

**THE KINGDOM OF THAILAND
MINISTRY OF INTERIOR
PUBLIC WORKS DEPARTMENT**



**FEASIBILITY STUDY OF
FLOOD PROTECTION AND DRAINAGE PROJECT
IN SAMUT PRAKAN EAST**



VOLUME I : EXECUTIVE SUMMARY

PREPARED BY

ENGINEERING CONSULTANCY SERVICES CENTER

THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

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AUGUST 1988

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Smith Kampeemool

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GOVERNOR



AUGUST 1988



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เรื่อง ส่งรายงานฉบับสุดท้ายของงานศึกษาความเหมาะสม
โครงการป้องกันน้ำท่วมสมุทรปราการฝั่งตะวันออก

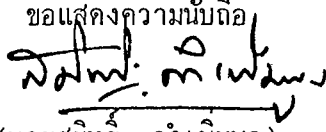
เรียน อธิบดีกรมโยธาธิการ

อ้างถึง สัญญาเลขที่ 33/2529 ลงวันที่ 19 กันยายน 2529

สิ่งที่ส่งมาด้วย รายงานฉบับสุดท้ายของงานศึกษาความเหมาะสมโครงการ จำนวน 50 ชุด

ตามสัญญาที่อ้างถึง กรมโยธาธิการ กระทรวงมหาดไทย ได้มอบหมายให้สถาบันวิจัย
วิทยาศาสตร์และเทคโนโลยีแห่งประเทศไทย (วท.) ทำการสำรวจศึกษาเพื่อกำหนดแผนหลักศึกษา
ความเหมาะสมโครงการ และออกแบบรายละเอียดของระบบป้องกันน้ำท่วมและการระบายน้ำ
จังหวัดสมุทรปราการฝั่งตะวันออกของแม่น้ำเจ้าพระยา ซึ่ง วท. ได้ดำเนินการเสร็จเรียบร้อยครบ
ถ้วนทุกประการ จึงขอส่งมอบรายงานฉบับสุดท้ายของงานศึกษาความเหมาะสมโครงการ จำนวน
50 ชุด ซึ่งได้ปรับปรุงแก้ไขจากรายงานฉบับร่างตามข้อเสนอแนะจากคณะกรรมการที่ปรึกษาและผู้ที่เกี่ยวข้องแล้ว โดยมีรายละเอียดปรากฏในสิ่งที่ส่งมาด้วย

วท. หวังเป็นอย่างยิ่งว่า ผลงานในโครงการนี้จะเป็นประโยชน์ต่อการพัฒนา
จังหวัดสมุทรปราการ ให้เจริญก้าวหน้าอย่างรวดเร็วตามความมุ่งหมายของราชการ และขอขอบคุณ
ต่อกรมโยธาธิการ ที่ได้ให้เกียรติและส่งเสริมให้มีการร่วมมือกันระหว่างหน่วยงานภาครัฐบาล เพื่อ
ช่วยกันพัฒนาประเทศในโครงการนี้ และหวังเป็นอย่างยิ่งว่าจะได้มีโอกาสได้ร่วมมือกันในโอกาสต่อไป
อีกด้วย

ขอแสดงความนับถือ

 (นายสมิทธิ์ คำเพิ่มพูล)

ผู้ว่าการ

ศูนย์บริการวิศวกรรมที่ปรึกษา

โทร. 5797529

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Thailand Institute of Scientific and Technological Research (TISTR) wishes to thank Public Works Department (PWD) for privileged opportunity in undertaking this feasibility study for flood protection and drainage of Samut Prakan East.

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TISTR feels greatly indebted to the following governmental agencies. The Royal Thai Survey Department provided a full cooperation in making up-to-date and top quality aerial photographs which were a crucial input necessary for the timely improvement planning of the flood protection and drainage facilities. Department of Town and Country Planning furnished its recently prepared 1:4 000 cartographic maps covering the project area. The Office of the National Environment Board allowed access to its reference bench marks in Samut Prakan, which have been used as reference datum in this project. A number of local government offices and private sector provided useful data and

BOARD OF PROJECT ADVISERS
 FLOOD PROTECTION AND DRAINAGE PROJECT
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Chinda	Kulwatto	Public Works Department
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Arporn	Thavisuwan	Samut Prakan Province
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Virat	Khaoupptum	Royal Irrigation Department
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Vichien	Tiendam	Department of Highways
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Kraisorn	Udomratn	Department of Town & Country Planning
Sunthad	Somchevita	Office of the National Environment Board
Pornchai	Taranatham	Office of the National Environment Board
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FOR SAMUT PRAKAN EAST

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Vithaya	Songporn	Samut Prakan Province
Sombhop	Unhawat	Public Works Department
Kitti	Areeraksakul	Public Works Department
Rajatin	Syamananda	Public Works Department
Thiraphan	Thongpravat	Public Works Department
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		Pranom	Nuchprasoed
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GLOSSARY AND ABBREVIATIONS

(A) GENERAL

<u>ABBREVIATION</u>	<u>DESCRIPTION</u>
A.D.	anno Domini
B.E.	Buddhist Era
BOD, BOD ₅	Biochemical Oxygen Demand
DO	Dissolved Oxygen
FY	Fiscal Year
GPP	Gross Provincial Product
Klong	Canal (Thai word)
MPN	Most Probable Number
msl, MSL	Mean Sea Level
NEB	Office of the National Environment Board
NESDB	National Economic and Social Development Board
p.a.	Per Annum
PWD	Public Works Department
RID	Royal Irrigation Department
TDS	Total Dissolved Solids
TISTR	Thailand Institute of Scientific and Technological Research

(B) UNITS OF MEASUREMENT

<u>ABBREVIATION</u>	<u>FULL NAME</u>	<u>DESCRIPTION</u>
฿, B	baht	Thai Currency
฿, MB	million baht	Thai Currency
°C	degree Celsius	Temperature Unit
cfs, ft ³ /s	cubic foot per second	Flow Rate Unit
d	day	Time Unit
cm	centimeter	Length Unit
cms, m ³ /s	cubic meter per second	Flow Rate
ft	foot	Length Unit
gal	U S gallon	Volume Unit
g, gm	gram	Weight or Mass Unit
gpm	U S gallon per minute	Flow Rate
GWh	gigawatt-hour	Energy Unit
ha	hectare	Area Unit
h, hr	hour	Time Unit

GROSSARY AND ABBREVIATIONS (CONT'D)

(B) UNITS OF MEASUREMENT (CONT'D)

<u>ABBREVIATION</u>	<u>FULL NAME</u>	<u>DESCRIPTION</u>
HP	horse power	Power Unit
Hz	hertz (cycle per second)	Frequency Unit
JTU	Jackson turbidity unit	Turbidity Unit
kg	kilogram	Weight Unit
km	kilometer	Length Unit
kV	kilovolt	Electric Potential Unit
kVA	kilovolt-ampere	Electric Power Unit
kW	kilowatt	Power Unit
kWh	kilowatt-hour	Energy Unit
l	liter	Volume Unit
lb	pound	Weight or Mass Unit
lpcd	liter per capita per day	Water Consumption Rate
mcm, MCM	million cubic meter	Volume Unit
MW	megawatt	Power Unit
MWh	megawatt-hour	Energy Unit
m	meter	Length Unit
m(msl), m MSL	meter above mean sea level	Elevation Unit
mm	millimeter	Length Unit
m ³ /s, cms	cubic meter per second	Flow Rate
mg	milligram	Weight or Mass Unit
mg/l	milligram per liter	Density Unit
μmho	micro-mho	Electric Conductance Unit
μg	microgram	Weight or Mass Unit
ngan	ngan	Thai Unit Measurement of Area
NTU	Nephelometric turbidity unit	Turbidity Unit
ppm	part per million	Density Unit
ppt	part per thousand	Density Unit
Rai, rai	rai	Thai Unit Measurement of Area
rpm	revolution per minute	Angular Velocity
s, sec	second	Time Unit
sq km	square kilometer	Unit Measurement of Area
yr	year	Time Unit
wa	wa	Thai Length Unit

CONVERSION TABLE

1 inch	=	2.54	cm
1 inch	=	25.4	mm
1 mile	=	1.6093	km
1 km	=	0.6214	miles
1 ft	=	0.3048	m
1 m	=	3.28	ft
1 wa	=	2	m
1 ft ²	=	0.0929	m ²
1 m ²	=	10.7584	ft ²
1 hectare	=	6.25	rai
1 acre	=	2.53	rai
1 km ²	=	100	hectares
1 rai	=	1 600	m ²
1 ngan	=	400	m ²
1 ft ³	=	0.0283	m ³
1 m ³	=	35.31	ft ³
1 mcm	=	1 000 000	m ³
1 cfs	=	0.0283	cms
1 cms	=	35.31	cfs
1 MkWh	=	1 000 000	kWh
1 GWh	=	1 000 000	kWh
1 MW	=	1 000	kW
	=	1 000 000	W
1 kg	=	2.205	pounds
1 ton	=	1 000	kg



EXECUTIVE SUMMARY
FEASIBILITY STUDY OF FLOOD PROTECTION AND DRAINAGE
PROJECT IN SAMUT PRAKAN EAST

BACKGROUND

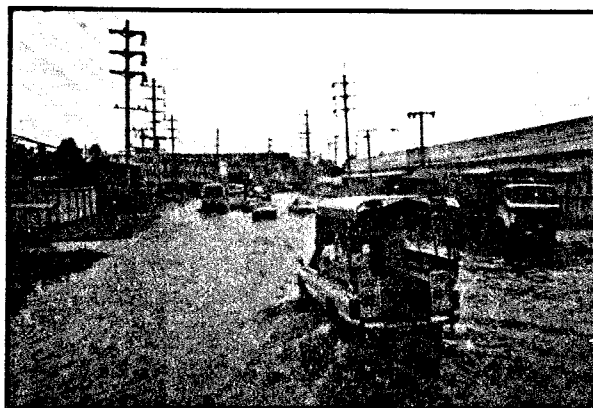
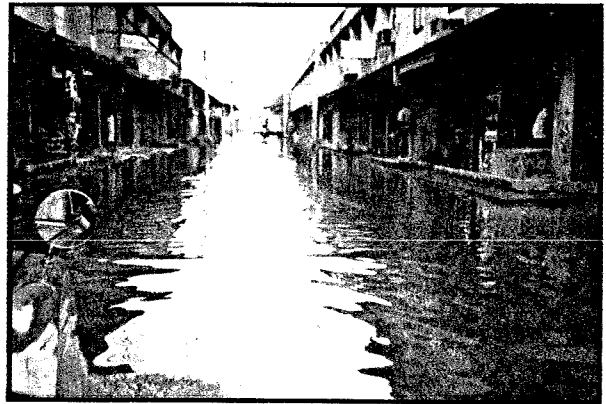
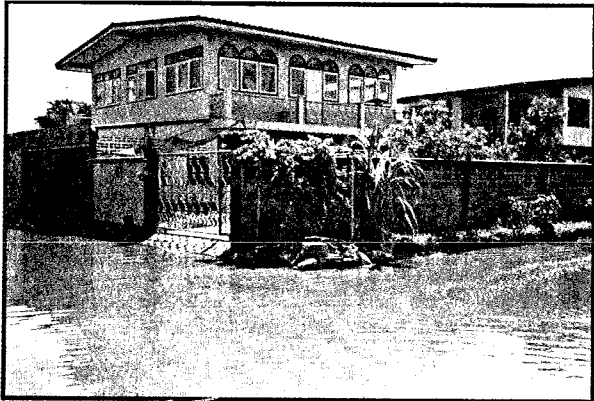
Samut Prakan East is a relatively flat land having ground elevation close to the mean sea level, and covers the whole area of Samut Prakan province on the east bank of the Chao Phraya river. Majority of the 512 000 population of Samut Prakan East lives in about 220 square kilometers area on the west of the King's flood protection dike (Figure 1). Samut Prakan plays a significant role in economics, especially in industry and trading. In 1985 its annual industrial products value was about 9 800 million baht, or about 68.5 percent of its gross provincial products. In 1986 taxes revenue from Samut Prakan was 4 400 million baht per annum, which was the second highest of the country, and inferior only to Bangkok.

In the past 4-5 years, Samut Prakan areas adjacent to the Gulf of Thailand have been faced with increasing flood problems. These include floods caused by heavy rainfall similar to Bangkok which is located just to the north, and frequent floodings at high tides even during periods with no rain. The tidal floodings are relatively predictable, and have occurred during a period from October through January. The frequency of floodings average about 7 days per month, and last about 4 hours per day. These frequent floodings which constantly cause repeated losses and inconveniences to the area definitely deserve immediate attention. After the 1983 record flood in Bangkok and its vicinity area much efforts have been spent in investigations and implementation aiming to mitigate the damaging flood problems. In the eastern suburban area of Bangkok, a

master plan using the polder type system was adopted. According to such plan, it is necessary to drain flood water from about 240 square kilometers area, known as flood "retarding area", through Samut Prakan East for subsequent drainage into the Chao Phraya river. Therefore, a properly planned drainage and flood protection system in Samut Prakan East area is needed to enable coordinated drainage on the east bank. The Department of Public Works has, therefore, authorized TISTR to carry out the flood protection and drainage project for Samut Prakan East, commencing on 25 September 1986. After a master plan preparation in the first 12 months, a feasibility study of the flood protection and drainage project as proposed for the master plan area has been scheduled for another 8 months period.

PREVAILING FLOOD PROBLEMS AND REMEDIAL MEASURES

Floodings in the project area may be categorized into 2 types. One type of floodings is due to rising tides and corresponding high stages of the Chao Phraya river, causing overflows of nearby low lands. This is characterized by frequent floodings in a period from October to January for about 7 days per month, and for about 4 hours in each day with this type of floodings. Another type of floodings is a result of heavy rain and inadequate drainage facilities. The frequent floodings have caused economic losses detrimental to economic development in the area for a long time. In addition to the opportunity loss in area development to its full potential, the floodings have adversely affected the local residents in their daily livings due to the degraded living environment caused by decomposition of the long standing flood water. The maximum annual flood losses was estimated at 778 million baht, while the expected value of annual flood losses was estimated at about 384 million baht.



สภาพน้ำท่วมประจำเนื่องจากน้ำทะเลหนุน
REGULAR FLOODINGS AT HIGH TIDES

Of all remedial measures, two projects are assessed to have the most significant effects in providing a short-term relief to lessen flood losses. These are the King's flood protection dike together with dredging of canals in the area, and the short-term flood protection and drainage works for the polder system serving the most populated center of Samut Prakan. Although the flood problems have been relieved to a certain degree in some parts of the project area, there is still a definite need for further improvement to adequately cope with the remaining problem. Areas needing immediate attention include the area along the Chao Phraya river to the west of Sukumvit road, and the area along the gulf coast south of Sukhumvit road. These areas are presently not yet protected from high tides and high river stages, thus subjected to frequent floodings even during fair weather. Even in the project area east of Sukhumvit road which is presently protected from tidal floodings improvement of main drainage system is still necessary.

MASTER PLAN FOR FLOOD PROTECTION AND DRAINAGE

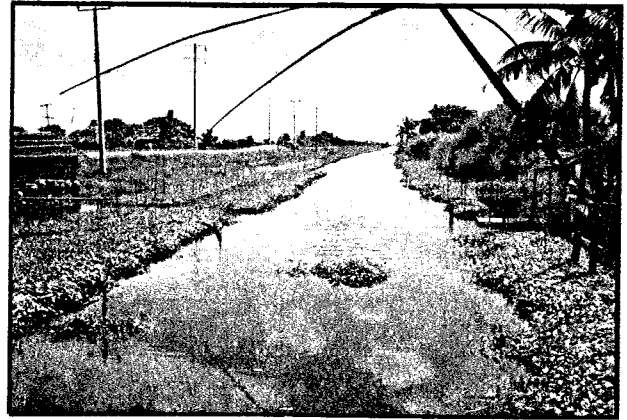
Flood protection and drainage system proposed in the master plan, which would be adequate for future land use in the year 2001, consists of the followings :

Flood barrier	53.4	km
Gates	28	gates
Pumping station	13	stations with 133 cms capacity
Main drain canals and pipes		
a. New drain canals	29.1	km
b. Canal improvement	60.4	km
c. Main drain	73.8	km
Sub-total canals and pipes	163.3	km
Flood retention storages	126	rai

The proposed flood protection system includes flood barrier of various designs and equipped with necessary appurtenant structures. The system is intended to prevent overflow from outside the flood protection area, and also from one polder to the others. With the exception of about 41 km flood barrier along the Chao Phraya river and along the Gulf, most of the proposed flood barrier will be existing roads and other existing structures which can be used with very minimum improvement cost. Different designs suitable to the existing land use are adopted for the flood barrier along the river and the Gulf, with only about 5.75 km being the relatively high cost structure(master pile with panel and anchorage).

The proposed main drainage system consists of main drain canals, main drain pipes, pumping stations, and flood retention storages. The system has been designed to be adequate for 5 year short duration rainfall (72 mm/hour for 60 minute duration) for most of the area. For the area served by main drain pipes a 2 year short duration rainfall was adopted (59 mm/hour for 60 minute duration). Drainage in the master plan area has been designed as 3 independent polders (Figure 2), including Klong Samrong polder, Pak Nam polder, and Klong Bang Nang Greng polder. Each polder would be drained by its main drainage system for discharging into the Chao Phraya river through its pumps and gates.

