

THE KINGDOM OF THAILAND
BANGKOK METROPOLITAN ADMINISTRATION

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

FINAL REPORT
VOLUME I: MAIN REPORT

MARCH, 1984

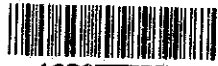
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BANGKOK METROPOLITAN ADMINISTRATION**

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JAPAN INTERNATIONAL COOPERATION AGENCY

国際協力事業団

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PREFACE

It is with great pleasure that I present to the Government of the Kingdom of Thailand this report entitled "PRELIMINARY STUDY OF FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN -- BANGKOK".

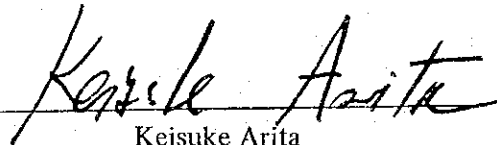
This report embodies the result of the study which was carried out in the eastern suburbs of BANGKOK from May 1983 to March 1984 by the Japanese study team commissioned by the Japan International Cooperation Agency following the request of the Government of the Kingdom of Thailand to the Government of Japan.

The Study team, headed by Mr. Saburo FUKAGAWA, Pacific Consultants International, had a series of discussions on the Project with the officials concerned of the Government of Thailand, conducted a wide-ranging field survey and prepared the present report.

I hope that this report will be useful as a basic reference for development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the Japanese team.

March, 1984

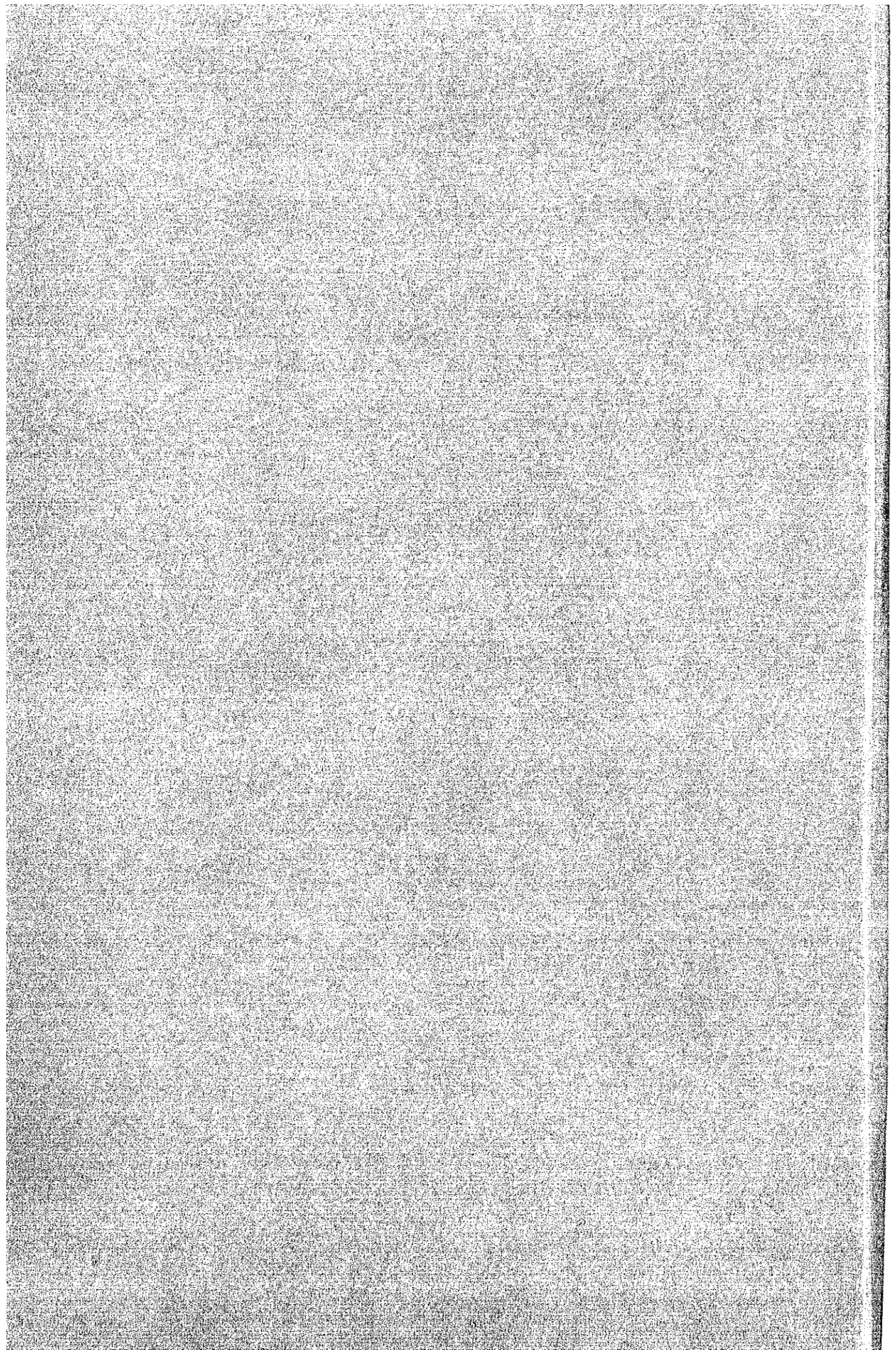


Keisuke Arita

President

Japan International Cooperation Agency

SUMMARY

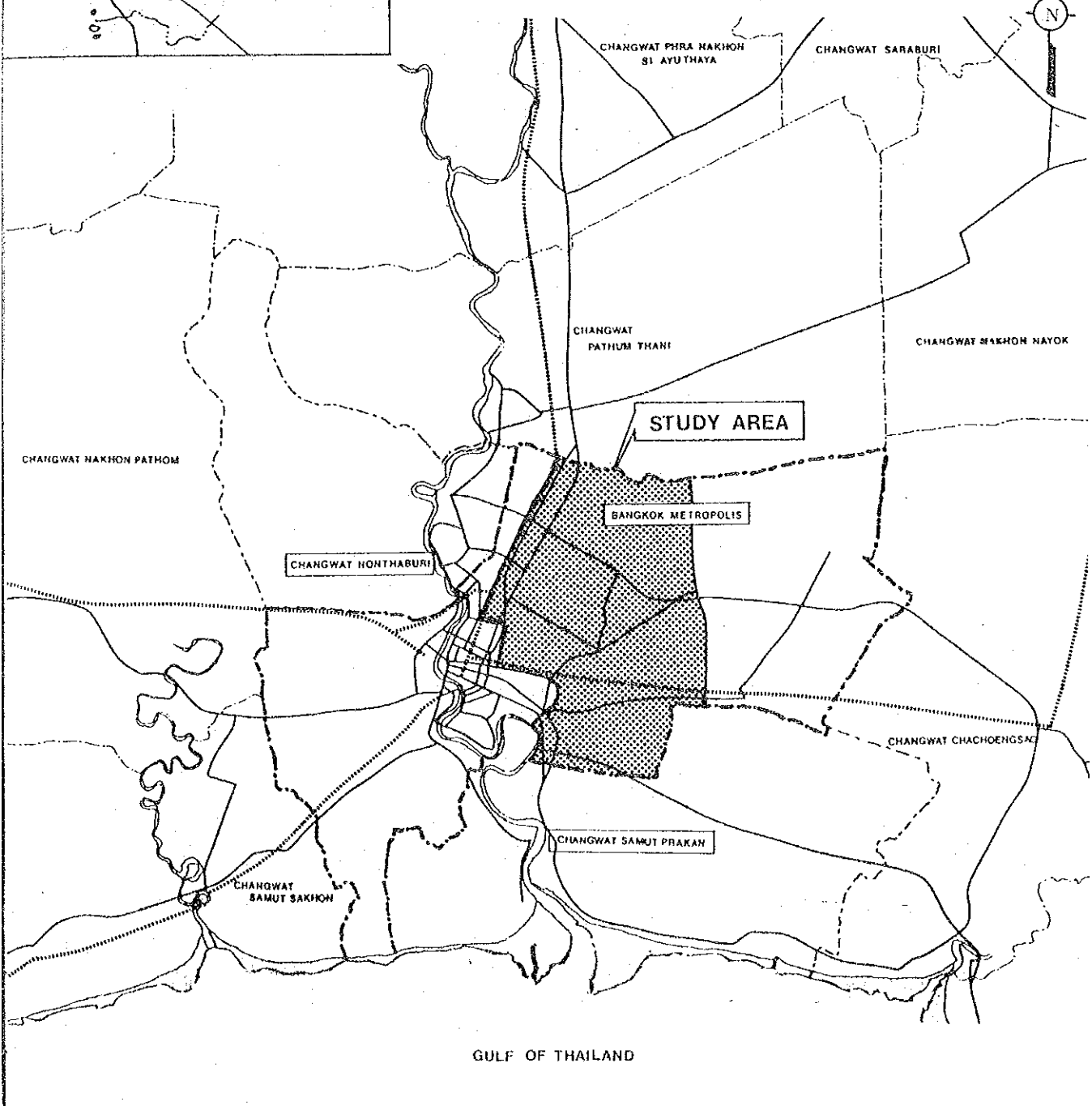
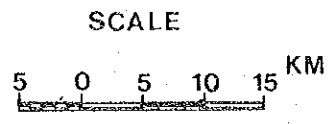
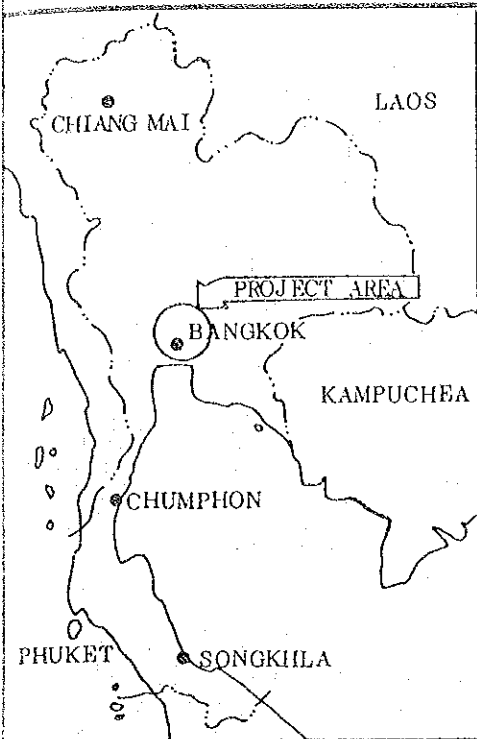


SUMMARY

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LOCATION OF THE STUDY AREA



1. INTRODUCTION

1.1 Background and Necessity of the Study

Bangkok, the capital of Thailand, is located on the flat deltaic plain of the Chao Phraya River which has a drainage area of about 160,000 km² — about one-third of the total area of Thailand.

