THE KINGDOM OF THAILAND

BANGKOK METROPOLITAN ADMINISTRATION

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

APPENDIX

FEBRUARY, 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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APPENDIX

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LIST OF APPENDICES

APPENDICES

APPENDIX A

TOPOGRAPHICAL SURVEY

APPENDIX A TOPOGRAPHICAL SURVEY

List of Tables

List of Figures

APPENDIX A TOPOGRAPHICAL SURVEY

The topographical survey has been conducted to supplement the survey results carried out in the Preliminary Study (1983) and the Master Plan (1984). The surveyed locations are shown in Fig. A.1. The surveyed items are as follows and the results are included in Drawings:

- Survey on klongs
  Cross sections of 75 km klongs at intervals of 200 m.
- Survey on main roads
  Cross sections of 30 km roads (underneath which drain's are planned) at intervals of 200 m.
- Survey on levels of the installed 11 water level gauging stations
- Levelling on 6.2 km dykes along the Chao Phraya river.

In addition, base maps (scale 1:4,000) covering the Feasibility Study Area, have been prepared based on areal photos (1983), supplemental field reconnaisance etc.

Datum line for the levelling was delivered from the BM31 of Royal Thai Survey Department, located in Samut Prakan Province and the accuracy of levelling was limited to $10\sqrt{S}$ (mm, S = length, km).

Eleven BMA bench marks (Note: length of their foundation piles is 12 to 17 meters) were checked based on the BM 31. The surveyed elevations in 1985, together with those in 1983 and 1984 (surveyed by JICA) and 1978 and 1981 (surveyed by Royal Thai Survey Department) are shown in Table A.1. These results reveal that the land subsidence for one year is 10 cm at maximum subsided place (See Fig. A.2).

Further, land subsidence between July 1984 and July 1985 was observed, utilizing temporary bench mark of JICA and installed 11 water level gauging stations. These results as shown in Fig. A.2 indicate that center of land subsidence is located around Ramkhamaeng and Bang Na area.

Table A-1 Elevation of BMA Bench Mark

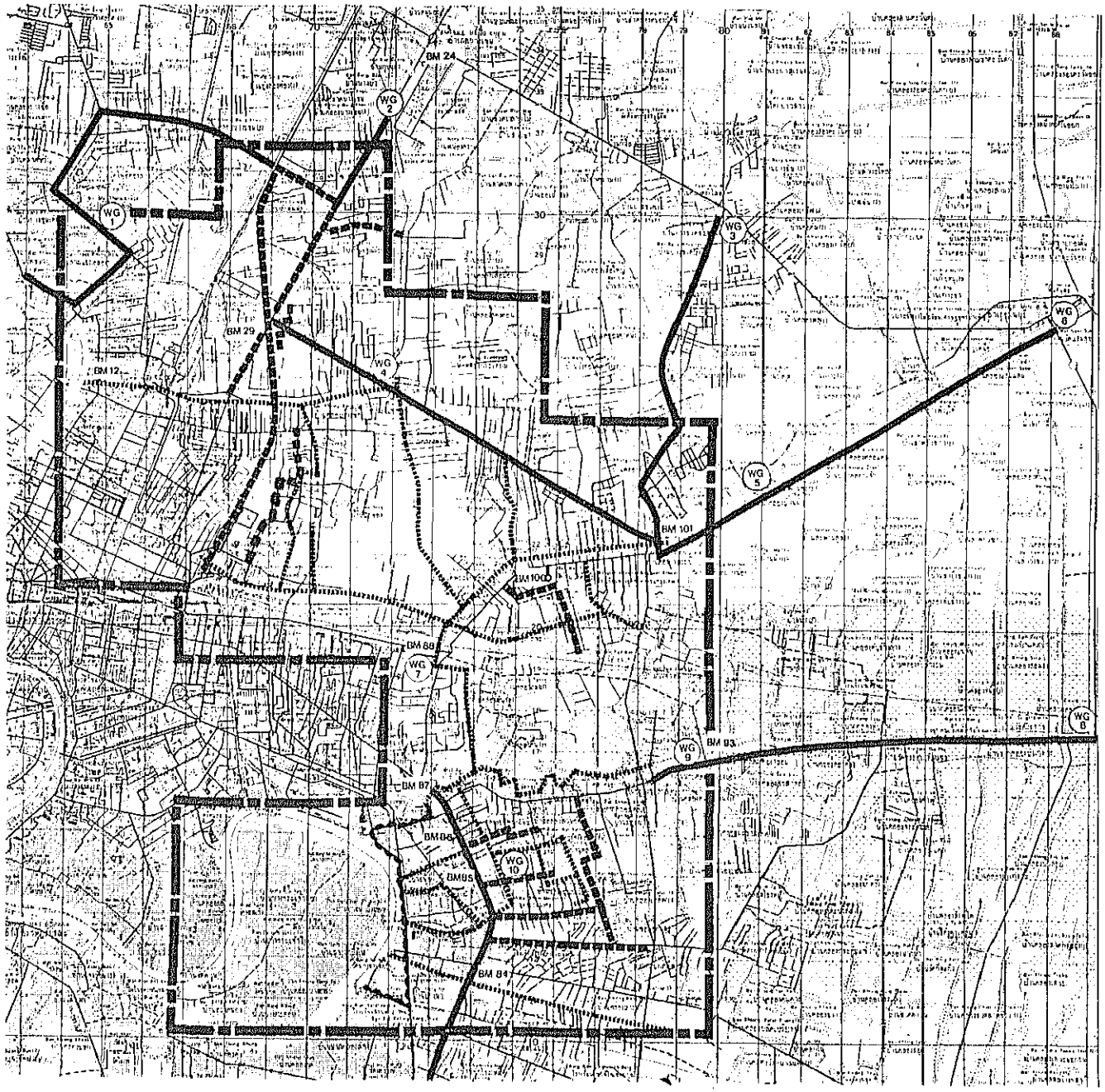
(Unit: meter MSL)

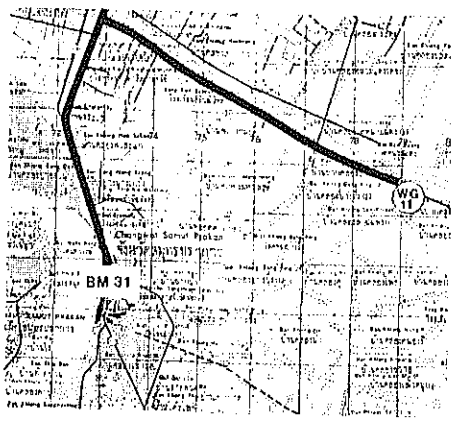
Surveyed Year / Number	Aug., 78	May, 81	July, 83	July, 84	July, 85
BM012	3.273	-	-	2.927	2.917
BM024	2.210	2.038	1.829	1.710	-
BM029	2.285	-	-	-	1.724
BM084	1.968	-	1.407	1.341	1.298
BM085	1.923	-	1.393	1.311	1.262
BM086	1.881	1.607	1.359	1.282	1.245
BM087	2.361	-	2.015	1.947	1.912
BM088	5.817	-	5.237	5.153	5.100
BM093	2.238	-	-	-	1.931
BM100	1.587	-	1.023	0.957	0.908
BM101	1.394	1.173	0.908	0.807	0.740

Table A-2 Rate of Land Subsidence

(Unit: cm/year)

Surveyed Year / Number	Aug., 78	May, 81	July, 83	July, 84	July, 85
BM012		5.8			1.0
BM024		6.3	10.0	11.9	
BM029			8.0		
BM084		11.2		6.6	4.3
BM085		10.6		8.2	4.9
BM086			11.2	7.7	3.7
BM087		6.9		6.8	3.5
BM088		11.6		8.4	5.3
BM093			4.4		
BM100		11.3		6.6	4.9
BM101		8.0	12.0	10.1	6.7





LEGEND

- CONTROL LEVELLING SURVEY (FOR THE WATER GAUGE STATION)
- PROFILE & CROSS SECTION SURVEY (FOR THE MAIN PIPE)
- CROSS SECTION SURVEY (FOR THE KLONG)
- ROUTE SURVEY OF EMBANKMENT
- (WG 1) NUMBER OF WATER GAUGE STATION
- BASE MAP COMPILATION

