

JAPAN INTERNATIONAL COOPERATION AGENCY

PUBLIC WORKS DEPARTMENT
MINISTRY OF INTERIOR
THE KINGDOM OF THAILAND

**THE STUDY ON MASTER PLANNING
FOR
THE SEWERAGE DEVELOPMENT PROJECT
FOR
LOWER CHAO PHRAYA RIVER BASIN
IN
THE KINGDOM OF THAILAND**

VOLUME 2-I

MAIN REPORT

JANUARY 1964

NIIPPON KOSSEIING SEIKEN CO., LTD.
PACIFIC CONSULTANTS INTERNATIONAL

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a master planning and preliminary design study on Master Planning for the Sewerage Development Project for Lower Chao Phraya River Basin and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr. Masatoshi Momose, Nippon Jogesuido Sekkei co., Ltd., and composed of members from the said company and Pacific Consultants International 4 times between May 1992 and December 1993.

The team held discussions with the officials concerned of the Government of Thailand, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

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

January 1994

A handwritten signature in cursive script, reading "Kensuke Yanagiya".

Kensuke Yanagiya

President

Japan International Cooperation Agency

January, 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Yanagiya

Letter of Transmittal

We are pleased to submit herewith the final report of the study on Master Planning for the Sewerage Development Project for Lower Chao Phraya River Basin in the Kingdom of Thailand.

The field investigations and studies were conducted starting from the end of March 1992 and completed by the end of December 1993.

The final report consists of four volumes consolidating two times each of progress report and interim report: One-Summary report which succinctly describes the study and recommendations; Two-Main report which covers water pollution control plan, sewerage master plans for eight areas and preliminary design of two selected areas; Three-Supporting report including detailed analysis and relevant information; Four-Data report covering field findings and data.

We hope that the implementation of the proposed sewerage projects would greatly contribute to the improvement of water quality in the public water body and sanitation conditions in the study area.

We wish to take this opportunity to express our sincere gratitude to your Agency. We also would like to show our appreciation to the Public Works Department, Ministry of Interior, Thailand on the close cooperation and assistance extended to us during our study.

Very truly yours,



Masatoshi Momose

Team Leader

The Study on Master Planning
for the Sewerage Development
Project for Lower Chao Phraya
River Basin

MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT
FOR
LOWER CHAO PHRAYA RIVER BASIN

VOLUME 2

TABLE OF CONTENTS

	<u>Page</u>
PREFACE	
LETTER OF TRANSMITTAL	
Table of Contents	TOC-1
List of Tables	TOC-17
List of Figures	TOC-26
Abbreviations	TOC-36
GENERAL INTRODUCTION	1
 PART I WATER POLLUTION CONTROL PLAN	
CHAPTER 1 INTRODUCTION	
1.1 General	1-1
 CHAPTER 2 ADMINISTRATIVE COMPOSITIONS AND NATURAL CONDITIONS	
2.1 Outline of the Study Area	2-1
2.1.1 Local Administration Overview	2-1
2.1.2 Administrative Composition of the Study Area ..	2-5
2.2 Topography, Geology and Hydrogeology in the Chao Phraya River Basin	2-12
2.2.1 Topography and Geology	2-12
2.2.2 Hydrogeology	2-13
2.3 Meteorology and Characteristics of the Study Basin ..	2-16
2.3.1 Meteorology	2-16
2.3.2 Characteristics of the Study Basin	2-19
2.4 Inundation and Flood Control	2-20
2.4.1 Inundation and Flood Control Damage	2-20
2.4.2 Flood Control	2-24

	<u>Page</u>
CHAPTER 3 LAWS AND REGULATIONS RELEVANT TO WATER POLLUTION CONTROL AND WATER POLLUTION STATUS	
3.1 Administrative/Institutional Set-up Related to Water Pollution Control	3-1
3.2 Present Policies and Countermeasures for Water Pollution Control	3-14
3.2.1 The Seventh National Economic and Social Development Plan (NESDP)	3-14
3.2.2 Special Committee for the Formulation of Policies and Countermeasures to Control Water, Air and Noise Pollution in Thailand	3-16
3.3 Environmental Water Quality Standards, and Relevant Laws and Regulations	3-21
3.3.1 Effluents	3-21
3.3.2 Surface Water	3-28
3.4 Water Pollution Status	3-33
3.4.1 Concerned Agencies Undertaking Water Quality Examination	3-33
3.4.2 Water Pollution Status in Rivers	3-36
CHAPTER 4 SANITATION CONDITIONS AND SEWERAGE SYSTEMS AT PRESENT AND IN THE FUTURE	
4.1 Sanitation Conditions	4-1
4.2 Existing Sewage Works in Thailand and On-going Pollution Control Plans in the Study Area	4-12
4.2.1 Existing Sewage Works and Plans in Thailand ..	4-12
4.2.2 On-going Pollution Control Plans in the Study Area	4-17
CHAPTER 5 SOCIO-ECONOMIC PROFILE AND LAND USE AT PRESENT AND IN THE FUTURE	
5.1 Socio-Economic Perspective	5-1
5.1.1 National Perspective	5-1
5.1.2 Study Area	5-4
5.2 Present and Future Land Use	5-10
5.2.1 Overall Land Use in the Past and at Present ..	5-10
5.2.2 City Planning for the Municipalities	5-11

	<u>Page</u>
CHAPTER 6 POPULATION, INDUSTRY, AGRICULTURE AND FISHERY AT PRESENT AND IN THE FUTURE	
6.1 Population Projection	6-1
6.1.1 Methodology	6-1
6.1.2 Population Projection in Provincial and Amphoe Levels	6-4
6.1.3 Population Projections for Municipalities and Sanitary Districts	6-4
6.2 Industrial Development	6-4
6.2.1 General	6-4
6.2.2 Situation of Industries	6-9
6.2.3 Methodology of Projection	6-9
6.2.4 Upper Central Region	6-11
6.2.5 Pathum Thani and Nonthaburi	6-17
6.3 Livestock and Fishery Development	6-20
6.3.1 General	6-20
6.3.2 Livestock	6-20
6.3.3 Fishery	6-22
6.4 Slaughterhouse and Fresh Market	6-24
6.4.1 General	6-24
6.4.2 Slaughterhouse	6-24
6.4.3 Fresh Market	6-24
CHAPTER 7 WATER USE AND HYDROLOGICAL CONDITIONS OF RIVERS THROUGH THE FUTURE	
7.1 Water Use in the Chao Phraya River	7-1
7.1.1 Domestic and Industrial Water Supply	7-1
7.1.2 Irrigation Water Use	7-1
7.2 Hydrological Conditions of the Rivers	7-5
7.2.1 Rainfall Observation	7-5
7.2.2 Rainfall Intensity by Return Period	7-7
7.2.3 Flow Pattern	7-7
7.2.4 Flow Rate and Water Level Observation	7-9
7.2.5 Flow Rate and Water Level along the River in Dry and Wet Season	7-9
7.2.6 Flow Rate Estimation and Balance of Flow	7-12

	<u>Page</u>
CHAPTER 8 UNIT WASTEWATER QUANTITY AND QUALITY	
8.1 General	8-1
8.2 Domestic Wastewater	8-1
8.2.1 Unit Quantity of Domestic Wastewater	8-1
8.2.2 Unit BOD Load of Domestic Wastewater	8-12
8.3 Industrial Wastewater	8-19
8.3.1 Unit Quantity of Industrial Wastewater	8-19
8.3.2 Unit BOD Load of Industrial Wastewater	8-21
8.4 Unit Quantity and BOD Load of Other Wastewater Sources	8-24
8.4.1 Livestock	8-24
8.4.2 Slaughterhouse	8-24
8.4.3 Fresh Market	8-25
8.4.4 Fish Pond	8-25
8.4.5 Natural Pollution	8-26
CHAPTER 9 PRESENT WATER POLLUTION ANALYSIS	
9.1 General	9-1
9.2 Run-off Model of Pollution Load with Water Quality Checking Points	9-1
9.3 Frame Values and Generated/Discharged Pollution Load by Administrative Unit in Terms of Different Land Use	9-7
9.3.1 Domestic Wastewater	9-7
9.3.2 Industrial Wastewater	9-7
9.3.3 Other Wastewater Sources	9-13
9.4 Frame Values and Generated/Discharged Pollution Load by Each Area of Water Quality Checking Point/Pollution Load Inflow Point	9-18
9.5 Study on Concentrated and Purification Ratios	9-28
9.5.1 Concentrated Ratio	9-28
9.5.2 Measured Residual Purification Ratio	9-38
9.5.3 Flow Rates and Water Quality at Strategic Points for Present Pollution Analysis	9-40
9.5.4 Self-Purification Coefficient	9-48