As Bangkok was founded on marshland near the mouth of the Chao Phraya River, floods have occurred regularly from its beginnings. As the traditional style of houses built on stilts has been steadily changing since the 1950s due to economic development, accompanied by modernization in life-style, flood waters have brought increasing amounts of damage.

As early as in the 1960s, various plans for flood protection were proposed, from which a 370 km² master plan in the central area of Bangkok was prepared by the engineering consultant firm, Camp Dresser & McKee (CDM) in 1968 (CDM Plan). This plan which covers not only the central area but also southwestern parts of the Study Area was approved officially. At that time, the Bhumipol Dam and Sirikit Dam encompassing flood control functions were constructed upstream of the Chao Phraya River. It was believed that these projects would protect Bangkok from severe flood damage.

However, severe floods hit Bangkok frequently during the 1970s. Because of rapid urbanization, the construction of infrastructure could not keep pace. Large amounts of groundwater were extracted, causing land subsidence which further aggravated flood conditions in the Study Area. The 1980 flood lasted for more than two months.

Under these circumstances, the Government of Thailand decided to implement fundamental solutions to the flood problem in Bangkok. The plan for the central area (City Core Project) is covered as part of the Fifth National Development Plan. The eastern suburban area undertaking is planned for implementation during the Sixth Plan.

The preliminary and master plan studies on Flood Protection/Drainage Project in Eastern Suburban--Bangkok was requested by the Government of Thailand and agreed to by the Government of Japan. These studies are divided into 2 parts; a preliminary study in the first year which is summarized in this report and the master plan study in the second year.

The Preliminary Study was undertaken during May 1983 to March 1984 by the Japan International Cooperation Agency (JICA), the official agency for technical cooperation in Japan, together with the Department of Drainage and Sewerage (DDS) of the Bangkok Metropolitan Administration (BMA).

1.2 Objective and Target Year of the Study

The Study aims at planning adequate flood protection and drainage facilities. The project is planned for consistency with the socioeconomic situation of Thailand as well as with other related projects, with a view toward long-range operation of the facilities.

Guiding principles for planning are as follows:

- (1) Flood plain management such as efficient land use and control of potential flood occurrence should be emphasized.
- (2) Future urbanized areas should be provided with adequate flood protection/drainage measures.
- (3) The project should be as flexible as possible to cope with future development of the city.

Target year for the Master Plan Study has been set for the year 2000, considering the necessity for consistency with other related plans or projects [e.g., "Draft of the Structural Plan for Bangkok Metropolis and its Vicinity", prepared by DTCP and "Master Plan on Flood Protection/Drainage Project in Bangkok Metropolis", prepared by Camp Dresser and McKee (CDM Plan)].

1.3 Conclusion of the Preliminary Study

The general concept for the flood protection/drainage method, consisting of flood plain management and structural measures, in the 501 km² of the Study Area, is established (Figs. S.5 and S.6).

As a result, a Master Plan Area of 260 km² was selected on the west side of the Study Area (Fig. S.8). Structural measures are to be executed there. The remaining area should be declared as a retarding area and conserved as existing agricultural land.

The Master Plan on flood protection/drainage facilities in the Master Plan Area will be studied in the next stage of the Study.

2. BASE STUDY FOR FLOOD PROTECTION/DRAINAGE METHOD

In the Preliminary Study to establish a basic flood protection/drainage method and to select a Master Plan Area, the following studies and investigations were conducted:

1. Characteristics of the Study Area
2. Existing flood protection/drainage facilities
3. Past floods and causes of flooding
4. Review of previous studies and relevant plans
5. Estimation of future urbanized area
6. Estimation of land subsidence

2.1 Characteristics of the Study Area

(1) Topography and Land Subsidence

The Study Area of 501 km², located in eastern suburban Bangkok is characterized by extremely low and flat land since it is located in the deltaic alluvial plain of the Chao Phraya basin. Even now, the high water level of the Chao Phraya River exceeds the ground surface in the Study Area during high tide and flood season. (Fig. S.1) Furthermore, severe land subsidence (the rate of which is 10 cm/year at severe place) caused by excessive withdrawal of groundwater, has lowered and is expected to further lower the originally low-lying Study Area.

(2) Hydrology

Of the average 85% annual rainfall recorded during the rainy season from June to October, 40 percent occurs during September to October.

The water level of the Chao Phraya River is high from September to November as a result of both flood water from upstream and high tide, which reduces the gravity flow capacity from the Study Area to the Chao Phraya River.

(3) Population and Land Use

Urbanization has been gradually expanding from the central area toward north-eastern areas. The population of the Study Area was estimated to be 1,160,000 in 1980 which constituted about one-quarter of the Bangkok Metropolis population. The annual population growth rate in the Study Area for the past 10 years was 5.2% which was higher than the average for the entire Bangkok Metropolis area (4.0%). However, the eastern parts of the Study Area are agricultural land without urbanization except in scattered places.