Fig. A.1 SURVEYED LOCATIONS

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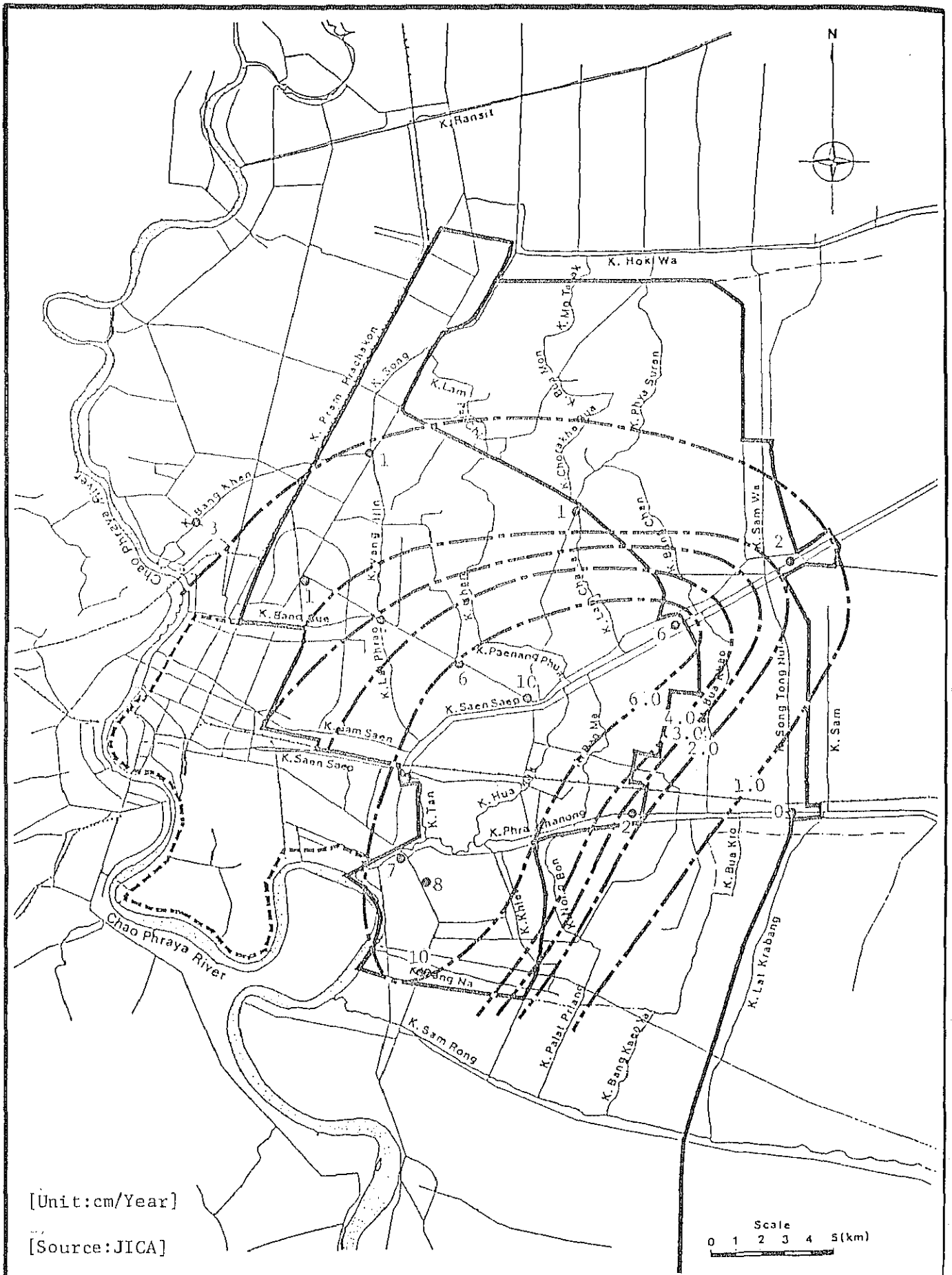

Fig. A.2 LAND SUBSIDENCE RATE BETWEEN 1984 AND 1985

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APPENDIX B

EXITSING FACILITY

APPENDIX B EXISTING FACILITY

List of Tables

List of Figures

APPENDIX B EXISTING FACILITY

Various flood control measures, particularly structural measures have been undertaken (See Fig. B.1) since 1983 flooding based on the concept proposed by the Preliminary Study (May 1983 to March 1984). The concept of the proposed structural measures is;

1) to form an outer polder covering over 950 km^2 of the east bank area of Bangkok.

2) to separate the urbanized and urbanizing areas from an agricultural area and

3) to provide mainly the former areas with drainage facilities.

A constructed permanent flood protection barrier, consisting of dyke and gates, now forms an outer polder and currently protects against flooding. The degree of protection, however, will decrease due to developping urbanization and land subsidence.

Inside the outer polder some inner polders have been planned in the urban areas. These polders are the south, north and east polders (located in the Core Area) and Bang Na, Phra Khanong and Bang Khen-Bang Sue polders (in the eastern suburbs). In addition, north Hua Mark (Ramkhamhaeng) polder is planned within Phra Khanong polder.

Existing drainage facilities in polder are classified into primary, secondary and tertiary ones. This classification is related with function of pumping station, klongs and culverts or drain pipes.

1) Primary drainage facilities consist of main klongs and main pumping stations, which are intended to transport and flow out rain water into outer area.

2) Secondary drainage facilities consist of small pumping stations and small klongs which provide major feeders to the primaries; or which provide connections between primaries.

3) Tertiary drainage facilities which lead to secondaries.

The primary, secondary and tertiary drainage facilities included in the Feasibility Study Area are shown in Table B.1 and Fig. B.2 The details are shown in Tables B.2 - B.5 and Figs. B.4 - B.6 (See Drawings).

Table B.1 Existing Drainage Facilities

Polder / Facility	Bang Khen - Bang Sue	Phra Khanong	Bang Na	Total
Pumping Station (No of Sta., m^3/s)				
Primary	3 (57.0)	1 (105.0)	2 (33.0)	6 (195)
Secondary	4 (5.0)	7 (9.75)	3 (7.8)	14 (23)
Tertiary	3 (6.5)	5 (2.47)	6 (3.9)	14 (13)
Total	10 (68.5)	1 (117.22)	11 (44.7)	34 (231)
Klong (km)				
Primary (*)	31.0	32.0	9.5	72.5
Secondary	16.3	59.8	15.8	91.9
Tertiary	8.0	61.9	18.7	88.6
Total	55.3	153.7	44.0	253.0
Box Culvert or Pipe (km)				
Primary	-	-	-	-
Secondary	8.0	-	5.6	13.6
Tertiary	8.0	8.0	7.0	23.0
Total	16.0	8.0	12.6	36.6

