2015	10	85	418	447	151	56	57	9	1,233
17	2016	10	85	418	447	151	56	57	9	1,233
18	2017	10	85	418	447	151	56	57	9	1,233
19	2018	10	85	418	447	151	56	57	9	1,233
20	2019	10	85	418	447	151	56	57	9	1,233
21	2020	10	85	418	447	151	56	57	9	1,233
22	2021	10	85	418	447	151	56	57	9	1,233
23	2022	10	85	418	447	151	56	57	9	1,233
24	2023	10	85	418	447	151	56	57	9	1,233
25	2024	10	85	418	447	151	56	57	9	1,233
26	2025	10	85	418	447	151	56	57	9	1,233
27	2026	10	85	418	447	151	56	57	9	1,233
28	2027	10	85	418	447	151	56	57	9	1,233
29	2028	10	85	418	447	151	56	57	9	1,233
30	2029	10	85	418	447	151	56	57	9	1,233
31	2030	10	85	418	447	151	56	57	9	1,233
32	2031	10	85	418	447	151	56	57	9	1,233
33	2032	10	85	418	447	151	56	57	9	1,233
34	2033	10	85	418	447	151	56	57	9	1,233
35	2034	10	85	418	447	151	56	57	9	1,233
36	2035	10	85	418	447	151	56	57	9	1,233
37	2036	10	85	418	447	151	56	57	9	1,233
38	2037	10	85	418	447	151	56	57	9	1,233
39	2038	10	85	418	447	151	56	57	9	1,233
40	2039	10	85	418	447	151	56	57	9	1,233
41	2040	10	85	418	447	151	56	57	9	1,233
42	2041	10	85	418	447	151	56	57	9	1,233
43	2042	10	85	418	447	151	56	57	9	1,233
44	2043	10	85	418	447	151	56	57	9	1,233
45	2044	10	85	418	447	151	56	57	9	1,233
46	2045	10	85	418	447	151	56	57	9	1,233
47	2046	10	85	418	447	151	56	57	9	1,233
48	2047	10	85	418	447	151	56	57	9	1,233
49	2048	10	85	418	447	151	56	57	9	1,233
50	2049	10	85	418	447	151	56	57	9	1,233
Total		513	4,104	18,794	20,120	7,174	2,739	2,766	428	56,638

Table I4-9 Cost Benefit Stream for Each Component (3/4)

(US$1,000)

No.	Year	Total Cost	Benefit									B-C
			Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8	Total	
1	2000	50,421	0	0	0	0	0	0	0	0	0	-50,421
2	2001	46,832	27	0	646	531	365	196	53	0	1,818	-45,014
3	2002	27,253	29	3,730	1,384	1,139	784	421	113	0	7,600	-19,654
4	2003	27,387	31	3,999	2,226	1,832	1,260	451	121	0	9,919	-17,468
5	2004	19,969	33	4,287	3,181	2,618	1,351	484	130	0	12,083	-7,886
6	2005	20,066	35	4,596	4,263	3,508	1,448	518	139	0	14,508	-5,558
7	2006	20,162	38	4,926	5,484	4,513	1,552	556	149	0	17,218	-2,943
8	2007	20,258	41	5,281	6,858	5,644	1,664	596	160	0	20,244	-14
9	2008	20,354	44	5,661	8,402	6,915	1,784	639	171	0	23,616	3,262
10	2009	1,233	47	6,069	10,133	8,339	1,912	685	184	0	27,369	26,136
11	2010	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
12	2011	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
13	2012	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
14	2013	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
15	2014	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
16	2015	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
17	2016	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
18	2017	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
19	2018	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
20	2019	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
21	2020	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
22	2021	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
23	2022	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
24	2023	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
25	2024	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
26	2025	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
27	2026	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
28	2027	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
29	2028	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
30	2029	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
31	2030	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
32	2031	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
33	2032	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
34	2033	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
35	2034	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
36	2035	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
37	2036	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
38	2037	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
39	2038	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
40	2039	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
41	2040	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
42	2041	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
43	2042	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
44	2043	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
45	2044	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
46	2045	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
47	2046	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
48	2047	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
49	2048	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
50	2049	1,233	50	6,506	10,863	9,933	2,050	734	197	0	30,333	29,100
Total		303,260	2,323	298,790	477,098	432,359	94,121	33,905	9,100	0	1,347,696	1,044,436

Table I4-9 Cost Benefit Stream for Each Component (4/4)

No.	Year	Benefit - Costs							
		Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comp.6	Comp.7	Comp.8
1	2000	-2,094	-8,463	-9,281	-9,936	-7,552	-5,647	-5,703	-1,747
2	2001	16	-8,505	-8,682	-9,454	-7,224	-5,478	-5,679	-9
3	2002	18	3,646	-7,990	-8,896	-6,843	364	56	-9
4	2003	20	3,914	-7,194	-8,253	-6,405	395	64	-9
5	2004	22	4,202	-6,285	-7,517	1,200	427	73	-9
6	2005	25	4,511	-5,250	-6,676	1,297	462	82	-9
7	2006	27	4,842	-4,076	-5,721	1,401	499	92	-9
8	2007	30	5,197	-2,747	-4,640	1,513	539	103	-9
9	2008	33	5,577	-1,250	-3,419	1,633	582	114	-9
10	2009	36	5,984	9,716	7,892	1,761	628	127	-9
11	2010	40	6,421	10,445	9,486	1,899	678	140	-9
12	2011	40	6,421	10,445	9,486	1,899	678	140	-9
13	2012	40	6,421	10,445	9,486	1,899	678	140	-9
14	2013	40	6,421	10,445	9,486	1,899	678	140	-9
15	2014	40	6,421	10,445	9,486	1,899	678	140	-9
16	2015	40	6,421	10,445	9,486	1,899	678	140	-9
17	2016	40	6,421	10,445	9,486	1,899	678	140	-9
18	2017	40	6,421	10,445	9,486	1,899	678	140	-9
19	2018	40	6,421	10,445	9,486	1,899	678	140	-9
20	2019	40	6,421	10,445	9,486	1,899	678	140	-9
21	2020	40	6,421	10,445	9,486	1,899	678	140	-9
22	2021	40	6,421	10,445	9,486	1,899	678	140	-9
23	2022	40	6,421	10,445	9,486	1,899	678	140	-9
24	2023	40	6,421	10,445	9,486	1,899	678	140	-9
25	2024	40	6,421	10,445	9,486	1,899	678	140	-9
26	2025	40	6,421	10,445	9,486	1,899	678	140	-9
27	2026	40	6,421	10,445	9,486	1,899	678	140	-9
28	2027	40	6,421	10,445	9,486	1,899	678	140	-9
29	2028	40	6,421	10,445	9,486	1,899	678	140	-9
30	2029	40	6,421	10,445	9,486	1,899	678	140	-9
31	2030	40	6,421	10,445	9,486	1,899	678	140	-9
32	2031	40	6,421	10,445	9,486	1,899	678	140	-9
33	2032	40	6,421	10,445	9,486	1,899	678	140	-9
34	2033	40	6,421	10,445	9,486	1,899	678	140	-9
35	2034	40	6,421	10,445	9,486	1,899	678	140	-9
36	2035	40	6,421	10,445	9,486	1,899	678	140	-9
37	2036	40	6,421	10,445	9,486	1,899	678	140	-9
38	2037	40	6,421	10,445	9,486	1,899	678	140	-9
39	2038	40	6,421	10,445	9,486	1,899	678	140	-9
40	2039	40	6,421	10,445	9,486	1,899	678	140	-9
41	2040	40	6,421	10,445	9,486	1,899	678	140	-9
42	2041	40	6,421	10,445	9,486	1,899	678	140	-9
43	2042	40	6,421	10,445	9,486	1,899	678	140	-9
44	2043	40	6,421	10,445	9,486	1,899	678	140	-9
45	2044	40	6,421	10,445	9,486	1,899	678	140	-9
46	2045	40	6,421	10,445	9,486	1,899	678	140	-9
47	2046	40	6,421	10,445	9,486	1,899	678	140	-9
48	2047	40	6,421	10,445	9,486	1,899	678	140	-9
49	2048	40	6,421	10,445	9,486	1,899	678	140	-9
50	2049	40	6,421	10,445	9,486	1,899	678	140	-9
Total		-284	277,761	374,776	322,816	56,741	19,874	-5,072	-2,175
IRR		-0.54%	24.76%	11.04%	9.11%	5.26%	4.77%	-2.07%	-
B/C		0.18	2.92	1.10	0.91	0.57	0.51	0.14	-
NPV (thousand US$		-1,793	32,601	6,413	-5,880	-12,010	-5,544	-9,878	-

Note : (1) Rate of annual growth of economic benefit until 2010 : 7.20% /year

(2) A discount rate at 10% per year is applied for deriving B/C ratio and net present value (NPV).

Table I4-10 Expenditures of MPWT, MPP, DPWT and DSD

Item	1995	1996	1997	Jan.-Aug. 1998
(Overall Comparison in million Riel)				
1. Ministry of Public Works and Transport	8,011	7,158	8,340	4,075
2. Total of national budget	667,172	793,925	870,000	482,168
3. % of MPWT to total	1.2	0.9	1.0	0.8
4. Municipality of Phnom Penh	17,505	22,185	19,651	n.a.
5. Department of Public Works and Transport	1,503	994	2,065	n.a.
6. Drainage and Sewerage Division	313	333	384	n.a.
(Detail of DPWT's expenditure in Riel)				
7. Salary for full-time workers	370,364,206	340,695,191	326,991,521	n.a.
8. Salary for labors	394,740,000	388,260,000	388,260,000	n.a.
9. Cultural and social expense	4,411,720	5,223,130	12,056,920	n.a.
10. Administrative expenditure	85,976,950	56,838,980	33,102,285	n.a.
11. Capital expenditure (big repairs)	648,189,720	202,991,362	1,304,537,110	n.a.
Total	1,503,682,596	994,008,663	2,064,947,836	-
(Detail of DSD's expenditure in Riel)				
12. Salary for full-time workers	78,891,320	70,002,350	61,125,530	n.a.
13. Salary for labors	62,100,000	62,100,000	62,100,000	n.a.
14. Cultural and social expense	1,052,500	2,450,590	754,670	
15. Administrative	0	0	0	n.a.
16. Maintenance and repair	170,751,950	198,700,940	259,727,230	n.a.
Total	312,795,770	333,253,880	383,707,430	-
(Expenditure of DPWT by Source of Revenue in Riel)				
17. Municipality of Phnom Penh (3)	1,300,926,596	898,588,663	1,365,861,726	n.a.
18. Ministry of Public Works and Transport	202,756,000	73,420,000	38,000,000	n.a.
19. Council of Minister	0	22,000,000	0	n.a.
20. Department of Economy and Finance	0	0	661,086,110	n.a.
Total	1,503,682,596	994,008,663	2,064,947,836	n.a.

Note :

(1) Abbreviations

MPWT : Ministry of Public Works and Transport

DPWT : Department of Public Works and Transport, Municipality of Phnom Penh

DSD : Drainage and Sewerage Division, Department of Public Works and Transport

(2) Original source of budget is the Ministry of Public Works and Transport

Source :

(1) Monthly Bulletin of Statistics September 1998, Ministry of Economy ad Finance

(2) Department of Public Works and Transport

Table I4-11 Estimate of Central Government Revenue in 2010 and 2020

Item	Unit	Growth Scenario	
		Standard	Low
GDP growth rates			
1996-1997	%/year	2.0	2.0
1996-2006/2010 (1)	%/year	7.2	3.6
2010-2020 (2)	%/year	5.0	2.0
GDP in 1996 price level			
1996	million Riel	8,200	8,200
2006	million Riel	15,637	11,499
2010	million Riel	22,138	13,723
2020	million Riel	36,060	16,728
Proportion of government revenue to GDP			
1996	%	9.1	9.1
2006 (2)	%	16.9	9.1
2010	%	16.9	9.1
2020	%	20.0	12.0
Government revenue			
1996	million Riel	749	749
2006	million Riel	2,643	1,046
2010	million Riel	3,741	1,249
2020	million Riel	7,212	2,007
Growth rate of government revenue			
1996 - 2010	%/year	12.2	3.7
2010 - 2020	%/year	6.8	4.9

Note :
(1) Based on Socio-Economic Framework for standard growth scenario and half the standard scenario for the low growth sdenario.
(2) Assumed to be lower than the 1996-2006/2010 period.