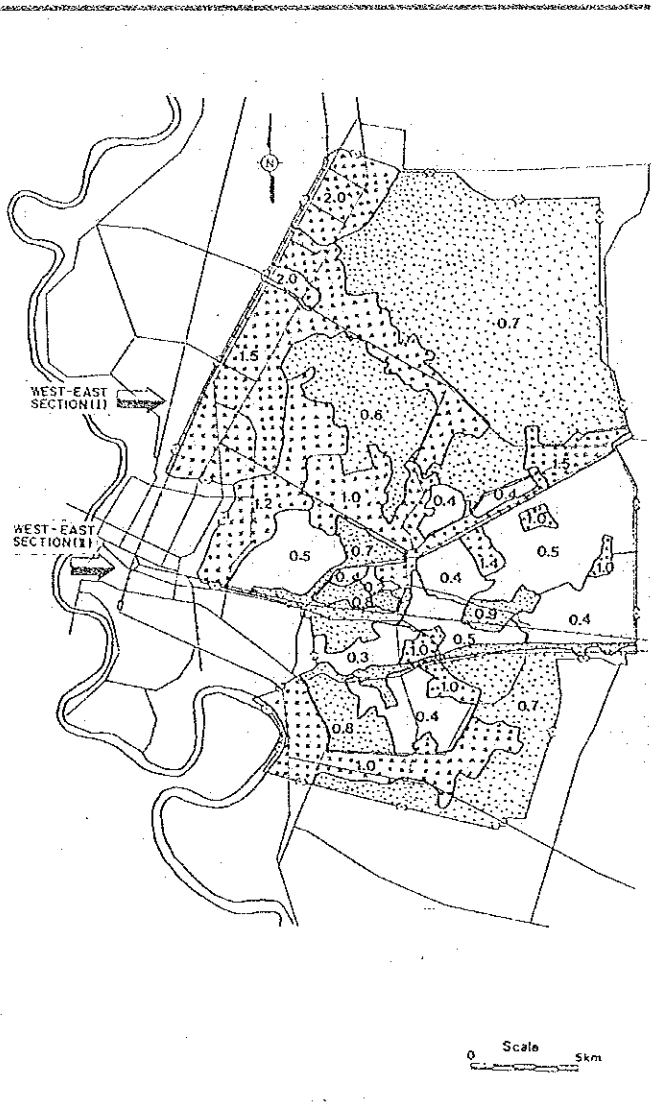


FIG. S.1.a Ground Elevation in the Study Area as of 1983

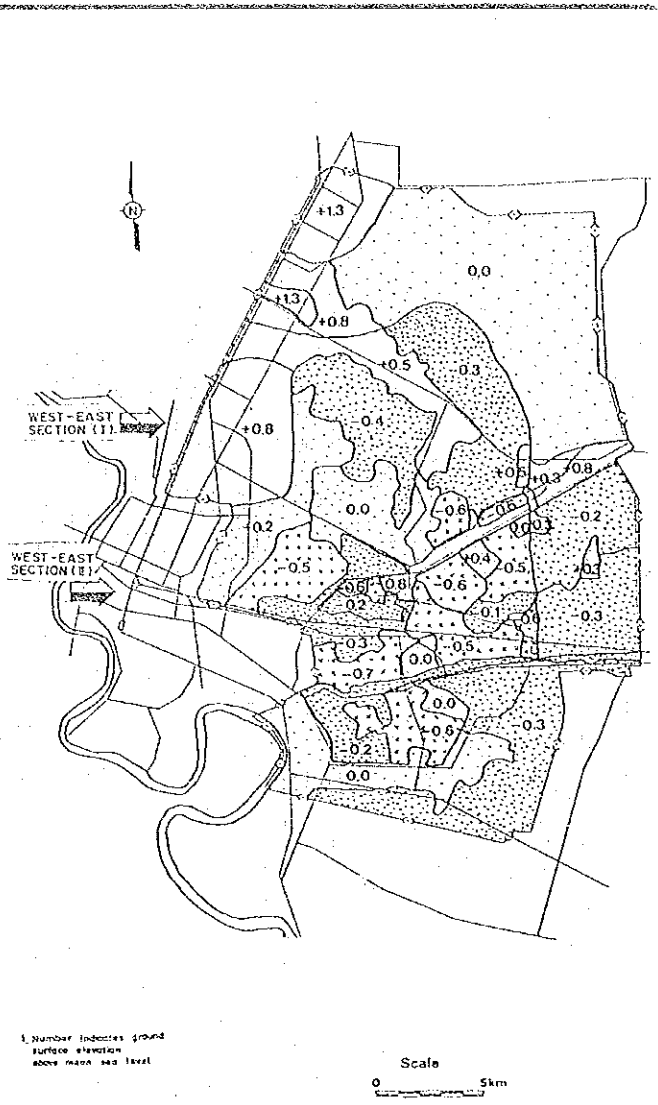
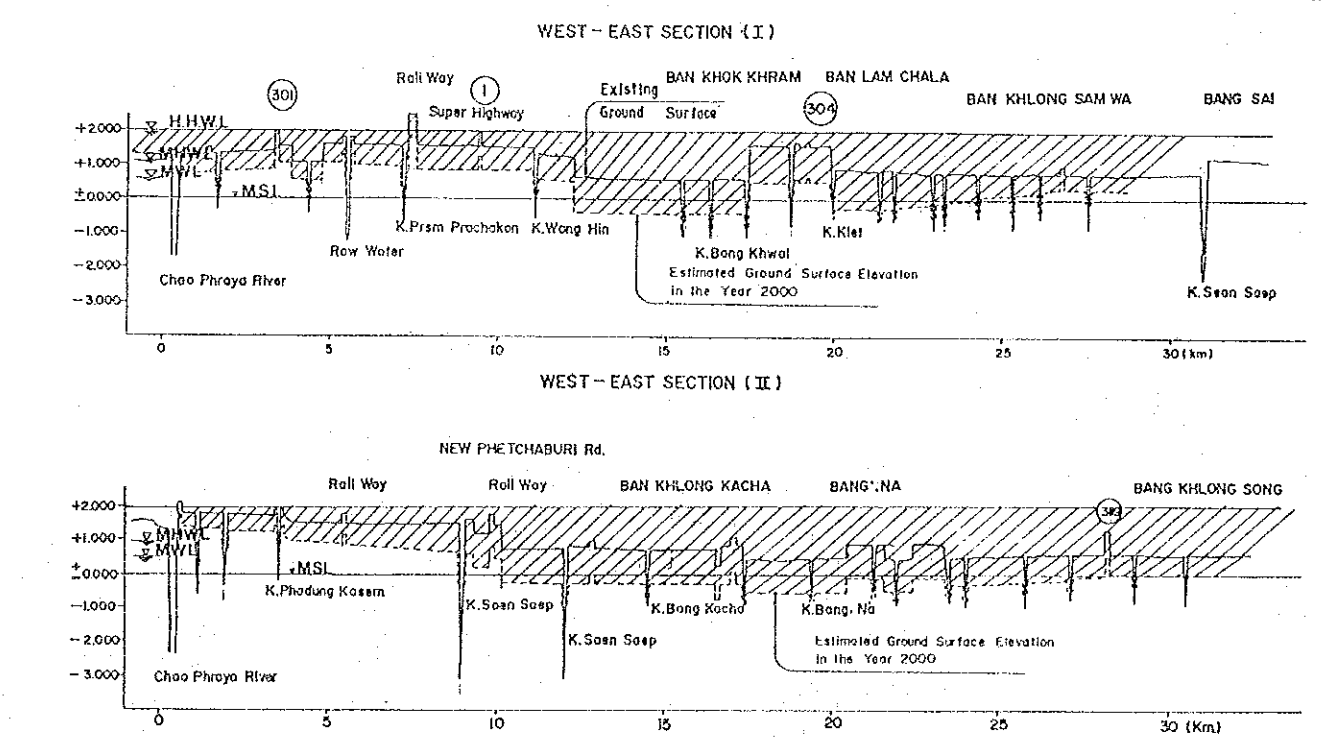


FIG. S.1.b Estimated Ground Surface Elevation in the Study Area in the Year 2000



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. S.1.c Estimated West-East Profile of the Study Area in the Year 2000
 FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

(4) Roads

Roads are usually raised to about 1.0 to 2.5 meters above mean sea level in order to avoid being flooded. Therefore, they function as excellent flood barriers within the Study Area.

2.2 Existing Flood Protection/Drainage Facilities

In 1977, the Bureau of Drainage and Sewerage (now called "the Department of Drainage and Sewerage") was established as a result of the 1975 flood. The emergency flood protection scheme of the 100 square kilometer area in the center of Bangkok was devised in 1978. Since then, flood protection activities by DDS have been expanded towards the eastern suburban area (Study Area).

The extensive network of klongs (canals) in the Study Area is utilized as drainage channels. However, the capacity of the klongs to divert flood waters is insufficient due to their extremely gentle gradient as well as their narrowness.

There is no permanent pumping station in the Study Area. Some temporary pumping stations have been installed although they are insufficient in both quantity and capacity.

For example, in the Phra Khanong Pumping Station, which is the largest outlet in the Study Area, capacity is only about 15 m³/sec. This allows discharge of storm-water equivalent only to 3 mm/day rainfall.

2.3 Past Floods and Causes of Flooding

Recent floods in Bangkok occurred in 1975, 1978, 1980, 1982 and 1983. Among these, the 1983 flood was the largest, with 1,080 mm rainfall during August through October, compared to the average of 500 mm. The Bang Na area located in the southwest of the Study Area and Ramkhamhaeng area in the west of the Study Area were for the most part inundated for a period of more than 2 months.

For reference, a view of the inundation areas in the 1983 floods is shown in Fig. S.2 in which inundation of eastern agricultural land has been omitted.

The Study Team surveyed flood damage in the 1982 floods in cooperation with DDS. The preliminary damage value is estimated at about 400 million Baht, including direct, indirect (only for traffic delays) and uncertain (only for flood prevention cost spent) damage.



Note: (1) This map indicates the flood areas only in the Urbanized Area.
 (2) Figures indicate the depth of flood water on the road in centimeter.

FIG. S .2

Flood Area in the Urbanized Area on Oct. 24, 1983

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Floods are caused by a combination of the following factors:

- (1) Heavy Rainfall
- (2) Inflow from Outside Areas
- (3) Change in Discharge Patterns
- (4) Low, Flat Plain and High Water Level of the Chao Phraya River
- (5) Progressive Land Subsidence
- (6) Insufficient Drainage Capacity

Although floods have occurred for a long time due mainly to the natural conditions mentioned above, flood damage has increased recently due to the influx of urban population into this area.

2.4 Previous Studies and Relevant Plans

The following plans and projects on the left bank of the Chao Phraya River are considered to influence the drainage system in the Study Area. (Fig. S.3)

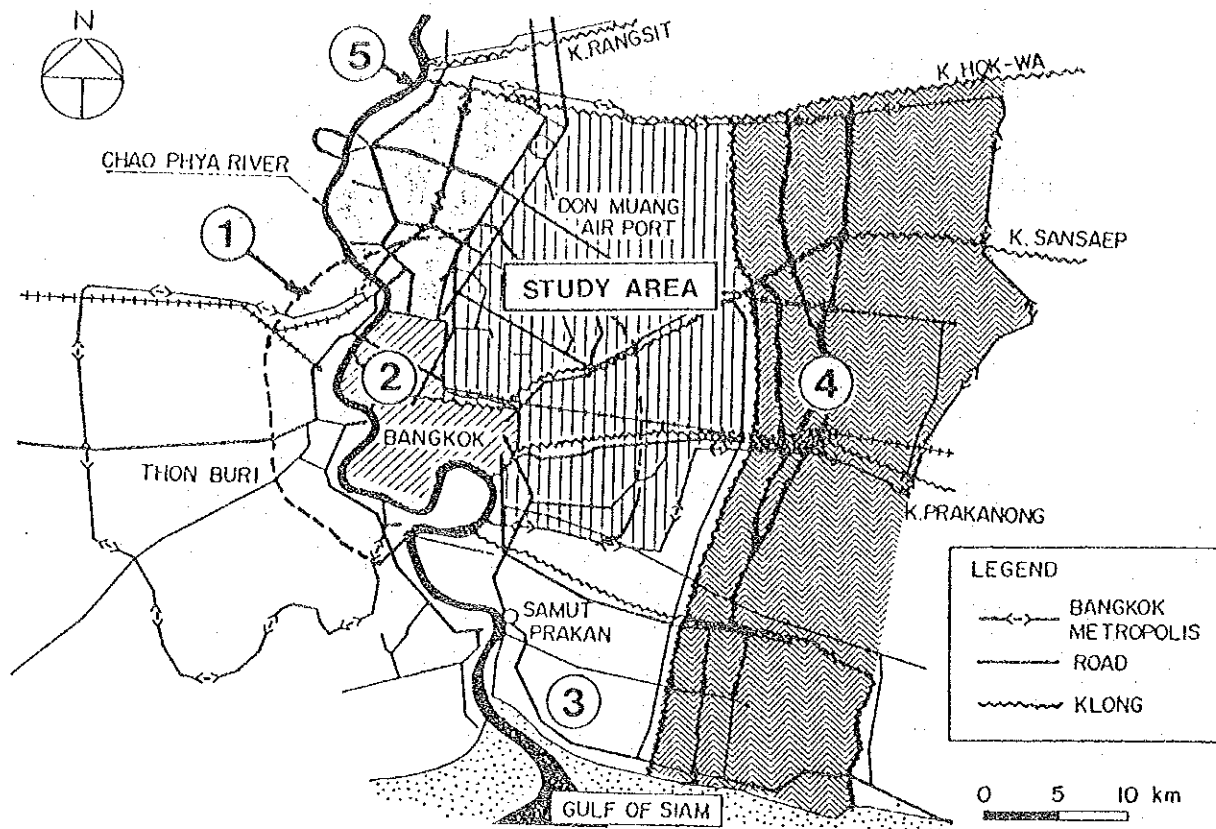
- (1) CDM Plan
- (2) City Core Project
- (3) Samut Prakan Sea Wall Project
- (4) Green Belt Project
- (5) Chao Phraya River Water Level Lowering Plan
- (6) Urgent Plans due to the 1983 Floods

The first three items aim at flood protection and drainage, while plans (4) and (5) aim mainly at blocking inflow from outer areas or reducing the water level itself. Among the six plans, plans (4) and (6) will greatly contribute to flood mitigation in the Study Area. Urgent plans are considered only as provisional flood protection/drainage measures in the Study Area.

2.5 Future Urbanized Area

The recorded urbanized area and the population in the Study Area in 1980 were 148 km² and 1.16 million respectively. In the year 2000, the estimated urbanized area and the population are forecast to be 230 km² and 2.5 million respectively, according to estimates made by the Study Team.

It is especially noted that there is at present no authorized city plan of the Metropolis. Therefore, a future land use plan in the Study Area was studied, based on "The Draft Structural Plan for Bangkok Metropolis and its Vicinity" prepared by DTCP, in collaboration with the staff of DTCP and BMA.



