BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE PROCUREMENT OF EQUIPMENT
FOR
FLOOD CONTROL CENTER
IN BANGKOK AND ITS VICINITY
IN
THE KINGDOM OF THAILAND

SEPTEMBER, 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan has decided to conduct a basic design study on the Project for the Procurement of Equipment for Flood Control Center in Bangkok and its Vicinity and has entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr. Koichi Baba, Director of the Office of Disaster Protection, River Bureau, Ministry of Construction from June 6 to July 3, 1988.

The team had discussions on the Project with the officials concerned of the Government of Thailand and conducted a field survey in Bangkok and its vicinity. After the team returned to Japan, further studies were made, a draft report was prepared and a mission was dispatched to Thailand to explain and discuss it. As a result, the present report has been prepared.

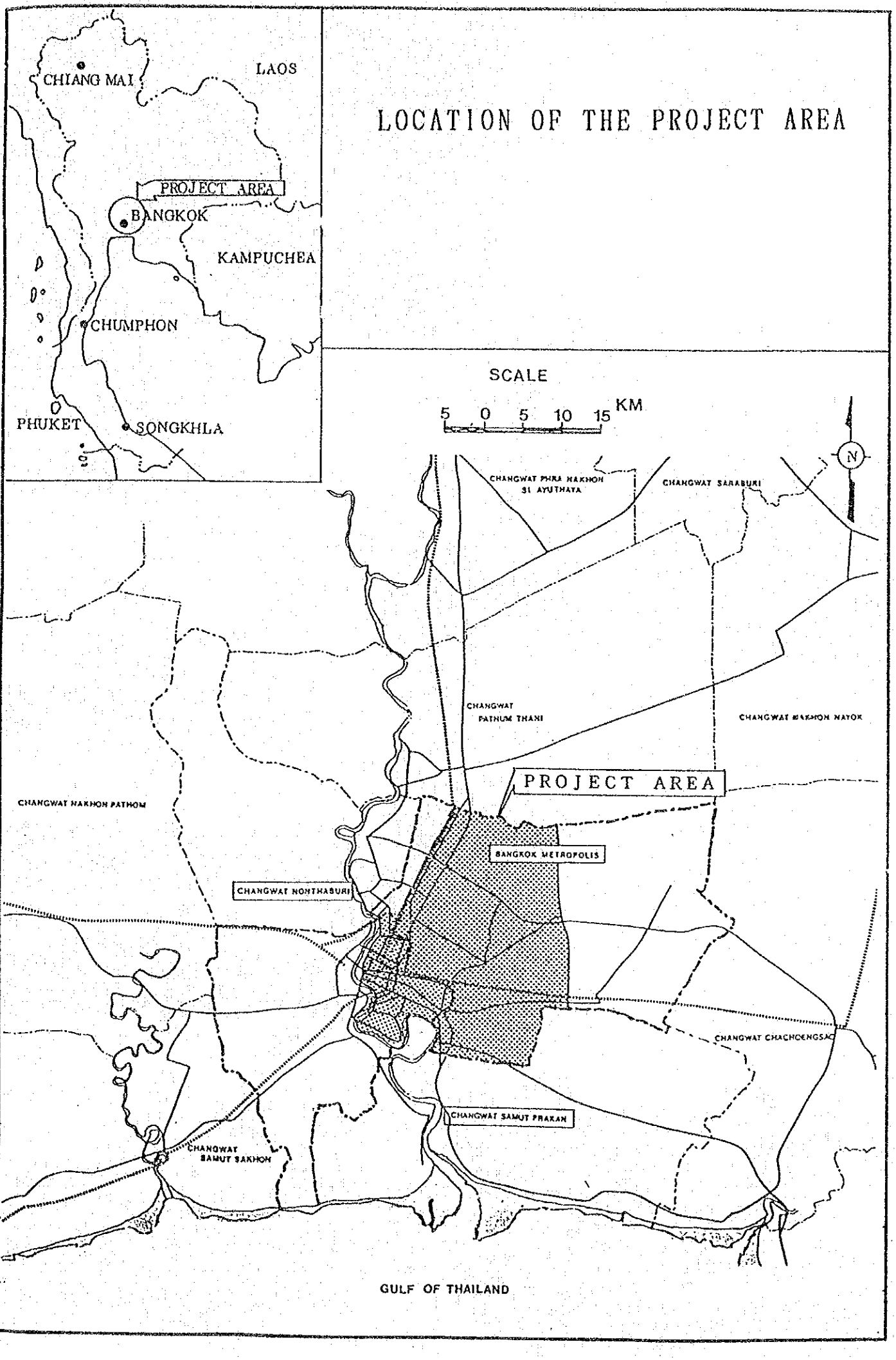
I hope that this report will contribute to the development of the project and to the promotion of friendly relations between our two countries.

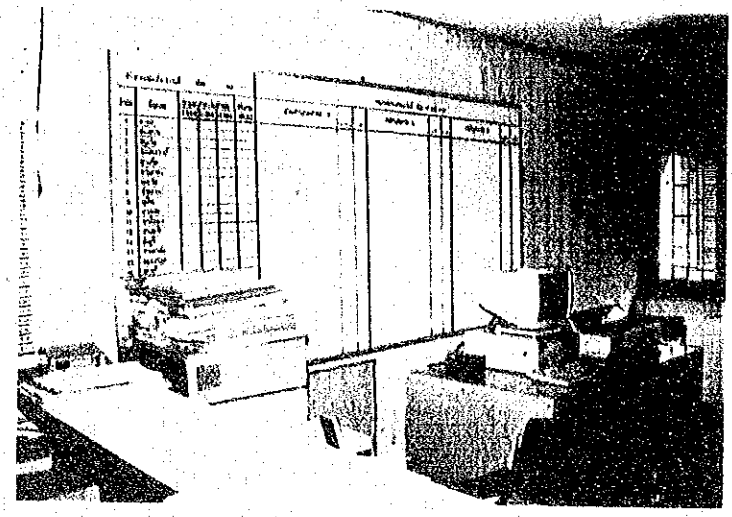
I wish to express my appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

September, 1988.

