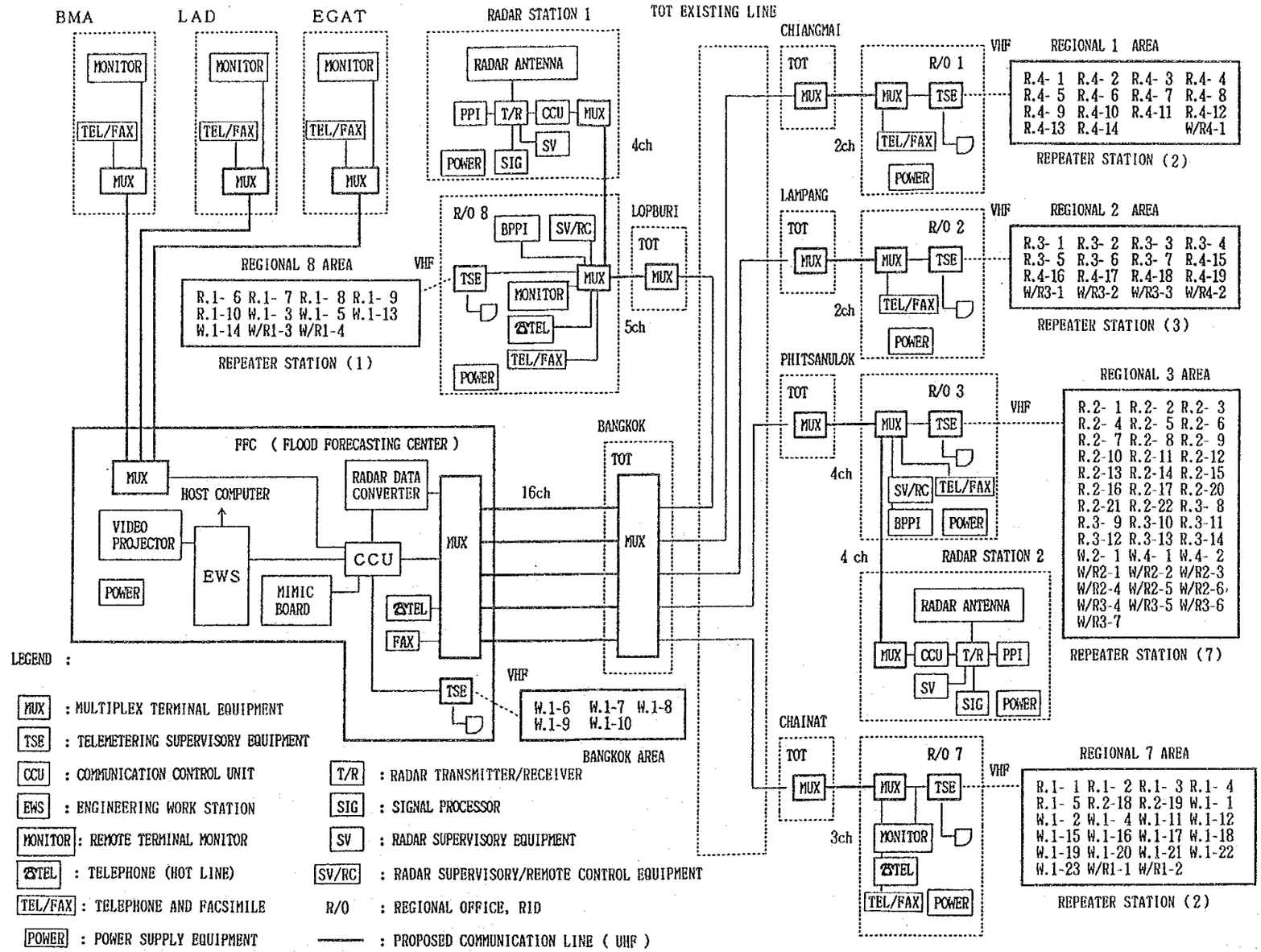


Fig. 3-18. PROPOSED TELECOMMUNICATION NETWORK (Step 2)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

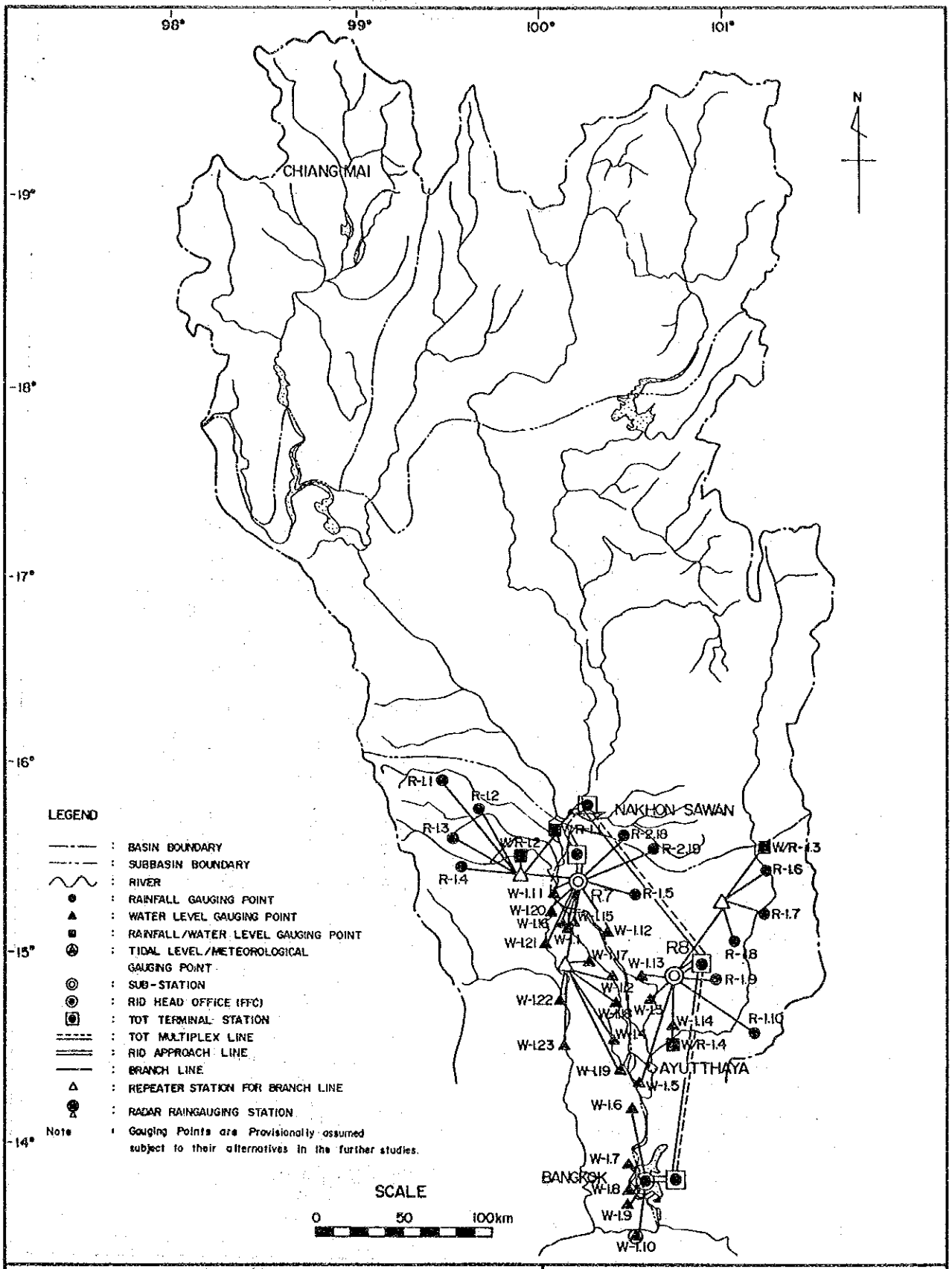


Fig. 3-19(1/5). STAGEWISE EXTENTION OF TELECOMMUNICATION NETWORK (PHASE 1)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

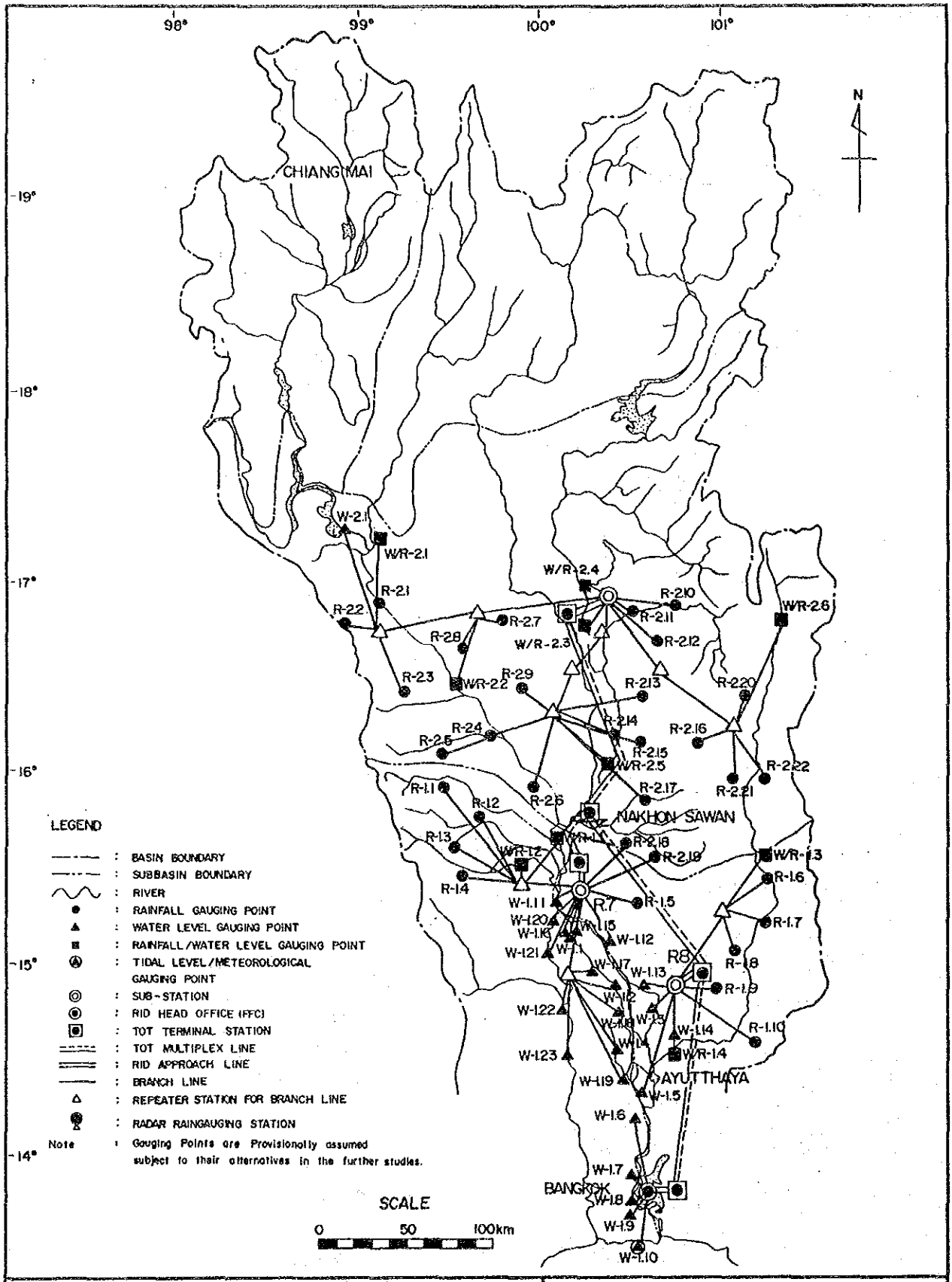


Fig. 3-19(2/5). STAGEWISE EXTENTION OF TELECOMMUNICATION NETWORK (PHASE 2)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

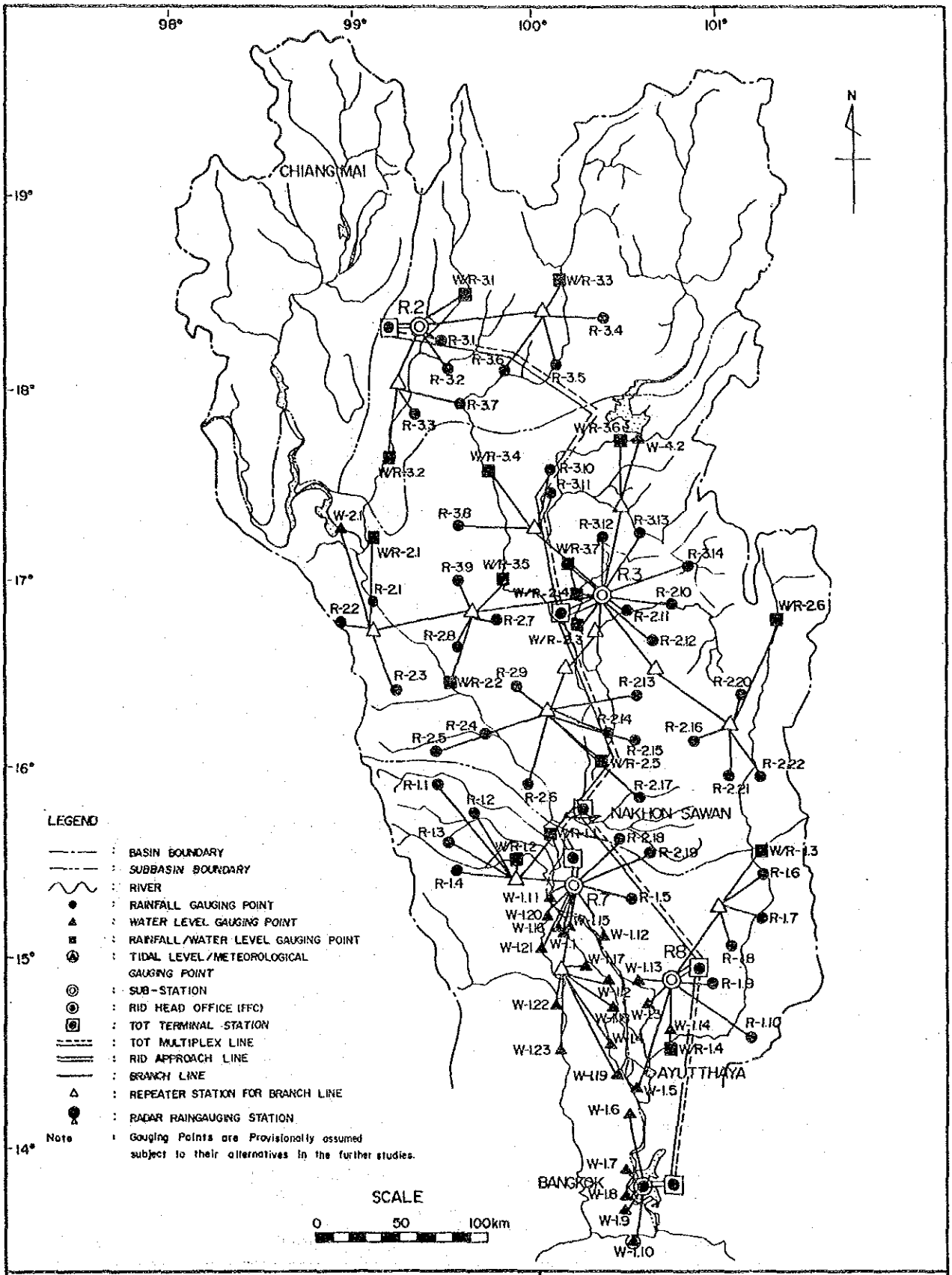


Fig. 3-19(3/5). STAGEWISE EXTENTION OF TELECOMMUNICATION NETWORK (PHASE 3)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

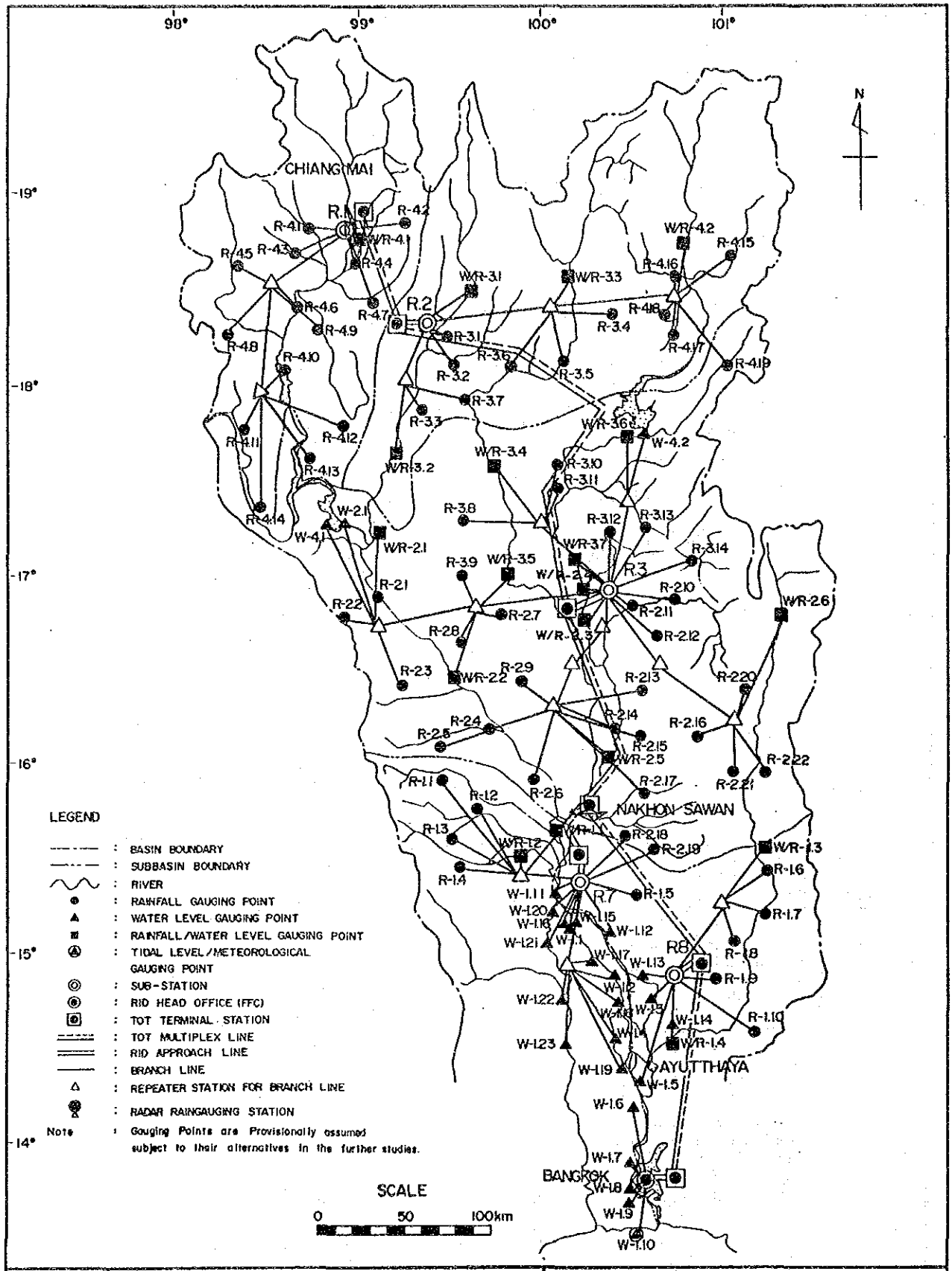


Fig. 3-19(4/5). STAGEWISE EXTENTION OF TELECOMMUNICATION NETWORK (PHASE 4)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

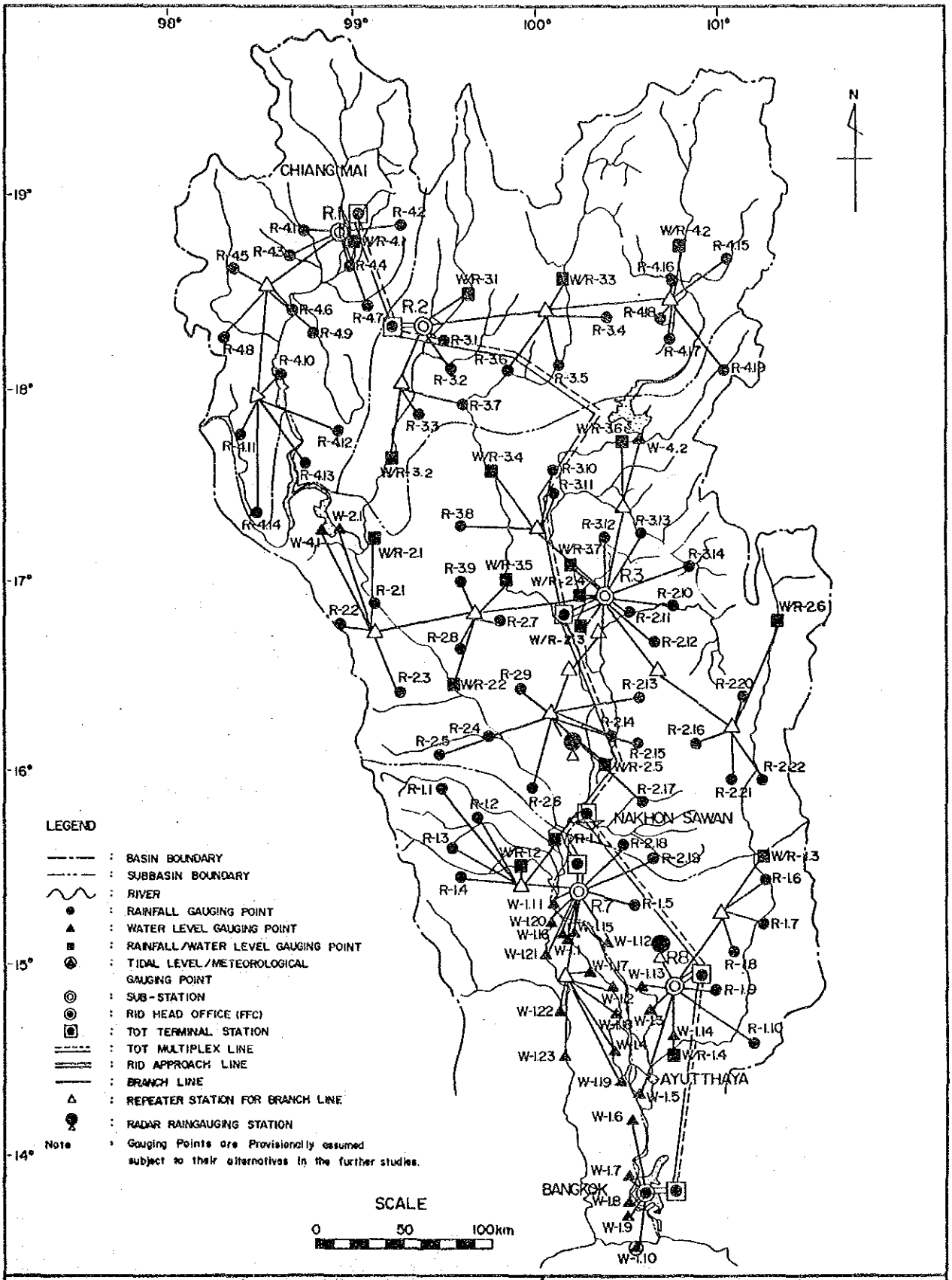


Fig. 3-19(5/5). STAGEWISE WXTENTION OF TELECOMMUNICATION NETWORK (PHASE 5)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

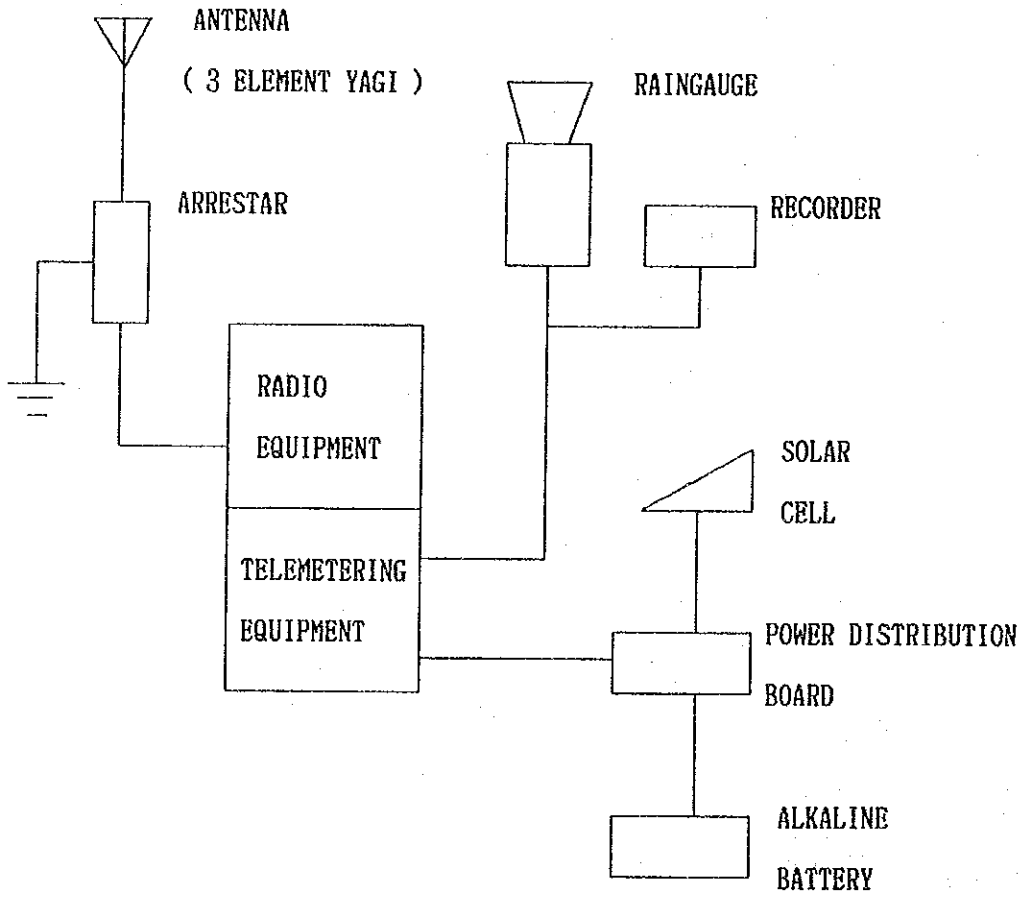


Fig. 3-20. DIAGRAM OF RAINFALL GAUGING STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