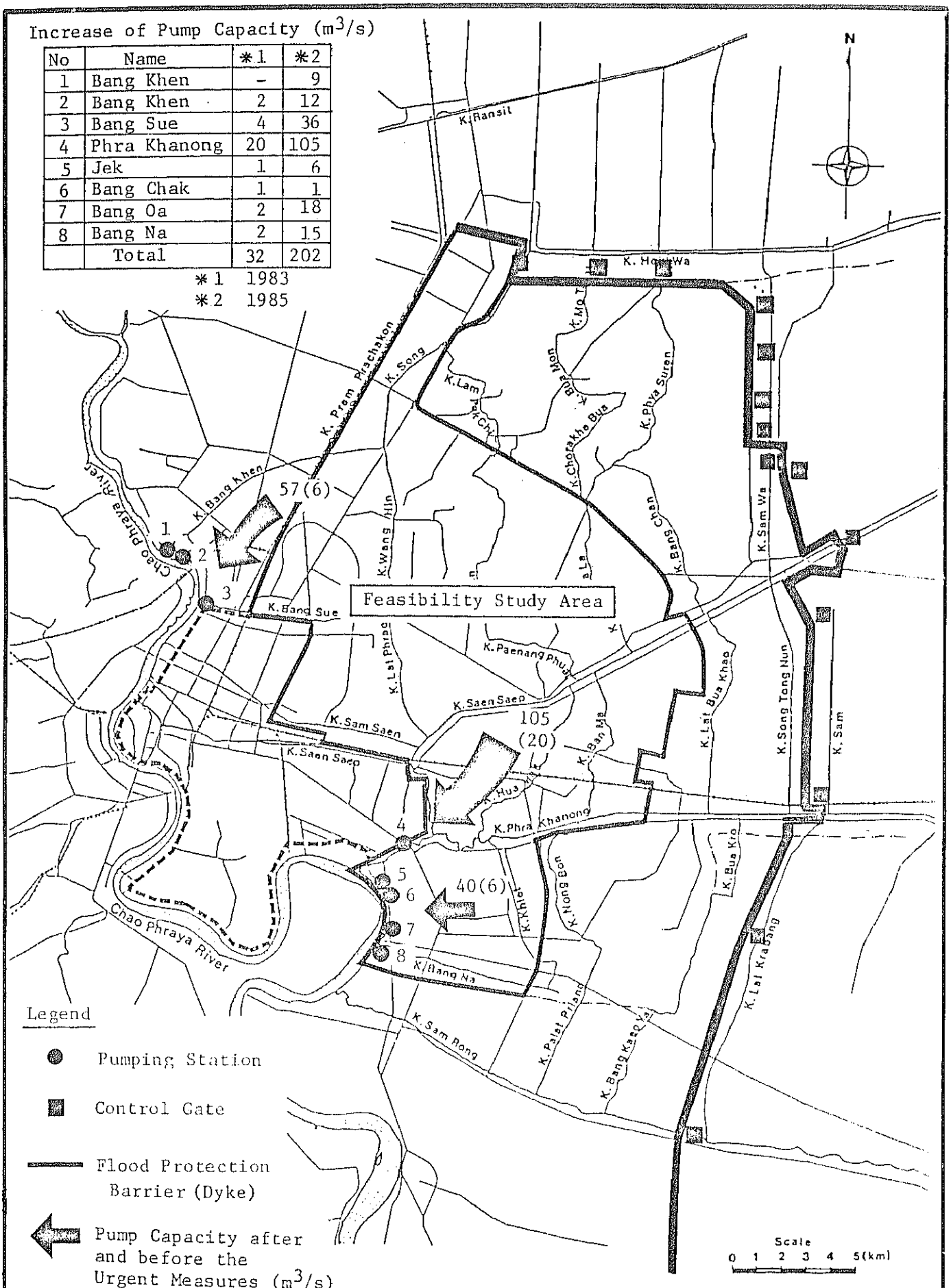
Note: * Primary kongs in Phra Khanong polder are called as trunk klongs in the Master Plan.

Despite the recently constructed drainage facilities, flooding is expected. Fig. B.3 shows examples of effect of the constructed facilities, which indicate klong improvement is to be taken.

Increase of Pump Capacity (m^3/s)

No	Name	*1	*2
1	Bang Khen	-	9
2	Bang Khen	2	12
3	Bang Sue	4	36
4	Phra Khanong	20	105
5	Jek	1	6
6	Bang Chak	1	1
7	Bang Oa	2	18
8	Bang Na	2	15
	Total	32	202

*1 1983
*2 1985



Legend

- Pumping Station
- Control Gate
- Flood Protection Barrier (Dyke)
- Pump Capacity after and before the Urgent Measures (m^3/s)

Fig. B.1 FACILITIES CONSTRUCTED AS URGENT MEASURES

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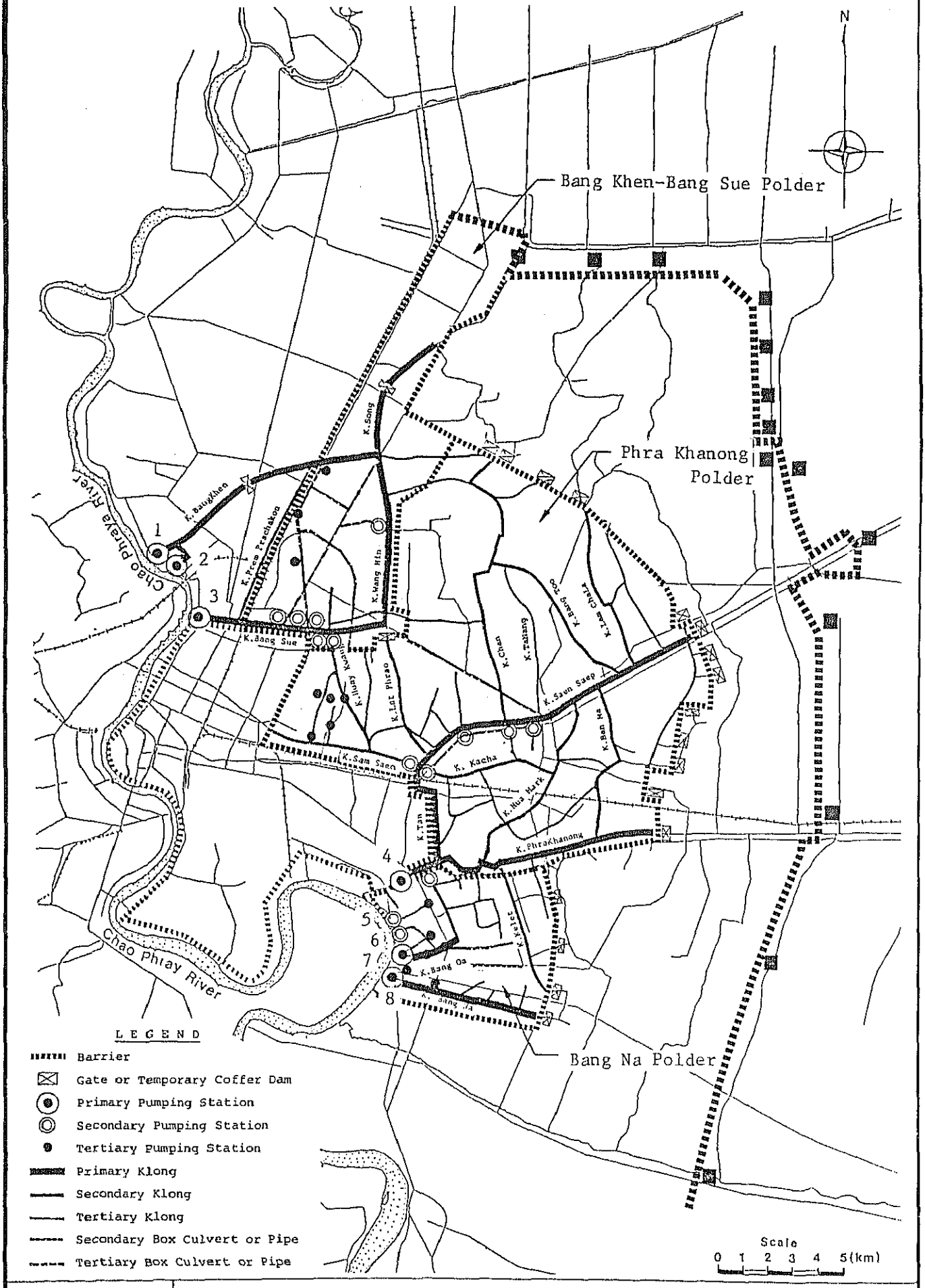

Fig. B.2 EXISTING FLOOD PROTECTION AND DRAINAGE FACILITIES(1985)