Table I4-12 Estimate of DPWT and DSD's Revenue in 2010 and 2020

Item	DPWT		DSD	
	Standard	Low	Standard	Low
Growth Rates (%/year)				
1997-2010	12.2	3.7	12.2	3.7
2010-2020	6.8	4.9	6.8	4.9
Projected Revenue				
(Riel million)				
1997	1,521	1,521	343	343
2010	6,793	2,439	1,532	550
2020	13,115	3,935	2,958	887
($ million)				
1997	0.39	0.39	0.09	0.09
2010	1.75	0.63	0.39	0.14
2020	3.38	1.01	0.76	0.23

Note :

$1=Riel 3880 (mid point average in October 1998)

FIGURES

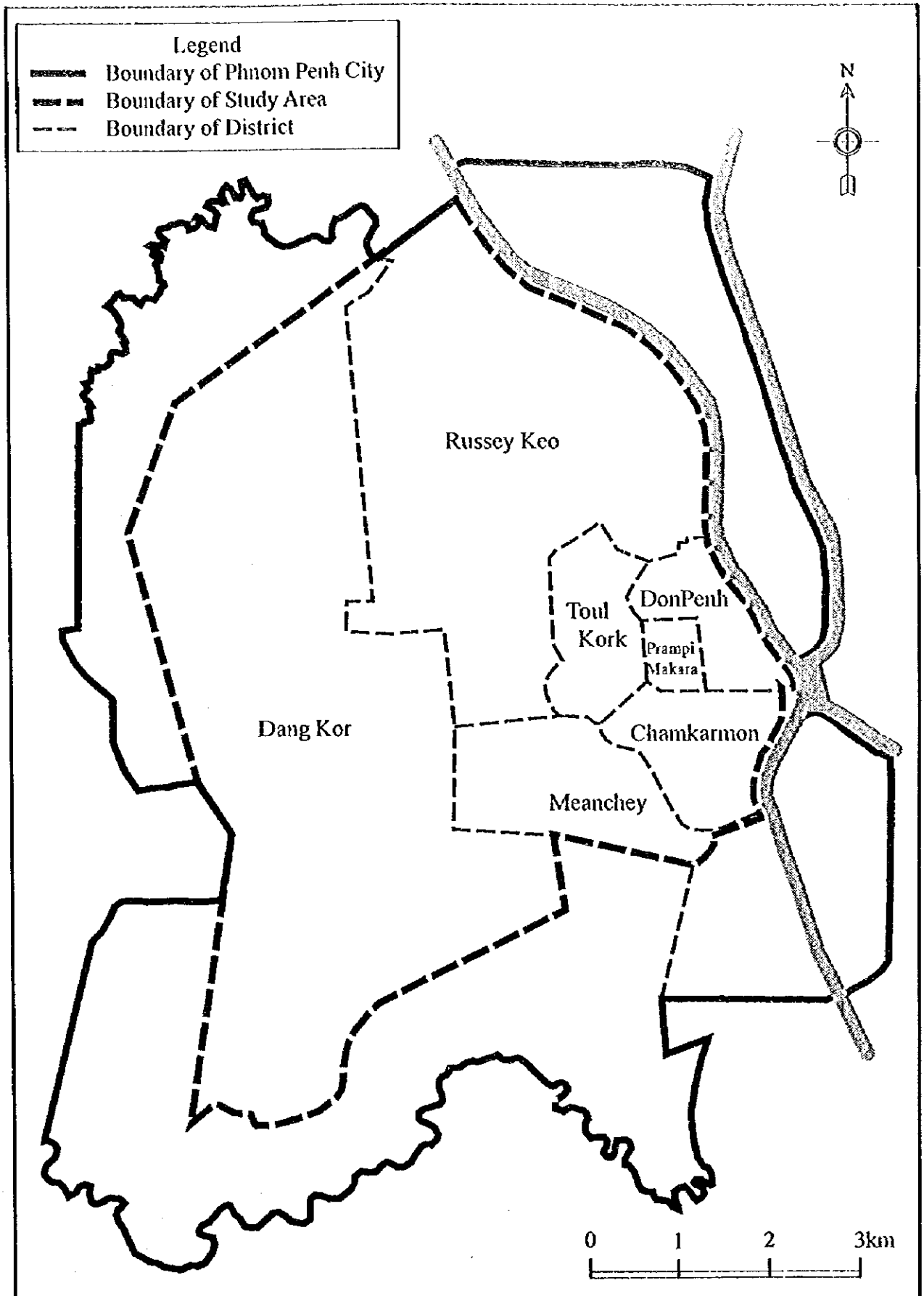

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Figure 12-1
Boundaries of Phnom Penh City, Study Area and Districts

Base map: APUR BAU

- Dense activities (activities and industries requiring important buildings and infrastructure)
- Dense urban centre (important buildings, chinese compartments, side by side houses)
- Dense residential (urban villas, buildings with small gardens)
- Loose residential (small villas and buildings, much green spaces and agricultural land)
- Loose activities (small-size activities mixed with residential or waste grounds)
- Agricultural land (rice fields, unused land, important vegetable or fruit gardens)
- Green spaces and parks (all urban green spaces of noticeable size, exluding villa gardens)
- Fish Ponds
- Lakes and ponds (all other water-covered surfaces, including rivers and swamps)

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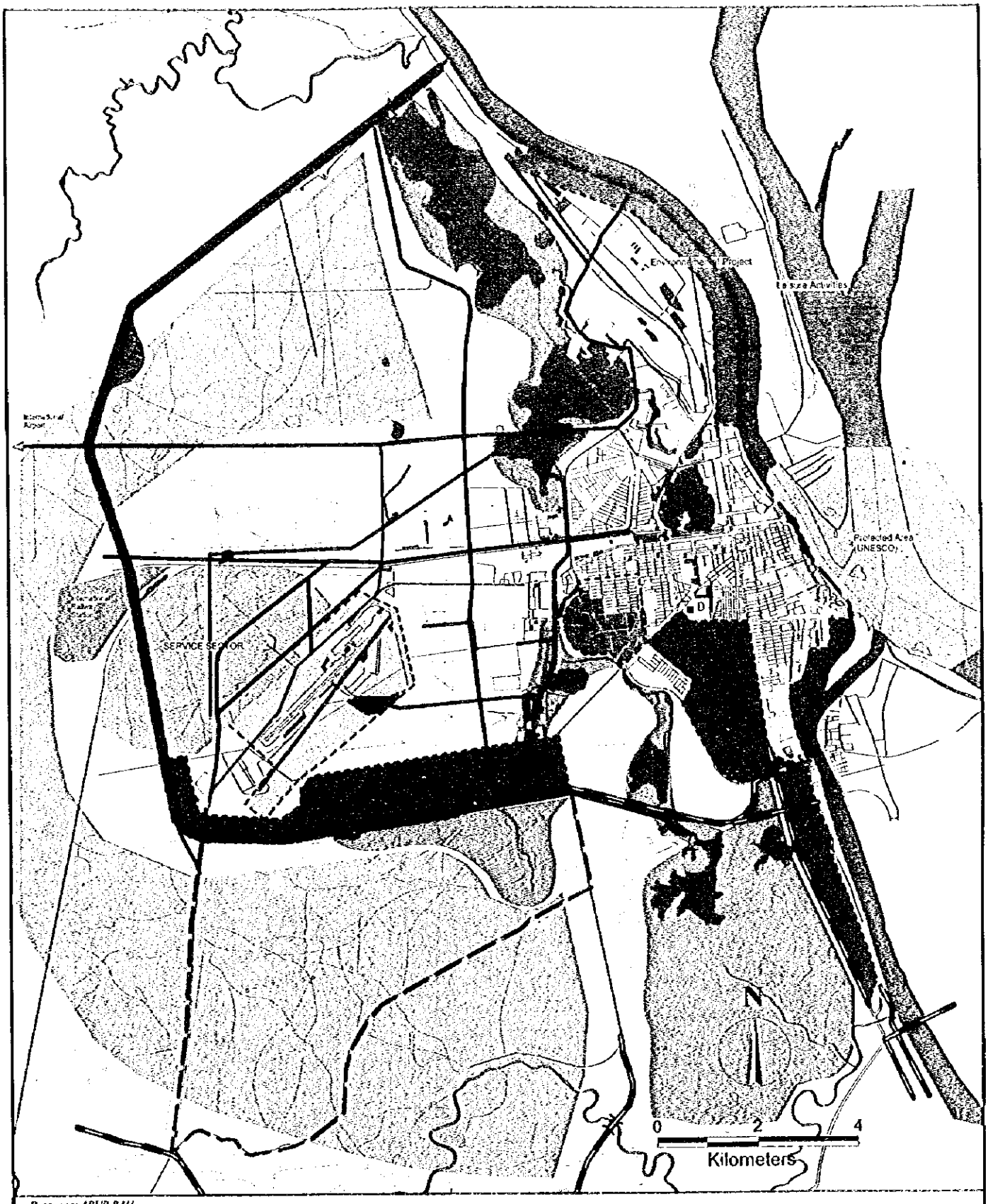
Figure I2-2
Present Land Use



Base map: APUR BAU

Areas where urban land management project has been developed

- Project approved by RGC
- Not yet approved Project
- Projects of private interest
- Green Belt
- Blue Belt: area subject to flooding, suitable for agricultural or leisure activities

Key roads under study or under realisation

- Primary road
- Secondary road
- Ring road and dike
- Canals & water surfaces
- Perimeter of study

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Figure I2-3
Identified Projects

Base map: APUR BAU

- Dense activities (activities and industries requiring important buildings and infrastructure)
- Dense urban centre (important buildings, chinese compartments, side by side houses)
- Dense residential (urban villas, buildings with small gardens)
- Loose residential (small villas and buildings, much green spaces and agricultural land)
- Loose activities (small-size activities mixed with residential or waste grounds)
- Agricultural land (rice fields, unused land, important vegetable or fruit gardens)
- Green spaces and parks (all urban green spaces of noticeable size, exluding villa gardens)
- Fish Ponds
- Lakes and ponds (all water-covered surfaces, including rivers and swamps)