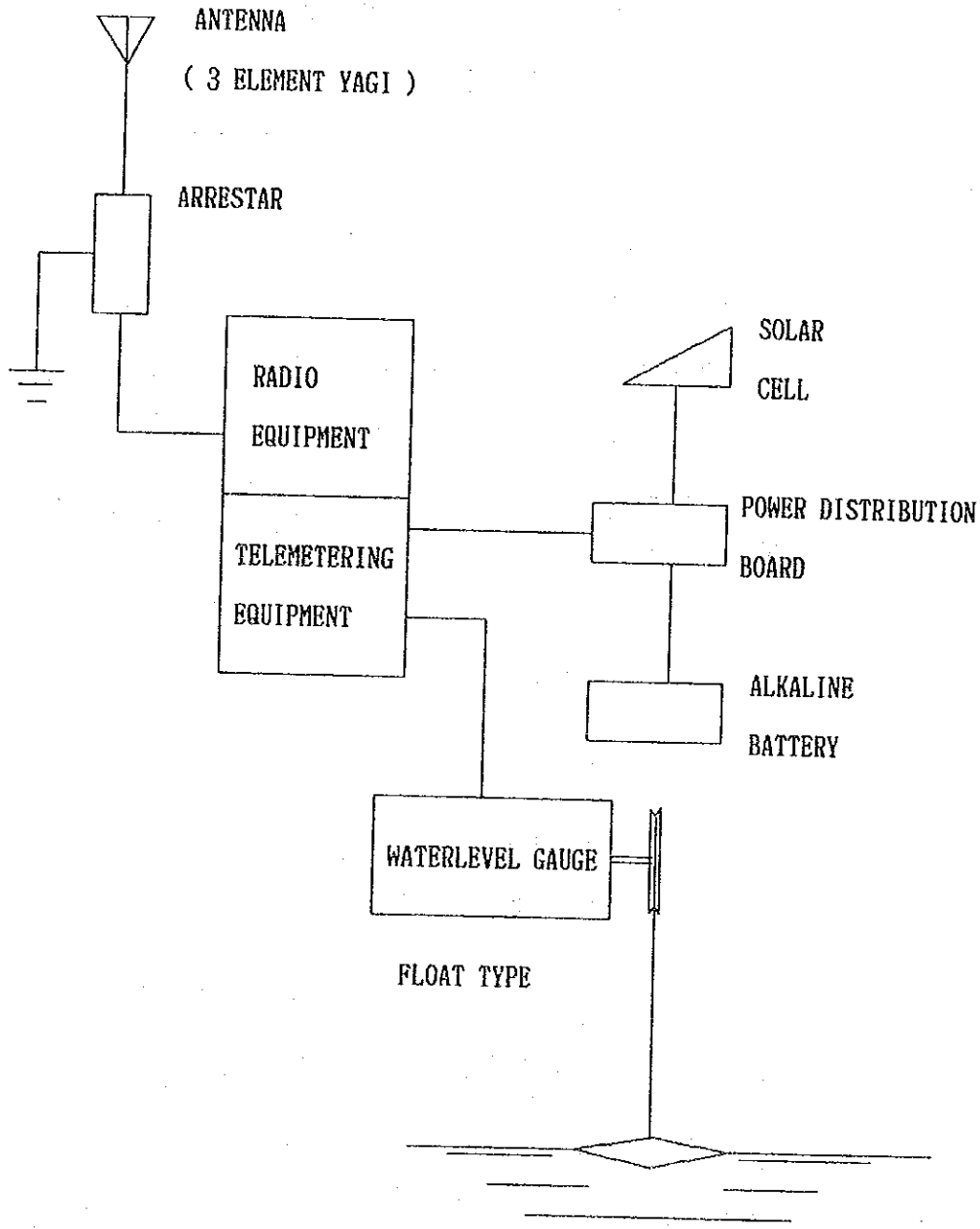


Fig. 3-21. DIAGRAM OF WATER LEVEL GAUGING STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY -

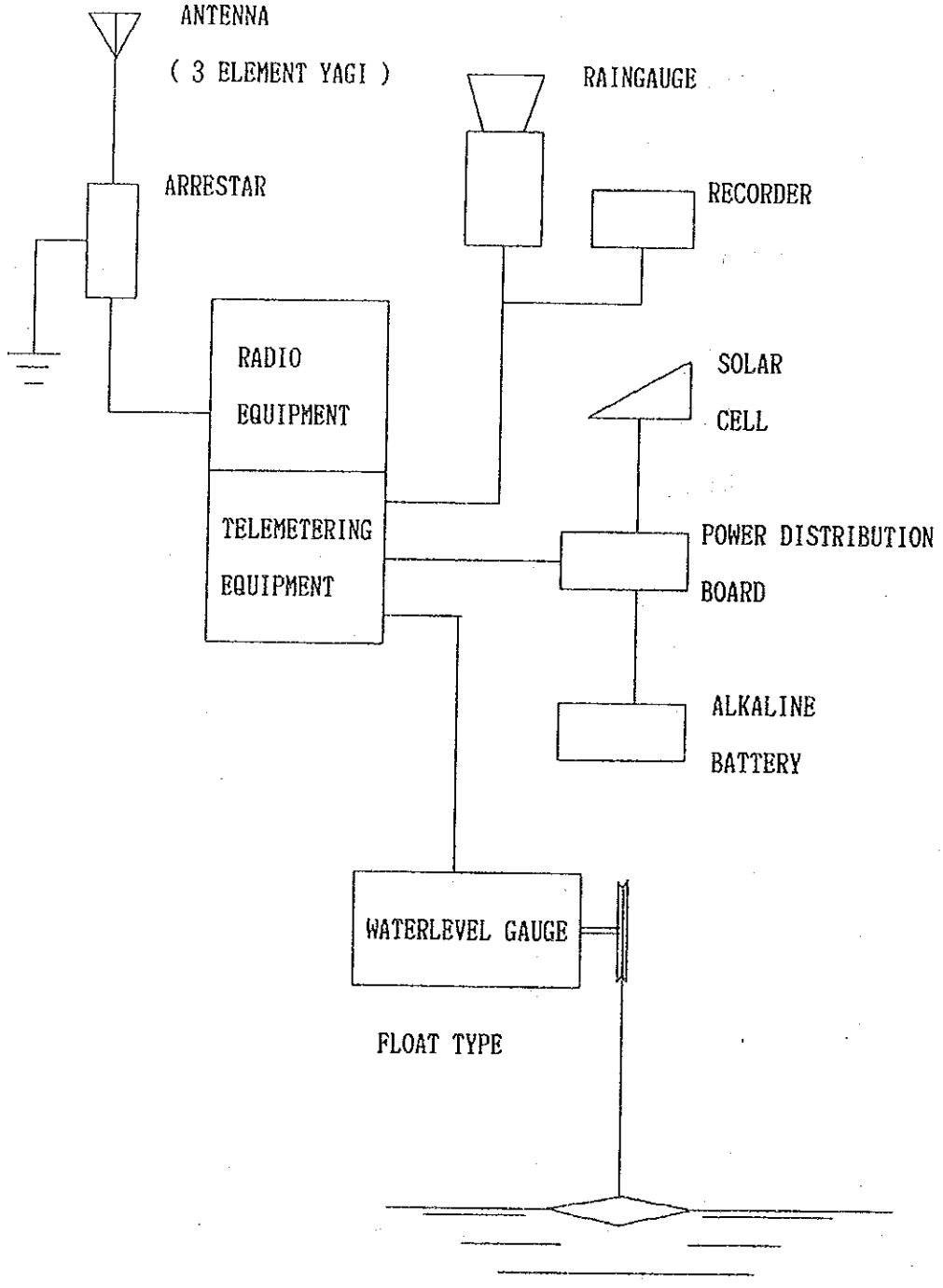


Fig. 3-22. DIAGRAM OF RAINFALL/WATER LEVEL GAUGING STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

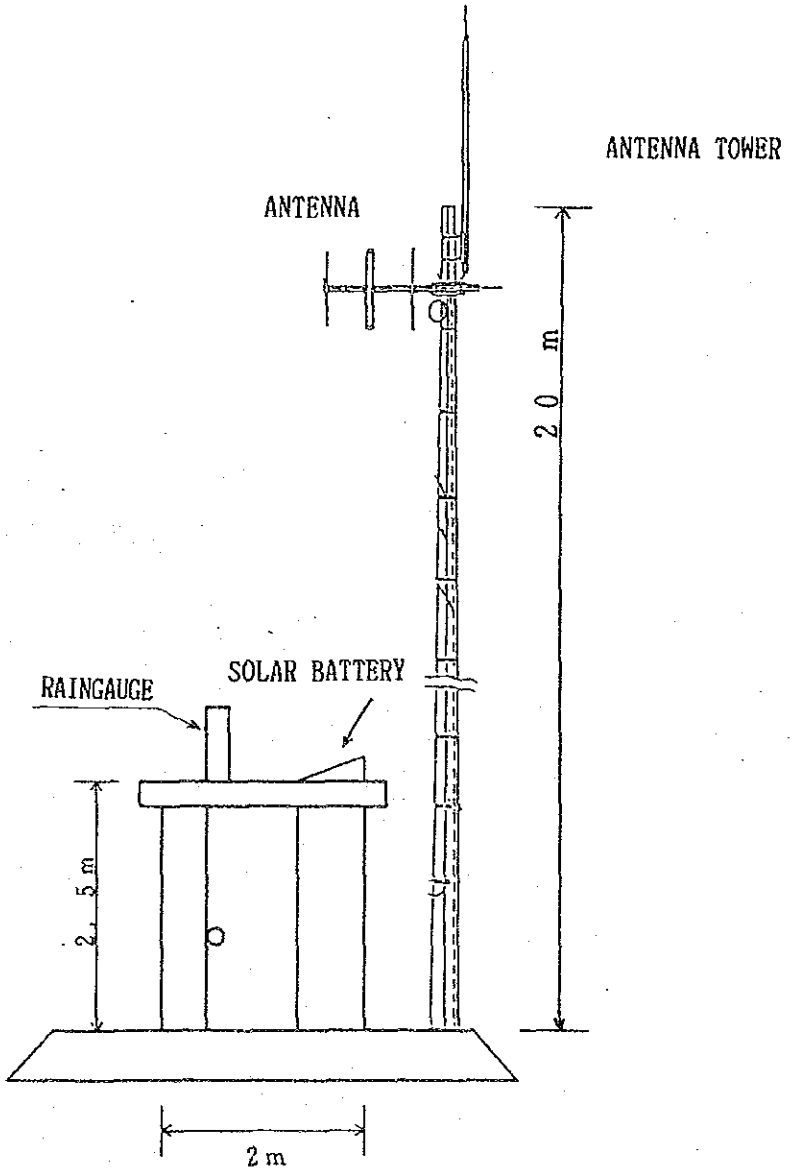


Fig. 3-23. STANDARD DRAWING OF RAINFALL GAUGING STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

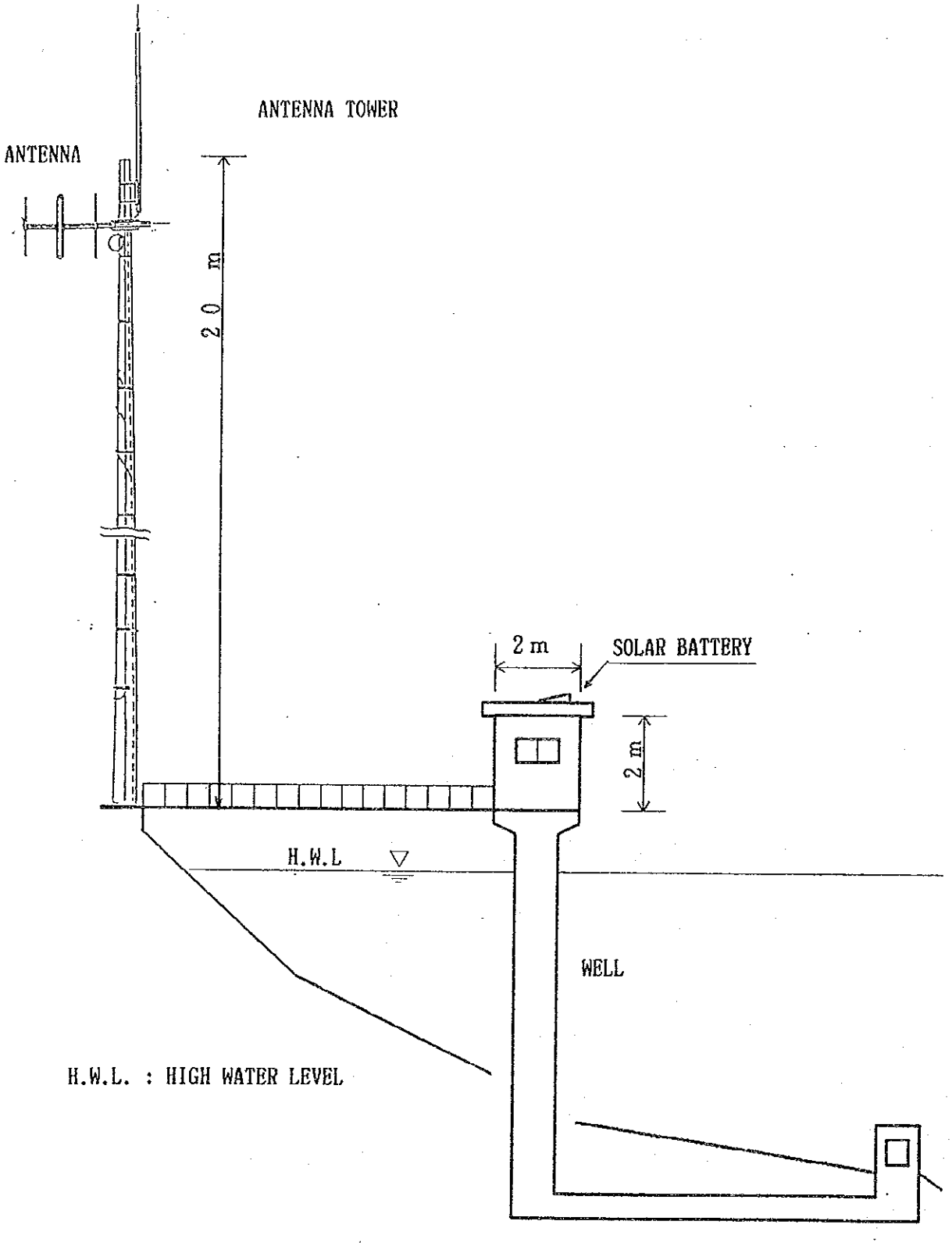


Fig.3-24. STANDARD DRAWING OF WATER LEVEL GAUGING STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

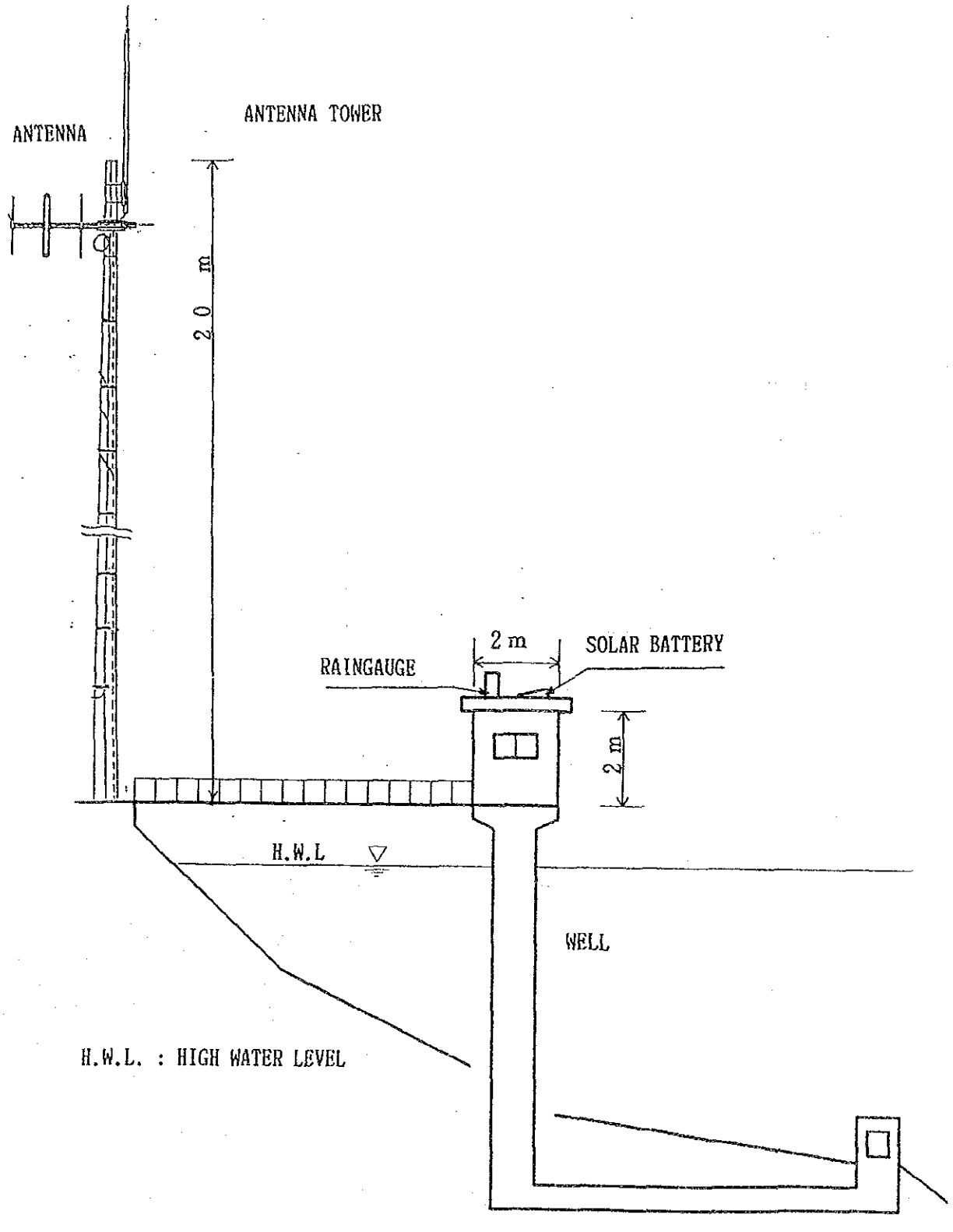


Fig. 3-25. STANDARD DRAWING OF RAINFALL/ WATER LEVEL GAUGING STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

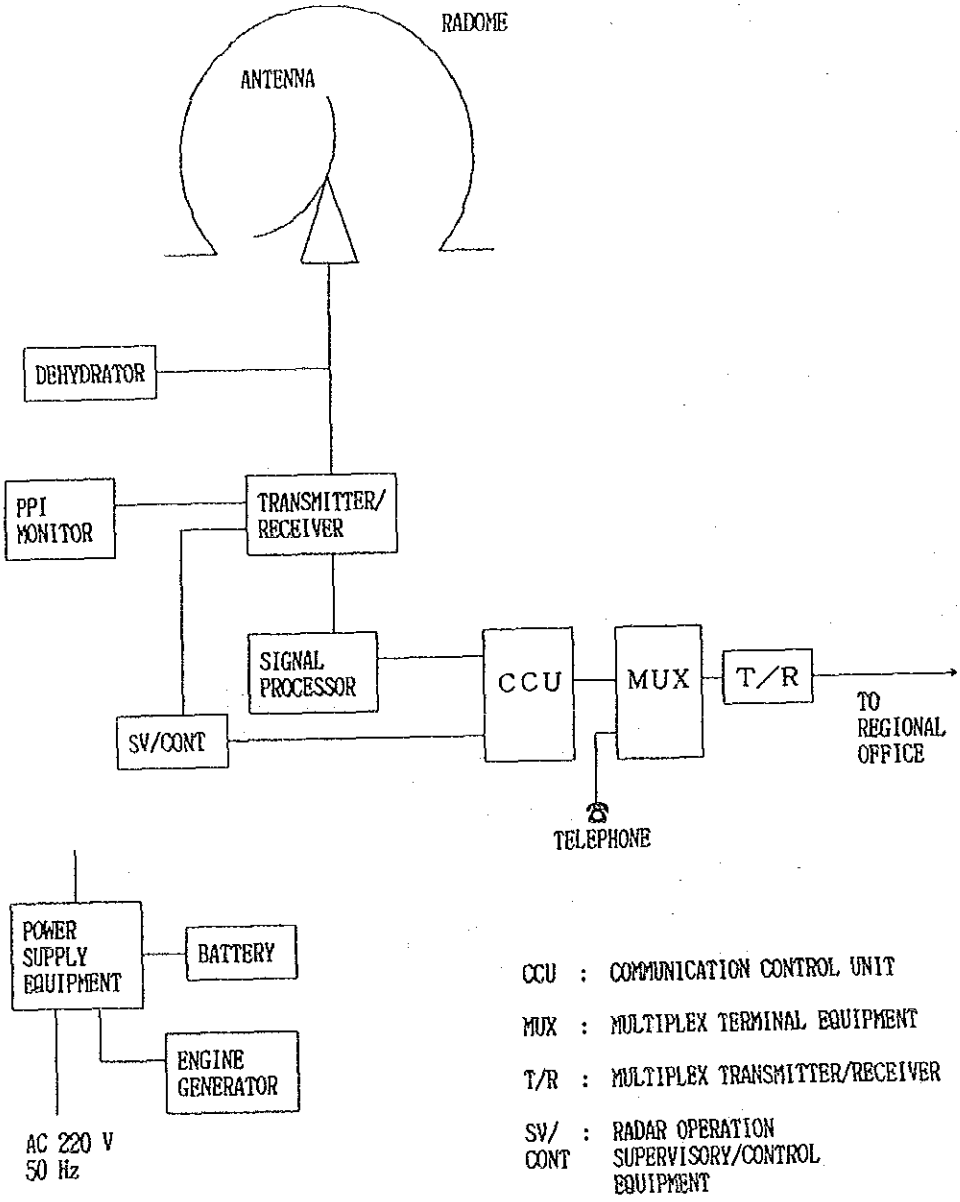


Fig. 3-26. DIAGRAM OF RADAR STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

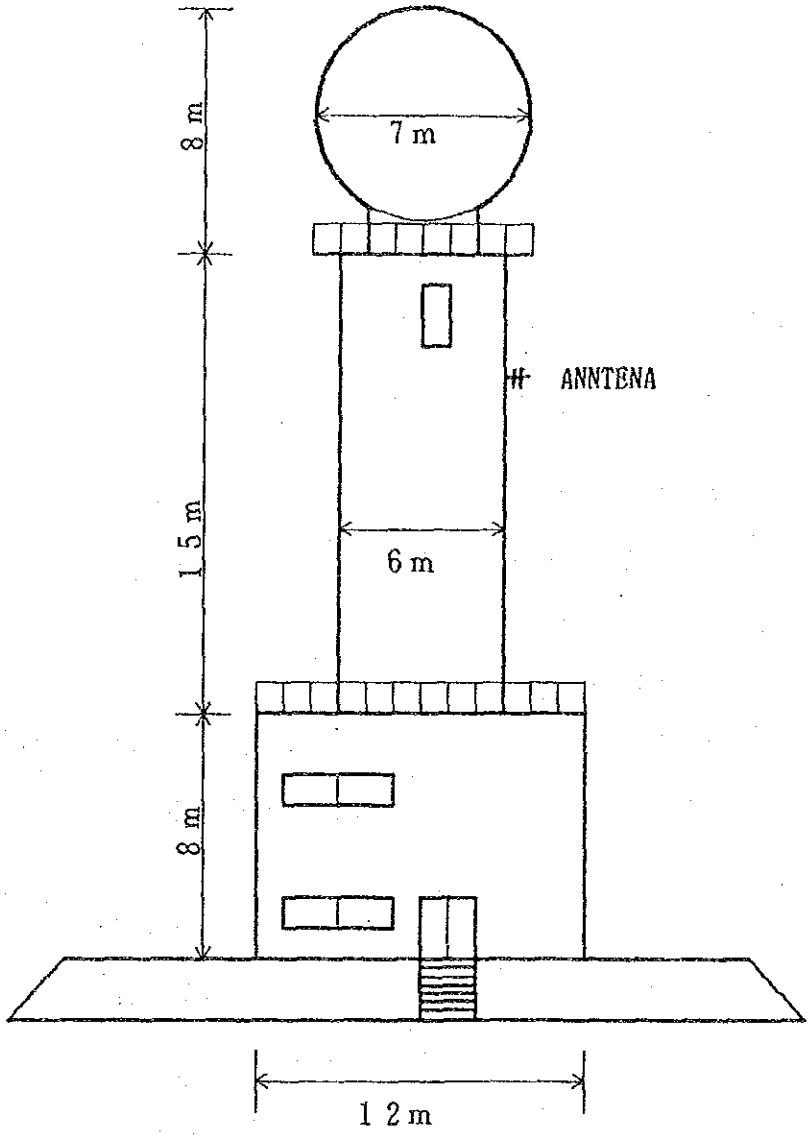


Fig. 3-27. STANDARD DRAWING OF HOUSING FOR RADAR STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