CHAPTER 10 FUTURE WATER POLLUTION ANALYSIS

10.1	General	10-1
10.2	Frame Values and Generated Pollution Load by Administrative Unit in Terms of Different Land Use	10-1
10.2.1	Domestic Wastewater	10-1
10.2.2	Industrial Wastewater	10-8
10.2.3	Other Wastewater Sources	10-8
10.3	Frame Values and Generated/Discharged Pollution Load by Sub-area	10-13
10.4	Concentrated BOD Load by Sub-area	10-26
10.5	Flow Rate for Future Water Pollution Analysis	10-30
10.6	Projection of Water Quality at Water Quality Checking Points	10-37

CHAPTER 11 POLLUTION LOAD TO BE REDUCED BY POLLUTION SOURCE

11.1	General	11-1
11.2	Allowable Pollution Load by Pollution Source at Respective Water Quality Checking Points	11-2
11.3	Pollution Load to be Reduced by Pollution Source by Water Quality Checking Point	11-5
11.4	Pollution Load to be Reduced at Respective Sub-area by Pollution Source	11-11

CHAPTER 12 RECOMMENDATIONS ON THE REDUCTION OF POLLUTION LOAD

12.1	General	12-1
12.2	Domestic Wastewater	12-1
12.3	Industrial and Slaughterhouse Wastewater	12-5
12.4	Livestock and Fish Pond Wastewater	12-9
12.5	Summary of Recommendations	12-9

PART II

SEWERAGE MASTER PLAN FOR THE EIGHT MUNICIPALITIES/AREAS

	<u>Page</u>
CHAPTER 1 INTRODUCTION	1 - 1
CHAPTER 2 BASIC POLICY AND COMMON CONDITIONS TO THE AREAS FOR PREPARATION OF SEWERAGE MASTER PLAN	2 - 1
SECTION 1 PREVIOUS STUDIES RELEVANT TO SEWERAGE PROJECT	2 - 1
SECTION 2 WATER POLLUTION STATUS AND FUTURE PROSPECTS IN THE LOWER CHAO PHRAYA RIVER BASIN	2 - 4
2.1 Present Status of Water Pollution	2 - 4
2.2 Future Prospect of Water Pollution	2 - 6
SECTION 3 DESIGN CONDITIONS, ASSUMPTIONS AND FUNDAMENTALS FOR SEWERAGE MASTER PLANNING	2 - 10
3.1 General	2 - 10
3.2 Design Year and Area to be Sewered and/or in Provision of Sanitation Improvement	2 - 10
3.3 Existing Sewerage/Sanitation and Flood Protection Facilities	2 - 11
3.3.1 Drainage Facilities	2 - 11
3.3.2 Toilet Facilities, Safe Water Supply and Refuse Disposal	2 - 20
3.3.3 Flood Protection Facilities	2 - 27
3.4 Water Supply at Present and in the Future	2 - 27
3.5 Frame Values and Land Use for Sewerage Master Planning	2 - 28
3.6 Wastewater Collection Method	2 - 34
3.7 Concept for the Alignment of Major Sewerage Facilities	2 - 40
3.8 Wastewater and Sludge Treatment Method	2 - 42
3.8.1 Findings on the Existing Wastewater Treatment Plants	2 - 42
3.8.2 General Selection of Wastewater and Sludge Treatment Methods	2 - 49

	<u>Page</u>
3.9 Technical Design Criteria Common to the Eight Study Areas	2 - 54
3.9.1 Capacity Calculation	2 - 54
3.9.2 Hydraulic Calculation	2 - 61
3.9.3 Structural Design of Sewerage Facilities	2 - 62
3.10 Construction materials and Methods	2 - 76
3.10.1 Conditions for Construction of Sewerage Facilities	2 - 76
3.10.2 Construction Materials	2 - 77
3.10.3 Construction Methods of Sewerage Facilities	2 - 78
3.11 Cost Estimates	2 - 81
3.11.1 Wastewater Collection Facilities	2 - 81
3.11.2 Wastewater and Sludge Treatment Facilities	2 - 85
3.12 Administrative and Financial Study	2 - 87
3.12.1 Construction Cost	2 - 87
3.12.2 Operation and Maintenance Cost	2 - 100
3.13 Administrative and financial Study	2 - 103
3.13.1 Administrative System	2 - 103
3.13.2 Legal System	2 - 118
3.13.3 Recommendations on the Management of Sewerage Projects	2 - 120
3.13.4 Financial Aspects	2 - 125
3.14 Economic Analysis and Project Justification	2 - 143
3.14.1 Economic Aspects	2 - 143
3.14.2 Water Quality Improvement after Construction of Sewerage system	2 - 143
3.15 Interim Measures	2 - 152
3.16 Environmental Impact by the Sewerage Projects and Recommended Countermeasures	2 - 155
3.17 Recommendations on the Sanitation Improvement in the DTCP Area	2 - 158

CHAPTER 3 SEWERAGE MASTER PLAN FOR RESPECTIVE MUNICIPALITIES/AREAS

SECTION 1 CHAI NAT MUNICIPALITY	3 - 1
1.1 Description of the Study Area	3 - 1

	<u>Page</u>
1.2 Existing Sanitation/Sewerage and Flood Protection Systems	3 - 2
1.2.1 Existing Sanitation Facilities	3 - 2
1.2.2 Existing Sewerage Facilities	3 - 2
1.2.3 Flood Protection Facilities	3 - 4
1.3 Water Supply	3 - 4
1.4 Population and Land Use	3 - 5
1.5 quantity and quality of Wastewater	3 - 7
1.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 7
1.5.2 Discharged Wastewater and BOD Load	3 - 8
1.6 Proposed Sewerage System	3 - 9
1.6.1 Service Area	3 - 9
1.6.2 Wastewater Collection System	3 - 11
1.6.3 Wastewater Treatment and Sludge Disposal System	3 - 15
1.7 Cost Estimates	3 - 18
1.7.1 Construction Cost	3 - 18
1.7.2 Operation and Maintenance Cost	3 - 21
1.8 Implementation Plan	3 - 21
1.9 Administrative and Financial Study	3 - 22
1.9.1 General	3 - 22
1.9.2 Existing Administration System	3 - 22
1.9.3 Recommendations	3 - 23
1.9.4 Financial Considerations	3 - 25
SECTION 2 SING BURI MUNICIPALITY	3 - 28
2.1 Description of the Study Area	3 - 28
2.2 Existing Sanitation/Sewerage and Flood Protection System	3 - 29
2.2.1 Existing Sanitation Facilities	3 - 29
2.2.2 Existing Sewerage Facilities	3 - 29
2.2.3 Flood Protection Facilities	3 - 31
2.3 Water Supply	3 - 31
2.4 Population and Land Use	3 - 31

	<u>Page</u>
2.5 Quantity and Quality of Wastewater	3 - 33
2.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 33
2.5.2 Discharged Wastewater and BOD Load	3 - 33
2.6 Proposed Sewerage System	3 - 35
2.6.1 Service Area	3 - 35
2.6.2 Wastewater Collection System	3 - 37
2.6.3 Wastewater Treatment and Sludge Disposal System for Sing Buri East Area	3 - 42
2.6.4 Wastewater Treatment and Sludge Disposal System for Sing Buri West Area	3 - 48
2.7 Cost Estimates	3 - 50
2.7.1 Construction Cost	3 - 50
2.7.2 Operation and Maintenance Cost	3 - 52
2.8 Implementation Plan	3 - 53
2.9 Administrative and Financial Study	3 - 53
2.9.1 General	3 - 53
2.9.2 Existing Administration System	3 - 53
2.9.3 Recommendations	3 - 54
2.9.4 Financial Considerations	3 - 56
SECTION 3 LOP BURI MUNICIPALITY	3 - 59
3.1 Description of the Study Area	3 - 59
3.2 Existing Sanitation and Sewerage Systems	3 - 60
3.2.1 Existing Sanitation Facilities	3 - 60
3.2.2 Existing Sewerage Facilities	3 - 61
3.3 Water Supply	3 - 61
3.4 Population and Land Use	3 - 63
3.5 Quantity and Quality of Wastewater	3 - 65
3.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 65
3.5.2 Discharged Wastewater and BOD Load	3 - 65
3.6 Proposed Sewerage System	3 - 67
3.6.1 Service Area	3 - 67
3.6.2 Wastewater Collection System	3 - 67
3.6.3 Wastewater Treatment and Sludge Disposal System	3 - 74