Along Sri Nakharin road which serves as the inner flood barrier (Figure 2) control gates have been planned for all canal crossings. During flood season water from the retarding area in Bangkok and from the flood relief area are planned to be drained to the south through a system of improved canals, for emptying into the Gulf mainly through the new gate planned at the flood barrier near the river mouth (Figure 2). During high tides when the gate has to be closed water has to be temporarily stored in the improved canal network and low areas in the flood relief area. The stored water is drained through the gate as soon as the tide



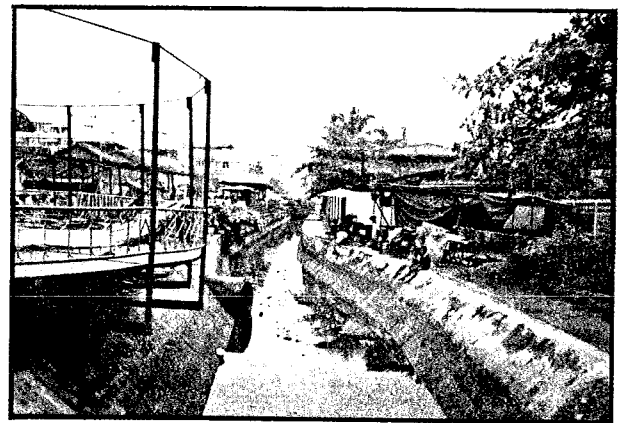
คันกั้นน้ำพระราชดำริป้องกันน้ำท่วมด้านตะวันออกของพื้นที่

KING'S DIKE SERVING AS FLOOD PROTECTION BARRIER ON THE EAST



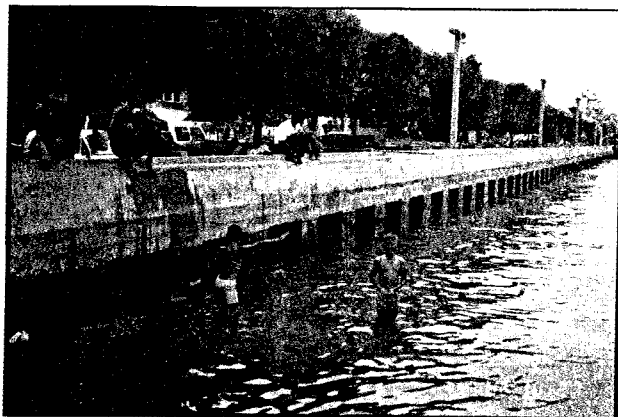
น้ำสันคันกั้นน้ำที่สร้างไว้ริมแม่น้ำเจ้าพระยา

OVERTOPPING OF OLD FLOOD WALL
ALONG THE CHAO PHRAYA RIVER



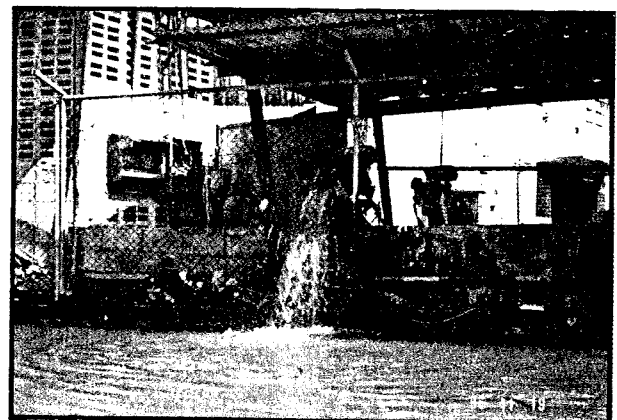
คลองโพงพางที่ปรับปรุงใหม่

RECENTLY IMPROVED KLONG PONG PANG



เขื่อนกั้นน้ำริมแม่น้ำเจ้าพระยาที่ปรับปรุงใหม่

IMPROVED FLOOD WALL ALONG THE
CHAO PHRAYA RIVER NEAR THE
PROVINCIAL OFFICES



การป้องกันน้ำท่วมด้วยตนเองของโรงงาน

CONCRETE WALL WITH PUMP-A
TYPICAL SELF FLOOD PROTECTION
OF INDUSTRIAL PLANTS

recedes to an elevation lower than the water level just upstream of the gate. Hydraulic analyses by mathematical models indicate that the proposed drainage system can adequately drain 2 year rainfall in the flood relief area.

IMPROVED FLOOD PROTECTION AND DRAINAGE SYSTEMS ADOPTED

IN THE FEASIBILITY STUDY

During the feasibility study period detailed improvement has been made on the flood protection and drainage system proposed in the master plan. Emphasis has been on the suitability of the system components with existing site condition, mainly to facilitate actual construction. Gate sizes in all polders have been economically optimized. Reviews and modifications have been made on drainage systems, to make them most suitable to the existing site conditions and most economical. Additional and more detailed field survey results have been employed together with hydraulic analyses using mathematical models. Then, through a process of economic optimization subjecting to engineering and practicality constraints, the optimum and most appropriate drainage system components are adopted for each polder.

For Klong Samrong polder, additional consideration has been made on the appropriate site for the Samrong gate and pumping station. The proposed site has been concluded at a location of about 400 m from the Chao Phraya river, where a navigation lock which can accommodate a 8.5 m wide boat with 2.0 m draft has also been proposed.

For the flood relief area, improvement have been made on the design of the Hua Lamphu gate. Its crest has been raised 0.40 m higher than the design in the master plan, so that only a very minimum dredging downstream of the gate will be required. This should result in a much

reduced maintenance of the outlet channel. The design of flood barrier along the Gulf has also been improved to be reinforced concrete wall on concrete piles.

The adopted flood protection and drainage systems for the three polders and the flood relief area, as planned for future land use in the year 2001, are shown in Figures 3, 4, 5 and 6 and can be summarized as follows:

Flood barrier	58.7 km
- Along Chao Phraya river	25.0 km
- Along the Gulf	12.6 km
- Inner barrier improvement	4.3 km
- Temporary barrier	16.8 km
Gates with pumping stations 8(2*) sites totaling	
88.5 (9.35) cms	
Gates	15(6) gates
- For flood protection and drainage	4(1) gates
- For dry season drainage	11(5) gates
Pumping station 1 station	1.5 cms
Main drain canals	95.9 km
- New canals	13.4 km
- Canal improvement	82.5 km
Main drain pipes	51.1 km
Flood retention storages with appurtenance structures	8 sites
- Land aquisition	206.5 rai
- Pumps	11.5 cms
- Gates	3 gates

* Number in parenthesis indicates existing item

IMPLEMENTATION SCHEDULE AND PROJECT INVESTMENT

Project cost estimate base on preliminary designs of all proposed project components, as planned for future land use in A.D.2001, indicates a total investment cost of about 2 088 million baht (end of 1986 price), as summarized in Table 1.

Present drainage requirement in the project area is considerably less than the future requirement due to the presently less intense land use. Therefore implementation of the planned project components is scheduled in phases corresponding to the existing land use, in conformance with budget aquisition plan, and suitable to priority ranking of different parts of the project area :

- (a) The first phase implementation to mitigate the prevailing frequent floodings by emphasizing flood protection system construction, together with only necessary improvement of drainage system using low cost measures (such as dredging). Land aquisition is, however, included to facilitate future construction. This first phase is scheduled for 3 years.
- (b) The second phase implementation to improve the flood protection and drainage systems to be adequate for the existing land use in the beginning of this phase, and to be adequate for the increasing land use at the end of this phase. This second phase has been scheduled for the final 4 years of the NESDB 7th five years plan (fiscal year 1993-1996).

The first phase work as planned for the first 3 years is the absolute minimum implementation, which should be carried out to expeditedly mitigate the long lasting losses from frequent and almost permanent floodings in many parts of the project area. To have adequate

TABLE 1
COST OF FLOOD PROTECTION AND DRAINAGE SYSTEMS

Item	Cost, million baht				
	Klong Samrong polder	Pak Nam polder	Klong Bang Nang Greng polder	Flood relief area	Total project
1. Flood barriers	78.940	95.011	120.230	111.091	405.272
2. Gates with pumping stations and appurtenance structures	119.720	43.196	59.252	-	222.168
3. Gates	4.650	25.726	6.322	26.460	63.158
4. Pumping stations	14.793	4.494	-	-	19.287
5. Main drain canals and pipes					
(1) New drain canals	1.702	41.511	4.242	10.736	58.191
(2) Canal improvement	178.744	205.387	87.435	3.088	474.654
(3) Main drain pipes	387.504	63.078	81.846	-	532.428
Sub-total item 5	567.950	309.976	173.523	13.824	1 065.273
6. Flood retention storages with pumping stations, gates, and appurtenance structures	62.885	36.441	-	-	99.326
7. Land aquisition and properties compensation	86.818	28.959	79.086	19.055	213.918
Total (end of 1986 price)	935.756	543.803	438.413	170.430	2 088.402
* Total (May 1988 price)	1 008.073	590.957	472.307	183.198	2 254.535

* All costs in this report are based on prices in August 1986 when this investigation commenced. For convenient reference to the price level at this report preparation time, the project costs have been adjusted to May 1988 price base on the comparison of the May 1988 material costs as related to each type of project components.

flood protection and drainage systems for the existing land use, some of the proposed works in the fourth through seventh year have to be implemented (see Figure 7 and Table 2).

The first 3 years implementation which is the absolute minimum implementation requires about 1 153 million baht investment (Table 3). The additional works necessary for the existing land use requires about 317 million baht additional investment. Therefore, the total investment required for the present land use amounts to about 1 470 million baht.

PROJECT BENEFIT AND ECONOMIC FEASIBILITY

The implementation of the proposed flood protection and drainage systems as planned for future land use will prevent the master plan area from flooding for all events with the tides or the Chao Phraya river stages not exceeding +2.0 m (msl), or 100 year tide and river stage. Even with high tides, the improved main drainage system as proposed will be capable of draining the 5 year short duration rainfall (72 mm/hour for 60 minute duration). Most of the area will be at least 0.5 m higher than the maximum stage in the nearby main drain, thus adequate head will be available for draining the land area. Only exceptions are the areas planned to be served by main drain pipes where 2 year rainfall was adopted for drainage design (59 mm/hour for 60 minute duration). Even in such areas, in the event of 5 year rainfall the maximum water levels in main drains will still be lower than general land elevation. Inadequate drainage with only local pondings will be of short duration due to much improved drainage capability.

Long period flooding lasting many days in the event of heavy rainfall for long duration, such as the experience in the 1983 record flood, will have very slim chance of occurring. There will be no flooding for the long duration rainfall not exceeding 5 year rainfall (about 850

TABLE 2
IMPLEMENTATION SCHEDULE

Item	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
<u>KLONG SAMRONG POLDER</u>								
Flood barriers								
Number of sites	4	1	3	-	-	-	-	-
Length, km	7.53	3.18	4.35	-	-	-	-	-
Land acquisition, rai	-	-	-	-	-	-	-	-
Cost, million baht	78.940	30.318	48.622	-	-	-	-	-
Gates, pumping stations and appurtenance structures								
Number of sites	6	2	3	-	-	-	-	1
Land acquisition, rai	4.66	4.66	-	-	-	-	-	-
Cost, million baht	143.045	64.227	69.782	-	-	-	-	9.036
Drain canals								
Number of sites	9	1	2	4	2	-	-	-
Length, km	21.250	4.11	5.83	9.94	1.37	-	-	-
Land acquisition, rai	26.610	8.60	12.34	5.67	-	-	-	-
Cost, million baht	192.449	6.280	6.316	150.665	29.188	-	-	-
Main drain pipes								
Number of sites	34 (8)*	1	-	3	(8)*	7	9	6
Length, km	35.661	0.85	-	8.28	(4.803)*	7.605	8.088	6.035
Land acquisition, rai	0.670	-	-	0.52	0.15	-	-	-
Cost, million baht	389.250	9.184	-	111.698	(51.722)*	80.298	78.852	57.496
Flood retention storages								
Number of sites	3	-	2	1	-	-	-	-
Land acquisition, rai	154.5	44.5	110.0	-	-	-	-	-
Cost, million baht	132.072	46.298	50.663	35.111	-	-	-	-
Total cost for Klong Samrong polder, million baht	935.756* (51.722)	156.307	175.383	297.474	80.910* (51.722)	80.298	78.852	66.532

Item	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
<u>PAK NAM POLDER</u>								
Flood barriers								
Number of sites	5	-	1	3	1	-	-	-
Length, km	18.460	-	2.97	13.78	1.71	-	-	-
Land acquisition, rai	46.95	46.95	-	-	-	-	-	-
Cost, million baht	99.135	4.124	25.823	67.281	1.907	-	-	-
Gates, pumping stations and appurtenance structures								
Number of sites	10	-	1	6	2	1	-	-
Land acquisition	-	-	-	-	-	-	-	-
Cost, million baht	73.416 (11.347)*	-	10.900	44.250	(11.347)*	6.919	-	-
Main drain canals and pipes								
Number of sites	34 (6)*	-	3	5	10 (4)*	5	6 (1)*	5 (1)*
Length, km	29.849	-	1.536	3.660	9.464 (3.557)*	7.263	4.474 (0.836)*	3.452 (0.836)*
Land acquisition, rai	23.020	8.73	14.29	-	-	-	-	-
Cost, million baht	319.902 (73.817)*	4.384	5.795	58.485	92.147 (57.252)*	50.350	45.444 (8.283)*	63.297 (8.282)*
Flood retention storages								
Number of sites	4 (2)*	-	1	1	2*	-	-	-
Land acquisition, rai	48.0	48.0	-	-	-	-	-	-
Cost, million baht	22.495* (5.737)	11.580	2.589	2.589	5.737*	-	-	-
Inner polder(Ruam Pattana)								
Flood barrier,million baht	6.704	-	0.472	6.232	-	-	-	-
Gates,pumps,million baht	4.532	-	-	4.532	-	-	-	-
Land acquisition, million baht	3.329	3.329	-	-	-	-	-	-
Main drain pipes, million baht	(12.563)*	-	-	-	(12.563)*	-	-	-
Flood retention storage, million baht	1.727	-	-	1.727	-	-	-	-
Sub-total Inner Polder, million baht	28.855* (12.563)	3.329	0.472	12.491	(12.563)*	-	-	-
Total cost for Pak Nam Polder, million baht	543.803 (103.464)*	23.417	45.579	185.096	123.701 (86.899)*	57.269	45.444* (8.283)	63.297* (8.282)

TABLE 2

TABLE 2 (CONT'D)

Item	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
<u>KLONG BANG NANG GRENG POLDER</u>								
Flood barriers								
Number of sites	8 (3) [*]	-	2	1	(2) [*]	(1) [*]	1	1
Length, km	19.721 [*] (4.006) [*]	-	1.300	6.757	(2.883) [*]	(1.123) [*]	5.880	1.778
Land acquisition, rai	56.170	11.76	30.23	14.18	-	-	-	-
Cost, million baht	163.677 [*] (34.927) [*]	5.205	47.141	20.387	(10.086) [*]	(24.841) [*]	48.044	7.973
Gates, pumping stations								
Number of sites	9 (2) [*]	-	1	1	(1) [*]	(1) [*]	3	2
Land acquisition	2.75	1.0	-	1.75	-	-	-	-
Cost, million baht	71.088 [*] (22.885) [*]	3.329	17.133	6.010	(19.094) [*]	(3.791) [*]	10.276	11.455
Main drain canals and pipes								
Number of sites	24 (2) [*]	1	2	6	5 (2) [*]	2	3	5 (1) [*]
Length, km	47.327 [*] (5.347) [*]	4.220	8.085	4.181	18.070 (4.020) [*]	2.600	4.025	6.146 (1.327) [*]
Land acquisition, rai	52.0	11.66	24.57	15.77	-	-	-	-
Cost, million baht	203.648 [*] (17.949) [*]	4.543	22.571	58.830	33.655 (1.043) [*]	47.812	14.034	22.203 (16.906) [*]
Total cost for Klong Bang Nang Greng polder, million baht	438.413 (75.761) [*]	13.077	86.845	85.227	62.835 (30.223) [*]	76.444 (28.632) [*]	72.354	41.631 (16.906) [*]

TABLE 2 (CONT'D)

Item	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
<u>FLOOD RELIEF AREA</u>								
Flood barriers								
Number of sites	3 (2) [*]	-	-	1	(1) [*]	(1) [*]	-	-
Length, km	10.912 [*] (8.912) [*]	-	-	2.000	(4.179) [*]	(4.733) [*]	-	-
Land acquisition, rai	182.50	124.69	57.81	-	-	-	-	-
Cost, million baht	124.650 [*] (86.219) [*]	9.269	4.290	24.872	(43.308) [*]	(42.911) [*]	-	-
Gates								
Number of sites	2	-	1	1	-	-	-	-
Land acquisition, rai	-	-	-	-	-	-	-	-
Cost, million baht	26.460	-	13.230	13.230	-	-	-	-
Drain canals								
Number of sites	2	-	1	1	-	-	-	-
Length, km	18.360	-	17.61	0.750	-	-	-	-
Land acquisition, rai	31.12	31.12	-	-	-	-	-	-
Cost, million baht	19.320	5.496	3.605	10.219	-	-	-	-
Total cost for Flood Relief area, million baht	170.430 [*] (86.219) [*]	14.765	21.125	48.321	(43.308) [*]	(42.911) [*]	-	-
Total cost of the whole project, million baht	2 088.402 (317.166) [*]	207.566	328.932	616.118	310.754 (212.152) [*]	256.922 (71.543) [*]	196.650 (8.283) [*]	171.460 (25.188) [*]

Notes

- * = items required after the third year to satisfy the need of the present land use.
- Number of sites represent the number of construction sites in each year. Some of the sites were planned for more than one year construction.
- Details of all construction items are described in the main report of this project.