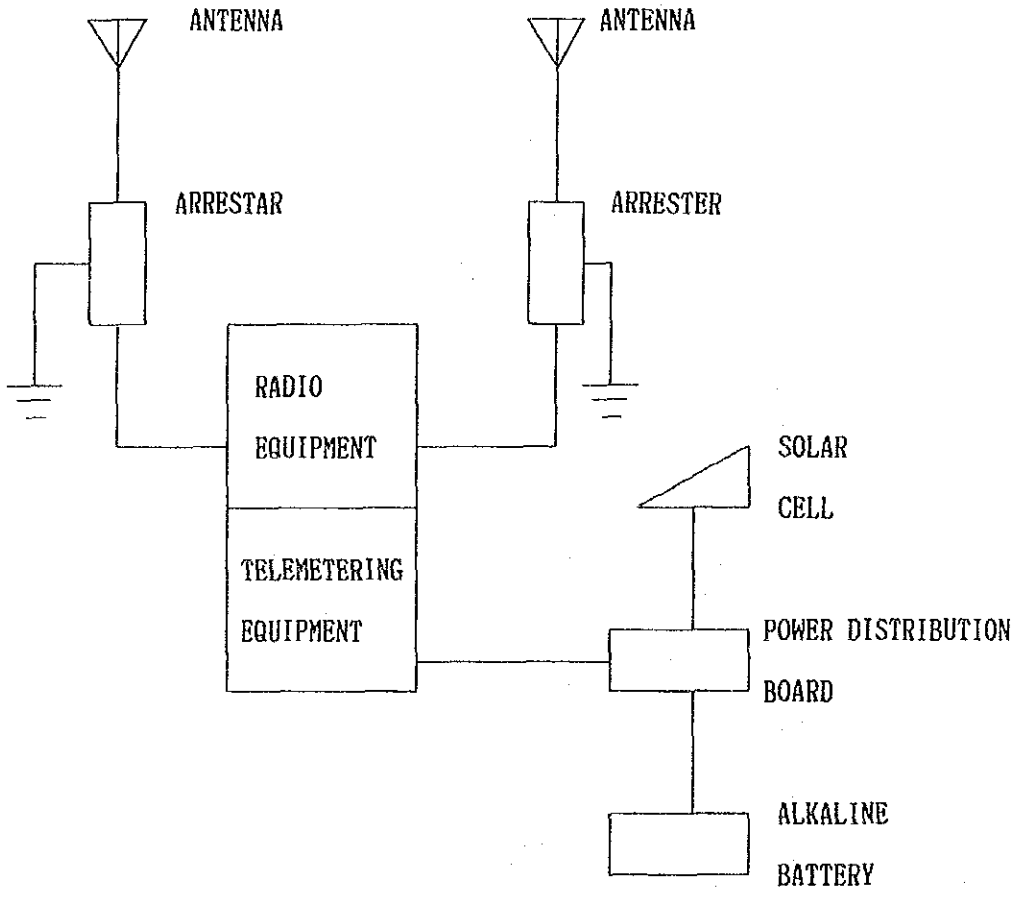


Fig. 3-28. DIAGRAM OF REPEATER STATION(VHF)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

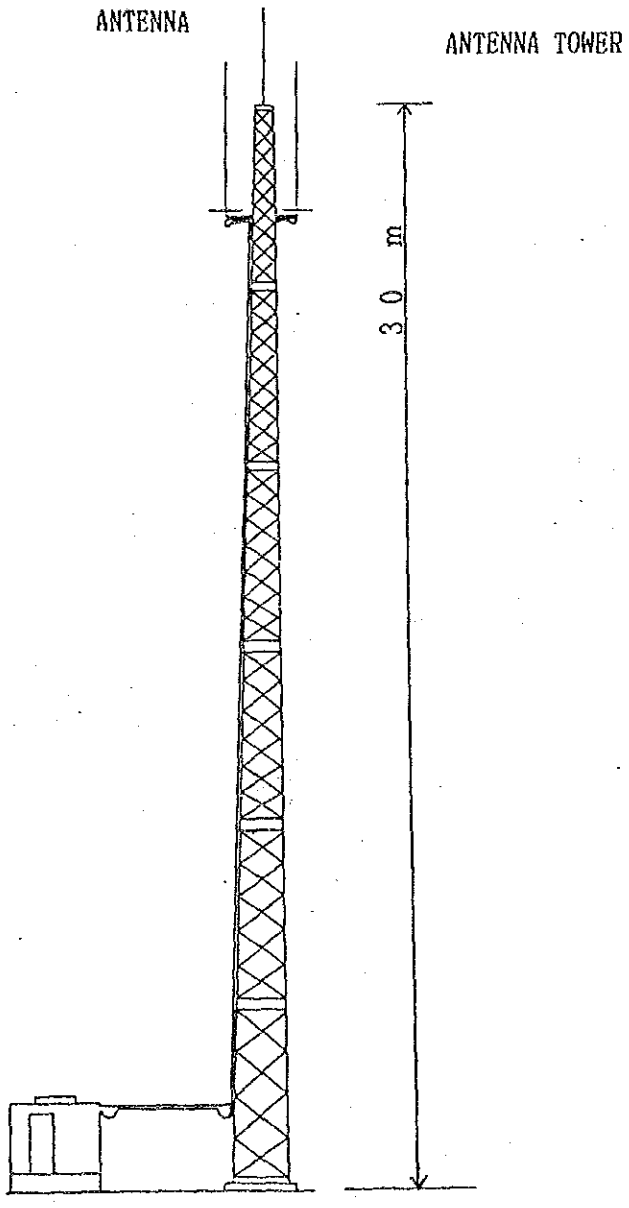


Fig. 3-29. STANDARD DRAWING OF REPEATER STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

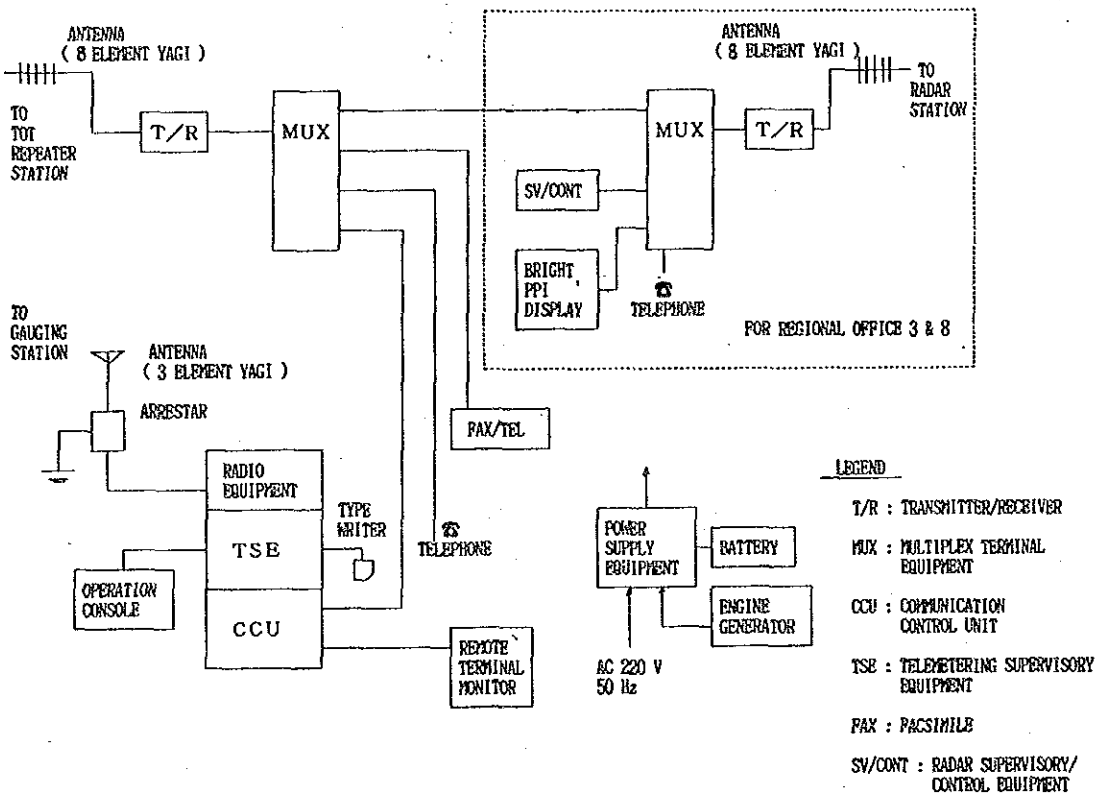


Fig. 3-30. DIAGRAM OF SUBSTATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

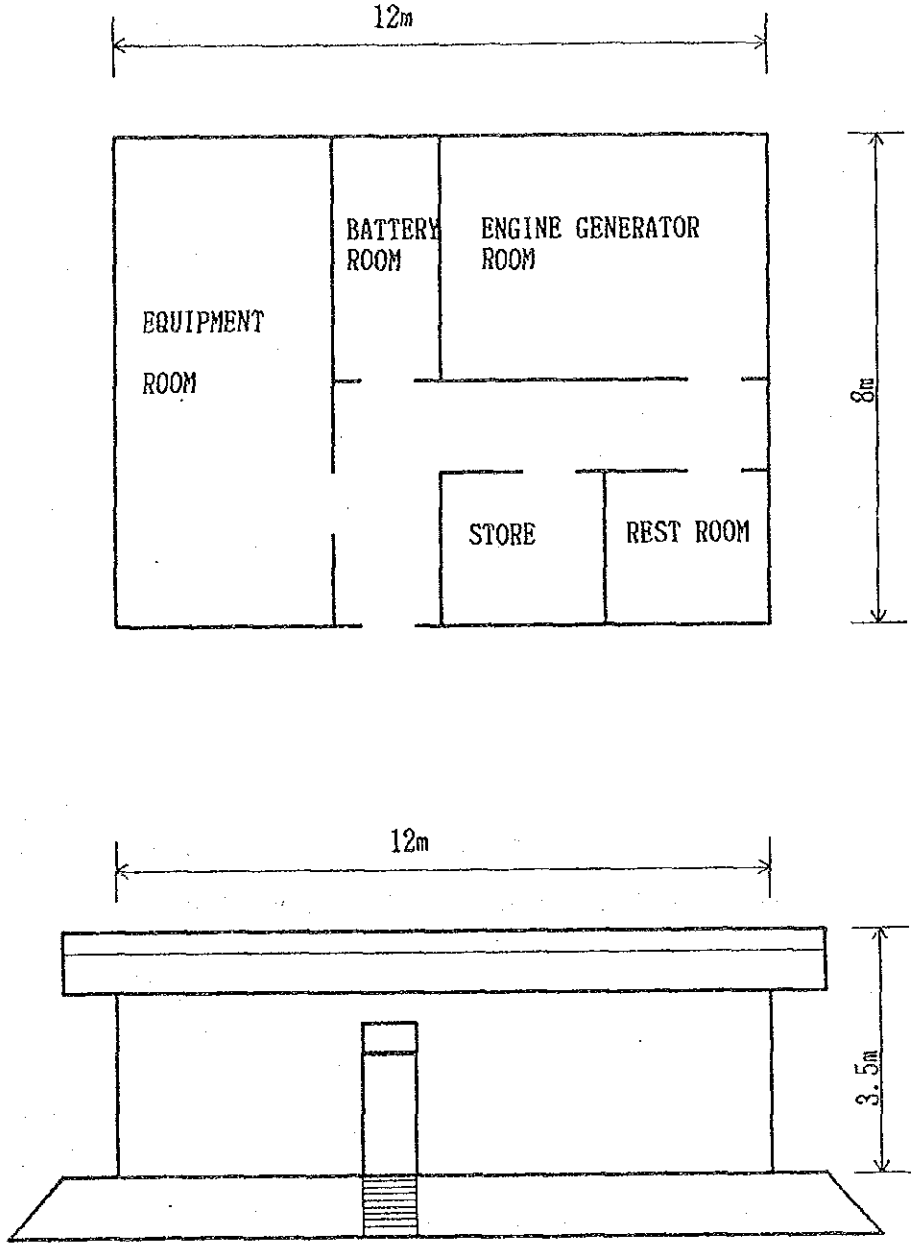
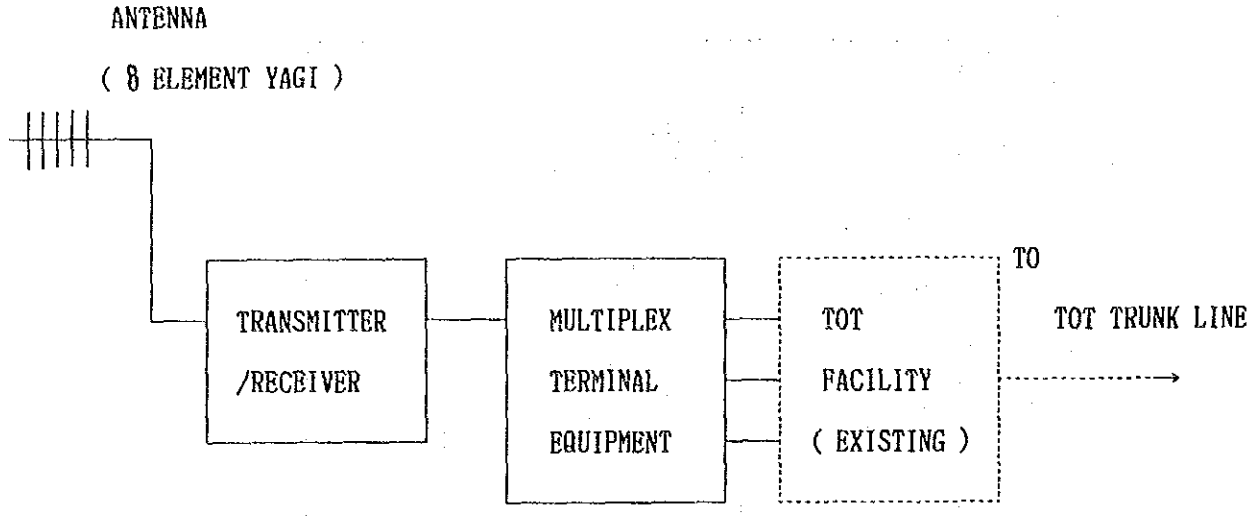


Fig. 3-31. STANDARD DRAWING OF HOUSING FOR SUBSTATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



1. Electric Power will be provided by TOT as part of charge.
2. Antenna will be installed on TOT Antenna Tower.

Fig. 3-32. DIAGRAM OF TOT TERMINAL STATION

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

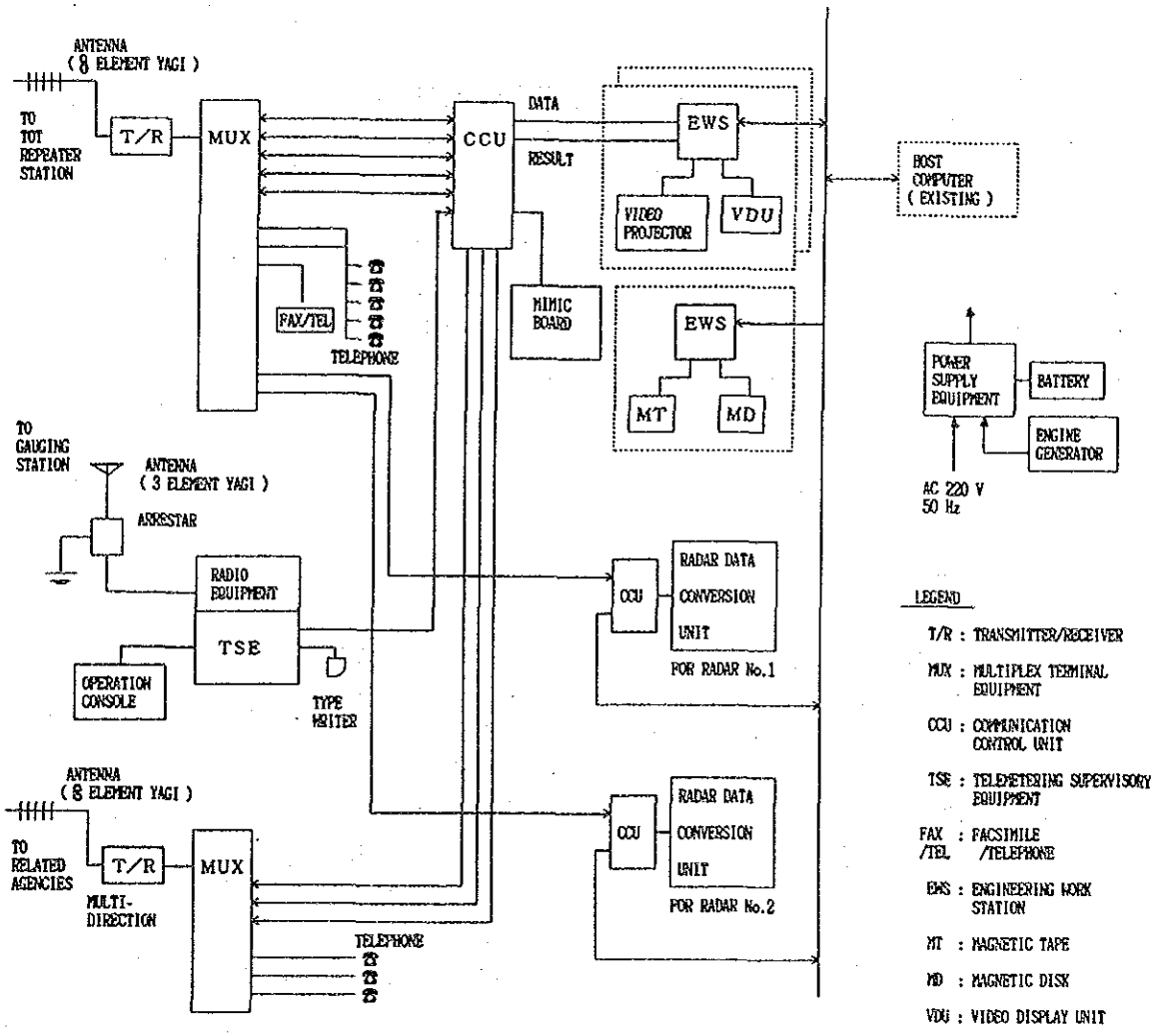


Fig. 3-33. DIAGRAM OF FFC

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

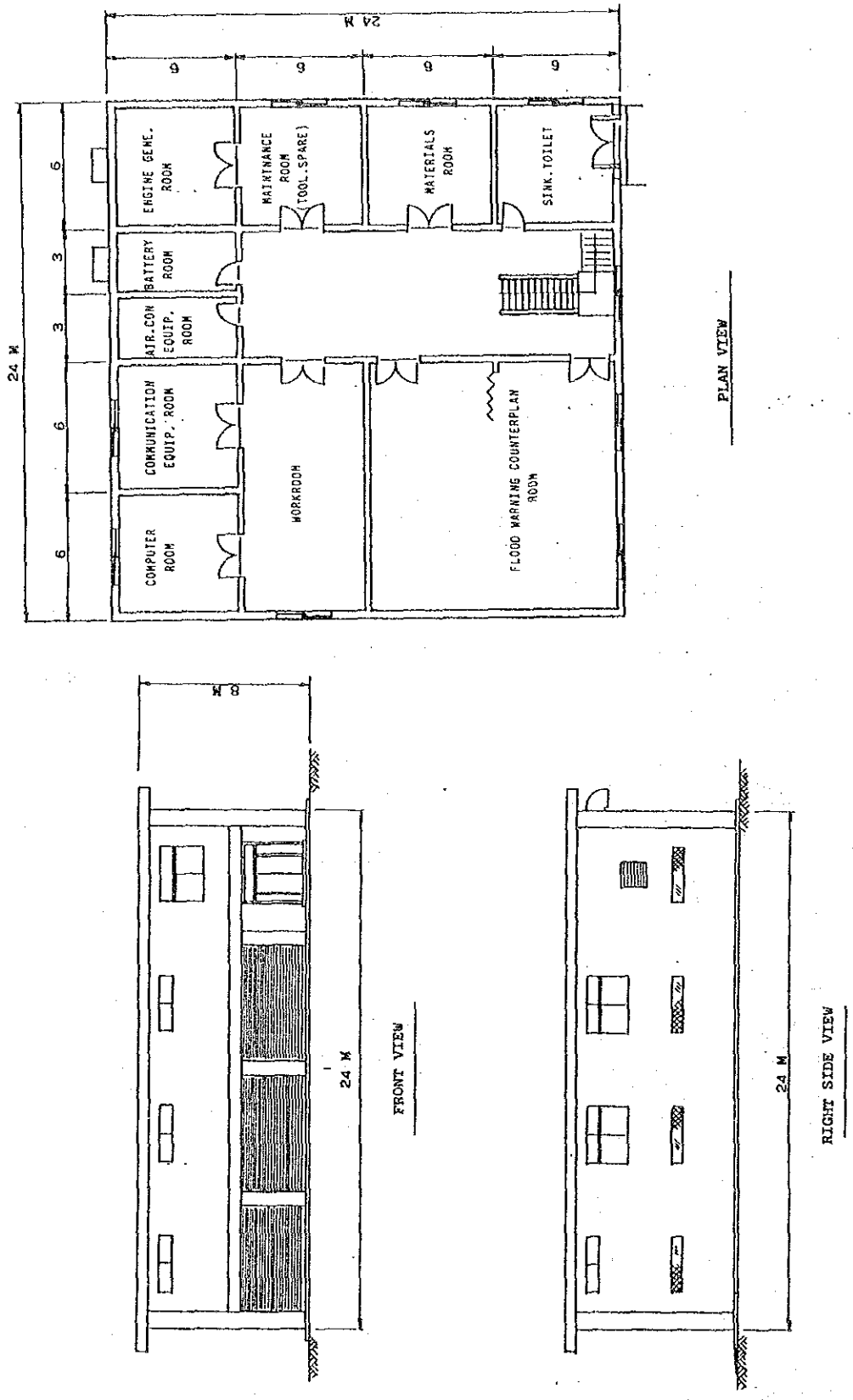
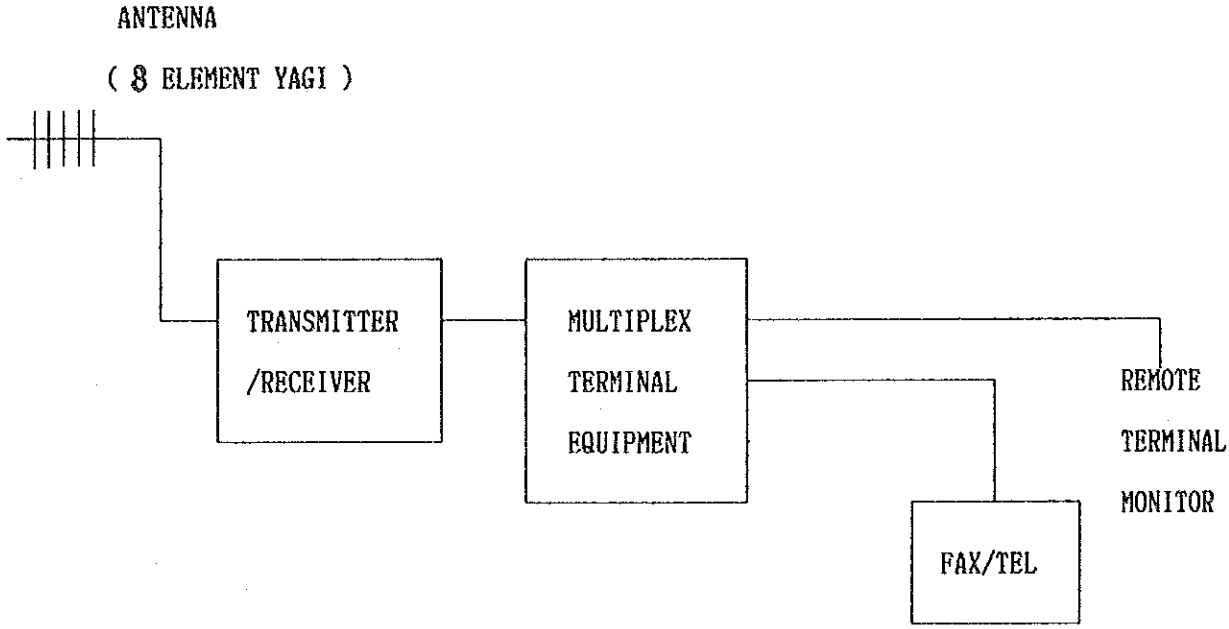


Fig. 3-34. STANDARD DRAWING OF HOUSING FOR FFC

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY



1. Electric Power will be provided by Related Agencies.
2. Antenna Tower will be provided by Related Agencies.

Fig. 3-35. DIAGRAM OF TELECOMMUNICATION FACILITIES IN RELATED AGENCIES

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

4. DATA MANAGEMENT

SUPPORTING REPORT
ON
DATA MANAGEMENT

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4. SUPPORTING REPORT ON DATA MANAGEMENT

1. General

The object of the data management system is to provide the flood prediction results based on the data collected during flooding time and to store such collected data together with those additionally collected for the use of the flood control works.