	<u>Page</u>
3.7 Cost Estimates	3 - 79
3.7.1 Construction Cost	3 - 79
3.7.2 Operation and Maintenance Cost	3 - 79
3.8 Implementation Plan	3 - 80
3.9 Administrative and Financial Study	3 - 80
3.9.1 General	3 - 80
3.9.2 Existing Administration System	3 - 81
3.9.3 Recommendations	3 - 82
3.9.4 Financial Considerations	3 - 83
SECTION 4 ANG THONG MUNICIPALITY	3 - 86
4.1 Description of the Study Area	3 - 86
4.2 Existing Sanitation/Sewerage and Flood Protection Systems	3 - 87
4.2.1 Existing sanitation Facilities	3 - 87
4.2.2 Existing Sewerage Facilities	3 - 87
4.2.3 Flood Protection Facilities	3 - 89
4.3 Water Supply	3 - 89
4.4 Population and Land Use	3 - 89
4.5 Quantity and Quality of Wastewater	3 - 91
4.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 91
4.5.2 Discharged Wastewater and BOD Load	3 - 91
4.6 Proposed Sewerage System	3 - 93
4.6.1 Service Area	3 - 93
4.6.2 Wastewater Collection System	3 - 93
4.6.3 Wastewater Treatment and Sludge Disposal System	3 - 98
4.7 Cost Estimates	3 - 100
4.7.1 Construction cost	3 - 100
4.7.2 Operation and Maintenance	3 - 103
4.8 Implementation Plan	3 - 103
4.9 Administrative and Financial Study	3 - 104
4.9.1 General	3 - 104
4.9.2 Existing Administration System	3 - 104
4.9.3 Recommendations	3 - 105
4.9.4 Financial Considerations	3 - 107

	<u>Page</u>
SECTION 5 PA MOK MUNICIPALITY	3 - 110
5.1 Description of the Study Area	3 - 110
5.2 Existing Sanitation/Sewerage and Flood Protection System	3 - 111
5.2.1 Existing Sanitation Facilities	3 - 111
5.2.2 Existing Sewerage Facilities	3 - 111
5.2.3 Flood Protection Facilities	3 - 113
5.3 Water Supply	3 - 113
5.4 Population and Land Use	3 - 114
5.5 Quantity and quality of Wastewater	3 - 115
5.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 115
5.5.2 Discharged Wastewater and BOD Load	3 - 117
5.6 Proposed Sewerage System	3 - 118
5.6.1 Service Area	3 - 118
5.6.2 Wastewater Collection System	3 - 122
5.6.3 Wastewater Treatment and Sludge Disposal System for Pa Mok East Area	3 - 123
5.6.4 Wastewater Treatment and Sludge Disposal System for Pa Mok West Area	3 - 126
5.7 Cost Estimate	3 - 131
5.7.1 Construction cost	3 - 131
5.7.2 Operation and Maintenance	3 - 133
5.8 Implementation Plan	3 - 133
5.9 Administrative and Financial Study	3 - 134
5.9.1 General	3 - 134
5.9.2 Existing Administration System	3 - 134
5.9.3 Recommendations	3 - 135
5.9.4 Financial Considerations	3 - 137
SECTION 6 SENA MUNICIPALITY	3 - 140
6.1 Description of the Study Area	3 - 140
6.2 Existing Sanitation/Sewerage and Flood Protection Systems	3 - 141
6.2.1 Existing sanitation Facilities	3 - 141
6.2.2 Existing Sewerage Facilities	3 - 141
6.2.3 Flood Protection Facilities	3 - 143

	<u>Page</u>
6.3 Water Supply	3 - 143
6.4 Population and Land Use	3 - 143
6.5 Quantity and Quality of Wastewater	3 - 143
6.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 143
6.5.2 Discharged WASTewater and BOD Load	3 - 145
6.6 Proposed Sewerage System	3 - 146
6.6.1 Service Area	3 - 146
6.6.2 Wastewater Collection System	3 - 147
6.6.3 Wastewater Treatment and Sludge Disposal System	3 - 150
6.7 Cost Estimates	3 - 153
6.7.1 Construction cost	3 - 153
6.7.2 Operation and Maintenance	3 - 156
6.8 Implementation Plan	3 - 156
6.9 Administrative and Financial Study	3 - 156
6.9.1 General	3 - 156
6.9.2 Existing Administration System	3 - 157
6.9.3 Recommendations	3 - 158
6.9.4 Financial Considerations	3 - 159
SECTION 7 RANGSIT MUNICIPALITY	3 - 162
7.1 Description of the Study Area	3 - 162
7.2 Existing Sanitation and Sewerage Systems	3 - 163
7.2.1 Existing sanitation Facilities	3 - 163
7.2.2 Existing Sewerage Facilities	3 - 163
7.3 Water Supply	3 - 165
7.4 Population and Land Use	3 - 165
7.5 Quantity and Quality of Wastewater	3 - 167
7.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 167
7.5.2 Discharged WASTewater and BOD Load	3 - 168
7.6 Proposed Sewerage System	3 - 169
7.6.1 Service Area	3 - 169
7.6.2 Wastewater Collection System	3 - 169
7.6.3 Wastewater Treatment and Sludge Disposal System	3 - 177

	<u>Page</u>
7.7 Cost Estimates	3 - 183
7.7.1 Construction cost	3 - 183
7.7.2 Operation and Maintenance	3 - 183
7.8 Implementation Plan	3 - 184
7.9 Administrative and Financial Study	3 - 184
7.9.1 General	3 - 184
7.9.2 Existing Administration System	3 - 185
7.9.3 Existing Relevant Regulations	3 - 187
7.9.4 Recommendations	3 - 187
7.9.5 Financial Considerations	3 - 189
SECTION 8 BANG BUA THONG MUNICIPALITY	3 - 192
8.1 Description of the Study Area	3 - 192
8.2 Existing Sanitation and Sewerage Systems	3 - 192
8.2.1 Existing Sanitation Facilities	3 - 192
8.2.2 Existing Sewerage Facilities	3 - 193
8.3 Water Supply	3 - 193
8.4 Population and Land Use	3 - 193
8.5 Quantity and quality of Wastewater	3 - 196
8.5.1 Unit Wastewater and Pollution Load on a Discharged Basis	3 - 196
8.5.2 Discharged Wastewater and BOD Load	3 - 196
8.6 Proposed Sewerage System	3 - 198
8.6.1 Service Area	3 - 198
8.6.2 Wastewater Collection System	3 - 200
8.6.3 Wastewater Treatment and Sludge Disposal System for Bang Bua Thong North Area	3 - 206
8.6.4 Wastewater Treatment and Sludge Disposal System for Bang Bua Thong South Area	3 - 209
8.7 Cost Estimate	3 - 214
8.7.1 Construction cost	3 - 214
8.7.2 Operation and Maintenance	3 - 216
8.8 Implementation Plan	3 - 216

	<u>Page</u>
8.9 Administrative and Financial Study	3 - 217
8.9.1 General	3 - 217
8.9.2 Existing Administration System	3 - 218
8.9.3 Existing Relevant Regulations	3 - 220
8.9.4 Recommendations	3 - 220
8.9.5 Financial Considerations	3 - 223