Keisuke Yanagiya
President
Japan International Cooperation Agency

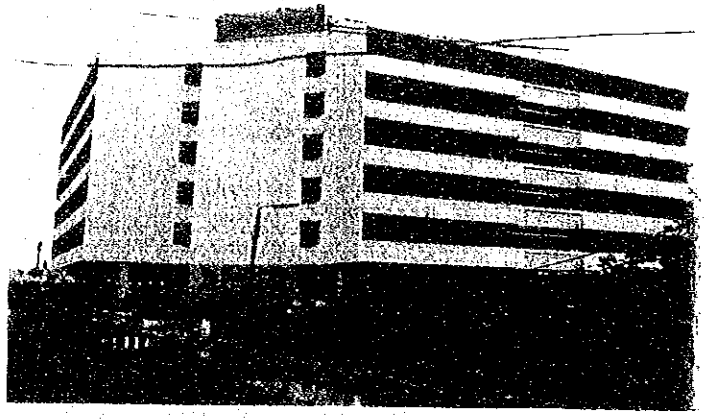
LOCATION OF THE PROJECT AREA

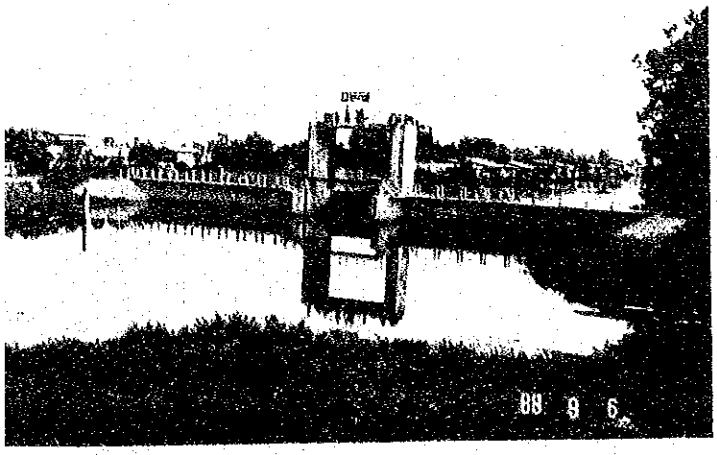




Present 「Flood Control Center」
In DDS Office

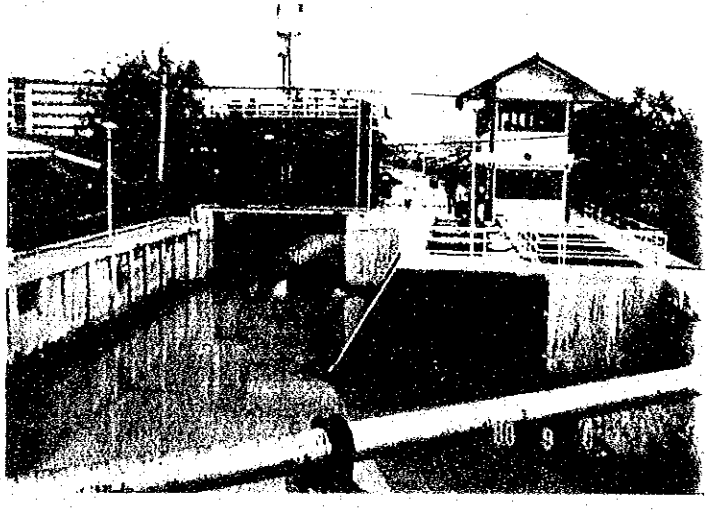
New BMA's Building
at Din Daeng

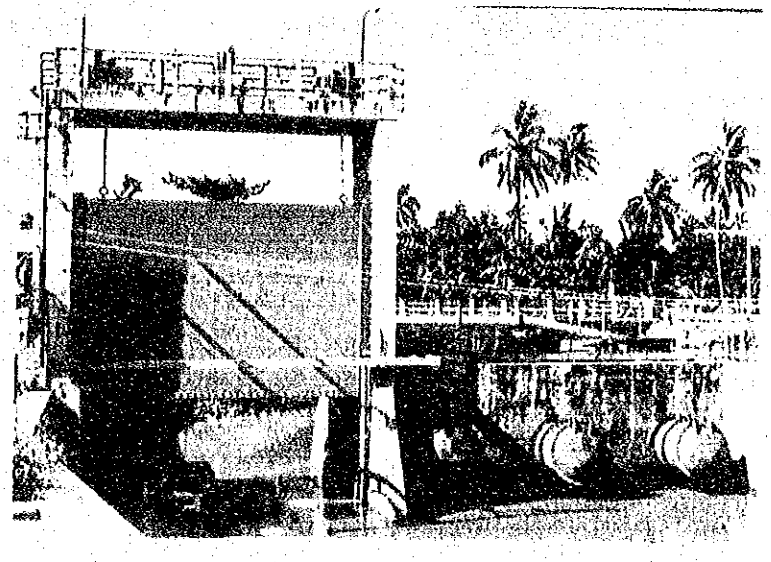




Water Gate at Don Muang
(Klong Song)

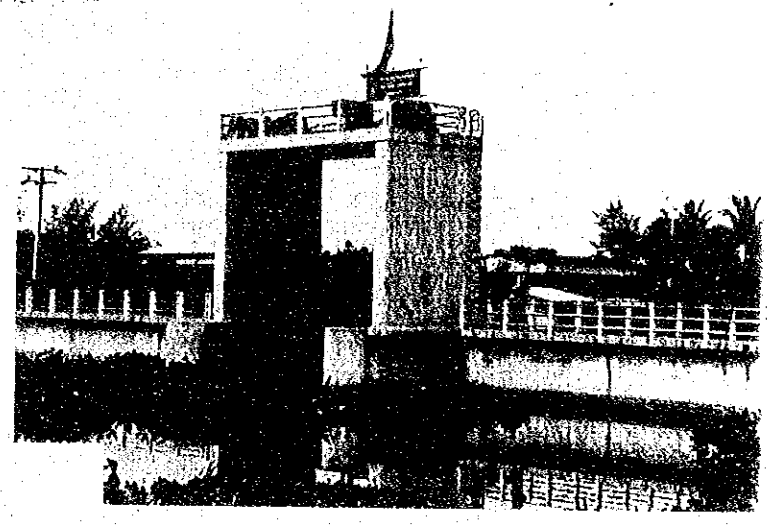
Bangkhen Pumping Station
(Klong Bangkhen South)