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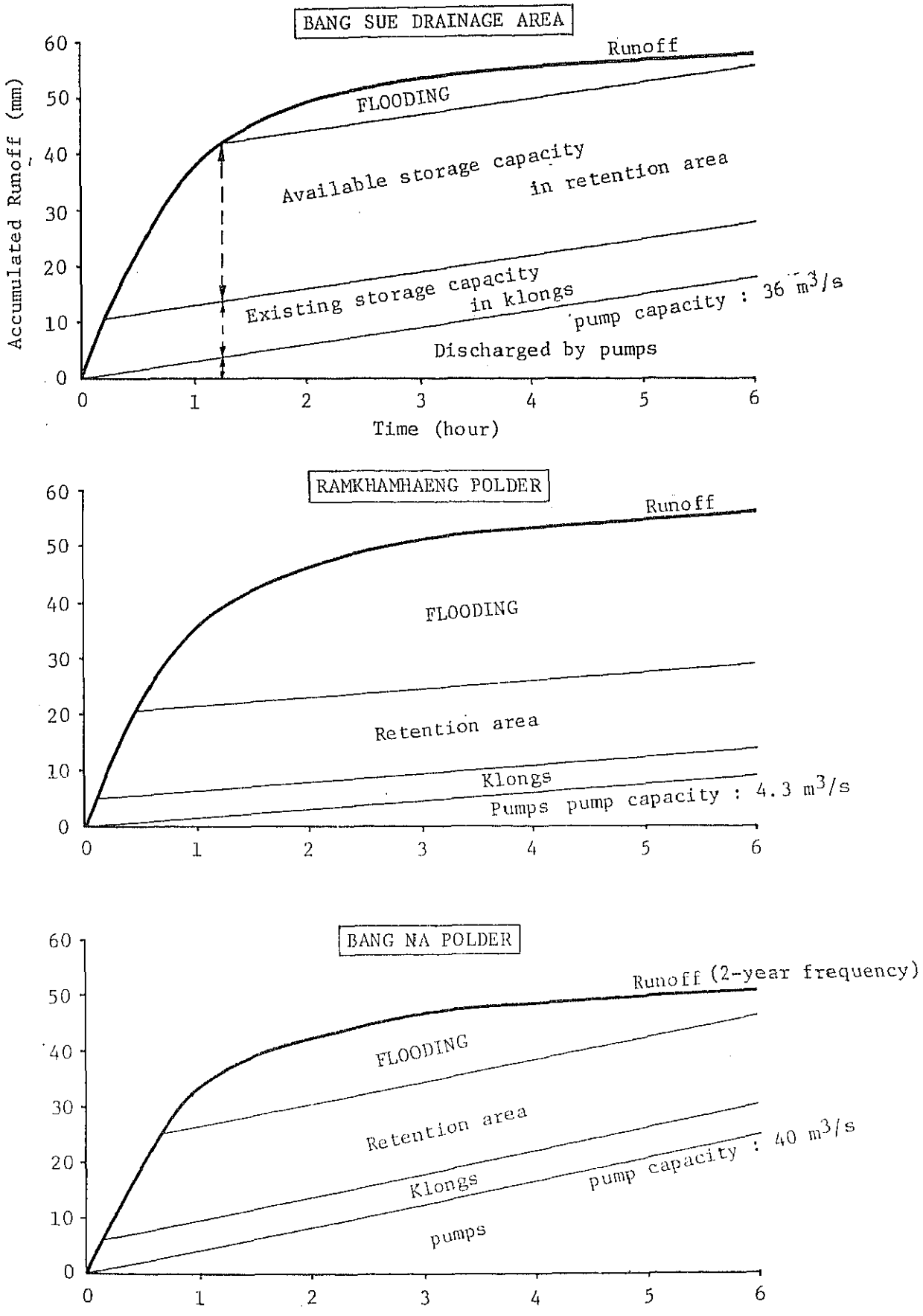

Fig. B.3 PUMP CAPACITY VERSUS EXISTING STORAGE CAPACITY

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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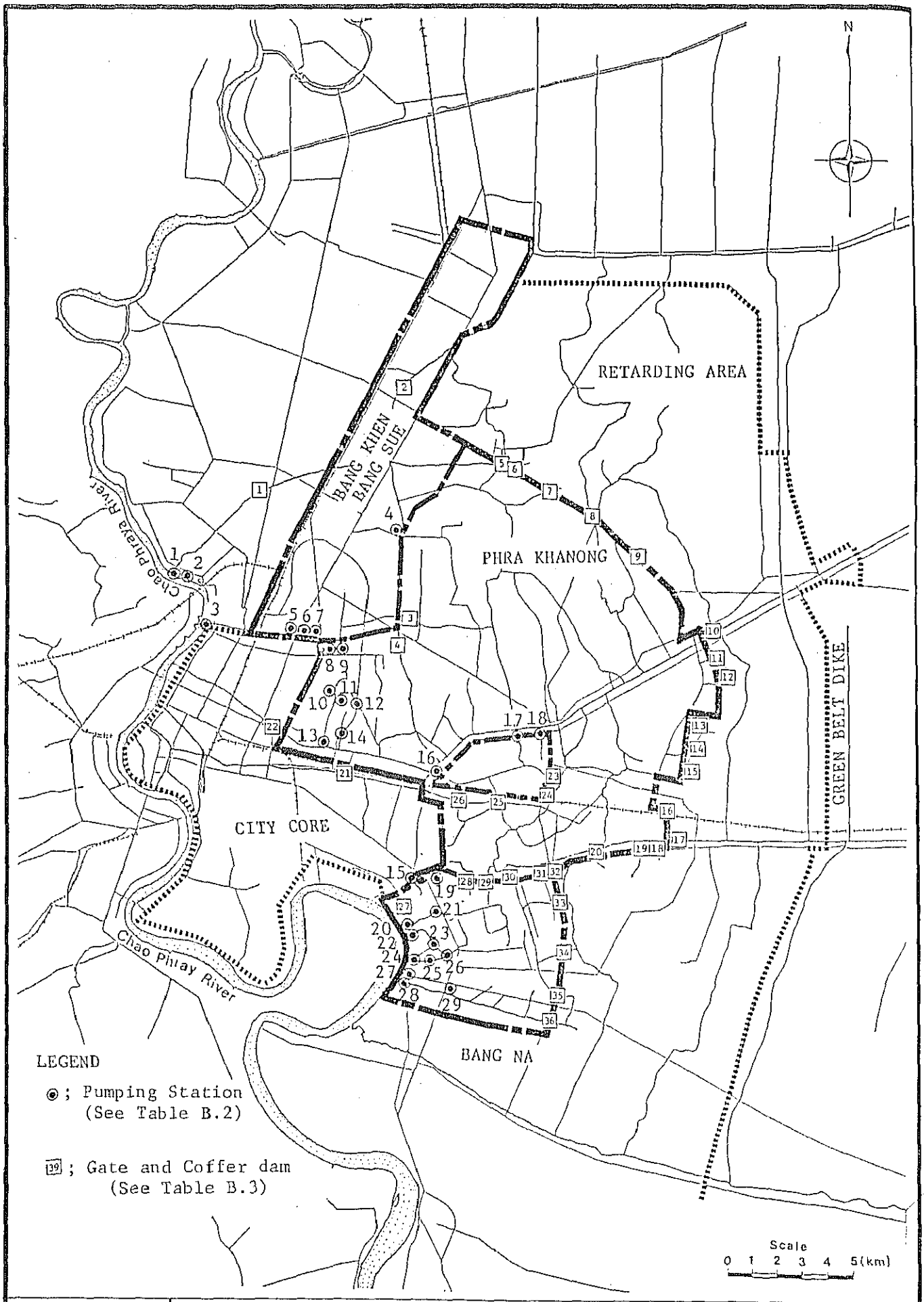

Fig. B.4 EXISTING PUMPING STATION, GATE AND COFFER DAM (1985)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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Table B.2 List of Existing Pumping Station in 1985

No.	Pumping Station	Type of Pump (Fix/Move)	Number of Pump Unit	Pump Size (Inch)	Total Pump Capacity -Nominal- (m^3/s)	Remarks
	Bang Khen Bang Sue Polder					
1	Bang Khen (North)	Submerge (Fix)	3	48"	9	
2	Bang Khen (South)	Submerge (Fix)	4	48"	12	
3	Bang Sue	Submerge (Fix)	12	48"	36	
4	Sena Nichom	Submerge (Move)	2	20"	1	
		Axial Flow (Fix)	2	16"	0.6	
5	Phahol Yothin (North)	Submerge (Move)	2	20"	1	
			2	16"	0.6	
6	Phahol Yothin (North)	Submerge (Move)	1	16"	0.3	
			2	12"	0.5	
7	Wipavadee Rangsit (North)	Submerge (Move)	1	24"	1	
	Phra Khanong Polder					
8	Wipavadee Rangsit (South)	Submerge (Move)	1	24"	1	
			1	16"	0.3	
9	Klong Huay Kuang I	Submerge (Fix)	1	20"	0.5	
		Axial Flow (Fix)	2	24"	2	
10	Pracha Song Krao Sump (North)	Submerge (Move)	2	8"	0.26	
11	Pracha Song Krao Sump (South)	Axial Flow (Move)	1	8"	0.13	
			1	6"	0.03	
12	Klong Huay Kuang II	Submerge (Fix)	1	20"	0.5	
			1	16"	0.3	
13	Klong Na Song	Submerge (Move)	2	20"	1	
14	Klong Yai Soon	Submerge (Move)	1	12"	0.25	
15	Phra Khanong	Submerge (Fix)	35	48"	105	
	Ramkamhaeng Polder					
16	Klong Kra Ja.	Submerge (Fix)	2	24"	2	
			3	20"	1.5	
17	Klong Gig	Submerge (Fix)	2	16"	0.6	
18	Klong Git	Submerge (Fix)	1	12"	0.25	
	Bang Na Polder					
19	Phra Khanong Sump	Axial Flow	1	16"	0.3	
		Submerge	2	12"	0.5	
20	Klong Jek	Submerge (Fix)	2	48"	6	
21	Sukhumvit $^{60}/_{1}$ Sump	Submerge (Move)	2	16"	0.6	
22	Bang Chek	Submerge (Move)	2	20"	1	
23	Sukhumvit 64 Sump	Submerge (Move)	2	16"	0.6	
24	Bang Oa	Submerge (Fix)	6	48"	18	
25	Sukhumvit $^{66}/_{1}$ Sump	Submerge (Move)	2	16"	0.6	
26	Bang Oa Sump	Axial Flow	1	16"	0.3	
		Submerge (Fix)	2	14"	0.6	
27	Sumpawvt Sump	Submerge (Move)	2	16"	0.6	
28	Klong Bang Na	Submerge (Fix)	5	48"	15	
29	Bang Na Sump	Submerge (Fix)	2	14"	0.6	