TABLE 3

PROJECT INVESTMENT COST

Unit : million baht

Fiscal year	Klong Samrong polder	Pak Nam polder	Klong Bang Nang Greng polder	Flood relief area	Total
2533	156.307	23.417	13.077	14.765	207.566
2534	175.383	45.579	86.845	21.125	328.932
2535	297.474	185.096	85.227	48.321	616.118
2536	80.910	123.701	62.835	43.308	310.754
2537	80.298	57.269	76.444	42.911	256.922
2538	78.852	45.444	72.354	-	196.650
2539	66.532	63.297	41.631	-	171.460
Total	935.756	543.803	438.413	170.430	2 088.402

Remark Additional investment after the third year of investment to have adequate systems for the present land use totals 317.166 million baht. As the investment in the first 3 years is 1 152.616 million baht, therefore the total investment which will be adequate for the present land use is 1 469.782 million baht.

mm in the 3 month rainy season). In the event of the 1983 heavy rainfall (about 1 340 mm in 3 months) there will only be much shorter duration floodings, and only in limited low areas. Such floodings should result in about one-fourth of the damages which would result should the heavy rain occur at present, or only about one-eighth of the damages experienced in 1983. Therefore, the proposed flood protection and drainage systems will provide very beneficial physical contribution to flood protection and drainage in the master plan area.

For the flood relief area, the proposed flood protection and drainage system will be adequate for preventing flooding from 100 year tides in the Gulf and in the river mouth, and can adequately drain 2 year rainfall of both long and short durations.

The physical contribution of the proposed flood protection and drainage systems will give rise to both benefit which can be quantified in monetary value, and the real benefit which can not readily be quantified in monetary value. The former benefit consists mainly of the reduction in flood losses due to the project investment, which has been estimated at an expected value of about 243 million baht/year under the existing land use, and increasing to 509 million baht/year under the future land use as planned for A.D.2001.

The implementation of this flood protection and drainage project will give rise to promotion of economic development in the area. It will mitigate inconvenience and hindrance to economic activities caused by floodings, thus will be very significant in promoting area economic development. This will, consequently, enable enhanced utilization of land and properties to their full potential. Besides, quality of life of the local residents will be significantly improved, mainly due to the improvement in daily living environment free from the frequent floodings.

Implementation of the proposed flood protection and drainage project as planned for future land use in A.D.2001 requires an investment of about 2 088 million baht. The investment has been planned in 2 main phases for a total of 7 years, to be completed in the NESDB 7th five years plan (A.D.1992-1996). Comparisons of project benefits to project costs in project economic analyses lead to a conclusion that the project is economically feasible. Direct project benefits exceed the investment cost, as indicated by a benefit-cost ratio of 2.5:1 (4% annual discount rate and 30 years useful life), and return on the investment exceeds opportunity cost of the investment as indicated by 24.8% annual internal rate of return of the project investment.

Therefore, it can be concluded that the proposed flood protection and drainage project for Samut Prakan East is economically and engineeringly feasible. It will give rise to other benefits which can not be quantified in monetary value. Hence necessary steps should be taken to enable project development as planned and proposed, so that the long lasting damages and sufferings from flood problems can be timely mitigated.

FINANCIAL PLAN

Project investment fund was planned to be from 3 sources : 50% from the government budget, 10% from local administrative offices (possibly through special fund allocation from the Ministry of Interior), and another 40% from foreign loan with an average annual interest rate of 4%.

Fund for project operation, maintenance, and replacement was estimated at about 43 million baht per year, which would be the maximum at full project development. This fund was planned to be acquired from local taxes, by improving efficiency in tax collection and improvement in local tax structures. These have been evaluated to be highly feasible, and should not be of any significant burden to local residents.

Fund for loan repayment was planned to be collected from project direct beneficiaries. The collection was planned for only 10 years, commencing one year after the beginning of project construction. Such collected fund should be regarded as a contribution from local beneficiaries for assisting in their own project construction. Shares from different types of project beneficiaries were justly specified according to their relative benefits from the project. For the 2 088 million baht investment the estimated contributions per year were 290 baht for an average house, 331 baht per an average commercial shop, and 26 315 baht per an average industrial plant.

In case of budget limitation and only the first phase investment is adopted, the investment fund will be 1 153 million baht for the first 3 years development. The corresponding fund from the government budget will be 577 million baht, 115 million baht from local administrative offices, and 461 million baht from foreign loan. In this case fund collection for loan repayment will be reduced to 149,170 and 13 520 baht per year per an average size of house, commercial shop, and industrial plant, respectively. It should be noted that if this limited investment scheme is adopted, there should be provision for future additional investment. Otherwise full project benefit will not be realized.

ORGANIZATION AND MANAGEMENT

Analyses of the existing organization and management aspects of flood protection and drainage in Samut Prakan, together with the functional need for overall operation and administration lead to a recommendation of an organization structure having a policy making level and an operational level.

The policy making level would be responsible for overall policy setting, coordination, and overseeing general operation of related offices. It is suggested to be in its existing form of a committee or board, but should have permanent members and have private sector participation. Methods of directing the operation of related offices should be objectively specified to enable close and effective monitoring.

A permanent office is recommended to be established for assuming full responsibility on system operation, maintenance, and related administration. The main purpose of this permanent office is to achieve efficient and smooth operation.

OPERATION AND MAINTENANCE

Because of the severe limitation due to frequent high tides surrounding the project area it is necessary to have efficient drainage system operation in conformance with the varying tides outside the project area. Operation plans should be established for flood control in rainy season, and for water quality management and navigation in dry season. Moreover, operation plan for the flood relief area should be well coordinated with irrigation water requirement in the area.

At present maintenance of the existing flood protection and drainage systems is responsible by many government offices, adopting rather different techniques in their maintenance activities. This practice should be changed for better efficiency. Routine preventive

maintenance is suggested for the system components, including drain canals, main drain pipes, flood barriers, pumping stations, gates, and flood retention storages. Suggested maintenance schedules for these components have already been outlined. Appropriate steps for maintenance operation have been outlined to include tentative maintenance plan preparation, annual inspection, annual maintenance plan preparation, maintenance according to the plan, and monitoring and evaluation for subsequent operation improvement.

HYDRAULIC AND ENVIRONMENTAL IMPACT

Construction and operation of the flood protection and drainage systems of the polders as planned have been assessed to have insignificant hydraulic impact to the Chao Phraya river, to the flood plain east of the King's flood protection dike, and to the Bangkok eastern suburban to the north.

Although some modifications have been made on the flood protection and drainage systems proposed in the master plan, conclusion on environmental impact as assessed in the master plan report is still valid. The project will provide a definite positive environmental impacts in the project area. Minor unfavorable impacts will be of temporary nature, with only slight effects which can be minimized by introducing appropriate mitigation measures.

As concerns water quality in the canal system, it was found that quality of canal water in the project area is presently very low. Dissolved oxygen levels at many locations were found to be very low, or even approaching no oxygen content level. The water quality of canals in the flood relief area is relatively better than those of the flood

protection area, but is still of low quality. Should no remedial measure be taken water quality degradation in the canal system will be of increasing severity year by year.

A temporary and economical mitigation measure could be a daily flushing by Chao Phraya river water in the project vicinity, at a rate of 3-5 times of the estimated volume of sewage reaching the canal system at the beginning stage. The flushing rate should be increased to 7-10 times of the estimated sewage flow rate in future. It is, however, necessary to consider implementing an appropriate sewerage and treatment system for serving the project area. The site of the sewage treatment plant should be close to the Chao Phraya river, or close to the sea, so that the treated sewage could be directly discharged into the river or the sea, thus avoiding further degradation of the canals water quality.

CONCLUSION AND RECOMMENDATION

The flood protection and drainage project in Samut Prakan East has been investigated and found to be economically and engineeringly feasible. It will provide significant favorable impact to overall environment in the project area. As flood losses and sufferings have already been experienced for a considerably long period, this project very well deserves expedited attention. It is, therefore, recommended that all necessary steps be taken to enable project implementation as planned. This should include submitting the project to related offices for consideration for eventual approval by the Government. The followings are recommended as necessary undertakings toward the project implementation.

(a) Main Responsible Agency

The Department of Public Works should be assigned as the main responsible agency (or implementing agency) for this project, at least until the proposed organization (policy making level and operation level) is ready to assume its responsibility. Emphasis in this beginning period should be on project proposal and promotion, follow-up, coordination in order to obtain project approval from the Government.

(b) Budget and Fund Procurement

Investment in the project implementation should be in phases, in accordance with the existing land use and the accelerated future development. The proposed first phase implementation requiring 1 153 million baht investment in the first 3 years should at least be invested to expeditedly mitigate the prevailing frequent floodings, and to procure land for future construction. However, to have adequate systems for the existing land use additional investment on some of the proposed works in the fourth through seventh year requiring an additional fund of 317 million baht should be made (see Figure 7 and Table 2). Hence the total investment required for the existing land use is about 1 470 million baht (end of 1986 price or about 1 610 million baht for May 1988 price). In addition, provision should be made for additional investment to cope with expanding land use in future.

Fund procurement should follow the proposed financial plan, i.e. 50% from the government, 10% from the local administrative offices, and 40% from foreign loan. Necessary arrangements should be made to enable official contacts with potential lending agencies as soon as the project is approved by the Government. This is to minimize the procurement time for the foreign loan portion, which should result in the expedited mitigation of flood problems.

(c) Land Aquisition

Land aquisition is a very important and time consuming matter. It should be addressed at the earliest possible time in order to have the needed land well in time for the planned construction. Special attention should be given to the aquisition of land for flood barrier construction along the Gulf, south of Sukhumvit road, as discrepancies have been noted between the information from Samut Prakan Land Office and the claimed land ownerships experienced in recent field survey in this project.

(d) Detailed Design

In order to have efficient, smooth, and timely project implementation, detailed survey and construction design should be carried out for the proposed project components necessary for mitigating the existing flood problem, and adequate for the present land use. The design should be completed in the fiscal year 1989, so that necessary drawings and details including specifications can be made available in the fiscal year 1990 as planned.

(e) Further Investigations

Further investigations on different aspects proposed in this study should be undertaken, including :

- detailed survey and assessment of the navigation lock proposed at the new site of gate and pumping station at the mouth of Klong Samrong near the Chao Phraya river.
- Promotional campaign including public promotion and subsequent attitude survey on fund contribution from direct project beneficiaries for foreign loan repayment as proposed in the financial plan.

- Detailed investigation, possibly in close cooperation with the Samut Prakan Land Office, on land ownership, and preparation of necessary preparatory measures for subsequent land acquisition.

