Chapter 9

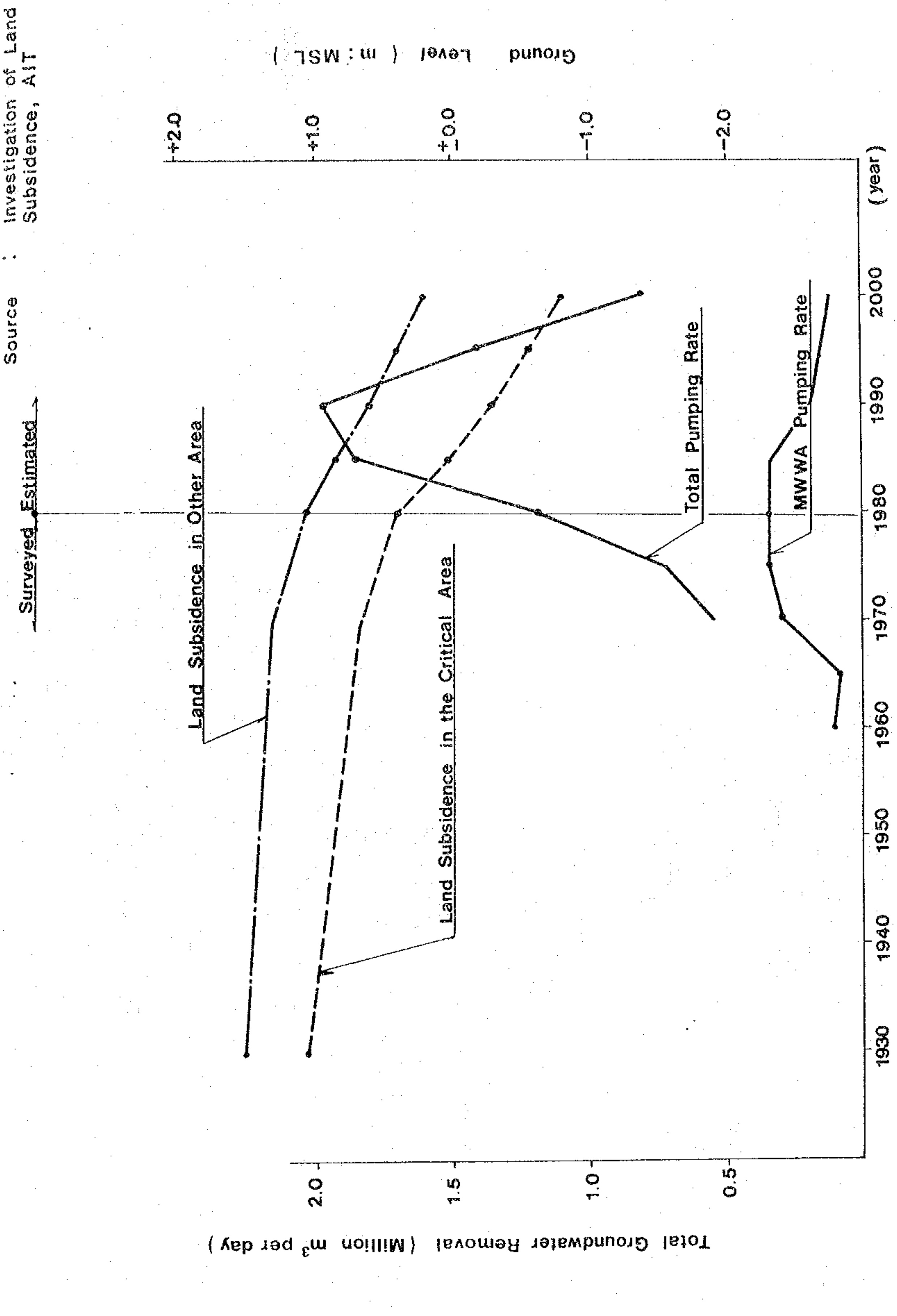


FIG. 9.1	**Land Subsidence and Groundwater Removal**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

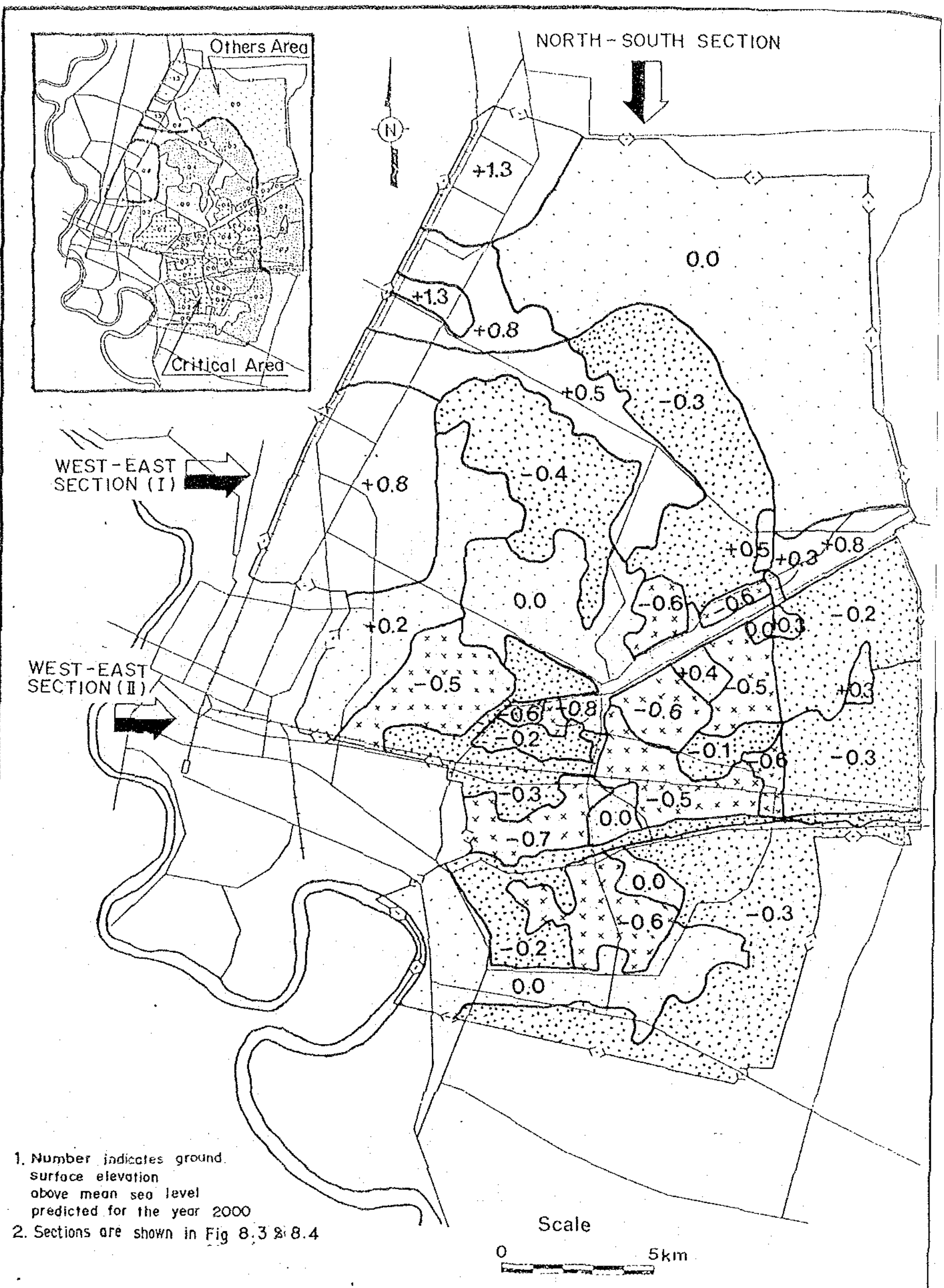
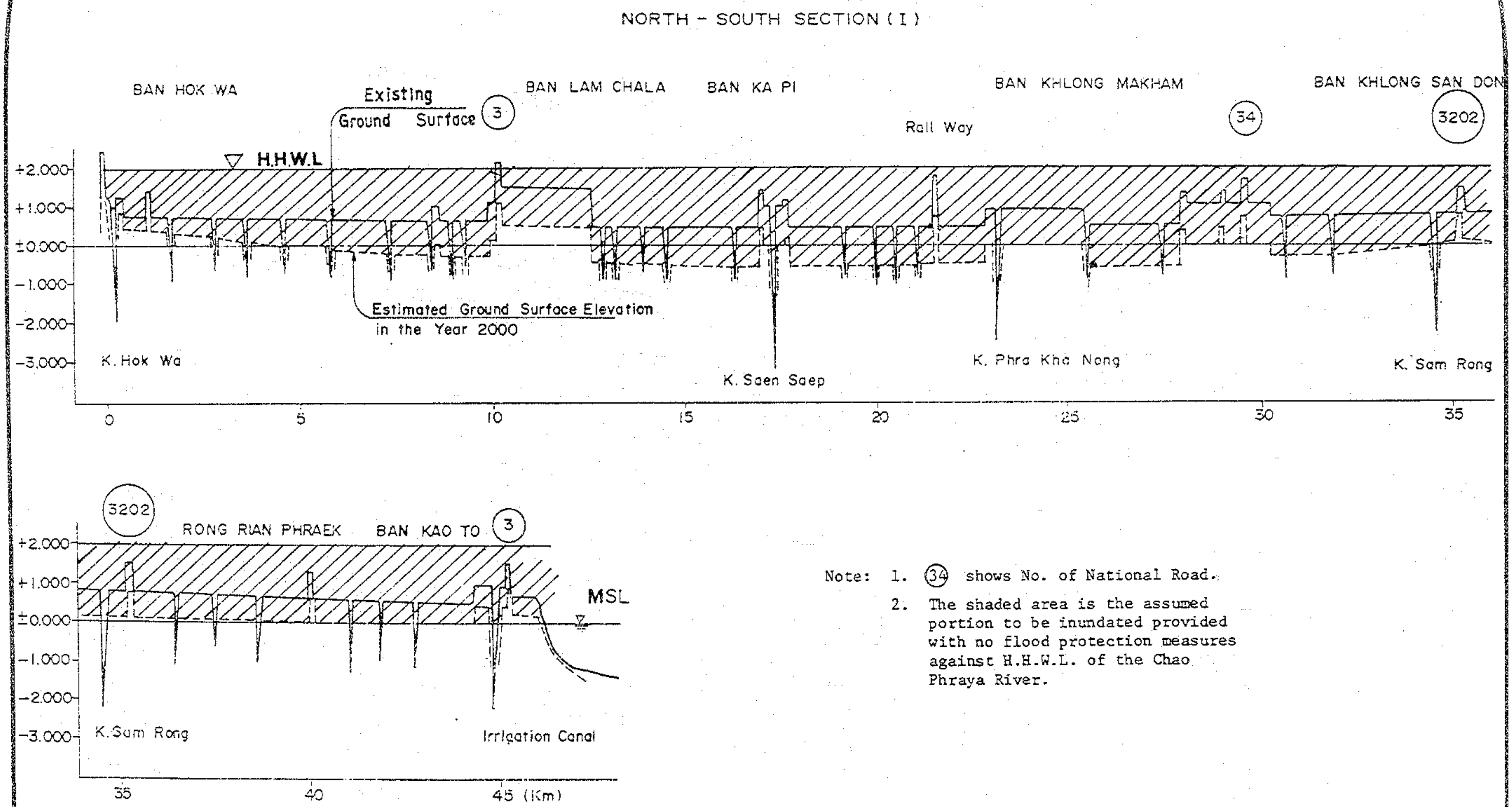


FIG. 9. 2	Estimated Ground Surface Elevation in the Study Area in the Year 2000

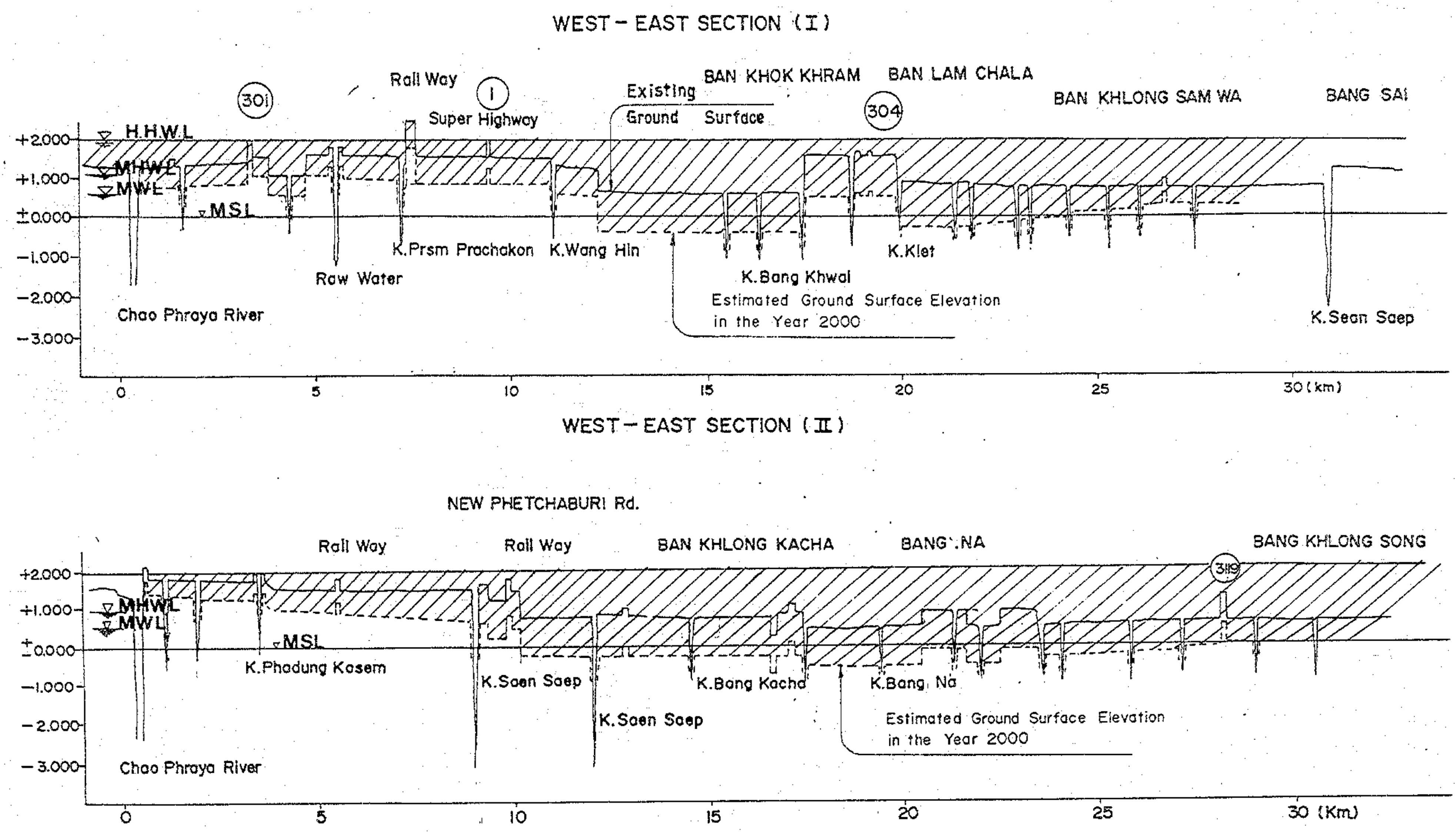
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Note: 1. (34) shows No. of National Road.
2. The shaded area is the assumed portion to be inundated provided with no flood protection measures against H.H.W.L. of the Chao Phraya River.

FIG. 9.3 Estimated North-South Profile of the Study Area in the Year 2000

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Note:
1. (1) shows No. of National Road.
2. The shaded area is the assumed portion to be inundated provided with no flood protection measures against H.H.W.L. of the Chao Phraya River.

FIG. 9.4 Estimated West-East Profile of the Study Area in the Year 2000

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Chapter 10

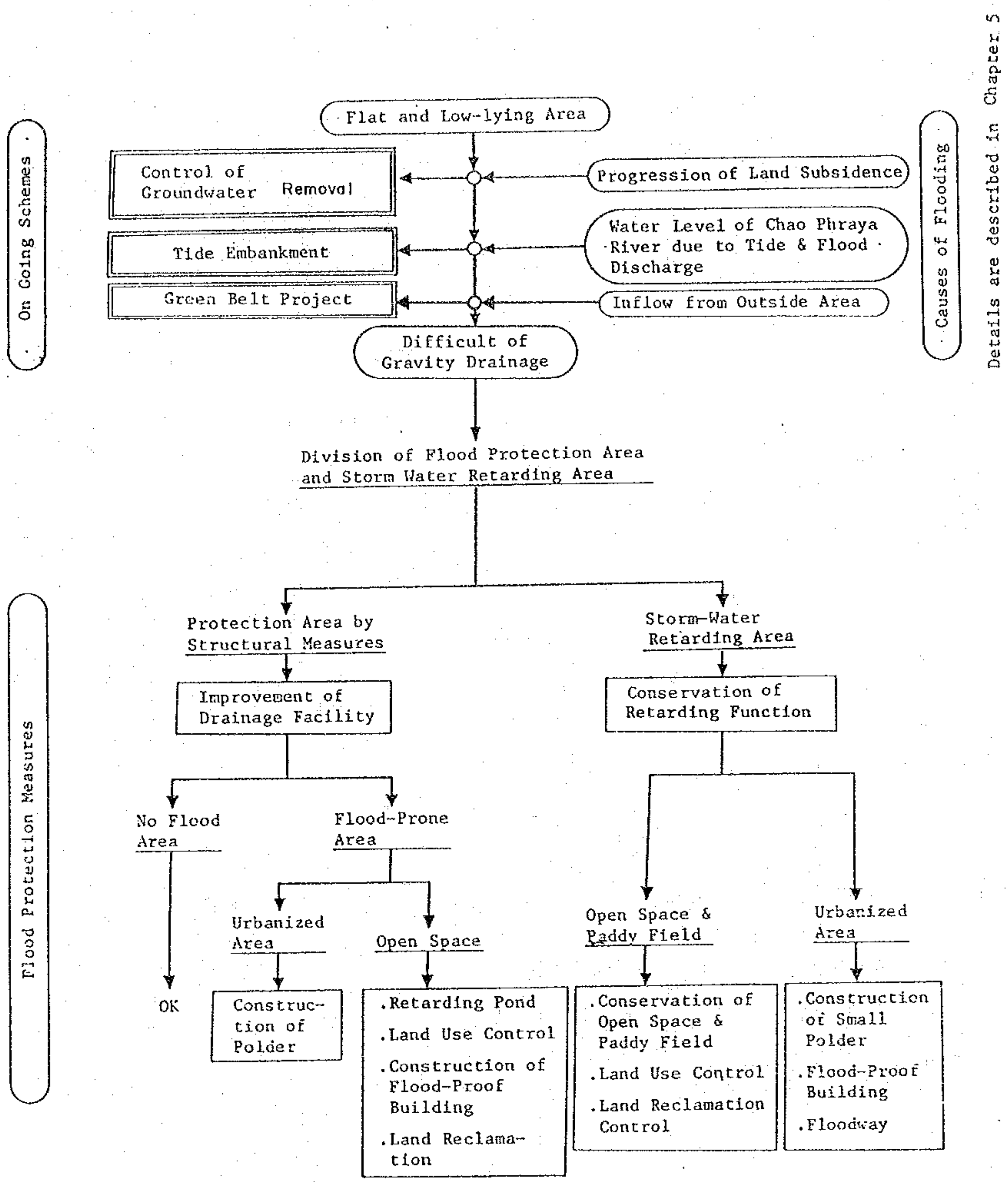


FIG. 10. 1 Outline of Flood Protection Measures

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

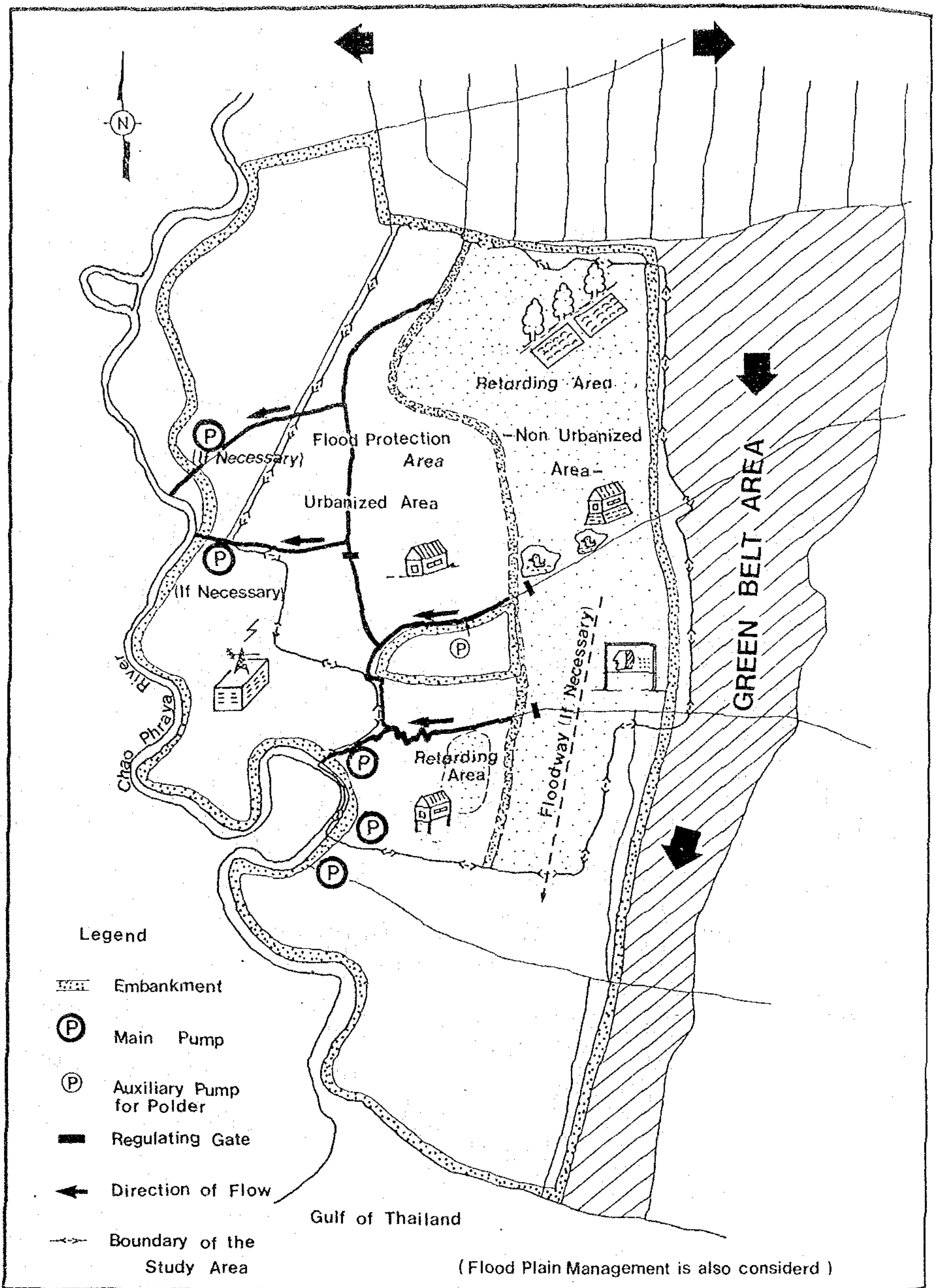


FIG.10. 2 Concept for Flood Protection Measures

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

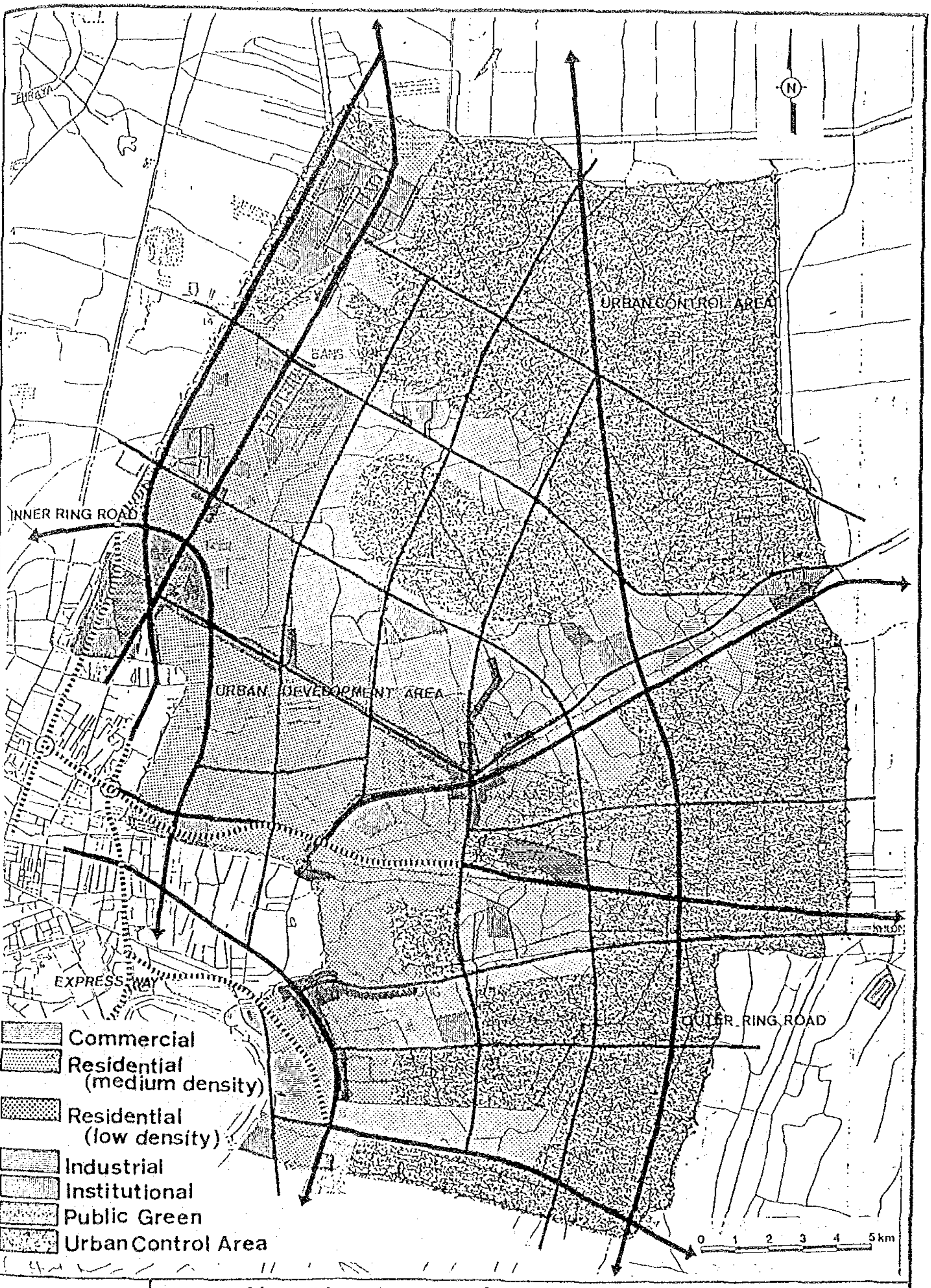


FIG. 10.3 Land Use Plan for the Study Area in the Year 2000

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Chapter 11

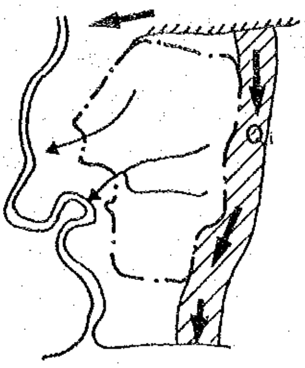
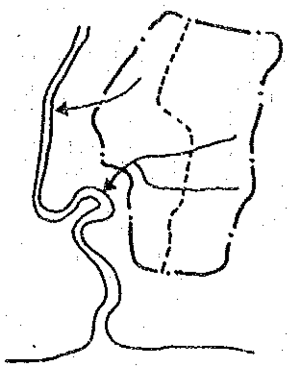
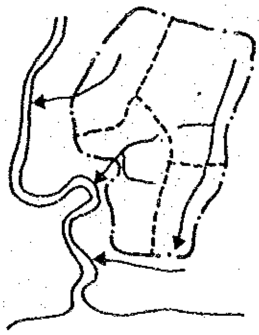
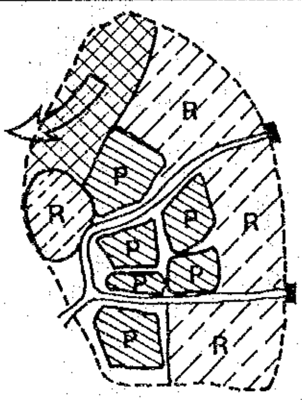
Steps of Study			
No.	Study Area	Schematic Figure	Key Words
Step I	Whole Area		Green Belt
Step II	Whole Area		Consevation ofRetardingArea
Step III	Proposed Master Plan Area		Zoning of Drainage Area
Step IV/V	Proposed Master Plan Area		Polder System