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Figure I2-4
Future Land Use

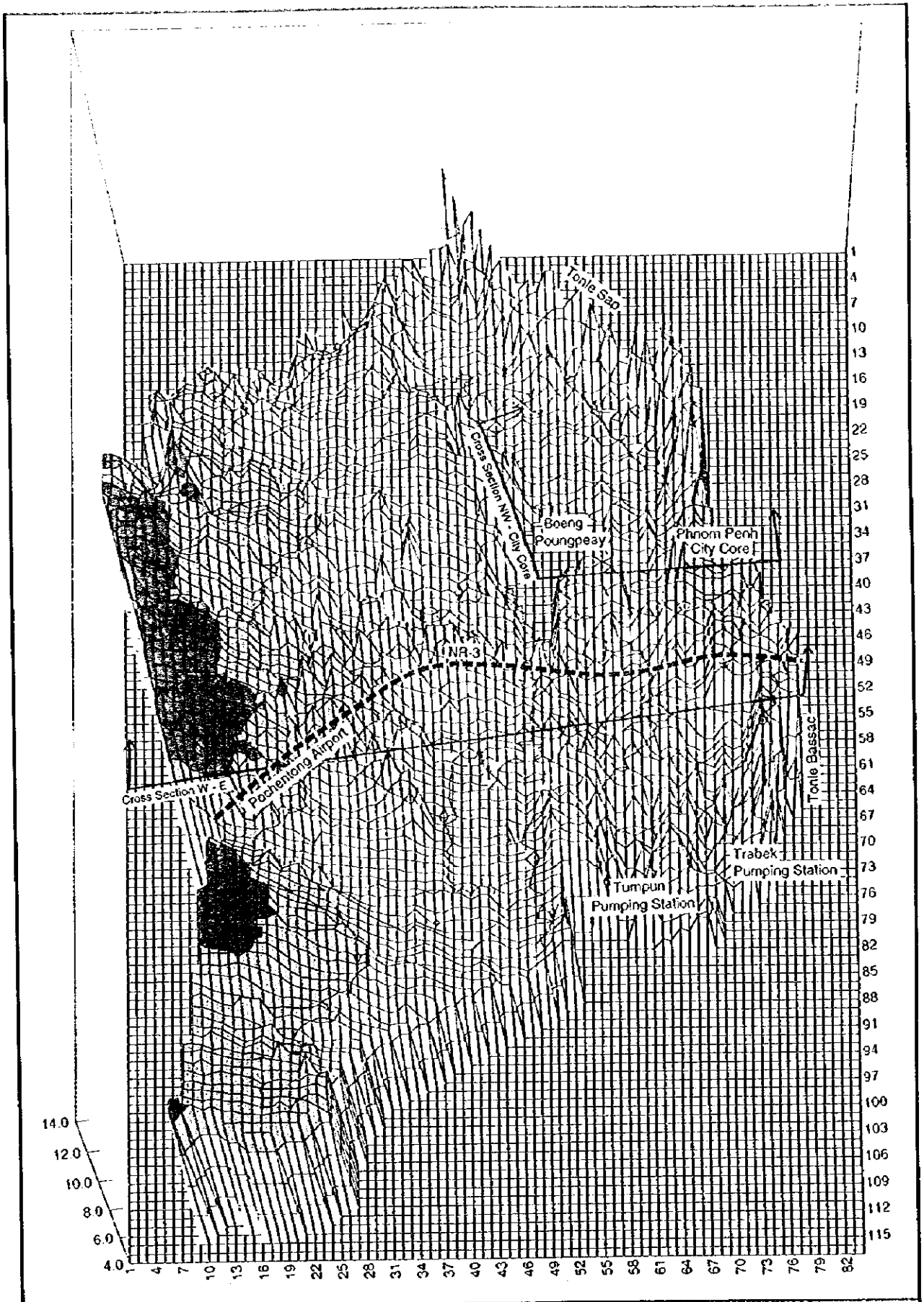

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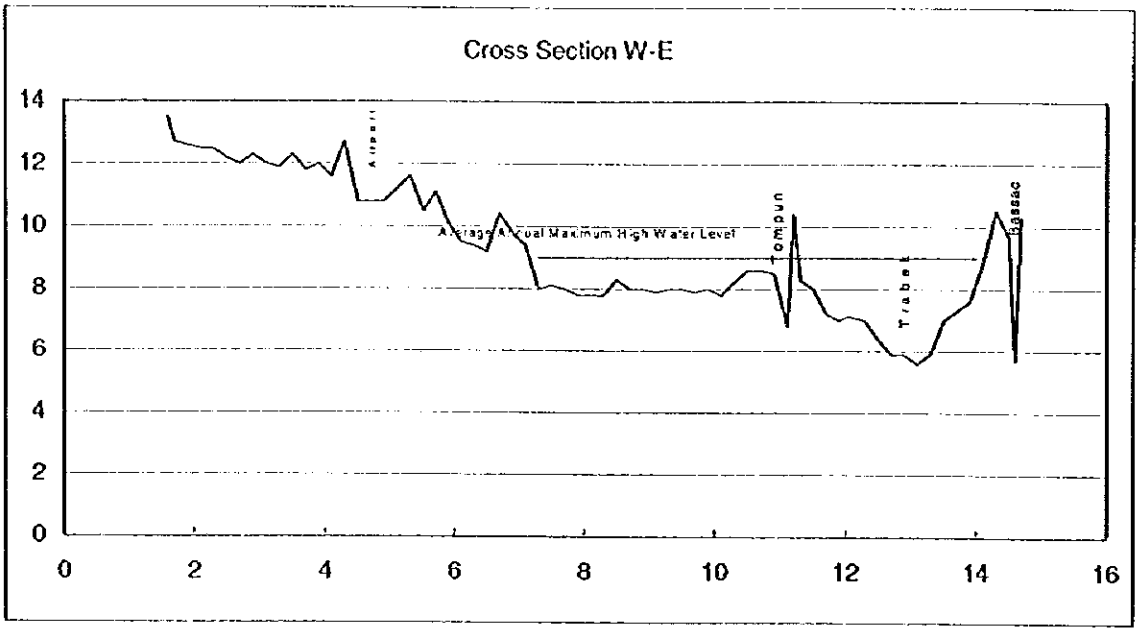
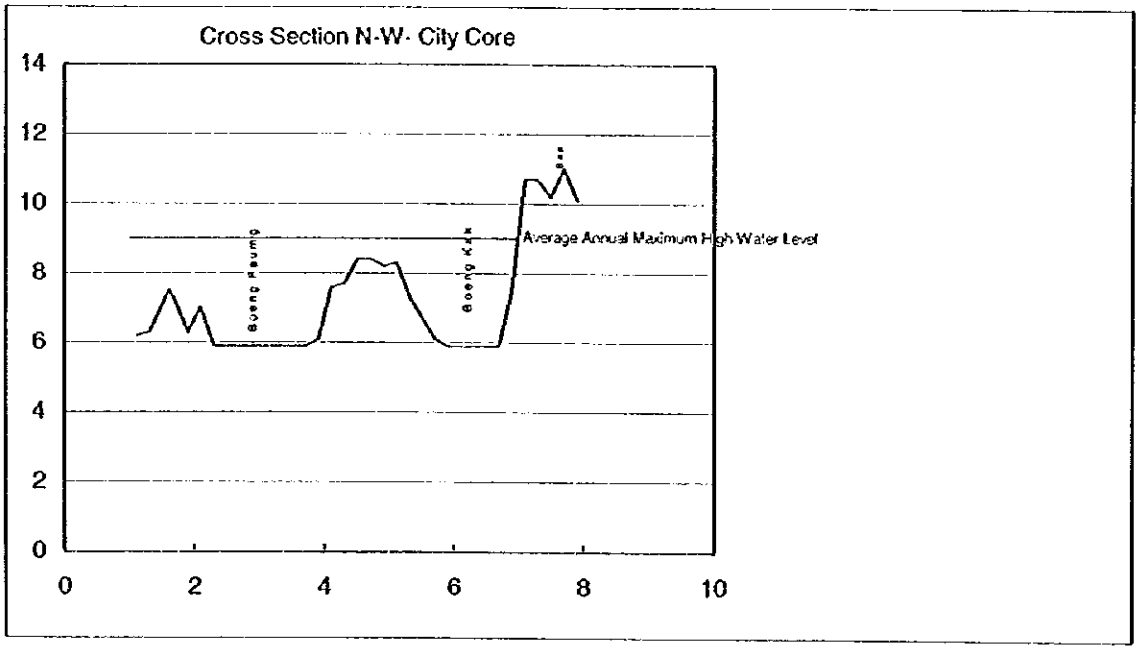
Figure I2-5
Three-dimensional View of Study Area





The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd.-Nippon Koei Co., Ltd.	Figure I2-6 Profiles of Study Area

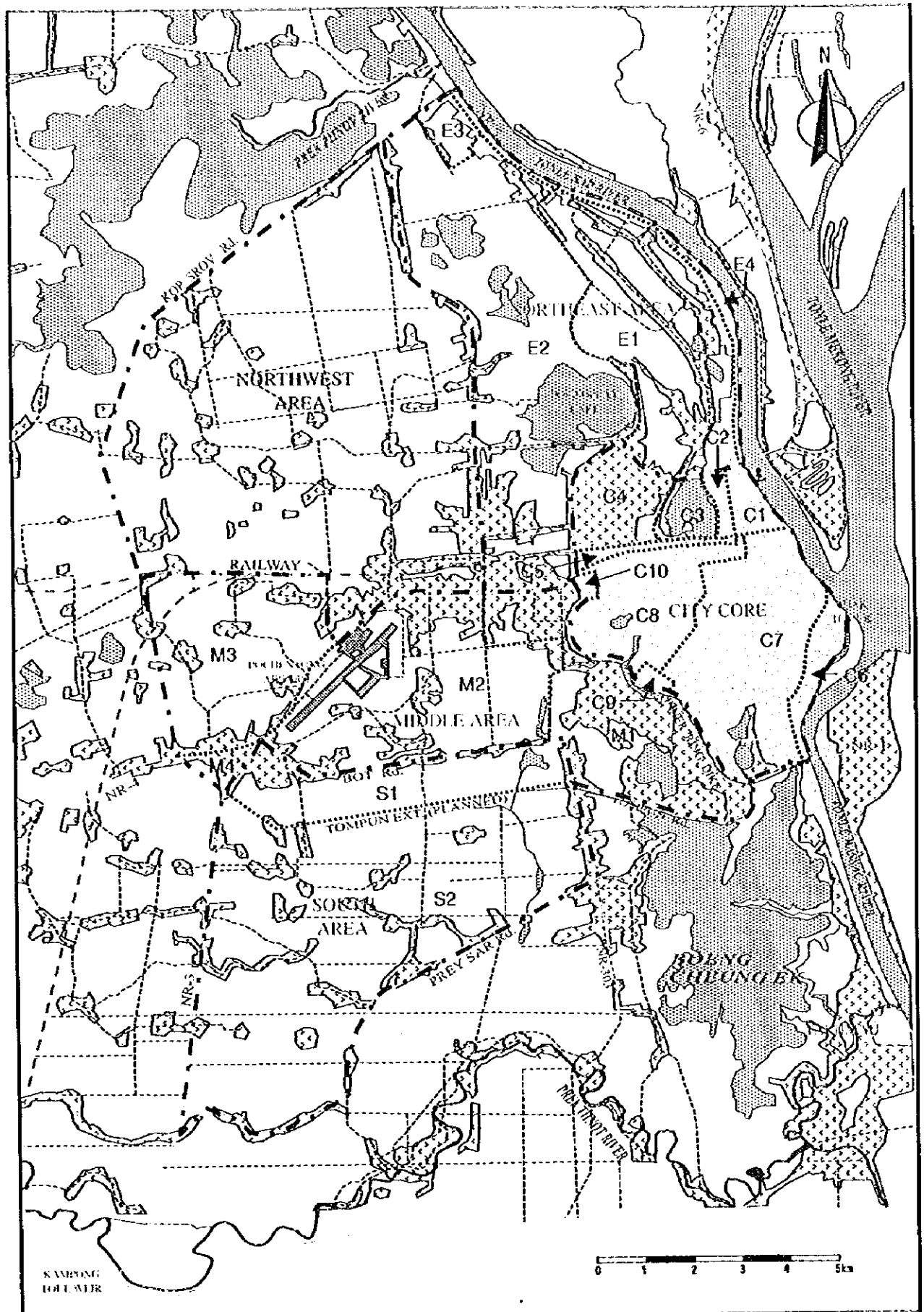


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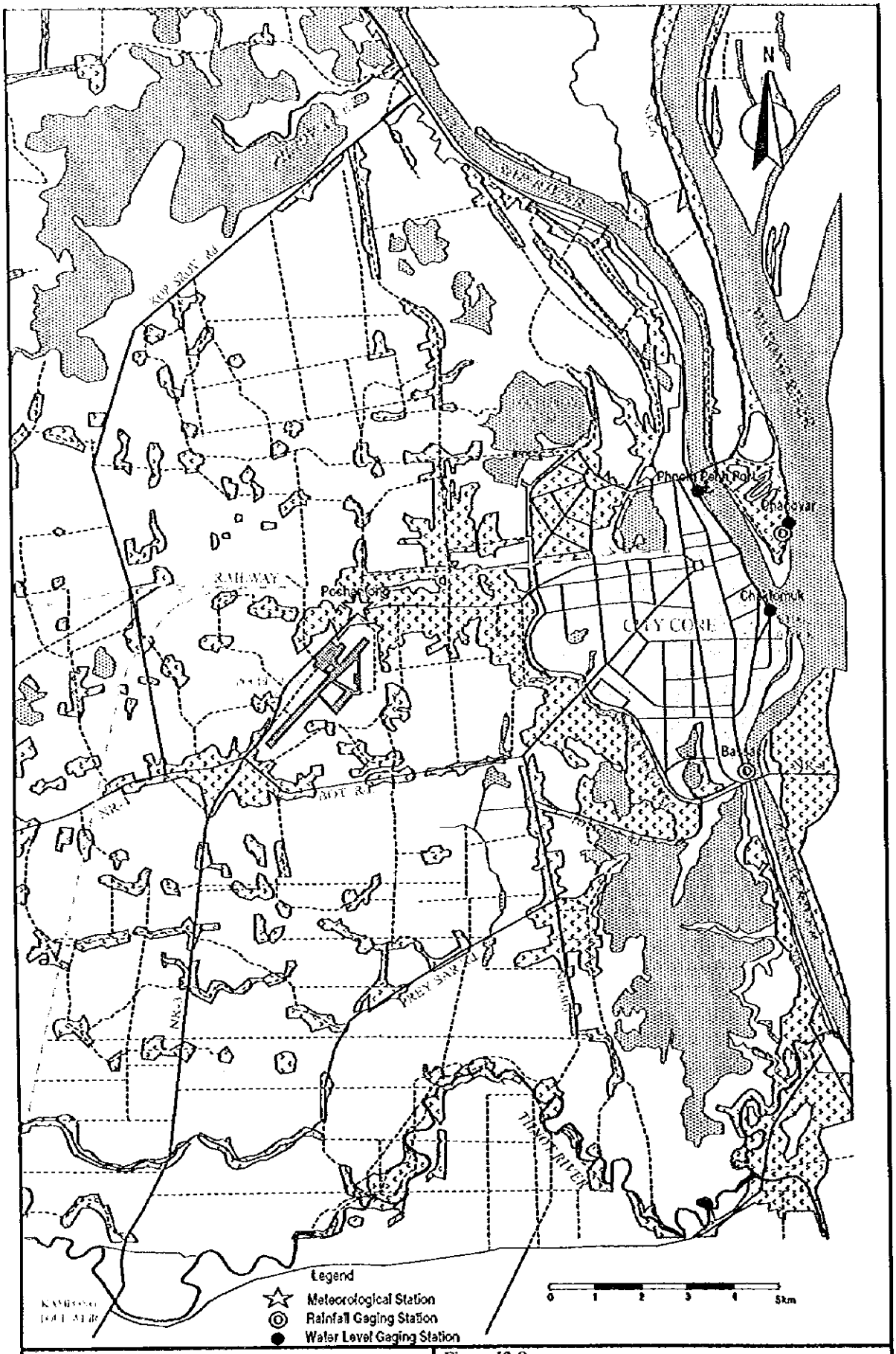
Figure 12-7
Watersheds



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure I2-8 Location of Observation Stations