For the purpose, the data management system is formulated so as to especially have the following functions:

(1) Real time data filing and processing;
(2) Real time flood prediction;
(3) Hydrological analysis;
(4) Displaying visual information; and
(5) Monitoring basin condition.

The flood forecasting system is set up in two steps according to the concept: Step 1 based on the utilization of existing facilities and Step 2 to satisfy the required function for effective flood forecasting system.

In this report, the study results on formulation of the data management systems, Step 1 and Step 2 are compiled together with the investigation results on the existing data management system of RID.

2. Existing Computer Network of RID

The present computer system of RID is shown in Table 4-1 and Fig. 4-1. Existing computers and peripherals by Division are listed in Table 4-2. With the technical cooperation of JICA, RID has introduced an advanced computer system in the Irrigation Engineering Center (IEC) Project which started in 1983. The host computer is installed in the Data Processing Division. (Refer to Fig. 4-2)

Main computers are composed of one super-minicomputer as host computer and two super-microcomputers. Computer terminals are provided in many Divisions. Personal computers are being installed in the Data Processing Division and in every regional office. The super-minicomputer is actually utilized for multi-task, i.e., administrative and technical calculation, by multi-users. One of the super-microcomputers is used as a data input machine by typing from the computer terminals. Another super-microcomputer is installed in the IEC Laboratory at Packred for research. Personal computers are utilized as stand-alone or work station of the main computers.

3. Existing Hydrological Data Management System

Hydrological data are filed and processed by computer. The existing data management system is administered by the Data Processing Division. Data processing and hydrological analysis are made by the Hydrology Division, while the simulation model of water management is carried out by the O&M Division. The output of the data processing and simulation model of water management are in the form of rating curve, hydrograph, hydrological report, probability of peak flood and weekly summary of flow and rainfall.

Hydrological data and related subjects are published by RID in the Hydrological Yearbook, List of Rainfall Stations in Thailand, List of Stream Gauging Stations under RID, Monthly Runoff Report, and List of Structures under Operation of Irrigation Projects in Thailand.

Advanced data management system is being formulated by the IEC Project, including the development of hydrological data bases. (Refer to Table 4-3.)

4. Applicability of the Existing Data Management System

According to the interview with the Data Processing Division, the computers are fully utilized and two more computers are planned to be supplied in the near future as shown in Fig. 4-3. These computers will be used especially for the system development by the IEC Project; namely, database of technical data on planning, design and construction; database of hydrological data; simulation model for irrigation water management, etc.

Even if the new host computer for the IEC project is installed in the near future, the availability for flood forecasting system is hardly identified. In this connection, the study is made on the assumption that existing and newly introduced CPUs and peripherals are not applicable to the flood forecasting system under study.

5. Data Management System for Step 1

The functions accomplished by Step 1 are data filing and processing by manual operation, flood prediction, hydrological analysis, and displaying computation results.

5.1 Selection of Data to be Managed

Data to be managed for the flood forecasting system are classified into the data for flood forecasting computation and the data for flood control plan, as listed in Table 4-4. The data for flood forecasting computation such as rainfall, water level and tidal level are selected as a result of hydrological study. The data to be managed for flood forecasting computation are 65 in total, i.e., 34 Rainfall Data (16 from RID and 18 from MD), 30 water level Data (28 from RID and 2 from MD), and, tidal data (from PAT).

The data and information for flood protection work are as follows:

(1) Hydrological data of stations in the basin including the said stations;

(2) Meteorological data;

(3) Inundation area, depth and duration;

(4) Flood damage;

(5) Record of flood protection work;

(6) Land use map, topographic map, and river cross section and longitudinal section;

(7) Land subsidence; and

(8) Features of river structures and operation rule.

The data excluding Item (6) are filed in the data base. Item (6) will be filed in an ordinary drawer. These data will be assembled in conformity with the IEC data management system.

5.2 Calculation of Memory Volume

The necessary equipment for the data management system basically include a central processing unit (CPU) for computation, data storage equipment for data filing and output equipment like printer and display. Among these equipment, it is needed to estimate the required memory volume for the CPU and the storage equipment for the design of the data management system, as discussed hereunder.

(1) Required Memory Volume to CPU

In comparison with the data volume among those for flood forecasting and flood control, the former is expected to be essential to decide the required memory volume to CPU judging from the contents and emergency of works.

The required memory volume for the flood forecasting is expected to be within 5 MB judging from the number of collected hydrological data from 65 stations and the program length of the flood prediction calculation consisting about 5,000 steps, together with the memory volume of about 10,000 dimensions to be held in the program.

(2) Required Memory Volume to Storage Equipment

The required memory volume to storage equipment unlike the case of CPU is estimated on the basis of the data for flood control which is stored for a long time as the data basis.

The data volume required for the flood control is depending on the number of objective hydrological gauging stations which will be changed due to new installation and/or abolition of the gauging stations. Although the required memory is hardly estimated under the said condition, that is expected to be less than 50 MB judging from the number of the existing hydrological gauging stations amounts to approx. 1,000.

5.3 Display Method and Output Format

The results of data processing and flood forecasting computation by computer will be output on the following equipment; namely, the CRT graphic display, the printer, the hard copy unit, and the video projector. The output of hydrological data is presented in tabulated form as shown in Table 4-5. The output of prediction results is presented in graphic form.

5.4 Configuration of Data Management System

The data management system is composed of hardware and software. The hardware for Step 1 is composed of the computer and its peripherals which are utilized specifically for flood

forecasting work. Generally, computers are selected from supercomputers, mainframes, minicomputers and microcomputers taking into consideration the purposes of use, required memories, etc. Engineering work station, which has the capability equivalent to that of a minicomputer, is adopted as the central processing unit since it is designed to respond to particular engineering problems.

The following hardware is arranged in the RID head office; namely, Engineering Work Station (EWS), Data Storage Equipment, Printer and Color Hard Copy Unit, and Video Projector. The specifications of the hardware are determined, as shown in Table 4-6, taking into consideration the following:

(1) Ability of monitoring, data filing, data processing, flood analysis, display of output results and data dissemination;

(2) Capacity of the system in accordance with the increase of software library and databases; and

(3) Compatability with the existing computer system in IEC since databases and application program will be held in common.

The configuration of the data management system is as shown in Fig. 4-4. Data from the hydrological observation network will be input to EWS manually and filed into the data storage equipment in a form of database. Flood forecasting computation and hydrological analysis will be executed by EWS, loading data from the hard disk drive or magnetic tape unit. Hard disk drive is used for the storage of operating system, application program and short term data. Magnetic tape unit is used for long term data storage as well as back-up of the operating system and application program.

5.5 Specification of Data Management Facilities

Hardware

The specifications of the engineering work station and its peripherals are described below and shown in Table 4-6.

(1) Engineering Work Station

The work station will consist of a 32 bit CPU (Central Processing Unit) with main memory of 5 MB, color graphic CRT (Cathode Ray Tube Display) and keyboard. It will serve as the hard copy of CRT display.

(2) Data Storage Equipment

As the data storage equipment, a hard disk drive with a memory volume of 100 MB and magnetic tape with a memory volume of 100 MB are provided.

(3) Printer and Color Hard Copy Unit

The printer and color hard copy unit should support the function of CRT hard copy.

(4) Video Projector

The video projector should display enlarged output results of EWS.

Software

Software consists of an operating system and application programs. The specifications of the software are shown in Table 4-7. The following software library should be included for the operation of EWS as standard; namely, operating system, FORTRAN compiler, data base, spread sheet, and graphics. The software of EWS should at least have the functions for easy correction of storage data, ability to update parameter of the data base easily, ability to use language corresponding to the compiler, and ability to

interchange and arrange software between the new and the existing computer system.

The application programs for the flood forecasting system should be prepared during or after installation of the data management facilities. Flow chart of the analysis system for flood forecasting is shown in Fig. 4-5. Data base will be established for flood prediction and the retrieval of hydrological data and flood information. The main application programs to be prepared are as follows:

(1) Flood prediction model;

(2) Hydrological and flood information data base;

(3) Discharge rating curve;

(4) Correlation analysis (rainfall-rainfall, rainfall-water level and water level-water level);

(5) Statistical analysis (probable rainfall and probable flood); and

(6) Runoff analysis.

5.6 Data Dissemination System

The flood information will be disseminated to related government agencies such as Regional Office Nos. 7 and 8, LAD, BMA, and EGAT. The flood prediction results consisting of the daily and hourly water stages during the flood prediction time at the flood prediction points (refer to Table 4-8) shall be disseminated by voice communication so as to be used for the flood protection work such as operation of flood control structures, flood fighting, etc.

Although 6 hours is considered as the desirable time interval of the data dissemination in the planning conditions, one day time interval will be applied to that in Step 1 system, since the hydrological data is renewed every one day.

6. Data Management System for Step 2

The data management system for Step 2 has been formulated to satisfy the functions required of an effective flood forecasting system, as mentioned in Section 1, General. Reinforced functions from that for Step 1 are as follows:

(1) Real time data filing and processing;
(2) Real time flood forecasting;
(3) Displaying visual information; and
(4) Monitoring basin condition.

6.1 Selection of Data to be Managed

As in Step 1, data to be managed for Step 2 are classified into two. The summary of data to be managed for real time flood forecasting calculation are as follows:

Type of Telemeter Data	No. of Data	Collection Interval
Rainfall	84	6 hours
Water level	42	6 hours
Tide	1	1 hour
Reservoir water level	2	6 hours
Total	129	

Radar rainfall data will be installed to grasp area rainfall. The number of radar stations is as follows:

Type of Radar Data	No. of Data	Collection Interval
Rainfall	2	5 minutes

Data and information for reference of the flood control plan, as shown in Table 4-4, are managed as in Step 1.

6.2 Calculation of Memory Volume

As well as that in Step 1 system, the required memory volume is studied in two cases: to CPU and data storage equipment.

(1) Required Memory Volume to CPU

In comparison with the data to be managed for flood forecasting system in Step 1, those in Step 2 system increase according to increment of the number of the objective hydrological gauging stations as stated below:

	Step 1	Step 2
Rainfall gauge	34	84
Water level gauge (including tide)	31	45
Rader gauge	-	2

The memory volume increased due to the increment of the objective hydrological gauging ststions is estimated at about 0.2 MB, so that the total required memory volume is expected to be still within 5 MB.

(2) Required Memory Volume of Storage Equipment

The data to be stored for flood control plan also increase according to increment of the objective hydrological gauging stations of about 60 rainfall and water level gauging stations and 2 radar rain gauge.

The increased memory volume for the storage equipment of these gauging stations, the data of which are attributed mainly to those by the radar rain gauge, is roughly estimated at 50 MB while that of Step 1 is 50 MB, so that the total required volume comes to about 100 MB.

6.3 Display Method and Output Format

Hydrological data collected by telemetering system are generally displayed to monitor data and present basin condition, replacing data at a certain time interval. Equipment that will be employed to display telemeter data are CRT monitor of telemeter supervisory equipment, Mimic board, and Video projector. The results of data processing and flood prediction computation by computer will be output on the CRT graphic display, Printer, Hard copy unit, and Video projector.

The output format of primary hydrological data processing are presented in fabulated form, as shown in Table 4-5. The output format of data processing and flood forecasting analysis will be designed as the appropriate form of graph to provide visual information for flood protection work. The example of output format and mimic board are shown in Figs. 4-6 and 4-7, respectively.

6.4 Configuration of Data Management System

Hardwares arranged in FFC are the Engineering Work Station (EWS), Data Storage Equipment, Printer and Color Hard Copy Unit, and Video Projector. The configuration of the data management system and the layout of hardware are illustrated in Figs. 4-8 and 4-9, respectively. As for EWS, 3 sets of EWS will be installed because processing such as real time flood prediction, real time data processing and retrieval of databases will be increased.

Generally, telemeter data is monitored to check basin condition and data error. Information on flood event which cannot be managed in a certain format is collected by audio visual equipment and scanner, and filed in a specific filing system. Equipment to be employed for such purposes are the Mimic Board, Electronic Filing System, and Video tape Recorder.

6.5 Specification of Data Management Facilities

Hardware

The specifications of EWS and its peripherals are described below and shown in Table 4-9.

(1) Engineering Work Station

The engineering work station for Step 2 is basically the same as that for Step 1. (Refer to Section 5.5).

(2) Data Storage Equipment

Basically, the data storage equipment for Step 2 is the same as that for Step 1. (Refer to Section 5.5).

Data input interface unit should interface with the telemetering supervisory/control equipment by BCD bit-parallel and work-serial format. Data output interface should interface with the CPU and mimic board by BCD bit-parallel and work-serial format.

(3) Printer and Color Hard Copy Unit

Printer and color hard copy unit should support the function of CRT hard copy.

(4) Video Projector

Video projector should display enlarged output results of EWS.

(5) Mimic Board

Telemeter data is displayed on mimic board to monitor the present basin condition and data error. Input interface unit should interface with the telemetering supervisory/control equipment by BCD bit-parallel and work-serial format.

(6) Electronic Filing System and Video Tape Recorder

Electronic filing system is supplied to store and retrieve the references on flood. Video tape recorder is supplied to store and retrieve the visual record of flood damage and flood protection work.

Software

The specifications of the software are as in Step 1 as shown in Table 4-7. The application programs for the river information should be prepared during or after installation of the data management facilities. The additional application programs for river information display model (rainfall condition, water level condition and dam data) are to be prepared in addition to those of Step 1.

6.6 Data Dissemination System

The related government agencies and regional offices are the same as in Step 1. The following facilities for dissemination will be provided at the government agencies concerned and Regional Office Nos. 7 and 8; namely, Remote Terminal Computer, Facsimile and Telephone, and Hot Line Telephone. The time interval of data dissemination is six hours according to the planning conditions.

An outline of the data dissemination system is shown in Fig. 4-7. Information to be disseminated consists of predicted water level at prediction points and present basin condition. Visual information will be prepared for dissemination. The authorized predicted water level at respective points presented in the form of hydrograph will be disseminated by facsimile, since it is necessary to get approval of a director who has responsibility for dissemination. Flood prediction points and kinds of predicted water level in accordance with the agencies concerned are the same as Step 1. Present basin condition will be disseminated through remote terminal computer not only to grasp present

condition but also to judge the near future condition. Telephone will be used for communication between FFC and the agencies concerned. Hot line telephone will be used for communication between FFC and Regional Office Nos. 7 and 8.

TABLES

Table 4-1. PRESENT COMPUTER SYSTEM OF RID

	Model	Quantity	Description
1.	Central Processing Unit (CPU)		
	VAX-11/750	1	32bit CPU with 6MB Memory
	Micro VAX II	2	32bit CPU with 5MB Memory
	Micro VAX II	1	32bit CPU with 16MB Memory
	VAX station II/GPX	1	32bit CPU with 5MB Memory
	PC AT	3	16bit CPU with 512KB Memory
	PC XT	1	16bit CPU with 256KB Memory
	APC IV	6	16bit CPU with 640KB Memory
	PC AT Compatible	1	16bit CPU with 1024KB Memory
2.	Work Station / Display Terminal		
	VT80	5	Thai/English Monitor
	VT220	26	Video Display
	VT241	3	Graphics Display
	VR290	1	Color Video Monitor
3.	Storage Equipment		
	RA60	1	205MB Removable Disk Drive
	RA80	1	121MB Fixed Disk Drive
	RA81	6	456MB Fixed Disk Drive
	RD54	2	159MB Fixed Disk Drive
	RL02	1	10MB Removable Disk Drive
	RX02	2	0.5MB Floppy Disk Drive
	TK50	4	95MB Magnetic Tape Subsystem
	TU58	1	256KB Magnetic Tape Subsystem
	TU80	2	1600BPI Magnetic Tape Subsystem
4.	Printer		
	LA100	4	Letterwriter
	LA100	15	Letterprinter
	LQ1500	7	Letter Quality Printer
	LQP02	1	Letter Quality Printer
	LPS16	1	600LPM Line Printer
	B1000	1	1000LPM Line Printer
	P7	7	Pinwriter
5.	Plotter		
	CalComp 1077	1	Plotter
	CalComp 1044GT	1	Plotter
	Roland DXY-990	1	Plotter
6.	Digitizer		
	CalComp 9480	1	Digitizer
	CalComp 91480	2	Digitizer

Table 4-2(1/3). COMPUTER SYSTEM OF RID BY DIVISION

Model	Quantity	Description
1. Irrigation Engineering Center (Samsen)		
1.1 Computer Machine Room		
DEC 750XA-AJ	1	11/750 CPU, 6 MB Memory
DEC FP750	1	Floating-point Accelerator
DEC DEUNA	1	Ethernet Controller
DEC DZ11	6	8-Line Asynchronous Interface
DEC LA100	1	Letterwriter (Console Terminal)
DEC RA80	1	121 MB Fixed Disk Drive
DEC RA81	3	456 MB Fixed Disk Drive
DEC RX02	2	0.5 MB Floppy Disk Drive
DEC RL02	2	10 MB Removable Disk Drive
DEC TU58	1	256 Cartridge Magnetic Tape
DEC TU80	2	1,600 BPI Magnetic Tape Unit
DEC DELNI	1	Local Network Interconnect
Centronics LPS16	1	600 LPM Line Printer
Dataproducts B1000	1	1,000 LPM Line Printer
1.2 Computer Terminal Room		
DEC VT80	1	Thai/English Monitor
DEC VT220	5	Video Display Terminal
DEC LA100	1	Letterprinter
1.3 Computer Graphics Room		
DEC SV-LV590	1	VAX Station II/GPX 8-Plan Color, CPU, FPU, 16 MB Memory
DEC DEQNA	1	Ethernet Controller
DEC RD54	2	159 MB Fixed Disk Drive
DEC TK50	1	95 MB Cartridge Tape
DEC VR290	1	10" Color Monitor
DEC VT241	1	Graphics Display Terminal
DEC LA100	2	Letterprinter
CalComp 1077	1	Dual-Mode Drum/Beltbed Plotter
Roland DXY-990	1	Plotter
CalComp 9480	1	Digitizer
IBM PC/AT	1	16 bit, 512 KB RAM, 20 MB Fixed Disk Drive, 1.2 MB Diskette Drive, Color Display
IBM PC/AT	1	16 bit, 512 KB RAM, 20 MB Fixed Disk Drive, 1.2 MB Diskette Drive, 360 KB Diskette Drive, Color Display
EPSON LQ-1500	1	Letter Quality Printer

Table 4-2(2/3). COMPUTER SYSTEM OF RID BY DIVISION

Model	Quantity	Description
1.4 Data Entry Room		
DEC DH-630Q5	1	Micro VAX II CPU, FPU, 5 MB Memory
DEC DEQNA	1	Ethernet Controller
DEC DHV11	1	8-Line Multiplexer
DEC RA60	1	205 MB Removable Disk Drive
DEC RA81	3	456 MB Fixed Disk Drive
DEC TK50	1	95 Cartridge Tape
DEC LA100	1	Letterwriter (Console Terminal)
DEC LA100	1	Letterprinter
DEC VT220	8	Video Display Terminal
1.5 Program Development Room		
DEC DH-630Q5	1	Micro VAX II CPU, FPU, 5 MB Memory
DEC DEQNA	1	Ethernet Controller
DEC DHV11	1	8-Line Multiplexer
DEC RA81	3	456 MB Fixed Disk Drive
DEC TK50	1	95 Cartridge Tape
DEC LA100-CB	1	Letterwriter (Console Terminal)
DEC LA100-ZB	1	Letterprinter
EPSON LQ-1500	1	Letter Quality Printer
DEC VT80	1	Thai/English Monitor
DEC VT220	1	Video Display Terminal
IBM PC/XT	1	16 bit, 256 KB RAM, 360 MB x 2 Diskette Drive, Color Display
PC AT Compatible	1	16 bit, 1,024 KB RAM, 20 MB Fixed Disk Drive, 1.2 MB Diskette Drive, 360 KB Diskette Drive, Monochrome Display
NEC P7	1	Pinwriter
1.6 Administration Section Room		
DEC VT220	1	Video Display Terminal
DEC LA100	1	Letterprinter
2. Irrigation Engineering Center (Pakred)		
DEC DH-630Q5	1	Micro VAX II CPU, FPU, 5 MB Memory
DEC DEQNA	1	Ethernet Controller
DEC DHV11	1	8-Line Multiplexer
DEC RA81	1	456 MB Fixed Disk Drive
DEC TK50	1	95 Cartridge Tape
DEC LA100-CB	1	Letterwriter (Console Terminal)
DEC LA100	1	Letterprinter
DEC VT220	2	Video Display Terminal
DEC VT241	1	Graphics Display Terminal
CalComp 1044GT	1	Plotter
CalComp 91480	1	Digitizer
IBM PC/AT	1	16 bit, 512 KB RAM, 20 MB Fixed Disk Drive, 1.2 MB Diskette Drive, Color Display
EPSON LQ-1500	1	Letter Quality Printer

Table 4-2(3/3). COMPUTER SYSTEM OF RID BY DIVISION

	Model	Quantity	Description
3.	Data Processing Division		
	DEC VT80	1	Thai/English Monitor
	DEC VT220	1	Video Display Terminal
	DEC VT241	1	Graphics Display Terminal
	DEC LA100	1	Letterprinter
	EPSON LQP02	1	Letter Quality Printer
	CalComp 91480	1	Digitizer
4.	project Planning Division		
	DEC VT220	2	Video Display Terminal
	DEC LA100	2	Letterprinter
5.	Program Coordination and Budget Division		
	DEC VT80	1	Thai/English Monitor
	DEC VT220	1	Video Display Terminal
	EPSON LQ-1500	3	Letter Quality Printer
6.	Hydrology Division		
	DEC VT220	1	Video Display Terminal
	DEC LA100	1	Letterprinter
7.	Medium Project Construction Division		
	DEC VT220	1	Video Display Terminal
	DEC LA100	1	Letterprinter
8.	Transport Division		
	DEC VT220	1	Video Display Terminal
	DEC LA100	1	Letterprinter
9.	Operation and Maintenance Division		
	DEC VT220	1	Video Display Terminal
	DEC LA100	1	Letterprinter
10.	Irrigation Regional Offices 3, 7 and 8		
	NEC APC/IV	1	16 bit, 640 KB RAM, 1.2 MB x 2 Diskette Drive, Color Display
	NEC P7	1	Pinwriter

Table 4-3. DATA BASE BY IEC PROJECT

1.	General Information	
1.1	D	River and Province
1.2	D	Administration
1.3	D	Map Information
2.	River Flow Information	
2.1	F	Rating Curve and Stage-Discharge Conversion
2.2	D	Hourly Height
2.3	F	Cross-section
2.4	F	Sedimentation
2.5	C	Water Quality
3.	Weather Information	
3.1	F	Daily Rainfall
3.2	C	Hourly Rainfall
3.3	D	Meteorological Data
3.4	C	Annaul Heaviest Rainfall and its Duration
4.	Irrigation Water	
4.1	D	Daily High and Low Discharge
4.2	C	Discharge Calculation Formula or Coefficient
4.3	C	Facilities Cross-section
5.	Reservoir	
5.1	C	Daily (Volume), Water Level, Inflow, Release, Evaporation and Rainfall
5.2	C	Water Level and Volume
6.	Crop	
6.1	D	Rice
6.2	D	Field Crop
6.3	D	Sugarcane
6.4	D	Vegetables
6.5	D	Perennials
6.6	D	Fishponds

Note: F = existing file system; D = under development; C = under consideration

Table 4-4. LIST OF DATA TO BE MANAGED

Classification	Data
(1) Data for Flood Prediction	° Rainfall data ° Water level, discharge, tide ° Discharge from main water control structures
(2) Data for Flood Control Plan	° Meteorological data (atmospheric depression, wind velocity, etc.) ° Flood inundation data (inundation area, depth and duration) ° Flood damage data (house, household effects, public facilities, agricultural products, etc.) ° Topographic map, land use map, etc. ° River cross-section, longitudinal profile, etc. ° Design features of water control structures and operation rule ° Land subsidence

Table 4-5. EXAMPLE OF OUTPUT FORM

ID Code : *********

Agency : *********

Location: Region = ********* Lat. = N 00-00-00
District= ********* Long. = E 000-00-00
Address = **********

Altitude: ***.* (m)

Establisted Date : ***. **,19** Records Available : 19**-19**

Gage : Type = ********* Manufacturer = *********
Observation Rule = **********

Extrema : Maximum Rainfall= ***.* (mm/d) Minimum Rainfall= ***.* (mm/d)
Date = ***. **,19** Date = ***. **,19**
Period = 19**-19** Period = 19**-19**

Source of Record : **********

Remarks : **********

Note, (1) R-Day means number of rainy days.
(2) Hyphone(-) means missing record.
(3) Astarisk(*) means detective value.