PART III

PRELIMINARY ENGINEERING DESIGN OF SEWERAGE SYSTEMS FOR RANG SIT AREA AND BANG BUA THONG MUNICIPALITY

	<u>PAGE</u>
CHAPTER 1 INTRODUCTION	1-1
CHAPTER 2 RANG SIT AREA	2-1
SECTION 1 STUDY AREA FOR FIRST STAGE SEWERAGE PROGRAM	2-1
SECTION 2 EXISTING SANITATION/SEWERAGE FACILITIES IN THE STUDY AREA	2-4
SECTION 3 POPULATION AND LAND USE	2-5
SECTION 4 QUANTITY AND QUALITY OF WASTEWATER	2-9
SECTION 5 DESIGN CRITERIA	2-12
SECTION 6 WASTEWATER COLLECTION SYSTEM	2-15
SECTION 7 WASTEWATER TREATMENT AND SLUDGE DISPOSAL SYSTEM	2-41
SECTION 8 CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE OF FACILITIES	2-56
8.1 Construction Methods, and Operation and Maintenance .	2-56
8.2 Mitigating Measures against Potential Negative Impact	2-58
SECTION 9 COST ESTIMATES AND CAPITAL INVESTMENT PROGRAM	2-60
9.1 Construction Cost	2-60
9.2 Operation and Maintenance Cost	2-61
9.3 Capital Investment Program	2-65
SECTION 10 ORGANIZATION AND MANAGERIAL ASPECTS	2-65
SECTION 11 FINANCIAL PLANNING	2-76
SECTION 12 BENEFITS OF THE PROJECT	2-84
CHAPTER 3 BANG BUA THONG MUNICIPALITY	3-1
SECTION 1 STUDY AREA FOR FIRST STAGE SEWERAGE PROGRAM	3-1
SECTION 2 EXISTING SANITATION/SEWERAGE FACILITIES IN THE STUDY AREA	3-4
SECTION 3 POPULATION AND LAND USE	3-5
SECTION 4 QUANTITY AND QUALITY OF WASTEWATER	3-8

	<u>PAGE</u>
SECTION 5 DESIGN CRITERIA	3-11
SECTION 6 WASTEWATER COLLECTION SYSTEM	3-12
SECTION 7 WASTEWATER TREATMENT AND SLUDGE DISPOSAL SYSTEM	3-22
SECTION 8 CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE OF FACILITIES	3-29
8.1 Construction Methods, and Operation and Maintenance .	3-29
8.2 Mitigating Measures against Potential Negative Impact	3-36
SECTION 9 COST ESTIMATES AND CAPITAL INVESTMENT PROGRAM	3-38
9.1 Construction Cost	3-38
9.2 Operation and Maintenance Cost	3-40
9.3 Capital Investment Program	3-43
SECTION 10 ORGANIZATIONAL AND MANAGERIAL ASPECTS	3-44
SECTION 11 FINANCIAL PLANNING	3-47
SECTION 12 BENEFITS OF THE PROJECT	3-51

LIST OF TABLES

PART I

<u>Table</u>	<u>Page</u>
2.1.1 The Functions of Municipality	2-3
2.1.2 The Functions of Sanitary DDistrict	2-4
2.1.3 The Functions of Changwat Administrative Organization (C.A.O.)	2-5
2.1.4 Present Population and Area in the Study Area	2-7
2.3.1 Climatological Data at Bangkok	2-17
2.4.1 Discharge Rate by River	2-23
3.2.1 Short-Term Water Pollution Countermeasures	3-17
3.2.2 Long-Term Water Pollution countermeasures	3-20
3.3.1 Industrial Effluent Standards	3-22
3.3.2 Industrial Water Pollution Control Regulations (I)	3-23
3.3.3 Industrial Water Pollution Control Regulations (II)	3-24
3.3.4 Industrial Water Pollution Control Regulations (III)	3-24
3.3.5 Domestic Effluent Guidelines	3-25
3.3.6 Wastewater Quality Analysis Guidelines	3-26
3.3.7 Proposed Building Effluent Standards	3-27
3.3.8 Water Classification Criteria	3-28
3.3.9 Chao Phraya River Water Quality Classification	3-28
3.3.10 Surface Water Quality Standards	3-31
3.4.1 Parameters for Water Quality Monitoring Program (ONEB)	3-34
3.4.2 Common Water Quality Indices Examined by ONEB	3-34
3.4.3 Water Quality Monitoring by Concerned Agencies	3-35
3.4.4 Summary of Water Quality Data at Major Five Points	3-37
3.4.5 Average Water Quality in Chao Phraya River by Classified Section	3-38
3.4.6 Average Values of Water Quality in Pathum Thani and Monthaburi (PWD)	3-45
3.4.7 Water Quality of Irrigation Channel	3-46
3.4.8 Heavy Metals of the Chao Phraya River Water (1980 - 1990 average)	3-47
4.1.1 Population of Thailand	4-1
4.1.2 Population Coverage of Drinking Water	4-2
4.1.3 Evaluation of Water Quality	4-3
4.1.4 Service Coverage by Province for Latrine, Safe Water and Refuse Disposal	4-7
4.1.5 Implementation Institutions and Their Physical Output in Water Supply	4-9
4.1.6 Institution for Planning in Water Supply and Sanitation	4-10
4.1.7 Institution for Implementation in Sanitation	4-11
4.2.1 Sewerage Project by BMA	4-13
4.2.2 Implementation Arrangements for Sewage Works	4-14
4.2.3 Sewerage System in Local Area	4-15
4.2.4 Community Plant constructed by NHA	4-18
5.1.1 Major Development Targets of Economic and Social Development During The Seventh Plan (1992-1996)	5-3
5.1.2 1989 Gross Provincial Product (GPP) at Current Prices	5-6
5.2.1 Overall Land Use in Thailand	5-12
5.2.2 Land Use in the Study Area	5-13

<u>Table</u>	<u>Page</u>
5.2.3 Land Use Plan of the Subject Municipalities & Sanitary District	5-11
6.1.1 Projected Population of Province and Amphoe	6-5
6.1.2 Projected Population of Municipality	6-6
6.1.3 Projected Population of Sanitary Districts	6-7
6.1.4 Area and Projected Population in the Basin	6-8
6.2.1 Projected GRP in UCR	6-12
6.2.2 Number of Employees by Industrial Group in 1988	6-13
6.2.3 Composition Ratio of Employee Number	6-13
6.2.4 Projected GRP by Province by Industrial Group	6-14
6.2.5 Projection of Labor Productivity	6-15
6.2.6 Projected No. of Employees by Province by Industrial Group.....	6-16
6.2.7 Gross Regional Products under Industrial Sector (past trend and future projection)	6-17
6.2.8 Number of Employees in Pathum Thani	6-18
6.2.9 Projection of GRP Breakdown in Pathum Thani	6-19
6.2.10 Projection of GRP Breakdown in Nonthaburi	6-19
6.2.11 Projected No. of Employees in Pathum Thani and Nonthaburi	6-20
6.3.1 Number of Livestock (past record and future projection)	6-21
6.3.2 Number of Farms and Area of Fresh Water Fishes Cultivation in Thailand by Type of Culture	6-22
6.3.3 Area of Fish Pond by Municipality and Amphoe in 1990	6-23
6.4.1 Number of Slaughtered Livestock (past record and future projection)	6-26
7.1.1 Water Intake by Gates and Pumping Stations in Chao Phraya River and its Tributaries(Averaged between 1988-1992)	7-4
7.2.1 Average Monthly Rainfall in Chao Phraya River Basin (Averaged between 1980-1989)	7-6
7.2.2 Stochastic Consecutive Maximum Rainfall in the Chao Phraya River Basin.....	7-8
7.2.3 Flow Rate in Chao Phraya River and its Tributaries Observed by RID (Averaged between 1988-1992)	7-10
7.2.4 Peak Flow Rate Observed by RID	7-11
7.2.5 Water Level in Chao Phraya River and its Tributaries Observed by RID (Between 1988-1992)	7-13
8.2.1 Present Water Supply for Municipalities and Sanitary Districts in the Study Area	8-3
8.2.2 Classification of Municipalities in the Study Area	8-5
8.2.3 Water Consumption Rate by Category	8-11
8.2.4 Investigation Results on Domestic BOD Load in Thailand.....	8-13
8.2.5 Unit Generated BOD Load of Domestic Wastewater	8-17
8.2.6 Unit discharged BOD Load of Domestic Wastewater	8-18
8.3.1 Number of Employees and Wastewater Quantity by Industrial Type (1991)	8-19
8.3.2 Labor Productivity Increase Factor	8-20
8.3.3 Ratio of Industrial Water Use Saving	8-20
8.3.4 Industrial Water Use Saving Rate	8-21
8.3.5 Unit Industrial Wastewater Quantity per Employee	8-21
8.3.6 BOD Load of Industrial Wastewater by Industrial Type	8-22
8.3.7 Projected Unit BOD Load per Employee (Generated)	8-22