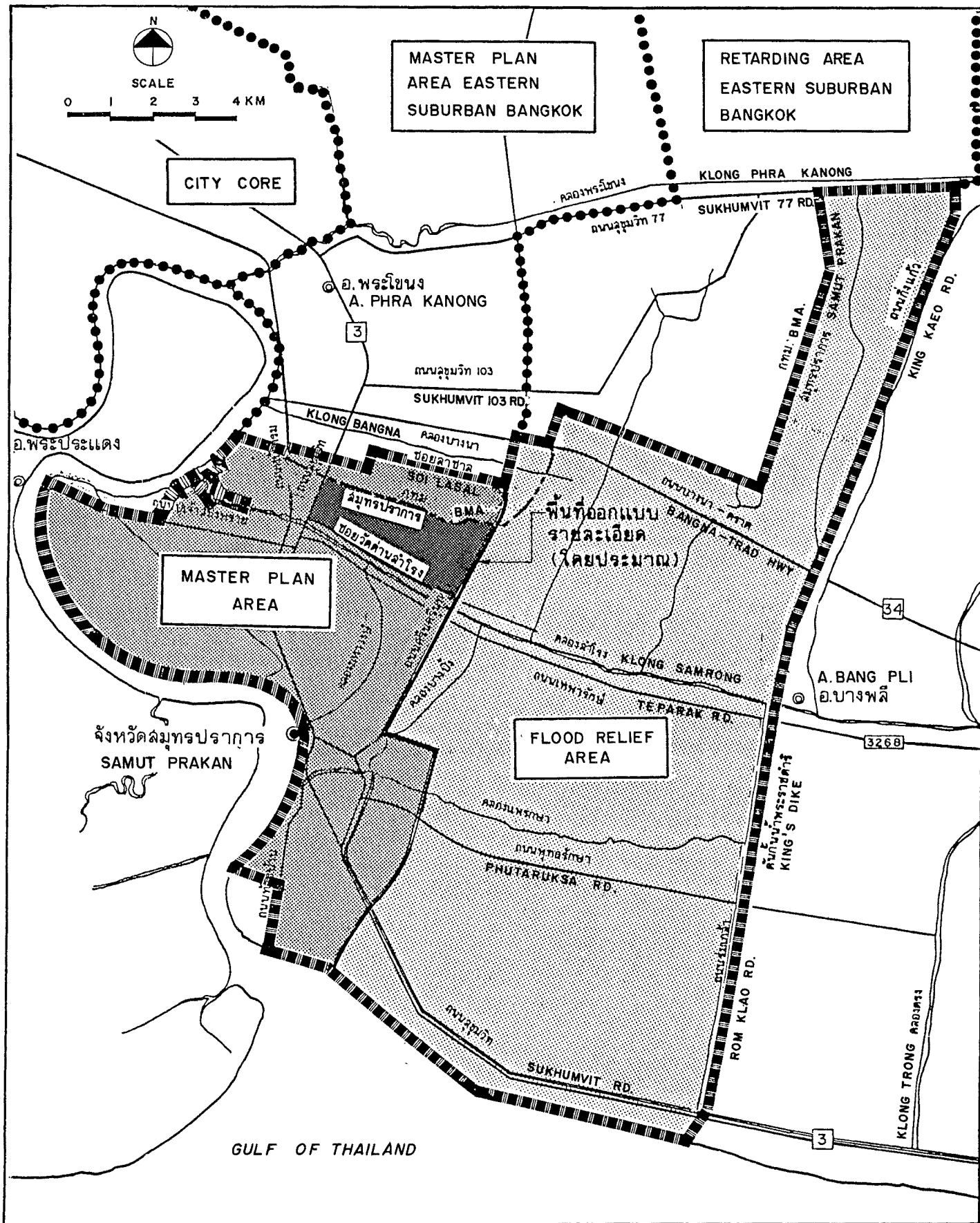


FIGURE I
PROJECT AREA

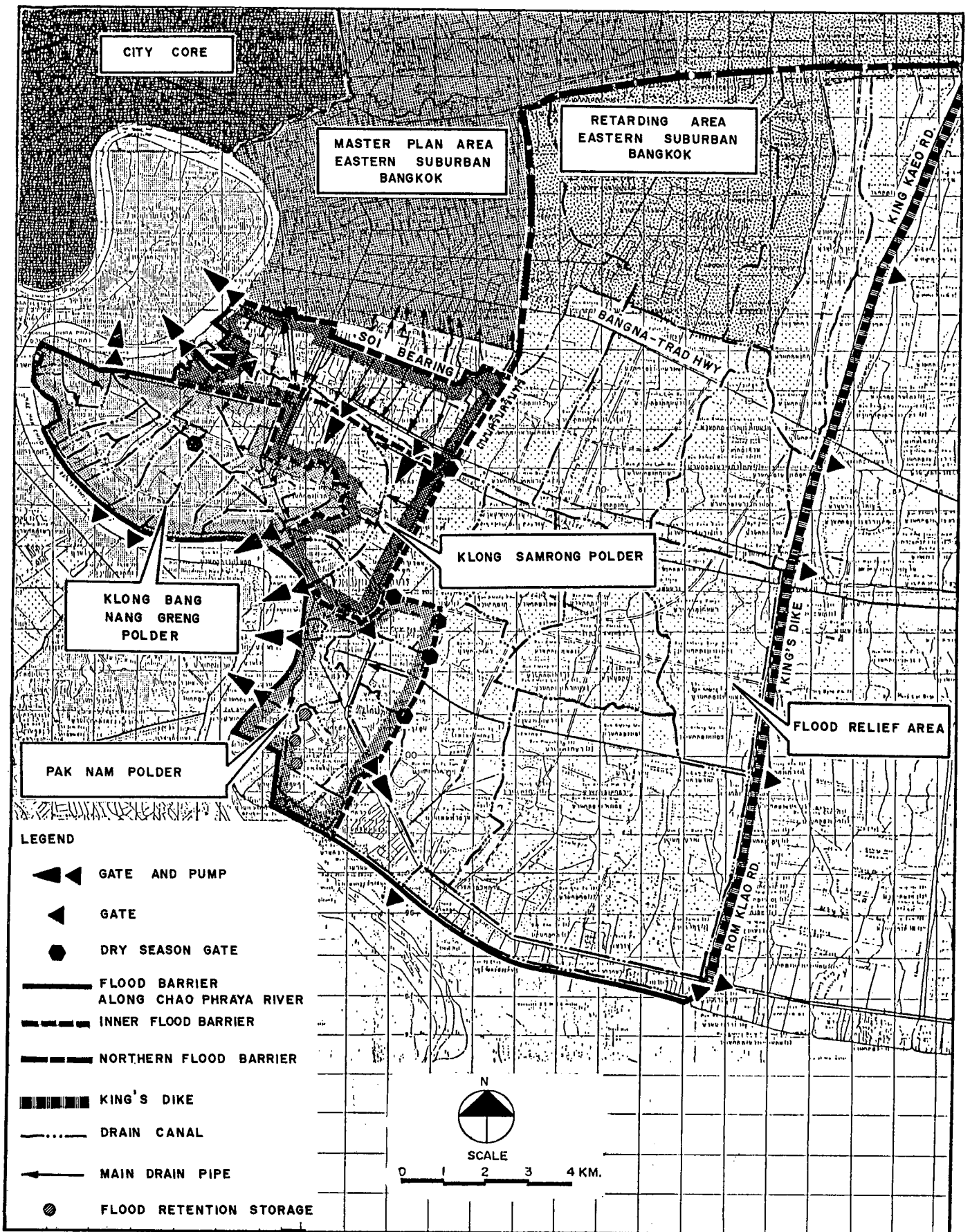


FIGURE 2
MASTER PLAN FOR FLOOD PROTECTION AND DRAINAGE
IN SAMUT PRAKAN EAST

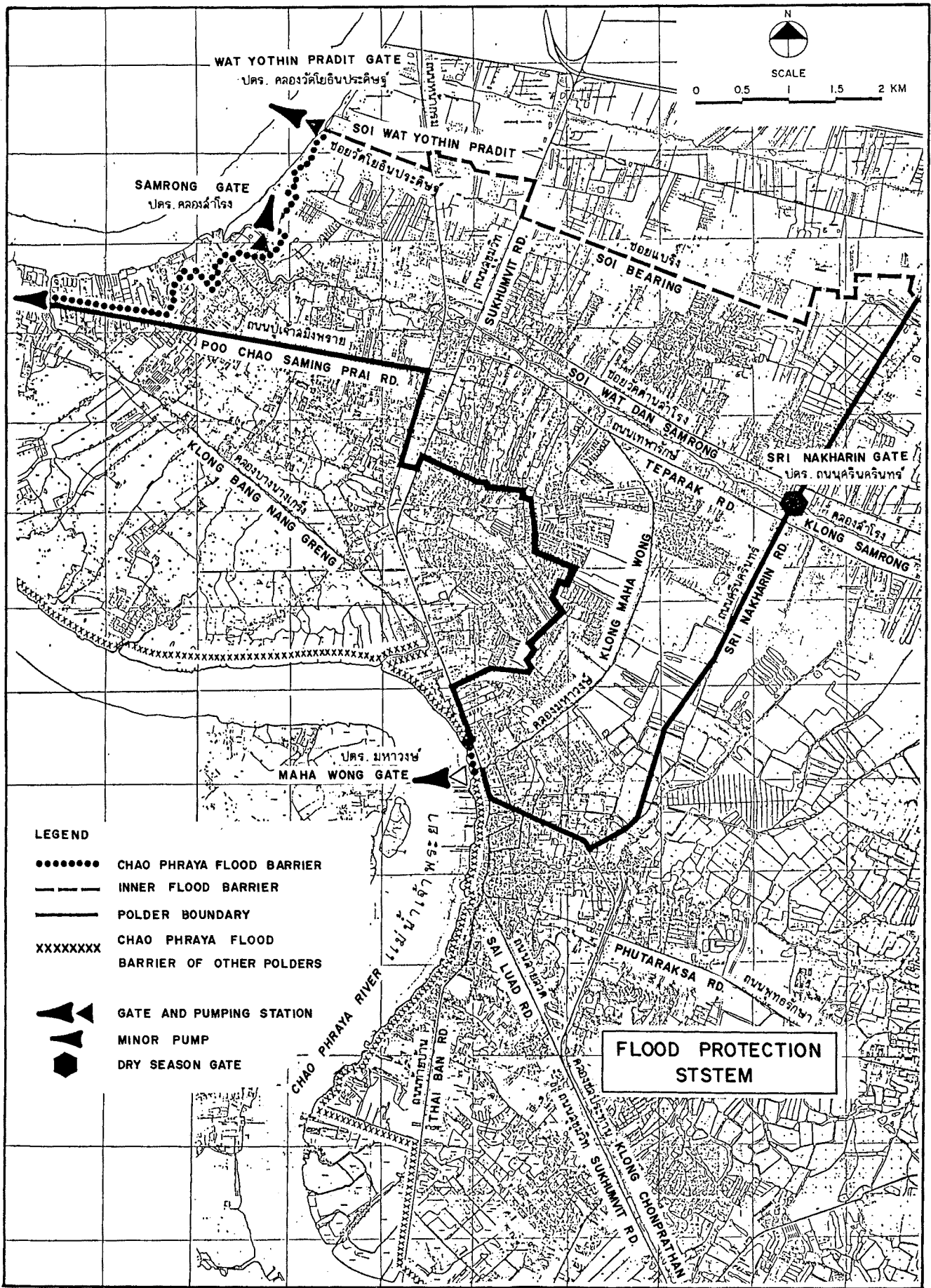
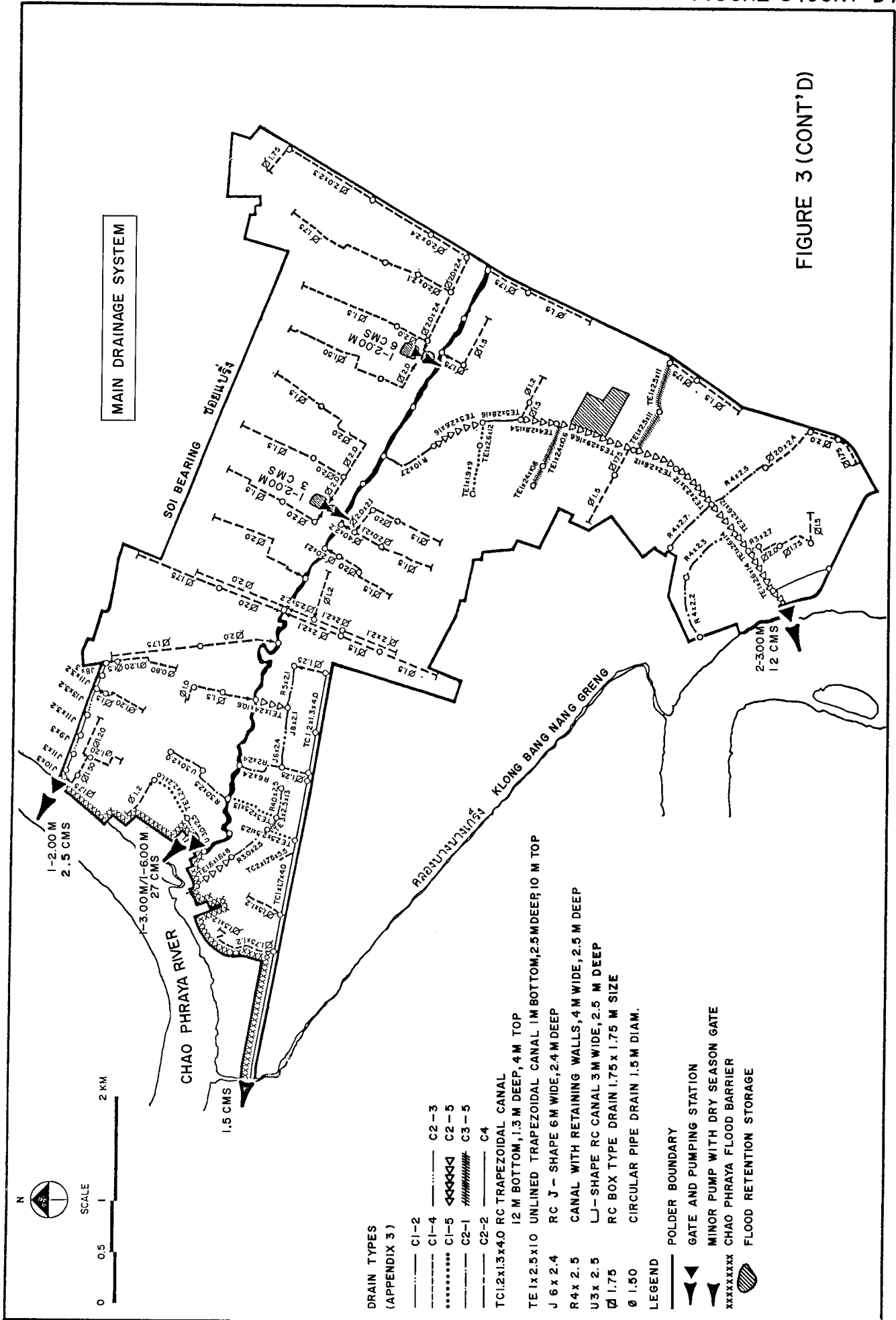


FIGURE 3

FLOOD PROTECTION AND DRAINAGE SYSTEMS OF KLONG SAMRONG POLDER

FIGURE 3 (CONT'D)



FLOOD PROTECTION SYSTEM

FIGURE 4

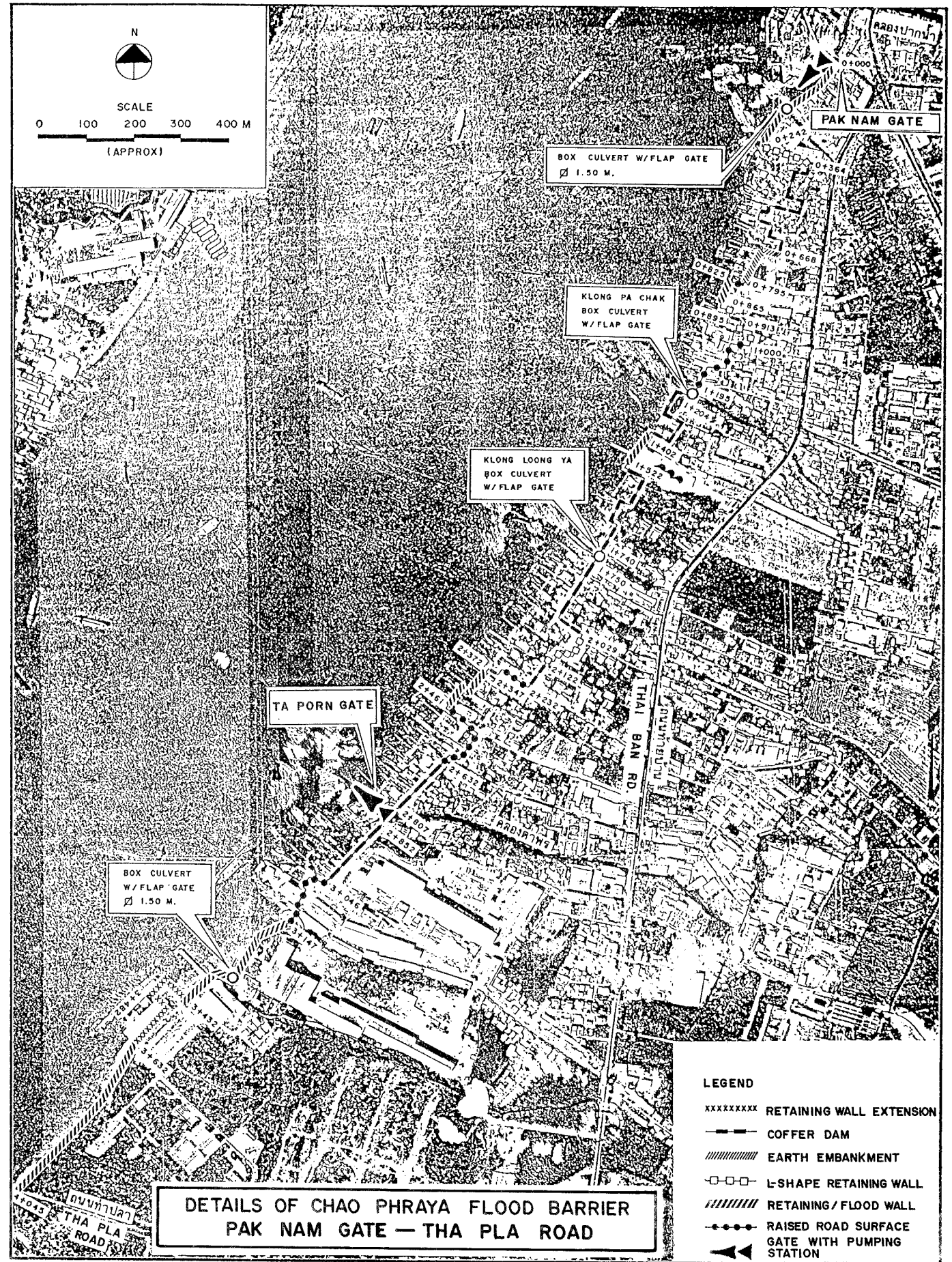
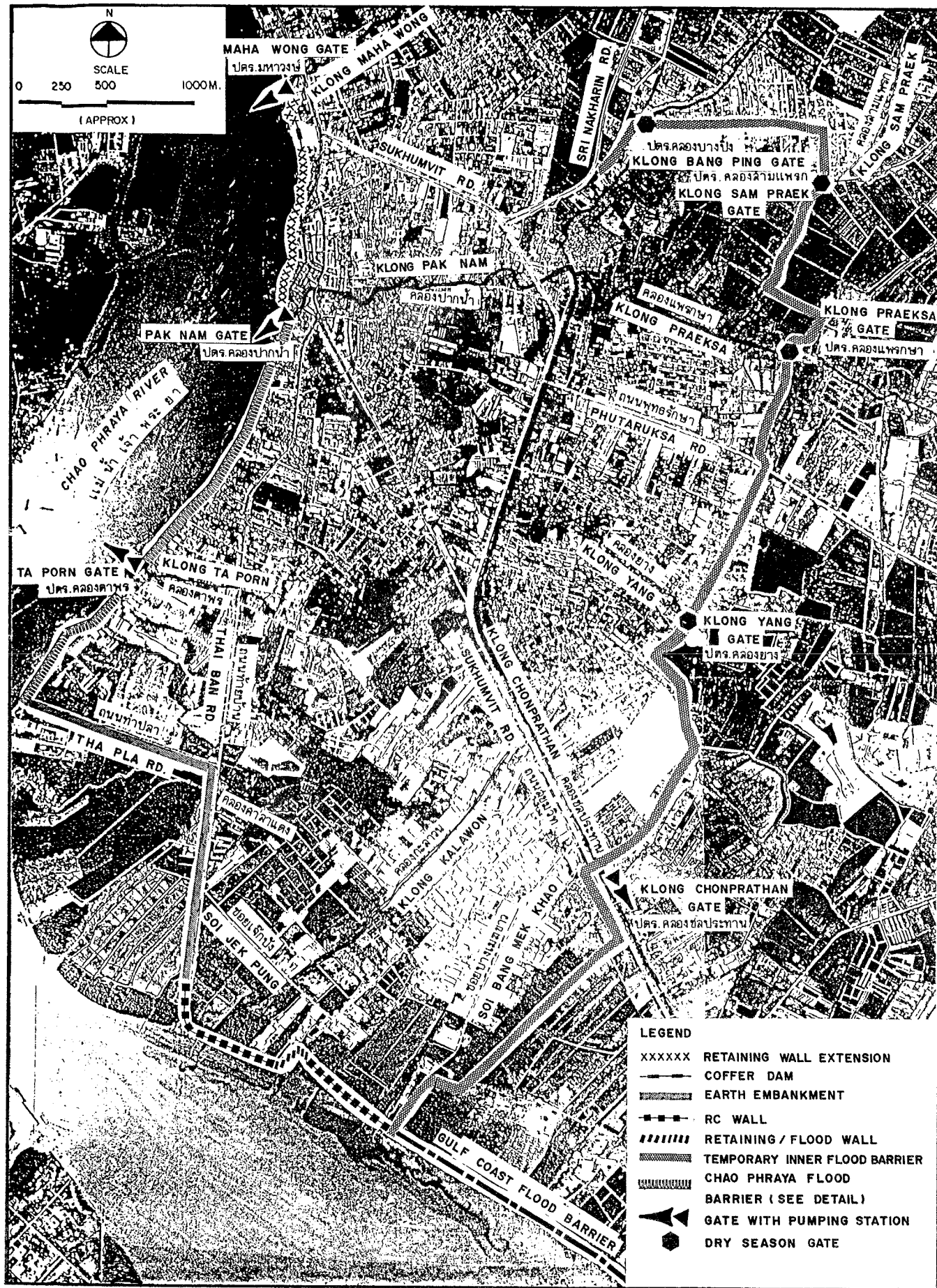