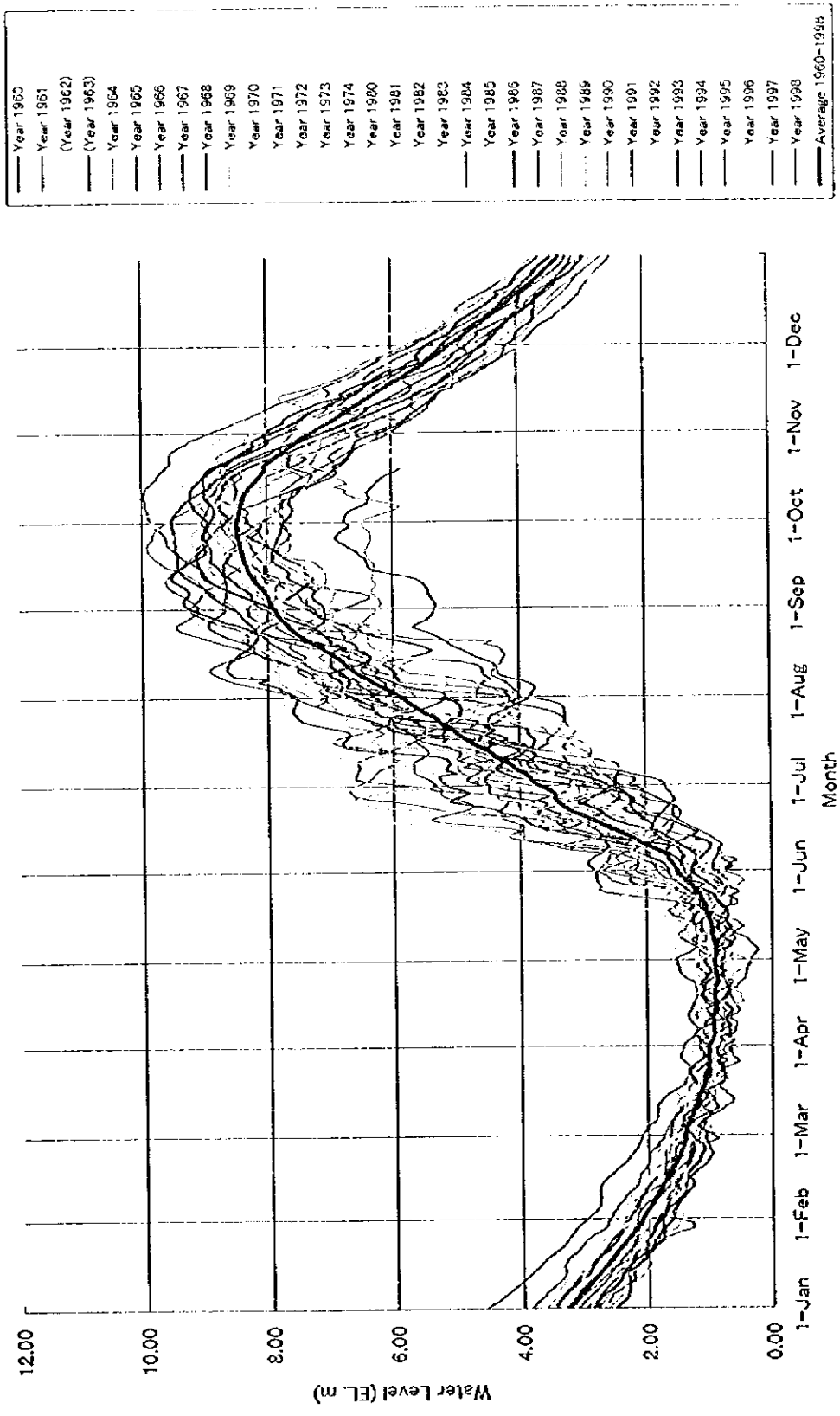


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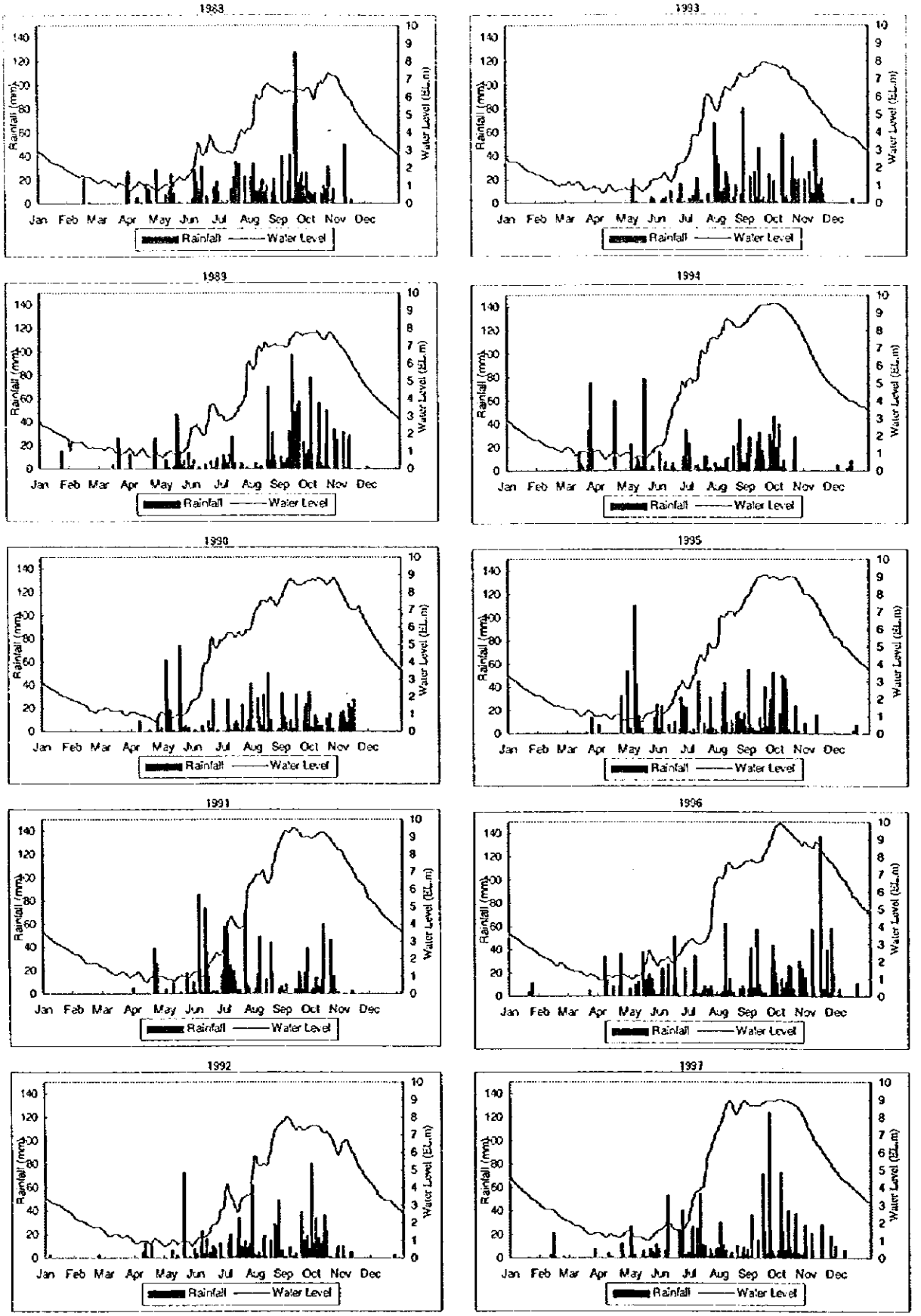
Figure I2-9
Seasonal Variation of Water Level at Chaktomuk Station



Note:Water level at Chaktomuk and rainfall at Pochentong

The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure 12-10 Water Level and Daily Rainfall in the Last Decade

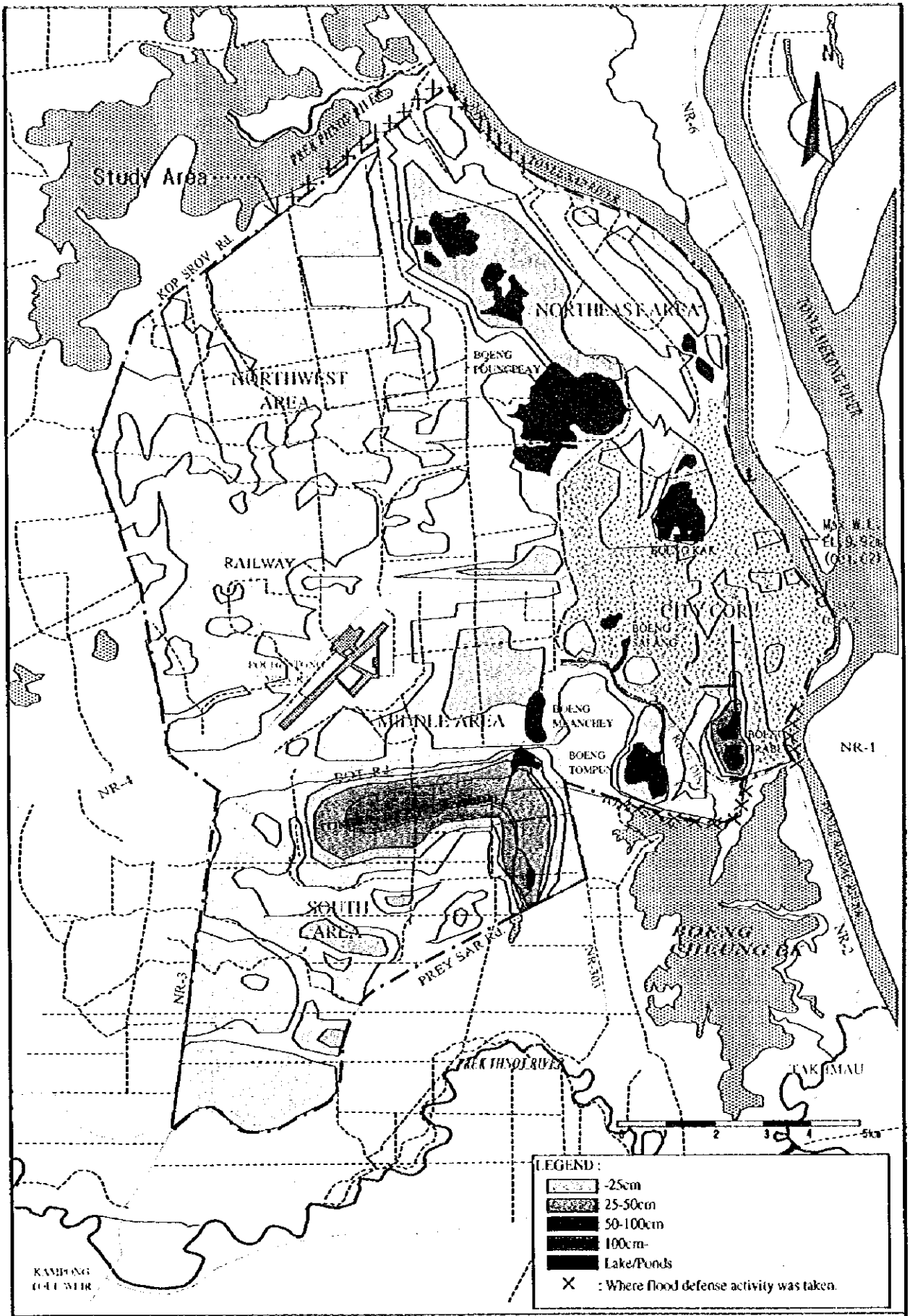


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Figure 12-11
Flood and Inundation Map in Year 1996