Table B.3 List of Existing Gate and Cofferdam in 1985

No.	Location	Gate Leaf Dimension				Remarks
		Unit	Width (m)	Height (m)	Inv. Elev. (m)	
	Bang Khen Bang Sue Polder					
1	Phra Cha Chuen	1	6.0			
2	Song Lak See	1	6.0			
3	Klong Nam Kaew					
4	Lat Phrao	1	6.0	4.0		
	Phrakhanong Polder					
5	Ban Kilo I	1	3.0			Under Const.
6	Ban Kilo II	1	3.0			"
7	Klong Lum Phai	1	3.0			"
8	Klong Lam Cha La	1	3.0			"
9	Branch of K.Kret	1	3.0			"
10	Klong Bang Chan	1	3.5			
11	Branch of K.Loa Loe No.1	1	2.0	3.0	33.5	
12	Branch of K.Loa Loe No.2	1	2.0	3.0	33.5	
13	Branch of K.Loa Loe No.3	1	3.0	5.0	31.5	
14	Klong Vung Yai	1	2.0	3.0	33.5	
15	Branch of K.Tab Chang Lang	1	2.0	3.0	33.5	
16	Side ditch along Railway	2	1.5	4.0	32.5	
17	Side of Wat Kratoom Ser Pa	1	3.5			
18	Branch of K.Chorakhe Khop	1	3.0			Under Const.
19	Klong Song Hong	1	3.0			"
20	Klong Sa La Loi Lang	1	3.0			"
21	Bang Kapi					
22	Klong Sam Sean					
	Ramkamhaeng Polder					
23	Klong Chit	1	2.0	3.75	32.5	
24	Klong Chick	1	2.0	3.9	32.5	Side of Rajkrita Rd.
25	Klong Saen Sab	1	2.0	1.5		
26	Klong Lao	1	2.0	4.2	32.5	
	Bang Na Polder					
27	Klong Bang Jark					
28	Klong Suan Oye	1	2.5	3.9	32.5	
29	Klong Bang Lai	1	2.5	4.0	32.5	
30	Klong Klet	1	2.5	4.4	32.0	
31	Klong Kum Sakon	1	2.5	3.7	32.0	
32	Klong Prakhanong Kao	1	3.0			Under Const.
33	Klong Nong Pa Dook	1	2.0	3.6	32.0	
34	Klong Ta Chang	1	2.0	3.8	33.5	
35	Klong Klet	1	2.5	3.8	32.0	
36	Klong Bang Na	2	3.0	5.0	31.5	

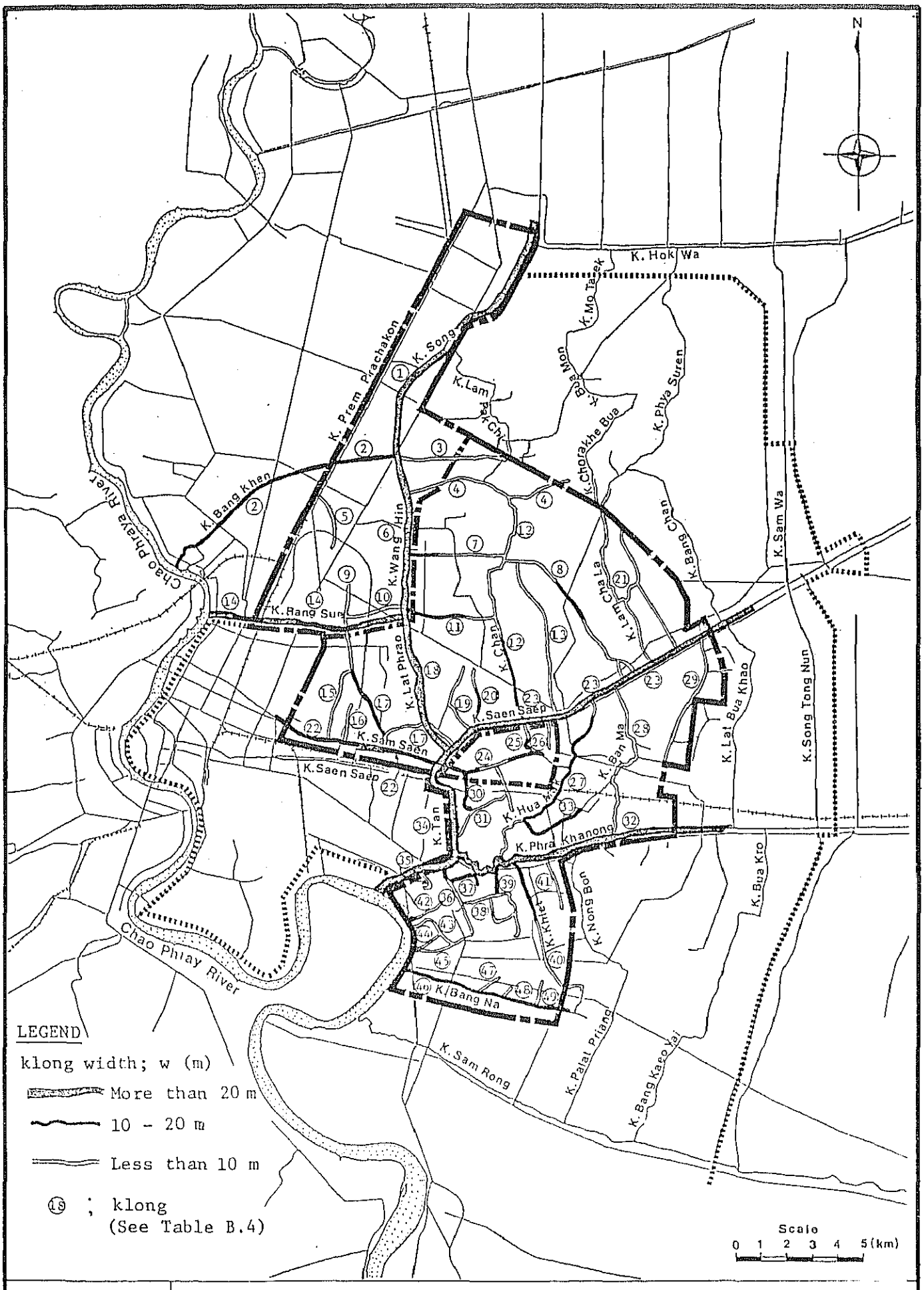

Fig. B.5 EXISTING KLONG IN STUDY AREA (1985)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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Table B.4 List of Existing Klong in 1985