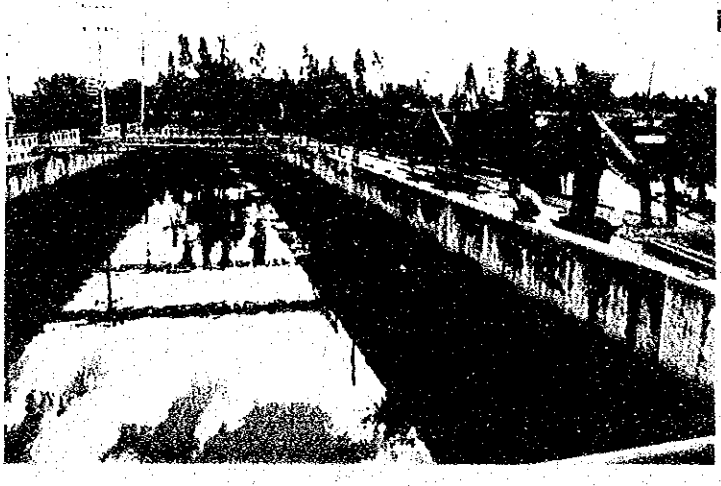




Bangkhen Pumping Station
(Klong Bangkhen North)

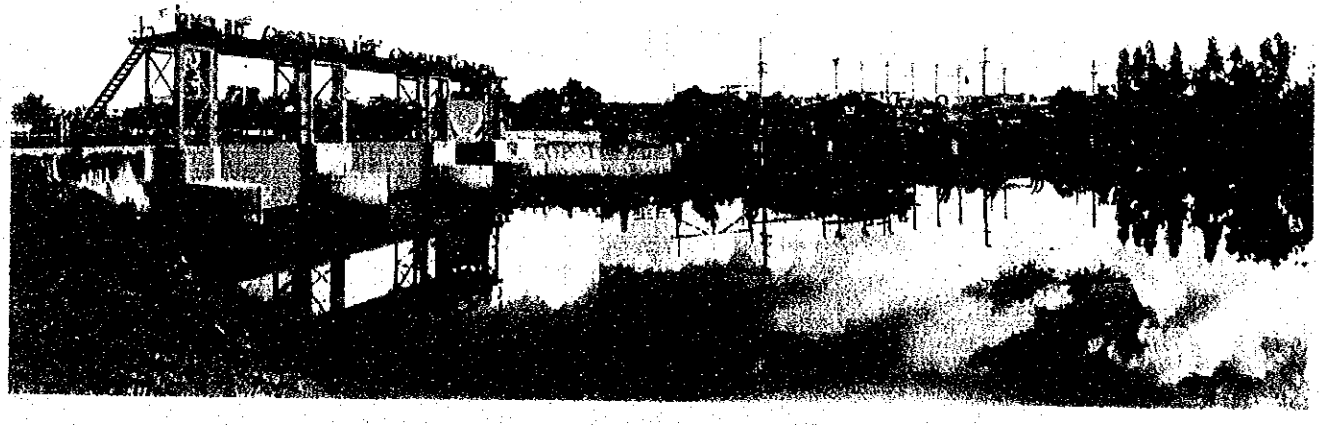
Water Gate at Minburi
(Klong Saen Saep)





Pump Arrangement at
Phra Khanong Pumping Station
(Right Bank of Klong Phra Khanong)

Phra Khanong Pumping Station
(View from up-stream)



SUMMARY

In 1782, the capital of the Kingdom of Thailand was transferred to Bangkok which is on the delta at the mouth of the Chao Phraya River.

Bangkok, together with the reclamation of the great plain of the Chao Phraya River, has been developed as the center city for international trade and as the accumulation place for agricultural products, mainly rice.

Since 1960, the population increase and the expansion of the city area in Bangkok have been extraordinary. Bangkok is called the "Exploding City." It has been changing into a modern city befitting the capital of a modern country.

Modernization, however, has brought on flooding problems. During the past few years frequent urban-type floodings have occurred.

The 1980 flood inundated a part of the city for more than two months. The 1983 flood inundated a part of the city for more than three months. The National Statistical Office estimated the flood damage to be 66 billion yen.

By making the 1983 flood the turning point, the Government of Thailand urgently established the "National Flood Prevention Committee" and implemented the Urgent Flood Prevention Project with a budget of 13 billion yen. The project was based on the preliminary design study for the Urban Drainage Development Plan in Bangkok City that had been made previously by JICA.

Currently in progress is the construction of the inner polder levees, gates, and pumping stations that were proposed in JICA's feasibility study, and the construction of the gates and pumping stations that were based on NEDECO's feasibility study of the City Core Project in Bangkok.

Including the existing facilities, there will be twenty (20) pumping stations and eleven (11) gates (excluding the auxiliary gates for pumping stations) that will be the major flood protection facilities after the above construction completion.

The management of flood and drainage data in Bangkok City is still performed by an off-line method, making it extremely difficult to centrally manage the many flood protection facilities. Thus, the operations of these facilities are not efficient and gate opening and closing troubles occur due to insufficient data management.

Judging from the complexities of the natural conditions and the maintenance and management of each flood control facility, and from the problems related to the competency of various agencies, the present management system will encounter extreme difficulty in collecting accurate pertinent data and in making effective and efficient use of the flood protection facilities. For this reason, JICA strongly proposed in its feasibility study report to establish a new centralized management system.

The Government of Thailand thoroughly understood the proposal and judged the urgency of establishing a Flood Control Center that would be the core of the centralized management system.

The Government of Thailand secured the space for the establishment of the Flood Control Center in the new Bangkok Metropolitan Administration (BMA) building that was scheduled to be completed in July 1988. In August 1987, they also requested grant aid cooperation from the Government of Japan for the procurement of the equipment for the Flood Control Center.

The Center will control an approximately 600 km^2 area of the Bangkok City core (8 districts) and its eastern suburbs (4 districts) on the left bank of the Chao Phraya River where the expansion of urbanization and the concentration of property are highly evident.