Year: 19** Unit:mm

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
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20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
31												
Total												
Mean												
Min.												
Max.												
R-Day												

*Annual Total= ***.* (mm) *Annual Mean= ***.* (mm) *Annual Min.= ***.* (mm) *Annual Max.= ***.* (mm)

Table 4-6(1/2). SPECIFICATION OF DATA MANAGEMENT FACILITIES (STEP 1)

(1) Engineering Work Station		
(1.1) CPU		
1. Quantity	:	1
2. Technical Specifications		
- Type/Size	:	32 bit central processor, graphic co-processor, floating point math co-processor
- Capacity/Memory	:	5 MB
(1.2) CRT Graphic Display/Keyboard		
1. Quantity	:	1
2. Technical Specifications		
- Type/Size	:	19 inch diagonal, 16 kinds of color, ASCII character set, programmable blinking cursor/ mouse, graphic
- Resolution	:	24 lines x 80 characters/line, 1,000 x 800 pixels
- Keyboard	:	Typewriter key, numeric keypad, cursor control keys, special operation keys, PF keys
- Character Set	:	256 characters
(2) Data Storage Equipment		
(2.1) Hard Disk Drive		
1. Quantity	:	1
2. Technical Specifications		
- Format Capacity	:	100 MB
- Access Speed	:	65 ms

Table 4-6(2/2). SPECIFICATION OF DATA MANAGEMENT FACILITIES (STEP 1)

(2.2) Magnetic Tape Drive		
1. Quantity	:	1
2. Technical Specifications		
- Type/Size	:	High speed, single density, inter block cap 0.60 inches
- Format Capacity	:	100 MB
- Data Rate	:	120 KB/sec (75 IPS read/write, 200 IPS rewind)
- Data Density	:	1,600 byte/inch, 9 track, ASCII format, ANSI
(3) Printer		
1. Quantity	:	1
2. Technical Specifications		
- Type/Size	:	Matrix printer or laser printer
- Character Set	:	Full ASCII, standard
- Printing Speed	:	600 LPM (line/min) or 8 PPM (page/min)
- Line Length	:	132 char./line
(4) Color Hard Copy		
1. Quantity	:	1
2. Technical Specifications		
- Color	:	7 colors minimum
- Copy Speed	:	50 seconds or less
- Resolution	:	6 dots/mm
(5) Video Projector		
1. Quantity	:	1
2. Technical Specifications		
- Size	:	100 inches
- Resolution	:	Video input: 550 TV lines, RGB input: 900 TV lines or 2,000 characters

Table 4-7(1/2). SPECIFICATION OF COMPUTER SOFTWARE

(1) OPERATING SYSTEM/SOFTWARE

1. Virtual storage/memory operating system
2. Interactive operating system
3. Multiple jobs
4. Data management system (DMS)
5. Automatic data compaction
6. Automatic print spooling
7. Background processing
8. Multiple language (FORTRAN, C, Assembler, etc.)
9. Data base
10. Spread sheet
11. Graphics
12. Security system

(2) UTILITY

1. Backup
2. Sort, Merge, Select
3. Copy
4. Tape copy
5. Display
6. Data entry/control
7. Create file
8. Editor
9. Security
10. Etc.

Table 4-7(2/2). SPECIFICATION OF COMPUTER SOFTWARE

(3) APPLICATION PROGRAM

1. Flood prediction model
2. Hydrological and flood information data bases
3. Statistic analysis
   (probable rainfall and probable flood)
4. Correlation analysis
   (rainfall-rainfall, rainfall-water level and water level-water level)
5. Discharge rating curve
6. Flood prediction model
7. Runoff analysis
8. River information display model /1
   (rainfall condition, water level condition and dam data)

/1: Item 8 is prepared at the stage of Step 2.

Table 4-8. DATA DISSEMINATION

Agencies for Data Dissemination	Items for Dissemination	Flood Prediction Point
BMA	Hourly water stage	Memorial Bridge, RID Samsen and Pakred
LAD	Daily water stage	Nakhon Sawan, Chai Nat, Singburi, Lop Buri, Angthong, Ayutthaya
EGAT	Daily water stage	Nakhon Sawan, Chai Nat
	Hourly water stage	Memorial Bridge, RID Samsen and Pakred
RID (Regional and Project Office)	Daily water stage	Angthong and Ayutthaya

Table 4-9(1/3). SPECIFICATION OF DATA MANAGEMENT FACILITIES (STEP 2)

(1) Engineering Work Station		
(1.1) CPU		
1. Quantity	:	3
2. Technical Specifications		
- Type/Size	:	32 bit central processor, graphic co-processor, floating point math co-processor
- Capacity/Memory	:	5 MB
(1.2) CRT Graphic Display/Keyboard		
1. Quantity	:	3
2. Technical Specifications		
- Type/Size	:	19 inch diagonal, 16 kinds of color, ASCII character set, programmable blinking cursor/ mouse, graphic
- Resolution	:	24 lines x 80 characters/line, 1,000 x 800 pixels
- Keyboard	:	Typewriter key, numeric keypad, cursor control keys, special operation keys, PF keys
- Character Set	:	256 characters
(2) Data Storage Equipment		
(2.1) Hard Disk Drive		
1. Quantity	:	1
2. Technical Specifications		
- Type/Size	:	Winchester Type
- Format Capacity	:	100 MB

Table 4-9(2/3). SPECIFICATION OF DATA MANAGEMENT FACILITIES (STEP 2)

(2.2) Magnetic Tape Drive

1. Quantity : 1

2. Technical Specifications

- Type/Size : High speed, single density, inter block cap 0.60 inches
- Format Capacity : 100 MB
- Data Rate : 120 KB/sec (75 IPS read/write, 200 IPS rewind)
- Data Density : 1600 byte/inch, 9 track, ASCII format, ANSI

(3) Printer

1. Quantity : 1

2. Technical Specifications

- Type/Size : Line Printer, 132 charaters/line, or Laser Printer, 300 x 300 DPI, 64 character ASCII
- Capacity/Speed : 600 LPM (Line Per Minute) or 8 PPM
- Character Set : Full ASCII, standard
- Interface : Sentronics/RS232C
- Printing Method : Dot Matrix impact with high density
- Printing Speed : 180 cps or more
- Line Length : 132 char./line at 10 cpi
- Graphics : 90 x 90 dots/inch dot address able raster graphics
- Paper Width : 15 inches

(4) Video Projector

1. Quantity : 1

2. Technical Specifications

- Size : 100 inches
- Resolution : RGB input 100 lines, 25 lines x 80 characters/line

Table 4-9(3/3). SPECIFICATION OF DATA MANAGEMENT FACILITIES (STEP 2)

(5) Mimic Board		
1. Quantity	:	1
- Type	:	Self-standing with basin map and display panel
- Display	:	Present date and time, observation time, rainfall data, water level data
(6) Electronic Filing System		
1. Quantity	:	1 set
2. Technical Specifications		
- Type	:	16 bit CPU, 17-inch display keyboard, mouse, image scanner, optical disk, laser printer
- Disk Capacity	:	800 MB
- Resolution	:	Scanner: 400 picture element/inch Printer: 400 picture element/inch
- Print Speed	:	8 pages/min
(7) Video Tape Recorder		
(7.1) Portable Video Cassette Recorder		
1. Quantity	:	1
2. Technical Specifications:		Remote control, editing, picture search
(7.2) Portable Video Camera		
1. Quantity	:	1
2. Technical Specifications:		Zoom, 525 lines 50 fields 2:1 interlaced scanning, 500(H)x 582(V) picture elements

FIGURES

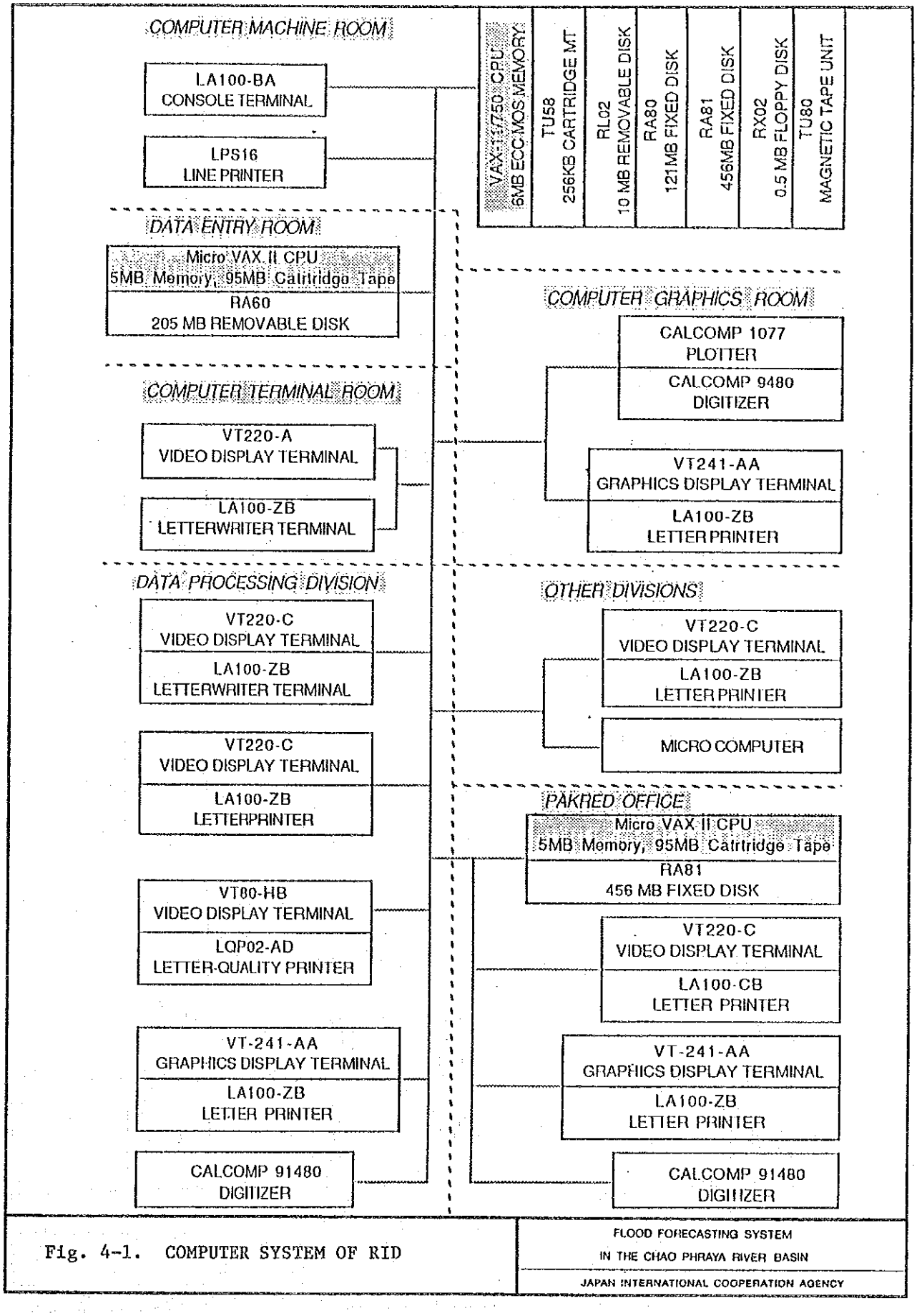


Fig. 4-1. COMPUTER SYSTEM OF RID

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

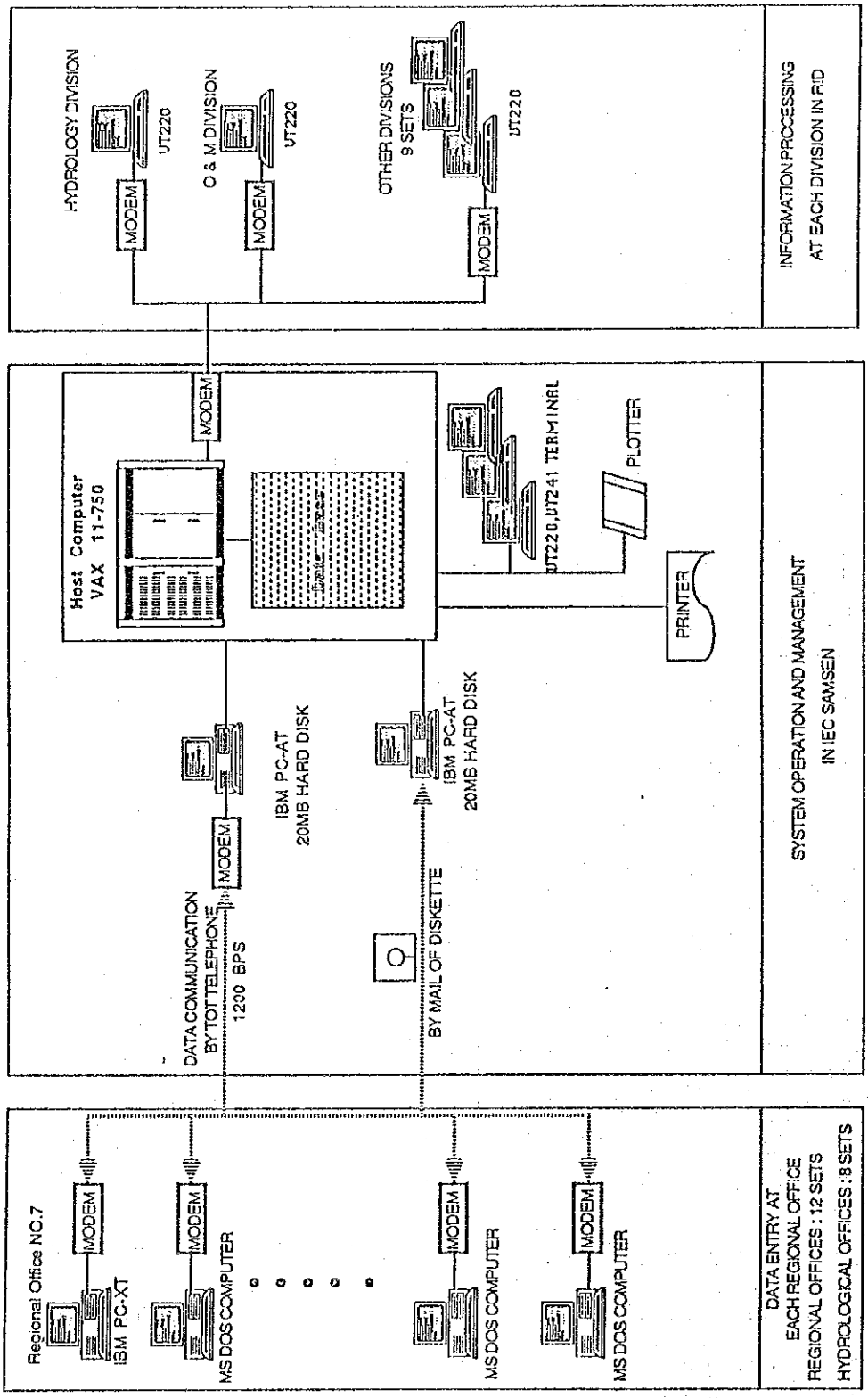


Fig. 4-2. COMPUTER NETWORK OF IEC

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

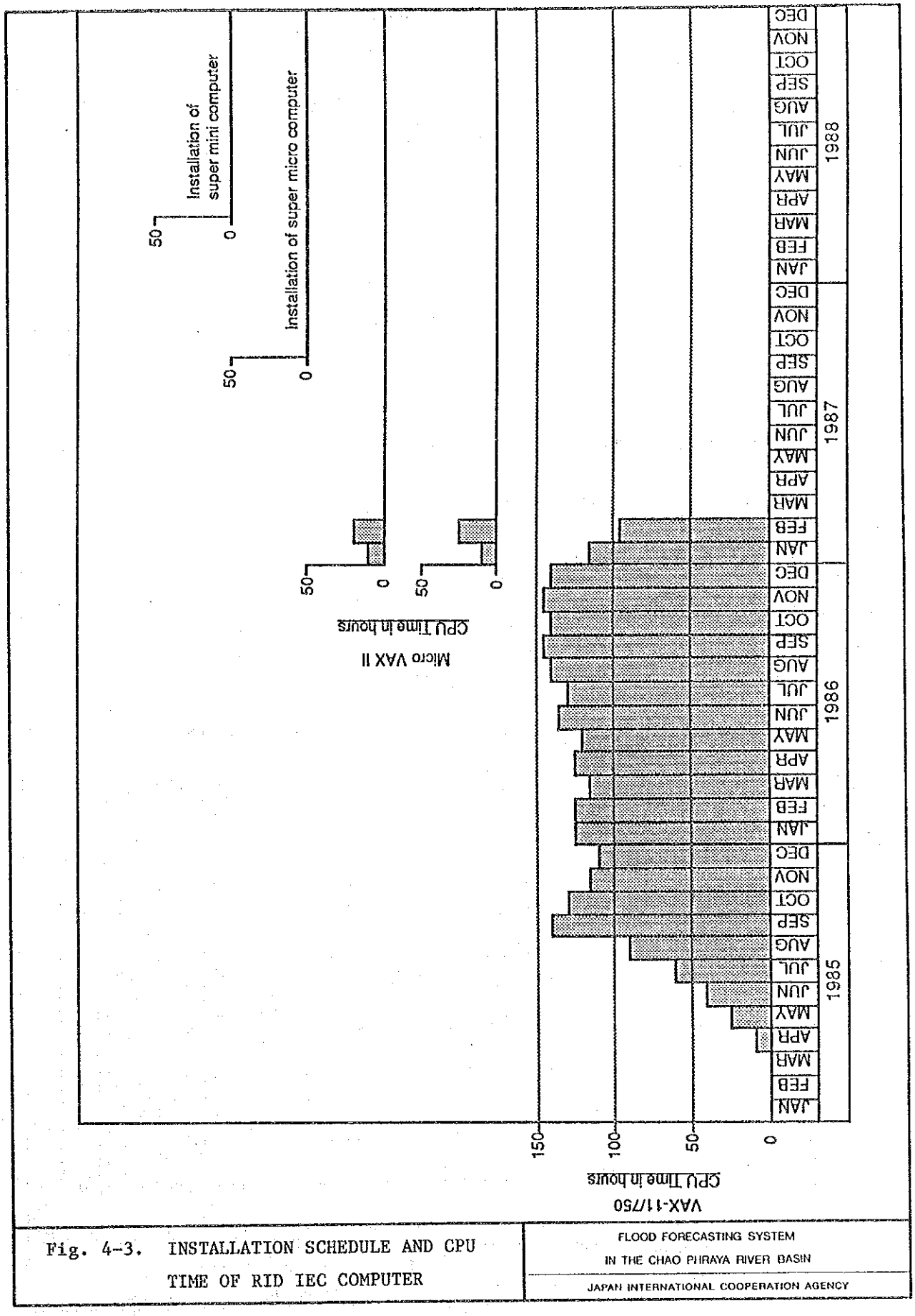


Fig. 4-3. INSTALLATION SCHEDULE AND CPU TIME OF RID IEC COMPUTER

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

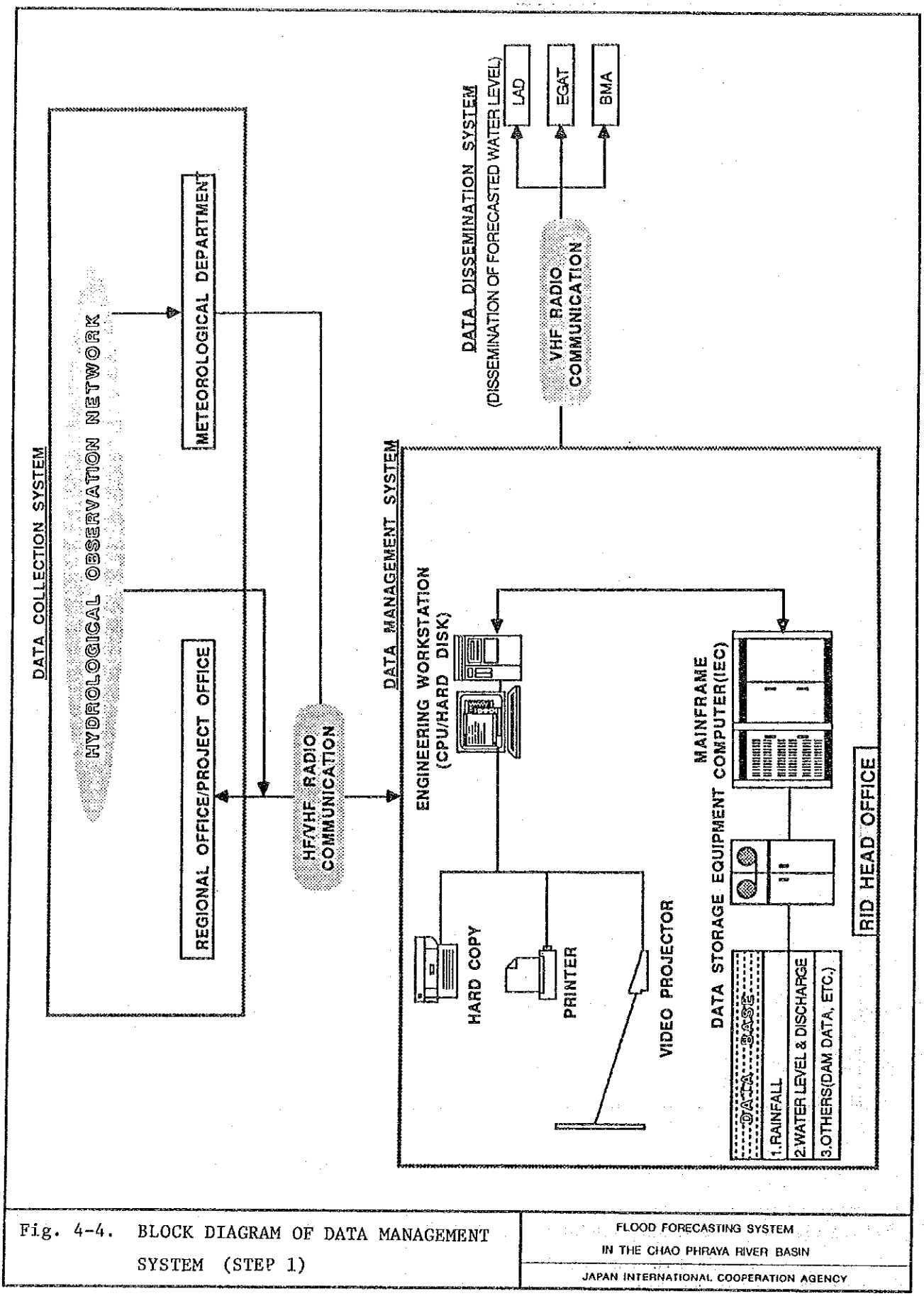


Fig. 4-4. BLOCK DIAGRAM OF DATA MANAGEMENT SYSTEM (STEP 1)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