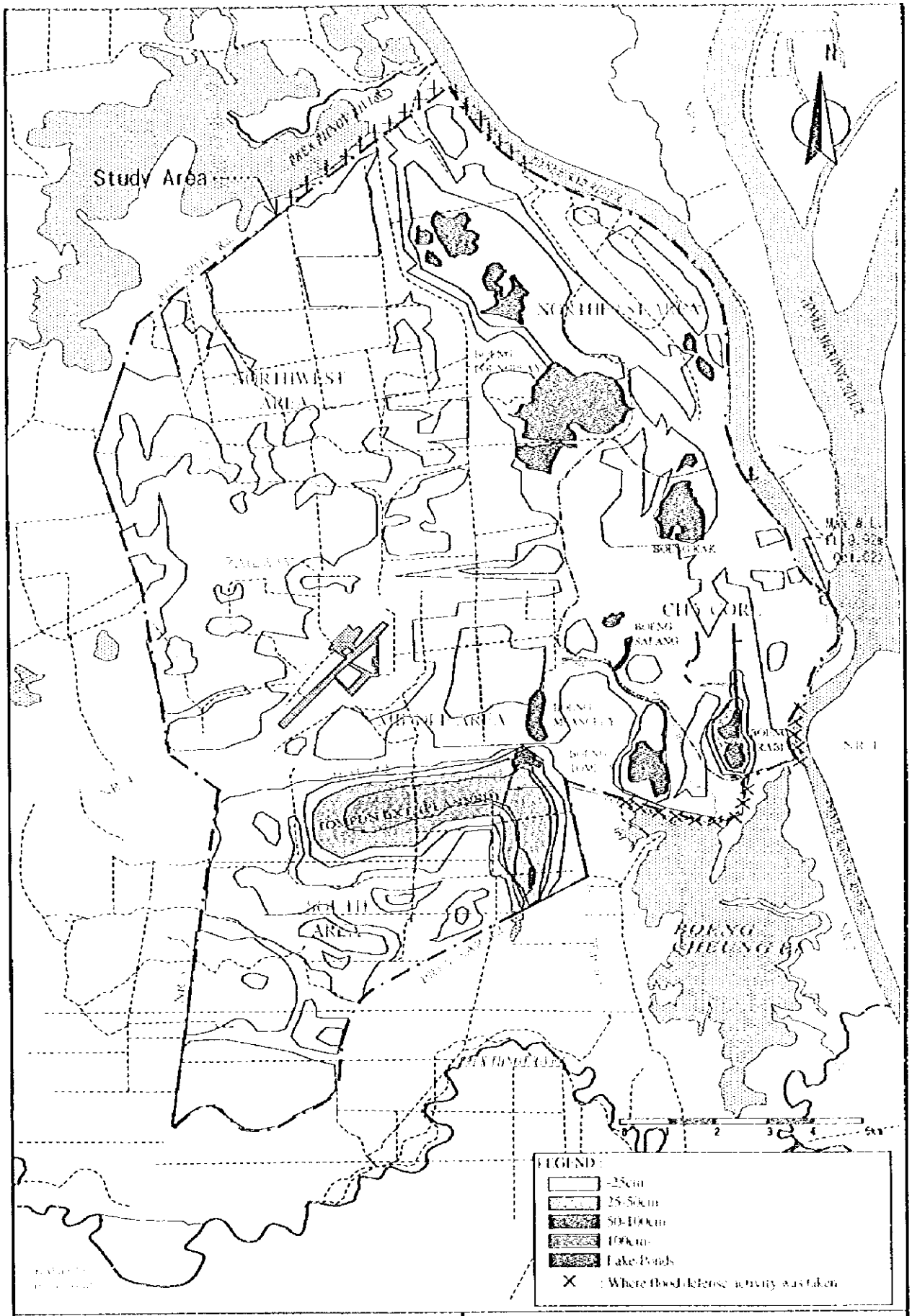

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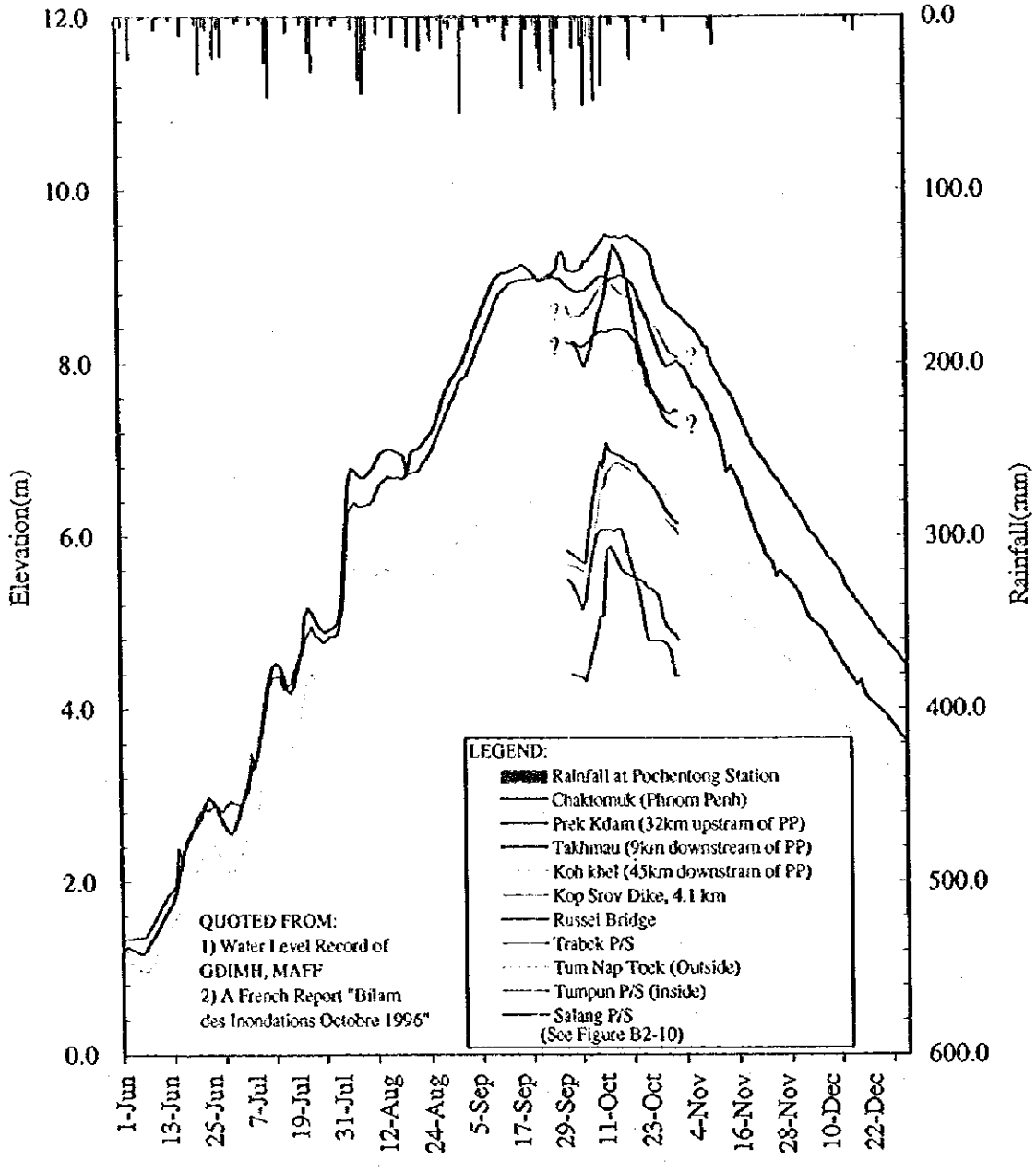
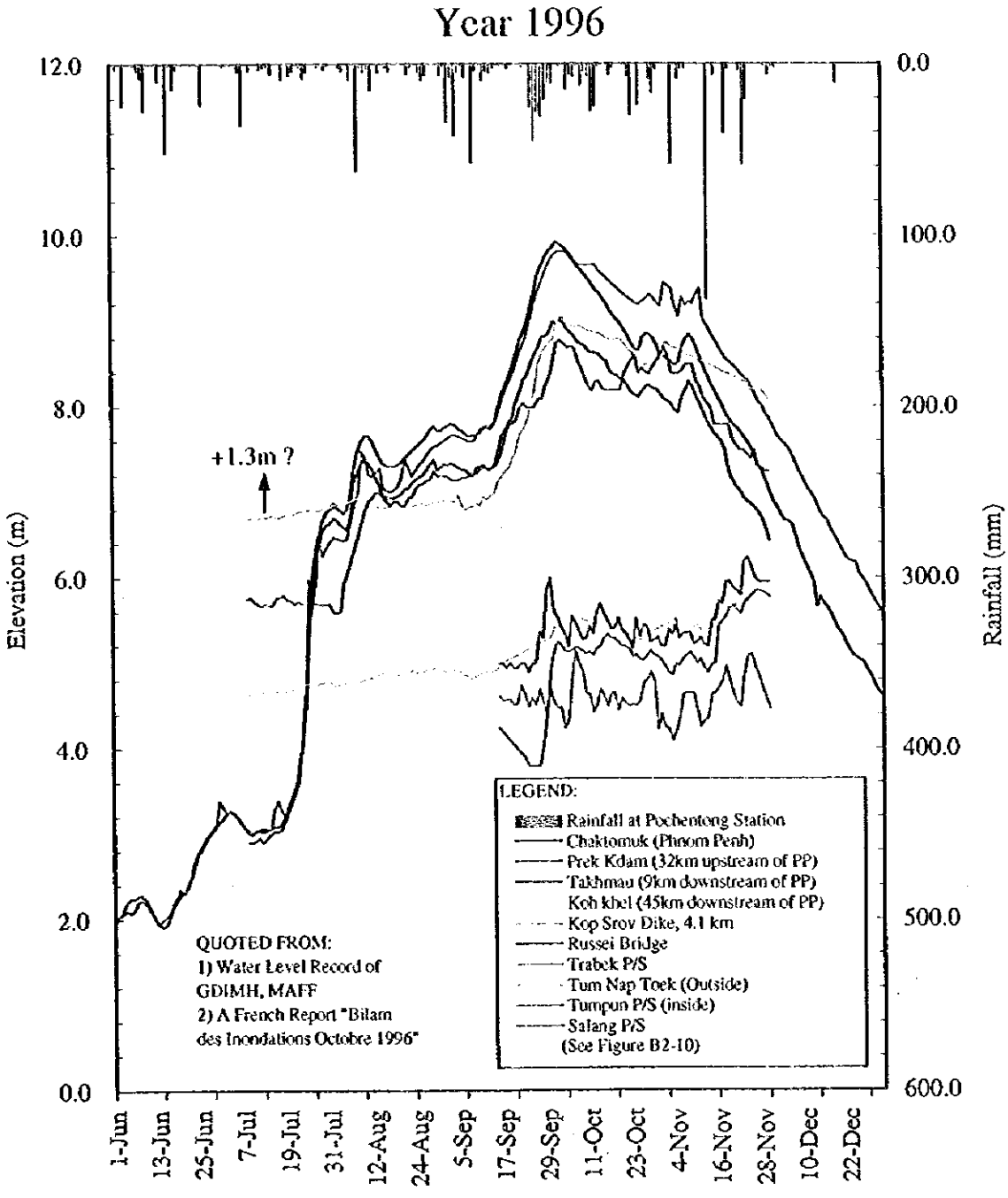
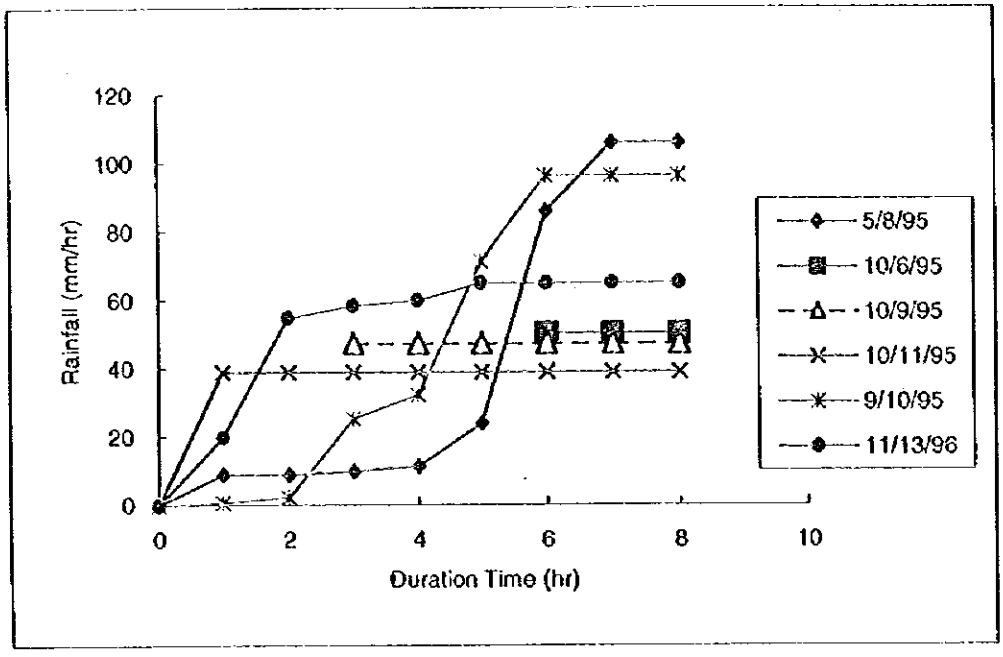
Figure 12-11
Flood and Inundation Map in Year 1996