FIG. 11.1 **Steps of Analysis for Flood Protection/ Drainage System**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

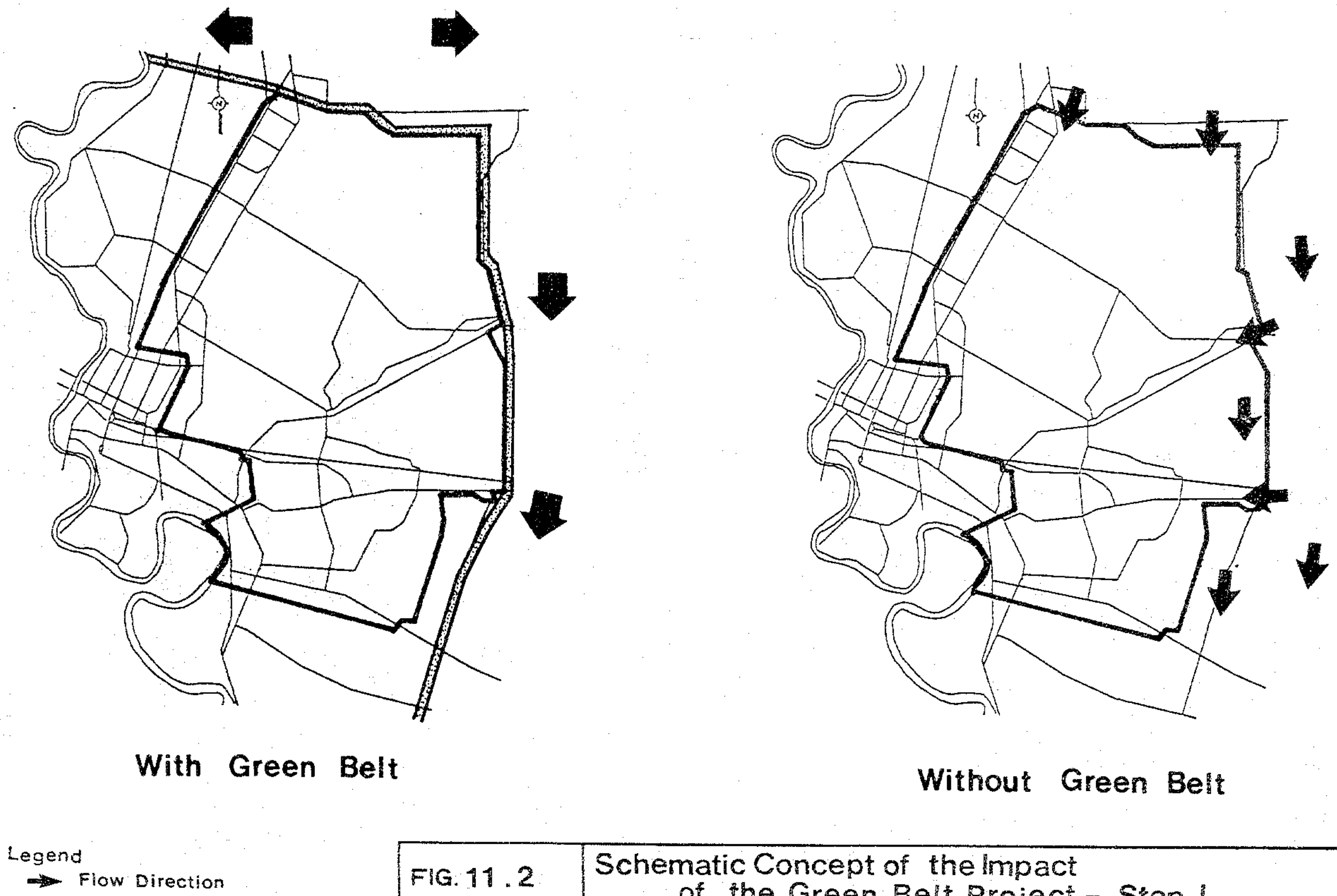


FIG. 11.2	Schematic Concept of the Impact of the Green Belt Project – Step I
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK	

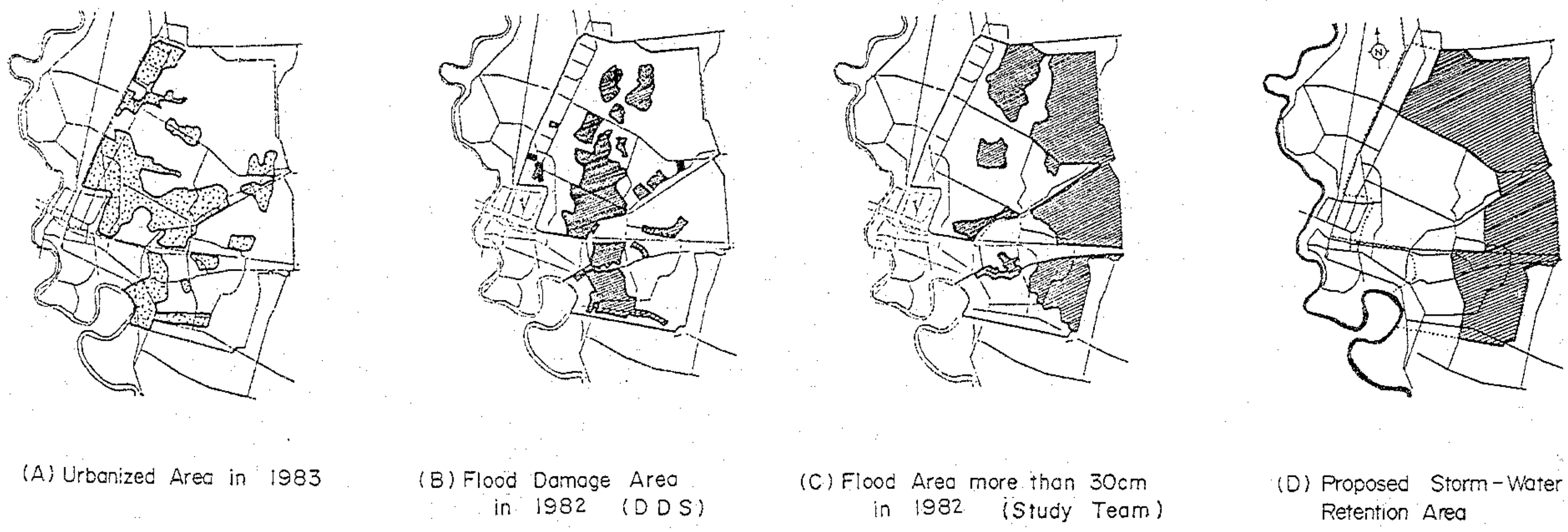
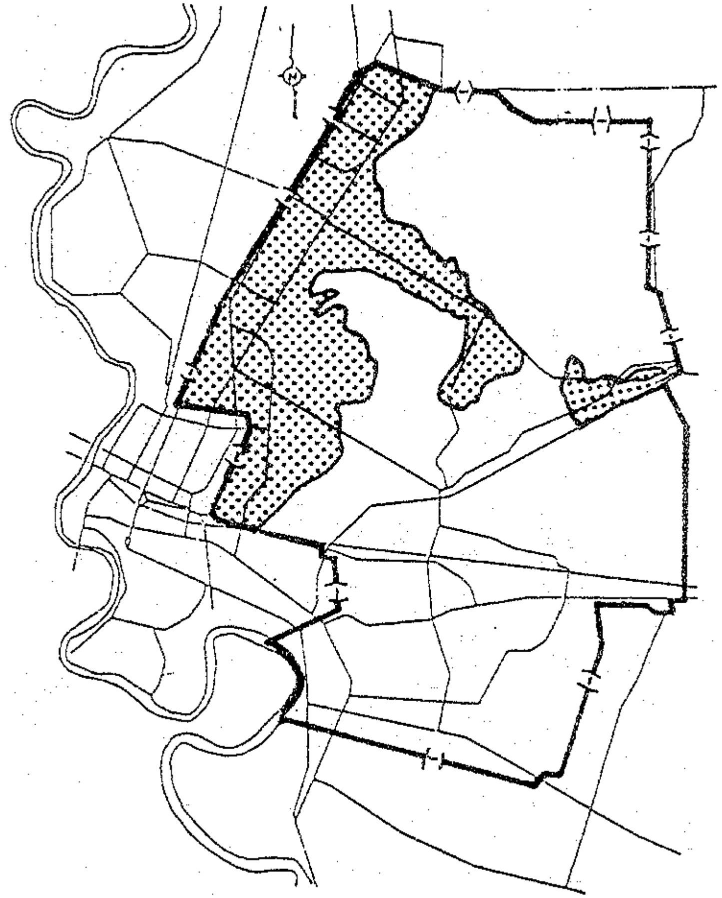
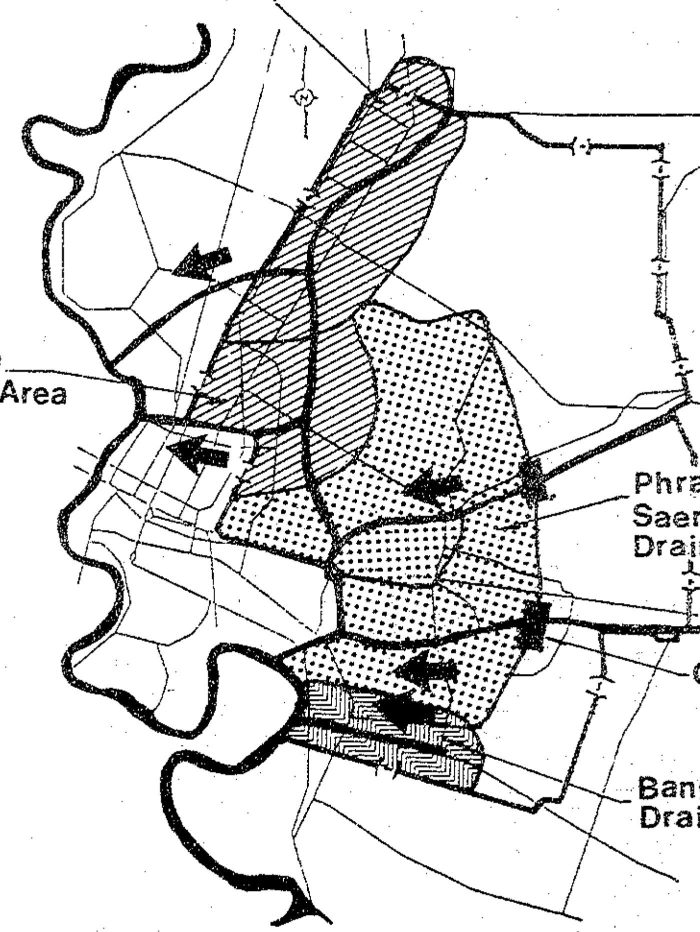


FIG. 11. 3 **Schematic Concept of the Impact of a Storm-water Retarding Area - Step II**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



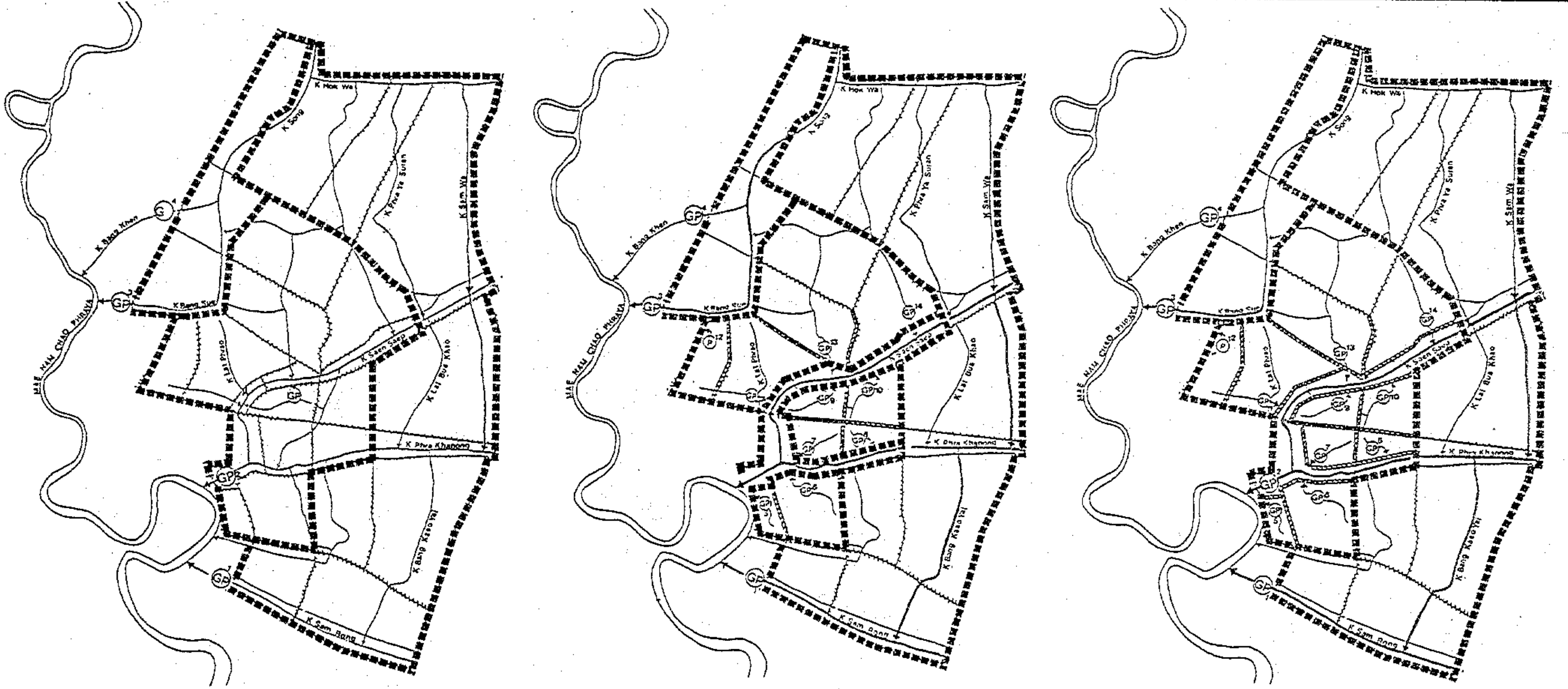
(A) Area of Ground Elevation of Higher than MSL in 2000



(B) Drainage Area

FIG. 11.4	Schematic Concept of Drainage Area – Step III

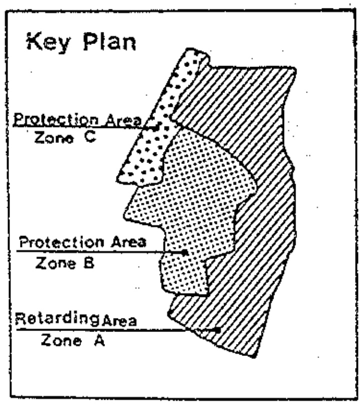
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Alternative – I

Alternative – II

Alternative – III



Legend

■■■■■ ; Main Embankment (Barrier of Zone)

////////// ; Line of Mesh

▭▭▭▭▭ ; Polder Embankment

(GP) ; Gate & Pump Station

FIG. 11.5	Alternatives for Zoning of Drainage Area and Basic Flood Protection／Drainage System (Step III)
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK	

Chapter 12

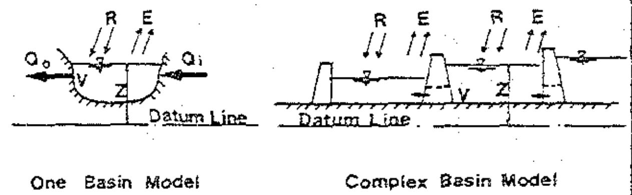
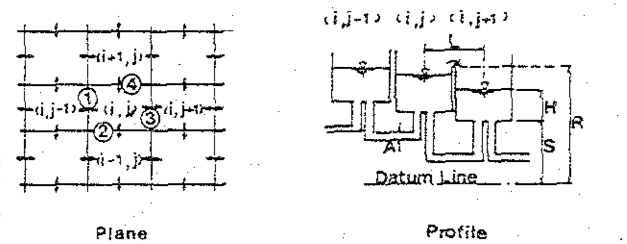
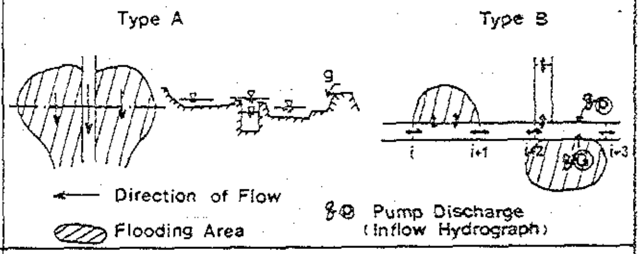
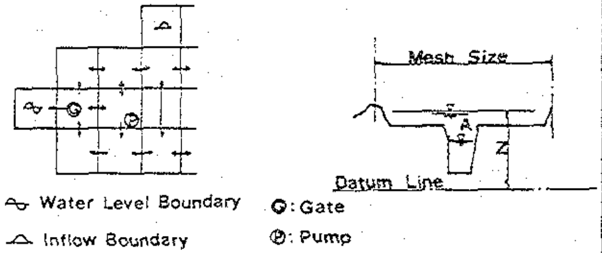
Model		Basic Equation		Schematic Diagram
Storage Type Model	Unidimensional Model (Complex Basin Model)	$\Delta V = (\Sigma Q_{in} - \Sigma Q_{out})dt$ $V_t = V_{t-dt} + \Delta V$ $V = F(Z)$	Q: Inflow and Outflow V: Storage ΔV: Change in Storage During "dt" Z: Water Level	
	Bidimensional Model (Plane Tank Model)	$\frac{\partial Z}{\partial t} = Q_{in} - Q_{out}$ $\frac{1}{gA}\frac{\partial Q}{\partial t} = \Delta(Z+S) - L\alpha Q\|Q\|$	S: Ground EL. of Mesh A: Sectional Area of Syphon Pipe L: Length of Syphon Pipe g: Gravity Acceleration	
Open Canal Type Model	Unidimensional Model	$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial X} = g(t)$ $\frac{\partial Q}{\partial t} + \frac{\partial}{\partial X}\left(\frac{Q^2}{A}\right) + gA\frac{\partial h}{\partial X} + g\frac{n^2\|Q\|Q}{A \cdot R^{4/3}} = 0$	g: Inflow Hydrograph A: Flow Area n: Coefficient of roughness	
	Bidimensional Model	$\frac{\partial Q_x}{\partial t} + \frac{\partial}{\partial X}\left(\frac{Q_x^2}{A_x}\right) + gA_x\frac{\partial Z}{\partial X} + g\frac{n^2\|Q\|Q}{AR^{4/3}} = 0$ $\frac{\partial Q}{\partial t} + \frac{\partial}{\partial y}\left(\frac{Q_y^2}{A_y}\right) + gA_y\frac{\partial Z}{\partial y} + g\frac{n^2\|Q\|Q}{AR^{4/3}} = 0$ $\frac{\partial Z}{\partial t} + \frac{\partial Q_x}{\partial X} + \frac{\partial Q_y}{\partial y} = (R - E)$	Q: X Direction Flow R: Rainfall E: Evapotranspiration	

FIG. 12.1 **Outline of Hydraulic Flooding Models**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Model	Sub-Model
Hydrological Model	**Rainfall Model** a) For the calculation of the runoff discharge, a front concentration type hyetograph is adopted into the Rainfall Pattern. b) The land use morphorogy such as residensial area, paddy field, open space etc., are considered in the Excess Rainfall Model. **Runoff Model** c) Quasi Storage Function Model is adopted in order to calculate the runoff. $S = K.Qi$ $K = tc/2$ $tc = C.A^{0.22}.re^{-0.35}$ where; S : Storage volume Q : Runoff K : Constant tc: Time of concentration C : Value to be determined depending on land use A : Drainage area re: Excess rainfall **One Basin Model** d) One Basin Model which facters are Inflow, Outflow and Storage Volume, is adopted in order to analize the flood stage and period in the area. $\frac{dV}{dt} = Qi - Qo$ Where; dV : Change of storage volume Qi : Total inflow Qo : Total outflow

Schematic Diagram

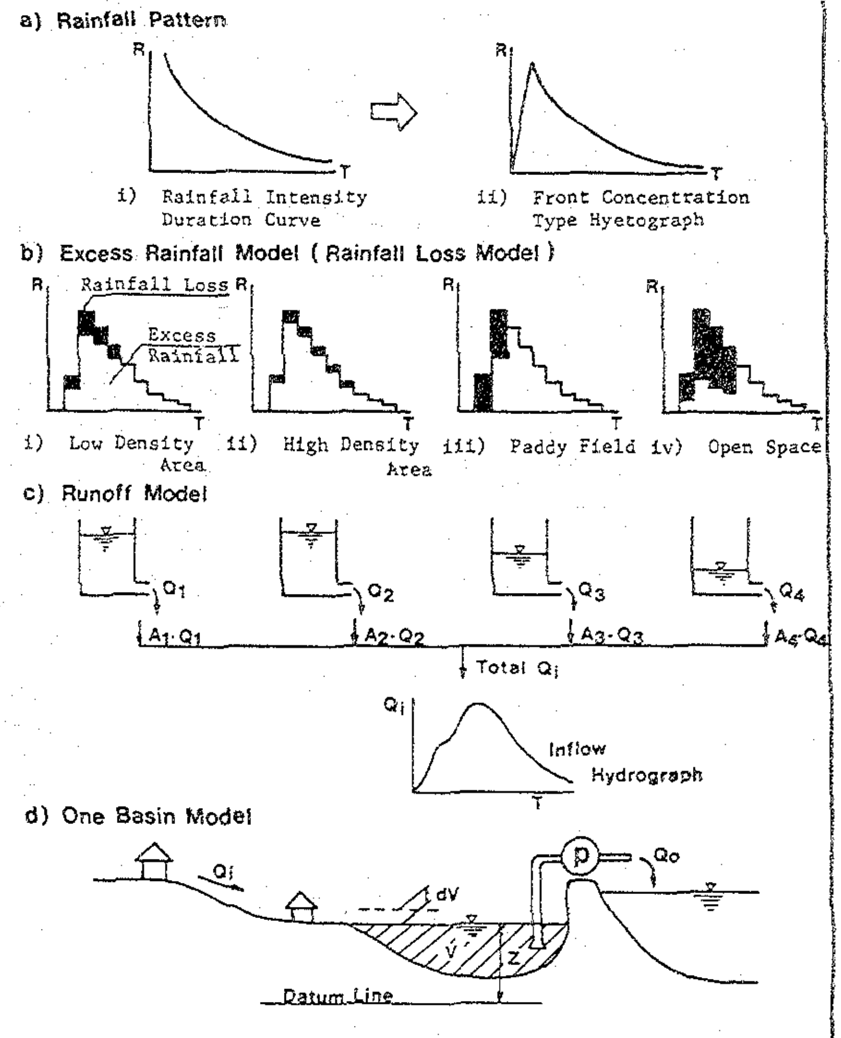


FIG. 12.2 Outline of Hydrological Models for Polder Drainage System

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

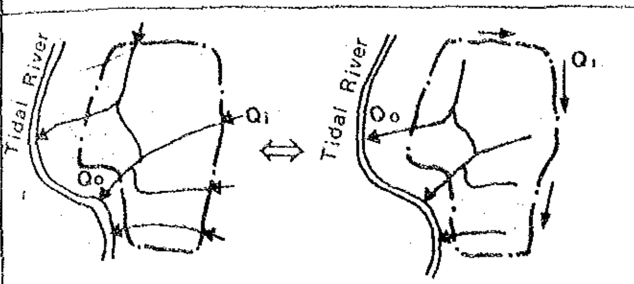
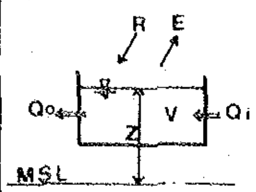
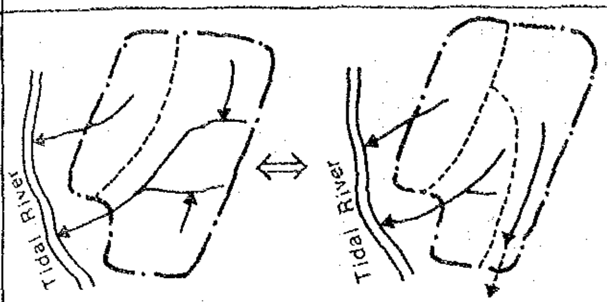
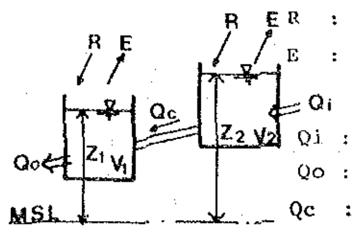
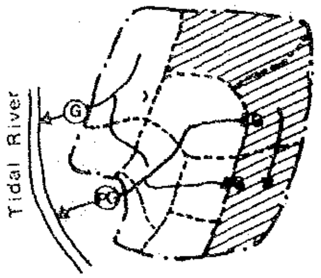
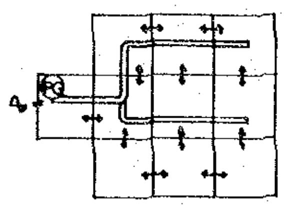
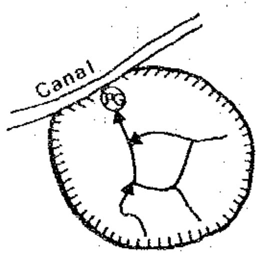
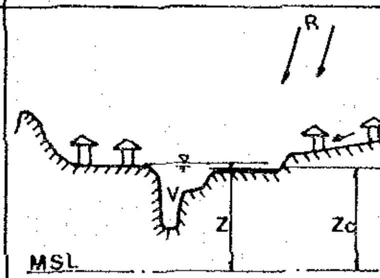
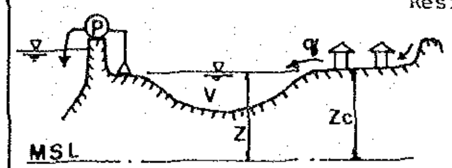
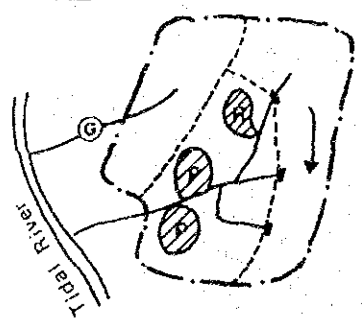
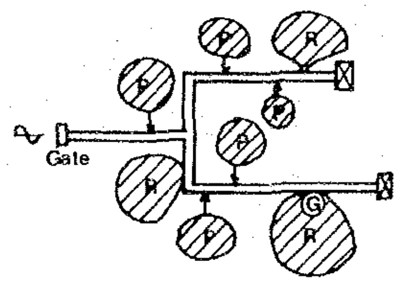
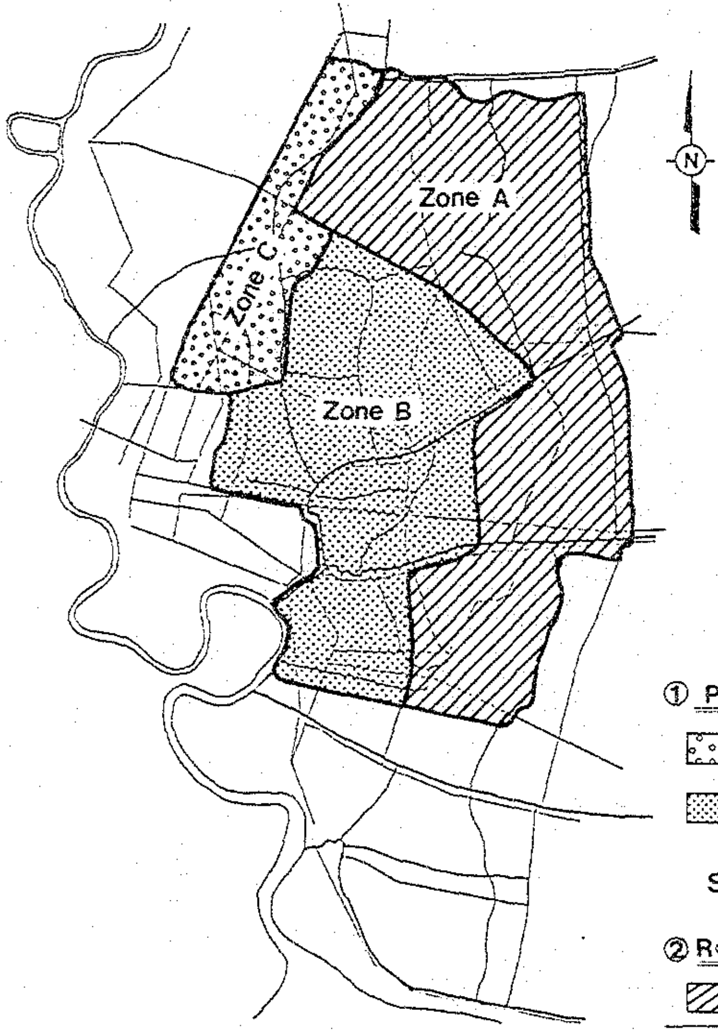
Step	Classification of Study Area	Schematic Model of Study Area	Major Evaluation Item	Application of Models	Index of Evaluation
Step I	 —·—·— : Boundary of Study Area Qi : Inflow Qo : Outflow	 R : Rainfall E : Evapotranspiration V : Storage Z : Water Level Qi : Inflow Qo : Outflow	1. Shutting Out (Qi) by Green Belt 2. Previous Flood Mark Height and Max. Storage	One Basin Model	Z : Water Level V : Storage Volume A : Flooding Area T : Duration Time
Step II	 —·—·— : Boundary of Study Area ------- : Partition Line ←— : Flow Direction of Canal	 R : Rainfall E : Evapotranspiration Qi : Inflow Qo : Outflow Qc : Connecting flow between each basin	1. Partition in Study Area 2. Shutting Out (Qi) 3. Previous Flood Mark Height and Max. Storage 4. Future Land Subsidence	Two Basin Model	Z : Water Level V : Storage Volume A : Flooding Area T : Duration Time C : Capacity of Drainage Facility
Step III	 —·—·— : Boundary of Study Area ------- : Partition Line for Mesh →(PG) : Drainage Facilities (Pump/Gate) ▨ : Retarding Area		1. Previous Flood Mark Height and Max. Storage 2. Future Land Subsidence 3. Alternative Drainage System	Bi-dimensional Model (Open Canal Type Model)	Z : Water Level V : Storage Volume A : Flooding Area T : Duration Time C : Capacity of Drainage Facility
Step IV	 : Polder Unit →(PG) : Drainage Facilities (Pump/Gate) → : Drainage Small Canal	 R : Rainfall q : Run-off Z : Water Level V : Storage Zc : Lowest El. of Residential Land 	1. Alternative Drainage Facility 2. Change in Run-off Discharge due to Land Use Condition	Hydrological Model . Rainfall Model . Excess Rainfall Model Sub-watershed Model (Storage Funct. Model) . Storage Pond Model	Z : Water Level V : Storage Volume A : Flooding Area T : Duration Time C : Capacity of Drainage Facility
Step V	 (P) : Polder Unit (R) : Retarding Basin		1. Alternative Total Flood Protection and Drainage System	Bi-dimensional Model Uni-dimensional Model Combined by Inflow Hydrograph of Polder	Z : Water Level V : Storage Volume A : Flooding Area T : Duration Time C : Capacity of Drainage Facility