LEGEND

- ① CAMP DRESSER & MCKEE (CDM) PLAN ----
- ② FLOOD CONTROL AND DRAINAGE PROJECT IN CENTRAL (CITY CORE) AREA ----
- ③ SUMUT PRAKAN SEA WALL PROJECT ----
- ④ GREEN BELT PROJECT ----
- ⑤ CHAO PHRAYA RIVER WATER LEVEL LOWERING PLAN ----

FIG. S.3

Previous Study and Relevant Plans

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

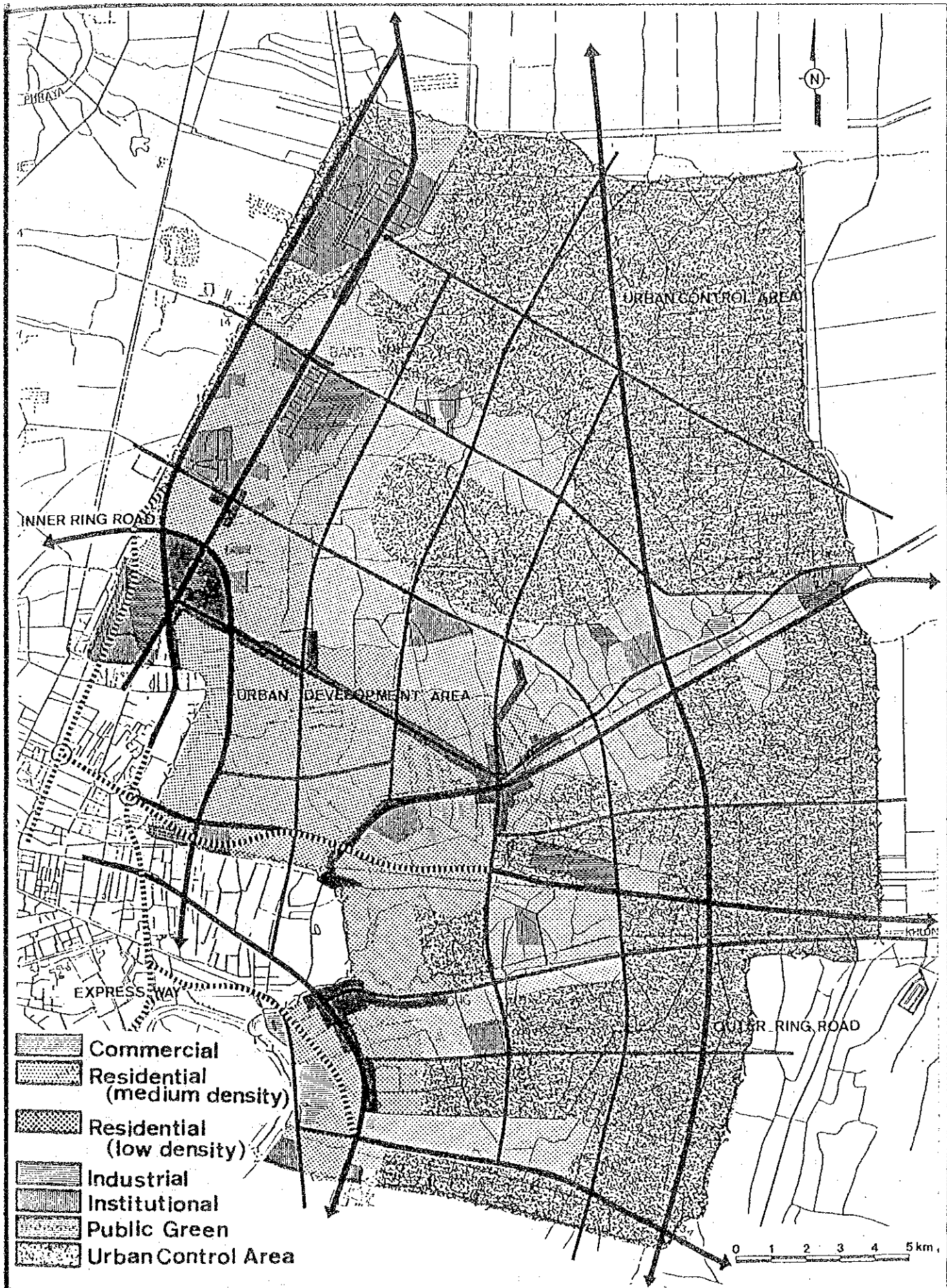


FIG. S.4

Land Use Plan for the Study Area
in the Year 2000

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

Fig. S.4 shows the estimated land use plan in the Study Area in the year 2000. Urbanized area is allotted to the western parts of the Study Area; the eastern part remains as an agricultural area.

2.6 Land Subsidence

The estimated amount of land subsidence between 1983 and 2000 is 1.0 meter in the critical area and 0.7 meters in another area. These figures are estimated based on the plan for groundwater extraction by Metropolitan Water Works Authority (MWWA) with reference to the land subsidence estimates made by the Asian Institute of Technology (AIT). The critical area is in the southwestern part of the Study Area.

Fig. S.1, which shows ground elevation in the Study Area in the year 2000 indicates that much of the Study Area will be below mean sea water level.

MWWA is now undertaking planning/implementing measures to substitute surface water for groundwater supply for mitigation of land subsidence. However, since these measures will take considerable time, land subsidence is expected to continue for the time being, at least up to the year 2000.

3. FLOOD PROTECTION/DRAINAGE METHOD

3.1 General Concept of Flood Protection/Drainage Method

The general concept of flood protection/drainage method was established as shown in Figs. S.5 and S.6. This concept has two aspects: flood plain management and flood protection and drainage measures.

Flood damage potential in the Study Area is rapidly increasing due to the progression of unplanned urbanization and land subsidence. To reduce this flood damage potential and to efficiently protect the Study Area, flood plain management as well as construction of flood protection/drainage measures (structural measures) will be indispensable.

3.1.1 Flood Plain Management

Flood Plain Management should be conducted in parallel with the construction of structural measures. Main items for the flood plain management are:

(1) Identification and Publicizing of Flood-Prone Areas

To enable the public to clearly recognize flood, the identification and publicizing of flood-prone areas to the public is necessary.

(2) Land Use Regulations

It is very important to control unplanned urbanization and to follow the land use plan. Especially new urban development in the eastern agricultural land with flood-retarding capacity should be controlled.

(3) Encouragement of Individual Flood-Proofing Measures

Flood-proofing measures should be individually encouraged for houses in the flood-prone areas.

(4) Emergency Flood Fighting and Flood Warning Systems

Emergency flood fighting and flood warning systems should be planned and executed.

(5) Flood Protection Committee

The establishment of a flood protection committee coordinated with other related organizations and representatives of residents is needed to correlate with other related plans or projects, to provide efficient flood fighting in the drainage areas.