No.	Klong	Length (km)	Width	No.	Klong	Length (km)	Width
1	K.Song	10.5	III	26	K.Chit	1.8	I
2	K.Bang Khen	10.4	II	27	K.Hua Mark	8.0	II
3	K.Bam Sam Kha	5.0	I	28	K.Bang Ma	8.0	I
4	K.Lum Phai	7.0	I	29	K.Lai Bua Khao	9.0	I
5	K.Lat Yao	2.2	I	30	K.Bun Pa	2.0	II
6	K.Wang Hin	7.0	III	31	K.Sakae	3.0	I
7	K.Sua Noi	4.0	I	32	K.Phra Khanong	14.0	III
8	K.Lam Cheak	4.0	I	33	K.Kok Wat	2.6	II
9	K.Phra Wake	2.0	I	34	K.Tan	3.6	III
10	K.Nam Kaew	2.2	I	35		0.7	I
11	K.Song Kla Tiam	4.0	II	36	K.Bang Na Jen	2.9	I
12	K.Chan	9.0	I	37	K.Kwang Lang	1.2	II
13	K.Ta Nang	6.2	I	38	K.Kwang Bon	1.7	I
14	K.Bang Sue	8.0	II	39	K.Ban Lai	4.0	I
15	K.Huai Kwang	4.5	I	40	K.Khlet	5.6	II
16	K.Yai Soon	1.6	I	41	K.Khun Sakon	4.0	I
17	K.Plab Pla	5.0	II	42	K.Jek	0.7	I
18	K.Lat Phrao	5.5	III	43	K.Bang Chak	1.1	I
19	K.Wat Tuk	3.2	I	44	K.Bang Oa Noi	1.2	I
20	K.Chao Khun Sing	2.6	II	45	K.Bang Oa Yai	1.9	I
21	K.Lam Cha La	7.5	I	46	K.Bang Na	6.2	II
22	K.Sam Saen	6.2	II	47	Bang Na Trad (K_1)	1.4	I
23	K.Saen Saep	13.0	III	48	" (K_2)	0.6	I
24	K.Kacha	5.5	II	49	" (K_3)	0.6	I
25	K.Gig	1.7	II				

Note:
Width - I :Less than 10m
-II :10m-20m
-III:More than 20m

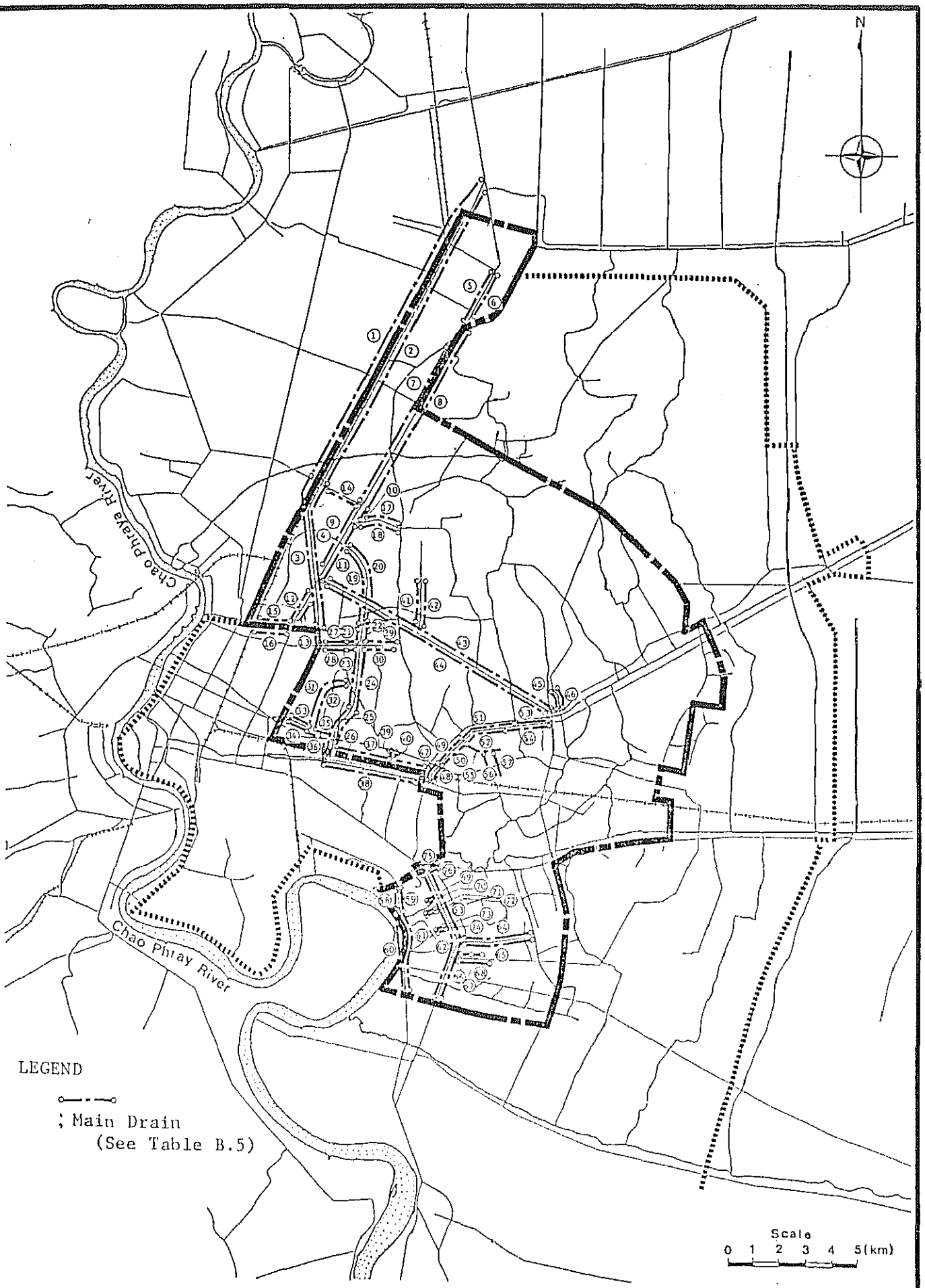

Fig. B.6 EXISTING MAIN DRAIN (1985)

FEASIBILITY STUDY ON FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

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Table B.5(a) List of Existing Main Drain (Pipe) in 1985 (1)

No.	Location (Rd.Name)	Size (mm)	Length (m)	Remarks
1	Wipavadee Rangsit	800	13,800	
2	"	"	"	
3	"	1,200	10,100	
4	"	"	"	
5	Phahol Yothin	1,200	2,200	
6	"	"	"	
7	"	1,200	15,000	
8	"	"	"	
9	"	1,000	3,900	
10	"	1,200	480	
11	"	1,000	3,200	
12	"	1,200	2,400	
13	"	"	"	
14	Ngam Wongwan	"	1,700	
15	Yan Phahol Yothin	1,750	1,200	
16	"	800	"	
17	Soi Saena Nichom	1,200 &1,500	930	
18	"	600	"	
19	Ruth Chada Phisagg	1,000 &1,500	3,320	
20	"	"	"	
21	"	2,000	850	
22	"	"	"	
23	"	1,200 &1,500	3,150	
24	"	"	"	
25	"	2,000	850	
26	"	"	"	
27	Intra Mara	1,000	1,400	
28	"	"	800	
29	"	800	1,600	
30	"	"	1,200	
31	Pra Cha Song Krao	600 &1,000	2,900	
32	"	"	"	
33	Asoke - Dindag	1,500	800	
34	"	"	"	
35	"	1,000	1,200	
36	"	"	"	
37	Phet Chaburee	800 &1,000	2,100	
38	"	"	"	
39	Soi Santi Gan	600	960	
40	"	"	960	
41	Soi Choakchai 4	1,200	1,840	
42	"	"	"	
43	Lat Phrao	1,200	10,900	
44	"	"	"	
45	Sukla Piban 2	1,200	1,000	

Table B.5(b) List of Existing Main Drain (Pipe) in 1985 (2)

No.	Location (Rd.Name)	Size (mm)	Length (m)	Remarks
46	Sukla Piban 2	1,200	0	
47	Ram Kum Haeng	800	750	
48	"	1,000	800	
49	"	1,500	1,700	
50	"	"	"	
51	"	1,750	1,700	
52	"	1,200	"	
53	"	"	1,700	
54	"	1,750	"	
55	Soi Mv Ban Saeree	800	1,920	
56	"	400	880	
57	"	"	1,600	
58	Tang Rosphai Sai Kao	800	880	
59	"	"	860	
60	"	600	2,600	
61	"	"	2,650	
62	Sukhumwit	100	5,120	
63	"	"	"	
64	Soi Sukhumwit 101/1	800	2,700	
65	"	"	"	
66	Soi Sukhumwit 103	1,000	265	
67	"	1,500	"	
68	"	1,000	1,200	
69	Soi Sukhumwit 60/1	1,500	200	
70	"	1,000	"	
71	Soi Sukhumwit 62	1,000	640	
72	"	"	"	
73	Soi Sukhumwit 64	1,500	640	
74	"	1,000	"	
75	Soi Sukhumwit 77	1,000	320	
76	"	"	"	

APPENDIX C

FLOOD PROTECTION/DRAINAGE SYSTEM

APPENDIX C FLOOD PROTECTION/DRAINAGE SYSTEM

Table of Contents

List of Tables

List of Figures

APPENDIX C FLOOD PROTECTION/DRAINAGE SYSTEM

This Appendix describes the recommended flood protection/drainage system, consisting of flood protection system for the flood water flowing from outer areas or the Chao Phraya River, and storm water drainage system for carrying internal storm-water away to the River. The planning of facilities proposed in this Appendix are described in the Appendix D.