FIG. 12.3 Application of Models

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Study Area in B.M.A



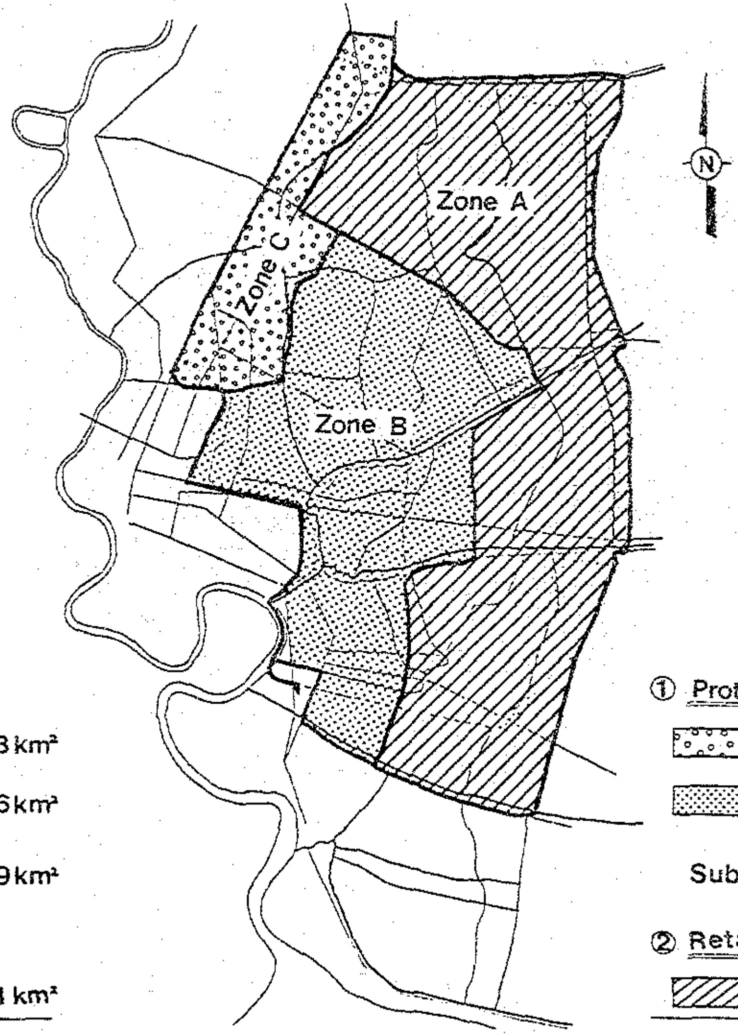
① Protection Area

Zone C,	60.3km²
Zone B,	195.6km²
Sub Total	255.9km²

② Retarding Area

Zone A,	245.1km²
Total	501.0km²

Study Area for Hydrological and Hydraulic Modeling



① Protection Area

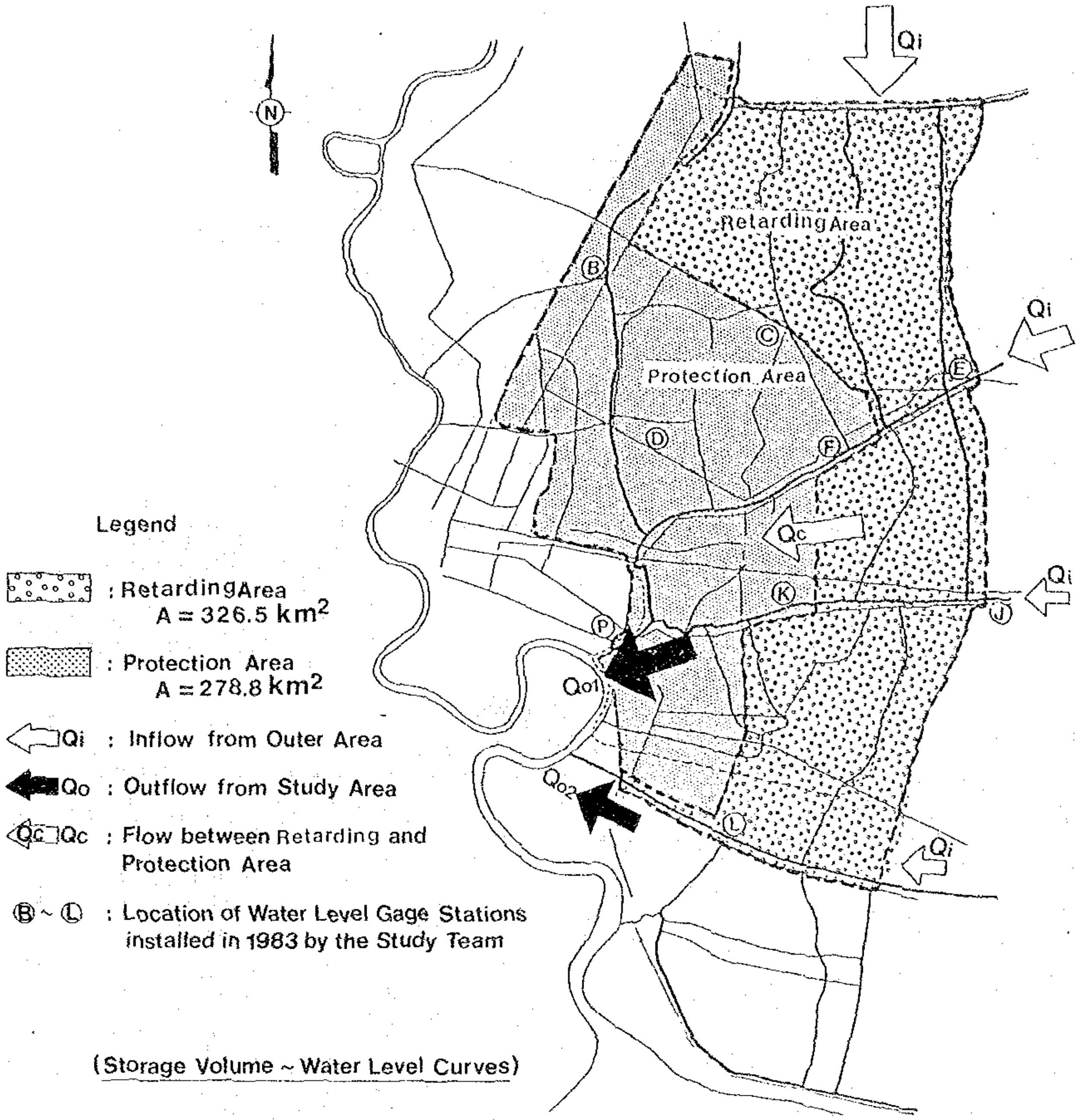
Zone C,	64.1km²
Zone B,	214.7km²
Sub Total	278.8km²

② Retarding Area

Zone A,	326.5km²
Total	605.3km²

FIG. 12.4 Study Area Size for Modeling

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



(Storage Volume ~ Water Level Curves)

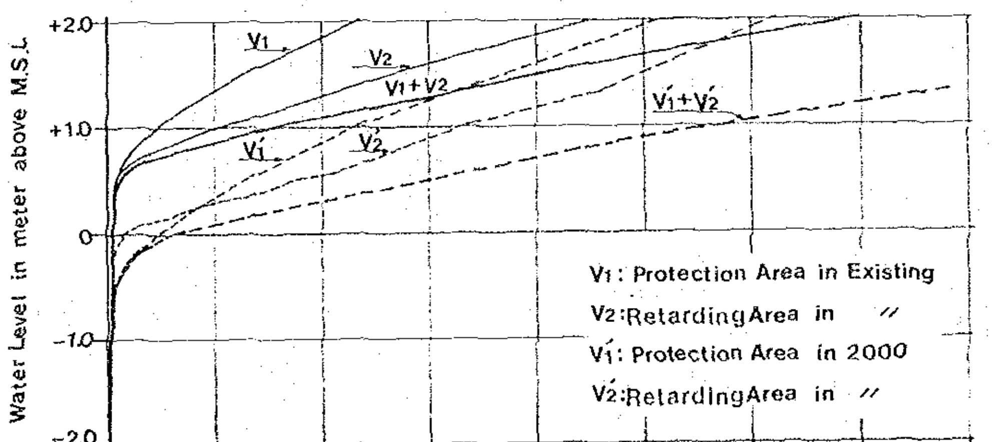


FIG. 12.5	Study Area for Two Basin Model

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

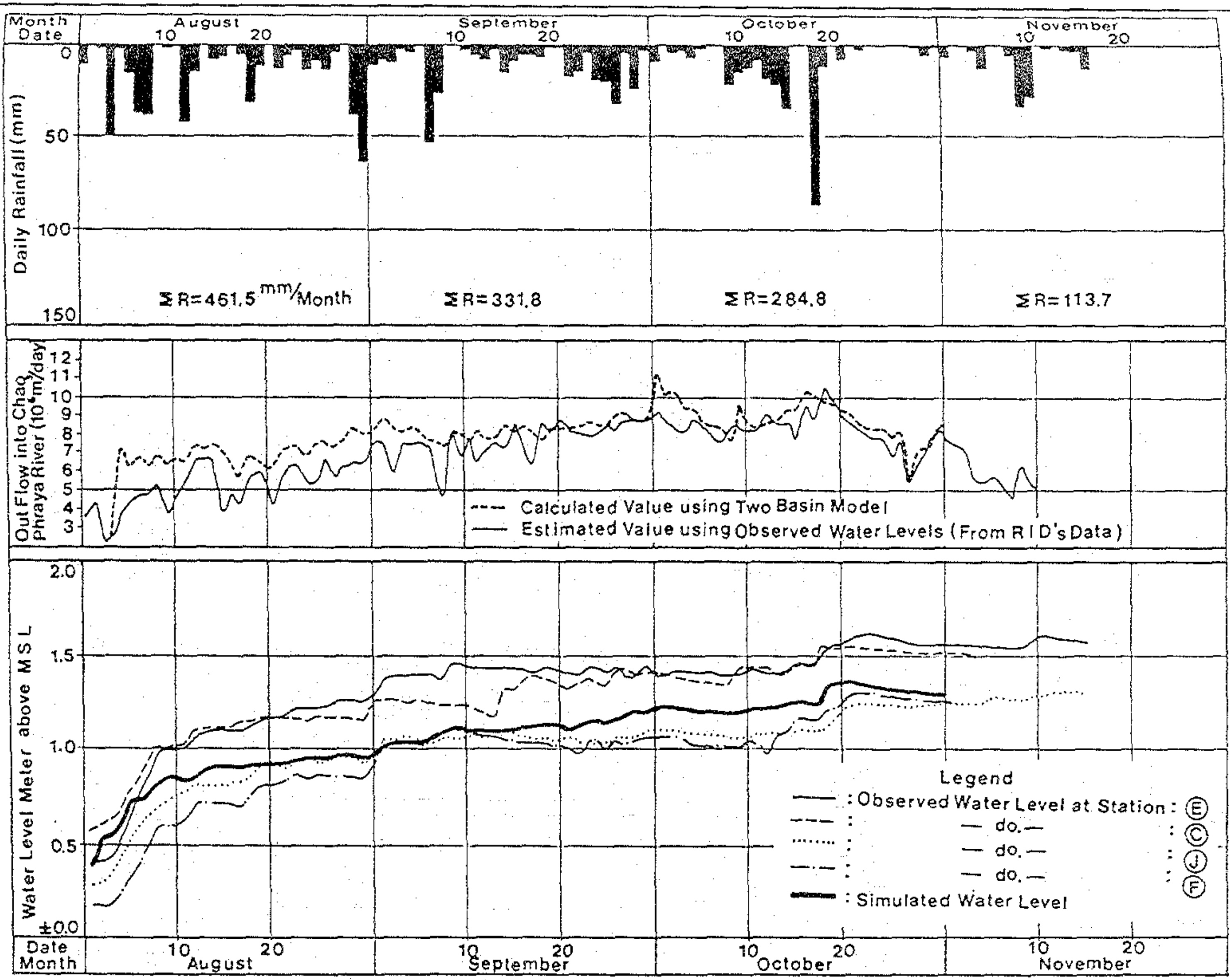


FIG. 12. 6	Comparison of Observed and Calibrated Water Levels in RetardingArea in 1983 using Two Basin Model -1

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

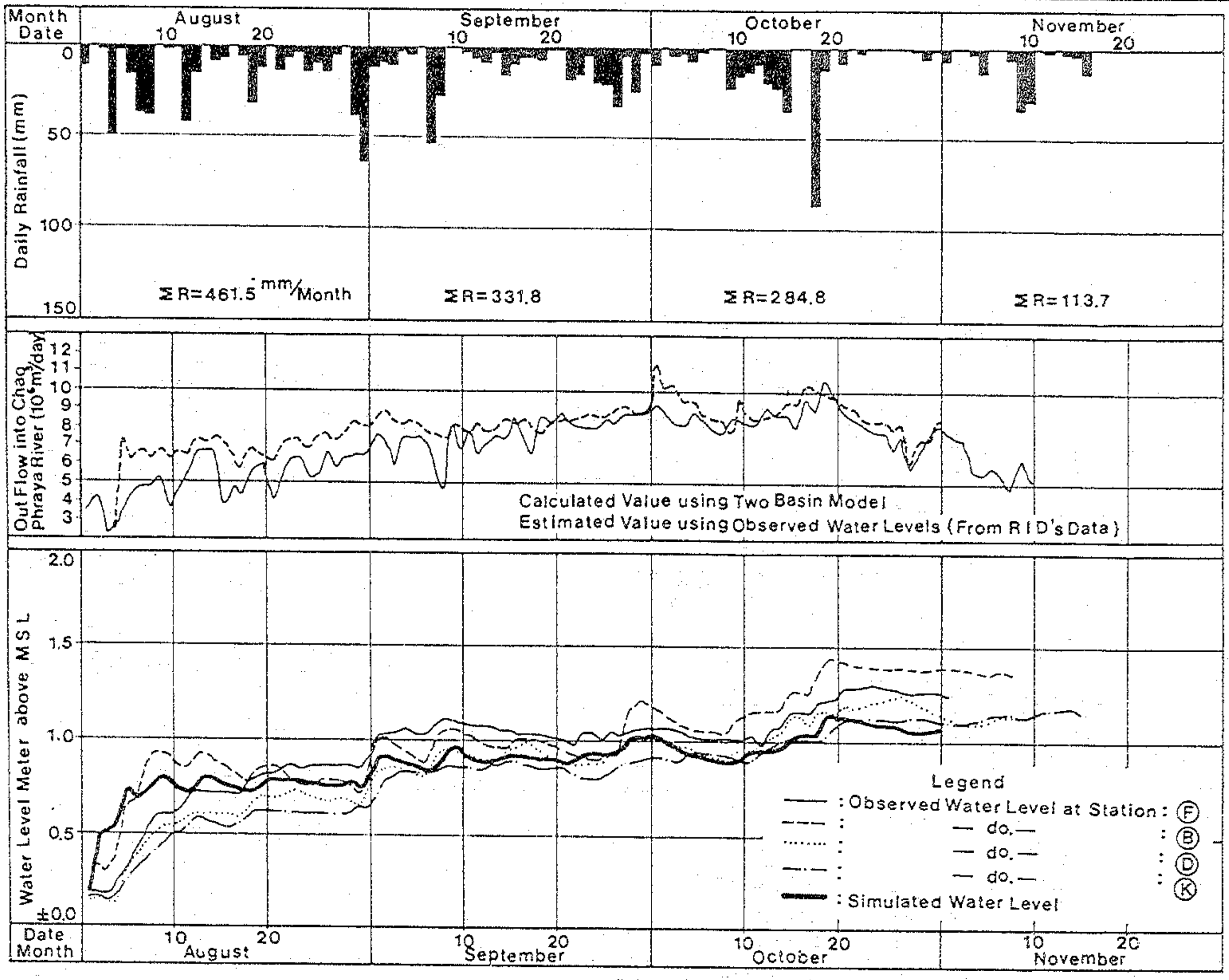


FIG. 12.7	Comparison of Observed and Calibrated Water Levels in Protection Area in 1983 using Two Basin Model - 2

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

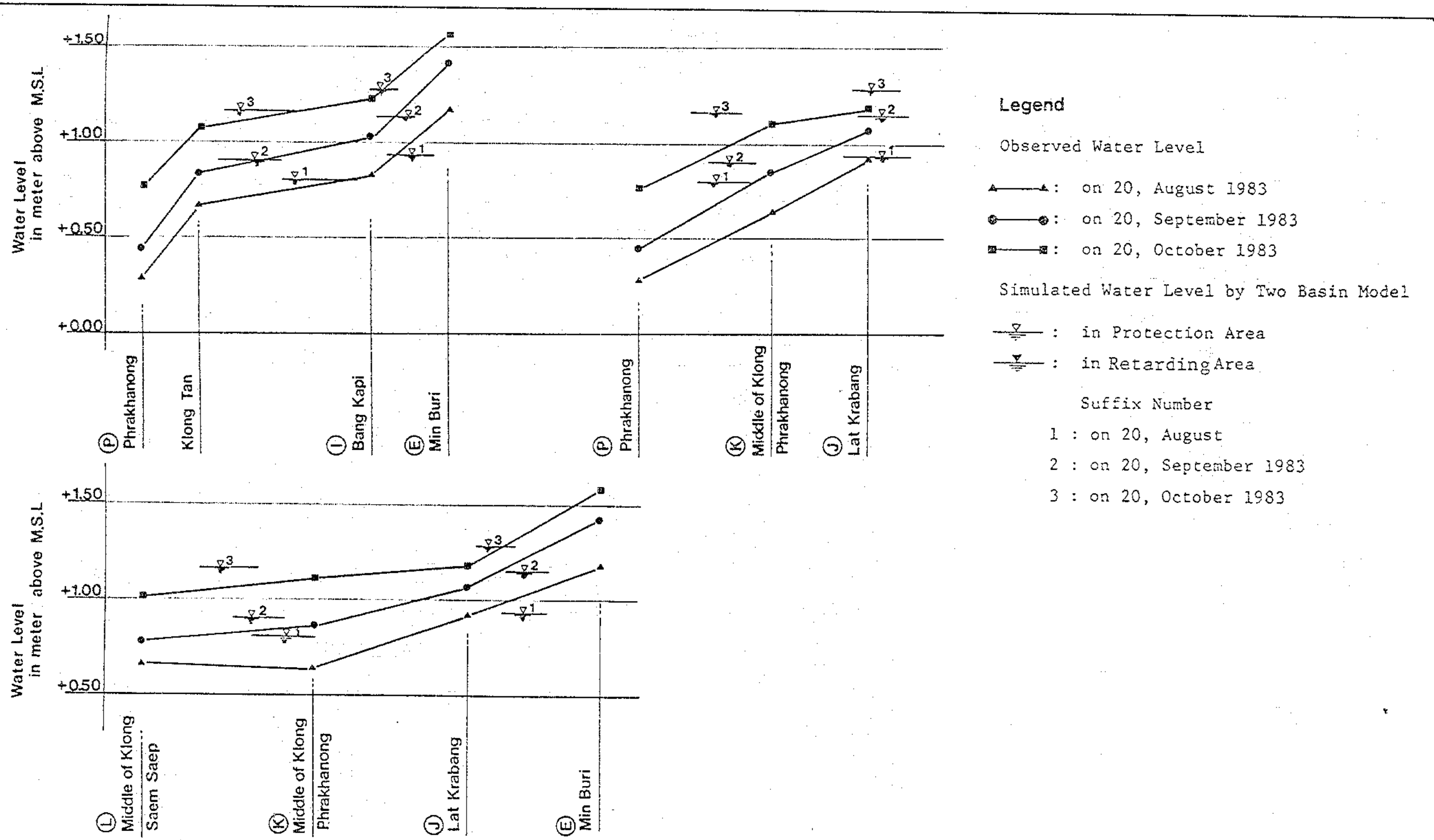
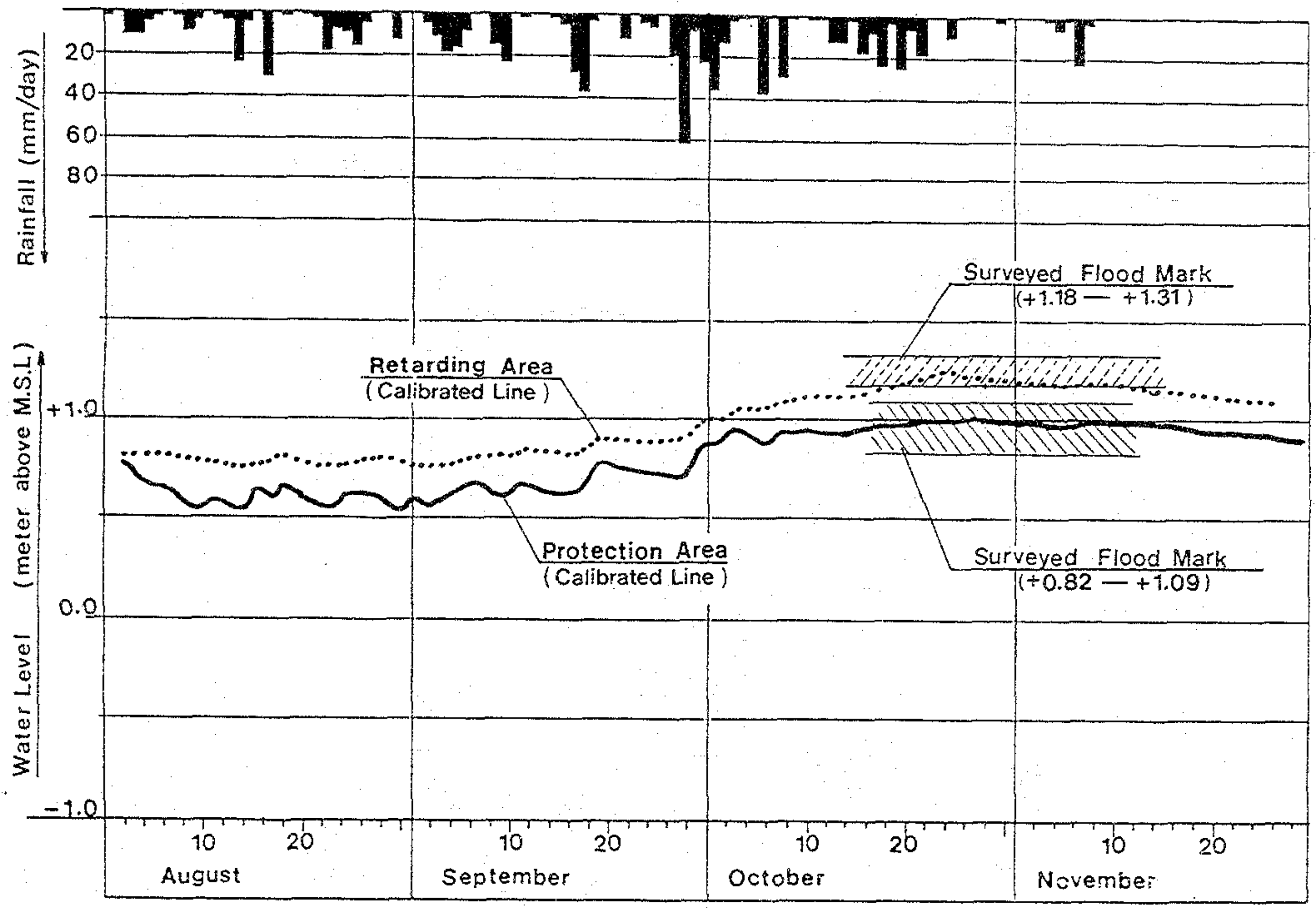


FIG. 12.8 Comparison of Observed Water Level and Calibrated Water Level in 1983 using Two Basin Model – 3

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Note ;

Surveyed Flood Marks in 1980 are shown on Fig. 3.5

FIG. 12.9	Comparison of Observed and Calibrated Flood Marks in 1980 using Two Basin Model