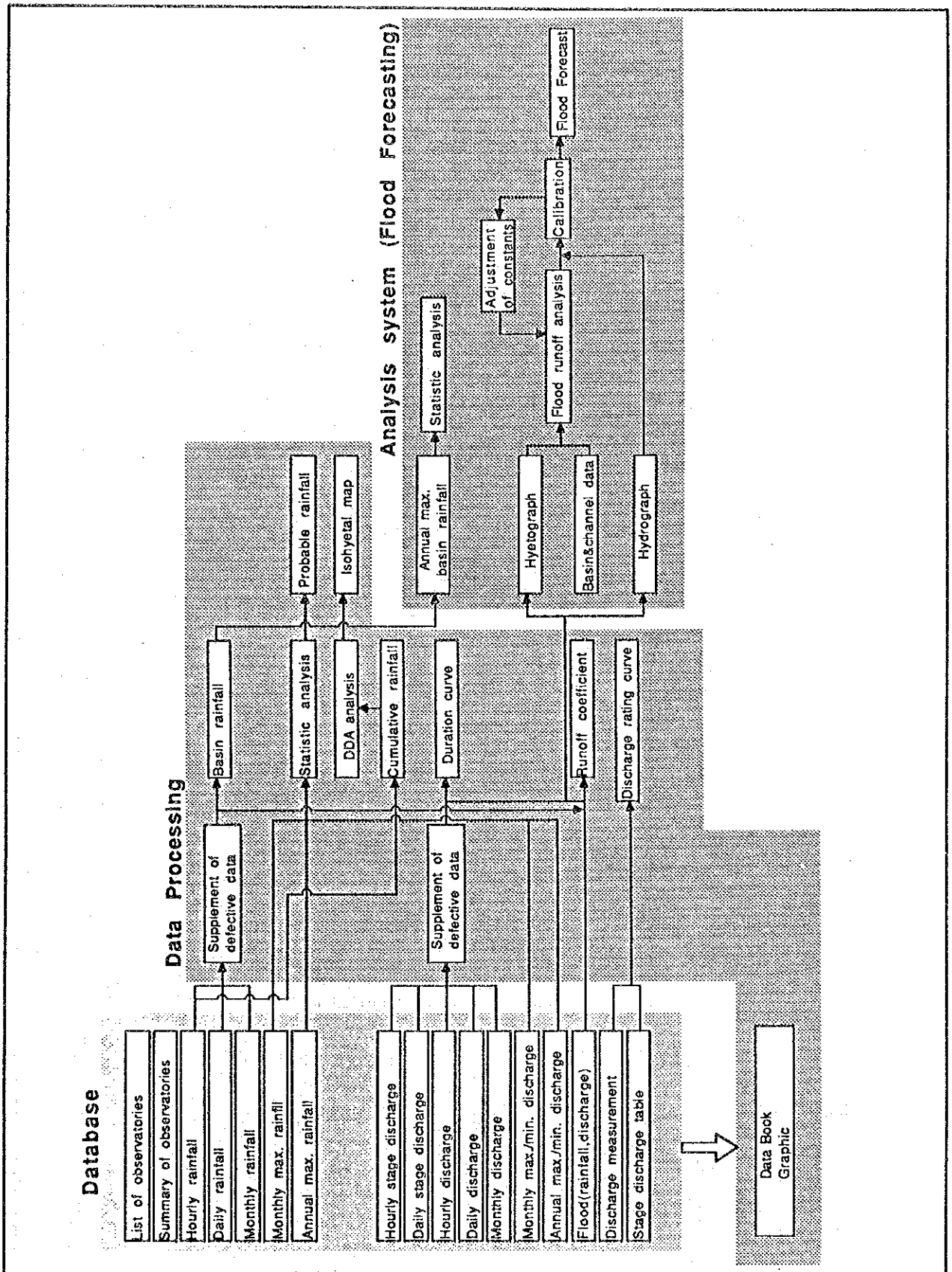


Fig. 4-5. HYDROLOGICAL ANALYSIS SYSTEM

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

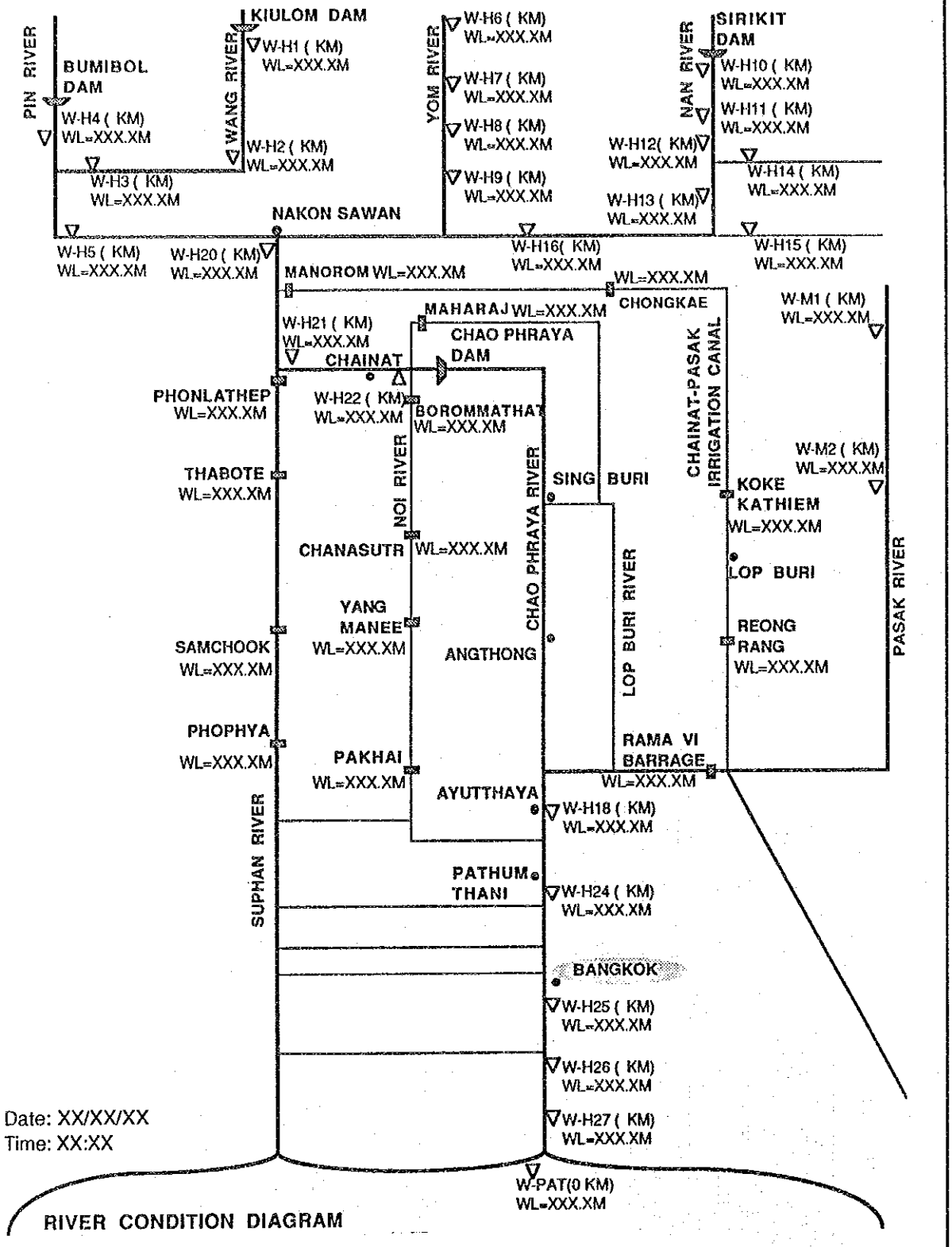


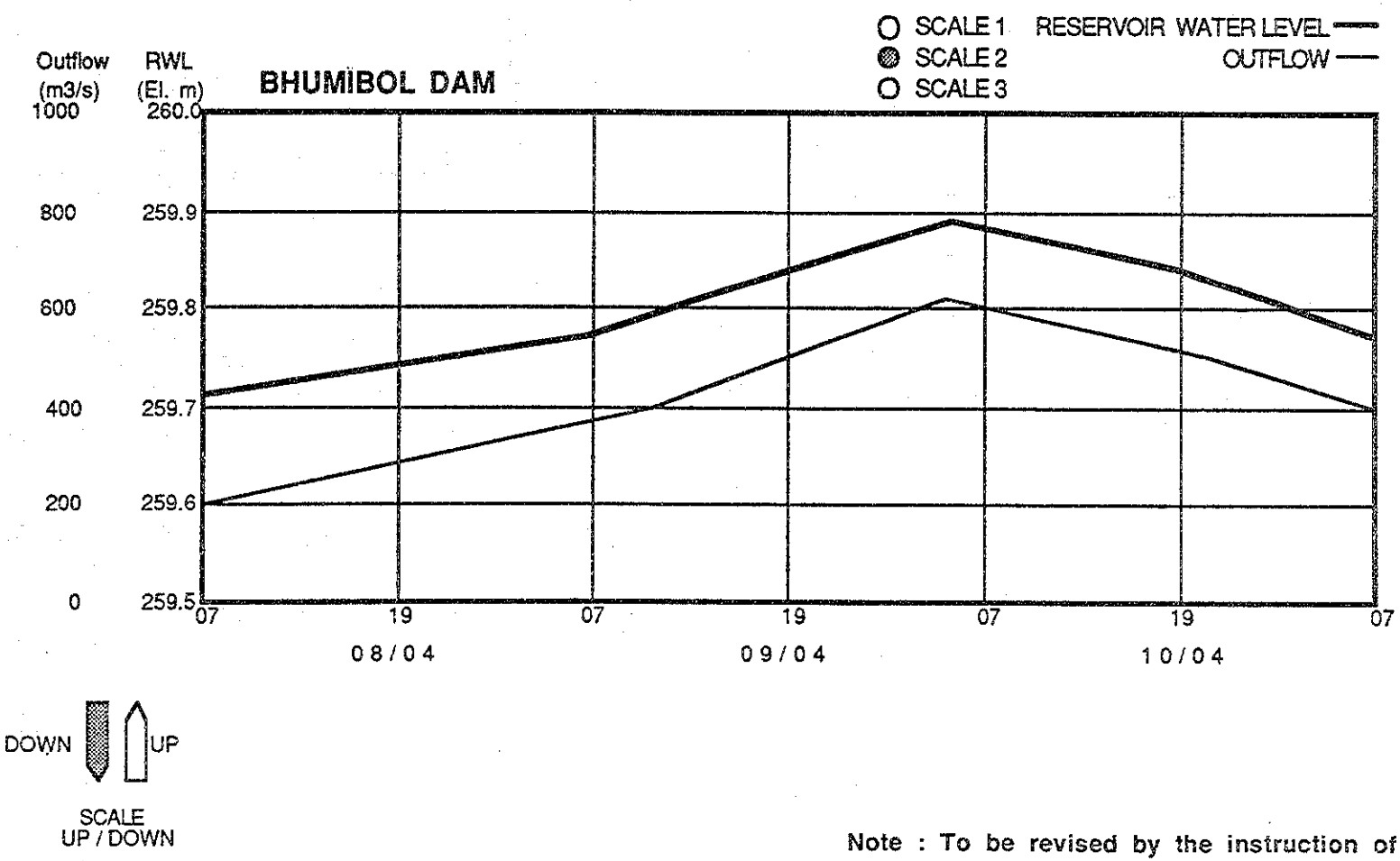
Fig. 4-6(1/3) EXAMPLE OF OUTPUT FORMAT

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 4-6(2/3) EXAMPLE OF OUTPUT FORMAT

HYDROGRAPH AT DAM OR RIVER

Date: XX/XX/XX Time: XX:XX



Note : To be revised by the instruction of RID

FLOOD FORECASTING SYSTEM IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

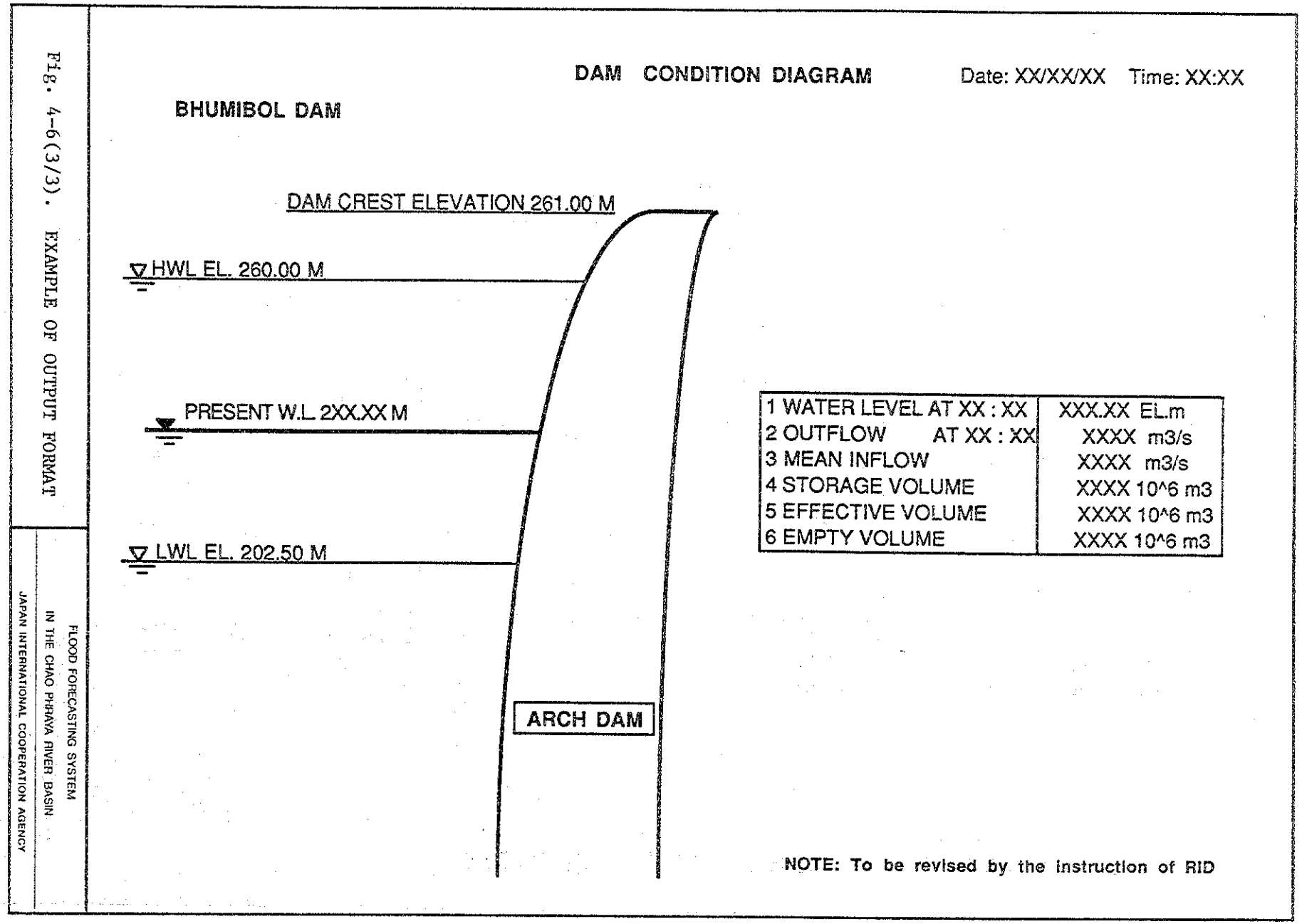


Fig. 4-6(3/3). EXAMPLE OF OUTPUT FORMAT

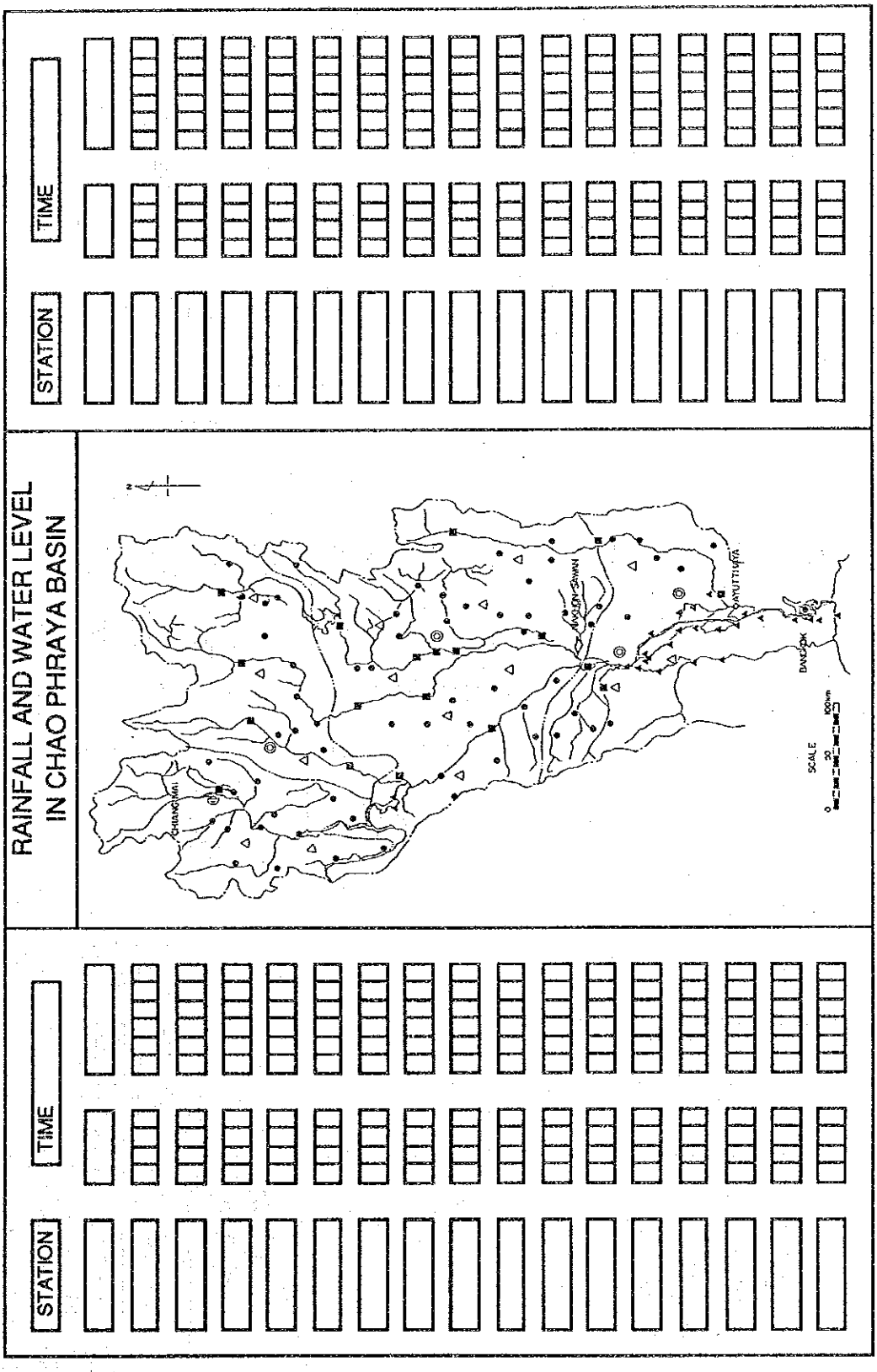


Fig. 4-7. EXAMPLE OF MIMIC BOARD

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

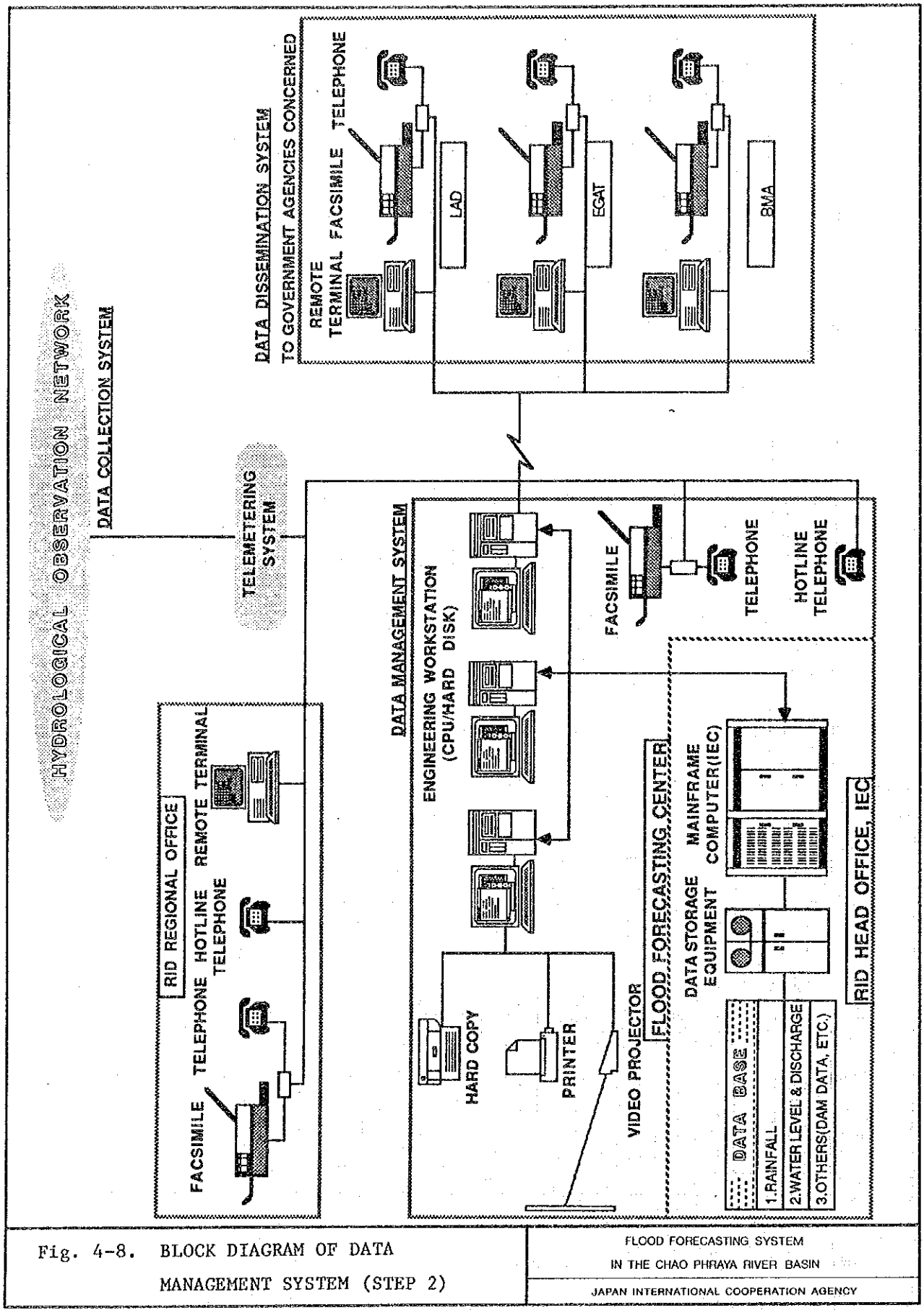


Fig. 4-8. BLOCK DIAGRAM OF DATA MANAGEMENT SYSTEM (STEP 2)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

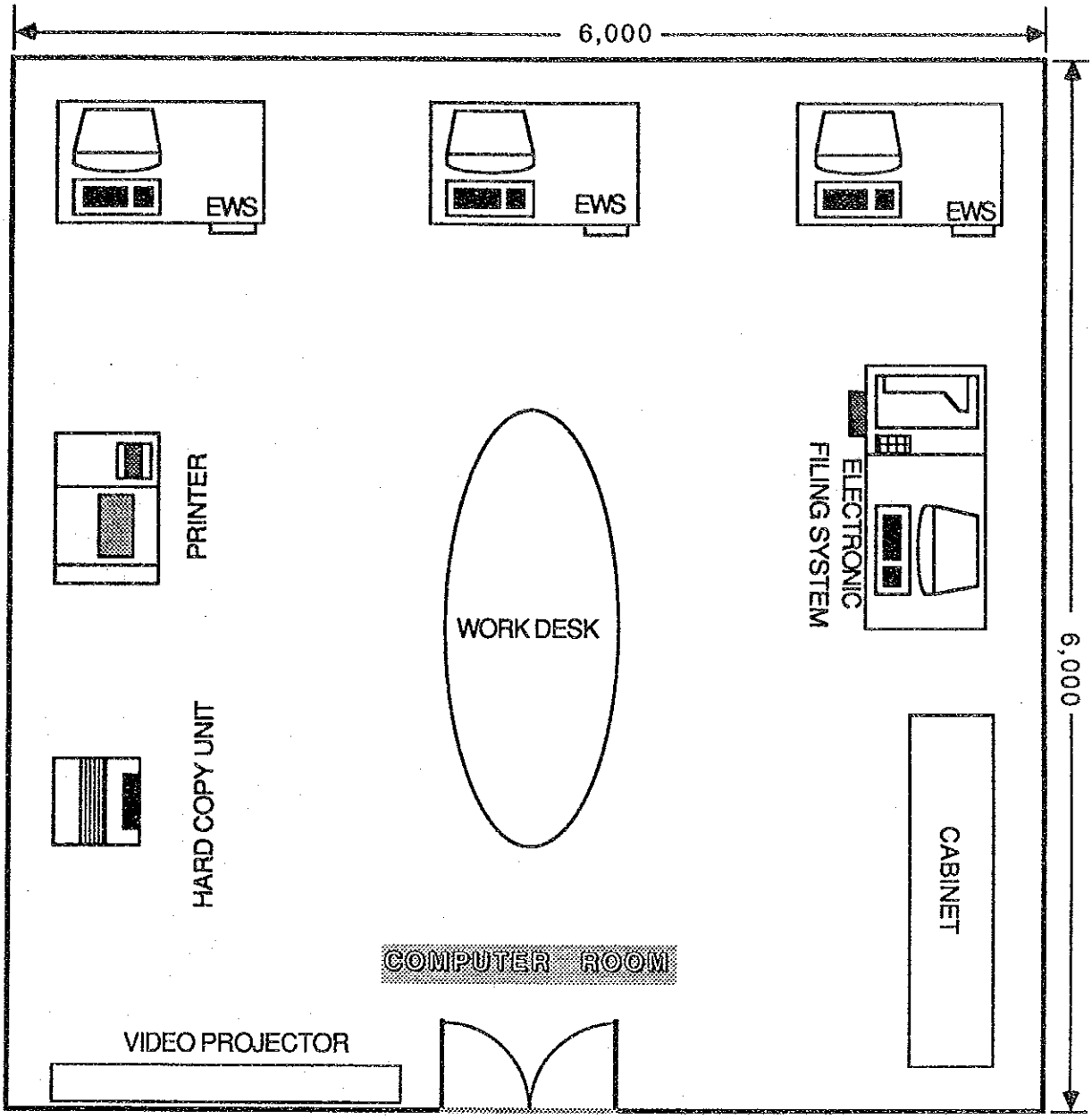


Fig. 4-9. LAYOUT OF DATA MANAGEMENT FACILITIES

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

5. IMPLEMENTATION SCHEDULE AND COST ESTIMATES

SUPPORTING REPORT
ON IMPLEMENTATION SCHEDULE
AND COST ESTIMATES

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5. SUPPORTING REPORT ON IMPLEMENTATION SCHEDULE AND COST ESTIMATES

1. General

This sector of the supporting report describes the implementation schedule and the cost estimates of the flood forecasting system in the Chao Phraya River Basin which will be implemented in two steps; namely, Step 1 and Step 2.

The implementation schedule was prepared taking into account such items as locally available materials, machinery and equipment, weather conditions and the capability of local contractors. The construction cost estimates were prepared on the basis of the preliminary design works, and the operation and maintenance costs were estimated on the basis of the administration cost such as personnel cost, cost of spare parts, etc.

2. Basic Conditions

The basic conditions for the study on implementation schedule and cost estimates are stated in the following descriptions.

Availability of Construction Materials and Equipment

According to the interview-survey, most of the construction materials for the facilities are locally available, while the necessary equipment has to be purchased mainly from foreign countries. In this connection, the study was made on the assumption that the equipment are imported.

Workable Days

In planning the schedule, 300 days are considered workable for indoor work. These are equivalent to approximately 80% of a year, with Sundays (52 days) and national holidays (14 days) excluded.

During the workable days, outdoor work such as construction of station housing, installation of tower and so on, can be done efficiently in the dry season from November to April, because it rains for less than 3 days a month in the Chao Phraya River Basin according to the meteorological data for 30 years. Working hours in a day are set at eight hours in accordance with the circumstances in this country.