<u>Table</u>	<u>Page</u>
8.3.8 Projected Unit BOD Load per Employee (Discharged)	8-23
8.3.9 Revised Unit BOD Load per Employee (Discharged)	8-23
8.4.1 Unit Pollution Load of Livestock	8-24
8.4.2 Unit Pollution Load of Slaughterhouse	8-25
9.2.1 Water Quality Checking Point	9-5
9.2.2 Sub-areas and In/Outflow Points of Pollution Load	9-6
9.3.1 Population by Land Use Type (1992)	9-8
9.3.2 Quality of Domestic Wastewater by Land Use Type (1992).....	9-9
9.3.3 Generated BOD Load of Domestic Wastewater by Land Use Type (1992)	9-10
9.3.4 Discharged BOD Load of Domestic Wastewater by Land Use Type (1992)	9-11
9.3.5 No. of Employee in Industrial Sector by Province (1992)....	9-12
9.3.6 Quantity of Industrial Wastewater by Province (1992)	9-12
9.3.7 Generated BOD of Industrial Wastewater by Province (1992)	9-12
9.3.8 Discharged BOD Load of Industrial Wastewater by Province (1992)	9-12
9.3.9 Number of Livestock and Generated/Discharged BOD by Province (1992)	9-14
9.3.10 Quantity and BOD Load of Slaughter-house wastewater by Province (1992).....	9-15
9.3.11 Quantity and Discharged BOD Load of Fresh Market Waste water	9-16
9.3.12 Quantity and Generated BOD Load of Fish Pond Wastewater	9-17
9.3.13 Natural Pollution Load by Province and Amphoe	9-19
9.4.1 Area of Provinces and Amphoes by Sub-area	9-20
9.4.2 Composition of Related River Basins by Province	9-21
9.4.3 Population by Sub-area (1992)	9-22
9.4.4 Generated BOD Load by Sub-area (1992)	9-26
9.4.5 Discharged BOD Load by Sub-area (1992)	9-27
9.5.1 Investigation Points by Study Purpose	9-29
9.5.2 Findings on the Study Areas: Concentration Ratio	9-32
9.5.3 Calculation Result of Concentration Ratio	9-35
9.5.4 Concentration Ratio in Japan	9-35
9.5.5 Recommended Concentration Ratio	9-37
9.5.6 Findings on the Study Areas: Residual Purification Ratio ..	9-39
9.5.7 Residual Purification Ratio	9-40
9.5.8 Flow Rate Measured/Reported along Chao Phraya River and its Tributaries	9-42
9.5.9 Specific Discharge Rate	9-44
9.5.10 Results of River Investigation	9-46
9.5.11 Concentrated BOD Load by Sub-area (1992)	9-51
9.5.12 Computation of Self-purification Coefficient	9-54
9.5.13 Recommended Self-purification Coefficients	9-55
10.2.1 Population by Land Use Type (1996)	10-2
10.2.2 Population by Land Use Type (2001)	10-3
10.2.3 Population by Land Use Type (2011)	10-4
10.2.4 Discharged BOD Load of Domestic Wastewater by Land Use Type (1996)	10-5
10.2.5 Discharged BOD Load of Domestic Wastewater by Land Use Type (2001)	10-6
10.2.6 Discharged BOD Load of Domestic Wastewater by Land Use	

<u>Table</u>	<u>Page</u>
Type (2011)	10-7
10.2.7 No. of Employee of Industrial Sector by Province	10-9
10.2.8 Discharged BOD Load of Industrial Wastewater by Province ..	10-10
10.2.9 Number of Livestock and BOD Load by Province	10-11
10.2.10 Quantity and BOD Load of Slaughter-house Wastewater by Province	10-12
10.3.1 Population by Sub-area (1996)	10-14
10.3.2 Population by Sub-area (2001)	10-16
10.3.3 Population by Sub-area (2011)	10-18
10.3.4 Generated BOD Load by Sub-area (1996)	10-20
10.3.5 Generated BOD Load by Sub-area (2001)	10-21
10.3.6 Generated BOD Load by Sub-area (2011)	10-22
10.3.7 Discharged BOD Load by Sub-area (1996)	10-23
10.3.8 Discharged BOD Load by Sub-area (2001)	10-24
10.3.9 Discharged BOD Load by Sub-area (2011)	10-25
10.4.1 Concentrated BOD Load by Sub-area (1996)	10-27
10.4.2 Concentrated BOD Load by Sub-area (2001)	10-28
10.4.3 Concentrated BOD Load by Sub-area (2011)	10-29
10.5.1 Flow Rate at RID's Observation Stations	10-31
10.5.2 Intake Amount by Major Irrigation Gates	10-32
10.6.1 Water Pollution Analysis (1996)	10-38
10.6.2 Water Pollution Analysis (2001)	10-39
10.6.3 Water Pollution Analysis (2011)	10-40
10.6.4 Summary of Future Water Pollution Analysis	10-47
11.2.1 Composition of Present Run-off BOD Load by Pollution Source Category	11-3
11.2.2 Allowable Pollution Load by Source Category	11-4
11.2.3 Present Pollution Load Remaining Ratio by Sub-area	11-6
11.3.1 Required Pollution Load Reduction (Category A)	11-7
11.3.2 Required Pollution Load Reduction (Category B)	11-8
11.3.3 Required Pollution Load Reduction (Category C)	11-9
11.3.4 Pollution Load Remaining Ratio by Sub-area in the Future...	11-10
11.4.1 Present Share of Run-off Pollution Load by Each Sub-area	11-12
11.4.2 Allocation of Required Pollution Load Reduction (Category A)	11-13
11.4.3 Allocation of Required Pollution Load Reduction (Category B)	11-15
11.4.4 Allocation of Required Pollution Load Reduction (Category C)	11-17
12.2.1 Reduction of Domestic Wastewater Pollution Load by Sewerage System	12-3
12.3.1 Average Quality of Industrial Wastewater	12-6
12.3.2 Required Percentage to be Treated	12-7
12.4.1 Required Percentage of Livestock Wastewater to be Treated	12-10
12.5.1 Findings and Recommendations for Pollution Load Reduction..	12-12

LIST OF TABLES

PART II

		<u>Page</u>
CHAPTER 1		
SECTION 2		
2.1.1	Conditions and Status of Relevant Sewerage Project (As of 1993)	2 - 3
SECTION 3		
3.2.1	Sub-Study Areas by Project Area	2 - 20
3.3.1	Existing Conditions of Desludging and Disposal of Toilet Sludge	2 - 26
3.5.1	Sewerage Master Planning Area and Pollution	2 - 29
3.5.2 (1)	Area and Share of Sewerage Development Area in 1984	2 - 31
3.5.2 (2)	Area and Share of Existing Land Use Pattern of Sewerage Development Area in 2011	2 - 31
3.5.2 (3)	Sewerage Service Area and Service Population in Each Classified Land use Pattern in 1991 .	2 - 33
3.5.2 (4)	Sewerage Service Area and service Population in Each Classified Land Use Pattern in 2011 .	2 - 33
3.8.1	Information on Existing Treatment Plants in Thailand	2 - 49
3.8.2	Outline of Receiving Waterway	2 - 51
3.10.1	Specifications and Cost of Pipe Materials	2 - 78
3.12.1 (1)	Labor Wages	2 - 89
3.12.1 (2)	Fuel and Material Cost	2 - 89
3.12.1 (3)	Rental Cost of Equipment	2 - 90
3.12.2	Construction Cost of Collection System	2 - 91
3.12.3 (1)	Construction Cost of Sewage Treatment Plant .	2 - 95
3.12.3 (2)	Construction Cost of Sewage Treatment Plant .	2 - 96
3.13.1	Municipality Classification	2 - 113
3.13.2	Staff Number of PWD in 1992	2 - 115
3.13.3	Staff Number of PWD	2 - 116
3.13.4	Budget of PWD	2 - 117
3.13.5	Budget Allocation of PWD in 1992	2 - 118
3.13.6	Land Acquisition Cost and the Ratio of 25% Cost to Public fixed Investment	2 - 130
3.13.7	O&M Cost and Cost-covering Tariff Rates	2 - 133
3.13.8	1993 Estimates of Selected Indicators in Central Region	2 - 134
3.13.9	O&M Cost, Sewerage Rate by Municipality	2 - 138
3.13.10	Projected Residual Values	2 - 139
3.13.11	Local Budgets and sharing Burden of Land Acquisition & Financing	2 - 141
3.14.1	BOD Load Reduction by Proposed Treatment Plants	2 - 144
3.14.2	BOD Load Reduction by On-going Sewerage Projects in the Study Area by PWD	2 - 145
3.14.3	Effects of Sewerage Projects	2 - 146
3.14.4	Land Value in the Project Service Area, 1993	2 - 149