FIGURE 4

FLOOD PROTECTION AND DRAINAGE SYSTEMS OF PAK NAM POLDER

MAIN DRAINAGE SYSTEM

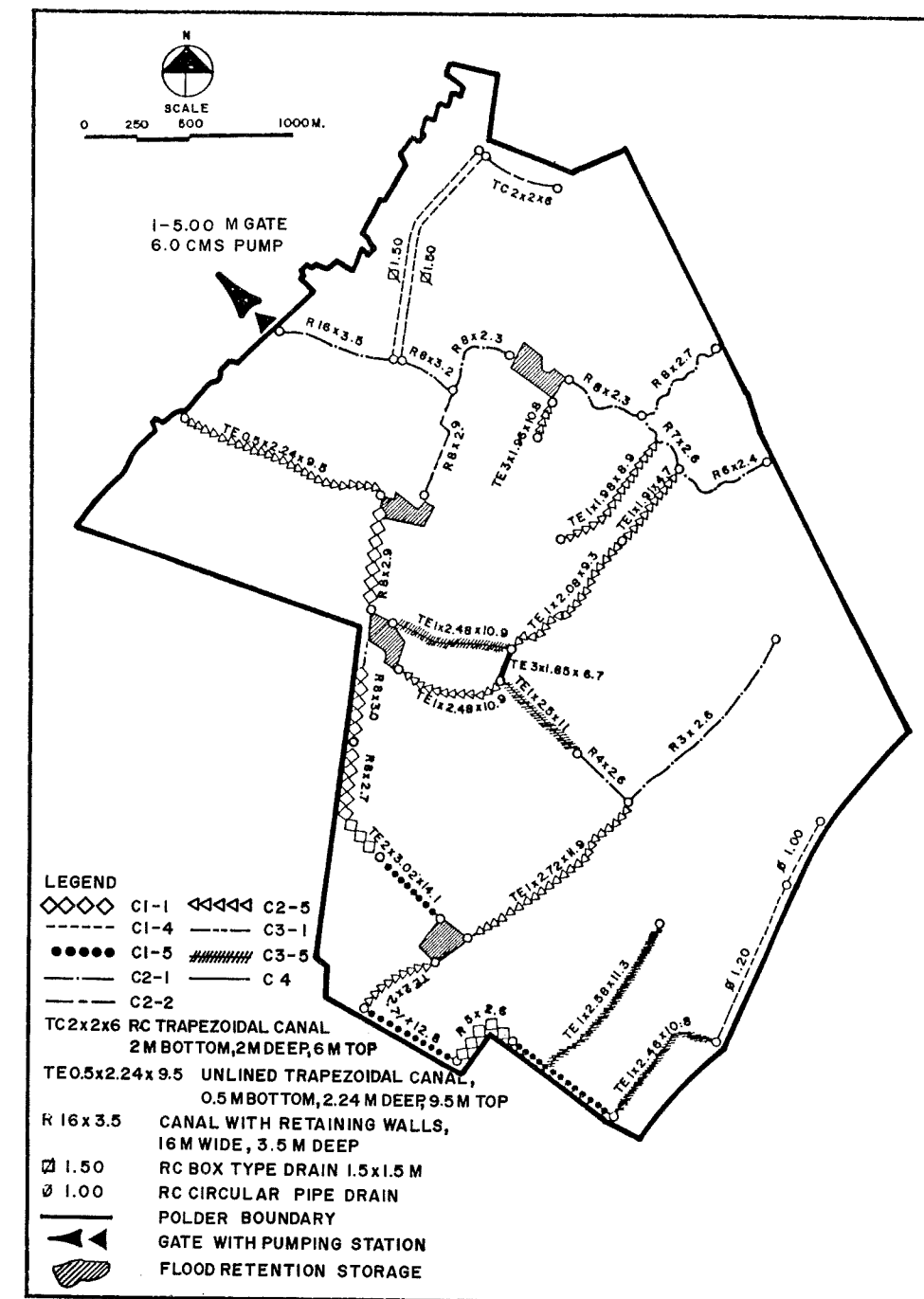
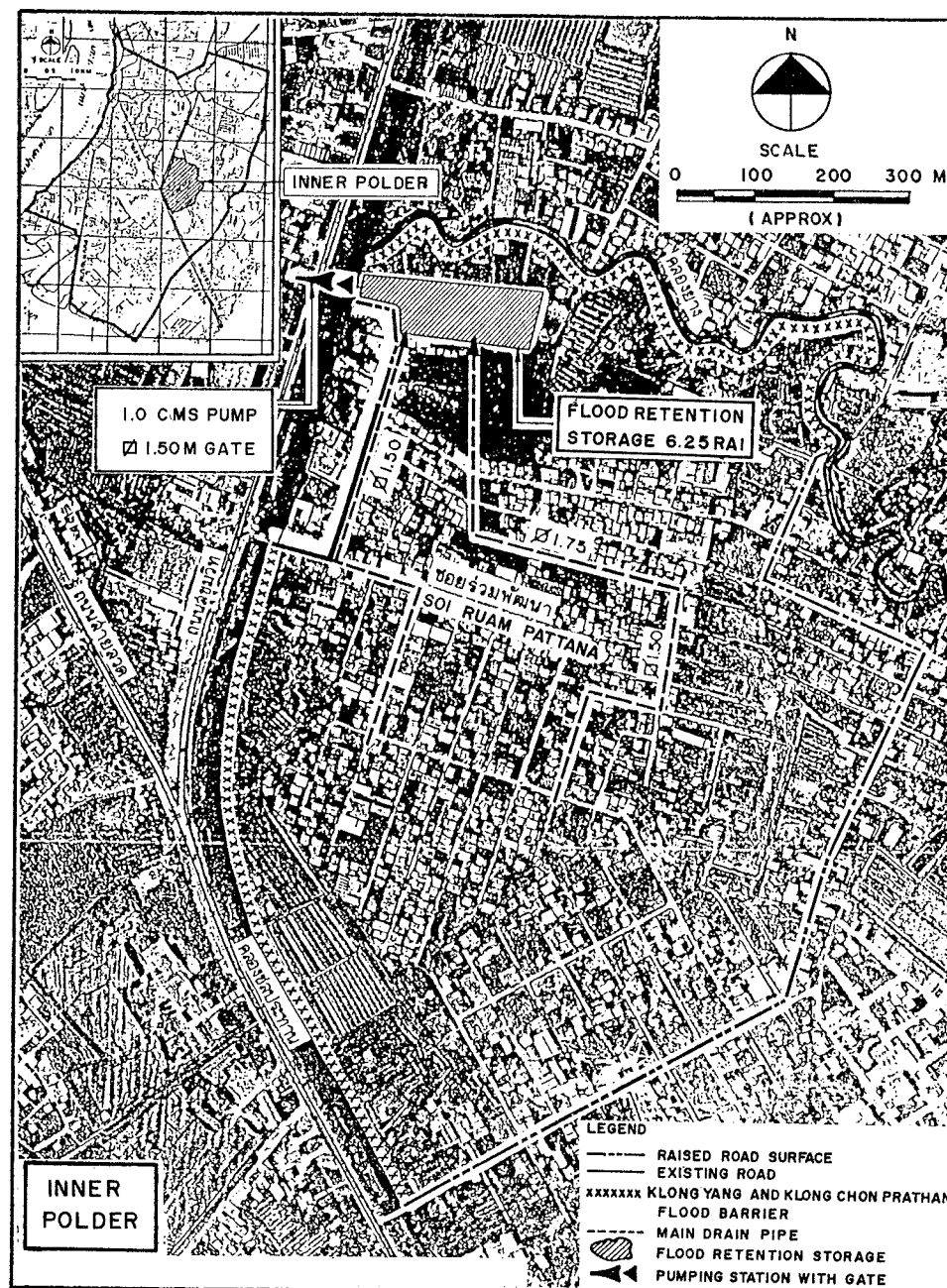
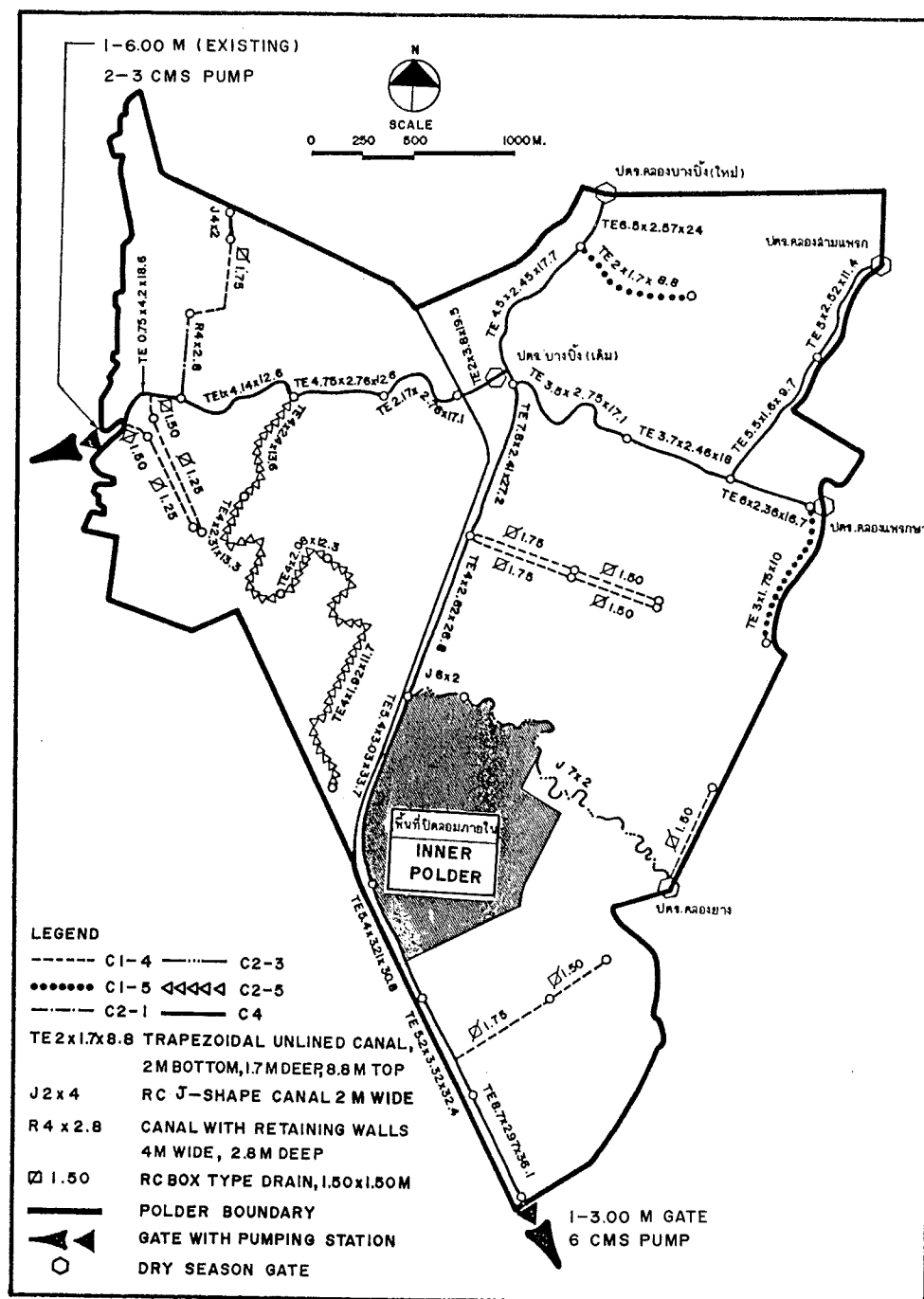


FIGURE 4 (CONT' D)

FIGURE 5

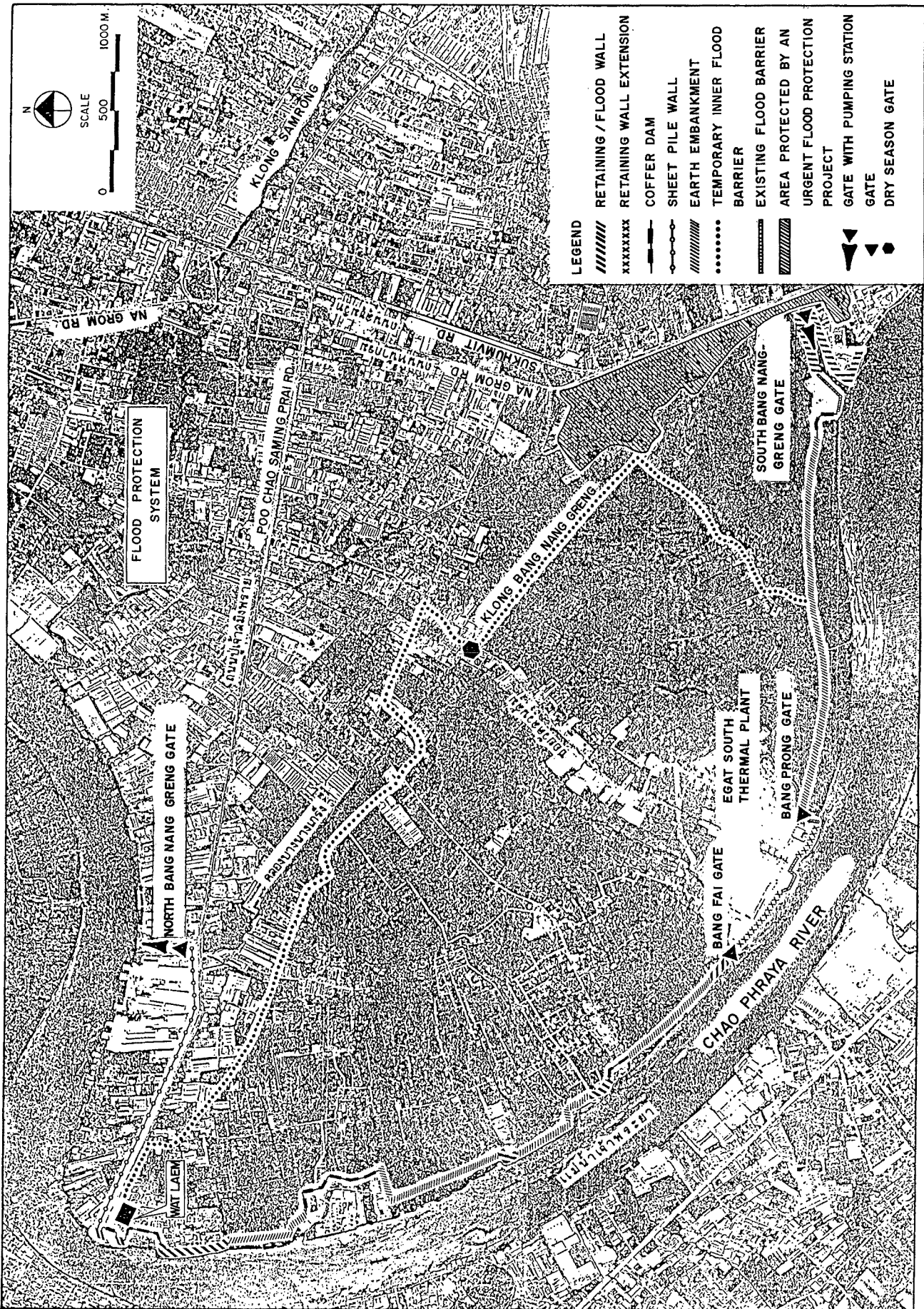


FIGURE 5
FLOOD PROTECTION AND DRAINAGE SYSTEMS OF KLONG BANG NANG GRENG POLDER

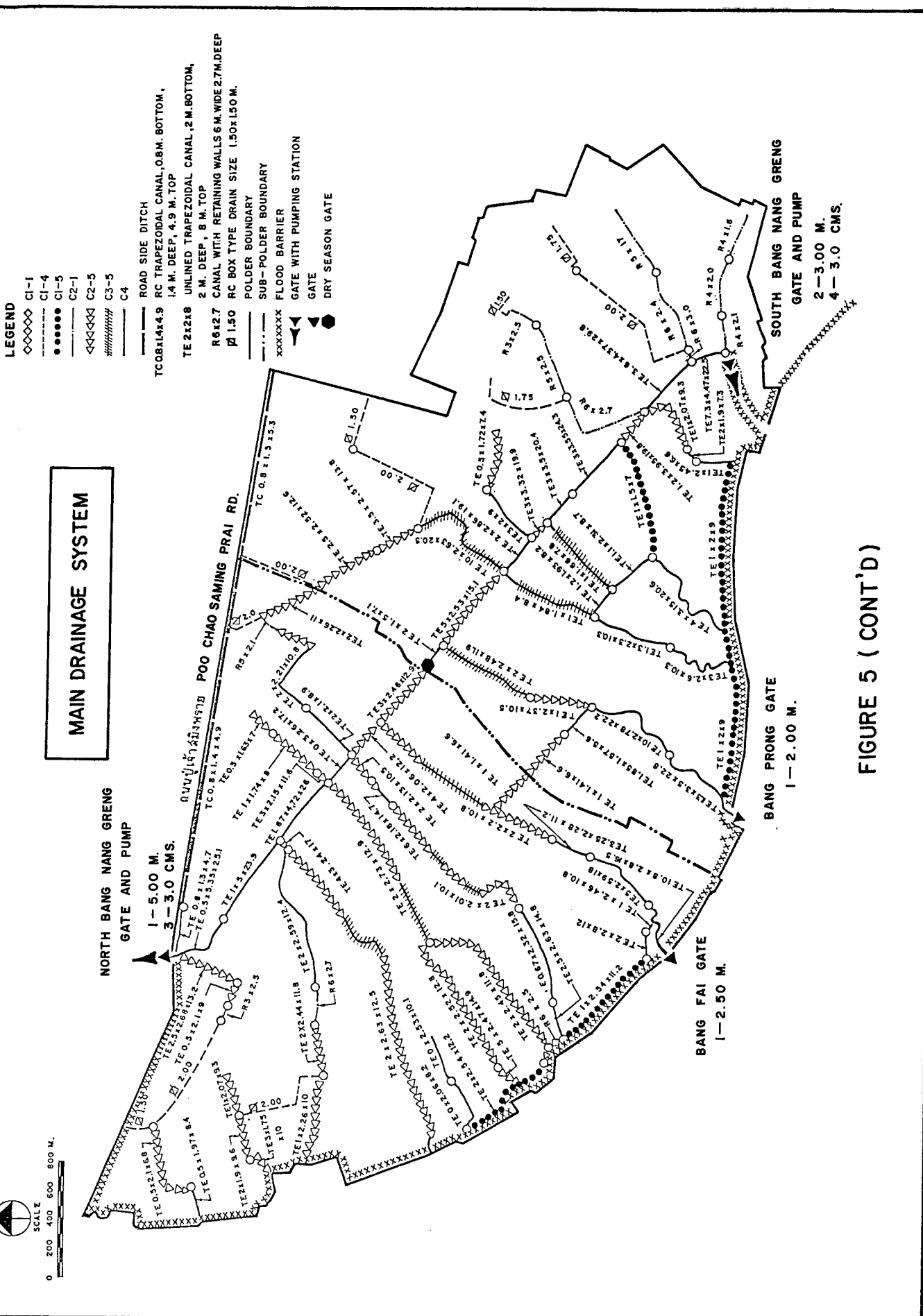


FIGURE 5 (CONT'D)