The Government of Japan examined the contents of the request and then decided to undertake the basic design study for the Project.

Based on the decision by the Government of Japan, the Japan International Cooperation Agency (JICA) sent the Basic Design Study Team to the Kingdom of Thailand from June 6 to July 3, 1988.

In order to confirm the propriety of the Project, the Study Team held a series of discussions concerning the contents of the request with the concerned officials of the Government of Thailand, conducted the field surveys related to the operation management of existing flood protection and drainage facilities and hydrologic and facilities operations data collecting methods, and collected various information necessary for the basic design of the Project.

The following facts were uncovered as a result of the field surveys:

1. The capacities of the existing pumping stations are set small based on the expectation of the temporary rain water storage capacities of the canals.

2. There is a necessity for securing the rain water storage capacities of the canals by pre-operating the existing facilities in advance of rainfalls; otherwise the planned safety factors of the existing flood protection and drainage facilities will be extremely small.

3. The system of collecting canal water levels, rainfall, and pump and gate operation data is poor -- the amount of data collected is limited in quantity and accuracy.

Data is not collected promptly. This is primarily due to the fact that verbal telephone communications is being used to collect the data and no feedback of the data is being made for facility operation purposes. Further, the operations management of each drainage facility is carried out based on the judgement of its operator. No centrally managed system exists. Thus, it is impossible to systematically operate the various facilities during flood periods which results in operational troubles and in local floodings.

In order to depend upon the rain water storage capabilities of the canals, it is necessary to lower their water levels. As the water quality of the canals is degraded due to waste water inflows, it is impossible to lower the water level below a certain point. For this reason, it was considered necessary to obtain water quality data.

Based on the results of the field surveys, the Study Team understood the need for a new Flood Control Center that would collect hydrologic (rainfall and water level), pump and gate operations, and water quality data by a computer supported on-line telemetering system, then process the data and utilize it for immediate or long-term facility operations management. The Study team also made the analyses of the optimum level of the Project system.

As a result, the Team concluded that grant aid cooperation from the Government of Japan would be essential for the procurement of the equipment necessary for the Project system's implementation.

A summary of equipment to be provided under the Project is as follows:

Monitoring Stations (26 stations):

- 21 rain gauges, 41 water level gauges, 2 water quality meters for DO, 2 quality meters for EC, 118 pump operation detectors, and 30 gate opening gauges.
- 26 outer terminal unit (OTU) stations.

Master Station (1 station):

- 1 set of main computer, 1 set of man machine interface equipment, 1 set of telemetering equipment, 1 set of uninterruptible AC power supply equipment, 1 unit of package type air conditioner, 1 set of free access floor space.

Other Related Equipment:

- 1 set of observation equipment spare parts, two patrol vehicles, 1 copy machine, 1 engineering work station, 1 set of test equipment.

All existing facilities to be including in the Project system will be under the management of the Bangkok Metropolis Administration starting sometime in 1988.

The Project implementation agency will be BMA. The maintenance and management of Project facilities will be carried out by the Department of Drainage and Sewerage (DDS).

After the signing of the Exchange of Notes for the Project by the governments of Thailand and Japan, it will take four (4) months to complete the detailed design, and thirteen (13) months for the actual Project construction.

The operation, maintenance and management costs for Project facilities are estimated to be 7.2 million bahts/year (about 36 million yen/year). These costs are to be borne by the Thailand side. Judging from BMA and DDS budget amounts, these costs will be sufficiently financed by them.

The maintenance and operation of Project equipment must be carried out in accordance with the equipment's "Periodical Inspection Manual." Further, it will be necessary to pay special attention to equipment management for smooth system operations. This can be accomplished by listening to what the equipment operators have to say about the system's operating conditions.

The long-term utilization plan of the collected data by the Project system shall be carried out by a step by step procedure in accordance with the amount of accumulated data.

The effective use and efficient operations of existing flood protection and drainage facilities will be made possible by implementing the Project. The following definite effects will be achieved:

- Stability of livelihood and the improvement of public health.
- Flooding forecasts will be possible and flood damage will be minimized by pre-operating pumps and gates.
- It will be possible to pre-announce flood information to residents.
- It will be possible to minimize problems related to gate openings and closings during rainy seasons.
- It will be easier to manage low water during dry seasons.
- It will be possible to provide the information needed for the improvement plan of flood protection and drainage facilities.
- It will be possible to provide the information needed for a water quality management plan.

. It will be possible to provided the information needed for an urban development plan (land use plan).

For successful Project implementation, it will be necessary to carry out Project construction in accordance with the planned construction schedule.

A step by step training plan will be necessary for the operation and maintenance of Project equipment and for making effective use of collected data. For this purpose, it will be necessary to provide technical cooperation by sending Japanese engineers and by making spot contracts with equipment suppliers for equipment maintenance and management purposes.

Table of Contents

ABBREVIATIONS

ABBREVIATION OF ORGANIZATIONS

AIT	:	Asian Institute of Technology
BMA	:	Bangkok Metropolitan Administration
CAT	:	Communication Authority of Thailand
DDS	:	Department of Drainage and Sewerage, BMA
DOH	:	Department of Highways
DPW	:	Department of Public Works
DTEC	:	Department of Technical and Economic Cooperation
EGAT	:	Electricity Generating Authority of Thailand
HD	:	Harbour Department
IEC	:	Irrigation Engineering Center, RID
LAD	:	Local Administration Department
MD	:	Meteorological Department
MEA	:	Metropolitan Electricity Authority
MWWA	:	Metropolitan Water Works Authority
NEA	:	National Energy Administration
NEB	:	National Environment Board
NESDB	:	National Economic and Social Development Board
NSO	:	National Statistical Office
PAT	:	Port Authority of Thailand
PTD	:	Post and Telegraph Department
RID	:	Royal Irrigation Department
SRT	:	State Railway of Thailand
TOT	:	Telecommunication Organization of Thailand
TISTR	:	Thailand Institute of Scientific and Technical Research
FCC	:	Flood Control Center
JICA	:	Japan International Cooperation Agency