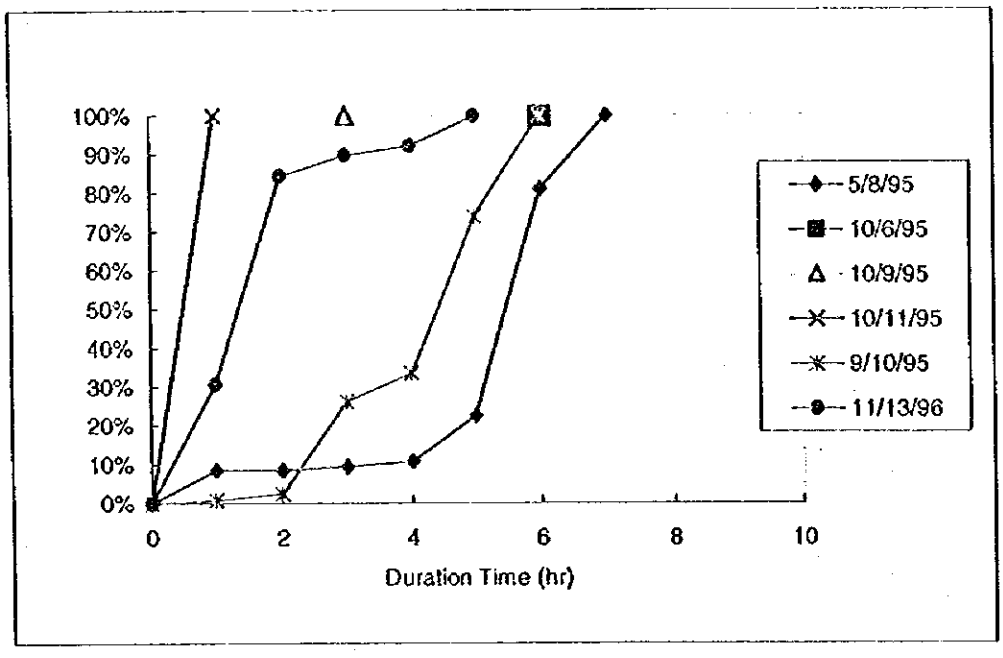


The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure I2-12 Water Levels and Rainfall in Year 1995

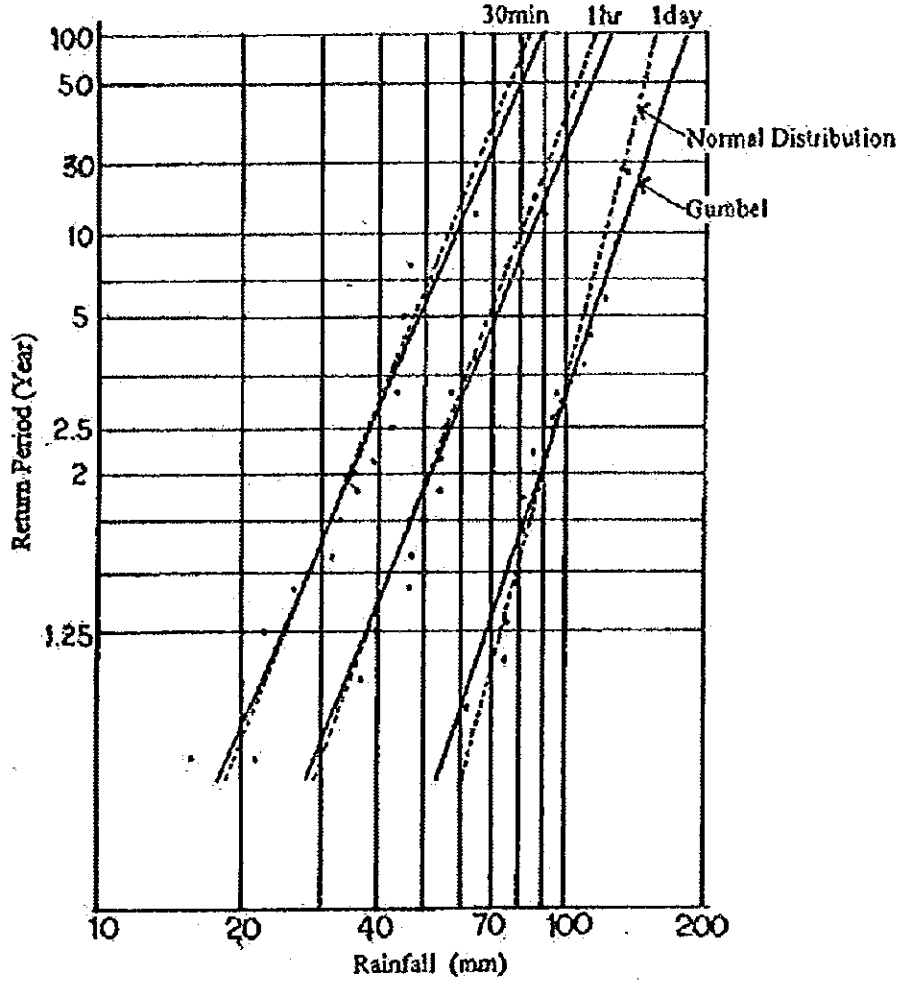


The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure I2-13 Water Levels and Rainfall in Year 1996

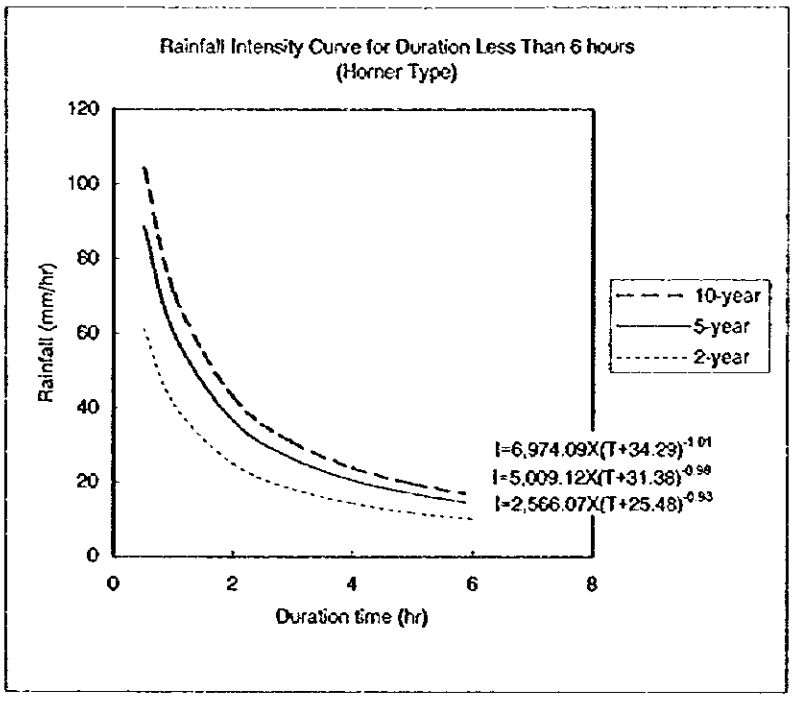


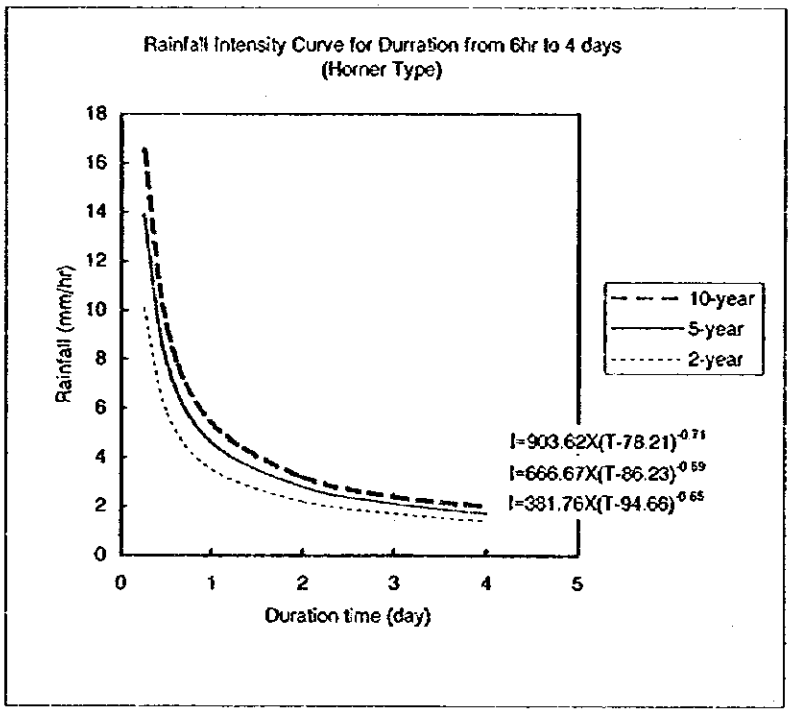


The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure I2-14 Actual Single Rainfall Duration



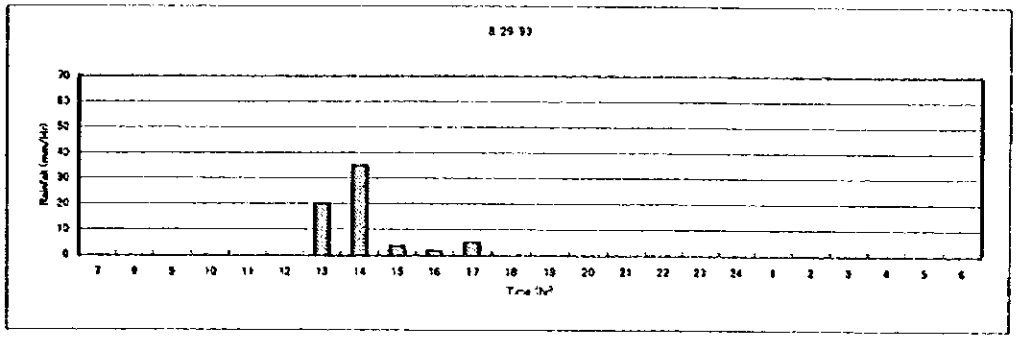
The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co.,Ltd.- Nippon Koei.,Ltd.	Figure I2-15 Probable Rainfall Analysis

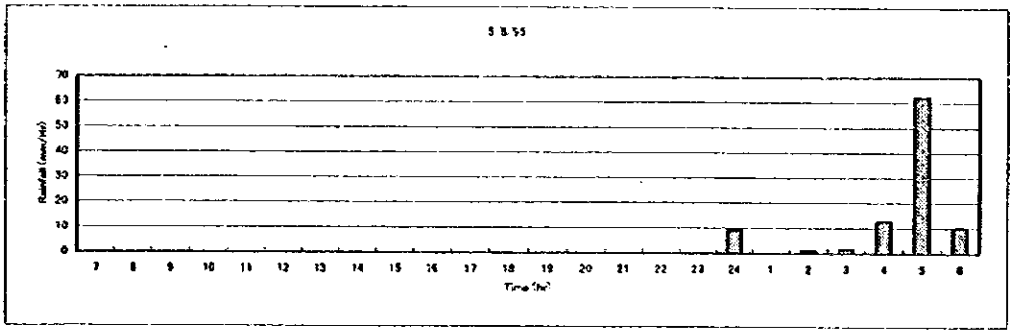


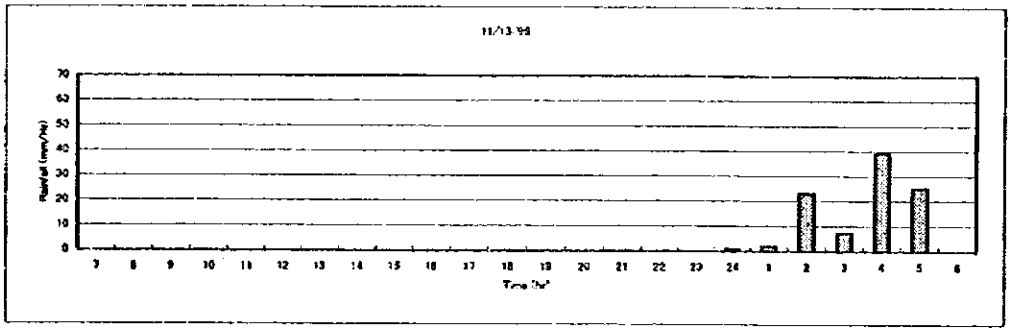


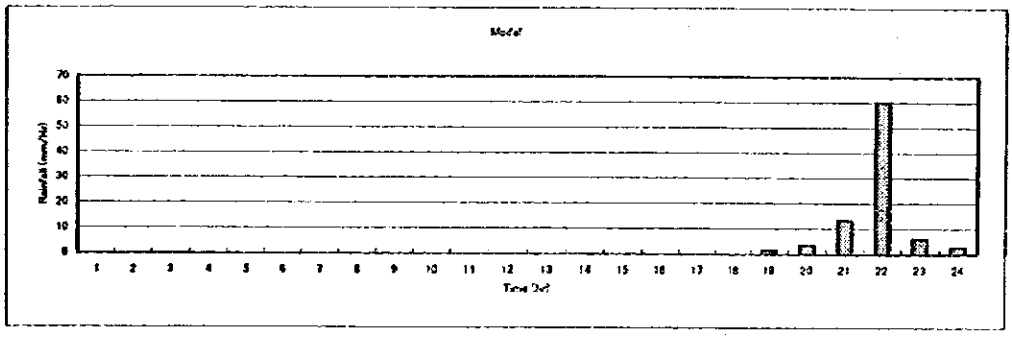
Notes : I : Rainfall Intensity (mm/hr)
T : Rainfall duration (min)

The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure I2-16 Rainfall Intensity Curves