FIGURE 6

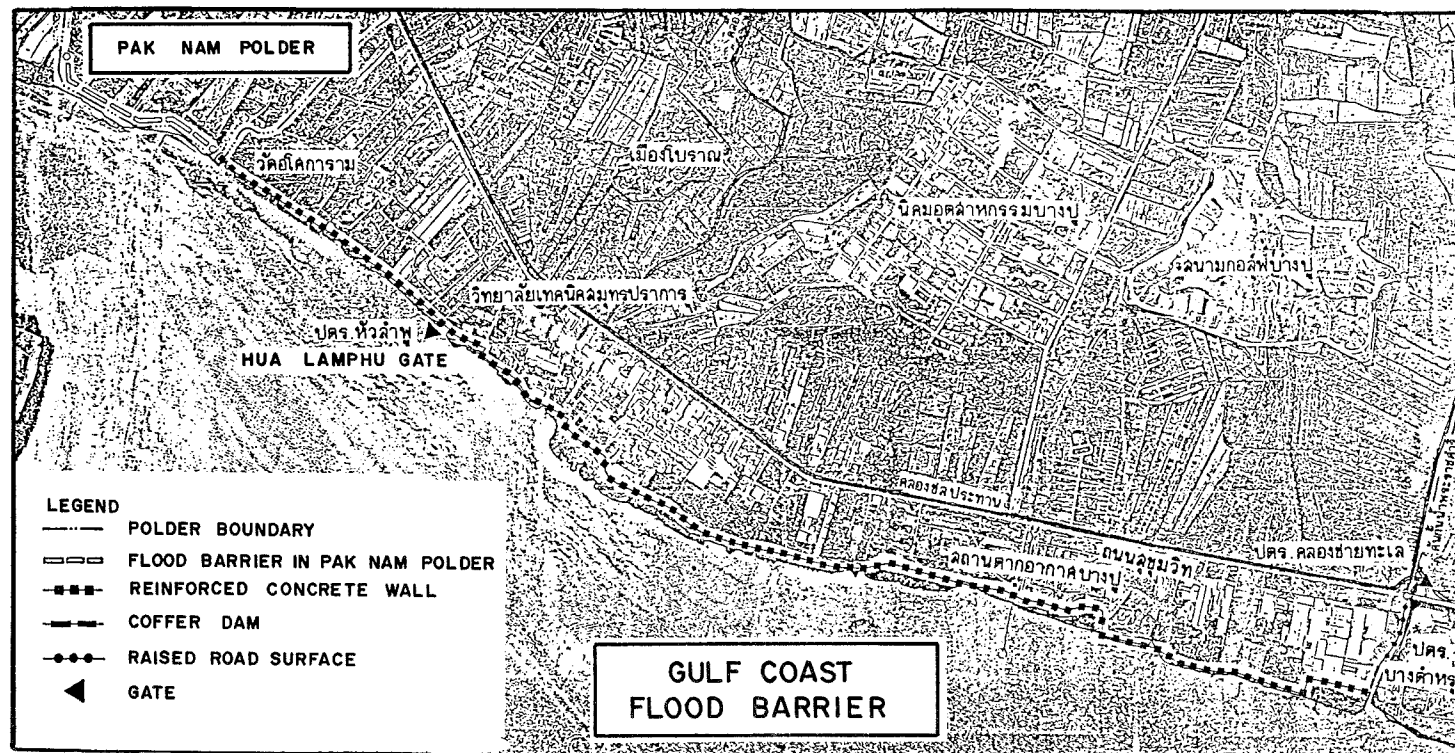
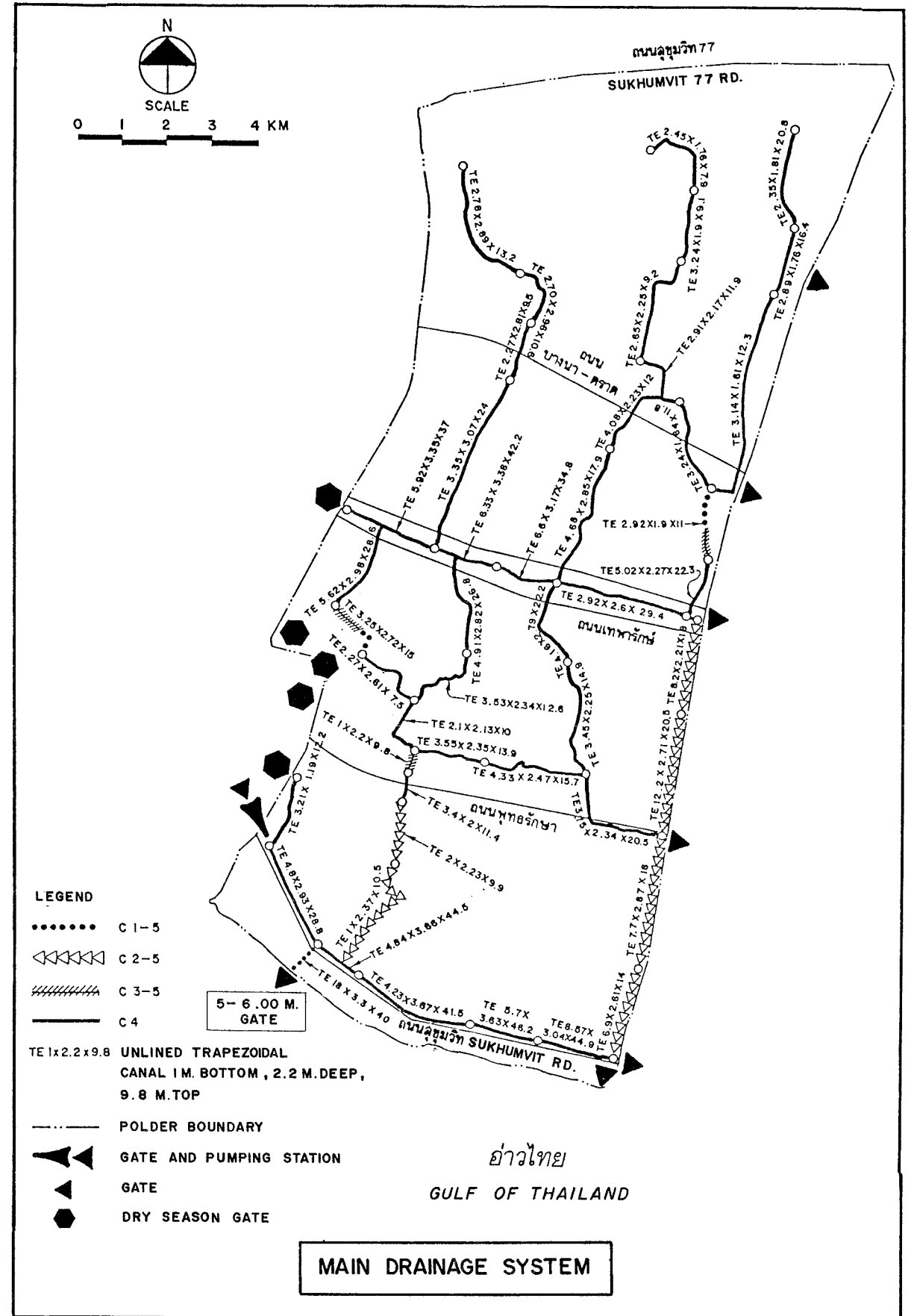
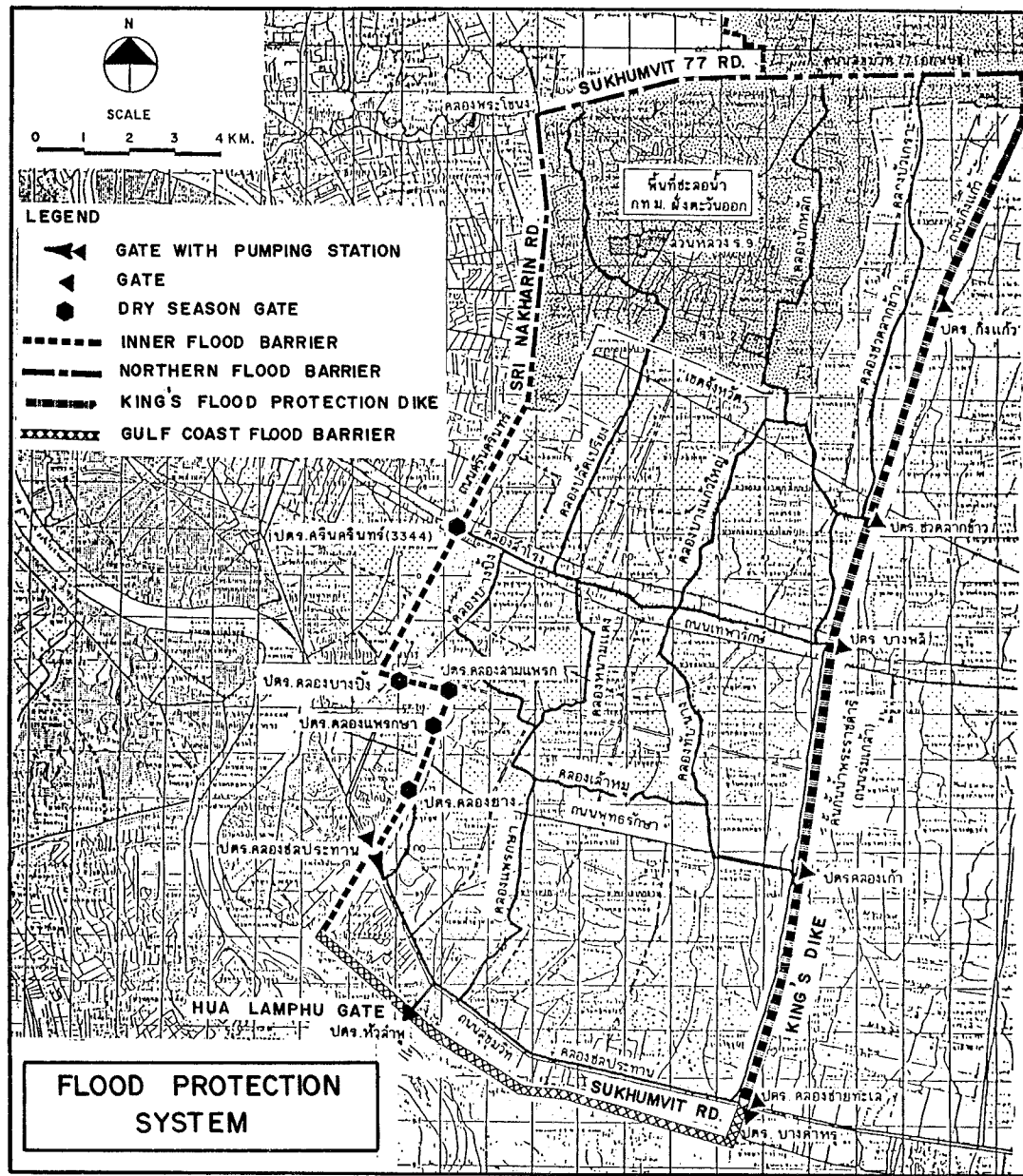
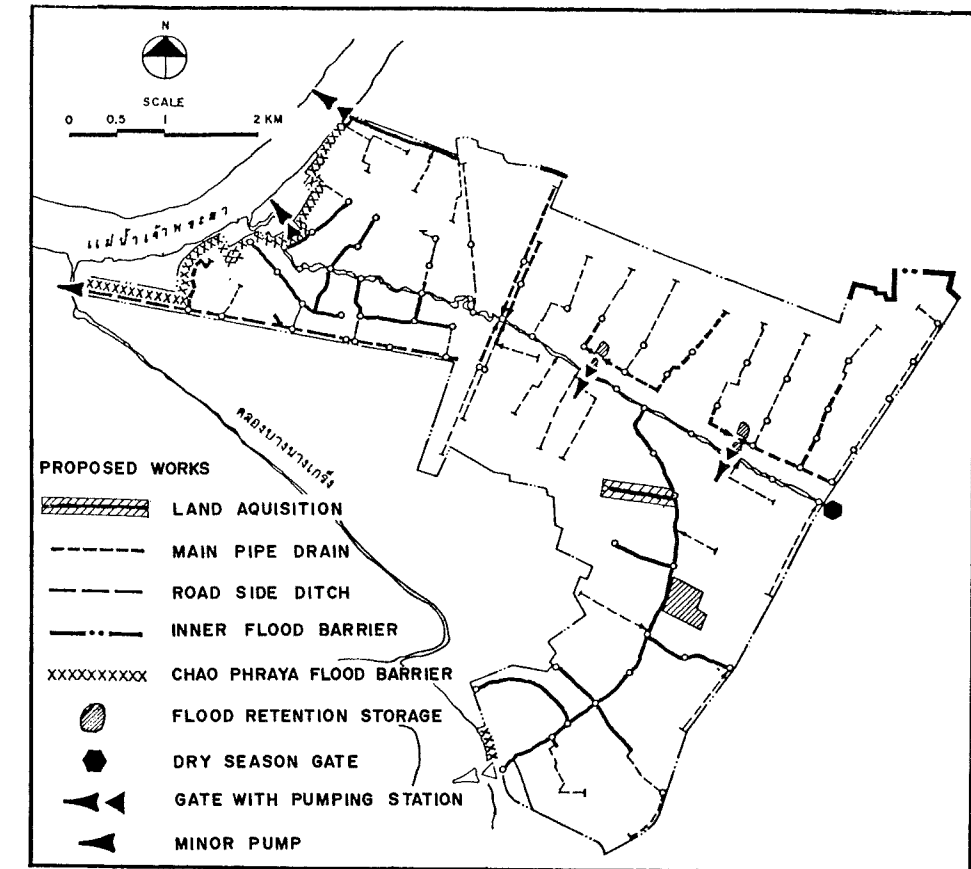
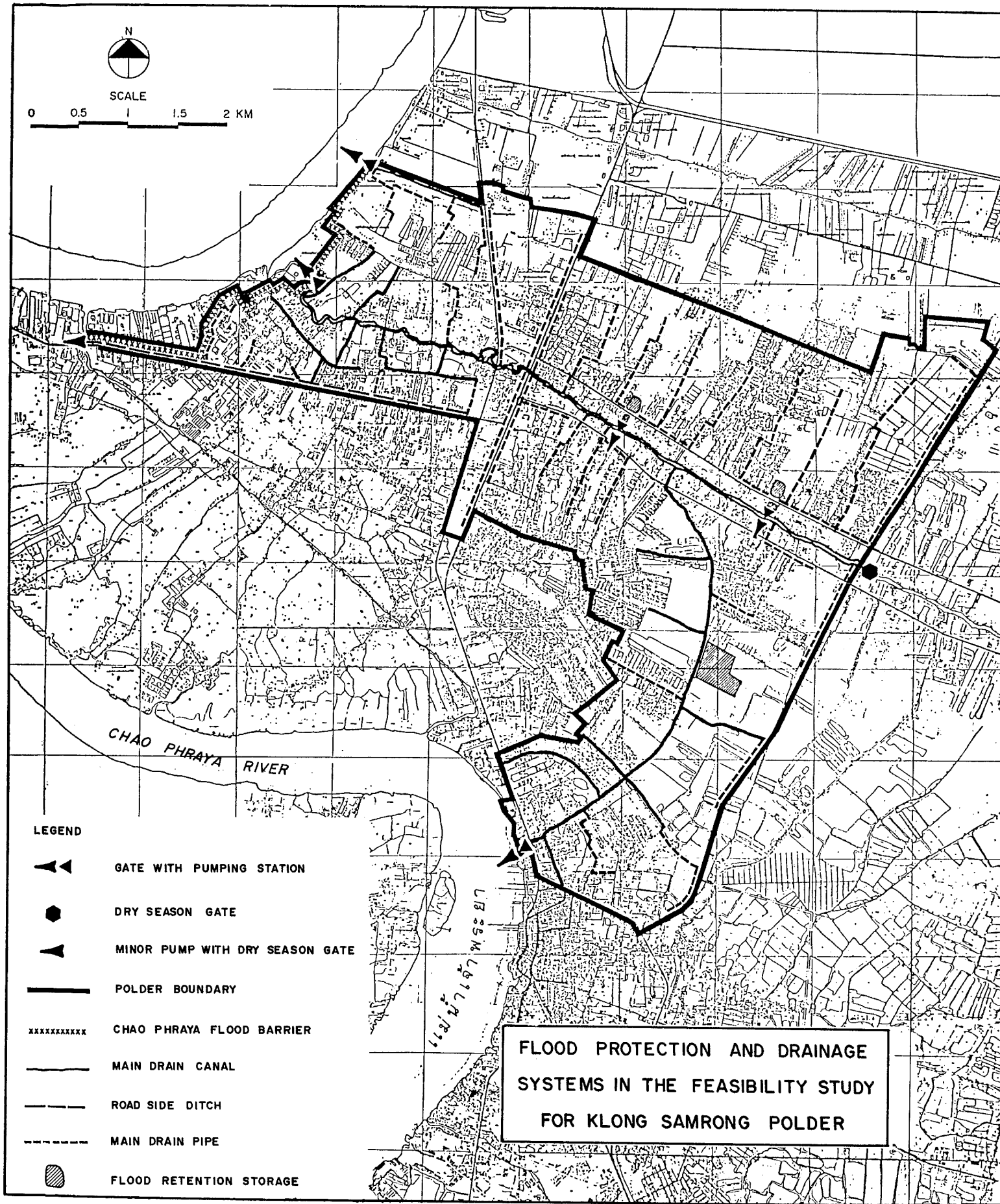
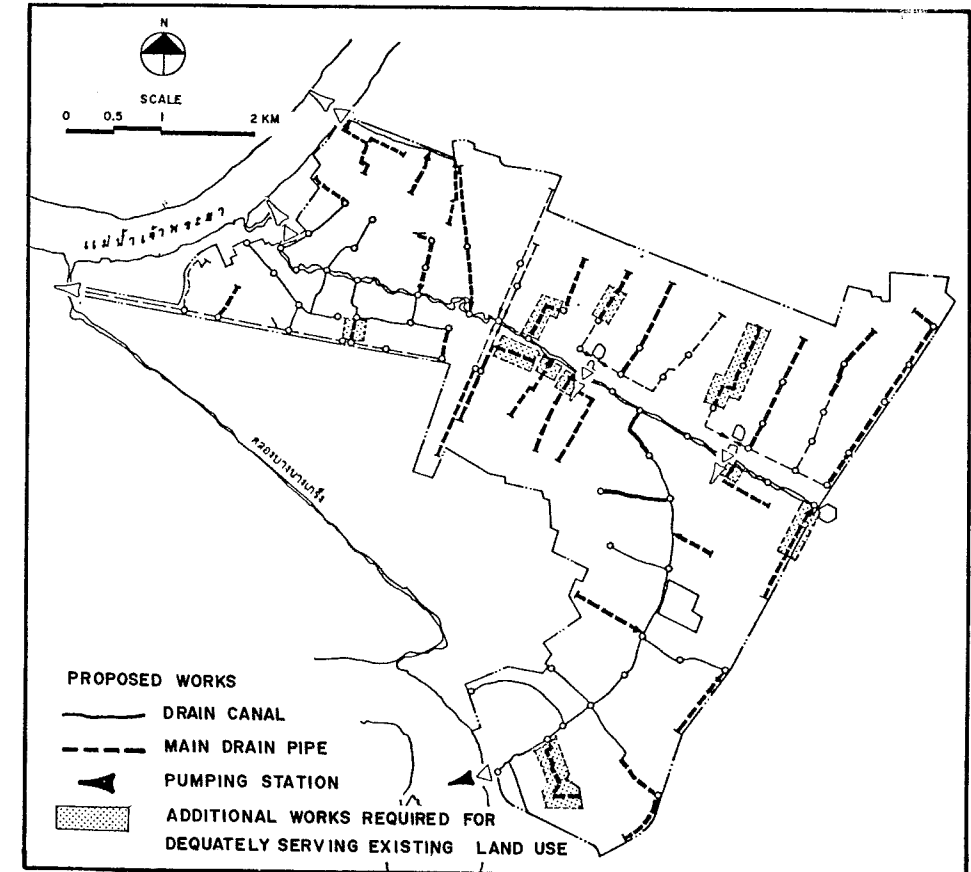