ABBREVIATION OF MEASUREMENT

Length

mm	: millimeter(s)
m	: meter(s)
km	: kilometer(s)

Area

ha	: hectare(s)
km^2	: square kilometer(s)
rai	: 0.16 ha
taran war	: 4 square meters

Volume

m^3	: cubic meter(s)
MCM	: million cubic meter(s)

Time

s, sec	: second(s)
h, hr	: hour(s)

Other Measurements

HWL	: High Water Level
MSL	: Mean Sea Level
°	: degree
'	: minute
"	: second
%	: percent
℃	: degree centigrade
m^3/s	: cubic meter per second
KB	: kilobyte
MB	: megabyte
RAD	: radian
bps	: bit per second
BPI	: bit per inch
AH	: Ampere Hour

ABBREVIATIONS

ABBREVIATION OF TELECOMMUNICATION AND COMPUTER TERMS

FM	: Frequency Modulation
HF	: High Frequency
SSB	: Singleside Band
VHF	: Very High Frequency
UHF	: Ultra-High Frequency
KHz	: Kilohertz
MHz	: Megahertz $=10^3$ KHz
GHz	: Gigahertz $=10^3$ MHz
CCU	: Communication Control Unit
CPU	: Central Processing Unit
MPU	: Main Processing Unit
MONITOR	: Remote Terminal Monitor
FAX	: Facsimile
TEL	: Telephone
BPPI	: Bright Plain Position Indicator
SV/RC	: Radar Supervisory/Remote Control Equipment
T/R	: Transmitter/Receiver
SIG	: Signal Processor
MUX	: Multiplex Terminal Equipment
TSE	: Telemetering Supervisory Equipment
MT	: Magnetic Tape
MD/HD	: Magnetic Disk/Hard Disk
LP	: Line Printer
UPS	: Uniterruptible Power Supply
AC	: Alternating Current
PPI	: Plan Position Indicator

OTHER ABBREVIATIONS/ACRONYMS

GDP	: Gross Domestic Product
GNP	: Gross National Product
GRP	: Gross Regional Product
GPP	: Gross Provincial Product
R/O	: Regional Office
O&M	: Operation and Maintenance
	:
INTELSAT	: International Communications Satellite Consortium

CHAPTER 1 INTRODUCTION

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Bangkok, the capital of Thailand, was developed on the delta of the Chao Phraya River mouth. Since its founding it has been assaulted by floods. Because of the low elevation marshy land, people -- since ancient times -- living in the area have adopted high-floor type housing structures to prevent flood damages during rainy seasons. Also, these people have considered long-term floodings as a natural phenomena.

Since 1960, however, the frequent occurrence of flooding together with the modernization of the mode of living by the residents, the expansion of sudden urbanization, and the progress of land subsidence has been recognized as a serious social problem.

In 1983, floods inundated the city for more than three months. Flood damage in the Bangkok Metropolitan Administration area was approximately 6.6 billion bahts (66 billion yen at 1983 exchange rates).

With the 1983 floods as a turning point, an urgent flood prevention project was implemented. A total amount of 600 million bahts was budgeted to construct the Polder levee gates, pumping stations, etc. Most of the existing major flood protection facilities were constructed under the urgent flood prevention project. However, flood information management in Bangkok is still carried out by the off-line verbal communication system; thus it is extremely difficult to manage many flood protection facilities at a centralized management center -- efficient operations management is virtually impossible.

Presently, gate opening and closing troubles occur due to the improper information management system. Further, the capacities of the existing drainage pumps were set small because of the utilization of klongs and retarding basins to temporarily store rain water.

Accurate data collection of water levels and amounts of rainfall is absolutely necessary for the efficient operations management of the flood protection and drainage facilities. For this reason, it is essential to change the present management system into a new centralized management system. The Government of Thailand, therefore, has decided

to establish a Flood Control Center to bring about the new centralized management system.

The Government of Thailand decided to set up the Flood Control Center in the new Bangkok Metropolitan Administration building and, in August of 1987, requested grant aid cooperation from the Government of Japan to procure the necessary equipment for the Center.

In response to the request, the Government of Japan conducted the preliminary study for the Center's construction in March 1988. Based on the preliminary study, it was decided to proceed with the "Project for Procurement of the Equipment for the Flood Control Center in Bangkok and Its Vicinity", and the Basic Design Study Team of JICA was formed for the Project.

The Basic Design Study Team, headed by Mr. Koichi BABA, Director, Office of Disaster Protection, Disaster Protection and Restoration Division, River Bureau, Ministry of Construction, was sent to Thailand from June 6 to July 3, 1988.

The Study Team held a series of discussions concerning the contents of the request with the concerned officials of the Government of Thailand. The Team also conducted the field surveys related to the present data collecting system of the existing flood protection and drainage facilities, hydrology, and facility operations in the Project Area that covers approximately a 600 km^2 area of the Bangkok City core and its eastern suburbs on the left bank of the Chao Phraya River. The Study Team also collected data necessary for preparing the basic design of the Project.

As a result of a series of discussions concerning field survey findings and the newly requested items by the Government of Thailand with the authorities concerned of the Government, the basic items agreed upon were written up as the Minutes of Discussions. The document was signed on June 14, 1988 by the representatives of both parties at the DDS office. DDS will be the Project implementation agency.

As the collection of accurate water level and rainfall data will effect the Project values, the confirmation of the proper arrangement plan of

the monitoring stations and the installation possibilities of the equipment necessary for the Project was carefully made during the field survey period.

In order to determine the method for transmitting monitored data to the Flood Control Center, whether it be by radio links or over TOT leased lines, the Study Team conducted extensive hearing investigations at concerned related agencies and held a series of discussions with the management agencies of the radio links and the telephone lines.

The Team discussed the results of the investigations and discussions, together with the future plan, with officials of DDS. the Team summarized the newly requested items by DDS and the contents of the discussions held with DDS as the Technical Notes. Both parties confirmed the contents of the Notes on the last day of the field survey period.

After returning to Japan, the Study Team made an overall analyses and examination of the data obtained during the field survey period and decided upon the equipment necessary for the Project that will be provided for under grant aid cooperation from the Government of Japan.