		<u>Page</u>
3.14.5	Economic Benefits and Economic Rate of Returns	2 - 151
3.16.1	Environmental Problems and Countermeasures ..	2 - 157
 CHAPTER 3		
SECTION 1		
1.2.1	Existing Drainage Facilities	3 - 2
1.6.1	Wastewater Collection Facilities	3 - 15
1.9.1	Selected Indicators for Chai Nat	3 - 27
SECTION 2		
2.2.1	Existing Drainage Facilities	3 - 29
2.6.1	Wastewater Collection Facilities	3 - 42
2.9.1	Selected Indicators for Sing Buri	3 - 58
SECTION 3		
3.2.1	Existing Drainage Facilities	3 - 61
3.6.1	Wastewater Collection Facilities	3 - 73
3.9.1	Selected Indicators for Lop Buri	3 - 85
SECTION 4		
4.2.1	Existing Drainage Facilities	3 - 87
4.6.1	Wastewater Collection Facilities	3 - 94
4.9.1	Selected Indicators for Ang Thong	3 - 109
SECTION 5		
5.2.1	Existing Drainage Facilities	3 - 113
5.3.1	Water Supply in Pa Mok Municipality	3 - 114
5.6.1	Wastewater Collection Facilities	3 - 123
5.9.1	Selected Indicators for Pa Mok	3 - 139
SECTION 6		
6.2.1	Existing Drainage Facilities	3 - 141
6.6.1	Wastewater Collection Facilities	3 - 150
6.9.1	Selected Indicators for Sena	3 - 161
SECTION 7		
7.2.1	Existing Drainage Facilities	3 - 163
7.6.1	Wastewater Collection Facilities	3 - 177
7.9.1	Selected Indicators for Rangsit	3 - 191
SECTION 8		
8.2.1	Existing Drainage Facilities	3 - 193
8.6.1	Wastewater Collection Facilities	3 - 205
8.9.1	Comparisons of Two Options	3 - 222
8.9.2	Selected Indicators for Bang Bua Thong	3 - 225

LIST OF TABLES

PART III

<u>Table</u>	<u>Page</u>
CHAPTER 2	
SECTION 1	
2.1.1 Administrative and Sewerage Design Area by Election Zone..	2-1
2.1.2 Existing Housing Estates in The Design Area.....	2-4
SECTION 3	
3.1.1 Population Distribution to each Election Zone.....	2-6
3.1.2 Population Distribution in the Preliminary Design Area....	2-7
3.2.1 Land Use and Population in 2011.....	2-7
3.2.2 Design Population in 2001.....	2-9
SECTION 4	
4.2.1 Quantity and Quality of Wastewater.....	2-13
SECTION 5	
5.1 Design Criteria for Sewerage Facilities.....	2-14
SECTION 6	
6.1 Wastewater Collection Facilities.....	2-41
SECTION 7	
7.3.1 Design Conditions for the Treatment Facilities.....	2-46
7.3.2 Design Capacity of Sludge Treatment Facilities.....	2-48
7.3.3(1) Specifications of Wastewater Treatment PLant.....	2-51
7.3.3.(2) Specifications of Wastewater Treatment Plant.....	2-52
7.3.3.(3) List of Major Mechanical and Electrical Equipment for Wastewater Treatment Plant.....	2-53
SECTION 9	
9.1.1 Project Cost on 1993 Price Level.....	2-61
9.3.2 Capital Investment Program for First Stage Project.....	2-66
SECTION 10	
10.2.1 Operations' Schedule for Rangsit.....	2-75
SECTION 11	
11.1.1 Cash Flow of the Sewage Project by Central Gov't for Rangsit and Bang Bua Thong, 1994-2024.....	2-78
11.1.2 Cash Flow of the Sewage Project by Central Gov't for Rangsit and Bang Bua Thong, 1994-2024.....	2-79

<u>Table</u>	<u>Page</u>
11.2.1 Rangsit: Cash Flow and Household User Cost	2-81
11.5.1 Sensitivity Analysis of Financial Returns.....	2-83
SECTION 12	
12.1.1 Effects of Sewerage Projects.....	2-84
12.1.2 Land Value in the Project Service Area in Rangsit, 1993.....	2-86
12.1.3 Economic Benefits and Economic Rate of Return.....	2-87
12.3.1 Sensitivity Analysis of Economic Returns.....	2-89
CAPTER 3	
SECTION 1	
1.1 Administrative and Sewerage Design Area	3-1
1.2 Housing Estates in The Design Area.....	3-4
SECTION 3	
3.1.1 Population in 1992.....	3-5
3.1.2 Present Population by Village.....	3-6
3.2.1 Land Use and Population in 2011.....	3-8
3.2.2 Design Population in 2001.....	3-8
SECTION 4	
4.2.1 Design Wastewater Quantity and BOD Load.....	3-10
SECTION 5	
5.1 Design Criteria for Sewerage Facilities.....	3-11
SECTION 6	
6.1 Wastewater Collection Facilities.....	3-13
SECTION 7	
7.3.1 Design Conditions for the Treatment Facilities.....	3-25
7.3.2 Design Capacity of Sludge Treatment Facilities.....	3-28
7.3.3(1) Specifications of Wastewater Treatment Plant.....	3-30
7.3.3.(2) Specifications of Wastewater Treatment Plant.....	3-31
7.3.3.(3) List of Major Mechanical and Electrical Equipment for Wastewater Treatment Plant.....	3-32
SECTION 9	
9.1.1 Project Cost on 1993 Price Level.....	3-40
9.3.2 Capital Investment Program for First Stage Project.....	3-45

<u>Table</u>	<u>Page</u>
SECTION 11	
11.2.1 Bang Bua Thong: Cash Flow and Household User Cost	3-48
11.5.1 Sensitivity Analysis of Financial Returns.....	3-50
SECTION 12	
12.1.1 Effects of Sewerage Projects.....	3-51
12.1.2 Land Value in the Project Service Area in Bang Bua Thong, 1993.....	3-53
12.1.3 Economic Benefits and Economic Rate of Return.....	3-54
12.3.1 Sensitivity Analysis of Economic Returns.....	3-56

LIST OF FIGURES

PART I

<u>Figure</u>	<u>Page</u>
2.1.1 Administrative Structure of Thailand	2-2
2.1.2 Location of Subject Provinces	2-6
2.2.1 Main Land Forms of the Chao Phraya River Basin	2-14
2.2.2 Hydrogeological Profile of Chao Phraya River Basin	2-15
2.3.1 Rainfall Distribution Map of Thailand	2-18
2.3.2 Chao Phraya River Basin	2-21
2.3.3 Composition of Provinces in the Chao Phraya River Basin ...	2-22
2.4.1 Hydraulic Structures Located along Chao Phraya River and Its Tributaries	2-25
3.1.1 Government Agencies involved in Environmental Management ..	3-2
3.1.2 Organization Chart of Department of Industrial Works	3-4
3.1.3 Organization Chart of the Public Works Department	3-7
3.1.4 Organization Structure of Environmental Management Offices/Departments under the MSTE	3-9
3.1.5 Organization of Royal Irrigation Department	3-12
3.1.6 Organization Chart of Ayutthaya Municipality	3-13
3.3.1 Chao Phraya River Water Classification	3-29
3.3.2 Restricted Zone for The Protection of the BMR Water Supply Source	3-32
3.4.1 Weighted Average of Water Quality on the Four Sampling Days (Chao Phraya River)	3-39
3.4.2 Average Water Quality in Dry Season and Rainy Season (PCD and This Study Data)	3-42
3.4.3 Variation of Yearly Water Quality (PCD Data)	3-44
4.1.1 Number and Percentage of Households with Latrine (1982-1988) and Latrine Distribution in Thailand (1987)	4-6
4.2.1 Sewerage System in Local Area	4-16
7.1.1 Flow Pattern in the Study Area	7-3
9.1.1 Flow System of the Pollution Load	9-2
9.2.1 Run-off Model	9-3
9.2.2 Sub-basin in the Study Area	9-4
9.5.1 Study Area and Investigation Points	9-30
9.5.2 Relationship between Concentration Ratio and Population Density	9-37
9.5.3 Flow Rates at Strategic Points of Main River	9-41
9.5.4 Fluctuation of Flow Rates	9-43
9.5.5 Weighted Average of Water Quality and Quantity on the Two Sampling Days	9-47
9.5.6 Flow Model for Present Water Pollution Analysis	9-52
9.5.7 Present Water pollution Analysis (1992)	9-53
10.5.1 Flow Rate for Future Water Pollution Analysis	10-33
10.6.1 Future Water pollution Analysis (1996)	10-41
10.6.2 Future Water pollution Analysis (2001)	10-42
10.6.3 Future Water pollution Analysis (2011)	10-43
10.6.4 BOD Load by Sub-area and Run-off Load at W.Q.C.P. (1996) ..	10-44
10.6.5 BOD Load by Sub-area and Run-off Load at W.Q.C.P. (2001) ..	10-45
10.6.6 BOD Load by Sub-area and Run-off Load at W.Q.C.P. (2011) ..	10-46