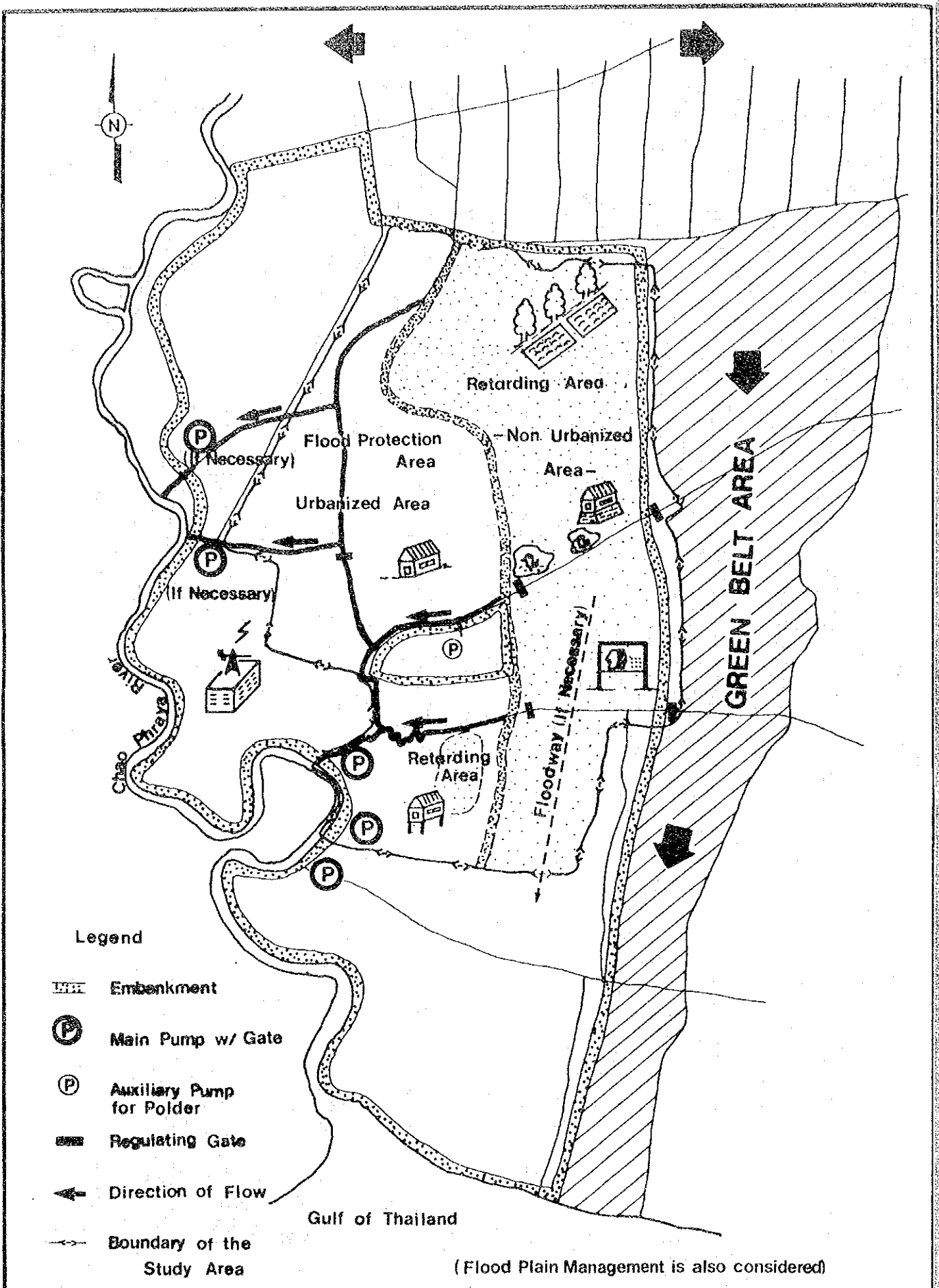
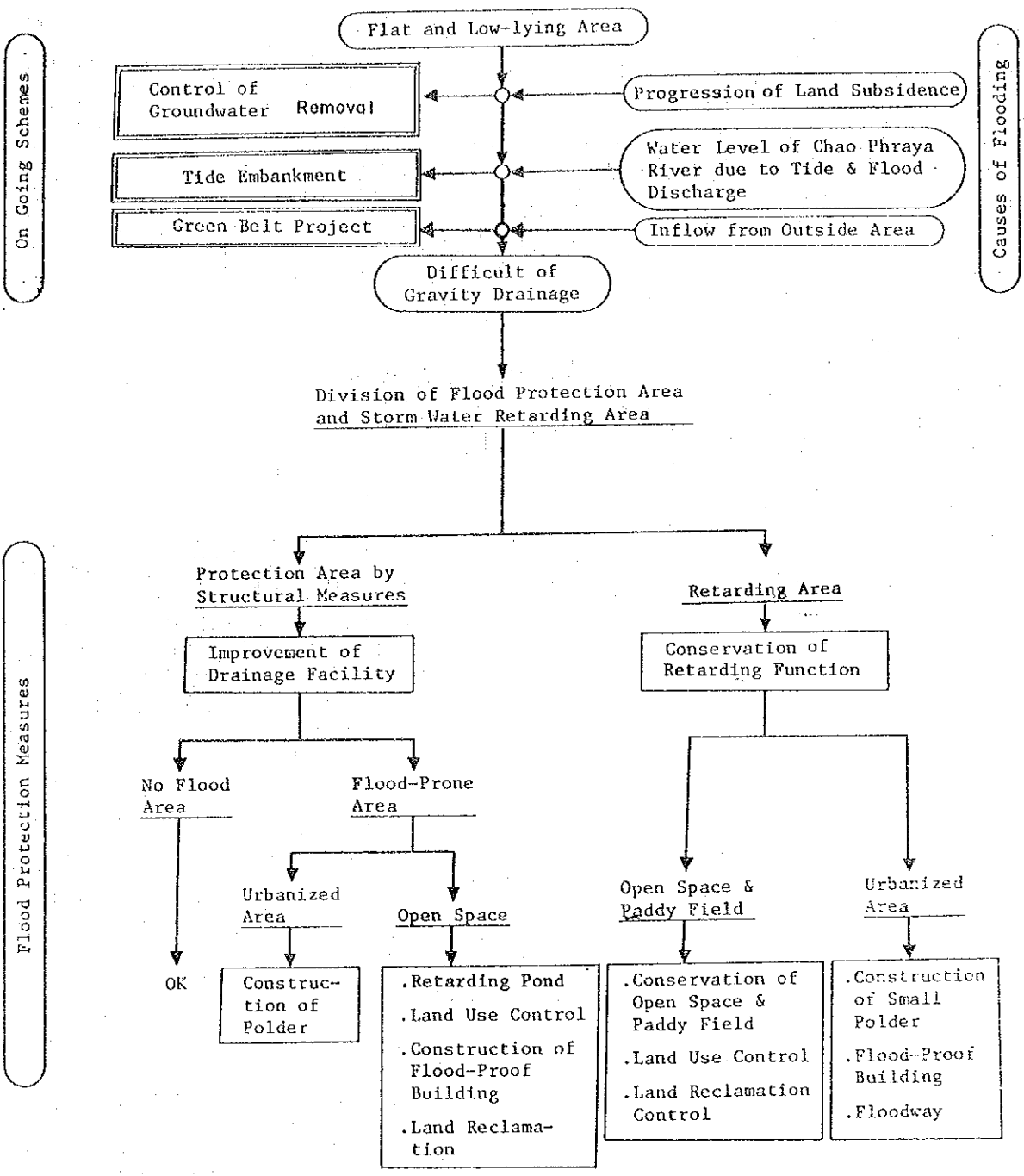


FIG. S.5

Concept for Flood Protection Measures

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK



On Going Schemes

Causes of Flooding

Flood Protection Measures

FIG. S.6 Outline of Flood Protection Measures
FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

3.1.2 Flood Protection and Drainage Measures

Flood protection/drainage measures are studied on the basis of the establishment of a polder system, as proposed by the CDM Plan. The polder system will prevent flooding from outside the Study Area and provide drainage of rainfall inside the polder.

(1) Prevention of Inflow from Outer Area

The Green Belt Project is now under way for prevention of inflow from northern and eastern areas beyond the Study Area. An embankment and several gates will be constructed to block backwater from the Chao Phraya River.

(2) Improvement of Drainage Capacities

Construction or improvement of polder levees, pumps, gates and klongs will be required to discharge stormwater.

3.2 Urban Development Area and Retarding Area

3.2.1 Criteria for Formulation of Drainage Zones and Establishing Drainage Zone Priority

As the criteria for the formulation of the drainage zones the following items are considered:

- (1) Topography and Land Subsidence
- (2) City Planning
- (3) Trend of Flood Damage
- (4) Location of Highways, Railways and Main Klongs

The determination of priority for establishing a drainage zone is made based on consideration of effective investment, economic activities in the Area and trends of past flood damage.

This consideration will also be made on setting priority areas for staged construction within the Master Plan area.

3.2.2 Division of Urban Development Area and Retarding Area

The establishment of a retarding area is proposed in order to utilize the topographical characteristics which have a natural water-detaining capacity. It is also necessary to have correlation with city planning, especially concerning future land use. The needs for both urbanization and natural water detaining functions should be combined/

harmonized. From these points of view, the retarding area should be conserved with its existing function. This is one of the prerequisite conditions for execution of the flood protection/drainage system in the urban development area.

The size of the retarding area was decided on the basis of the urban development area in the target year 2000. After the year 2000, this area will be used as an urban development area to cope with further development of Bangkok.

According to hydraulic study results from the 1980 flood, it is found that the flooded area in the urban development area would decrease by about 70% and flood depth by about 20 cm on the basis of existing drainage capacity and provided that there is no water inflow from the retarding area.

Flood water level in the retarding area will also decrease to about 20 cm from more than 50 cm, by the execution of the Green Belt Project. The flood depth of about 20 cm is considered as tolerable in the retarding area which are paddy fields.

3.2.3 Hydrological and Hydraulic Modeling

Three models; i.e., Two-Basin model, Bi-Dimensional model and Polder Drainage model, were used to evaluate hydrological and hydraulic effects after they had been identified as being effective, based mainly on calibration study of the 1983 floods.

3.3 Flood Protection/Drainage Measures

3.3.1 Hydrological Design Criteria

Large scale design is preferable for flood protection/drainage measures, in view of stable city activities, national economy and long-range operation of the facilities. The following design scale is principally established, taking into account those of other projects, such as the CDM Plan, City Core Project and Malaysia, Philippines and Japan.

(1) Rainfall for Calculating Discharge in Polders

Short duration rainfall of a 5-year return period is adopted. In addition, short duration rainfall of a 2-year return period will be considered for comparison.

(2) Rainfall for Calculating Discharge in Main Klongs

Long duration rainfall of a 5-year return period is adopted.

(3) Water Level of Chao Phraya River

Water level in 100-year return period is adopted.

Inundation is temporarily allowed for retarding and for very low land areas, the degree of which will be decided after taking natural conditions into consideration.

3.3.2 Flood Protection/Drainage System

The urban development area will be protected by flood protection/drainage measures.

The urban development area is topographically divided by the Bang Na Area in the northwest which is rather high land and the Phra Kanong area in the southwest which is lower than the Bang Na Area.

These two areas are to be enclosed by polder (main outer polder) respectively. For special lower lands, small inner polders within the main outer polder will be provided. (Fig. S.7) Details will be studied in the Master Plan Stage.