Condition of Currency Exchange

The cost estimates were based on prices in December 1987, and the currency exchange rate was fixed at US$1.00 = 25.5 Baht = 130 Yen. The cost estimation was carried out on the assumption that the system will be executed on the contract basis.

Unit Cost of Equipment, Materials, Labor and Land Acquisition

For the estimation of construction cost, information on prices of equipment, materials, labor and land acquisition were collected from local government offices, suppliers, and others.

(1) Equipment

The unit costs of equipment and materials required for the facilities are shown in Table 5-1 to 5-2. The cost of imported equipment includes customs tax and fees.

(2) Labor Cost

Labor cost consists of wages and allowances. The labor costs as of 1985 gathered from the data of the Department of Labor are shown in Table 5-3.

In this study, the unit labor cost has been adjusted to that of 1987 by using the price escalation rate from 1985 to 1987.

(3) Land Acquisition Cost

Since the land acquisition cost for this flood forecasting system is negligible compared with the total cost of the project, it is excluded from the cost estimation.

3. Implementation Schedule and Cost Estimates for Step 1

3.1 Implementation Schedule for Step 1

The implementation schedule for the Step 1 Flood Forecasting System is divided into two phases, namely, establishment of the flood forecasting system and development of the system. These phases consist of the work items shown in Fig. 5-1.

Establishment of Flood Forecasting System

In the period for establishment of the flood forecasting system, the necessary facilities and equipment are provided together with the execution of civil works, so that the Step 1 system can be operational after completion. The establishment of the system covers the following works (Refer to Fig. 5-1):

(1) Construction of Telecommunication and Data Management Facilities

The main works for the telecommunication and data management facilities are construction of housing for 34 gauging stations, and installation of telecommunication equipment for 38 stations and data management facilities in the RID Head Office. During this establishment stage, the detailed design, pre-construction and construction/installation works are performed.

In the detailed design stage, the necessary time of 3.5 months will be spent mostly for site inspection, surveying and preparation of drawings for the gauging stations. The preparation of specifications for telecommunication and data management facilities, which

will be done simultaneously during the detailed design stage, can be performed within the 3.5 months period.

In the pre-construction stage, procurement of contractors and suppliers is performed. Judging from past experiences, the time necessary for this stage is 4 months, more or less.

In the construction and installation stage, the necessary time will be used mainly for the construction of housings for gauging stations. In this project, the necessary time for construction of housing is estimated at about 5 months. The installation of facilities can be performed within this period.

(2) Programming of Flood Prediction Model

The basic flood prediction model has been developed in this study, as mentioned in the hydrology sector. Computer programs to calculate flood predictions will be arranged according to the flood prediction model, and the necessary time for programming is expected to be half a year judging from the contents of programming.

(3) Preparation of O&M Manual

Although the Step 1 system is based on the existing facilities, an operation and maintenance (O&M) manual will be needed for the equipment supplementarily introduced and for the operation and maintenance of data management facilities. For the preparation of this manual, two (2) months may be required.

Development of the System

Although the Step 1 system is operational after establishment, it has to be developed to upgrade the accuracy of prediction results through the experience obtained from its operation in two flood seasons, at least. The development of the system, including training of the staff concerned, will require

thirty (30) months. This phase of development shall cover calibration and modification of flood prediction models, on-the-job training and overseas training.

The on-the-job training for the transfer of technical know-how on operation and maintenance will be carried out during the construction/installation of equipment.

3.2 Cost Estimates for Step 1

The total construction cost of the Step 1 system comprises cost for purchase of equipment, costs for construction/installation and adjustment, engineering services and training costs, plus 10% physical contingency.

The total cost of the proposed system is estimated at Two Million Seven Hundred Eighty-Six Thousand U.S. Dollars (US$2,786,000), which is composed of the costs of system establishment and system development amounting to US$1,731,000 and US$1,055,000, respectively (refer to Table 5-4). The breakdown of cost for Step 1 is shown in Table 5-5.

4. Implementation Schedule and Cost Estimates for Step 2

4.1 Implementation Schedule for Step 2

Since the Step 2 Flood Forecasting System consists of a number of work items as presented in Table 5-6, it is practically infeasible to complete all the works in a short period of time. Thus, stagewise construction is considered to promptly realize the flood forecasting system within a certain extent and expect the effects of flood forecasting covering the whole basin.

In connection with the above, the stagewise development of the hydrological gauging network is proposed on the basis of priority of the target area as shown in Table 5-7. Since the hydrological gauging stations are essential to decide the work volume of system construction, the implementation schedule has been considered according to the development of the hydrological gauging stations.

The implementation schedule for the construction of gauging stations has been set up in five (5) phases, excluding the preparation and pre-construction stage. (Refer to Fig. 5-2.)

Integrated Study

In parallel with this study on flood forecasting system, the study on water management system in the Chao Phraya River Basin is presently going on. The water management system will have facilities such as hydrological gauging stations and telecommunication system which can be used commonly with the flood forecasting system.

The water management system study is expected to be completed within 1.5 years after completion of this study on flood forecasting system. Therefore, an integrated study has to be undertaken to adjust the necessary facilities to be commonly used, including the preparation of construction cost estimates. The integrated study will require 1.5 years, at least.

Acquisition of Necessary Funds

After the completion of the integrated study, the flood forecasting system project can proceed to the stage for the acquisition of funds. Based on past experiences, 1.5 years may be necessary for the acquisition of the necessary funds.

Procurement of Consultant

Regarding the procurement of consultant, 0.5 year is assumed for the period of advertisement, evaluation, selection, etc.

Detailed Design

The detailed design works covering the whole construction works include those for civil works consisting of station housings, tower, FFC, etc., and also those for the establishment of the telecommunication system, the data management system and the data dissemination system. Tender documents are also prepared during this stage. The necessary period for the detailed design phase is two (2) years.

Pre-Construction

During this stage, the appropriate contractor is selected through pre-qualification, tender calling and evaluation.

Construction

The construction of the system is to be executed in five phases, as mentioned before. The required period for each phase has been estimated, as described hereunder.

Judging from the workable days and work volume, the period for civil works is expected to be completed within 8 months and the manufacture of equipment can be finished within the period for civil works. Another 4 months is required for installation and adjustment.

Correspondingly, the required period for each phase of work is one (1) year, and five (5) years are scheduled for the construction of all the five phases. The construction schedule for each phase is shown in Fig. 5-3.

4.2 Cost Estimates for Step 2

Construction Cost

The total construction cost of the Step 2 system comprises cost for the purchase of equipment, construction/installation and adjustment cost, and engineering services cost, plus 10% physical contingency.

The total cost of the proposed system is estimated at US$55,947,500 (Refer to Table 5-8). In case of stagewise implementation, the cost for each phase is summarized as follows (refer to Table 5-9):

Detailed Design Work	:	US$ 3,882,800
Phase 1 Construction Works	:	US$11,582,000
Phase 2 Construction Works	:	US$ 5,249,500
Phase 3 Construction Works	:	US$ 5,212,400
Phase 4 Construction Works	:	US$ 5,222,500
Phase 5 Construction Works	:	US$24,798,300

The breakdown of cost of facilities for Step 2 is shown in Table 5-10. The breakdown of cost of engineering services is shown in Table 5-11.

Operation and Maintenance Cost

The operation and maintenance costs consist of the rental fee for the TOT line, personnel costs, costs for spare parts and consummables, and other miscellaneous expenses. As shown in Table 5-12, the annual maintenance and administration cost after completion of the system is estimated at US$1,688,600. The rental fee for the TOT line has been calculated on the basis of the tariff table for an exclusive line, as shown in Table 5-13.

Personnel cost for operation has been estimated on the basis of the proposed staff of the integrated organization for flood forecasting and the personnel cost of RID.

TABLES

Table 5-1. UNIT COST OF MAIN MATERIALS

Item	Unit	Baht
Compaction Soil	m^3	50
Crushed Stone	m^3	160
Sand	m^3	160
Rough Concrete	m^3	1,200
Reinforced Concrete	m^3	3,200
Rain Protection Concrete Block	m^3	115
Full Masonry with Smooth Plaster	m^3	320
Half Masonry with Smooth Plaster	m^3	145
Aluminum Wire Gauge	m^3	105
Reinforced Concrete Pipe	m^3	1,050
Iron Pipe (1" dia.)	m	210
Iron Pipe (4" dia.)	m	1,000
Pole (4" dia.)	m	40
Pole (5" dia.)	m	50
Pole (6" dia.)	m	60
Mosaic Woodwork	m^2	1,320
Painting	m^2	35

Table 5-2. UNIT COST OF MAIN EQUIPMENT

	Cost Item	Unit Cost (US$)
Telemetering Equipment	Rainfall Gauge	7,900
	Water Level Gauge	10,500
	Telemetering Equipment (1 data)	11,500
	Repeater Equipment	27,700
	Telemetering Supervisory Equipment	65,400
	Supervisory Panel	33,600
	Typewriter	6,900
	Radio Equipment (10 W)	5,000
	Antenna with Feeder (3 element YAGI)	1,200
	Antenna with Feeder (3 stage colinear)	2,900
	Solar Cell (8.5 W)	3,900
Radar Equipment	Antenna with Controller and Dehydrator	510,900
	Radome	210,000
	Transmitter/Receiver	340,000
	Signal Processor	540,000
	Radar Operational Supervisory/Control Equipment	338,500
	Communication Control Unit	606,900
	PPI Monitor	180,000
	Radar Supervisory/Control Equipment	161,500
	Bright PPI Display	136,500
	Data Conversion Processor	582,000
Telecommunication Equipment	Multiplex Radio Equipment (Sub-station)	62,000
	Multiplex Terminal Equipment (Substation) with Telephone Repeater	24,100
	Antenna with Feeders (Substation)	15,200
	Radio equipment (FFC)	72,400
	Terminal equipment (FFC)	44,400
	Radio equipment (Related Agencies)	69,800
	Terminal equipment (Related Agencies)	25,400
Data Management Equipment	Engineering Work Station	92,400
	Data Storage Equipment	
	- Magnetic Tape Unit	23,100
	- Hard Disk Unit	15,400
	Printer	30,800
	Color Hard Copy Unit	15,400
	Video Projector	34,100
	Mimic Board	384,600
	Electric Filing System	77,000
	Video Tape Recorder	38,500
	Operating System	3,000
	Application Software	384,600
	Remote Terminal Display	15,400
	Facsimile/Telephone	4,600

Table 5-3. LABOR WAGE FOR CONSTRUCTION WORKS

Category	Wage (Baht)	With Overhead (Baht)
Daily-Waged Labor	96.76	117.22
Monthly-Paid Labor	4,365.78	5,880.12
Piecework	1,934.23	1,938.39

Source: Department of Labor, Ministry of Interior, 1985

Table 5-4. TOTAL COST OF PROPOSED SYSTEM (STEP 1)

Item	Cost
Establishment of the System	
(1) Telecommunications (Refer to Tables 6-14 and 6-15)	US$ 960,360
(2) Data Management	203,120
(3) Engineering Services	179,300
- Foreign Engineers (4 M/M) - Local Engineers (19 M/M)	
(4) Programming of Flood Prediction Model Including Preparation of O&M Manual	231,000
Sub-Total	US$1,573,780
(5) Contingency	157,220
Total	US$1,731,000
Development of the System	
(1) Calibration/Modification of the Flood Prediction Model	US$ 805,200
- Foreign Engineers (24 M/M) - Local Engineer (12 M/M)	
(2) Training	154,000
- On-the-Job Training - Overseas Training	
Sub Total	US$ 959,200
(3) Contingency	95,800
Total	US$1,055,000
Grand Total	US$2,786,000

Table 5-5(1/4). BREAKDOWN OF CONSTRUCTION COST (STEP 1)

Cost Item	Quantity	Unit Cost (US$)	Amount (US$)
Telecommunication Facilities /1			
HF Radio Station			
With Housing	30	26,020	780,600
VHF Radio Station			
With Housing	4	24,540	98,160
Without Housing	4	20,400	81,600
Total			960,360

Table 5-5(2/4). BREAKDOWN OF CONSTRUCTION COST (STEP 1)

Cost Item	Unit Cost (US$)
HF Radio Station	
Equipment	
HF Radio Equipment (3-15 MHz; 100W)	2,340
Antenna, Mast and Materials	7,400
Engine Generator	3,200
Spare Parts and Accessories	240
Installation and Adjustment of Equipment	4,300
Miscellaneous Cost	4,380
Sub-Total	21,860
Station Housing	
Material and Installation	3,440
Miscellaneous Cost	720
Sub-Total	4,160
Grand Total	26,020

Table 5-5(3/4). BREAKDOWN OF CONSTRUCTION COST (STEP 1)

Cost Item	Unit Cost (US$)
VHF Radio Station	
Equipment	
VHF Radio Equipment (150 MHz; 10W)	2,900
Antenna, Mast and Materials	7,500
AC Power Supply Unit	700
Engine Generator	1,200
Spare Parts and Accessories	400
Installation and Adjustment of Equipment	4,300
Miscellaneous Cost	3,400
Sub-Total	20,400
Station Housing	
Material and Installation	3,440
Miscellaneous Cost	700
Sub-Total	4,140
Grand Total	24,540

Table 5-5(4/4). BREAKDOWN OF CONSTRUCTION COST (STEP 1)

Cost Item	Quantity	Unit Cost (US$)
Data Management Facilities		
Equipment		
Mini-Computer with CRT Display	1 set	49,170
Hard Disk Drive	1 set	24,640
Magnetic Tape Drive	1 set	12,320
Line Printer	1 set	49,170
Operating System	1 set	12,320
Video Projector	1 set	36,950
CVCF	1 set	12,320
Spare Parts and Accessories	1 set	5,500
Sub-Total		202,390
Installation and Adjustment of Equipment	L.S.	250
Miscellaneous Cost	L.S.	230
Total		202,870

Table 5-6. WORK ITEMS OF CONSTRUCTION (STEP 2)

Work Item	Number of Station
Telecommunication Facility	
A. Trunk Line	
1. Approach Line	
FFC	1
Substation	5
TOT Terminal Station	6
B. Branch Line	
1. Branch Line for Telemetering	
Rainfall Gauging Station	65
Waterlevel Gauging Station	26
Rainfall and Waterlevel Gauging Station	19
Radar Raingauge Station	2
Repeater Station (VHF)	15
Repeater Station (UHF)	2
Substation	5
FFC	1
2. Branch Line for Dissemination	
FFC	1
Related Agencies	3
Data Management and Data Dissemination Facility	
A. Facility for Data Management	
FFC	1
B. Facility for Data Dissemination	
FFC	1
Substation	5
Related Agencies	3

Table 5-7. STAGEWISE CONSTRUCTION OF FLOOD FORECASTING SYSTEM (STEP 2)

Phase	Target Area To Be Included	Coverage of Gauging Network	Gauging Facility	Communication Line
Phase 1	Bangkok	Chao Phraya River Lower Reaches from Bang Sai (C29)	Telemetering System for Bangkok Area	To Related Agencies
	Bangkok Ayutthaya	Chao Phraya River Lower Reaches from Nakhon Sawan (C2)	Telemetering System for Region 8 (Pasak River)	To Region 8
		Pasak River Lower Reaches from Wichian Buri	Telemetering System for Region 7	To Region 7
Phase 2	All Target Areas Except Nakhon Sawan	Sakae Krang River; Ping River Lower Reaches from P7A; Yom River Lower Reaches from Y14; Nan River Lower Reaches from N5A	Telemetering System for Region 3 and Remaining Area in Region 8	To Region 3
Phase 3	All Target Areas	Whole Chao Phraya River Basin, except Catchment Areas of Bhumibol and Sirikit Dams	Telemetering System for Remaining Area in Region 3; Telemetering System for Region 2	To Region 2
Phase 4	All Target Areas	Whole Chao Phraya River Basin	Telemetering System for Region 1	To Region 1
Phase 5	All Target Areas	Whole Chao Phraya River Basin	Radar Raingauge System for Middle Reaches and Lower Reaches	To Radar Site

Table 5-8. TOTAL COST OF THE PROPOSED SYSTEM (STEP 2)

Cost Item	Amount (US$)
1. Telecommunication Facilities	
Gauging Station	16,954,700
Substation	4,544,600
TOT Terminal Station	813,000
Flood Forecasting Center	5,291,700
Related Agencies	330,000
Sub-Total	27,934,000
2. Data Management and Dissemination Facilities	
Substation	101,000
Flood Forecasting Center	1,034,800
Related Agencies	123,900
Sub-Total	1,259,700
3. Engineering Services	
Detailed Design	3,134,800
Construction Supervision	5,634,500
Development of the System	1,422,000
Sub-Total	10,191,300
4. Training	600,000
Total of 1 to 4	39,985,000
5. Physical Contingency	3,998,500
Total of 1 to 5	43,983,500
6. Price Contingency	11,964,000
Grand Total	55,947,500

Table 5-9. COST BREAKDOWN FOR EACH PHASE OF WORK

(Unit: US$)

Work Item	Total	Detailed Design	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
1. Telecommunication Facilities							
Gauging Station	16,954,700	-	2,495,600	1,693,400	1,553,500	1,451,600	9,760,600
Substation	4,544,600	-	1,136,700	511,700	511,700	511,700	1,872,800
TOT Terminal Station	813,000	-	406,500	135,500	135,500	135,500	-
Flood Forecasting Center	5,291,700	-	1,682,700	-	-	-	3,609,000
Related Agencies	330,000	-	330,000	-	-	-	-
Sub-Total	27,934,000	-	6,051,500	2,340,600	2,200,700	2,098,800	15,242,400
2. Data Management and Dissemination Facilities							
Substation	101,000	-	77,000	8,000	8,000	8,000	-
Flood Forecasting Center	1,034,800	-	1,034,800	-	-	-	-
Related Agencies	123,900	-	123,900	-	-	-	-
Sub-Total	1,259,700	-	1,235,700	8,000	8,000	8,000	-
3. Engineering Services							
Detailed Design	3,134,800	3,134,800	-	-	-	-	-
Construction Supervision	5,634,500	-	1,126,900	1,126,900	1,126,900	1,126,900	1,126,900
Development of the System	1,422,000	-	284,400	284,400	284,400	284,400	284,400
Sub-Total	10,191,300	3,134,800	1,411,300	1,411,300	1,411,300	1,411,300	1,411,300
4. Training	600,000	-	120,000	120,000	120,000	120,000	120,000
Total of 1 to 4	39,985,000	3,134,800	8,818,500	3,879,900	3,740,000	3,638,100	16,773,700
5. Physical Contingency	3,998,500	313,500	881,800	388,000	374,000	363,800	1,677,400
Total of 1 to 5	43,983,500	3,448,300	9,700,300	4,267,900	4,114,000	4,001,900	18,451,100
6. Price Contingency	11,964,000	434,500	1,881,700	981,600	1,098,400	1,220,600	6,347,200
Grand Total	55,947,500	3,882,800	11,582,000	5,249,500	5,212,400	5,222,500	24,798,300

Table 5-10. BREAKDOWN OF CONSTRUCTION COST (STEP 2)

Unit: US$

No.	Cost Item	Q'ty	Unit Price	Amount
Telecommunication Facility				
1.	Hydrological Gauging Station			
	(a) Rainfall Gauging Station	65	49,000	3,185,000
	(b) Water Level Gauging Station	26	63,200	1,643,200
	(c) R/W Station	19	78,900	1,499,100
	(d) Radar Raingauge Station	2	4,289,300	8,578,600
	(e) Repeater Station (VHF)	15	78,800	1,182,000
	(f) Repeater Station (UHF)	2	433,400	866,800
2.	Substation	5	LS	4,544,600
3.	TOT Repeater Station	6	135,500	813,000
4.	FFC	1	LS	5,291,700
5.	Related Agencies	3	110,000	330,000
	Total			27,934,000
Data Management Facility				
1.	Substation (Regional Office 7, 8)	2	38,500	77,000
	(Regional Office 1, 2, 3)	3	8,000	24,000
2.	FFC	1	LS	1,034,800
3.	Related Agencies	3	LS	123,900
	Total			1,259,700

Table 5-11. BREAKDOWN OF ENGINEERING SERVICES AND TRAINING COST (STEP 2)

Cost Item	Amount(US$)
1. Detailed Design	3,184,800
(1) Implementation Management	489,200
Civil Engineer : 24 M/M	
(2) Survey of Civil Works	220,100
Civil Engineer : 6 M/M	
Local Engineer : 12 M/M	
(3) Telecommunication Survey and Radio Wave Propagation Test	730,000
Telecom. Engineer: 18 M/M	
Local Engineer : 36 M/M	
(4) Analysis and Support for Contract Project	730,000
Civil Engineer : 6 M/M	
Telecom Engineer : 6 M/M	
Computer Engineer: 6 M/M	
Local Engineer : 36 M/M	
(5) Modification of Flood Prediction Model for online Data	432,300
Civil Engineer : 6 M/M	
Computer Engineer: 6 M/M	
Local Engineer : 18 M/M	
(6) Data Management/Dissemination Program for Newly Addapted Data	583,200
Computer Engineer: 12 M/M	
Local Engineer : 36 M/M	
2. Engineering Services of each Phase	1,126,900
(1) Construction Supervision Except for Installation of Equipment	1,089,500
Civil Engineer : 18 M/M	
Telecom. Engineer: 12 M/M	
Tower Constructor: 10 M/M	
Computer Engieer : 6 M/M	
(2) Factory Inspection	37,400
Telecom. Engineer: 1 M/M	
Computer Engieer : 1 M/M	
3. Development of the System in Each Phase Calibration/Modification of Flood Prediction Model	284,400
Foreign Engineer : 12 M/M	
Local Engineer : 12 M/M	
4. Training	1,200,000
On-the-job Training	
Foreign Engineer : 30 M/M	
Overseas Training	
Foreign Engineer : 30 M/M	

Table 5-12. BREAKDOWN OF ANNUAL OPERATION AND MAINTENANCE COST (STEP 2)

Cost Item	Amount (US$)
1. Rental Fee for TOT Line /1	
Line Charge	42,500
Power Charge	3,800
Sub-Total	46,300
2. Operation	
Personnel	180,000
Consumables /2	25,300
Power Charge	500,000
Miscellaneous	200,000
Sub-Total	905,300
3. Maintenance	
Materials, Spare Parts and Unit /3	
- Telecommunication	558,700
- Data Management	25,300
Vehicles	153,000
Sub-Total	737,000
Grand Total	1,688,600

/1 Refer to Table 5-13.

/2 Cost for consumables is assumed to be 2% of data management facility cost.

/3 Cost for maintenance is assumed at 2% of equipment cost.

Table 5-13. RENTAL FEE FOR TOT LINE

Section	Distance (km)	Channel (Nos.)	Rental Charge /1 (B/Year)
Bangkok-R1	582	2	197,800
Bangkok-R2	513	2	174,420
Bangkok-R3	338	4	229,840
Bangkok-R7	163	3	83,130
Bangkok-R8	115	5	97,750
Total			783,000

Note: /1 Unit rental cost is 170 baht/channel/year.

In addition to the above rental charge for the TOT line, RID has to pay for space charge of 300,000 baht/year and power charge of 98,000 baht/year, resulting in a total charge of 1,181,000 baht (US$46,300).