<u>Figure</u>	<u>Page</u>
11.1.1 Manner of Calculation for Allowable Pollution Load by Pollution Source	11-1
12.2.1 Flow Chart to Calculate Service Area	12-2
12.3.1 Conceptual Reduction of Pollution Load	12-5

LIST OF FIGURES

PART II

<u>Figure</u>		<u>Page</u>
CHAPTER 2		
SECTION 2		
2.1.1	Present Water Population Status	2 - 5
2.2.1	Relationship between Concentrated BOD Load and Projected BOD Concentration	2 - 8
SECTION 3		
3.2.1	DTCP Area and Sewerage Master Plan area in Chai Nat	2 - 12
3.2.2	DTCP Area and Sewerage Master Plan area in Sign Buri	2 - 13
3.2.3	DTCP Area and Sewerage Master Plan area in Lop Buri	2 - 14
3.2.4	DTCP Area and Sewerage Master Plan Area in Ang Thong	2 - 15
3.2.5	DTCP Area and Sewerage Master Plan Area in Pa Mok	2 - 16
3.2.6	DTCP Area and Sewerage Master Plan Area in Sena	2 - 17
3.2.7	DTCP Area and Sewerage Master Plan Area in Rang Sit	2 - 18
3.2.8	DTCP Area and Sewerage Master Plan Area in Bang Bua Thong	2 - 19
3.3.1 (1)	Typical Domestic Wastewater Drain System	2 - 21
3.3.1 (2)	Apartment Mouse Wastewater Drain System	2 - 22
3.3.2 (1)	Typical Pour-Flush Toilet with Soakway	2 - 24
3.3.2 (2)	Standard Drawing of Septic Tank with Soakway	2 - 25
3.6.1	Staged Improvement of combined Wastewater Collection Method	2 - 37
3.8.1 (1)	Layout of Hua Hin Sewage Treatment Plant	2 - 43
3.8.1 (2)	Layout of Khon Kaen Sewage Treatment Plant ..	2 - 44
3.8.1 (3)	Layout of Pathong Sewage Treatment Plant	2 - 45
3.9.1 (1)	Typical Design of Overflow Chamber	2 - 66
3.9.1 (2)	Typical Design of Overflow Chamber	2 - 67
3.9.2	Typical Design of Siphon	2 - 68
3.9.3 (1)	Standard Drawing of Manhole Type Pumping Station	2 - 69
3.9.3 (2)	Standard Drawing of Pumping Station	2 - 70
3.10.1	Pipe Joints	2 - 79
3.12.1	Construction Cost of Collection System	2 - 92
3.12.2	Construction Cost of Large-Size Pumping Station (More than 5 m ³ /min.)	2 - 93
3.12.3 (1)	Relationship between treatment Capacity and unit Construction Cost	2 - 97
3.12.3 (2)	Relationship between treatment capacity and Unit Construction Cost	2 - 98
3.12.3 (3)	Relationship between treatment Capacity and unit Construction Cost	2 - 99

<u>Figure</u>		<u>Page</u>
3.12.4 (1)	Annual O&M Cost of Sewage Treatment Plant ...	2 - 101
3.12.4 (2)	Annual O&M Cost of Pumping Station	
	Annual O&M Cost (1,000 Baht)	2 - 102
3.13.1	Organization Chart of The Government of the Kingdom of Thailand	2 - 104
3.13.2	Organization of Ministry of Interior	2 - 106
3.13.3	Organization of Department of Public Work (PWD)	2 - 108
3.13.4	Organization of Sanitary Engineering Division (SED)	2 - 109
3.13.5	Organization of Department of Pollution Control	2 - 110
3.13.6	Organization of Department of Environmental Policy and Planning	2 - 111
3.13.7	Organization of Department of Environmental Quality Promotion	2 - 111
3.13.8	Structure of Central and Local Government ...	2 - 112
3.13.9	Structure of Local State Government	2 - 113
3.13.10	Units of Local autonomous Government	2 - 113
3.13.11	Organization of LSWA	2 - 123
3.13.12	Two Approaches for Financing	2 - 129
3.14.1	Projected Water Quality after Provision of Sewerage Systems (2011)	2 - 147
3.16.1	Potential Impact caused by Sewerage Projects.	2 - 156

CHAPTER 3

SECTION 1

1.2.1	Existing Drainage System in Chai Nat Municipality	3 - 3
1.4.1	Future Land Use - Year 2011 (Chai Nat)	3 - 6
1.6.1	Proposed Sewerage System for Master Plan (Chai Nat Municipality)	3 - 10
1.6.2 (1)	Master Plan of Chai Nat	3 - 12
1.6.2 (2)	Master Plan of Chai Nat	3 - 13
1.6.2 (3)	Master Plan of Chai Nat	3 - 14
1.6.3	Layout of Sewage Treatment Plant (Chai Nat) .	3 - 19
1.6.4	Hydraulic Profile of Sewage Treatment Plant (Chai Nat)	3 - 20
1.9.1	Administrative Structure of Municipality of Chai Nat	3 - 23
1.9.2	Option (A) for Municipality of Chai Nat	3 - 24
1.9.3	Option (B) for Municipality of Chai Nat	3 - 24

SECTION 2

2.2.1	Existing Drainage System in Sing Buri Municipality	3 - 30
2.4.1	Future Land Use - Year 2011 (Sing Buri)	3 - 32
2.6.1	Proposed Sewerage System for Master Plan (Sing Buri Municipality)	3 - 36
2.6.2 (1)	Master Plan of Sing Buri - East (1)	3 - 38
2.6.2 (2)	Master Plan of Sing Buri - East (2)	3 - 39

<u>Figure</u>		<u>Page</u>
2.6.2 (3)	Master Plan of Sing Buri - West (1)	3 - 40
2.6.2 (4)	Master Plan of Sing Buri - West (2)	3 - 41
2.6.3 (1)	Layout of Sewage Treatment Plant (Sing Buri East)	3 - 46
2.6.3 (2)	Layout of Sewage Treatment Plant (Sing Buri West)	3 - 46
2.6.4 (1)	Hydraulic Profile of Sewage Treatment Plant (Sing Buri East)	3 - 47
2.6.4 (2)	Hydraulic Profile of Sewage Treatment Plant (Sing Buri West)	3 - 51
2.9.1	Administrative Structure of Municipality of Sing Buri	3 - 54
2.9.2	Option (A) for Municipality of Sing Buri	3 - 55
2.9.3	Option (B) for Municipality of Sing Buri	3 - 56

SECTION 3

3.2.1	Existing Drainage System in Lop Buri Municipality	3 - 62
3.4.1	Future Land Use - Year 2011 (Lop Buri)	3 - 64
3.6.1	Proposed Sewerage System for Master Plan (Lop Buri Municipality)	3 - 68
3.6.2 (1)	Master Plan of Lop Buri	3 - 69
3.6.2 (2)	Master Plan of Lop Buri	3 - 70
3.6.2 (3)	Master Plan of Lop Buri	3 - 71
3.6.2 (4)	Master Plan of Lop Buri	3 - 72
3.6.3	Layout of Sewage Treatment Plant (Lop Buri) .	3 - 77
3.6.4	Hydraulic Profile of Sewage Treatment Plant (Lop Buri)	3 - 78
3.9.1	Administrative Structure of Municipality of Lop Buri	3 - 81
3.9.2	Option (A) for Municipality of Lop Buri	3 - 82
3.9.3	Option (B) for Municipality of Lop Buri	3 - 82