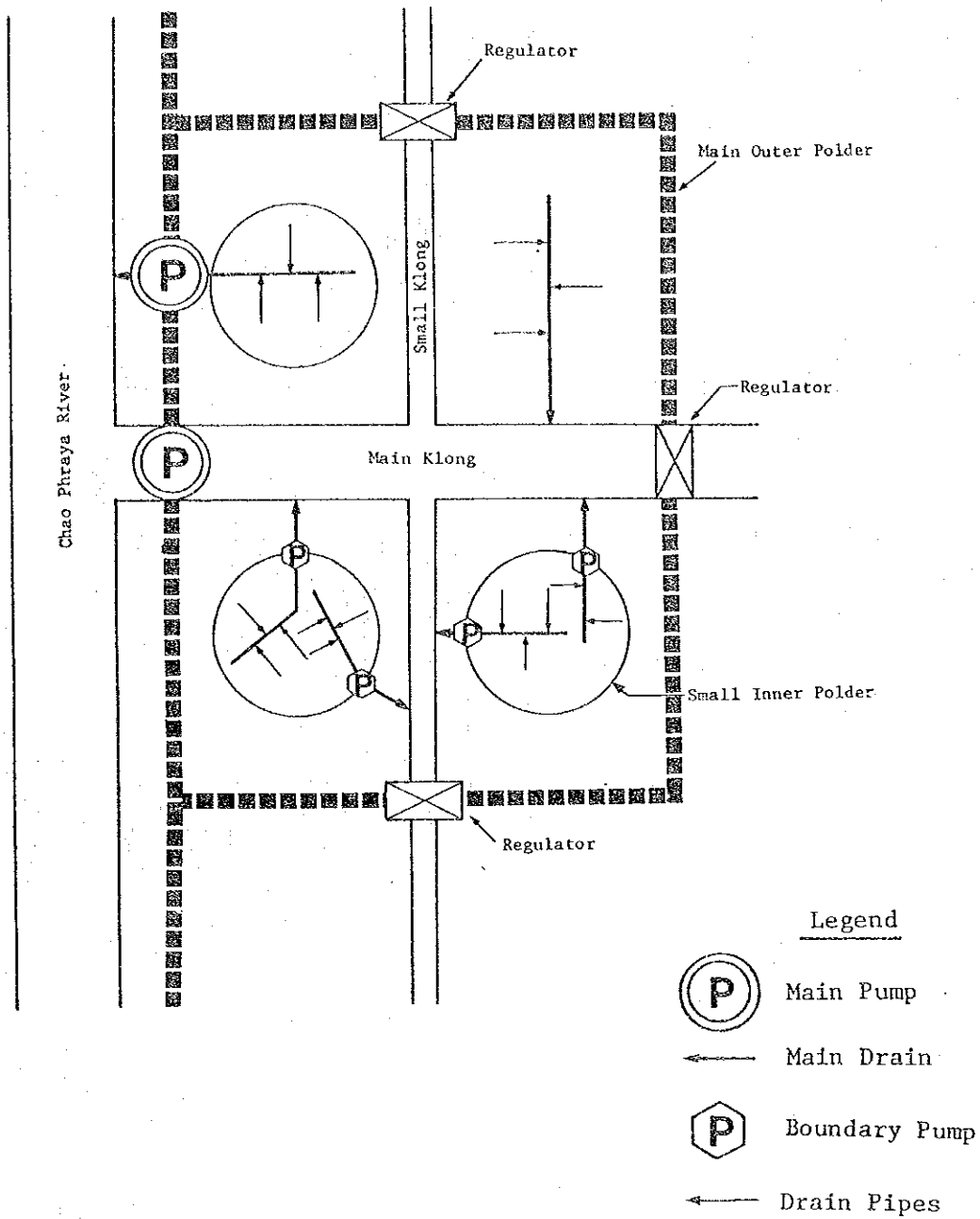


FIG. S.7

Schematic Diagram of Polder System

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

4. PROPOSED MASTER PLAN AREA

The urbanized flood-prone area is selected as the Master Plan Area where flood protection/drainage measures are to be implemented.

The Study Team has selected the 260 km² area as shown in Fig. S.8, based on the following considerations:

(1) Needs for Future Urbanized Area

The estimated urbanized area of 230 km² with 2.5 million residents in the year 2000 is allotted in the western part of the Study Area. The Master Plan Area is basically to correspond with this area. (Fig. S.4)

(2) Flood Damage

Flood damage has been increasing in the western part of the Study Area and future flooding is expected to be more severe due to land subsidence. (Figs. S.1 and S.2)

This area is basically included in the Master Plan Area.

(3) Physical Boundary Condition

As the boundary of the Master Plan Area, the existing as well as planned roads are to be utilized as flood protection barriers. (Fig. S.4)

(4) Hydrological Conditions

Retarding area in the eastern part of the Study Area is not included in the Master Plan area; however, flood conditions in the retarding area will be improved due to the Green Belt Project.

(5) Economic and Financial Conditions

According to a simple and rough study of cost-benefit analysis, positive economic benefits are expected. From a financial point of view, the proposed Master Plan area is considered sound as a long-range plan.

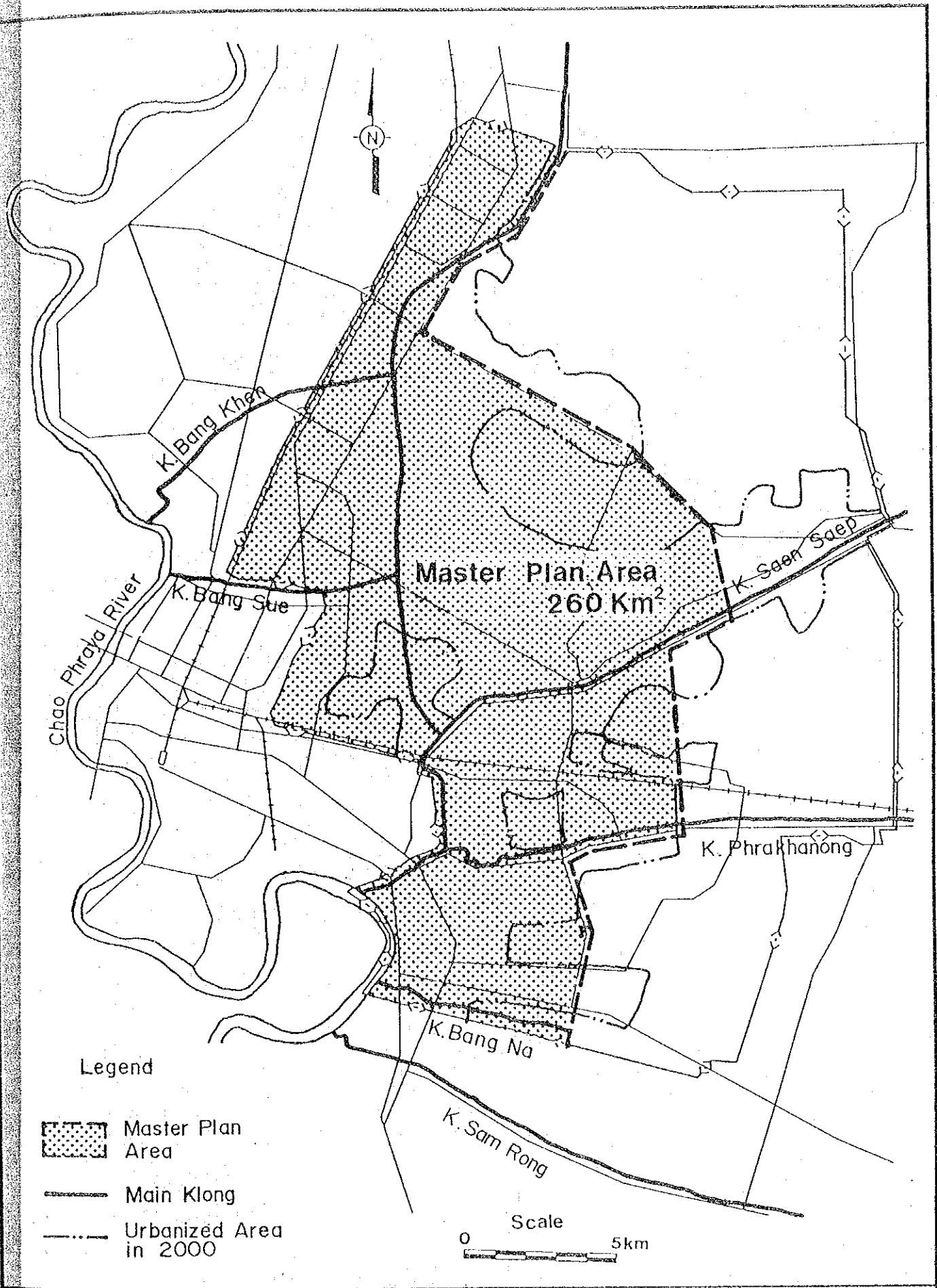


FIG. S. 8

Proposed Master Plan Area

FLOOD PROTECTION/DRAINAGE PROJECT IN EASTERN SUBURBAN-BANGKOK

5. ORGANIZATION, OPERATION AND MANAGEMENT PLAN

Special consideration should be given to the organizational and managerial aspects of implementation and operation to obtain maximum benefit from the project. The following recommendations are made:

- (1) Coordination with relevant government authorities should be strengthened.
- (2) Organizations should be set up to link residents in the area.
- (3) A project team should be set up for implementation of the Project within DDS.
- (4) A central control system for flood control should be established to consolidate the operation of drainage facilities in the area.
- (5) In addition to the operation of the drainage system for flood control purposes, consideration should be given for coping with environmental problems, transportation and irrigation functions of the klongs.

As for the financing of the project, the following two issues need to be considered:

- (1) Since the project cost is expected to be a substantial amount, new financial sources should be investigated.
- (2) Priorities within the Master Plan area for implementation of the project should be considered for staged construction.

PHOTOGRAPHS

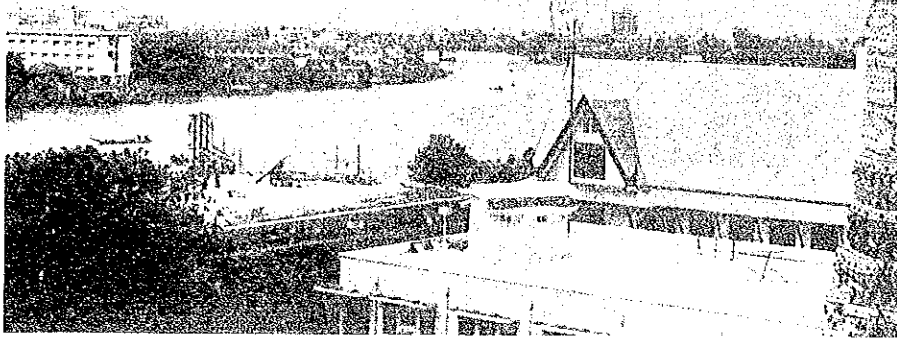


Photo--1 Chao Phraya River (Wat Arun)



Photo--2 Main Klong (Klong Bang Na)

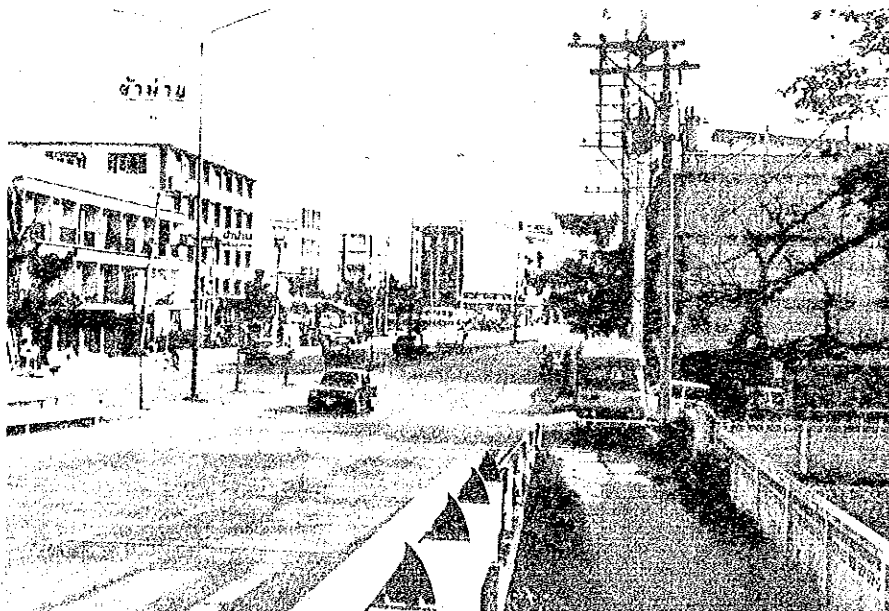


Photo--3 Commercial Area (Bang Kapi)