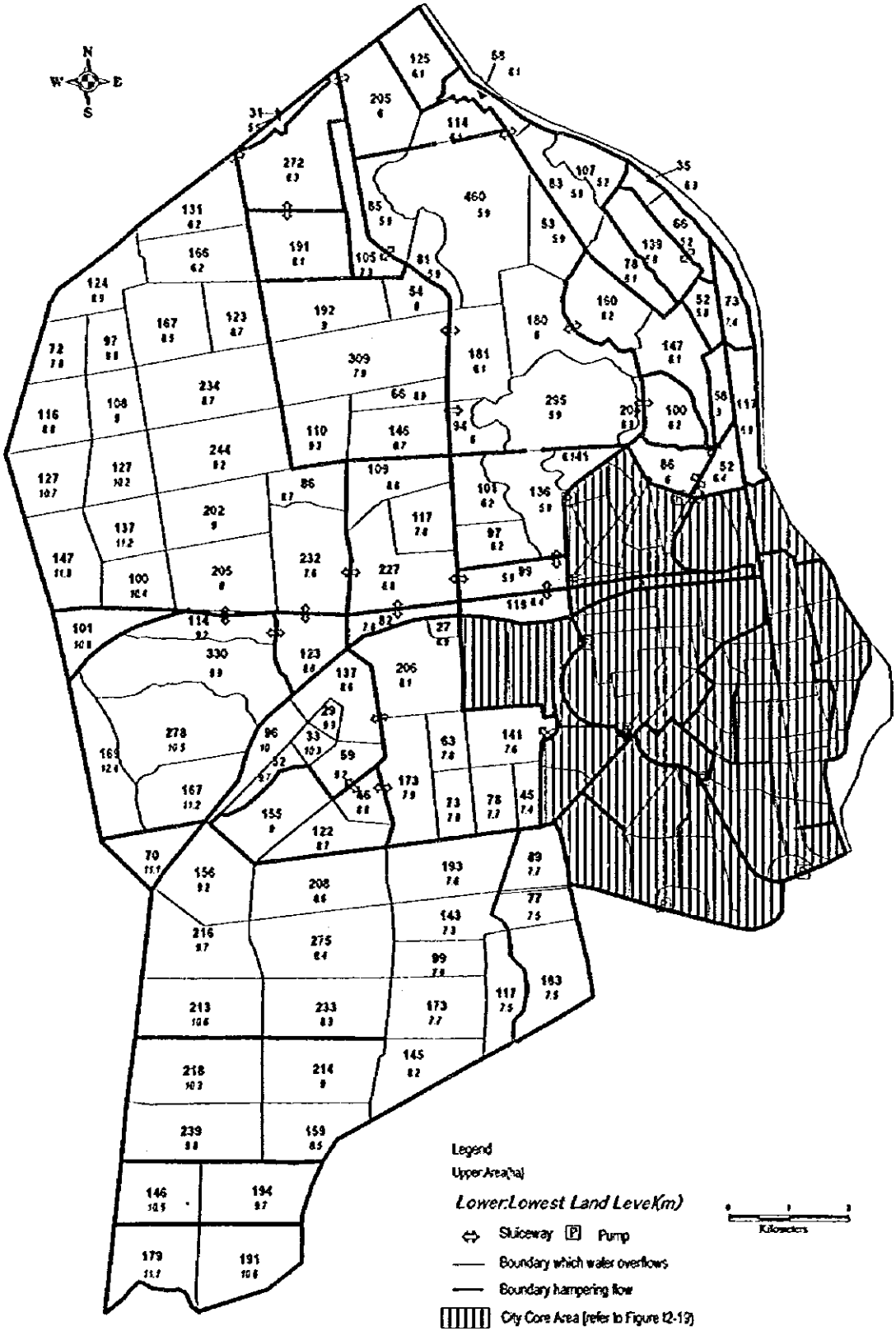






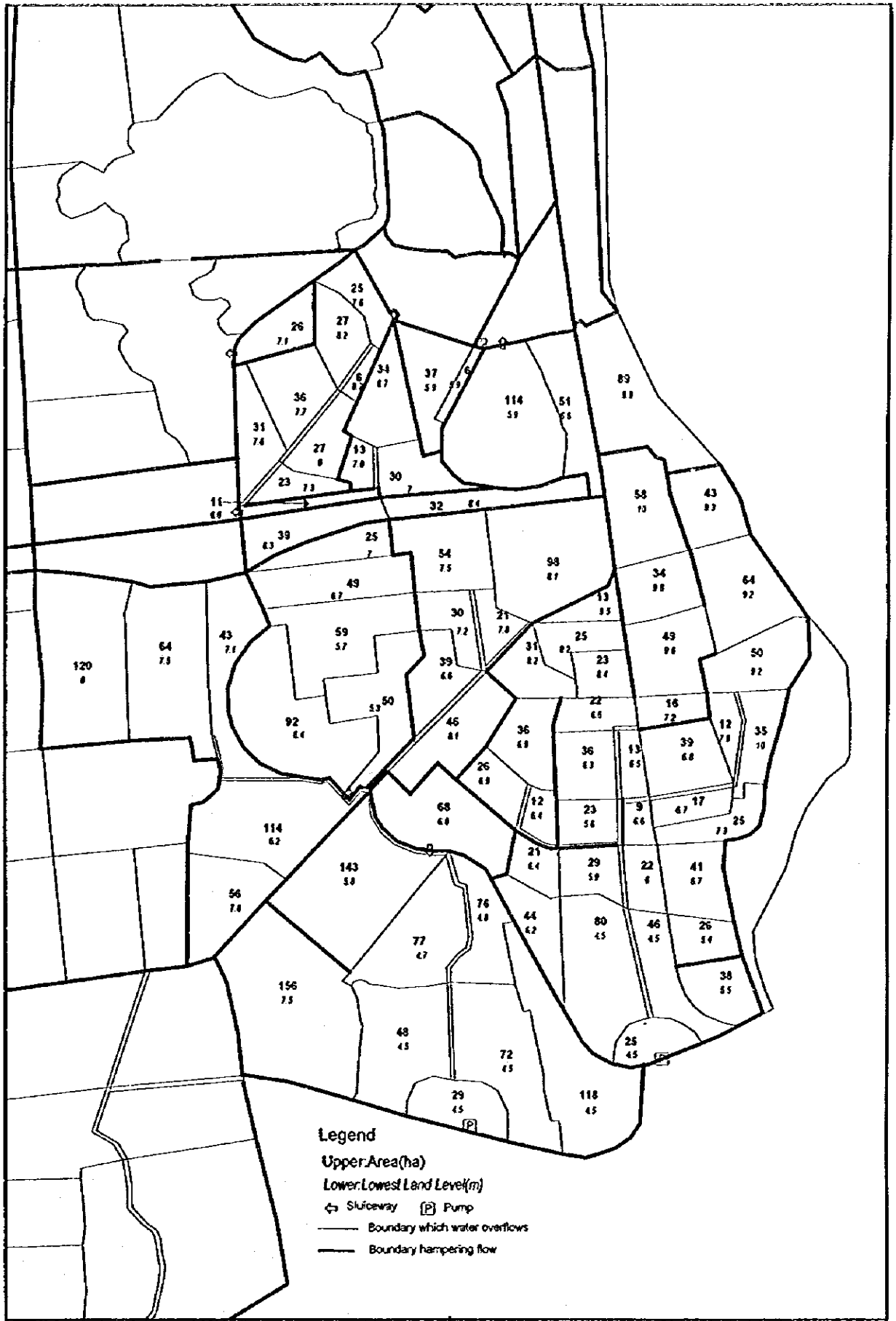


The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure 12-17 Actual Rainfall Patterns and Design Hyetograph (5-year Return Period)

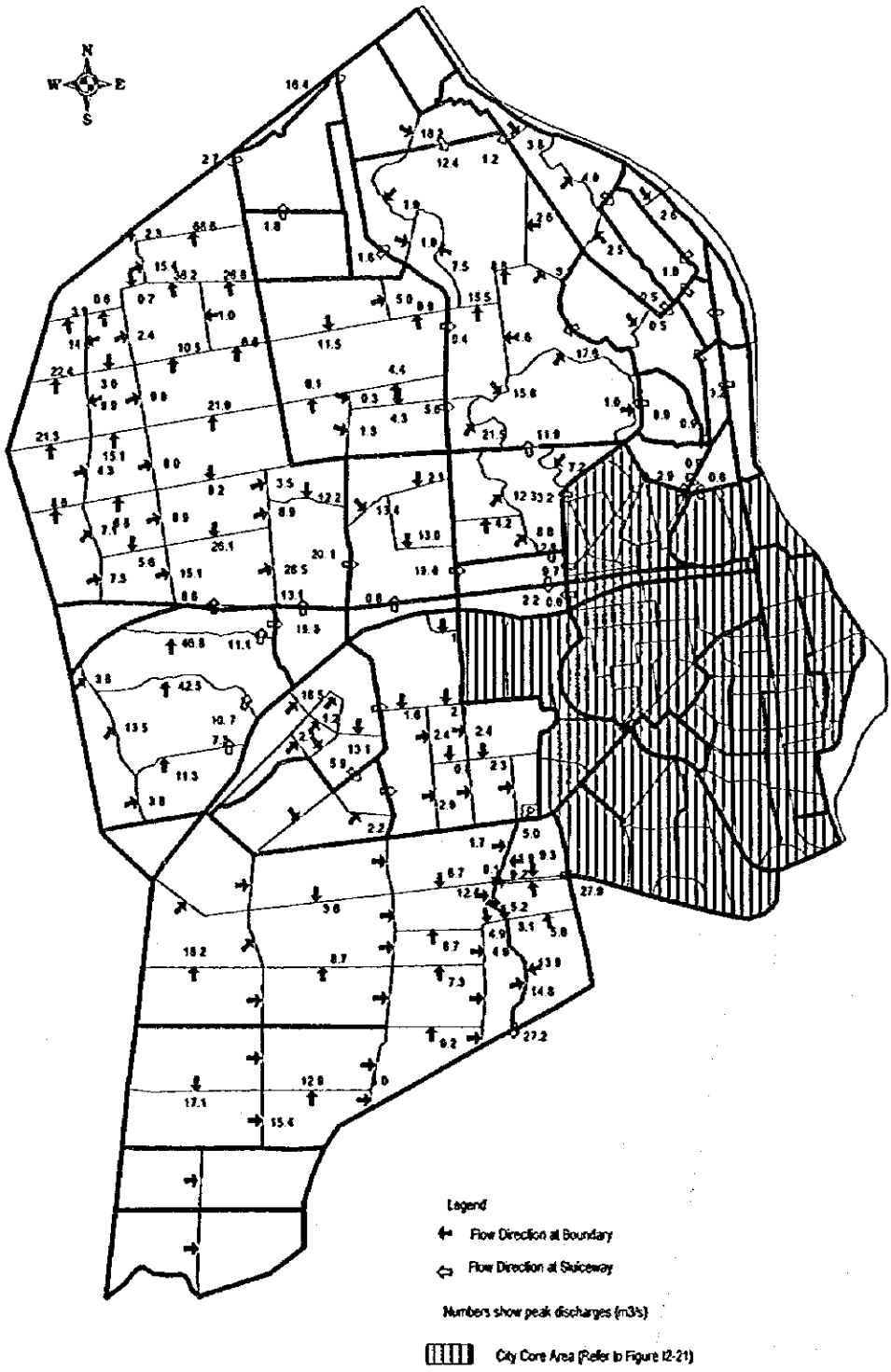


The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh
JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.