FIGURE 6
FLOOD PROTECTION AND DRAINAGE SYSTEMS
OF FLOOD RELIEF AREA

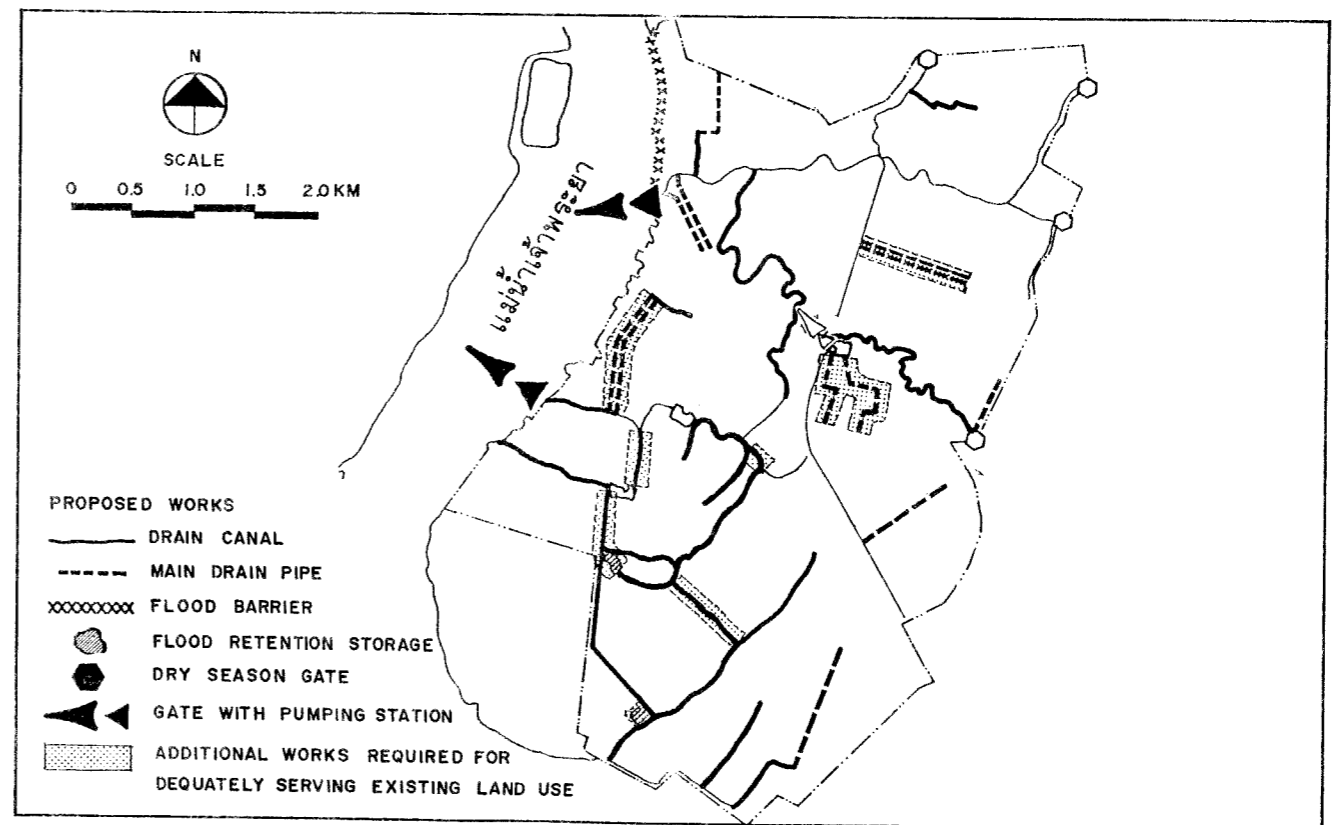
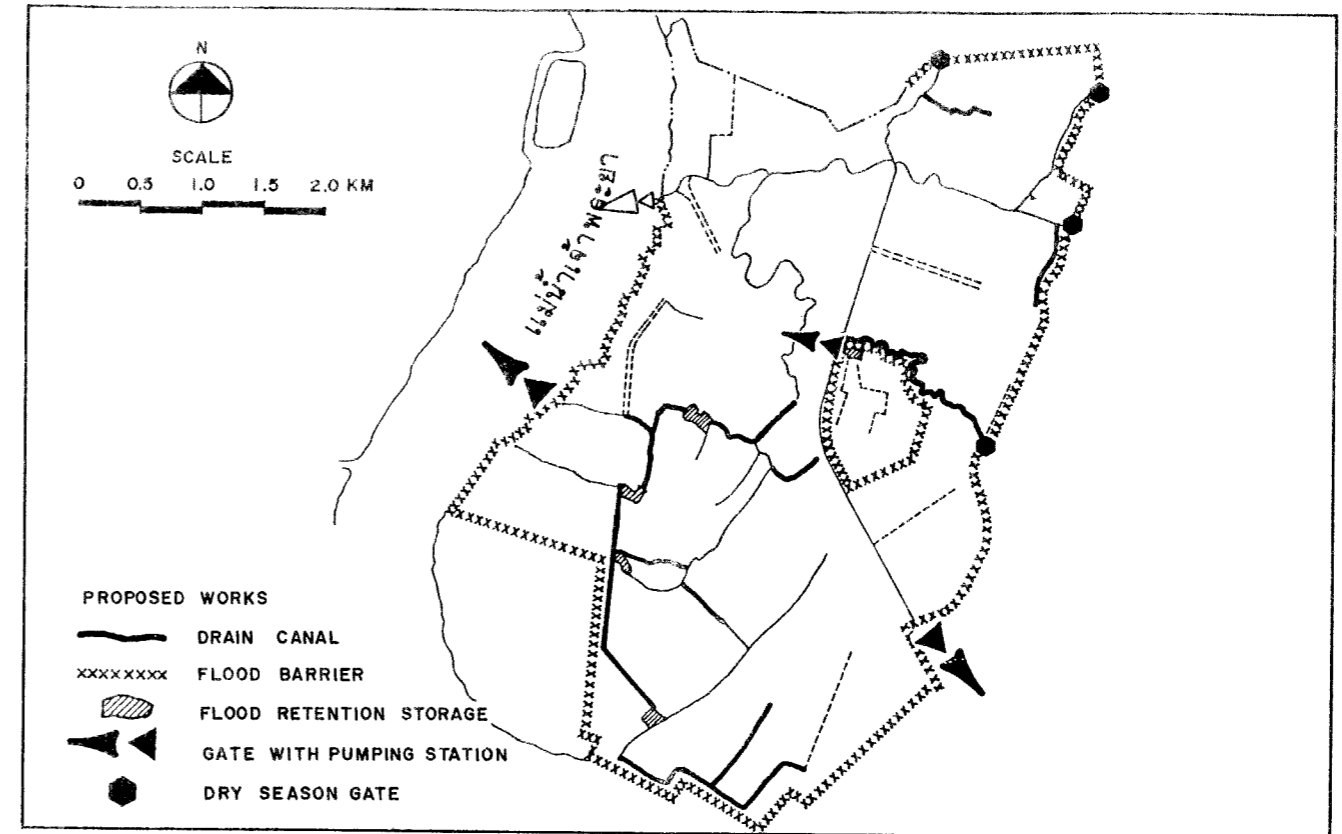
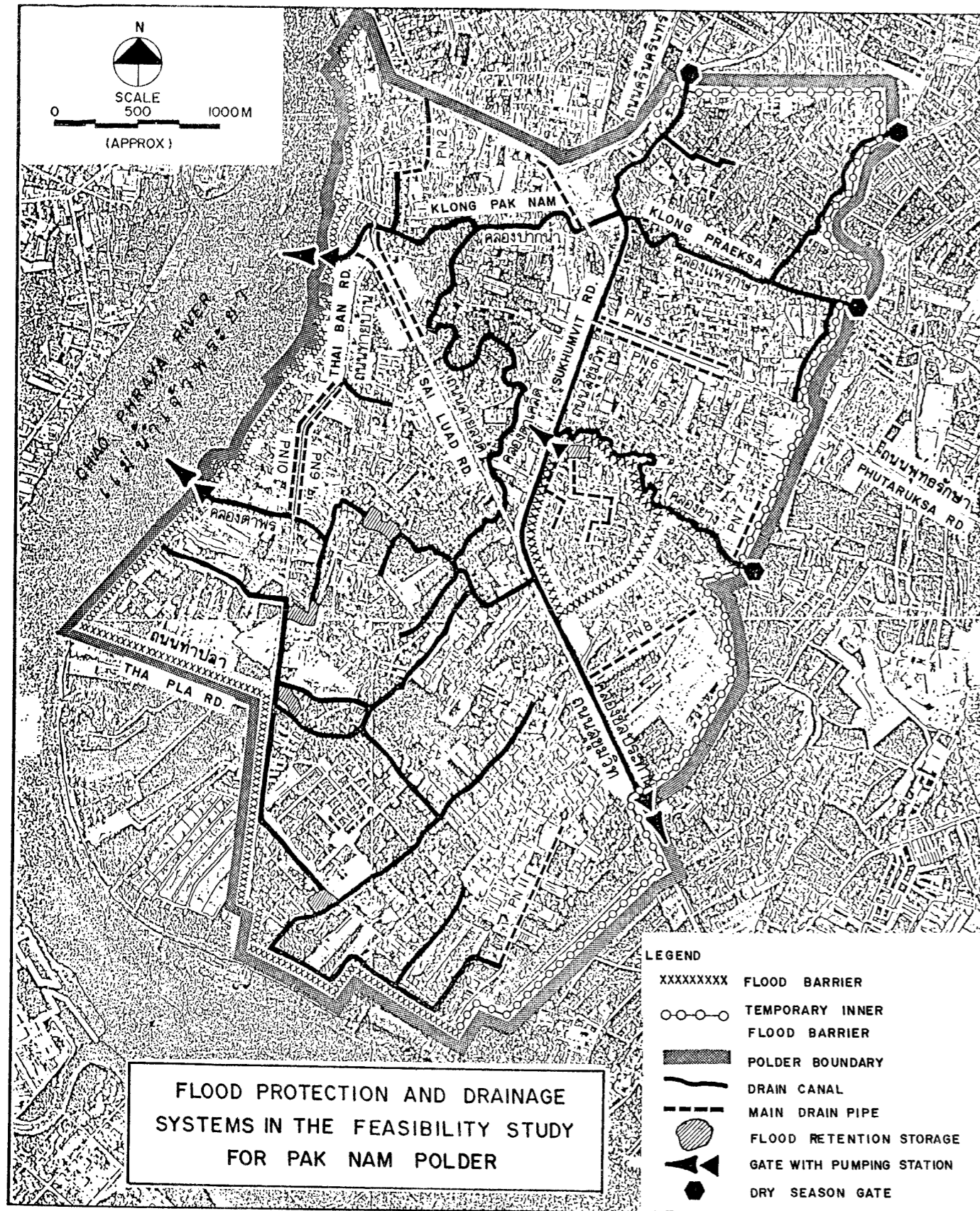