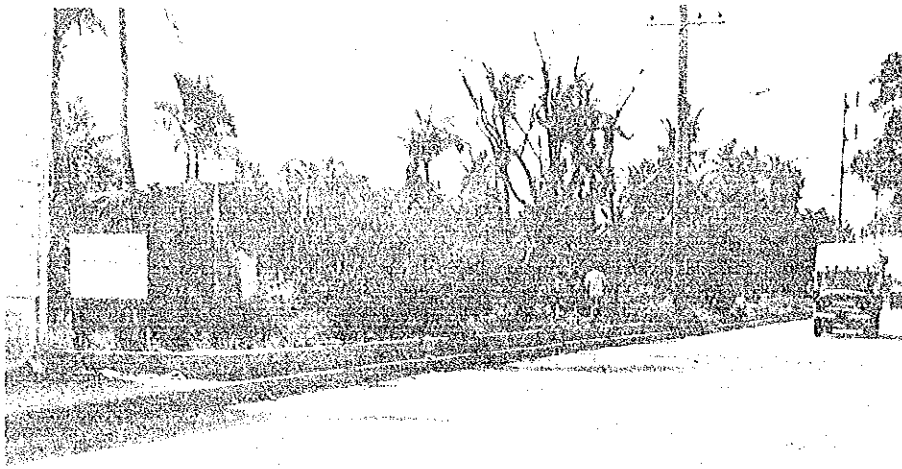


Photo-4 Embankment along the Chao Phraya River (Bang Na)

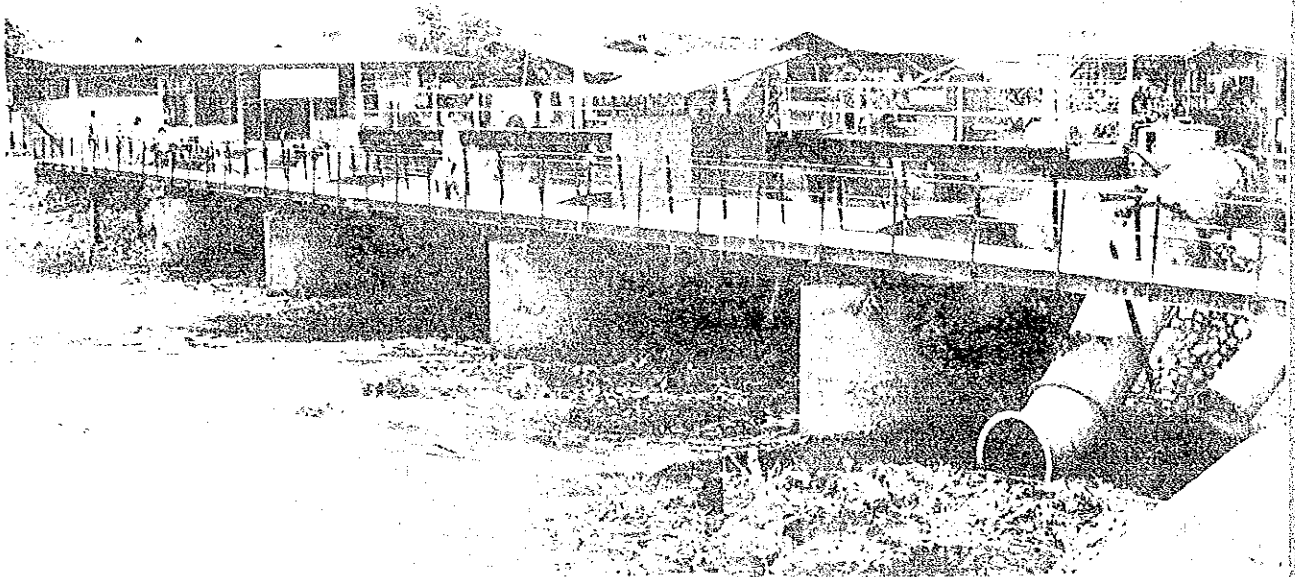


Photo-5 Phra Kanong Gate (View from Down Stream)

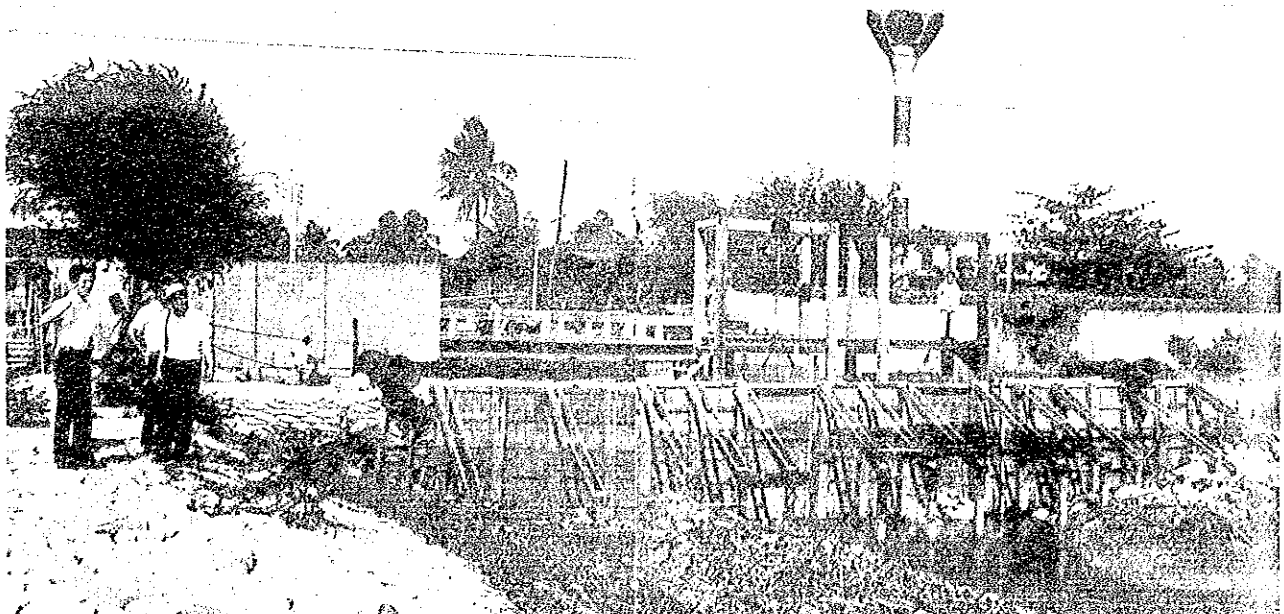


Photo-6 Bang Na Gate (View from Down Stream)

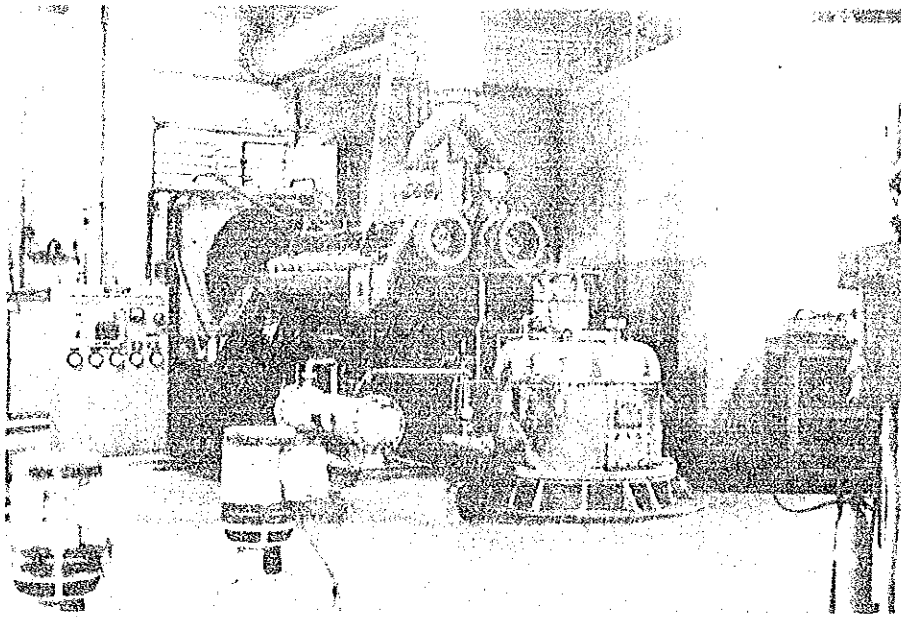


Photo-7 Rama IV Pumping Station

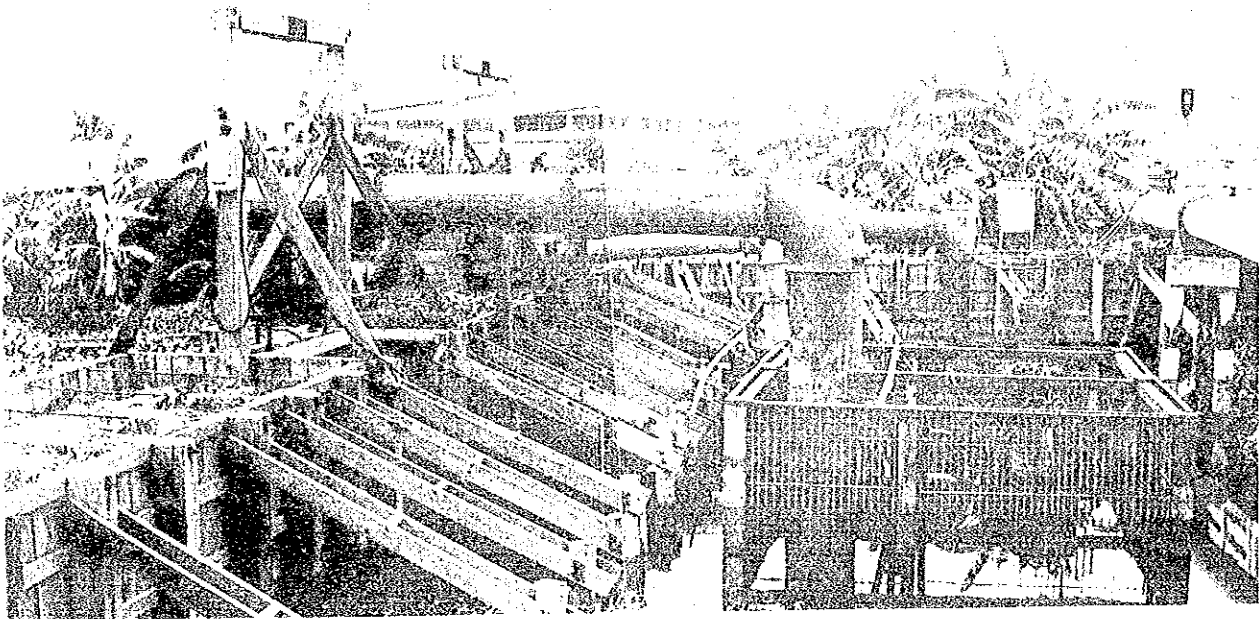


Photo-8 Provisional Pumping Station (Klong Kacha)