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

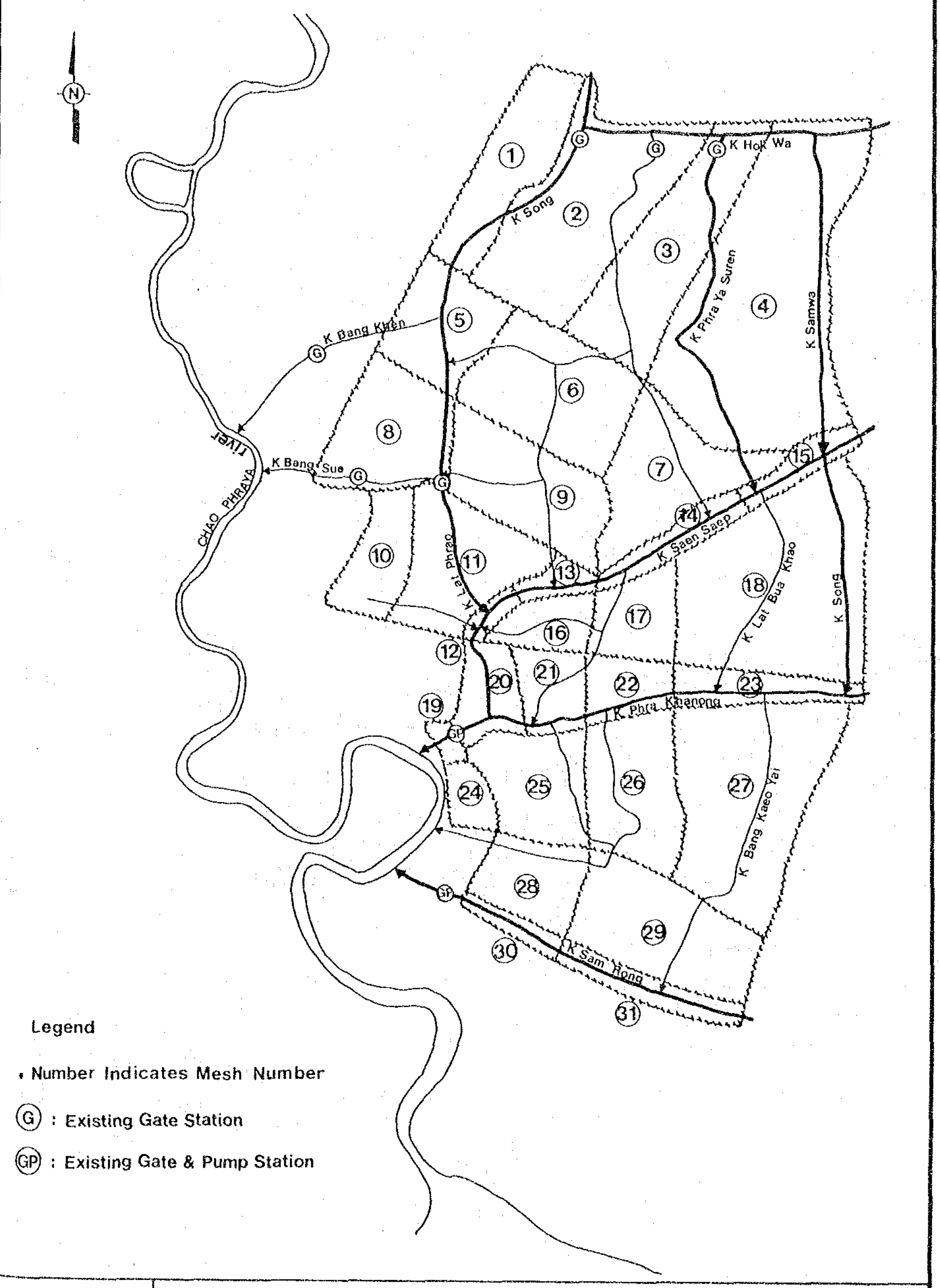
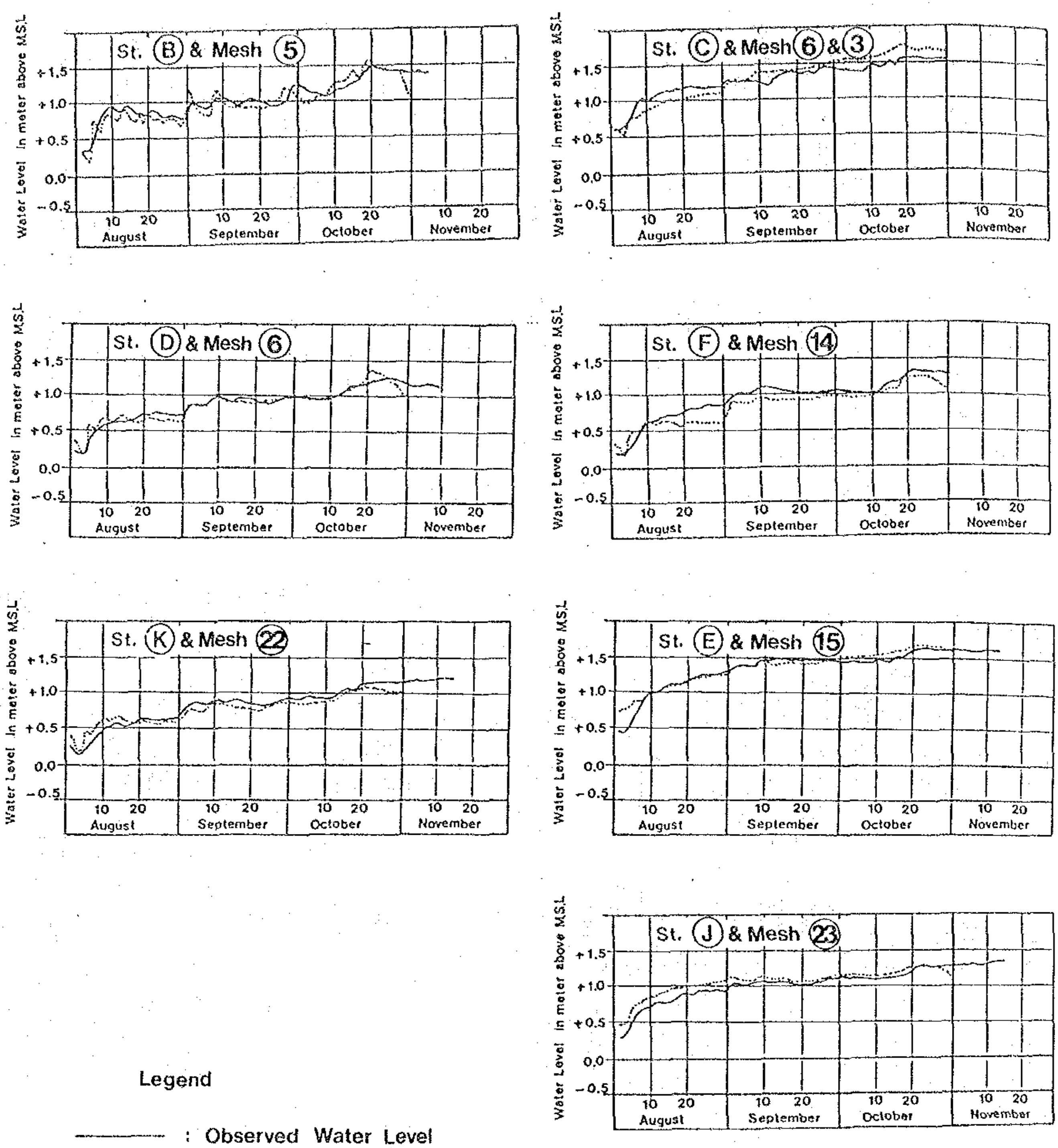


FIG. 12.10 Mesh Components for Bi-Dimensional Model

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Legend

——— : Observed Water Level

------- : Simulated Water Level

St(B) ~ St(5) : Stations of Water Level Gage installed in 1983 by the Study Team (Refer to Appendix Fig. F.4)

FIG. 12.11	Comparison of Observed and Calibrated Water Levels in 1983 using Bi-Dimensional Model

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

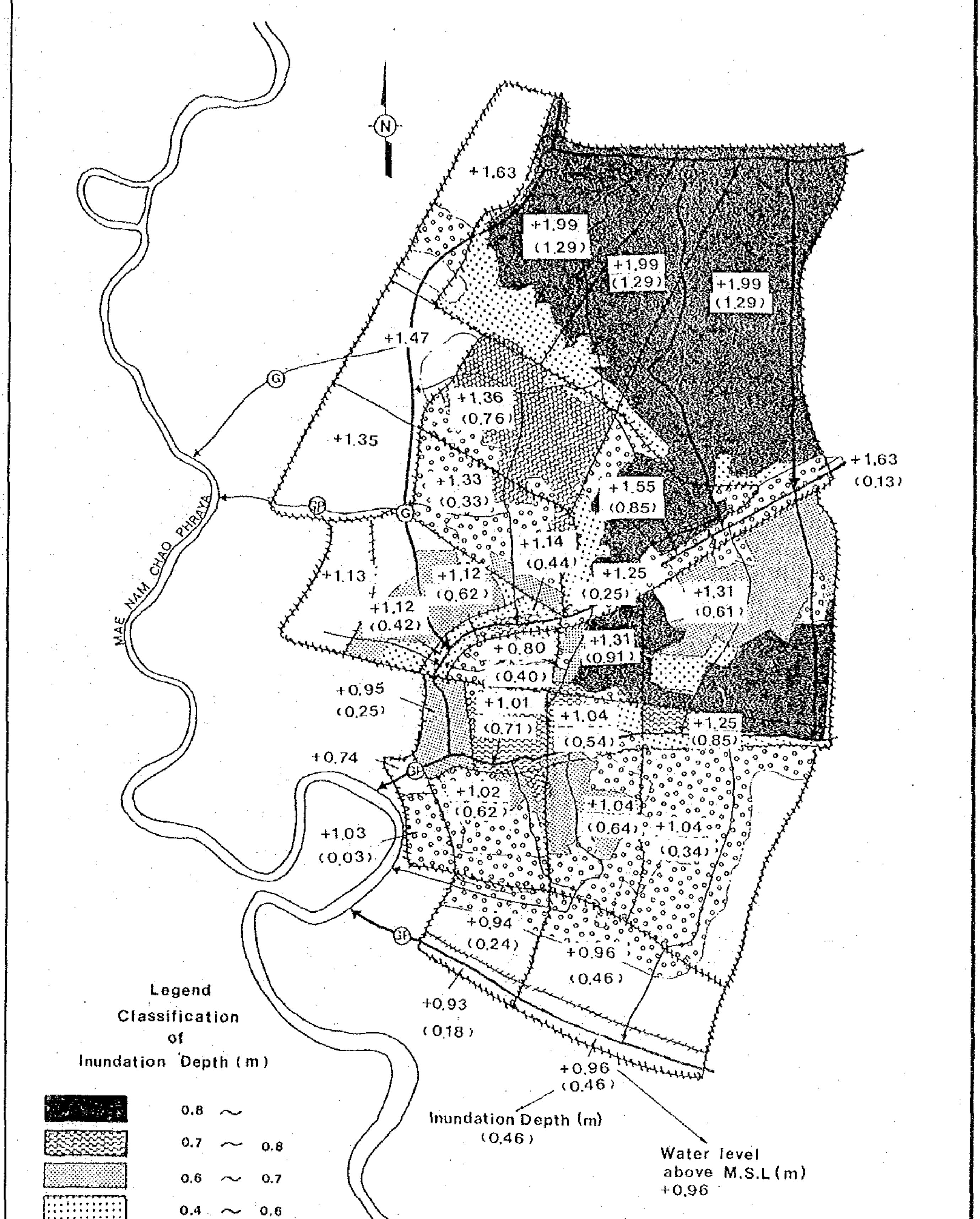
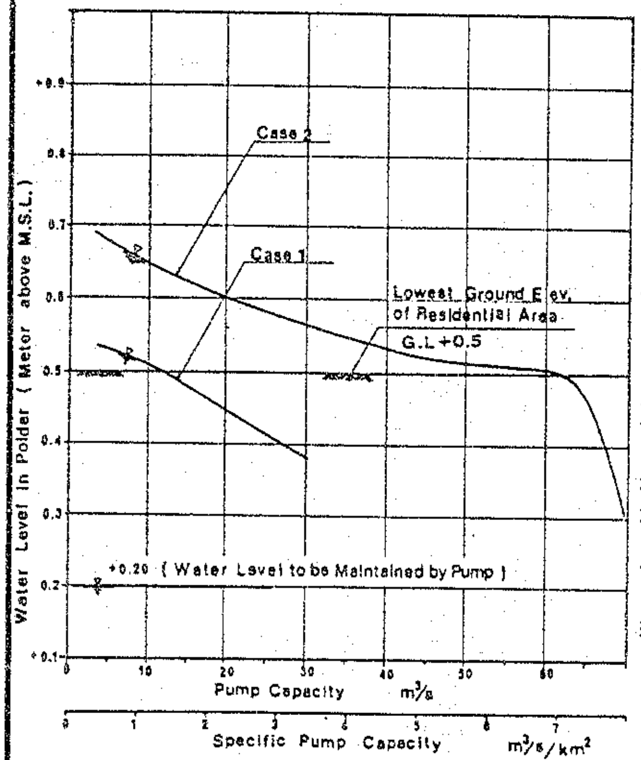
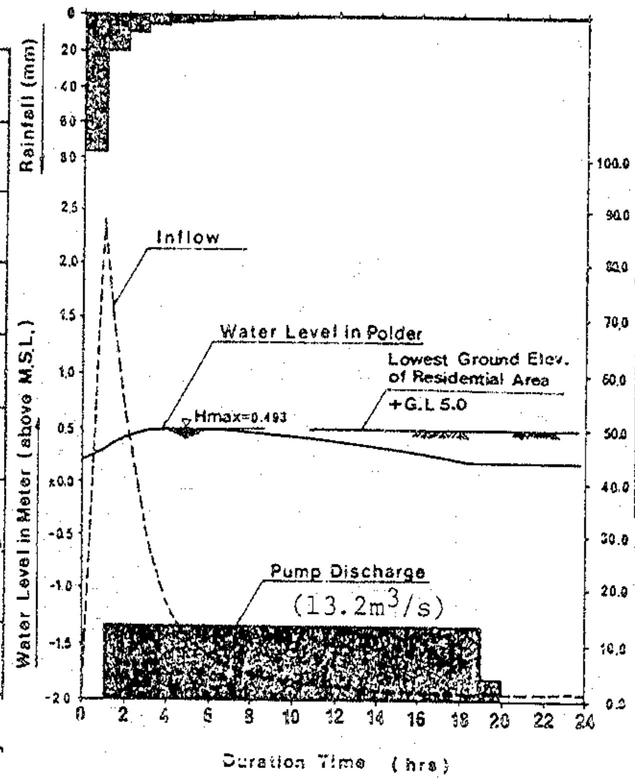


FIG. **12.12** **Calibrated Water Level and Inundation Depth in 1983 Flood using Bi-Dimensional Model**

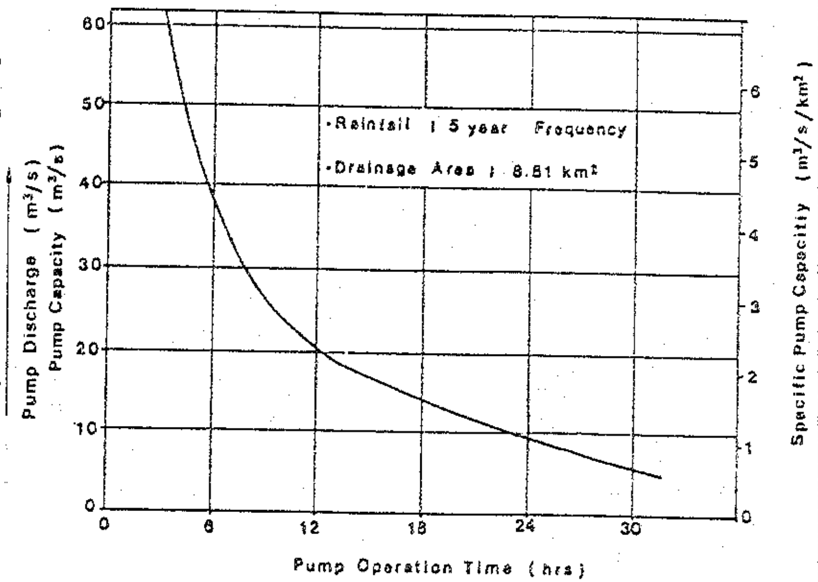
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



(1) Maximum Water Level - pump capacity



(2) Sample Calculation
(Case 1···Qp=13.2 m^3/s)



(3) Pump Operation Time - pump capacity.

Note

	Watershed Condition	Canal Condition
Case 1	Existing	Existing
Case 2	Urbanized	Improved Width : 9 meter Length : 9 km Height of shore : +0.5 m

◦ Total head of pump is not limitted

◦ Initial water level in polder is 0.2 meter above M.S.L..

FIG. 12.13 Sample Calculation in Polder Unit Using Hydrological Model (Ramkhamhaeng Site)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Chapter 13

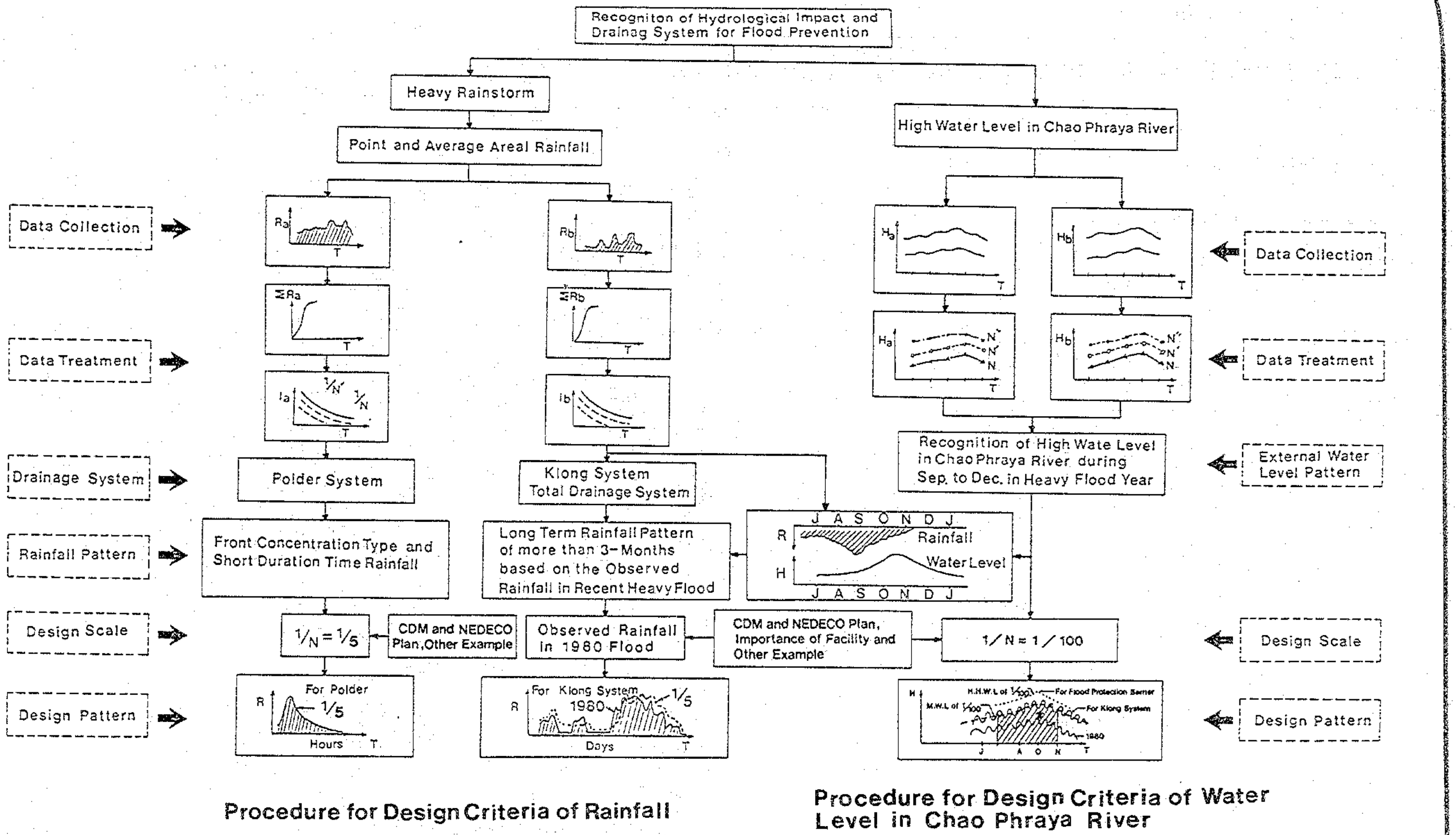
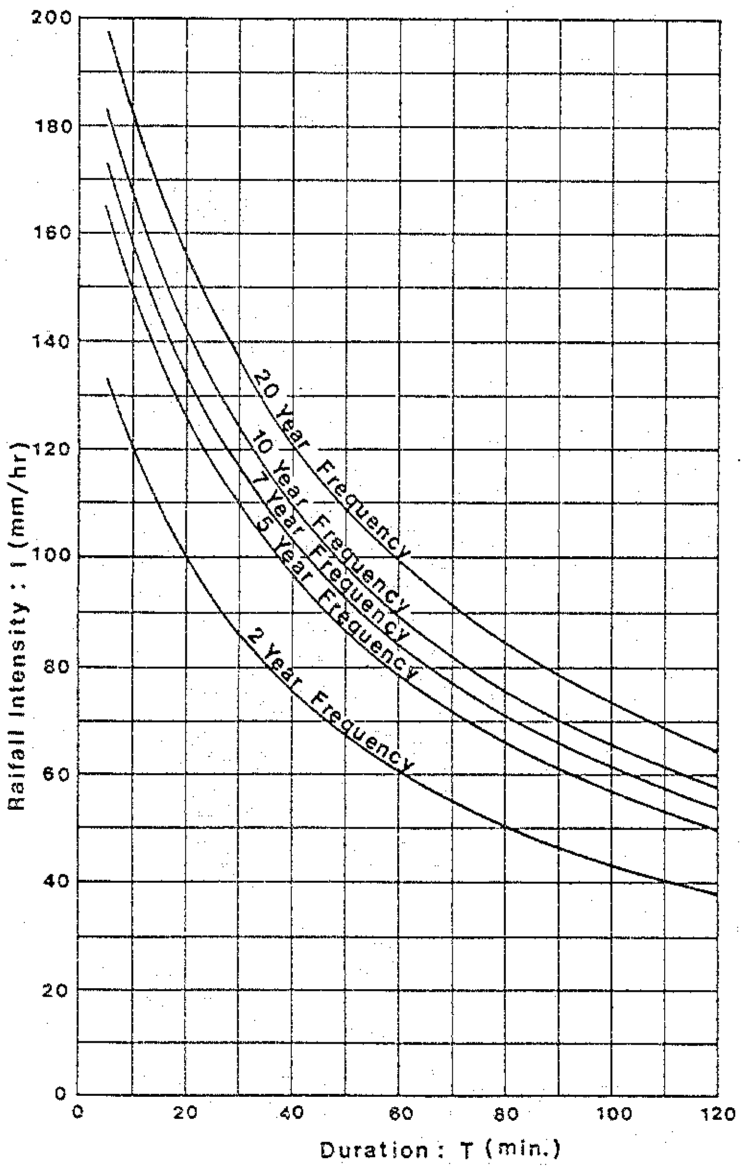
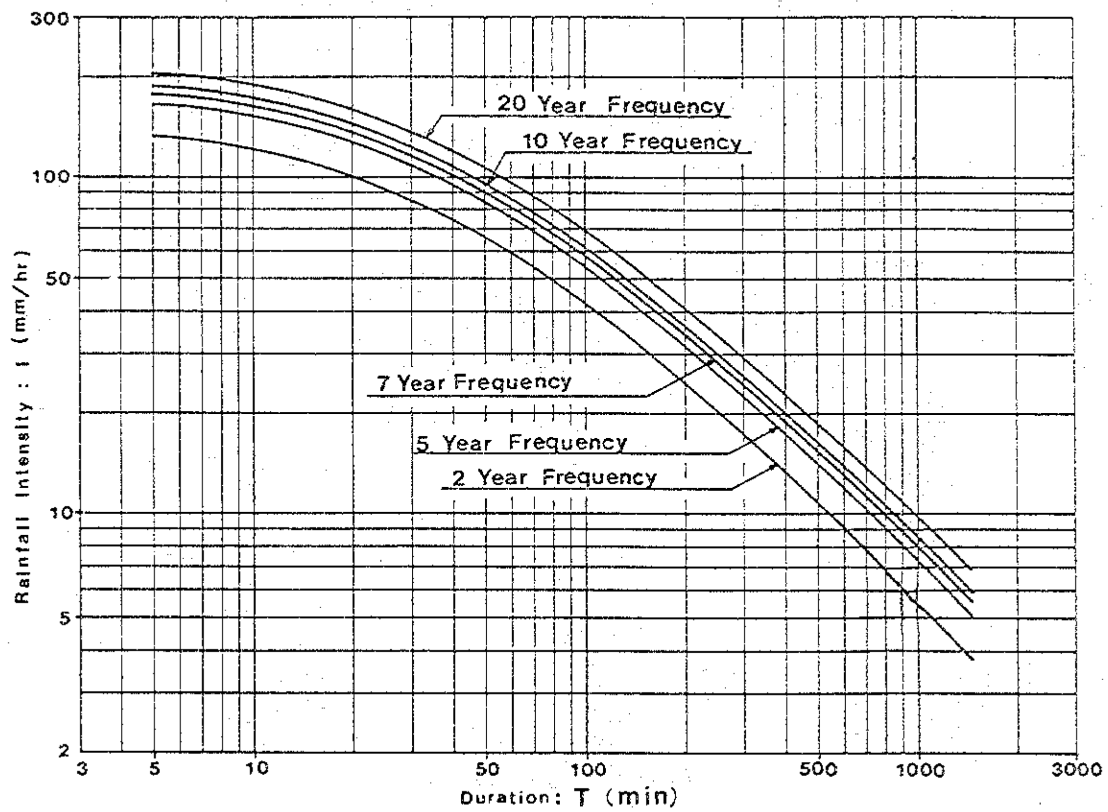


FIG. 13. 1 Procedure for the Decision of Hydrological Design Criteria

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Case A'



Case B'

Rainfall Intensity-Duration Formula

2 Year Probability : $i = \frac{5,690}{t + 37}$

5 " " : $i = \frac{7,600}{t + 40}$

7 " " : $i = \frac{8,230}{t + 41}$

10 " " : $i = \frac{8,850}{t + 42}$

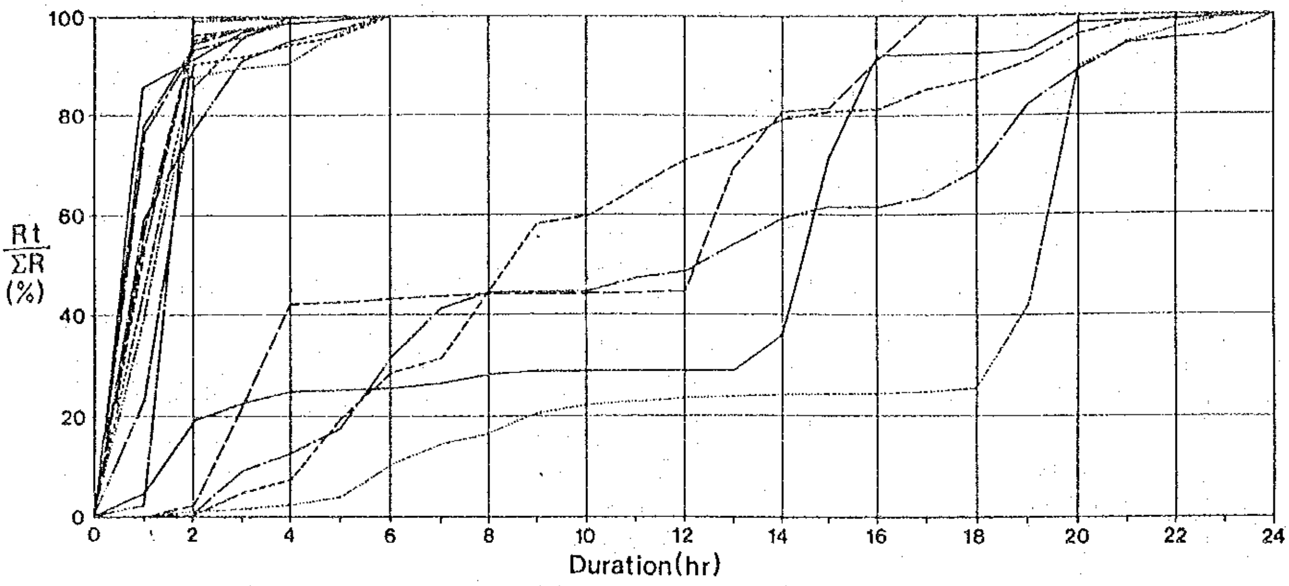
20 " " : $i = \frac{10,040}{t + 44}$

Note : 1. Case A' is used for the case when the time of concentra-tion is within 2 hours.