FIRST PHASE CONSTRUCTION FOR MITIGATING EXISTING PROBLEMS
SCHEDULED FOR 3 YEAR PERIOD



ADDITIONAL CONSTRUCTION TO COPE WITH INCREASING LAND USE
SCHEDULED FOR NESDB 7 TH FIVE YEAR PLAN

FIGURE 7
PHASING OF PROJECT IMPLEMENTATION



ADDITIONAL CONSTRUCTION TO COPE WITH INCREASING LAND USE
SCHEDULED FOR NESDB 7 TH FIVE YEAR PLAN

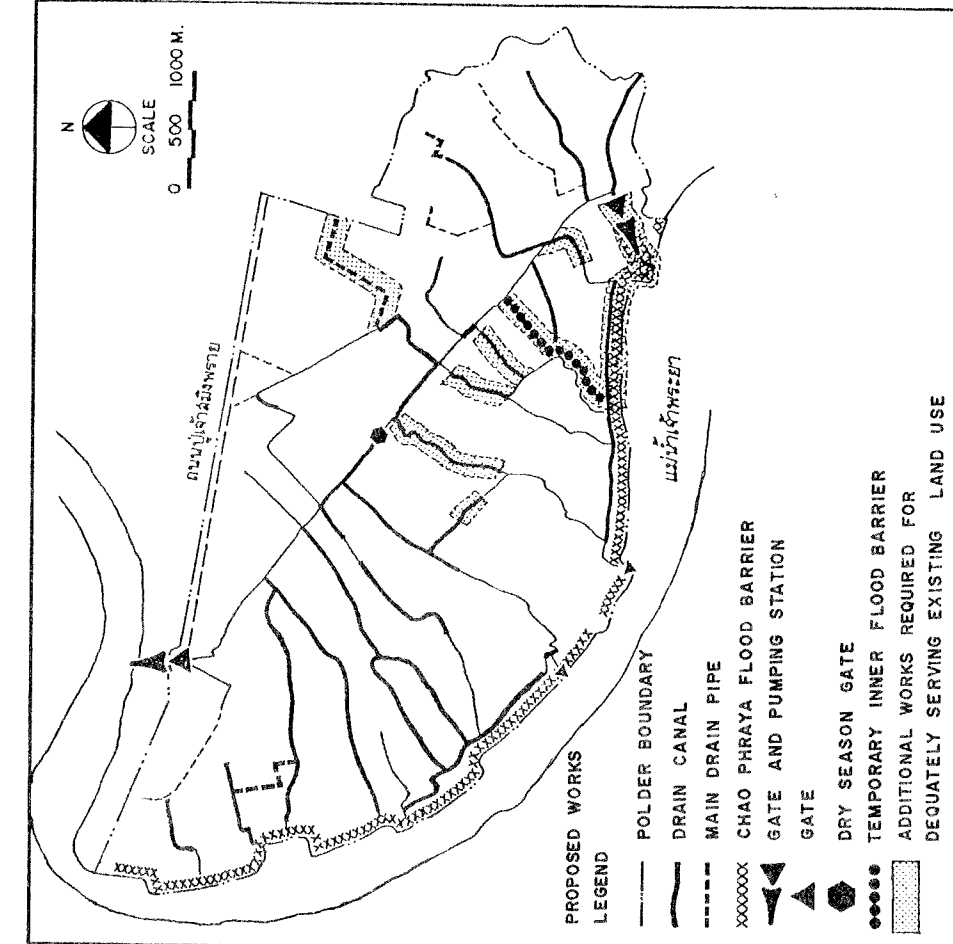
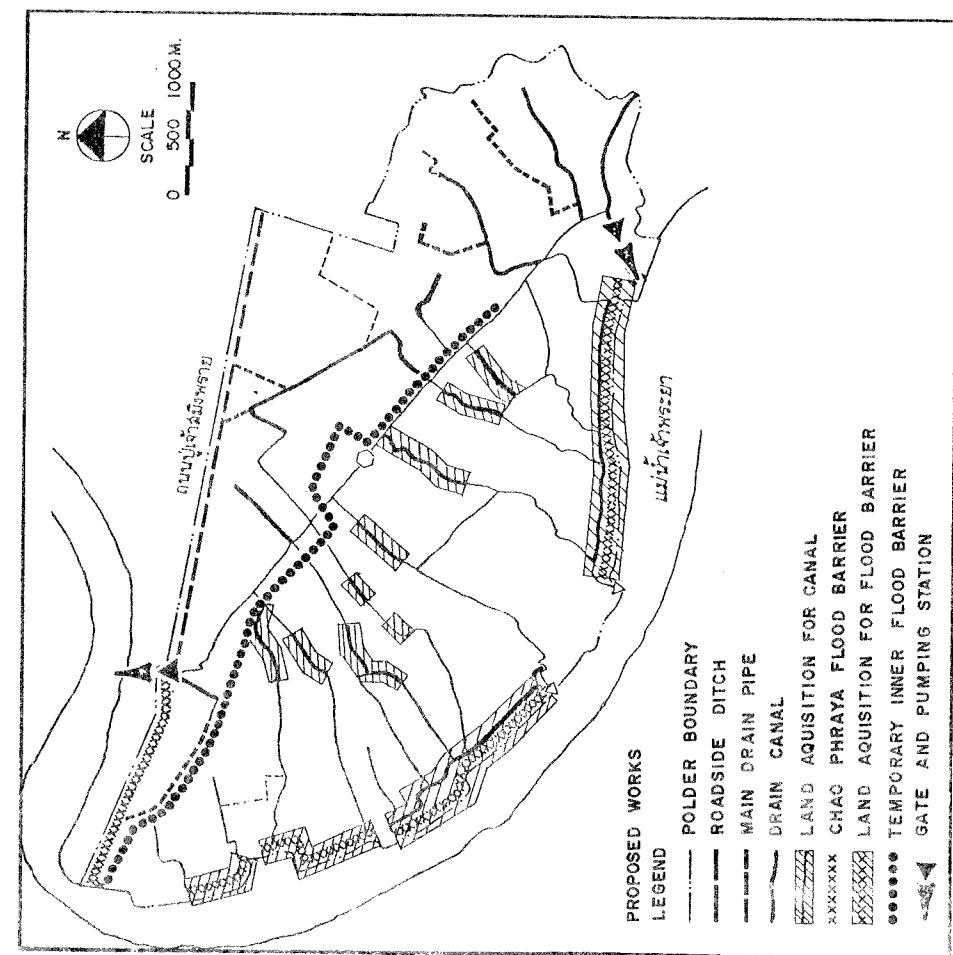
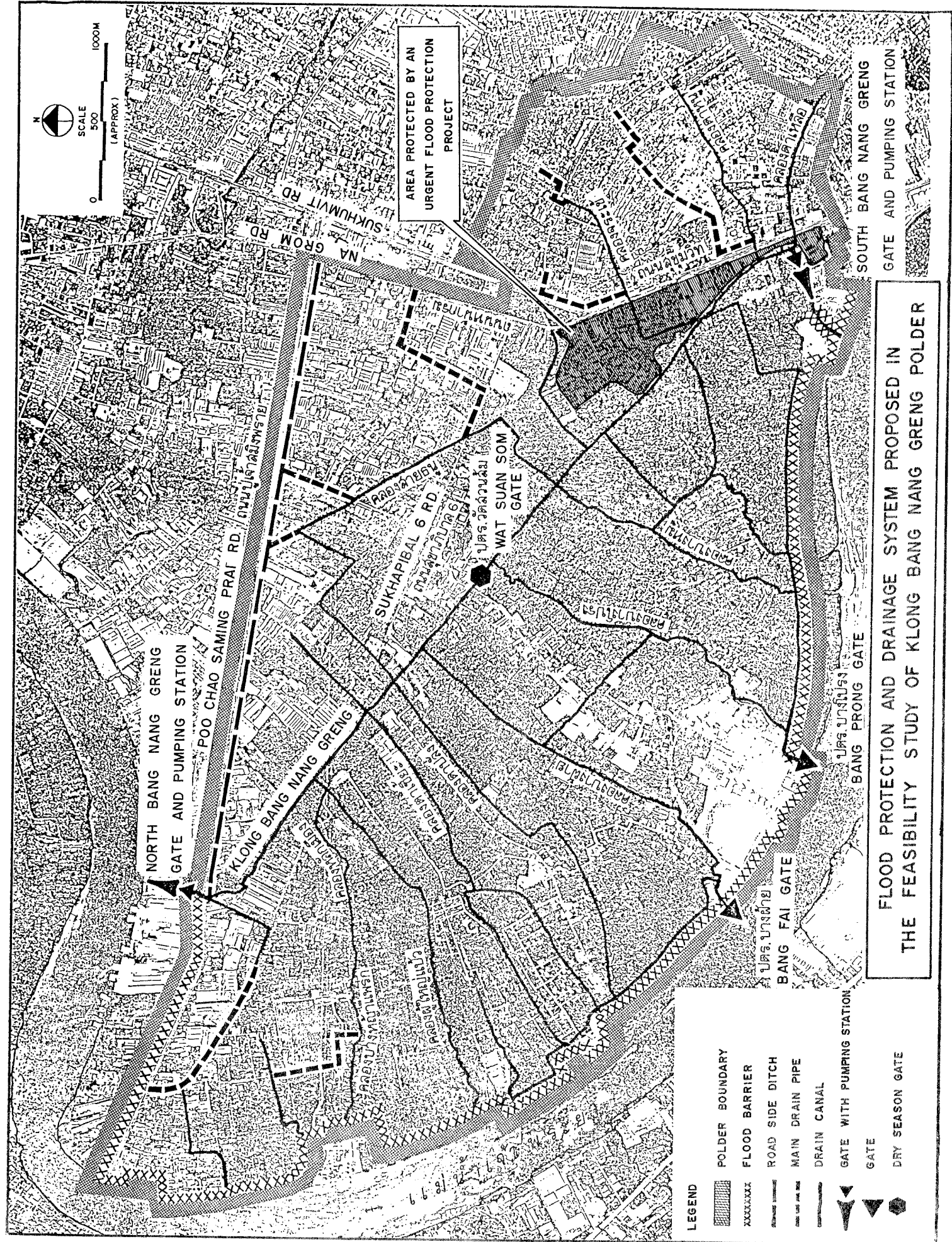
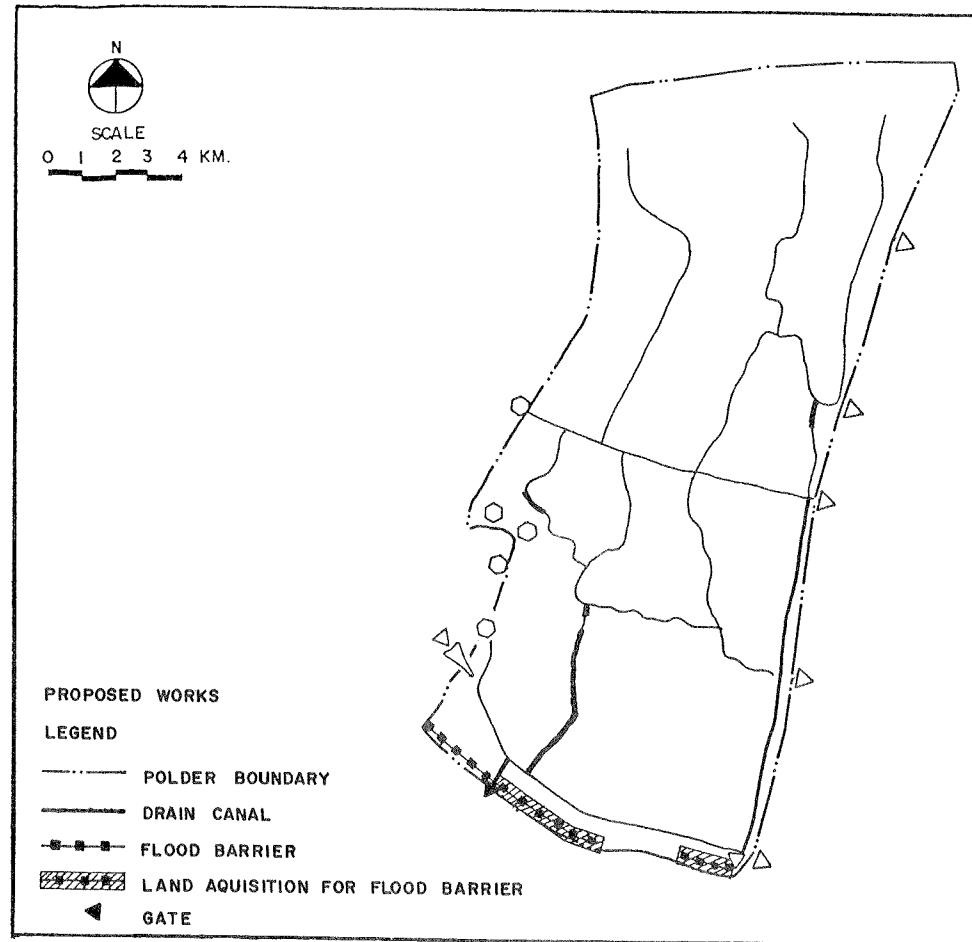
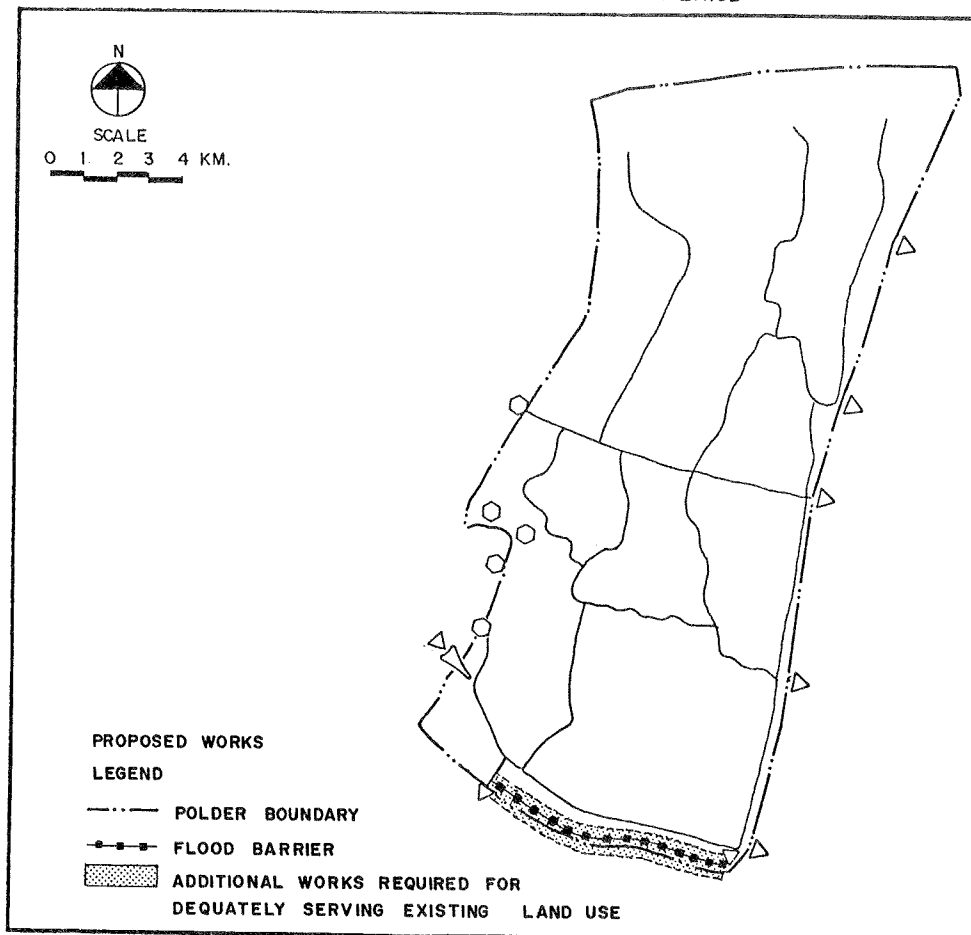


FIGURE 7 (CONT'D)

FIGURE 7 (CONT'D)



FIRST PHASE CONSTRUCTION FOR MITIGATING EXISTING PROBLEMS
SCHEDULED FOR 3 YEAR PERIOD



ADDITIONAL CONSTRUCTION TO COPE WITH INCREASING LAND USE
SCHEDULED FOR NESDB 7 TH FIVE YEAR PLAN

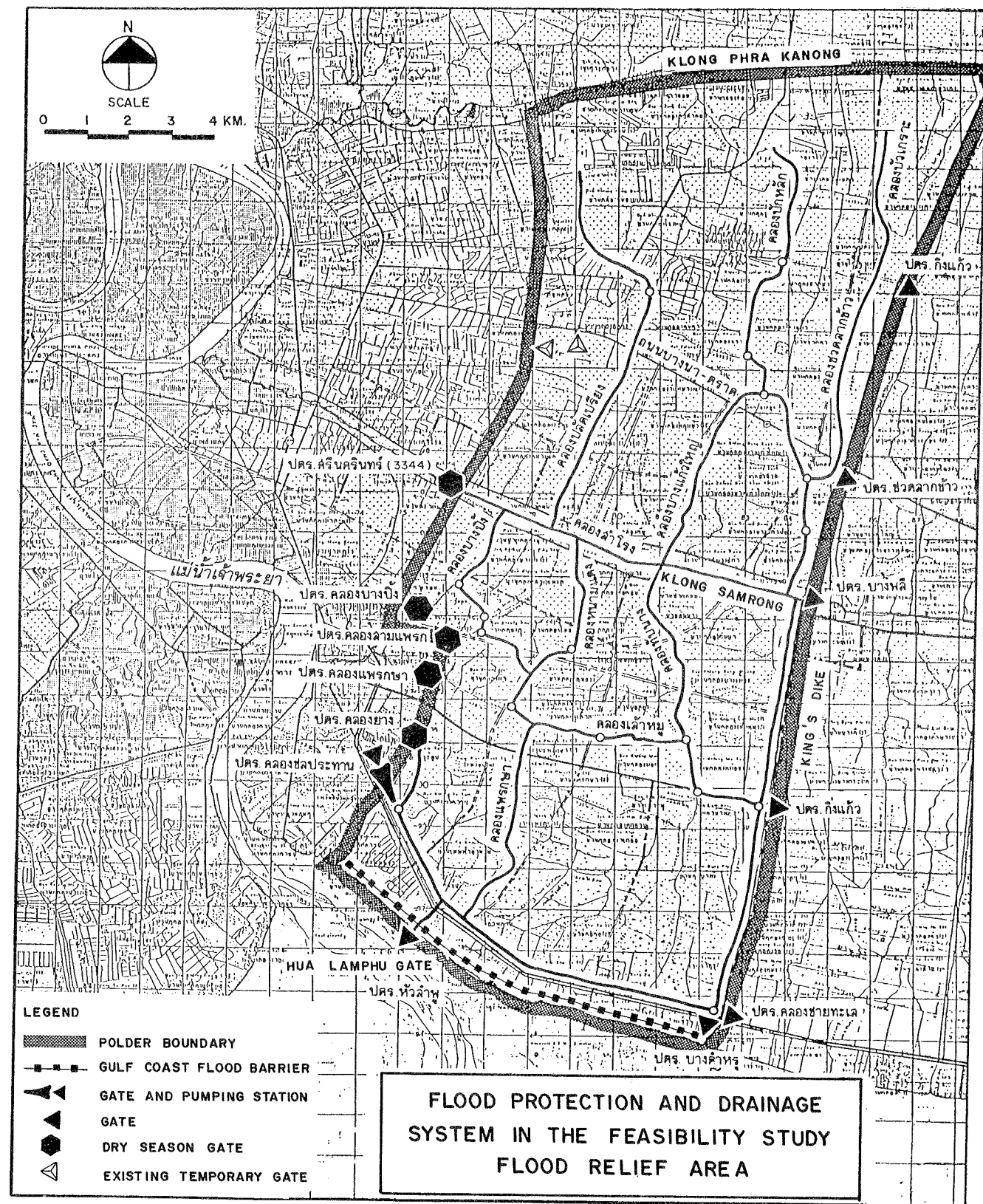


FIGURE 7 (CONT'D)

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ศูนย์ความรู้ (ศคร.)



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