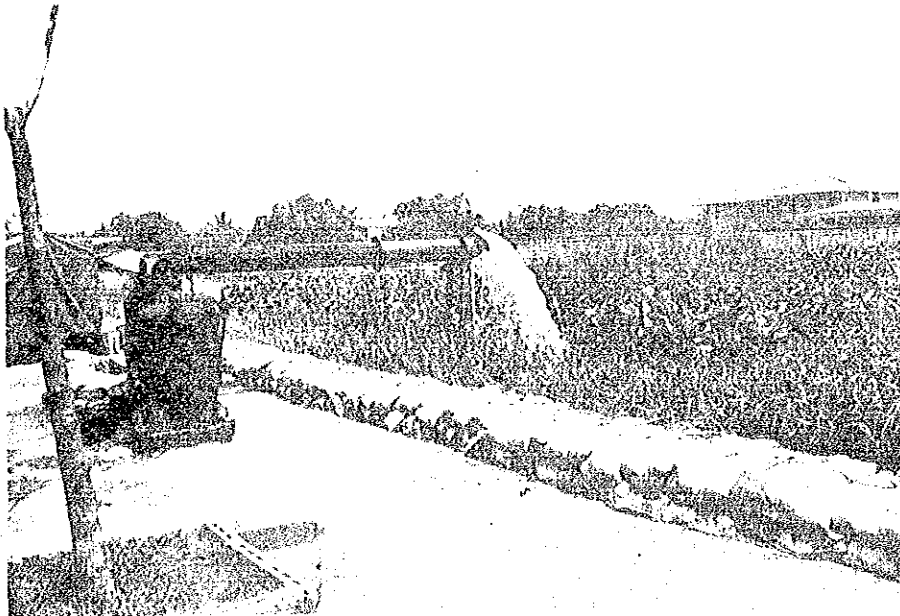


Photo-9 Movable Pump (Ramkhamhaeng)



Photo-10 New Residential Area (Bang Kapi)



Photo-11 Piloti Type Building in the Study Area

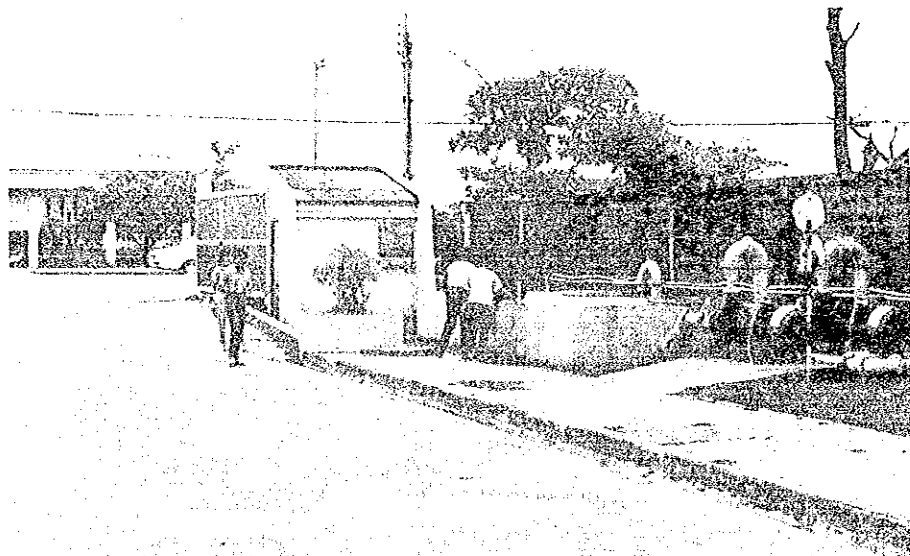
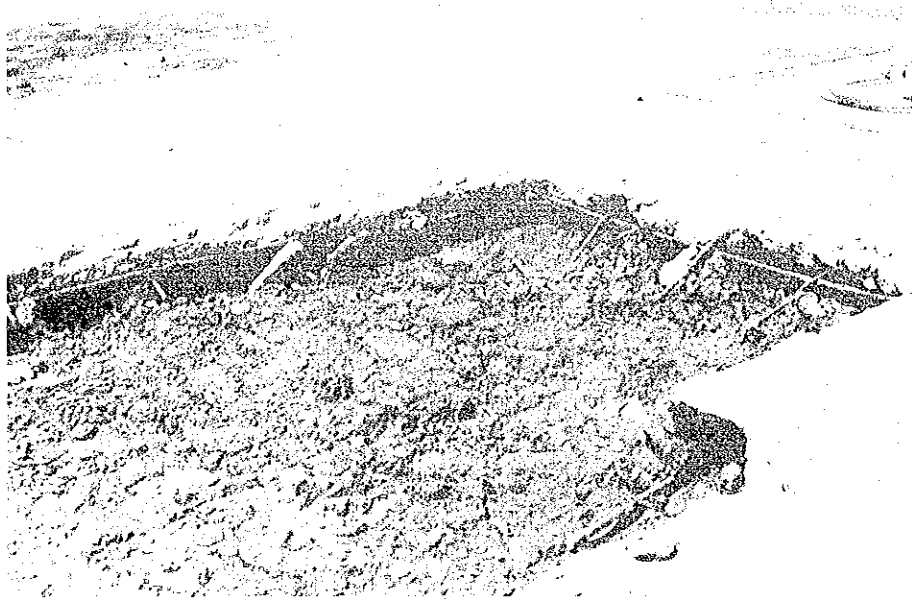
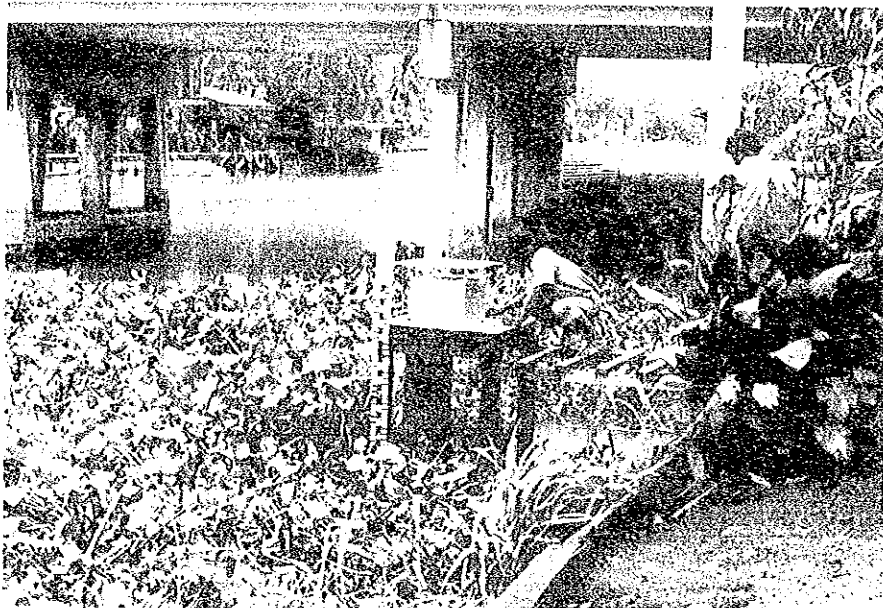


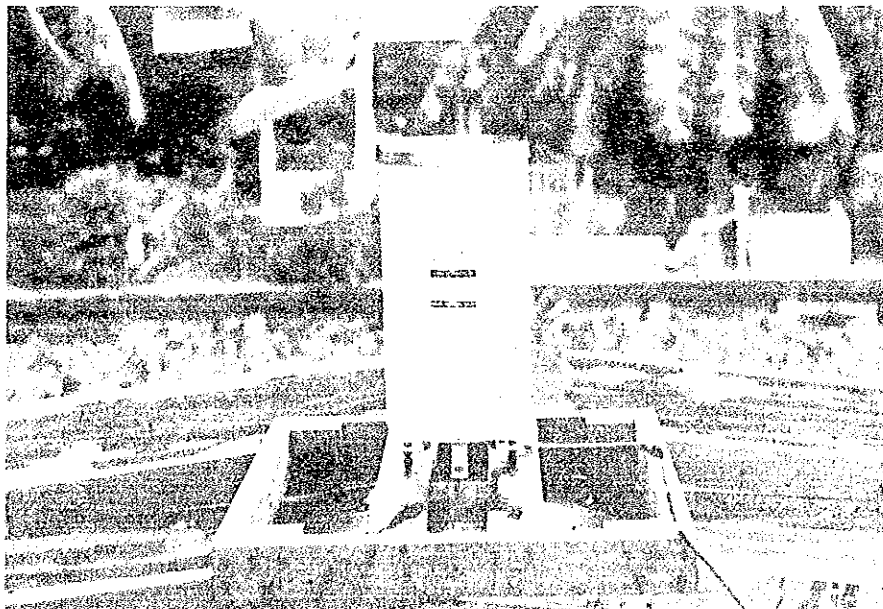
Photo-12 Private Drainage Facilities in the Study Area



Photo—13 Land Subsidence in the Study Area



Photo—14 Water Level Gage (Klong Saen Saep)



Photo—15 Rainfall Gage (Kanayao Police Station)