FIGURES

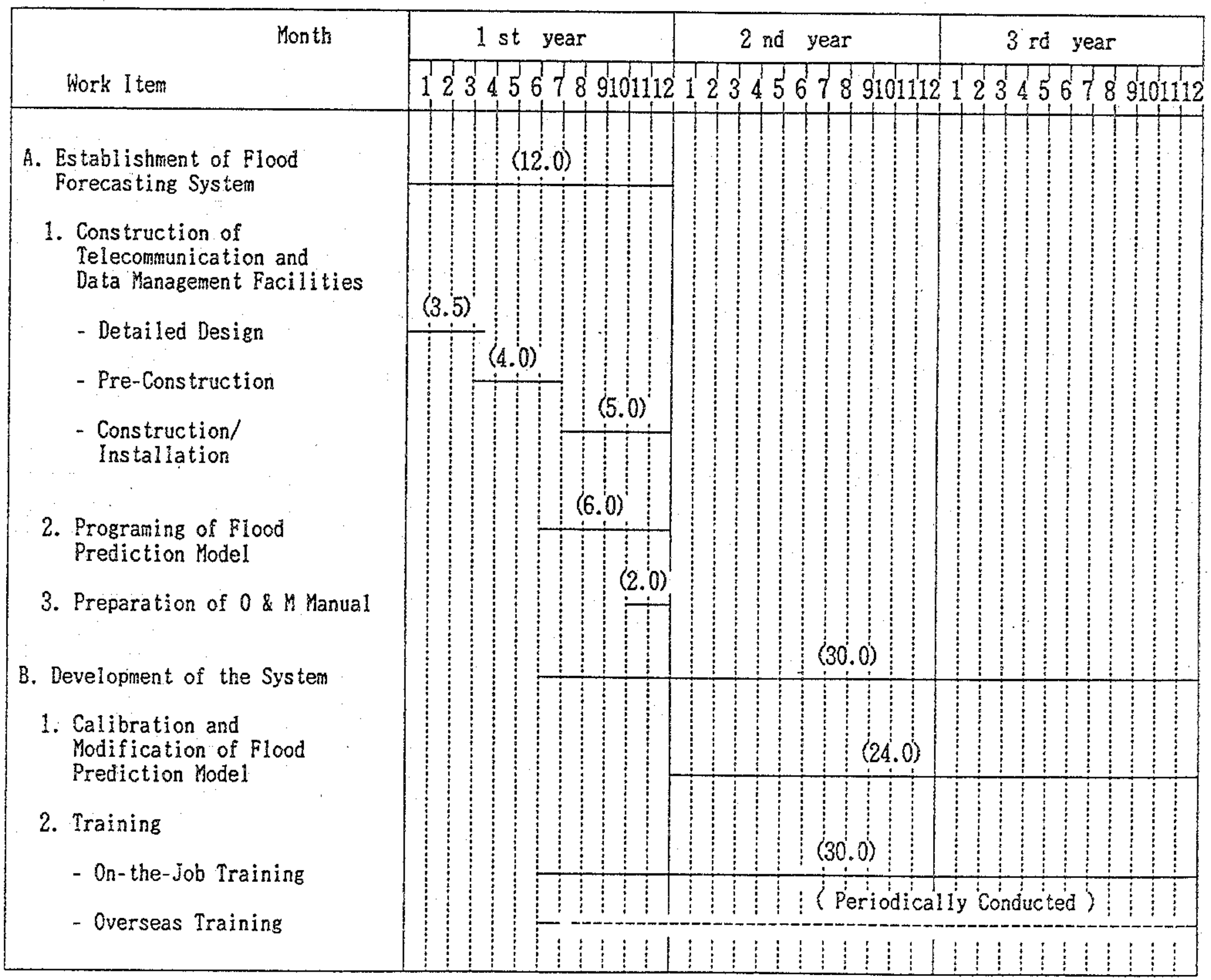

Fig. 5-1. IMPLEMENTATION SCHEDULE (STEP 1)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

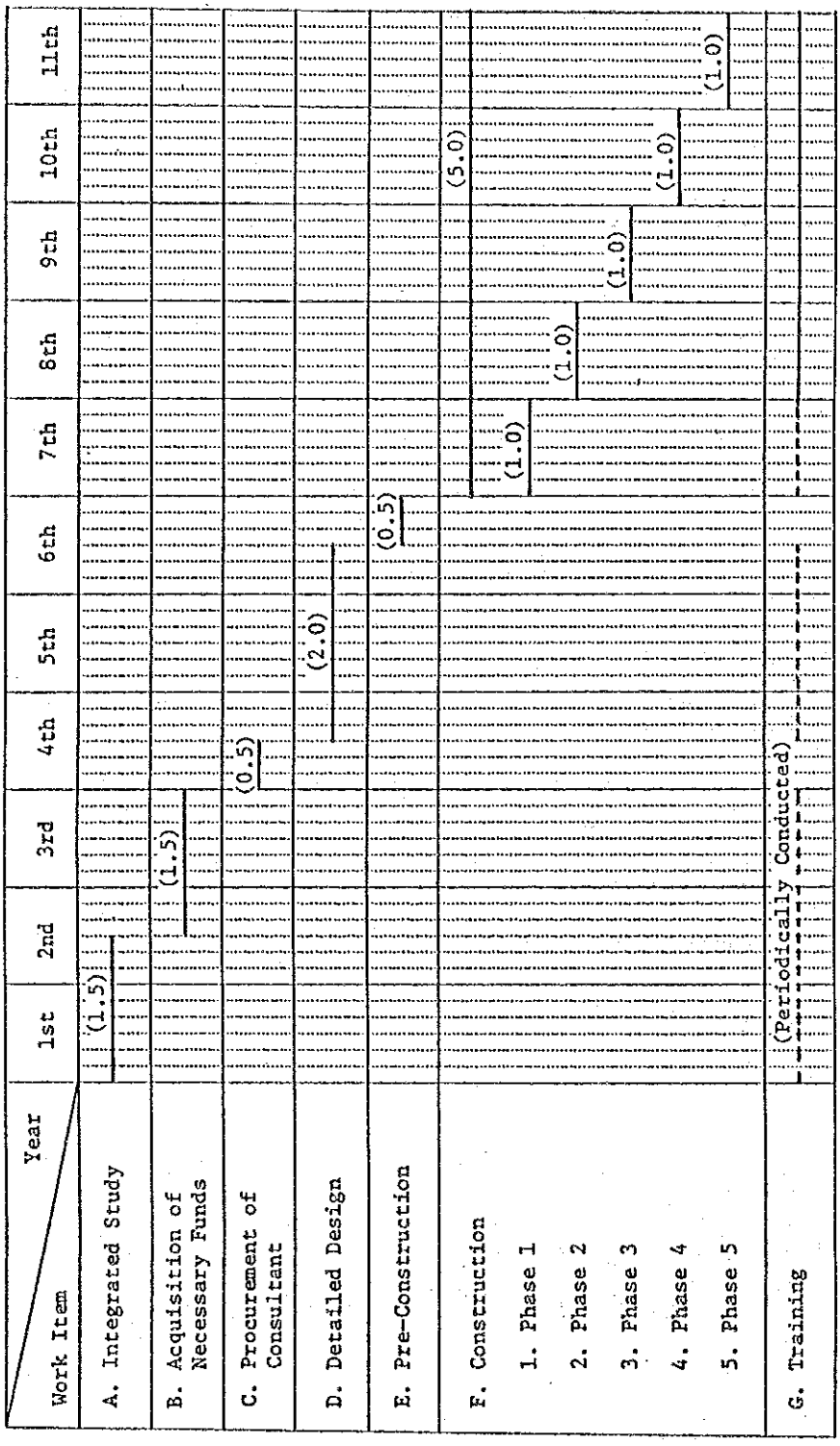

Fig. 5-2. IMPLEMENTATION SCHEDULE (STEP 2)

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

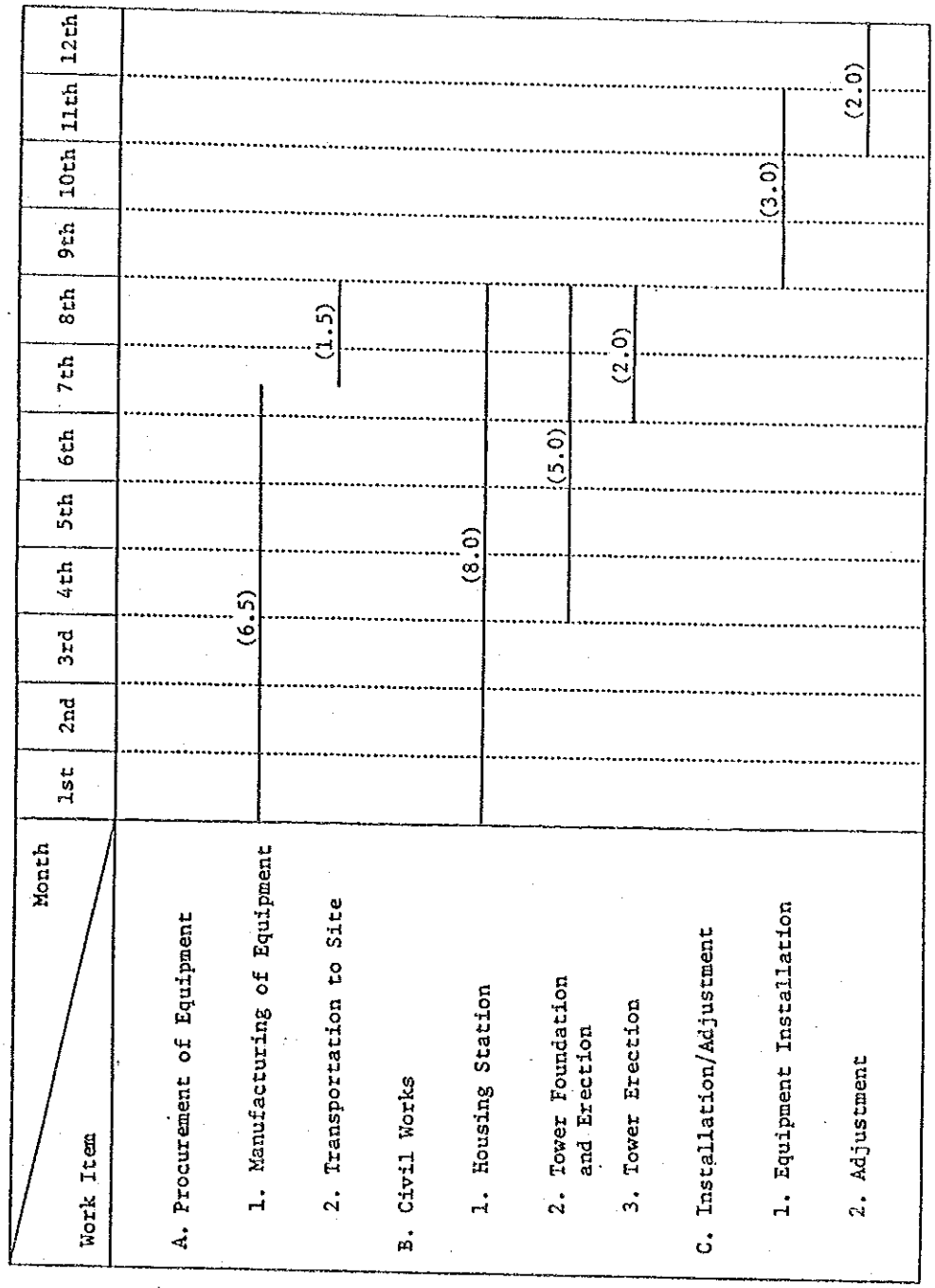

Fig. 5-3. CONSTRUCTION SCHEDULE FOR EACH PHASE OF WORK

FLOOD FORECASTING SYSTEM
IN THE CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

6. SOCIO—ECONOMY

SUPPORTING REPORT
ON
SOCIO-ECONOMY

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6. SUPPORTING REPORT ON SOCIO-ECONOMY

1. National Development Policy

1.1 Results of Past Development Plans

Since 1961, the Kingdom of Thailand has been achieving a notable development in its national economy and in the living standard of its people under the five economic and social development plans for the past 25 years. The Gross National Product (GNP) increased 18 times from 58,900 million baht in 1961 to 1,047,500 million baht in 1985, while the per capita income rose almost 10 times from 2,150 baht in 1961 to 20,420 baht in 1985. In the field of social development, the level of public services has risen; especially, a remarkable improvement has been achieved in both the fields of education and health which are basic services for the improvement in the quality of life of the Thai people. For example, in education, schools at the high school level were expanded to cover every district. In health, district hospitals were opened to serve 86% of the total number of districts, clinics were set up in 98% of the sub-districts, and basic health services were provided in about 90% of all villages in the country.

Although the economy of Thailand has achieved a remarkable growth as mentioned above and the growth rate was almost double the world's average rate, the economic growth rate has gone down during both periods of the Fourth and the Fifth National Economic and Social Development Plans (1976-1980 and 1981-1986) due to world recession, intensified international trade competition and protectionism caused by the low growth in the world economy. For example, during the Fifth Plan, the economic growth of Thailand averaged only 4.4% per annum compared with 7% per annum for the Fourth Plan period, and it was also lower than the 6.6% per annum targeted for the Fifth Plan period.

In addition to such a dull economic growth, Thailand had many problems and hindrances which should be solved at the end of the Fifth Plan, namely, increase in labor force, decrease in employment opportunities, trade and budget deficits, congestion of Bangkok Metropolitan Area, low growth in rural economy, deterioration in the quality of environment due to unsystematic utilization of natural resources, etc. The solution of these problems became a pressing matter on the national policy.

1.2 Sixth National Economic and Social Development Plan (1987-1991)

The major objectives of the Sixth National Economic and Social Development Plan are to raise the country's level of development for future progress and prosperity, while working to solve problems accumulated from the past.

The economic and social targets have been set in light of the above objectives. The economic target is to maintain at least the economic growth rate of 5% per annum (somewhat higher than the actual growth rate for the Fifth Plan period) so as to absorb the new entrants into the labor market which is probably more than 3.9 million people. The social target is to promote the development of the living conditions of the people so as to enable social progress and foster peace and equality.

To achieve the aforementioned economic and social targets, the following three development strategies have been set:

(1) To increase the country's efficiency in the development of human resources, science and technology, and natural resources;

(2) To improve production and marketing systems and to raise the quality of economic inputs so as to reduce production costs of goods; and

(3) To distribute income and prosperity to rural areas by establishing the principal target, so that the low income inhabitants in these areas will benefit from the development process of the country.

Furthermore, to achieve the above development strategies, the Sixth Plan has set ten (10) programs as the framework of operations of the government and the private sectors.

Table 6-1 shows the macroeconomic targets of the Sixth Plan, compared with results of the Fourth and Fifth plans. According to the Sixth Plan, the economic growth during the period is expected to be 5% per annum for GDP, especially, 6.6% per annum for the manufacturing/industrial sector. Concerning the investment sector, it is expected to achieve a high growth rate of 8.1% per annum compared with the low growth of -0.8% per annum for the Fifth Plan period. An active development policy of the Government appears not only in the investment sector, but also in the external trade sector which expects a 10.7% annual growth for exports and 9.5% for imports. On the other hand, concerning the population growth and consumer price escalation, the Sixth Plan is designed to maintain the low rates of 1.3% and 2.3% per annum, respectively.

When the above economic targets are realized at the end of the Sixth Plan period, it is expected that Thailand will establish a fairly high position among the Southeast Asian Countries in the economic aspect. In this case, per capita income will rise from 21,000 baht in 1986 to 28,000 baht in 1991.

2. Administrative Divisions

The Kingdom of Thailand with an area of 513,115 km2 is located in the tropics between 5°37'N and 20°27'N Latitude and between 97°22'E and 105°37'E Longitude. The country is bounded on the north by the Socialist Republic of the Union of Burma and the Democratic People's Republic of Laos, on the east by the

Democratic People's Republic of Laos and Democratic Kampuchea, on the west by the Socialist Republic of the Union of Burma, and the southern border faces the Gulf of Thailand, Malaysia and the Andaman Seas. The coastline is about 2,614 km long.

The country is geographically divided into six regions; the Central, Eastern, Western, Northeastern, Northern and Southern regions. Administratively, Thailand is divided into 73 provinces (changwat) which are composed of 733 districts (amphoe and king amphoe), 6,430 towns (tambon) and 57,415 villages (muban), as shown in Table 6-2.

The administration in regions is decentralized into the provinces and districts. Governors of provinces and head officers (khet officers) of districts are appointed by the Minister of Interior and receive orders through the Ministry. The governor or head officer is in charge of all civil servants in his province or district and also responsible for the efficient operation of all offices in his territory. The village master (phuyaiban), who serves and acts as representative of the village, is elected by the village people. The town headman (kamnan) is elected by all phuyaibans of villages composing the town, and kamnans are responsible to the khet officer of the district.

The Study Area for the socio-economic sector is defined as all the 29 provinces in and/or related to the Chao Phraya River Basin (refer to Fig. 6-1 and Table 6-2). Twenty-four (24) of these provinces are wholly situated in the basin, while the five provinces of Chiang Mai, Tak, Kamphaeng Phet, Phayao and Uthai Thani are only partly situated. The 29 provinces are administratively composed of 270 districts which include 22 sub-districts, 2,461 towns and 19,552 villages. The total area of these provinces is 194,479 km^2, which includes the basin area of about 162,000 km^2 corresponding to 31.5% of the whole country area.

In the Study Area, the Bangkok Metropolitan Area, which is composed of the Bangkok Metropolitan Administration (BMA) and

the five provinces of Nonthaburi, Pathum Thani, Sumut Prakan, Nakhon Pathom and Samut Sakhon, forms a greater community, and public works such as water supply, sewerage and electric supply systems are operated administratively as a large unit on an area of 4,700 km2.

3. Economic Structure and Budget

3.1 General

The traditional industry of Thailand is agriculture which is based on rice cultivation. However, in recent years the demand for rice has decreased in both aspects of domestic and external uses, and the result appeared as the decrease in farmer's income and exports.

To eliminate such an unfavorable situation, the Government encouraged the increase in production of upland crops such as maize and cassava. The Government has also promoted the development of light industries which produce substitutes for daily goods to be imported. Currently, the light industrial products together with some agricultural crops have come to play a more important role than ever in export goods.

Despite the rise in exports owing to the increased production of light industrial products and some agricultural crops, the external trade of Thailand indicates that imports still exceed exports. The majority of such a trade deficit have been covered by the capital investments from abroad, and as a result the international payments of Thailand have kept a favorable balance in recent years. However, in the balance of international payments in 1986, it is noted that the balance of current account in addition to the capital account turned to a surplus, supported by the prosperity of export and service accounts.

The GNP, GDP and the government budget, together with a more detailed presentation of the international balance of payments, are discussed in the succeeding subsections.

3.2 Gross National Product (GNP) and Gross Domestic Product (GDP)

In 1985, GDP and GNP of Thailand amounted to about 1,048,000 million baht and 1,010,000 million baht, respectively, at current market prices, and the per capita GNP indicated about 20,000 baht (refer to Table 6-3). Of the GDP, the contribution of each economic sector in the same year was 19.8% for the manufacturing industrial sector, 18.2% for the services sector of wholesale and retail trade, and 17.4% for the agricultural sector. The total amount of the above three sectors came to about 580,000 million baht which corresponds to 55% of the GDP. Among these sectors, it is noted that the share of the agricultural sector to the GDP decreased remarkably from 23.9% in 1981 to 17.4% in 1985 (refer to Table 6-4).

In recent years, Thailand's economy showed a fairly high growth owing to the increased production of upland crops other than rice and the development of light manufacturing industries, despite the economic recession in other countries of the world (refer to Table 6-5), namely, during the period from 1981 to 1985, the average annual growth rate of Thailand's economy was about 5% for both GDP and GNP, and about 3% for per capita GNP (refer to Table 6-6).

Bangkok Metropolitan Area and the Central Region, which are located in the lower reaches of the Chao Phraya River, serve as the core of Thailand's economy and have accounted for a half of the country's GDP, i.e., for example in 1985, 518,000 million baht which consisted of 475,000 million baht in BMA and 43,000 million baht in the Central Region. The average annual growth rate for the period from 1981 to 1985 was 5.4% for BMA and 4.2% for the Central Region which was close to the average growth rate (5%) of the GDP for the whole country (refer to Table 6-7).

On the other hand, per capita GRP (Gross Regional Product) in 1985 was about 60,000 baht for BMA and about 17,000 baht for the Central Region, i.e., the value in BMA showed three times of the average value of the whole country, while the average annual growth for the 1981-1985 period indicated a lower rate of 2.2% for BMA and a higher rate of 3.6% for the Central Region, compared with that (3%) of the whole country (refer to Table 6-8).

Tables 6-9 and 6-10 indicate the Gross Provincial Product (GPP) and the per capita GPP by province in the Study Area. GPP in the Study Area in 1985 amounted to about 668,000 million baht which corresponded to 64% of GDP (1,048,000 million baht) of the Kingdom. Of the GPP in the Study Area, the GPP of Bangkok City in the same year amounted to 389,000 million baht which accounted for 58% of that in the Study Area or 37% of the Kingdom's GDP. The growth in GPP in the Study Area for the 1981-1985 period was 5% or the same rate as the average growth rate of the GDP in the whole country. In the Study Area, the three provinces of Pathum Thani, Kamphaeng Phet and Tak achieved a fairly high growth in GPP or 13.1%, 9.0% and 8.85% per annum, respectively, during the same period.

Per capita GPP in the Study Area in 1985 was estimated at about 30,000 baht which corresponds to about 1.5 times of that in the whole country. Especially, Bangkok, Samut Prakan and Pathum Thani showed a fairly high GPP per capita which amounted to 68,000 baht, 63,000 baht and 48,000 baht, respectively.

3.3 External Trade

In 1985, the external trade of Thailand amounted to about 444,000 million baht which comprised exports of 193 million baht and imports of 251,000 million baht, and the trade deficit showed 58,000 million baht. Such a trade deficit has continued every year in recent years, despite the rise in

exports at the fairly high rate of 6% or more per annum since 1985 being supported by the increased export of foods and manufactured goods (refer to Table 6-11).

Among exports, the aggregate sum of foods, crude materials and manufactured goods accounted for 73% of the total exports, i.e., 142 million baht in 1985. On the other hand, imports were represented by machinery, mineral fuel, manufactured goods and chemicals which amounted to about 205,000 million baht in 1985, or 82% of the total imports (refer to Table 6-11). Principal commodities of export, in addition to manufactured goods, are rice, cassava, rubber, maize, sugar and prawns of agricultural products and tin of mining products. These exports amounted to about 80,000 million baht in 1984, accounting for nearly a half of the total exports (refer to Table 6-12).

3.4 Balance of International Payments

Since 1981, the international payments of Thailand have kept a favorable balance every year except 1983, in spite of the trade deficit, owing to the positive balance of invisible trade consisting of capital, transfer and service accounts. For example, in 1986 the balance of international payments came to a surplus of about 33,600 million baht which comprised the deficit of 16,500 million baht for the trade balance, the surplus of 10,800 million baht for the capital account, the surplus of 5,800 million baht for the transfer account, the surplus of 16,600 million baht for the service account and the other surplus of 16,900 million baht. In the 1986 international payment, it is most remarkable that the balance of current account turned to a surplus of 5.8 million baht against the deficit until 1985, as shown in Table 6-13.

3.5 Government Budget

The budget of the Government of Thailand increased at the average rate of 14% per annum during the past two decades, and in 1985 the public revenue and expenditures amounted to 159,000 million baht and 183,000 million baht, respectively. Although the finance deficit continued every year during the said period as shown in Table 6-14, yet it has indicated a reducing tendency since 1982.

In 1985, a majority of the revenue was accounted for by taxes and duties amounting to 139,000 million baht, or 87% of the total revenue. Concerning expenditures, the debt service payment showed the highest among expenditure items or 44,000 million baht. The expenditures on other items in the order of amount were 36,000 million baht for education, 31,000 million baht for defense, 26,000 million baht for economic services, 21,000 million baht for public health, and 10,000 million baht for internal security (refer to Table 6-15).

4. Population and Households

4.1 Population

The population census of Thailand has been conducted every 10 years since 1960, and it showed the population of 26.258 million in 1960, 34.393 million in 1970 and 44.825 million in 1980. The average annual rate of population growth for both periods of 1960-1970 and 1970-1980 was 2.74% and 2.68%, respectively. The population in 1985 amounted to 51.795 million according to the report of the National Statistical Office, and the growth rate was estimated at 2.93% per annum during the five years from 1980 to 1985 (refer to Table 6-16).

In the population by region, it is noticed that the population of Bangkok City made a remarkable growth, i.e., it rose from

2.136 million in 1960 to 3.077 million in 1970 at the growth rate of 3.72% per annum, and further to 4.697 million in 1980 at the rate of 4.32% per annum. Such a great growth in population was due mainly to the increased migration from rural areas and the high birth rate. However, this growth rate has declined gradually in the 1980's due to the decreased migration. According to the government report, the population of Bangkok City in 1985 amounted to nearly 5.400 million and the growth rate indicated 2.69% per annum during the period 1980-1985.

The population in the Study Area rose from 18.254 million in 1980 to 21.158 million in 1985 accounting for about 40% of the population in the whole country, and during the 1980-1985 period the population growth showed a rate of 3% per annum (refer to Table 6-17). In the Study Area, the ten (10) provinces of Nonthaburi, Pathum Thani, Lop Buri, Samut Prakan, Samut Sakhon, Kanchanaburi, Uthai Thani, Phetchabun, Kamphaeng Phet and Lamphun, during the same period, showed a very high growth in population at the rate of 6.41%, 3.77%, 4.01%, 6.45%, 4.99%, 5.18%, 4.64%, 5.88%, 4.13% and 3.52% per annum, respectively. Among them, the population growth in Nonthaburi, Pathum Thani, Samut Prakan and Samut Sakhon, which belong to the Bangkok Metropolitan Area, was very much influenced by the increase in migration from rural areas.

The population density in 1985 was estimated at 101 persons per square kilometer on the average in the whole country and 109 persons per square kilometer in the Study Area. In the Study Area, Bangkok City had the population density of nearly 3,500 persons per square kilometer in the same year. Following Bangkok City, the three (3) provinces of Nonthaburi, Samut Prakan and Samut Sakhon had a comparatively high population density, i.e., 811, 660 and 362 persons per square kilometer, respectively. In general, the population density in the Study Area was high in the lower reaches of the Chao Phraya River from Nakhon Sawan and low in the upper reaches, namely, over 200 persons per square kilometer and below 100

persons per square kilometer on the average, respectively (refer to Table 6-17).

4.2 Households

According to the 1980 Census, Thailand had about 8.419 million households at the average rate of 5.2 persons per household, and in the Study Area the number of households amounted to about 3.464 million (or 43% share in the whole country) at the rate of 5 persons per household. In the Study Area, the four (4) provinces of Nonthaburi, Samut Prakan, Nakhon Pathom and Phetchabun had over 5.5 persons per household on the average, which was more than those in other provinces by about 10%. Details on the number of households in the Study Area are shown in Table 6-17.

5. Price Index and Household Income

5.1 Price Index

The consumer price of Thailand has been stable for the last few years, reducing gradually the rate of price escalation, i.e., the rise in consumer price was only 2.4% in 1985 against 5.2% in 1982. During the 1981-1985 period, the average rise rate of the price was about 3% per annum, and there was not so much disparity among regions (refer to Table 6-18).

On the other hand, the producer price of Thailand showed a downward trend rather than stability, i.e., the producer price index in the whole Kingdom fell from 169.5 in 1981 to 169.0 in 1985 (100 in the base year 1976) at the average rate of -0.1% per annum. In the Central and Northern regions which include a majority of the Study Area, the producer price index fell 2% or more per annum on the average during the same period.