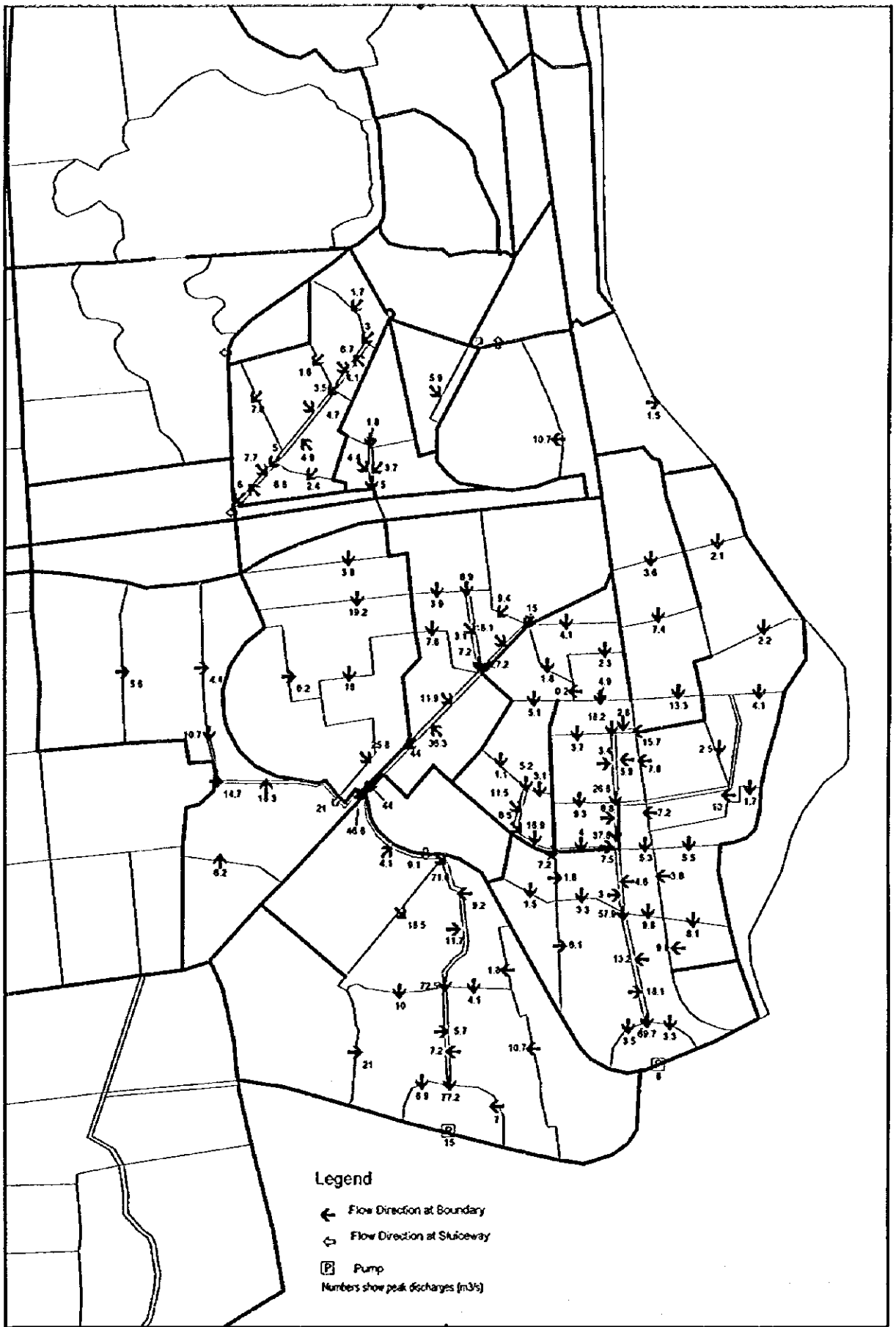
Figure I2-18
Modeling of Suburban Area



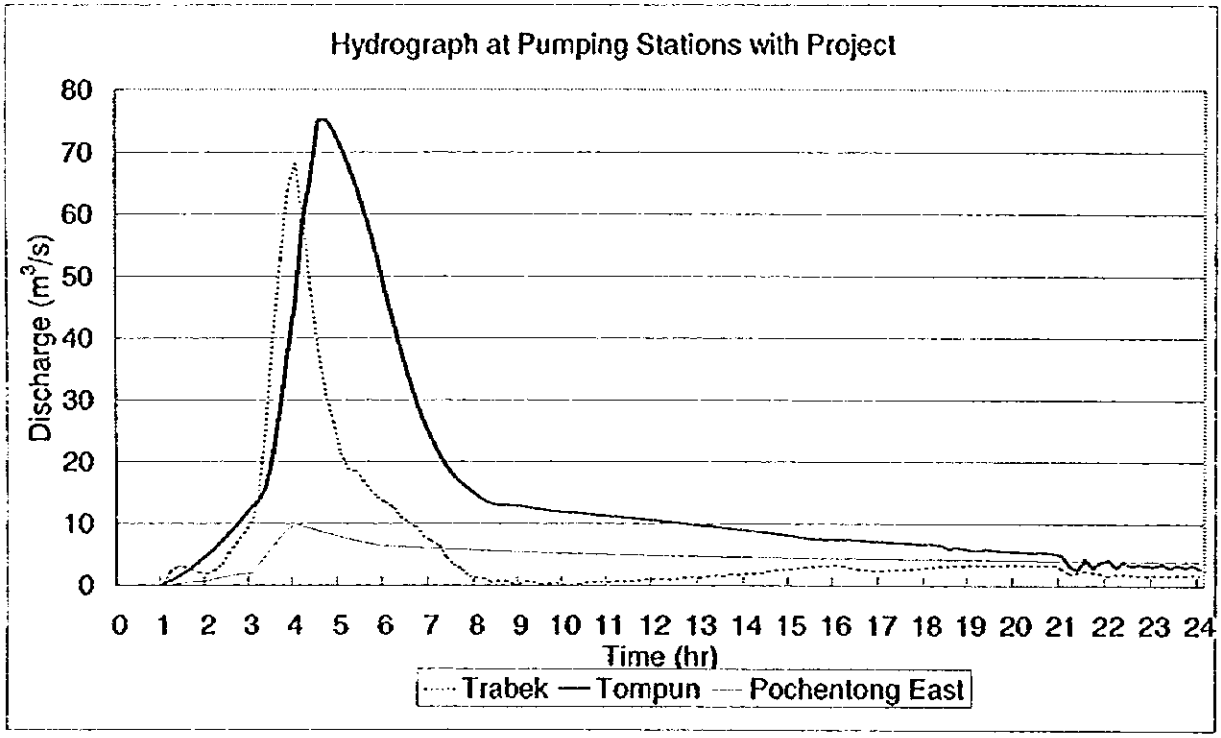
The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh **JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.**	Figure I2-19 Modeling of City Core



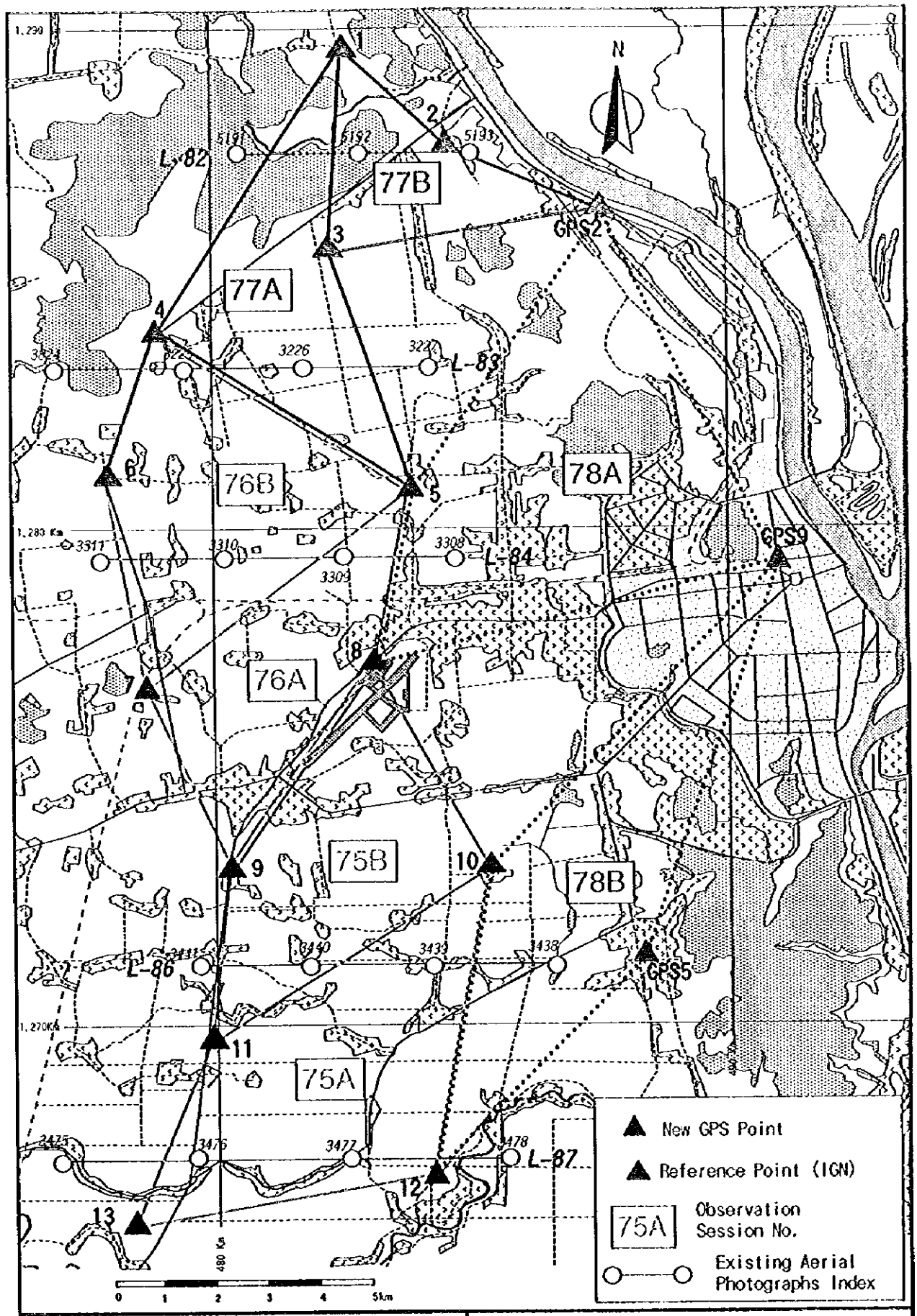
The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure I2-20 Flow Directions and Peak Discharges in Case 5 for Suburban Area (5-year Return Period, With-project)



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh **JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.**	Figure I2-21 Flow Directions and Peak Discharges in Case 5 in City Core (5-year Return Period, With-Project)



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure I2-22 Hydrograph at Pumping Station Sites (5-year Return Period, With-project)



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure I2-23 Ground Control Survey (GPS) Network

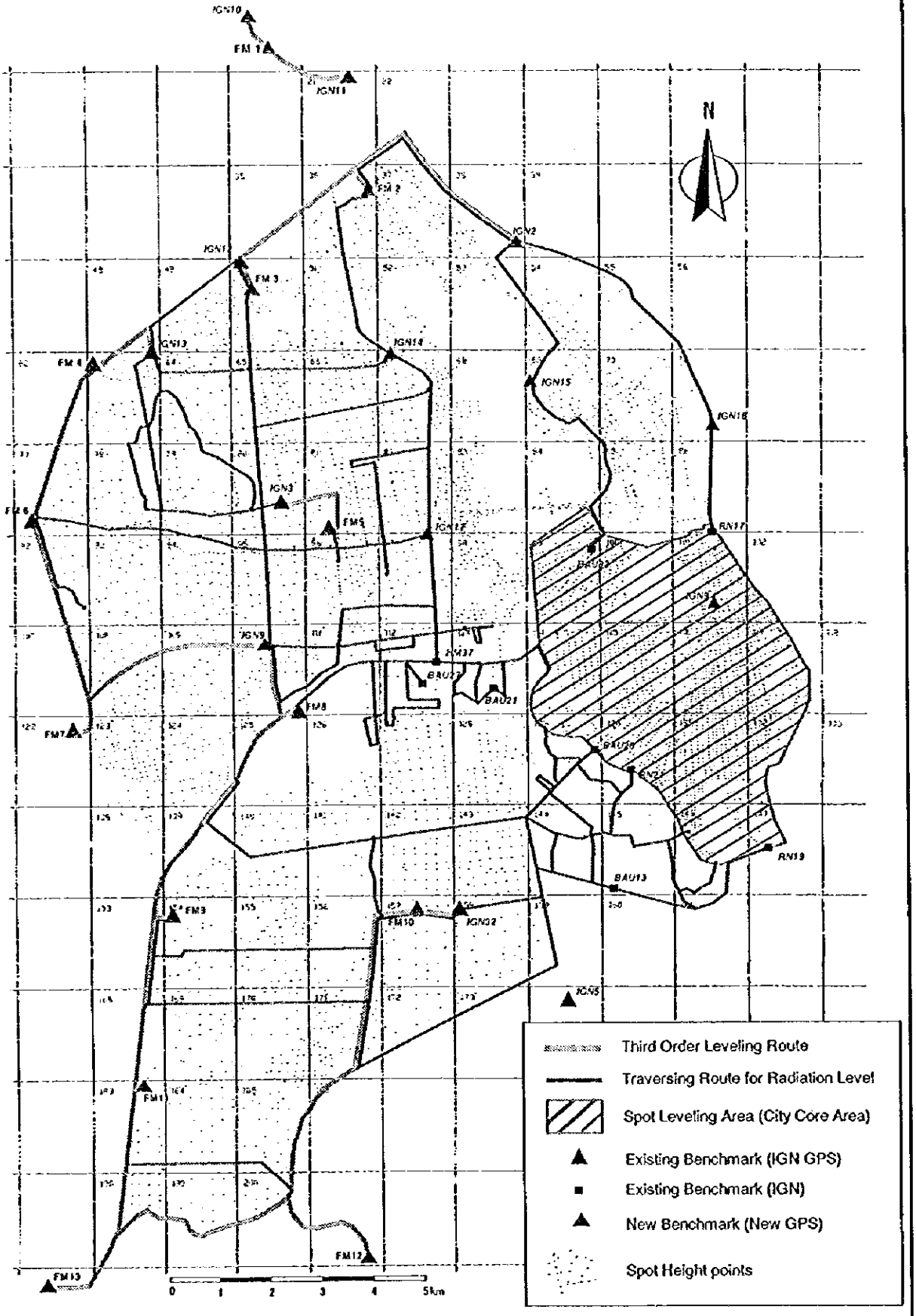


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Figure 12-24
Leveling Network Chart & Spot Height Point Distribution