Based on the Study Team's decision, the basic design of the equipment, the Project implementation plan, the Project cost estimates, and the maintenance and management plan were made and the propriety of the Project implementation was confirmed. As a result, this report, "The Basic Design Study Report on the Project for the Procurement of the Equipment for the Flood Control Center in Bangkok and Its Vicinity" has been prepared.

CHAPTER 2 BACKGROUND OF THE PROJECT

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2-1 Description of the Kingdom of Thailand

A general description of the Kingdom of Thailand is as follows:

Area:	514,000 km^2
Population:	52 million (1985, from National Statistics Bureau)
Capital:	Bangkok
Language:	Thai (Lao, Chinese, and Malay are also used locally)
Religion:	Buddhism (some Moslem)
Form of Government:	Constitutional Monarchy
Sovereign:	King Bhumipol Adulyadej, Rama IX
Currency:	Baht (1 U.S. dollar = 25.10 bahts in July, 1988)

2-1-1 Economy

GDP: 148 billion bahts (approximately 20,000 bahts per capita in 1985).
GDP growth rate during 1981-85 period: 5% per year.

GNP: 110 billion bahts (approximately 20,000 bahts per capita in 1985)
GNP growth rate during 1981-85 period: 3% per year.

- Presently, the country is in the course of the Sixth National Economic and Social Development Plan (1981-1991) that has aimed at achieving an average annual GDP growth rate of 5.0%.

- In the Sixth National Economic and Social Development Plan, it is planned to achieve 290 billion bahts of exports and 327 billion bahts of imports. The trade deficit will be 36 billion bahts.

- The consumer price index for the 1981-85 period increased 3.0% per year.

. According to 1981 data, the average household income for the entire country was 40,000 bahts; for Bangkok it was 70,000 bahts, while in the northeastern province it was 35,000 bahts.

2-1-2 Infrastructures

. Facilities related to the country's transportation are roads, railroads, waterways, and airports.

The shares of the country's transportation volume are 85% by roads (highways), 13% by railroads, and 1% by waterways and aircraft -- the percentage for highways is very high.

The total length of the highway network (including national and provincial roads) was 3,700 km in 1985.

. Bangkok Port is relatively well developed. 90% of the country's waterborne cargo is handled there. 12,000 DWT class ships can enter this port.

. The development of the telephone line network has been carried out with great urgency. The number of telephone subscribers in 1984 was 519,000; this number has been increasing at an annual rate of 9.2%. By 1991 it is expected that there will be one telephone for every 37 persons.

In the Metropolis of Bangkok, 400,000 telephone lines are presently in use. This figure can be interpreted to show that there is one telephone for every ten persons.

The expansion of telephone lines and the introduction of new services, such as low speed data communication systems and videotex, have been planned.

. Electric generating facilities are developed to meet the annual 13% demand increase rate. A total of 22 billion kwh was generated in 1984. The supply of electricity in Bangkok City is very good.

. The country's water supply facilities are managed by the Metropolitan Water Supply Corporation and the Rural Water Supply Corporation.

In 1986, the Metropolitan Water Supply Corporation supplied 820 million tons of water to an area of 475 km^2. It has been planned to expand the facilities to supply 1.4 billion tons of water to 7.8 million people (approximately 500 liters/person/day) by the year 2000. This planned expansion work has already started.

. Even in the metropolitan area of Bangkok sewerage facilities are not sufficiently developed. Small-scale anaerobic bacteria digestion sewerage treatment tanks are rather widely used, but modern public sewerage is practically nonexistent.

The safety factor against floods in the country (including the right bank area of the Chao Phraya River in the Bangkok metropolis) is extremely low and it is necessary to improve the overall flood control management facility system from the viewpoint of river, sewerage, and agricultural drainage systems.

2-2 Natural Conditions

2-2-1 Climate

Thailand's climate can be divided into three seasons: the cool season (November through January); the hot season (February through May); and the rainy season (July through October).

Precipitation occurs mostly during the rainy season. In September, especially, heavy rain occurs over a wide area as a result of tropical low pressure moving across the country.

2-2-2 Temperature and Humidity (see Fig. 2.1)

The average annual temperature in Bangkok is 27.7°C. The coolest month is December when the temperature is about 25°C. April is the hottest month with temperatures ranging from 30°C to 35°C. The average annual humidity is a relatively high 78%.

2-2-3 Rainfall (see Fig. 2.1 and Fig. 2.2)

An average of 1,460 mm of rain falls annually (1937-1966 period). However, in 1983, the year of a very large flood, the average annual rainfall was 2,130 mm. In that year, 90% of the annual rainfall, ie., 1,900 mm, occurred during the five-month long rainy season.

Probabilistic rainfalls recorded by the Meteorological Department in Bangkok are as follows:

	1 hour duration	24 hour duration
2-year probability rain	59 mm	94 mm (60.1 mm)
5-year probability rain	76 mm	122 mm (80.8 mm)
10-year probability rain	87 mm	144 mm (94.2 mm)

Note: Figures in parentheses are area averages.

The average duration of rainfalls is in the range of from two to four hours.

2-2-4 Water Level and Discharge of the Chao Phraya River
(see Figs. 2.3 and 2.4)

About a 50 to 60 km section in the vicinity of the Chao Phraya River mouth is the tidal compartment. The tide difference is about 2.0 m at the river mouth and about 1.0 m in the Bangkok City core. The spring tide high water level (HWL) at the Memorial Bridge during the rainy season is about MSL + 1.3 to + 1.4 m. However, the HWL during the 1983 flood period was recorded as being about MSL + 1.8 to 1.9 m.

The discharge of the Chao Phraya River in the Bangkok City core varies seasonally in the range of from 200 to 1,800 m^3/sec.

2-2-5 Water Levels and Discharges of Klongs

The water levels and discharges of the Klongs in Bangkok City are affected by the sizes and operating conditions of the drainage facilities to the Chao Phyraya River, the amount of outer water intrusion from the eastern area, and the amount of rainfall, ie., inner water.