2. For case B', the time of concentration is between 2 hours and 24 hours

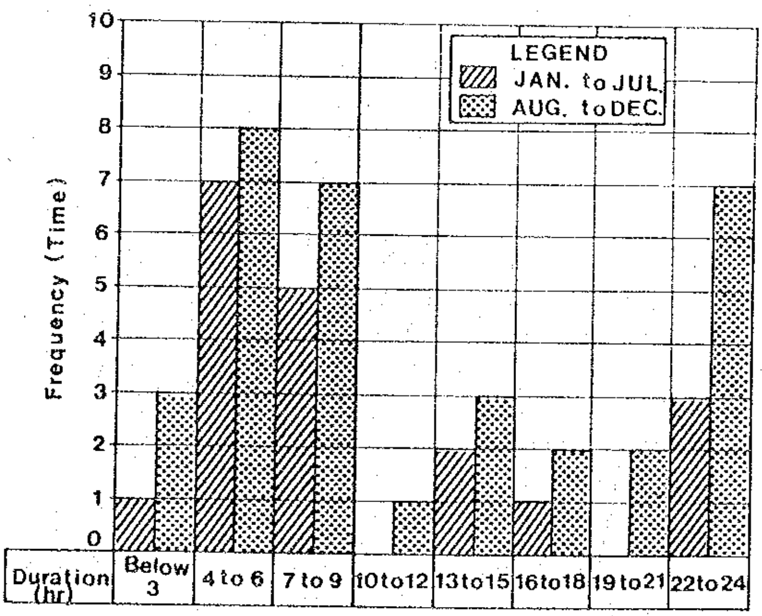
FIG. 13.2 Rainfall Intensity - Duration Curves and Formulas

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Time Distribution Diagram for Duration of Daily Rainfall above 90 mm/day

Note: Daily rainfall data (15 samples) above 90 mm/day were recorded at the Bangkok Station between 1951 and 1982.

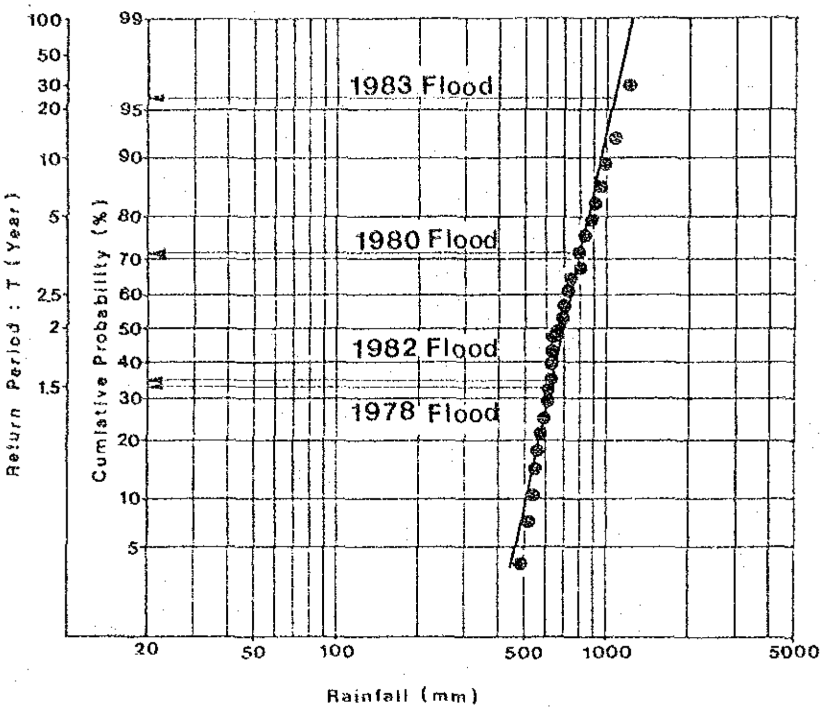


Frequency Diagram for Duration of Daily Rainfall above 60 mm/day

Note ; Daily rainfall data (52 samples) above 60 mm/day recorded at the Bangkok Station between 1951 and 1982 were used.

FIG.13.3	Time Distribution and Frequency of Daily Rainfall

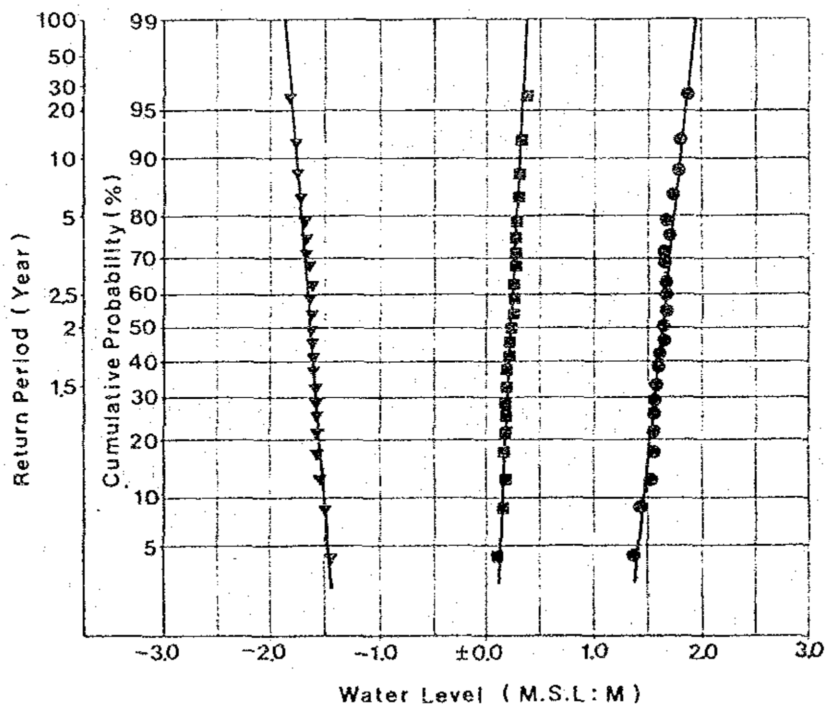
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Probable 3-Month Rainfall in the Study Area

Item	Return Period (Year)	Station: Average Study Area (mm)
3-Months Rainfall Probability	2 "	707.3
	5 "	872.4
	7 "	922.8
	10 "	973.4
	20 "	1065.7
	30 "	1117.1
	50 "	1179.9
	70 "	1263.0

Legend
⊕ ; Probable 3-Months Rainfall



Probable Water Level at Bangkok Port

Item	Return Period (Year)	Station: Bangkok Port (mm)
Highest High Water Level (H.H.W.L.)	2	1.61
	5	1.72
	10	1.77
	20	1.82
	30	1.85
	50	1.88
	100	1.92
Mean Water Level (M.W.L.)	2	0.22
	5	0.27
	10	0.30
	20	0.32
	30	0.34
	50	0.35
	100	0.37
Lowest Low Water Level (L.L.W.L.)	2	-1.64
	5	-1.73
	10	-1.77
	20	-1.81
	30	-1.83
	50	-1.85
	100	-1.88

Unit : Meter above MSL

Legend
● : Highest High Water Level
■ : Mean Water Level
▼ : Lowest Low Water Level

FIG. 13.4 **Probable 3-Month Rainfall in the Study Area and Probable Water Level at Bangkok Port**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

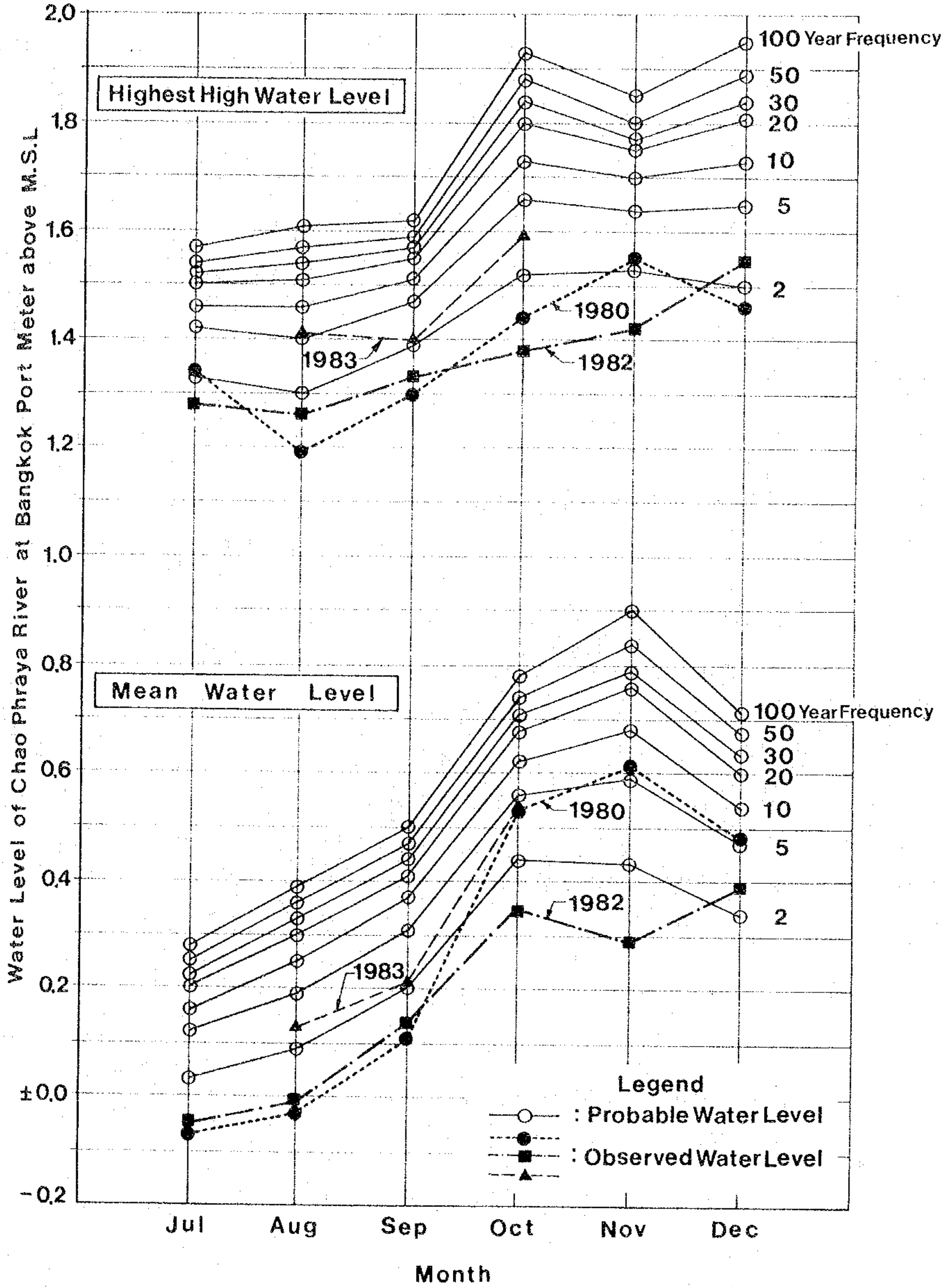
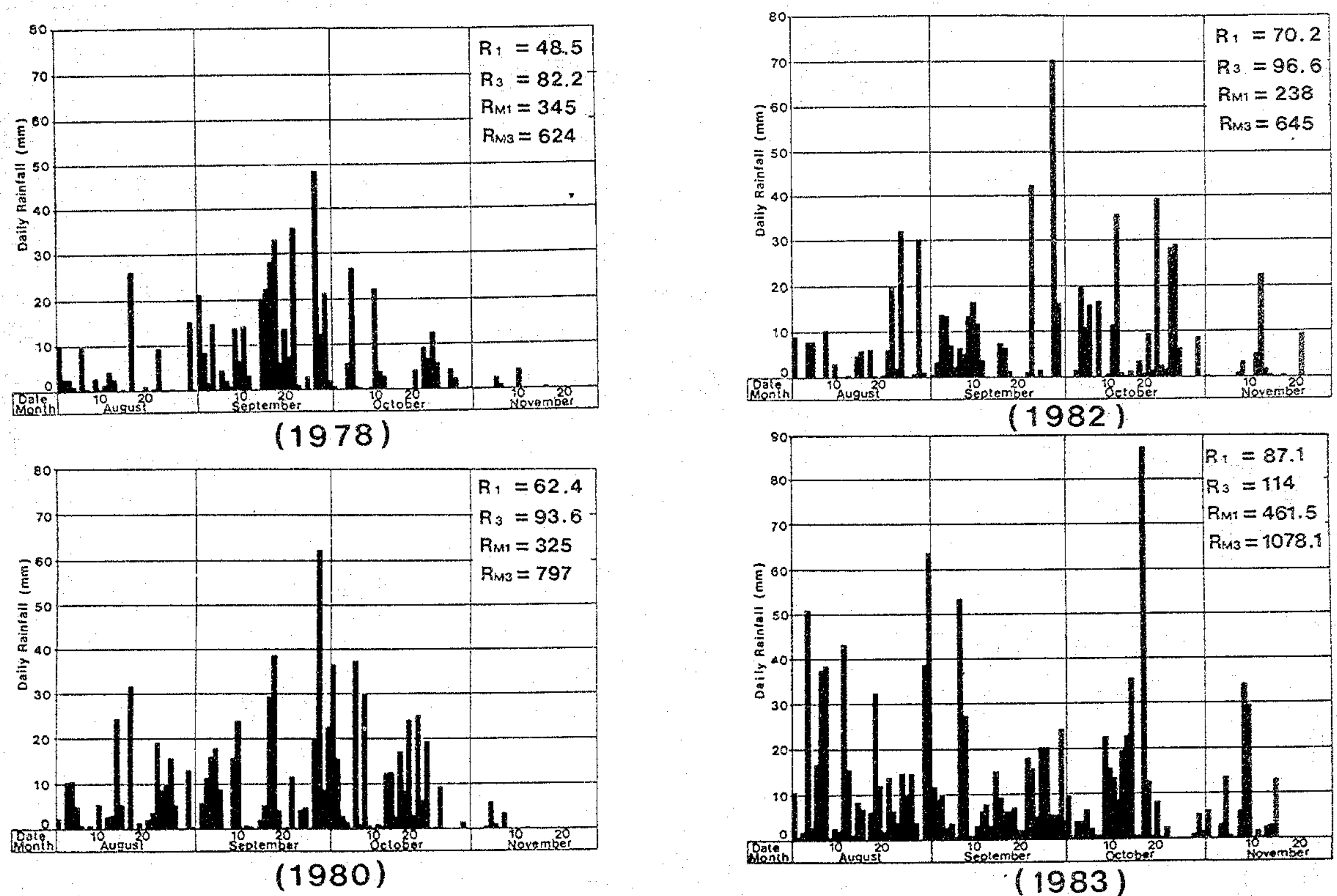


FIG. 13.5 Probable Monthly Water Level and Observed Water Level at Bangkok Port for 1980, 1982 and 1983

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Legend

R_1 : Maximum Daily Rainfall (mm)

R_3 : Maximum 3-Day Rainfall (mm)

Rm_1 : Maximum Monthly Rainfall (mm)

Rm_3 : Maximum 3-Month Rainfall (mm)

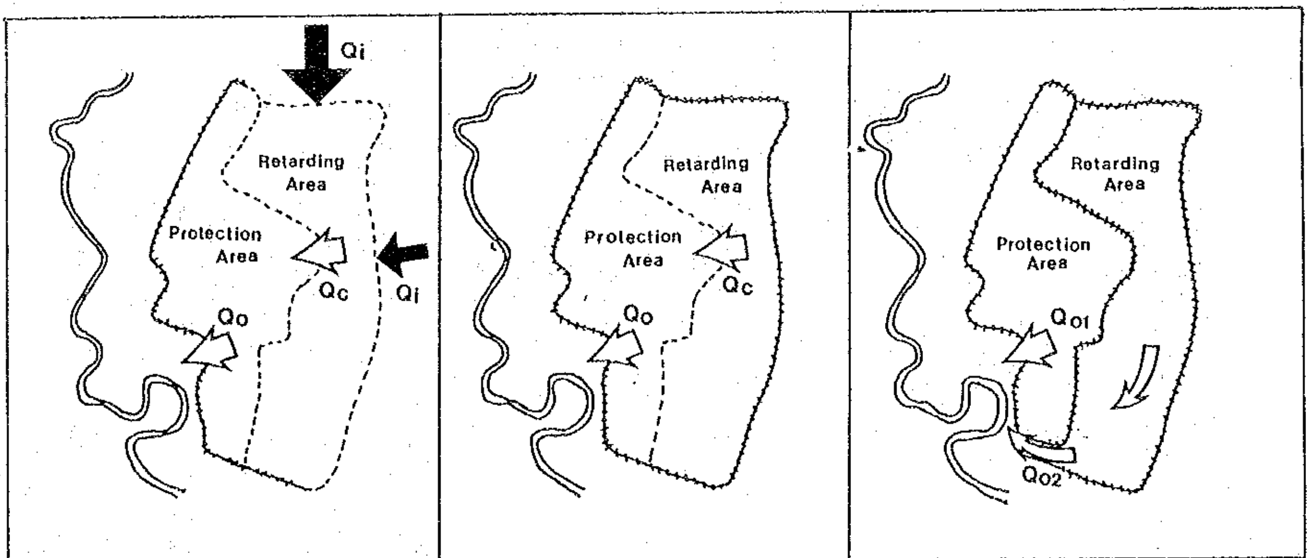
FIG. 13.6	Average Areal Daily Rainfall in the Study Area for the Recent Flood Years,1978,1980, 1982 and 1983
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK	

Chapter 14

o Evaluation Cases using Two Basin Model

Case / Mark	Cases: Rainfall in 1980	Cases: Rainfall in 1983	F: Qi 1st Barrier (Green Belt)	F: Qc 2nd Barrier	Fo: Protection Area Gate	Fo: Protection Area Pump		Fo: Retarding Area Gate	Fo: Retarding Area Pump		Ls: Topography
0	Two B (101)	Two B (001)	No Barrier	No Barrier	ΣW = 30	Qp = 16.0		-	-		Existing
1	" (102)	" (002)	Considered	No Barrier	ΣW = 30	Qp = 16.0		-	-		Existing
2	" (103-11)	" (003-11)	Considered	Considered	ΣW = 24	Qp = 14.5		ΣW = 6	Qp = 1.5		Existing
3	" (103-14)	" (003-14)	Considered	Considered	ΣW = 24	Qp = 50.0		ΣW = 6	Qp = 20.0		Existing
4	" (103-16)	" (003-16)	Considered	Considered	ΣW = 24	Qp = 200.0		ΣW = 6	Qp = 100.0		Existing
0	Two B (102F-01)	Two B (002F-01)	No Barrier	No Barrier	ΣW = 30	Qp = 16.0		-	-		Future (AD 2000)
1	" (102F-02)	" (002F-02)	Considered	No Barrier	ΣW = 30	Qp = 16.0		-	-		"
2	" (102F-11)	" (002F-11)	Considered	No Barrier	ΣW = 24	Qp = 14.5		ΣW = 6	Qp = 1.5		"
3	" (102F-14)	" (002F-14)	Considered	Considered	ΣW = 30	Qp = 50.0		ΣW = 12	Qp = 20.0		"
4	" (102F-16)	" (002F-16)	Considered	Considered	ΣW = 30	Qp = 200.0		ΣW = 12	Qp = 100.0		"

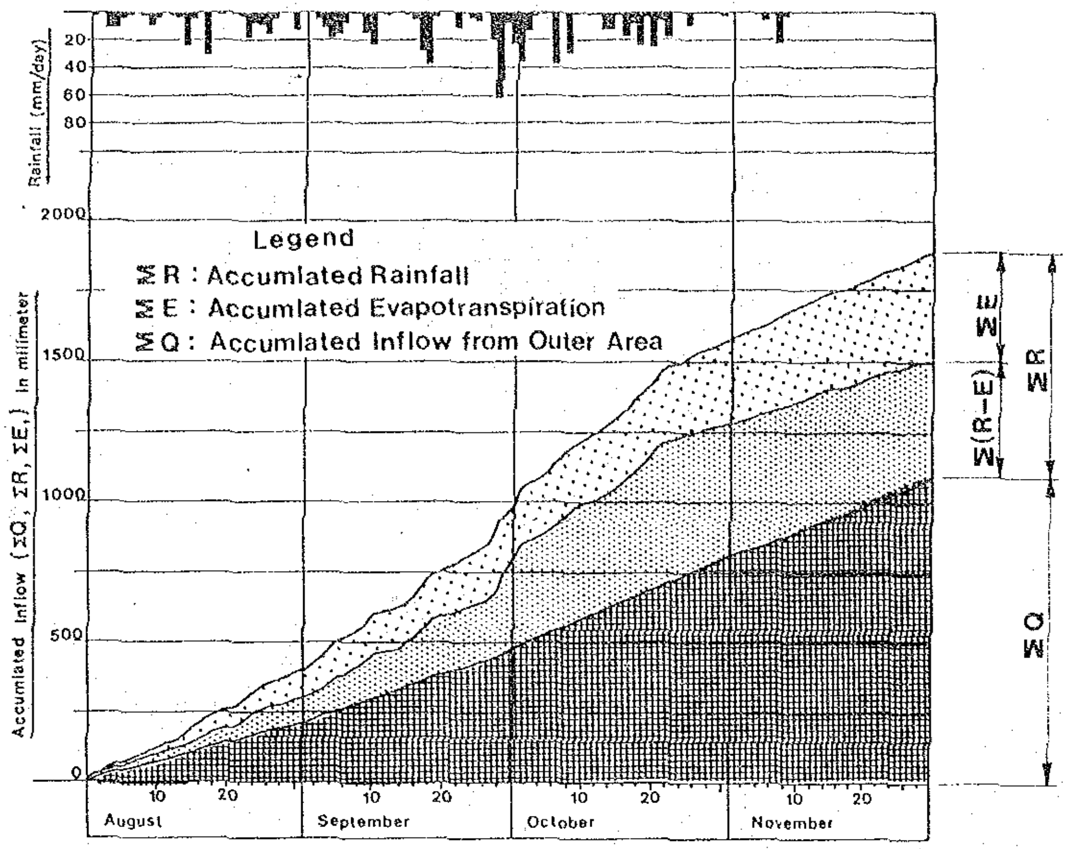
o Schematic Calculation Types using Water Balance Model



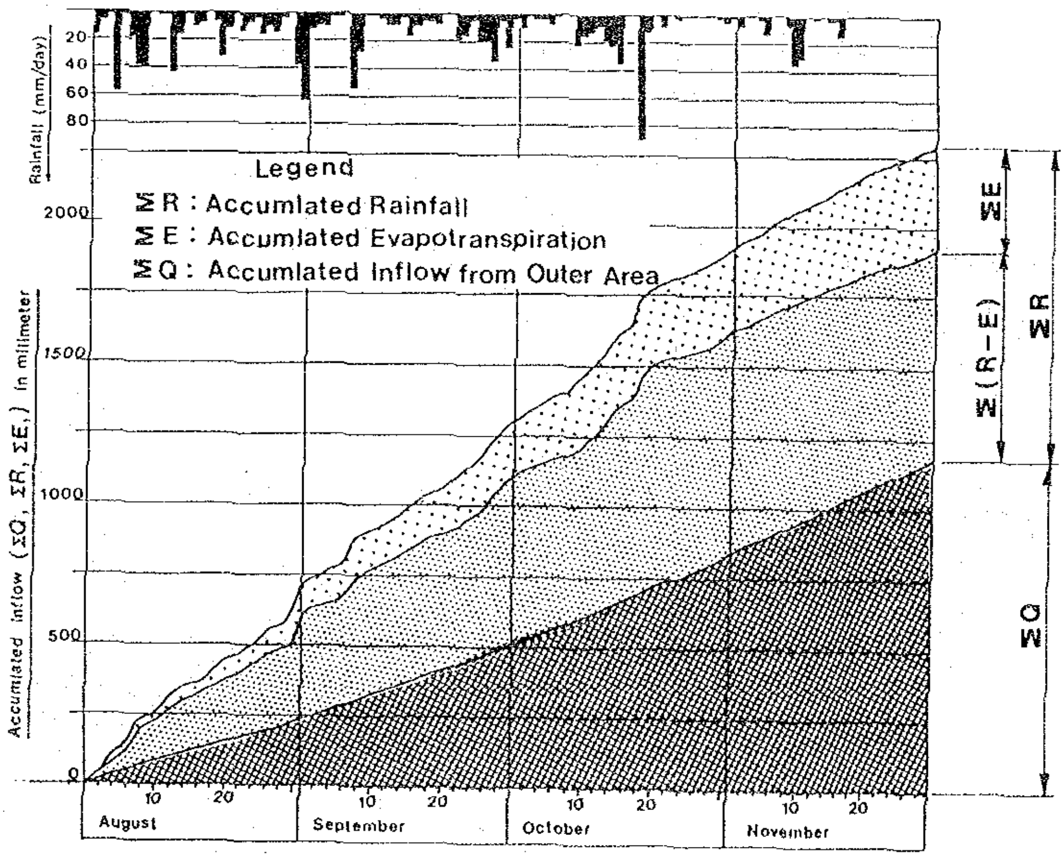
Calculation Type	A	B	C		
Calculation Cases	101 102F01	102 102F02	103-11, 102F-11,	103-14, 102F-14,	103-16, 102F-16,
	001 002F01	002 002F02	003-11, 002F11,	003-14, 002F14,	003-16, 002F16,

FIG. 14.1 Evaluation Cases for Impact of Barriers using Two Basin Model

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



– 1980 –

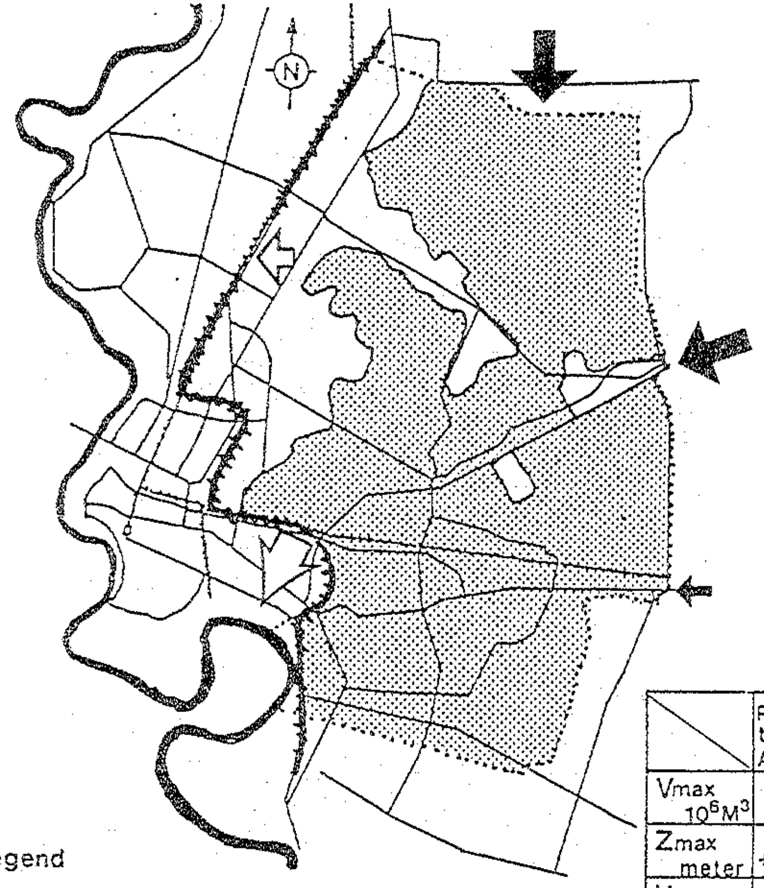


– 1983 –

FIG. 14.2	Rate of Compsition of Accumlated Inflow in Study Area

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Topographical Condition; Existing −1983−