1 FLOOD PROTECTION BARRIER (DYKE)

1.1 General

The flood protection and drainage measures in Bangkok is fundamentally an establishment of polder system i.e., the external flood water is blocked by the peripheral flood barrier and the rain-water inside the polder is drained out by gravity, or by pumping.

The study area is consisted of three polders that are Bang Khen-Bang Sue, Phra Khanong and Bang Na polders. These polders are surrounded by a so called outer protection barrier which is 103.4 km long. Besides there are inner barrier of 30.7 km which is located at the border of these three polders and a inner polder (See Fig. C.1).

Almost all sections of these barrier are located on the existing roads and railways having sufficient elevation at present and even for the year 2000. Some is located on the barrier to be constructed by City Core Project. Therefore, required sections to be constructed in this project are parts of Section 1 and 5 as shown in Table C.1 and Fig. C.1.

Along the flood protection barriers, the control gates are planned to be constructed at the necessary places shown in Table C.2 and Fig. C.1. At present, there are many gates, or wooden gates which are of temporaory nature and considered to be improved to permanent type. As the control gate to be constructed/reconstructed in the feasibility study, 4-gates are selected which are located in the main klongs Phra Khanong, Saen Saep, Son and Lolae.

1.2 Alignment of Flood Protection Barrier

1.2.1 Along the Chao Phraya River (A part of the Section 1)

In the Master Plan, the barrier (6.8 km) between the Phra Khanong Pumping Station and border of Bangkok and Samut Prakan province are proposed to be newly constructed.
However, the 3.4 km long barriers (1.6 km in downstream side of the Phra Khanong Pumping Station and 1.8 km long in Port area) are not included in the Feasibility Study from the following reasons;

a) The 1.0 km retaining wall was newly constructed in 1984 from Phra Khanong Pumping Station to down stream. Crest elevation of the wall is +1.90 MSL and in near future it is planned to be raised to sufficient height.

b) The retaining wall of 0.6 km long, adjacent to the above mentioned section is also planned to be constructed in near future.

c) It is not required to construct new barrier of 1.8 km in Port Authority area since +2.35 crest elevation of existing quay is enough height against +1.90 of the river high water.

For the other part of Section 1 (3.4 km), there exists retaining wall of the Petroleum Authority, private company and the Navy along the river. New barriers are needed to be constructed because the existing crest level of +1.2m is insufficient. For the study of the barrier of 3.4 km in Section 1, two alternatives of the barrier alignments have been considered along the Na Krom road and the Chao Phraya River bank as shown in Fig. C.2. As a result, the alignment along the river is adopted for the protection of the entire riverine area. The exact location of the barrier shall be determined by the land owners in riverine area taken into account the function and usage of the land.

1.2.2 Along Klong Tub Chang Bon (A part of Section 5)

For the alignment of the barrier along Klong Tub Chang Bon in section 5, two alternatives were considered i.e., connected straight route in shortest length and along K. Tub Chang Bon (See Fig. C.2).

In order to minimize land acquisition and to protect the entire riverine area, the alignment along Klong Tub Chang Bon is adopted. This recommended barrier alignment is the same as the present DDS paln.

1.3 Barrier Height

1.3.1 Planning Conditions

For the planning of the barriers to prevent outside water, the following conditions are set out;

(1) Flood level of Chao Phraya River
The 100 years frequency flood level of 1.90 meter above MSL is adopted for the design of crest elevation of the barrier along the Chao Phraya River (Fig.C.3). In the City Core Project and Samut Prakan Project, the same 100 year frequency water levels were adopted.

(2) Flood level along the Eastern Border of Master Plan.
The 5 year frequency flood levels are adopted for barrier along K.Tub Chang Bon at border of the Study Area, same design criteria for the trunk facilities (Fig. C.1 and C.3).

(3) Land subsidence and settlement
The crest level of the barrier should be considered in relation to the land subsidence estimated as 1.0 meters in the target year 2000 as described in Master Plan Report. In view of the staged construction implementation, however, half of the estimated land subsidence (50cm) is considered in this feasibility stage for the barrier along the Chao Rhraya River.

As for the port structure with pile foundation, the settlement due to land subsidence is considered half of above mentioned in this stage; (0.25 m).

In addition, settlement of embankment fill normally occurs immediately after placing and continues for a long time, caused by consolidation of the lower soft ground layers. In this stage, 25% of embanked height (H) is considered for the proposed barrier along the Klong Tub Chang Bon (3% for embankment fill, 22% for subsoil).

(4) The flood barrier should be planned to have a freeboard taking into account the effects of waves and a safety allowance. Considering the importance of the proposed barriers, a freeboard of 30 cm has been adopted along the Chao Phraya River and the eastern border of Master Plan Area.

1.3.2 Barrier Height

(1) Along the Chao Phraya River (Section 1)
The required crest elevation of the Section 1 is determined to be +2.2 m MSL based on the river high water level of 100 year frequency (+1.90 m) plus freeboard of 0.3 m. Therefore, the barrier height above the estimated ground elevation of +0.7 m MSL considered 50 cm land subsidence is approximately 1.5 m.

(2) Along Klong Tub Chang Bon (Section 5)
The crest elevation of the Section 5 (embankment type) is adopted to be +1.50 m same as the BMA (DDS)'s construction plan. This value is justified based on the design water level (+0.84 MSL at present) of 5 year frequency plus freeboard of 30 cm, and settlement of embankment 38 cm (=0.25H).

Table C.1 PROPOSED FLOOD BARRIER

Polder	Section	Location	Proposed Barrier in M/P					Proposed Barrier in F/S						Remarks
			Length	Required Crest Elev.	Design W.L.	Free Board	Land Subsid.	Utilized. Exist.			To be Newly Constructed			
								Type	Length	Crest Elev.	Type	Length	Crest Elev.	
			Km	(MSL)m	(MSL)m	m	m			(MSL)m			(MSL)m	
Bang Na	1	Along Chao Phraya River(Phrakhanong P.S to Samut Prakhang Border)	6.8	+3.20 (+2.20)	+1.90	0.30	1.00	Conc. Wall Quay Wall	3.4	1.9-2.3	Conc. Wall	3.4	+2.70	In F/S, 50 cm land subsidence is considered
Phrakhanong	2	Along City Core Boundary	19.4	+1.10 (+0.10)	+0.80 (-0.20)	0.30	1.00	City Core Boundary	19.4	+1.00	--	--	--	
Bangkhen Bang Sue	3	Along Railways in Nonthaburi	20.9	+0.90 (-0.10)	+0.60 (-0.40)	0.30	1.00 0.70	Railway	20.9	+2.40	--	--	--	
Bangkhen Bang Sue Phrakhanong	4	Paholyothin Rd. and Ram Intra Rd.	26.4	+1.40 (+0.40)	+1.10 (+0.10)	0.30	0.70 1.00	Roads	26.4	+1.80	--	--	--	
Phrakhanong	5	Along K.Tuby Chang Bon, On Nut Rd. and Bang Na Trad. Rd.	29.9	* +1.5 (+0.12)	+0.84 (-0.18)	0.30	1.00	Roads	9.2	+1.50	--	--	--	
Bang Na				+0.66 (-0.34)	(+0.36) -0.64			--	--	--	Embankment	1.7	+1.50	
								Roads	19.0	+1.00	--	--	--	
Bangkhen Bang Sue Phrakhanong	6	Along Bang Sue and Lat Phrao	12.1	+0.95 (-0.05)	+0.85 (-0.15)	0.10	1.00	Roads	12.1	+1.10	--	--	--	
Phrakhanong Bang Na	7	Along On Nut Rd.	5.6	+0.7 (-0.10)	+0.6 (-0.20)	0.10	1.00	Roads	5.6	+0.80	--	--	--	
Phrakhanong	8	Surrounding Ramkhamhaeng Area	13.0	+0.70 (-0.30)	+0.60 (-0.40)	0.10	1.00	Roads Railway	13.0	+1.00	--	--	--	
			Km						Km			Km		
Total			134.1	--	--	--	--	--	129.0	--	--	5.1	--	

1) * For earthfill structure, in this figure, settlement of 36cm is added.
2) Figure in ( ) shows future elevation considering land subsidence.