The water levels of the Klongs during dry seasons are in the range of MSL -0.5 to +0.3 m, and the levels during rainy seasons is about MSL +1.0 to +1.4 m. The discharges of the Klongs vary from Klong to Klong. Water levels at one of the larger Klongs are about 10 to 20 m^3/sec during dry seasons and about 30 to 80 m^3/sec during rainy seasons depending upon the capacities of the drainage facilities.

The ground elevations of the residential areas in the Project Area are in the range of MSL +0.3 to 1.3 m. Therefore, the safety factor against the Klong overflowing is still low due to the continuing land subsidence even though drainage facilities were substantially improved under the Urgent Flood Prevention Project in 1984.

2-2-6 Canal Water Quality (see Fig. 2.5)

The water quality of the canals in the Bangkok City core is extremely poor. The biochemical oxygen demand (BOD) of canal water is about 8 to 10 ppm and its DO is about 0 to 1 ppm. It is believed that the main cause of water quality deterioration in the suburb area is the rapid development of suburb an type housing.

2-2-7 Topography and Geology (see Figs. 2.6, 2.7 and 2.8)

Bangkok is located on the downstream delta of the Chao Phraya River. Its ground elevation is very low. Housing land elevations are about MSL +0.3 to +1.3 m.

Land subsidence caused by ground water pumping has been progressing at a rate of from 10 to 15 cm/year, and the safety factor against floods is decreasing yearly.

The geology of Bangkok is that of a typical alluvial plain. Alternate layers of clay and sand reach to the depth of more than 400 m from the ground surface. The surface layer is soft silty clay having qc' = 2 to 4 kg/cm^2 (C = 1.3 to 2.7 tons/m^2). A lightweight structure can be supported by friction piles.

2-3 Conditions of Existing Flood Protection and Drainage Facilities

The existing major facilities, excluding Klongs, in the Project Area are as follows (see Fig. 2.9):

2-3-1 Number of Major Facilities

. Green belt levee gates:	10 gates (sluice gates, electrical power operated, managed by RID)
. Secondary Klong cofferdams:	2 dams, double closure with log drops, concrete fence, managed by DDS
. Gates in polders:	3 gates, one electrical power operated radial gate, one electrical power operated sluice gate, and one manually operated sluice gate
. Pumping stations (excluding small-sized pumping stations in polders):	Total 14 stations: . 12 stations with auxiliary gates and submersible pumps . One station with a diagonal flow pump . One station with a vertical centrifugal pump

2-3-2 Sizes of Major Facilities

The gates are standard size. Gates managed by RID are 6 m wide. Those managed by DDS are 4 m wide. Most of the gates are of the sluice type. Gate heights are from about 4 to 5 m.

Most of the pumps are standardized submersible types having suction diameters of 1,200 mm. Only a small number of the pumps are submersible types having suction diameters of 500 to 600 mm.

There are approximately 120 existing pumps having a total drainage capacity of about 350 m^3/sec. The average specific discharge of these pumps is about 0.6 $m^3/sec/km^2$. This is about

one-tenth of that for Japanese urban drainage pumps (7 to 8 m^3/sec/km).

2-3-3 Operations Management of Major Facilities

According to the hearings that took place during the field survey period, it was found that the major facilities presently being managed by RID will be transferred to DDS within the year.

Each facility location has a management office staffed by two people (three during rainy seasons) who are on duty at all times.

Operations management of all facilities located within the City core area is conducted by issuing orders to the facilities by telephone and radio.

Pumps and gates are operated in accordance with the operation manual -- inner water levels are to be kept at about MSL - 0.5 m.

The gates of the green belt levees that are in the eastern area are operated in accordance with orders issued over telephone or radio.

2-4 Present Flood Control System

2-4-1 System of DDS

1) Flood Protection Center

At the outset of the founding of DDS, the Flood Protection Center was established. The Center's roles are as follows:

- Hydraulic and hydrologic data collection and management.
- To comprehend drainage pump station and gate operating conditions and to provide instructions for their operation.
- To comprehend flood conditions and flood damage.
- To provide instructions pertaining to emergency measures and relief activities.
- To exchange information between DDS and other agencies.

The Center is located on the second floor of the DDS building. It is furnished with writing boards on which to record rainfall and water level data that is collected over the telephone, a microcomputer to manually input the collected data, a facsimile unit for receiving weather data from the meteorological department, a VHF radio unit, and two telephones.

During rainy seasons an additional member joins the Center that will then be operated using two shifts on a twenty-four hour basis.

2) Hydrologic Data Collection and Management

Rainfall data (collected in storage cylinder type gauges and recorded by visual readings) and water level data (made from visual readings of staff gauges) are normally written down at the gauge sites and then telephoned into the Center. Input of the collected data into a microcomputer is performed manually. During periods of heavy rain, the obtained data is transmitted by telephone at 30 or 60 minute intervals. This data is then written on the recording boards.

In the past, the stored collected data consisted of handwritten notes. Since last year, however, personal computer floppy disks are being used for storing data.

3) Operating Conditions of the Drainage Pump Stations and Gates

The operating condition of each pump is recorded as its daily operating hours. This information is manually inputted into a microcomputer for data storing purposes.

Daily, each pump's operating hours are recorded and stored in a microcomputer. Presently, gate operations are not recorded.

4) Communications, Instructions, and Transmission System

Telephones are normally used for communications, issuing instructions and for the transmission of data. On days of heavy rain during rainy seasons, DDS uses one channel of the 4-channel VHF two way radio that is installed in BMA's main building.

5) Collection of Weather Data from the Meteorological Department

DDS collects rainfall data obtained by radar rain gauges in addition to nationwide weather data from the Meteorological Department by use of a facsimile machine.

6) Emergency Measures and Relief Activities

As soon as a flood occurs, DDS immediately dispatches flood fighting teams, gains a full understanding of the flood area, flood depth, and flood damage and issues instructions to related departments concerning the appropriate emergency measures to be taken. In the meantime, DDS, with the cooperation of BMA's Relief Center, instructs the related departments to commence relief activities. Emergency measures consist of the mobilization of pump cars, building temporary cofferdams using sand bags, etc.

Mainly, relief activities secure the means of transportation by providing truck services.

2-4-2 RID's System

RID has 460 rainfall observation stations and 280 water level observation stations within its management area. About 40% of the data that is collected daily is passed to RID's main office via RID's communications network. The remaining data is mailed to RID's main office once a month.