Legend

: Inflow from Outer Area

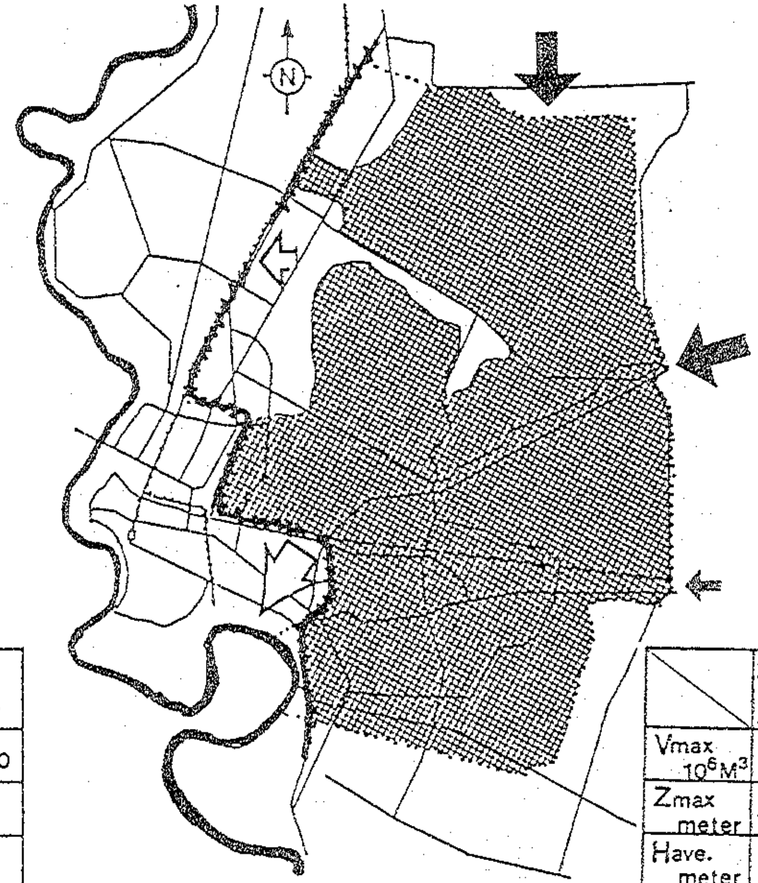
: Outflow from Study Area

: Inundated Area

	Protection Area	Retarding Area	Total
Vmax 10^6M^3	56	184	240
Zmax meter	+1.02	+1.21	
Have. meter	0.52	0.51	

Case	1st.Barrier Green Belt	2nd.Barrier	Drainage Facilities
101	X	X	$Gw=30^m$ $Qp=16m^3/s$

Topographical Condition; Future −2000−



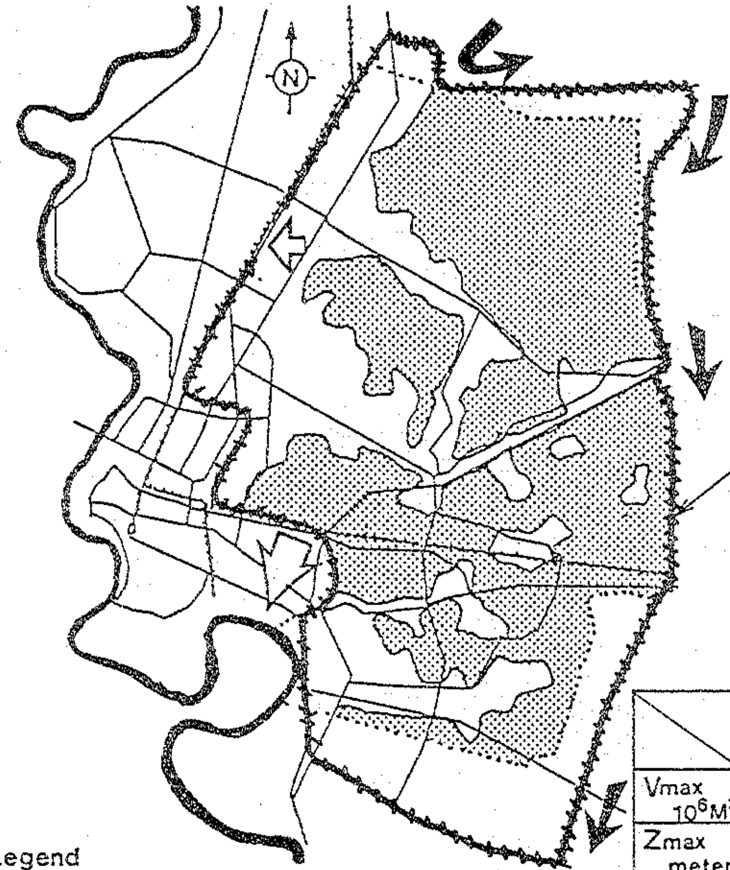
	Protection Area	Retarding Area	Total
Vmax 10^6M^3	183	300	483
Zmax meter	+0.76	+0.90	
Have. meter	1.26	0.90	

Case	1st.Barrier Green Belt	2nd.Barrier	Drainage Facilities
102F−01	X	X	$Gw=30^m$ $Qp=16m^3/$

FIG.14.3 Inundated Condition without Green Belt (1st Barrier) (Rainfall in 1980)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

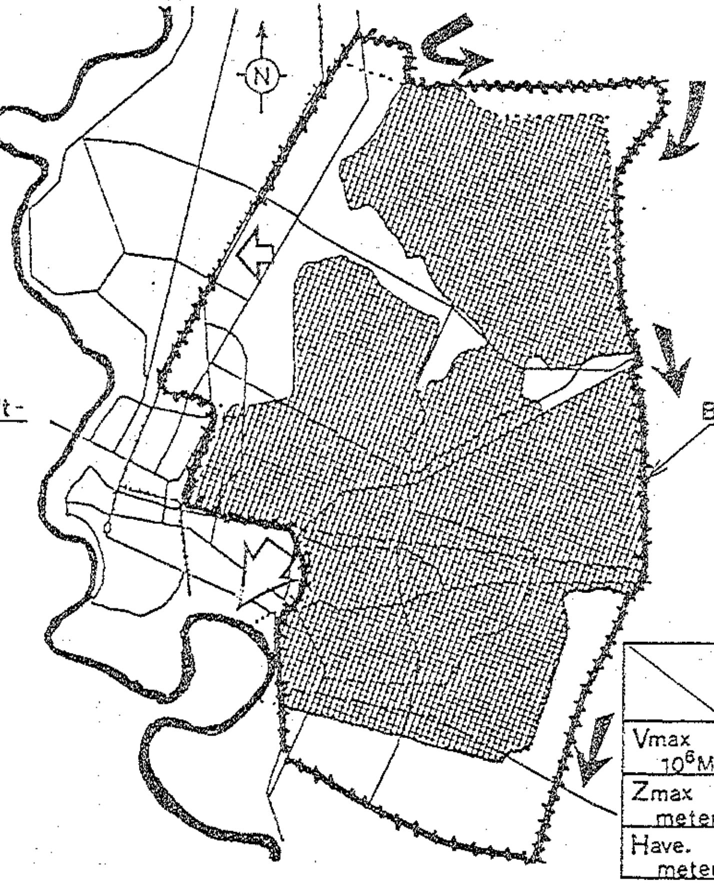
Topographical Condition; Existing -1983-



	Protection Area	Retarding Area	Total
Vmax $10^6 M^3$	22	37	59
Zmax meter	+0.74	+0.76	
Have. meter	0.24	0.06	

Case	1st. Barrier Green Belt	2nd. Barrier	Drainage Facilities
102	O	X	$G_W=30^m$ $Q_P=16$

Topographical Condition; Future -2000-



	Protection Area	Retarding Area	Total
Vmax $10^6 M^3$	91	104	195
Zmax meter	+0.27	+0.28	
Have. meter	0.77	0.28	

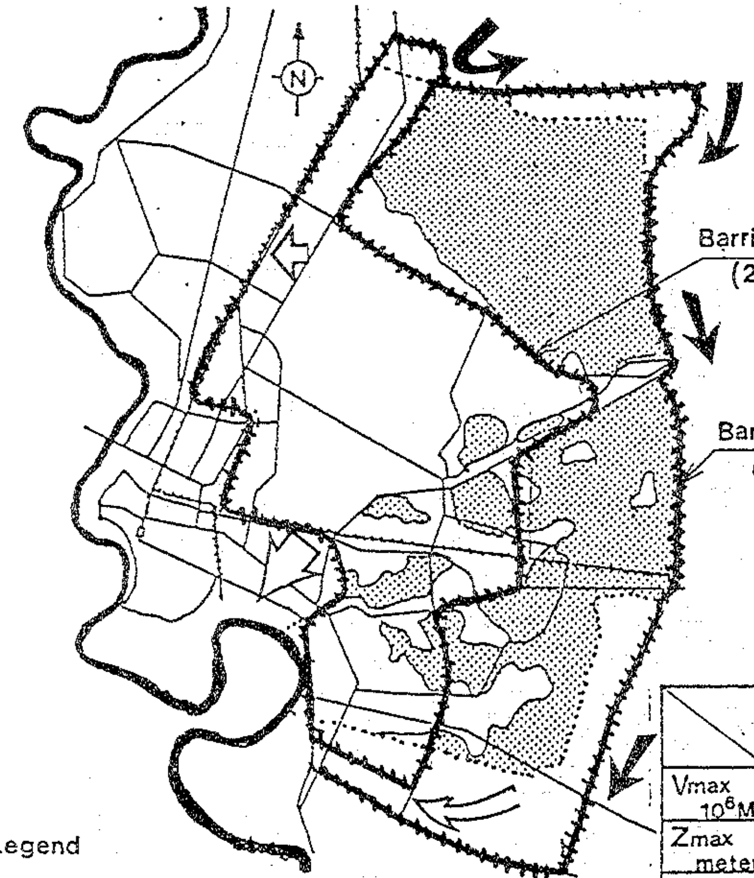
Case	1st. Barrier Green Belt	2nd. Barrier	Drainage Facilities
102F-02	O	X	$G_W=30^m$ $Q_P=16 m^3/s$

Legend
- : Inflow from Outer Area
- : Outflow from Study Area
- : Inundated Area

FIG. 14.4 Inundated Condition with Green Belt (1st Barrier) (Rainfall in 1980)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

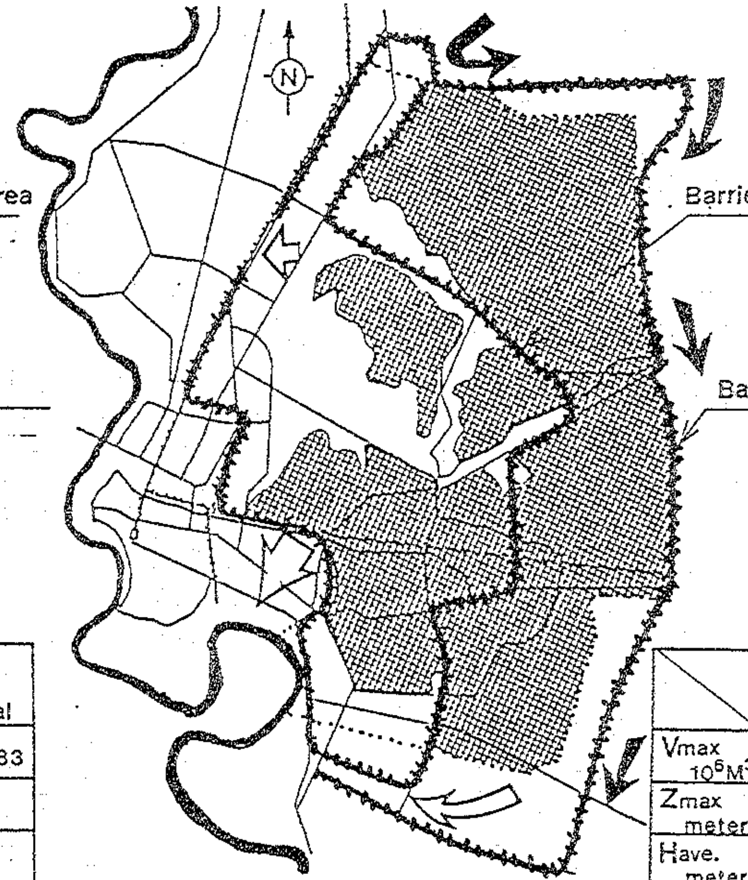
Topographical Condition; Existing -1983-



	Protec-tion Area	Retar-ding Area	Total
Vmax 10^6M^3	8	75	83
Zmax meter	+0.49	+0.89	
Have. meter	-0.01	0.19	

Case	1st.Barrier Green Belt	2nd.Barrier	Drainage Facilities
103-11	o	o	Gw=24^m Qp=14.5m^3/s
			Gw=6^m Qp=1.5m^3/s

Topographical Condition; Future -2000-



	Protec-tion Area	Retar-ding Area	Total
Vmax 10^6M^3	44	131	175
Zmax meter	-0.06	+0.35	
Have. meter	0.44	0.35	

Case	1st.Barrier Green Belt	2nd.Barrier	Drainage Facilities
102F-11	o	o	Gw=24^m Qp=14.5m^3/s
			Gw=6^m Qp=1.5m^3/s

Legend

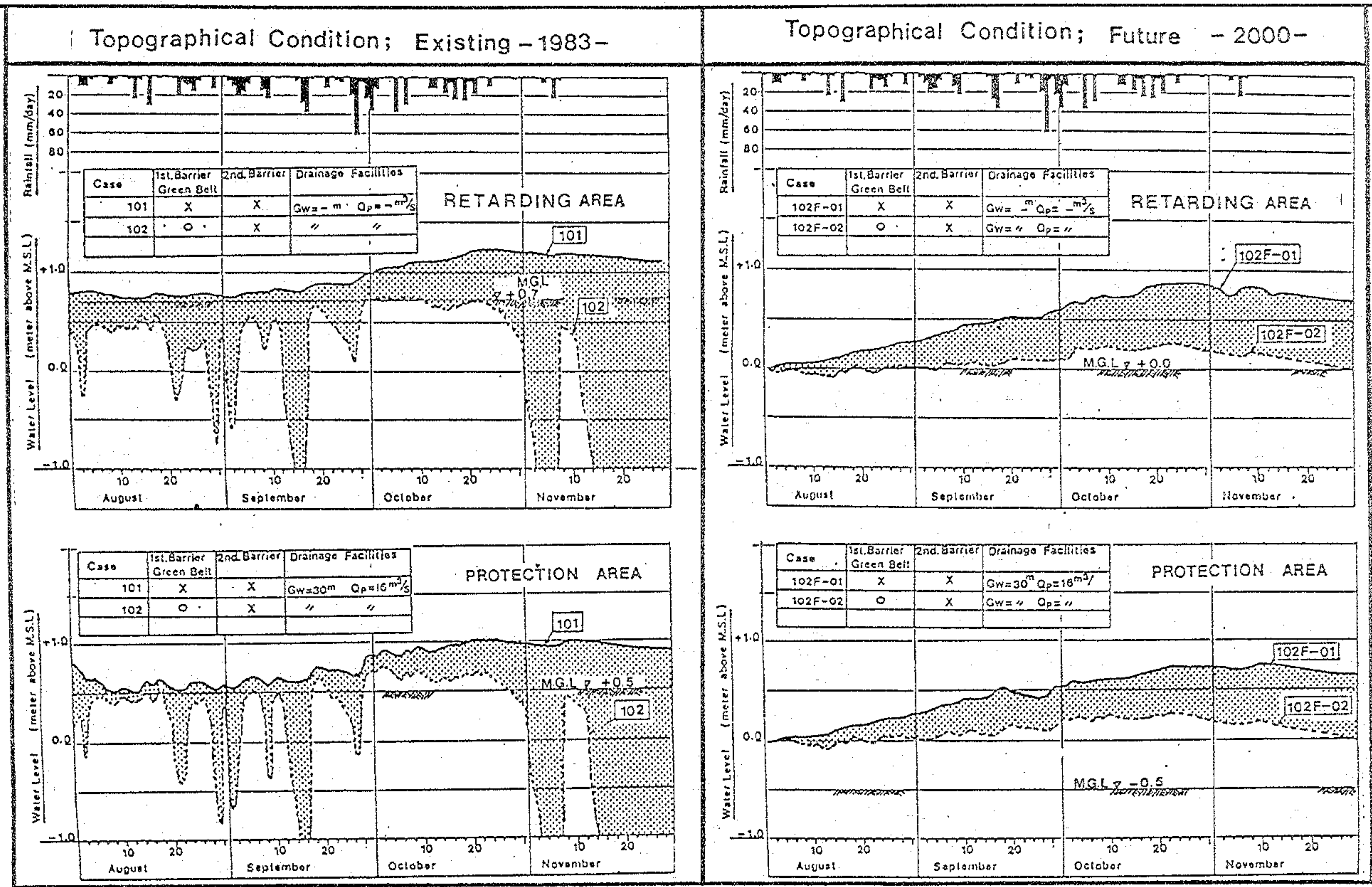
: Inflow from Outer Area

: Outflow from Study Area

: Inundated Area

FIG. 14.5 Inundated Condition with Barrier of Protection Area (2nd Barrier) (Rainfall in 1980)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



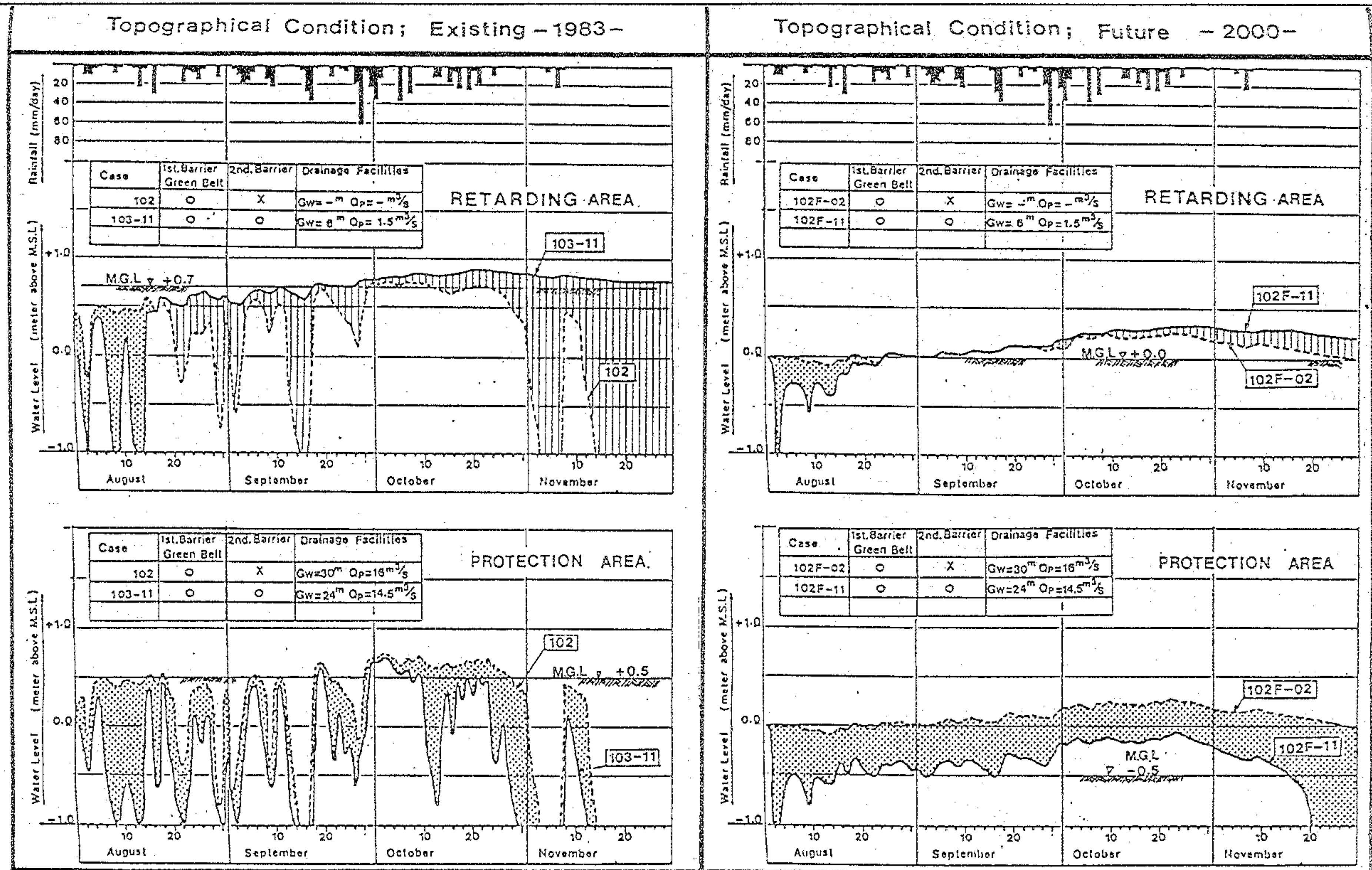
Legend

▒ : Decreased Difference of Simulated Water Level

MGL : Mean Ground Elevation above M.S.L

FIG. 14.6 Flood Water Levels with & without 1st Barrier (Green Belt) (Rainfall in 1980)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Legend

: Decreased Difference of Simulated Water Level

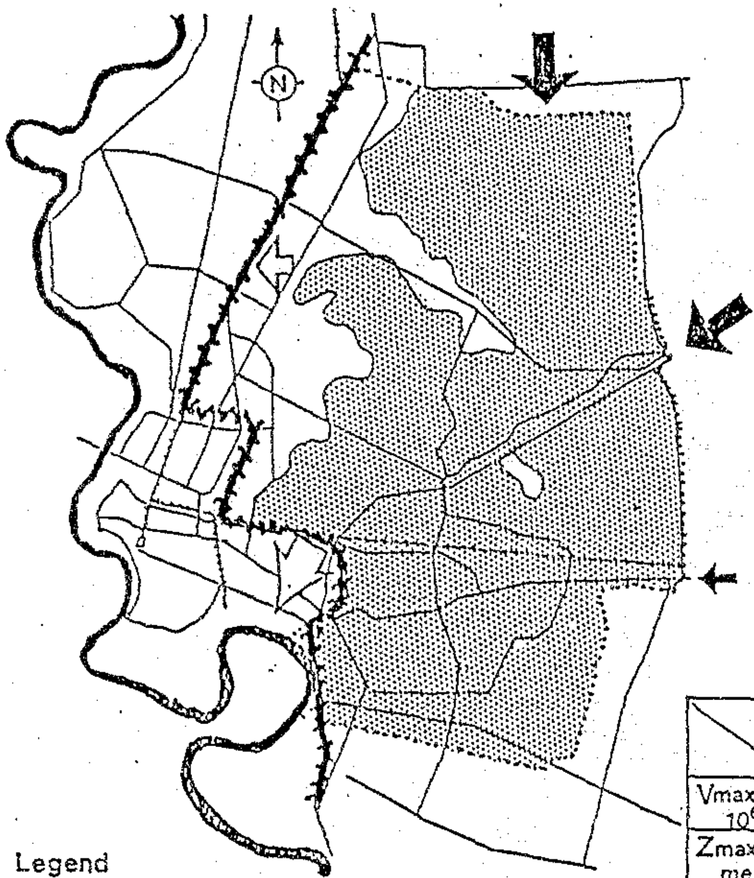
: Increased Difference of Simulated WAter Level

MGL : Mean Ground Elevation above M.S.L

FIG. 14.7 Flood Water Levels with & without 2nd Barrier (Rainfall in 1980)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

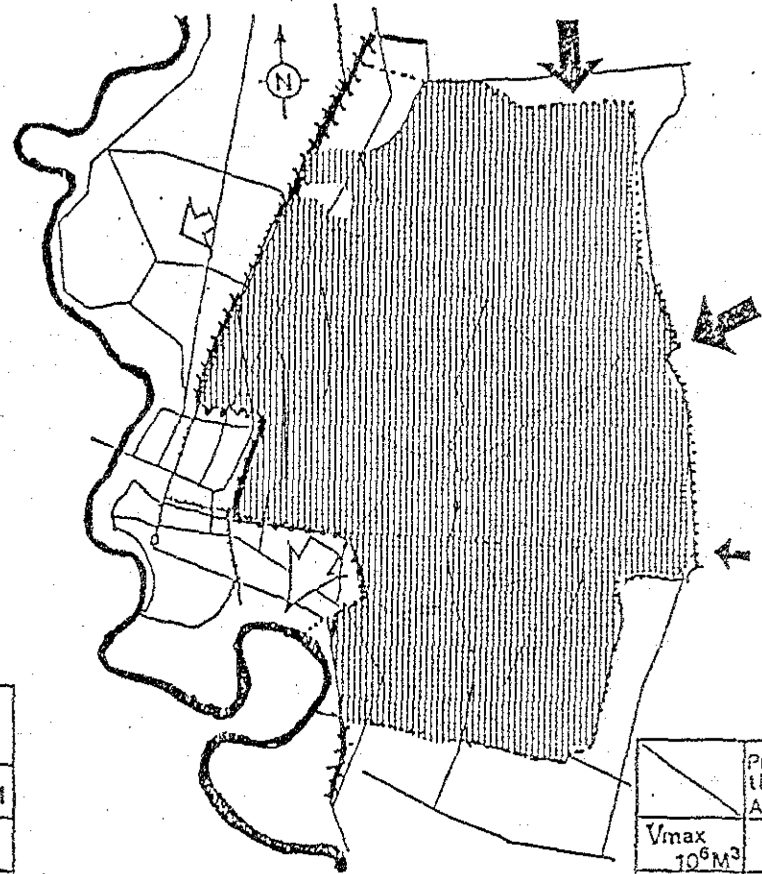
Topographical Condition; Existing -1983-



	Protection Area	Retarding Area	Total
Vmax $10^6 M^3$	73	248	321
Zmax meter	+1.17	+1.37	
Have. meter	0.67	0.67	

Case	1st. Barrier Green Belt	2nd. Barrier	Drainage Facilities
001	X	X	Gw=30m Qp=16 m^3/s

Topographical Condition; Future -2000-



	Protection Area	Retarding Area	Total
Vmax $10^6 M^3$	224	362	586
Zmax meter	+0.93	+1.06	
Have. meter	1.43	1.06	

Case	1st. Barrier Green Belt	2nd. Barrier	Drainage Facilities
002F-01	X	X	Gw=30m Qp=16 $m^3/$

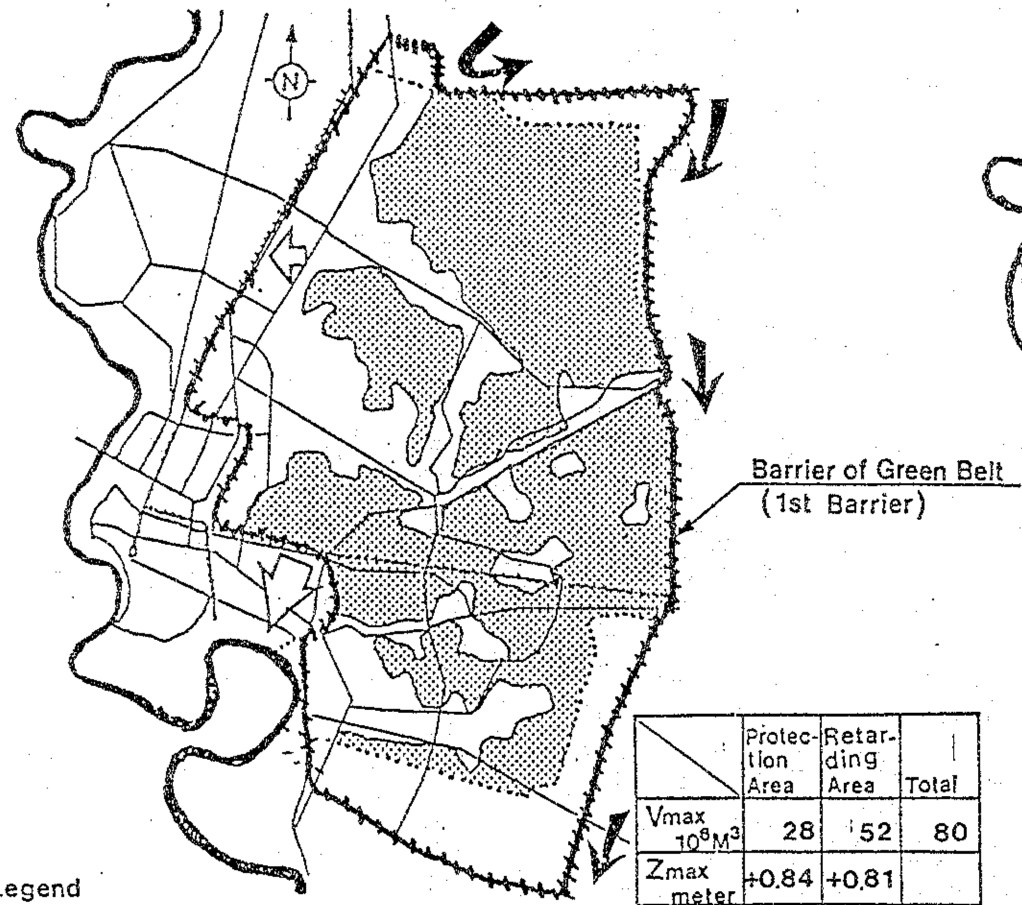
Legend

- ; Inflow from Outer Area
- ; Outflow from Study Area
- ; Inundate Area

FIG. 14.8 Inundated Condition without Green Belt (1st Barrier) (Rainfall in 1983)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