Table C.2 Proposed Gate

Polder	Section	Proposed Gate in M/P			Proposed Gate in F/S		
		Number of Station	Gate Width (m)	Klong width (m)	Utilizing Existing Gate	To be constructed in future	To be newly constructed
Bang Na	I	PP(3)	8-12	10-15	EP(3)	-	-
		P(4)	4	10	E(4)	-	-
Phrakhanong	II	PP(1)	36	36	EP(1)	-	-
		P(3)	-	-	-	* 3	-
Bang Khen-Bang Sue	III	PP(3)	8-24	10-25	EP(3)	-	-
Bang Khen-Bang Sue Phrakhanong	IV	P(6)	4	10	E(6)	-	-
		3	6	19-42	-	-	P(3)
Phrakhanong	V	P(14)	4	10	E(14)	-	-
Bang Na		P(1)	6	35	-	-	P(1)
BangKhen-	VI	PP(1)	6	10	-	-	PP(1)
Bang Sue		P(2)	4	10	E(2)	-	-
		P(2)	4	10	-	2	-
Phrakhanong	VII	PP(3)	6	10	-	-	PP(3)
Bang Na		P(2)	4	10	E(2)	-	-
Ramkhamhaeng	VIII	PP(1)	6	10	-	-	PP(1)
		P(6)	4	10	E(6)	-	-
TOTAL		55	-	-	41	5	P(4)+PP(5)

Figure in ( ) shows number of gate station

E : Existing Gate

EP : Existing Gate at P.S.

P : Gate to be newly constructed in F/S

PP : Gate to be newly constructed at P.S. in F/S

* : Gate to be constructed by City Core project

2. Drainage System

Drainage facilities which will contribute to alleviate overall floodings and local flooding in the highly urbanized, are proposed to be implemented at the first stage of Master plan and to be the objectives for the Feasibility Study. Therefore, these facilities are reviewed and presented in section 2.4. Firstly, criteria for hydraulic study and hydraulic model are explained in sections 2.2 to 2.3 in order. Section 2.5 deals with hydraulic study for economic analysis.

2.1 Modified Drainage Works

The drainage facilities for the Feasibility Study proposed by the Master Plan, are as follows;

- pumping station with gate : 5 stations
- klong improvement : 75 km
- main drain pipe : 21 km^2 (30 km)

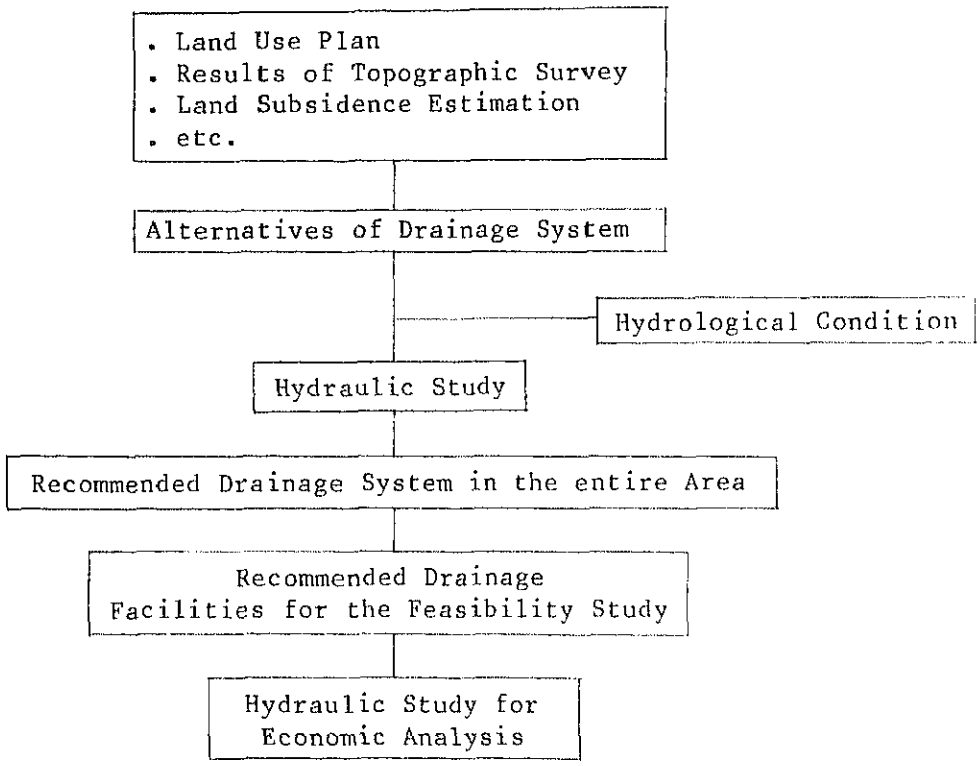
These facilities are located mainly in Bang Na polder, Ramkhamhaeng polder, west Huay Kwang drainage area and Bang Sue drainage area. Therefore, the drainage system in these polders are reviewed from the result of field reconnaisance, survey of klongs and roads, etc.

Further primary drainage system in Phra Khanong polder is reviewed because this polder consists of west Huay Kwang drainage area, Ramkhamhaeng polder etc. As a result, some klongs and drains for the Feasibility Study proposed by the Master Plan are modified as shown in Table C.3 and Fig. C.4.

Table C.3 Modified Drainage Works

Items	Proposed by Master Plan	Modified by Feasibility Study
Pumping Station	5 stations ° Bang Sue ° Kacha ° Gig ° Bang Na Chine ° Bang Na	5 stations ° Huay Kwang ° Saen Sab ° Bang Na Chine ° Bang Lai ° Klet
Klong Improvement	75 km	93 km
Pipe Improvement	30 km	4 km

Procedure of the hydraulic study in this section is shown below.



Flow Chart of Hydraulic Studies

2.2 Criteria for Hydraulic Study

2.2.1 Basic Conditions

(1) Land Use

Existing land use is shown in Fig. C.5. Land use in 2000 as shown in Fig. C.6 is planned based on existing land use, future population, future urbanized area, flood risk in each area (which are explained in section 2 of Appendix F) etc. These land uses at present and in future, which govern run-off discharge, are the base for the hydraulic study.

(2) Topography

Existing ground elevation is shown in Fig. C.7 which are surveyed by the JICA Study Team during Preliminary Study, Master Plan and Feasibility Study. Ground elevation in 2000 is estimated as shownm in Fig. C.8 taking into account of land subsidence of 1.0 to 0.7 meter and land reclamation in future urbanized area. These ground elevations are the base for the hydraulic study.

2.2.2 Hydrological Conditions

Hydrological conditions are in principle the same as those of the Master Plan (Refer to section 6 of Appendix H, Master Plan). Followings are the main items:

(1) Rainfall Intensity

Fig. C.9 shows rainfall intensity-duration curves at Bangkok station.

(2) Rainfall Pattern

Type : Front concentration type

Duration : 6 hours

(3) Areal Reduction Factor

Areal rainfall in each polder is determined by applying reduction factor as shown in Fig. C.10 to point rainfall.

2.2.3 Design Criteria for Facilities

(1) Return Period of Rainfall and Water Level

The drainage system is designed with a 2-and 5-year return period rainfall in combination with a 100-year return period Chao Phraya river level as shown in Fig. C.11 (+1.9m in Bang Na and Phra Khanong polders, and +2.1 m in Bang Khen-Bang Sue polder). The 5-year return period rainfall is applied only to the following primary (trunk) facilities in the Phra Khanong Polder:

- Klongs Phra Khanong, Tan and Saen Saeb
- Phra Khanong pumping station

(2) Maintenance Water Level in Klongs

Maintenance water level in klongs are planned as shown in Table C.4. The levels are defined as the level to be maintained just upstream of the pumping station during rainy season, aiming at increasing storm-water retention in klongs for decrease of the scale of drainage facility.

Table C.4 Maintenance Water Level in Klong

Polder Area	Maintenance Water Level	
	Present	Future (in 2000)*
Bang Khen - Bang Sue	-0.80	-1.50
Phra Khanong	-0.80	-1.80
Bang Na	-0.80	-1.80
North Hua Mark (Within Phra Khanong Polder)	-0.80	-1.80

* considering land subsidence