RID's communications emanates at the observation stations, then relayed to the project offices, to the regional offices and then to the main office. Communications are verbal and are carried by HF/SSB and VHF/FM two way radio and by telephone.

RID is presently investigating the possibility of installing a computer communications network between the main office and regional offices.

RID owns five super minicomputers -- VAX-11/750; VAX-8350; MDS-402; MVS-404; and GPX-303. these computers are used for their own particular purposes, such as ① hydraulic simulation, ② engineering calculations, ③ program development and data inputting, and ④ administration and accounting.

Water levels at the ten water level observation stations in Bangkok City are presently being recorded once a day into notebooks. No computer inputs are made. The present phydraulic and hydrologic collection system is a manual processing off-line system. Computers are not effectively used. For this reason, RID is requiring that a flood forecasting and warning system be installed that is equipped with an on-line communications network having the basic functions for hydraulic and hydrologic data observation and collection, data processing and transmission, and computer data processing.

For the above purpose, JICA made a design study and presented the final report in May of this year.

2-4-3 Meteorological Department's System

Rainfall data in the Bangkok metropolis area is collected daily from 63 ground rain gauge stations. Storage cylinder type rain gauges are used at these stations. Observations are made by volunteer citizens. The observed data is transmitted verbally by telephone.

The collected rainfall data, rain area maps made by radar observation (maps sketched from radar screen), typhoon information, and other general meteorological data are transmitted to DDS by facsimile.

In May of this year, a computer center was completed in the Meteorological Department (MD) building. The Norwegian Norsk Data Company's computer system having the following equipment was installed in the Center:

ND 550/cx:	1 unit
Magnetic tape cabinet:	2 units
Magnetic disc cabinet:	1 unit
Data input terminals:	20 units
Regular telephone line modem:	1 unit

At the present time, past data is urgently being inputted into the new computer.

It is planned to use the new computer for the following services:

1) The meteorological data information service with computer access by telephone is scheduled to start in July of 1988.
2) The radar image information service is scheduled to start in 1990.

In view of the above background, conditions for connecting the DDS's and MD's data communications with an on-line system have already been established.

2-5 Existing Problems

2-5-1 Existing Pump Drainage Facilities' Safety Factors Against Floods

Planned safety factors for existing pump drainage facilities seem to be for about a four year probability rainfall. However, the safety factors are based on the expectation that the canals' capacities can be depended upon to temporarily store rain water; this can only be done by lowering canal water levels by pre-operating the pumps before the rain starts. If pump pre-operation is not definitely made, or if measurements of canal water levels are not taken, the storage capacities of the canals will not be known; thus the safety factors of the drainage facilities will be extremely low and the possibility of flood damage occurrence will increase.

At the present time, the pre-opoeration of pumps are made based on each operator's experience and judgement. Further, the amount of canal water level data is very limited and the rainfall data is daily accumulated amount and not real time data. Rainfall and water level data is not utilized for pump operations management. If it were, the temporary rain water storage capacities of the canals might be increased.

In view of the above background, it can be said that the safety factors for the existing flood protection and drainage facilities are very low due to the insufficient functions of the backup system to effect efficient facility operations.

2-5-2 Outer Water Shutoff Gates

Gates are used to shutoff the high water of the Chao Phraya River and the outer water of the eastern green belt levees. These gates are operated electrically. However, observations of the outer water levels are made by visual readings of the staff gauges; it is very difficult to positively control the opening and closing operations of the gates to meet the conditions of the outer water levels.

As the gates of the green belt levees are located about 15 to 18 km away from the city core, it takes a relatively long time for the DDS office, which is in the city core, to learn of gate operations. Thus, the delivery of proper gate operation orders is carried out inefficiently.

2-5-3 Problems of DDS's Flood Control System

DDS's flood control system is as described in Section 2-4-1. The following problems exist for actual system management:

- The rain gauges being used are old storage types. It is impossible to make continuous recordings of rainfall.
- Water level gauges being used are visual reading staff gauges. It is impossible to make continuous recordings of water level changes during rainy seasons.
- Data transmission is carried out verbally by use of telephone communications. The speed and accuracy of this method are poor.
- Data that is received at the present flood prevention center is written down on a whiteboard. The amount of data received is limited. Thus, it is difficult to make prompt judgements prior to issuing facility operation management orders.
- As a result of the problems outlined above, the transmission of messages and directions from the flood prevention center are not issued timely and problems related to facility operation management occur.

Because of the aforementationed problems, it is practically impossible to centrally manage the facilities -- including the main facilities that are scheduled to be transferred under DDS's management from RID -- by the present off-line flood protection and drainage facility data management system. Therefore, it is necessary to make extensive changes to convert the existing system into a new centrally managed flood control system that will provide effective and efficient pump and gate operation management.

2-6 Administrative Agencies Related to the Flood Protection and Drainage in the Project Area

2-6-1 RID

The General Government of the Kingdom of Thailand consists of the Prime Minister's Office and Thirteen Ministries.

RID belongs to the Ministry of Agricultural Cooperation.

RID's budget represents about 60% (10 billion bahts) of the Ministry of Agricultural Cooperations's total budget of 16 billion bahts.

Green belt levees and their gates, and the major pump stations to the Chao Phraya River in the Project Area were constructed under the direct supervision of RID. The management of these facilities is scheduled to be transferred to BMA within the year 1988.

2-6-2 BMA

The Bangkok Metropolitan Administration (BMA) controls the Bangkok metropolitan area (1,596 km^2) that consists of 24 districts. BMA provides public services, such as security, health, education, sanitation, social welfare, roads, drainage, etc., through its 11 departments and 24 district offices.

BMA has 13,240 staff members and a budget of approximately 7 billion bahts.

2-6-3 DDS

DDS is one of BMA's departments. It is in charge of flood, drainage, and sewerage problems. It has 460 staff members and approximately 1,400 workers who are assigned to four different divisions and to various offices. In 1988, DDS's budget was about 600 million bahts.

DDS is the implementation agency of the Project. The structure formation of the Flood Control Center is eagerly being examined by many DDS staff members, particularly by the engineers.