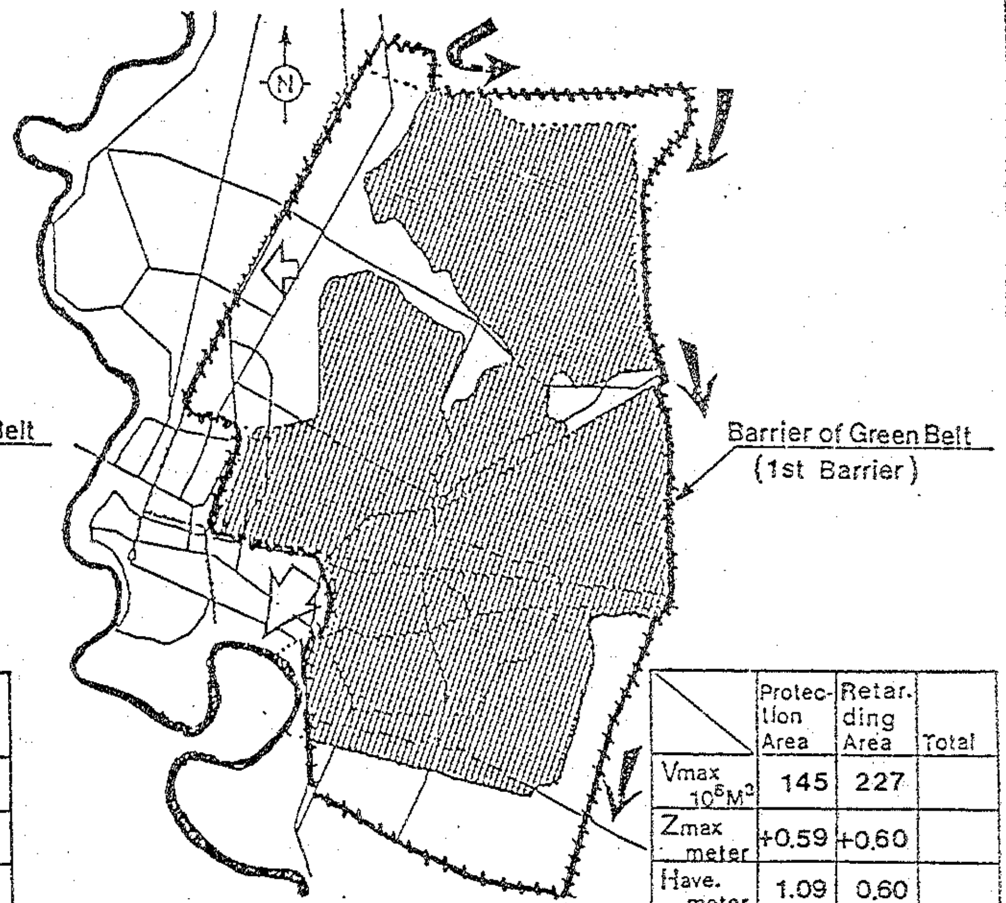
Topographical Condition; Existing -1983-



	Protec-tion Area	Retar-ding Area	Total
Vmax $10^6 M^3$	28	52	80
Zmax meter	+0.84	+0.81	
Have. meter	0.34	0.11	

Case	1st.Barrier Green Belt	2nd. Barrier	Drainage Facilities
002	O	X	$G_W=30^m$ $Q_P=16$

Topographical Condition; Future -2000-



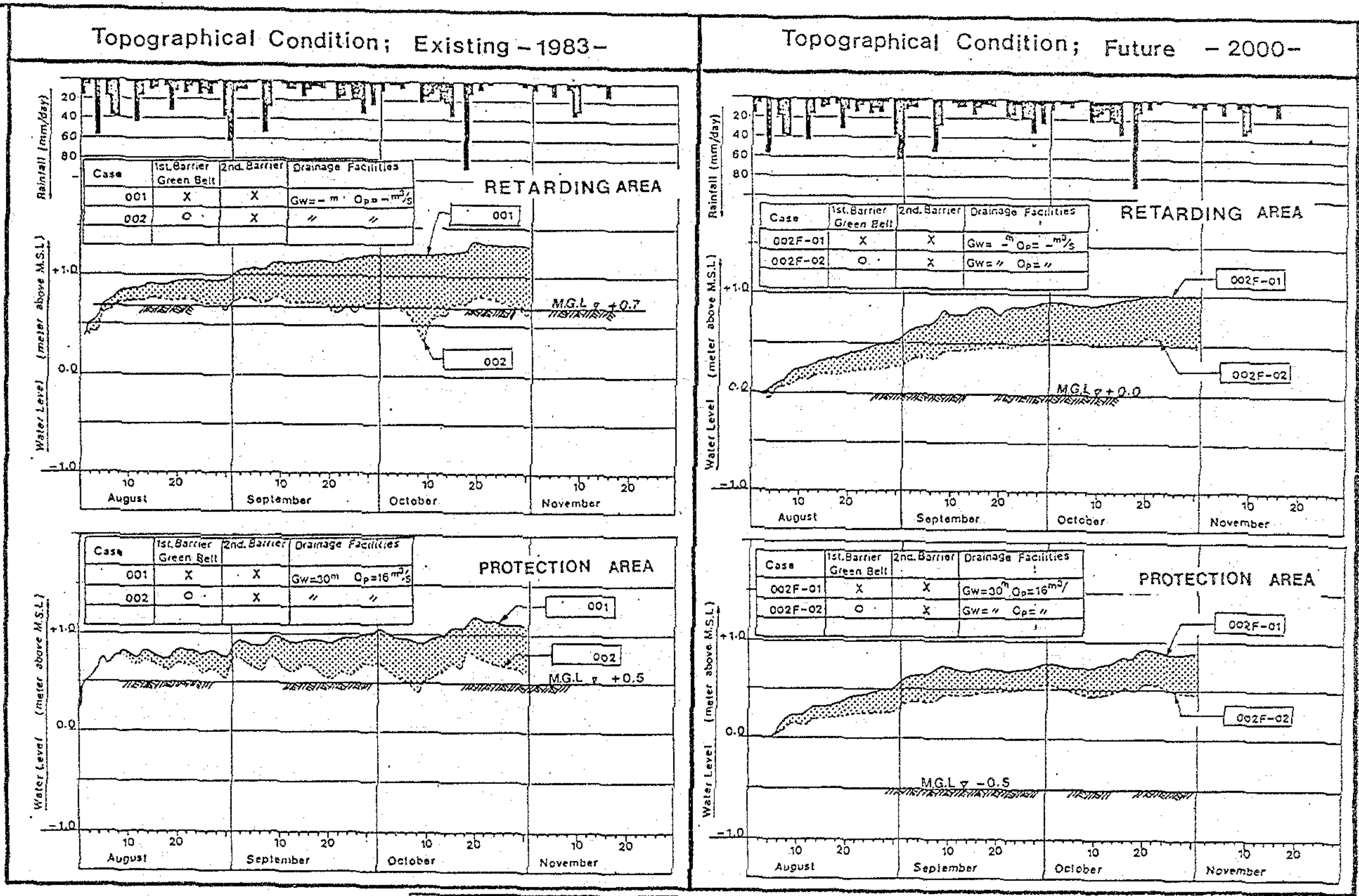
	Protec-tion Area	Retar-ding Area	Total
Vmax $10^6 M^3$	145	227	
Zmax meter	+0.59	+0.60	
Have. meter	1.09	0.60	

Case	1st.Barrier Green Belt	2nd. Barrier	Drainage Facilities
002F-02	O	X	$G_W=30^m$ $Q_P=16^{m^3}/s$

Legend
; Inflow from Outer Area
; Outflow from Study Area
: Inundate Area

FIG. 14.9 Inundated Condition with Green Belt (1st Barrier) (Rainfall in 1983)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



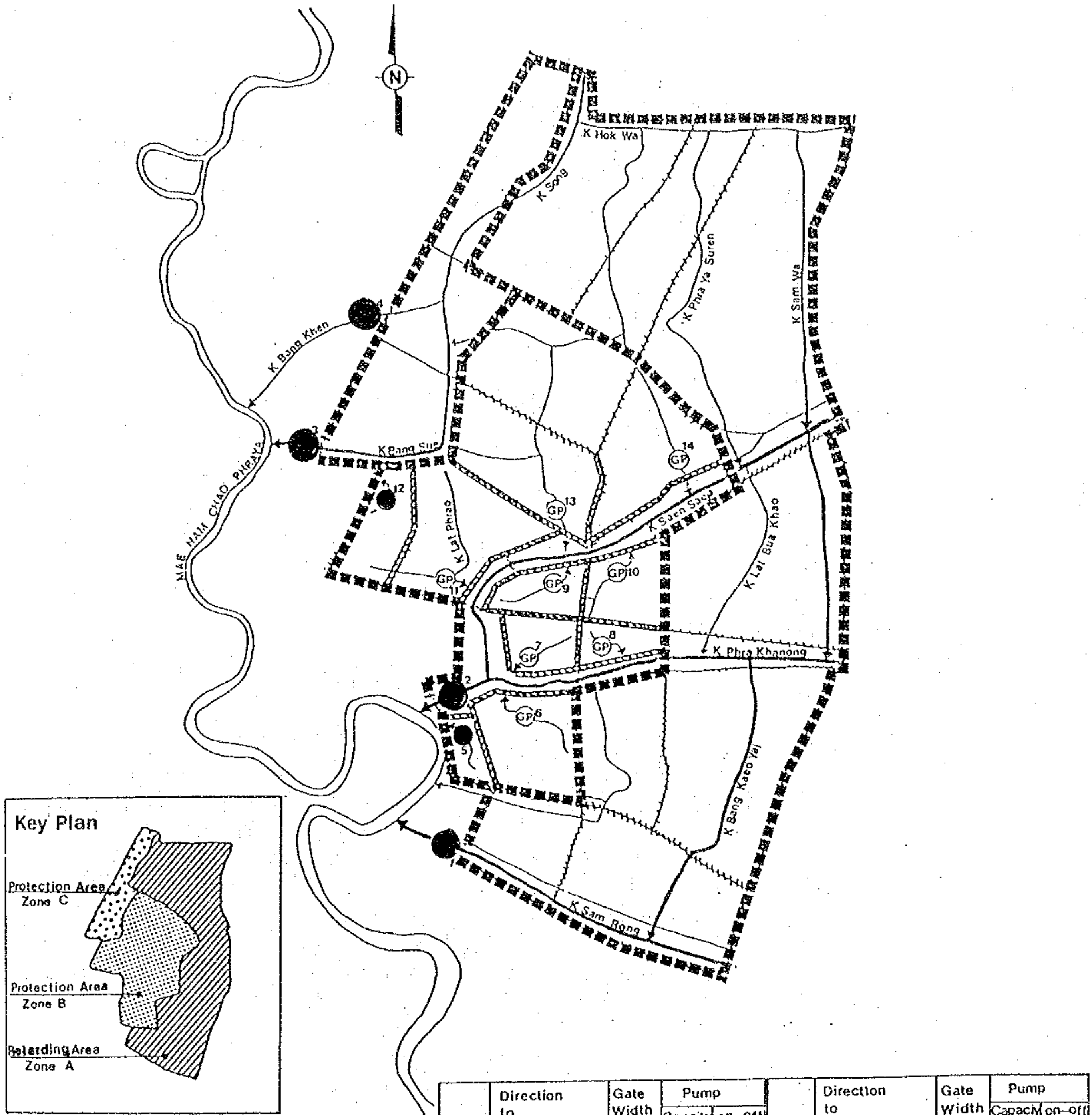
Legend

(shaded) : Decreased Difference of Simulated Water Level

MGL : Mean Ground Elevation above M.S.L

FIG. 14.10 Flood Water Levels with & without 1st Barrier (Green Belt) (Rainfall in 1983)

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Legend

▪▪▪▪▪ ; Main Levee (Barrier of Zone)

; Polder Levee

; Line of Mesh

● ; Main Pump - System Outside

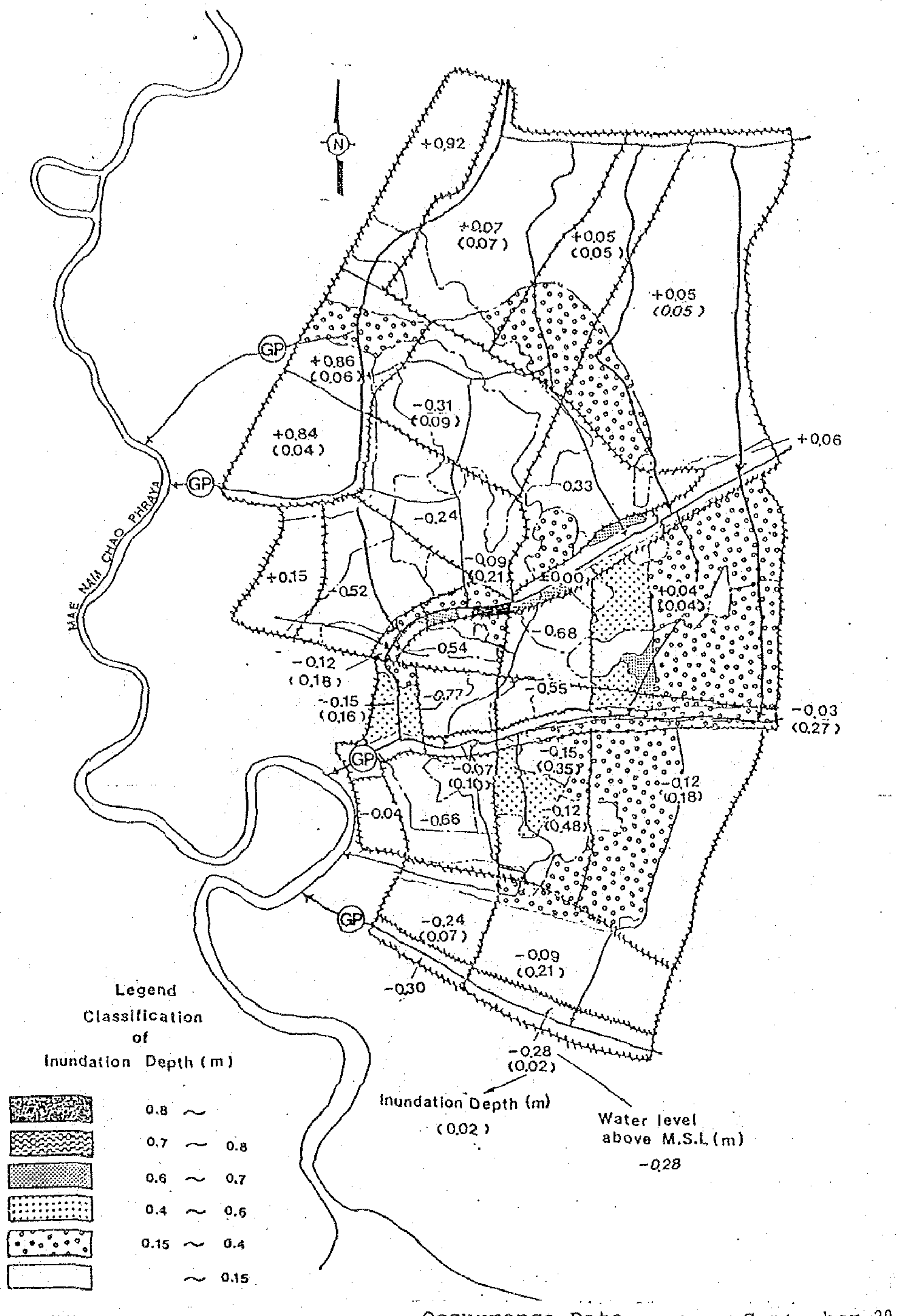
○ ; Polder Pump - System Inside

	Direction to Discharge	Gate Width (m)	Pump Capcity (m^3/s)	Pump on-off Level above M.S.L		Direction to Discharge	Gate Width (m)	Pump Capacity (m^3/s)	Pump on-off Level above M.S.L
● 1	Chao Phraya R.	12.	20.00	-0.3	GP 8	K. Phra Kanong	6.	9.00	-0.5
● 2	〃	30.	42.00	-1.0	GP 9	K. Saen Saep	6.	9.00	-0.5
● 3	〃	6.	5.00	+0.8	GP 10	〃	6.	12.00	-0.6
● 4	〃	6.	3.00	+0.8	GP 11	〃	12.	17.00	-0.5
● 5	〃	6.	8.00	+0.0	● 12	K. Bang Sue	-	10.00	+0.2
GP 6	K. Phra Kanong	6.	24.00	-0.6	GP 13	K. Saen Saep	6.	29.00	+0.0
GP 7	〃	6.	13.00	-0.7	GP 14	〃	6.	19.00	-0.3

Pump Capcity (m^3/s)	Total	System Outside	System Inside
	220.00	88.00	132.00

FIG. 14.11 **Sample Case of Study for Mixed System (Alternative III)**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



Occurrence Date : September 29

FIG. 14.12	Simulated Water Level and Inundation Depth for Alternative-III

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Chapter 15

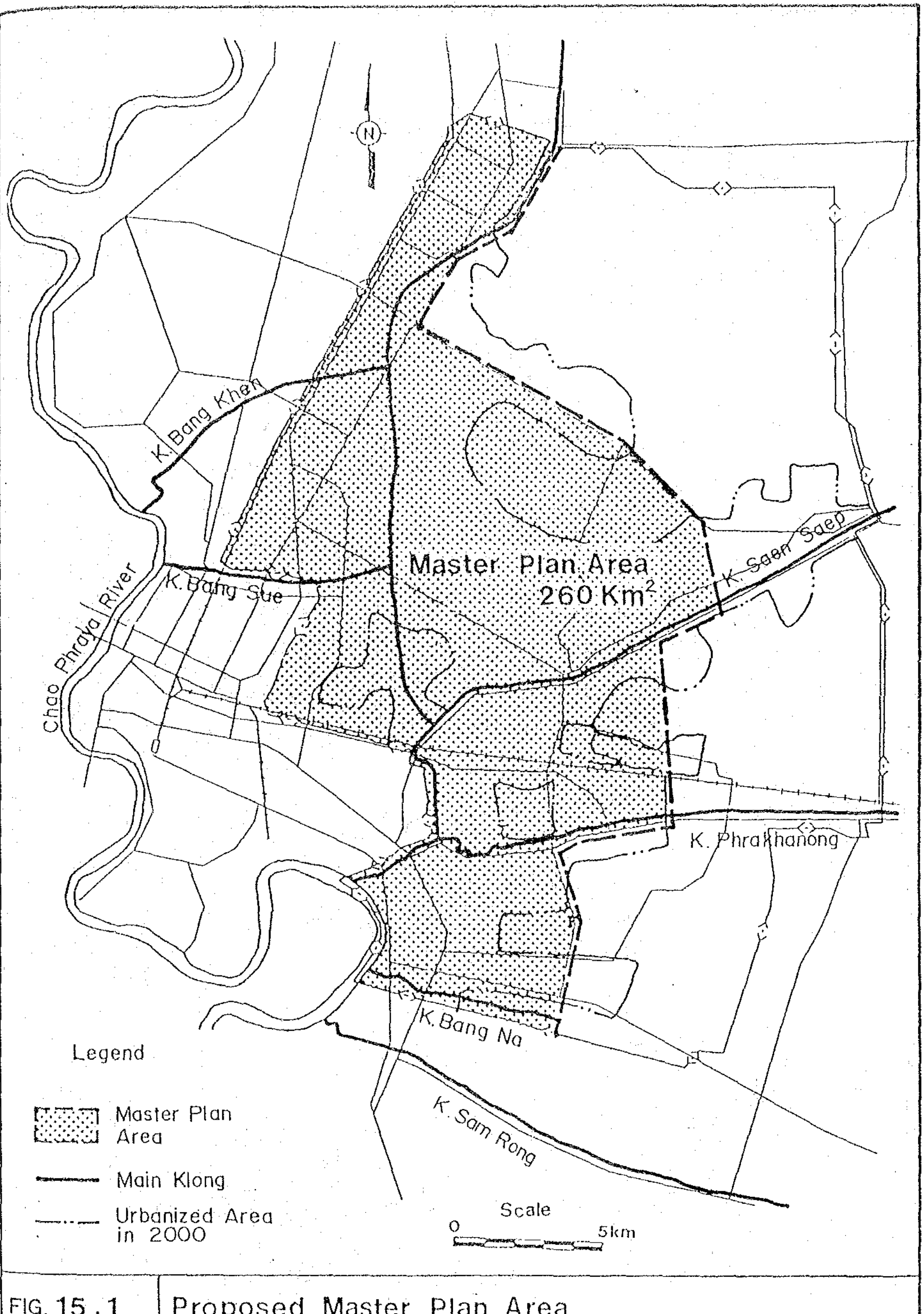
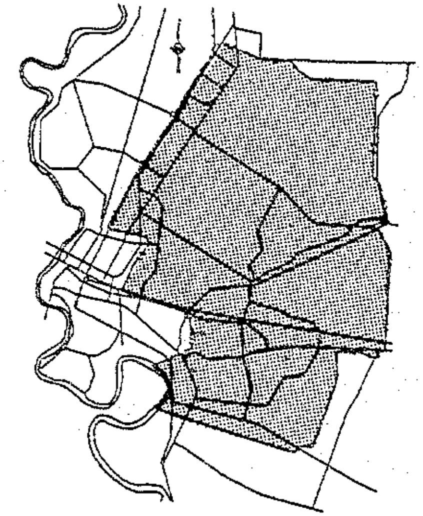
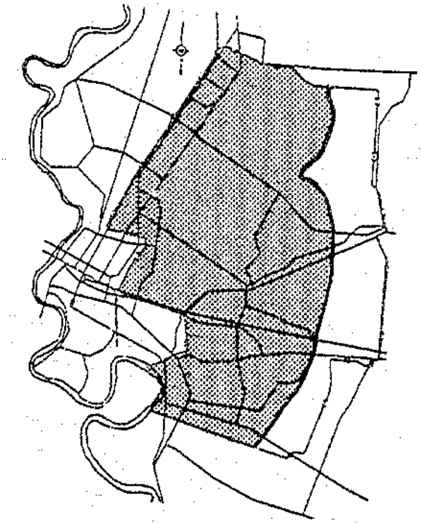


FIG. 15 . 1 Proposed Master Plan Area

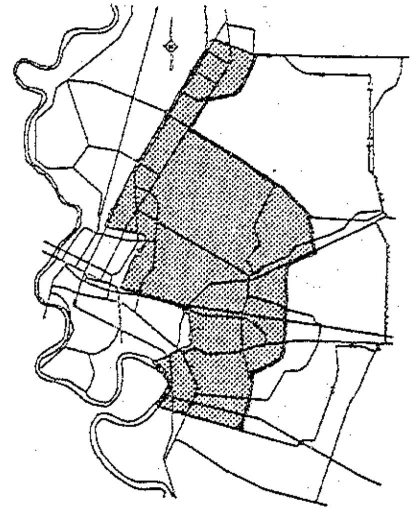
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



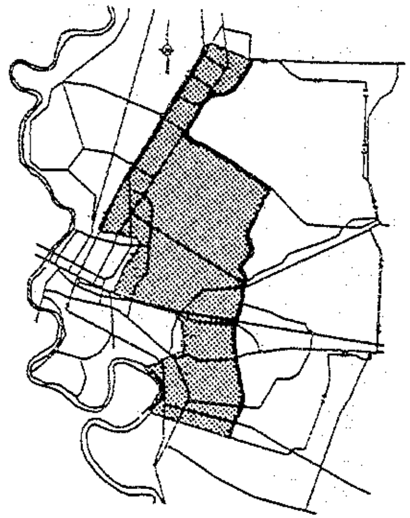
Case-1 Entire Area; 501 km^2



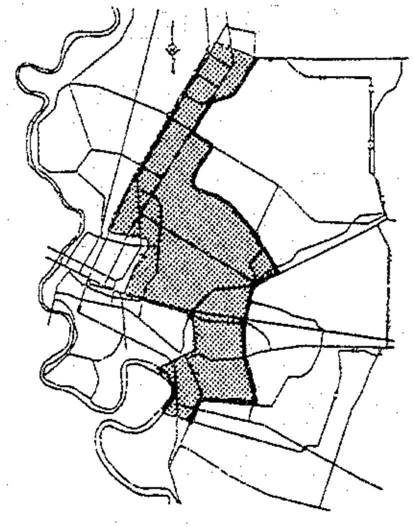
Case-2 DDS Protection Area; 370 km^2



Case-3 Entire Urban Area; 260 km^2



Case-4 Urban Area; 200 km^2



Case-5 Urban Area; 170 km^2

FIG. 15.2 **Alternatives of Master Plan Area**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

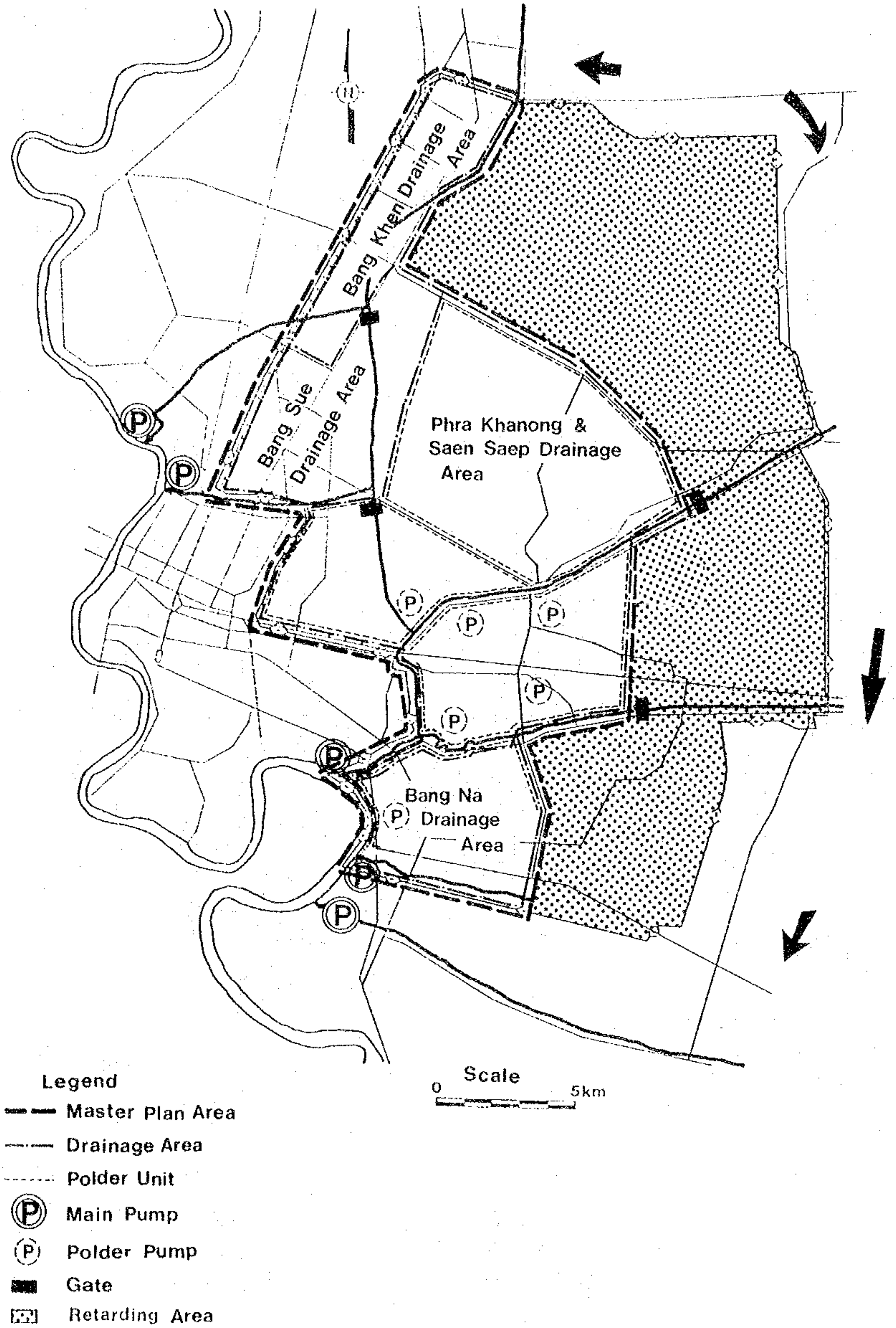


FIG. 15.3 Preliminary Flood Protection/ Drainage System for the Study Area

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

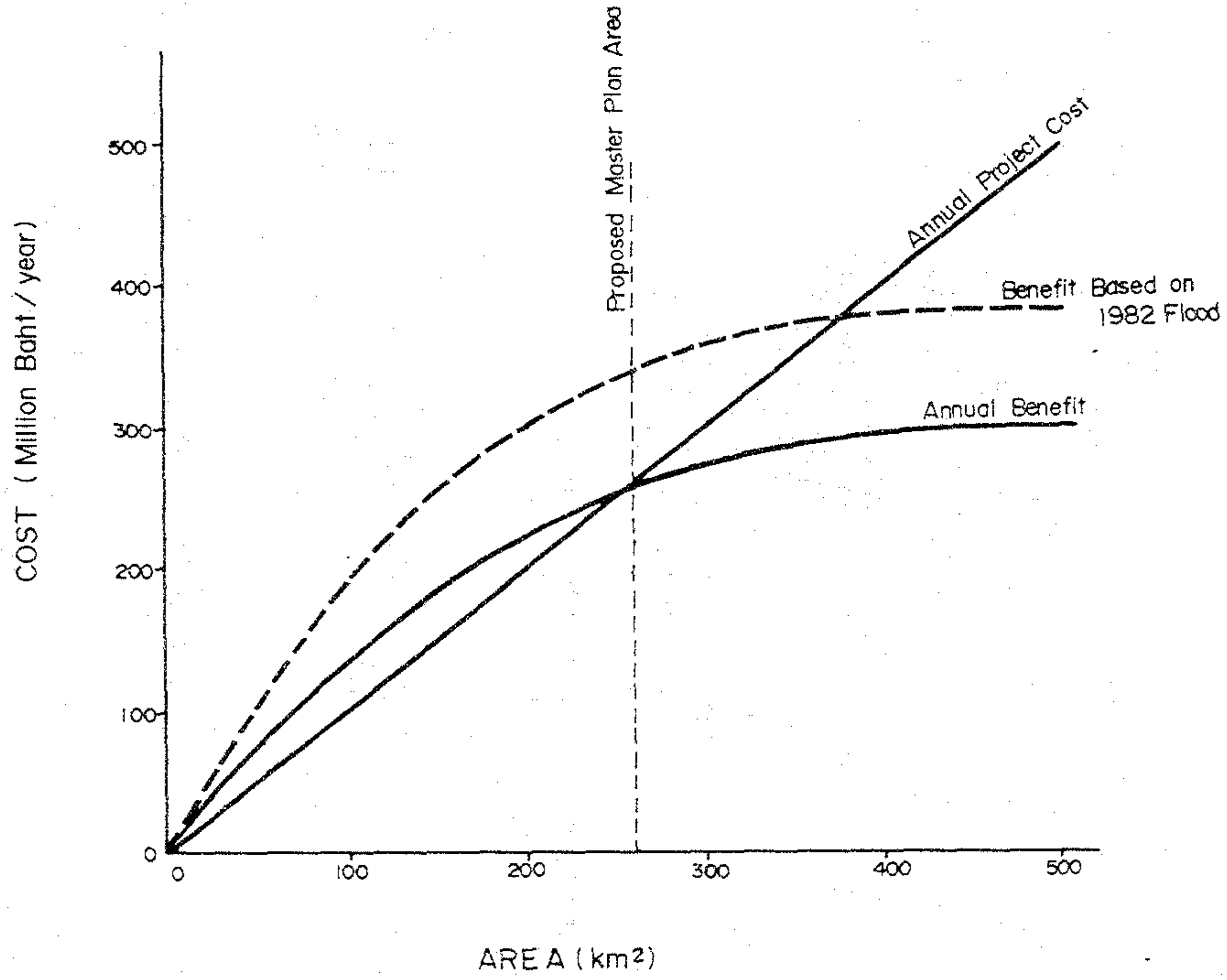


FIG.15. 4 Benefit & Cost According to Area

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Chapter 16

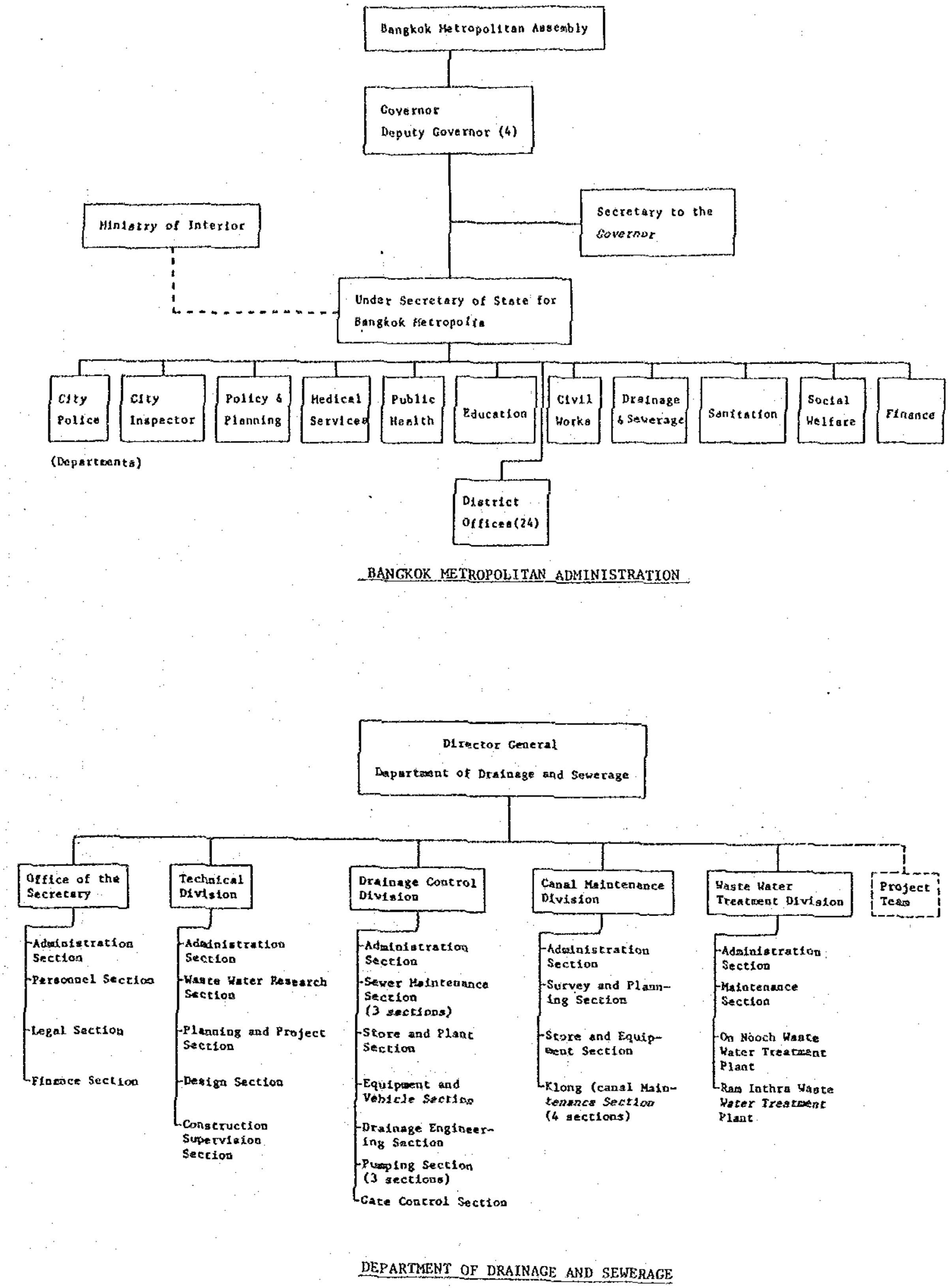


FIG. 16.1 **Organization Chart of B M A and D D S**

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

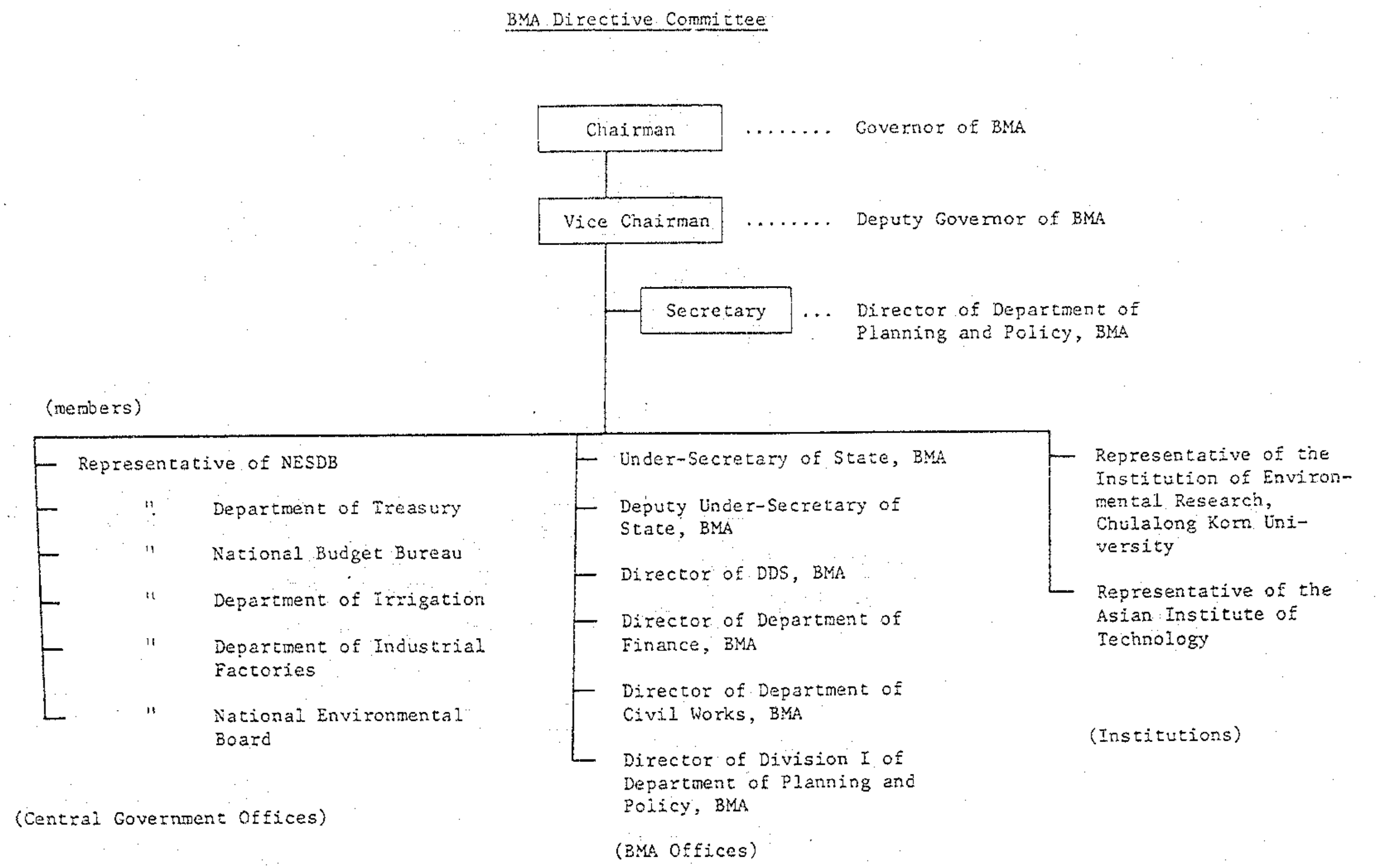


FIG. 16.2 BMA Directive Committee

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

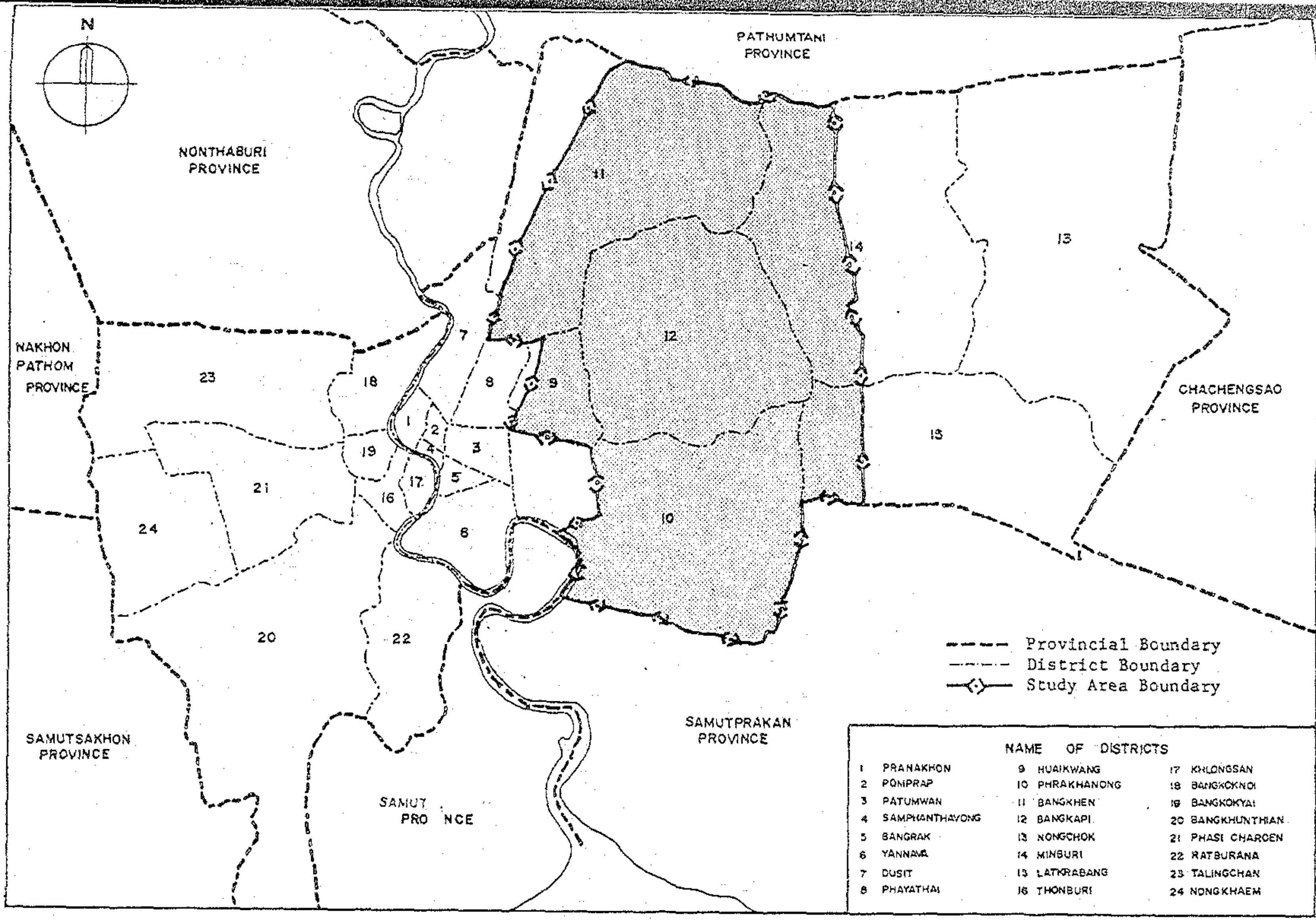


FIG. 16.3 Administrative Districts of B M A

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Chapter 17

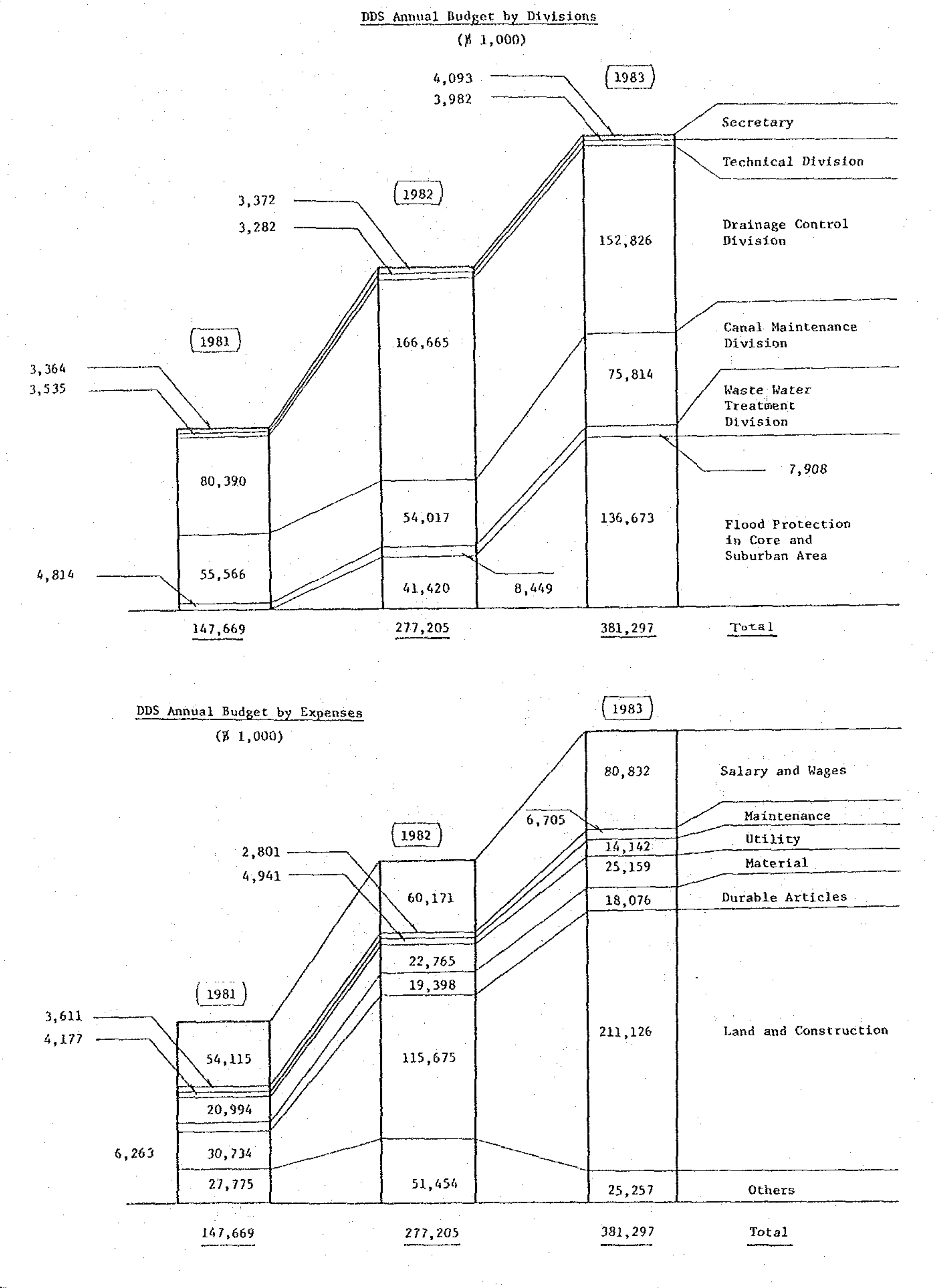
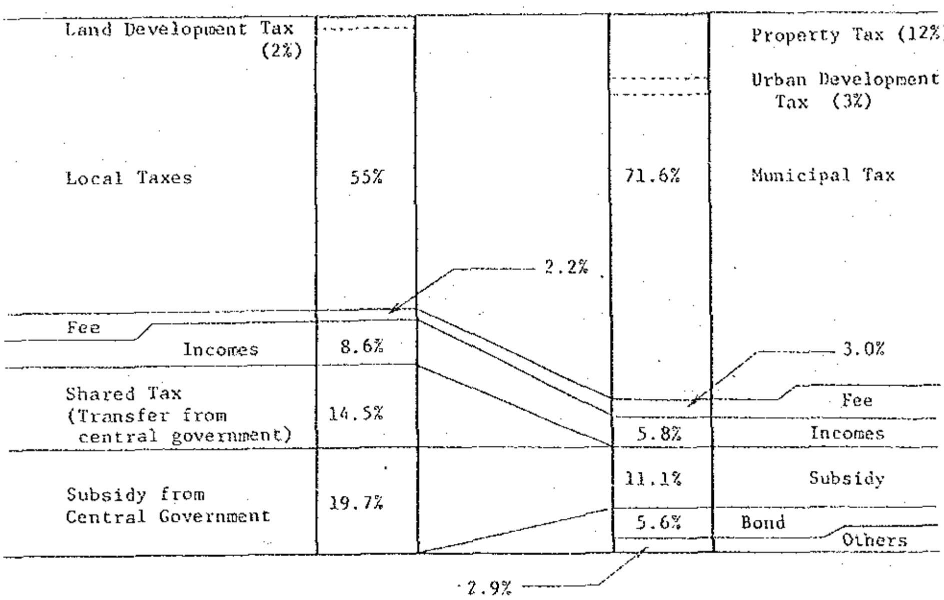


FIG. 17.1 **DDS Annual Budget**

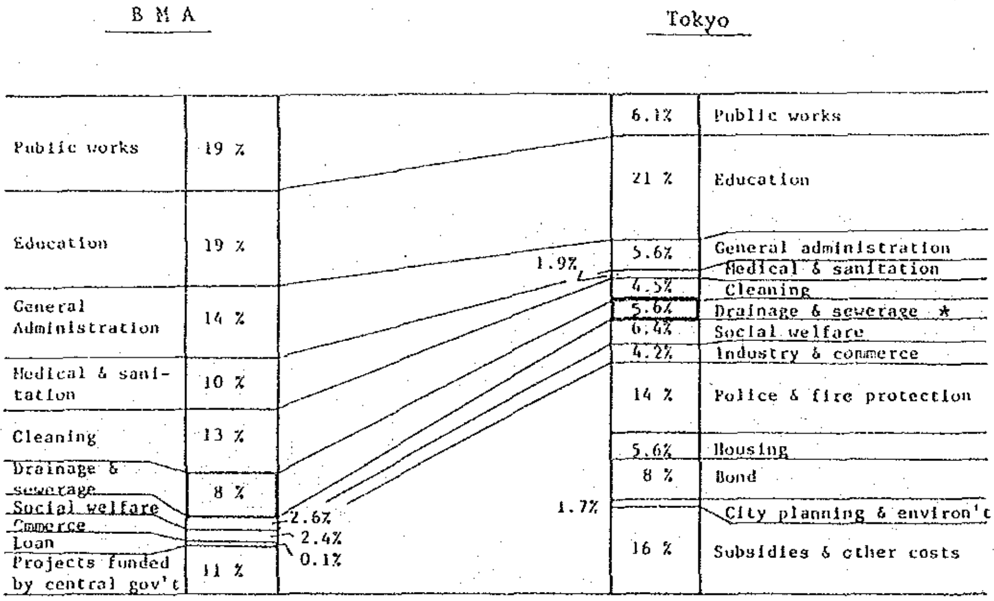
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Comparison of Sources of Revenue between BMA and Tokyo Metropolis (1983)



	BMA	TOKYO METROPOLIS
Total Revenue:	฿4,526 mill. ($197 mill)	¥3,430,000 mill ($13,720 mill)
Population :	5,726,000	11,743,000

Comparison of Expenditure of BMA and Tokyo Metropolis (1983)



	BMA	Tokyo
Total	฿ 4,641 million (US$ 197 million)	¥ 3,430,000 million (US$ 13,720 million)

* Drainage cost is 1.7 % of the total budget (¥ 59 billion). Sewerage cost (3.9 %, ¥ 132 billion) is a subsidy for Sewerage Authority, a public enterprise owned by Tokyo Metropolis, which has its own revenue collected from residents. The total budget of Sewerage Authority is ¥ 584 billion.

(Ref. to Table 17.1 and 17.2)

FIG. 17.2 **Budget of BMA, DDS and Tokyo Met.**

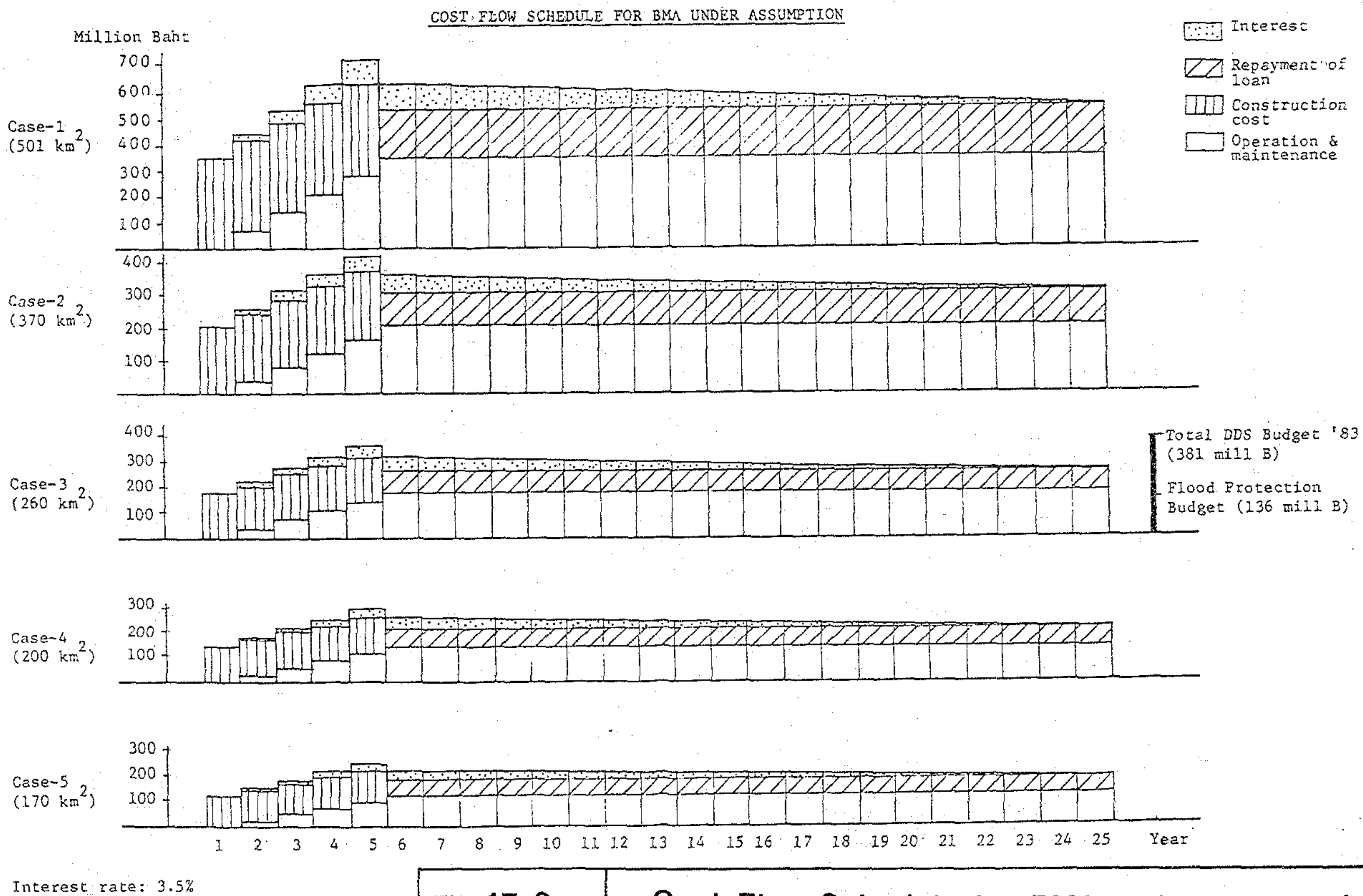


FIG. 17.3 Cost Flow Schedule for BMA under Assumption

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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