SECTION 4

4.2.1	Existing Drainage System in Ang Thong Municipality	3 - 88
3.4.1	Future Land Use - Year 2011 (Ang Thong)	3 - 90
4.6.1	Proposed Sewerage System for Master Plan (Ang Thong Municipality)	3 - 95
4.6.2 (1)	Master Plan of Ang Thong	3 - 96
4.6.2 (2)	Master Plan of Ang Thong	3 - 97
4.6.3	Layout of Sewage Treatment Plant (Ang Thong)	3 - 101
4.6.4	Hydraulic Profile of Sewage Treatment Plant (Ang Thong)	3 - 102
4.9.1	Administrative Structure of Municipality of Ang Thong	3 - 105
4.9.2	Option (A) for Municipality of Ang Thong	3 - 106
4.9.3	Option (B) for Municipality of Ang Thong	3 - 106

FigurePage

SECTION 5

5.2.1	Existing Drainage System in Pa Mok Municipality	3 - 112
5.4.1	Future Land Use - Year 2011 (Pa Mok)	3 - 116
5.6.1	Proposed Sewerage System for Master Plan (Pa Mok Municipality)	3 - 119
5.6.2 (1)	Master Plan of Pa Mok - East/West	3 - 120
5.6.2 (2)	Master Plan of Pa Mok - East/West	3 - 121
5.6.3 (1)	Layout of Sewage Treatment Plant (Pa Mok - East)	3 - 127
5.6.3 (2)	Layout of Sewage Treatment Plant (Pa Mok - West)	3 - 127
5.6.4 (1)	Hydraulic Profile of Sewage Treatment Plant (Pa Mok - East)	3 - 128
5.6.4 (2)	Hydraulic Profile of Sewage Treatment Plant (Pa Mok - West)	3 - 132
5.9.1	Administrative Structure of Municipality of Pa Mok	3 - 135
5.9.2	Option (A) for Municipality of Pa Mok	3 - 136
5.9.3	Option (B) for Municipality of Pa Mok	3 - 136

SECTION 6

6.2.1	Existing Drainage System in Sena Municipality	3 - 142
6.4.1	Future Land Use - Year 2011 (Sena)	3 - 144
6.6.1	Proposed Sewerage System for Master Plan (Sena Municipality)	3 - 148
6.6.2 (1)	Master Plan of Sena	3 - 149
6.6.3	Layout of Sewage Treatment Plant (Sena)	3 - 154
6.6.4	Hydraulic Profile of Sewage Treatment Plant (Sena)	3 - 155
6.9.1	Administrative Structure of Municipality of Sena	3 - 157
6.9.2	Option (A) for Municipality of Sena	3 - 158
6.9.3	Option (B) for Municipality of Sena	3 - 158

SECTION 7

7.2.1	Existing Drainage System in Rangsit Municipality	3 - 164
7.4.1	Future Land Use - Year 2011 (Rangsit)	3 - 166
7.6.1	Proposed Sewerage System for Master Plan (Rangsit Municipality)	3 - 170
7.6.2 (1)	Master Plan of Rangsit	3 - 172
7.6.2 (2)	Master Plan of Rangsit	3 - 173
7.6.2 (3)	Master Plan of Rangsit	3 - 174
7.6.2 (4)	Master Plan of Rangsit	3 - 175
7.6.2 (5)	Master Plan of Rangsit	3 - 176
7.6.3	Layout of Sewage Treatment Plant (Rangsit) ..	3 - 181
7.6.4	Hydraulic Profile of Sewage Treatment Plant (Rangsit)	3 - 182
7.9.1	Administrative Structure of Municipality of Rangsit	3 - 186

<u>Figure</u>		<u>Page</u>
7.9.2	Option (A) for Rangsit Area	3 - 188
7.9.3	Option (B) for Rangsit Area	3 - 188
 SECTION 8		
8.2.1	Existing Drainage System in Bang Bua Thong Municipality	3 - 194
8.4.1	Future Land Use - Year 2011 (Bang Bua Thong).	3 - 195
8.6.1	Proposed Sewerage System for Master Plan (Bang Bua Thong Municipality)	3 - 199
8.6.2 (1)	Master Plan of Bang Bua Thong - North (1) ...	3 - 201
8.6.2 (2)	Master Plan of Bang Bua Thong - North (2) ...	3 - 202
8.6.2 (3)	Master Plan of Bang Bua Thong - South (1)	3 - 203
8.6.2 (4)	Master Plan of Bang Bua Thong - South (2)	3 - 204
8.6.3 (1)	Layout of Sewage Treatment Plant (Bang Bua Thong North)	3 - 210
8.6.3 (2)	Layout of Sewage Treatment Plant (Bang Bua Thong South)	3 - 210
8.6.4 (1)	Hydraulic Profile of Sewage Treatment Plant (Bang Bua Thong North)	3 - 211
8.6.4 (2)	Hydraulic Profile of Sewage Treatment Plant (Bang Bua Thong South)	3 - 215
8.9.1	Administrative Structure of Municipality of Bang Bua Thong	3 - 219
8.9.2	Option (A) : Attachment	3 - 221
8.9.3	Option (B) : Independent	3 - 221
8.9.4	Proposed Sewerage Organization for Bang Bua Thong	3 - 223

LIST OF FIGURES

PART III

<u>Figure</u>	<u>Page</u>
CHAPTER 2	
SECTION 1	
2.1.1 Preliminary Design Area and Composition of Election Zone..	2-2
2.1.2 Location of Housing Estates in Preliminary Design Area....	2-3
SECTION 3	
3.2.1 Future Land Use in the Preliminary Design Area (2011).....	2-8
SECTION 6	
6.1 Proposed Sewerage System for Preliminary Design	2-16
6.2(1) Preliminary Design for the Sewerage Development Project for Lower Chao Phraya River Basin.....	2-17
6.2(2) Preliminary Design for the Sewerage Development Project for Lower Chao Phraya River Basin.....	2-18
6.2(3) Preliminary Design for the Sewerage Development Project for Lower Chao Phraya River Basin.....	2-19
6.2(4) Preliminary Design for the Sewerage Development Project for Lower Chao Phraya River Basin.....	2-20
6.2(5) Preliminary Design for the Sewerage Development Project for Lower Chao Phraya River Basin.....	2-21
6.3(1)-1 Preliminary Design of No.1 Pump Station Rang Sit Area.....	2-22
6.3(1)-2 Preliminary Design of No.1 Pump Station Rang Sit Area.....	2-23
6.3(2)-1 Preliminary Design of No.2 Pump Station Rang Sit Area.....	2-24
6.3(2)-2 Preliminary Design of No.2 Pump Station Rang Sit Area.....	2-25
6.3(3) Preliminary Design of No.3 Pump Station Rang Sit Area.....	2-26
6.3(4)-1 Preliminary Design of No.5 Pump Station Rang Sit Area.....	2-27
6.3(4)-2 Preliminary Design of No.5 Pump Station Rang Sit Area.....	2-28
6.3(5)-1 Preliminary Design of No.6 Pump Station Rang Sit Area.....	2-29
6.3(5)-2 Preliminary Design of No.6 Pump Station Rang Sit Area.....	2-30
6.3(6)-1 Preliminary Design of No.7 Pump Station Rang Sit Area.....	2-31
6.3(6)-2 Preliminary Design of No.7 Pump Station Rang Sit Area.....	2-32
6.3(7)-1 Preliminary Design of No.11 Pump Station Rang Sit Area....	2-33
6.3(7)-2 Preliminary Design of No.11 Pump Station Rang Sit Area....	2-34

<u>Figure</u>	<u>Page</u>
6.3(8)-1	
Preliminary Design of No.12 Pump Station Rang Sit Area.....	2-35
6.3(8)-2	
Preliminary Design of No.12 Pump Station Rang Sit Area.....	2-36
6.4(1)	
Preliminary Design of Sihon.....	2-37
6.4(2)	
Preliminary Design of Sihon.....	2-38
6.4(3)	
Preliminary Design of Sihon.....	2-39
6.4(4)	
Preliminary Design of Sihon.....	2-40
SECTION 7	
7.3.1 Wastewater Treatment Process.....	2-43
7.3.2 Mass Balance of SS in Rangsit Sewage Treatment Plant.....	2-49
7.3.3 Layout of Sewage Treatment Plant.....	2-54
7.3.4 Hydraulic Profile of Sewage Treatment Plant.....	2-55
SECTION 9	
9.3.1 Implementation Program for the First Stage Project.....	2-65
SECTION 10	
10.1.1 Organization of Office of Sewage Works (OSW).....	2-67
10.1.2 Organization of National Sewage Works Authority (NSWA)....	2-69
10.2.1 Organization of LSWA for Rangsit.....	2-73
10.2.2 Organization of LSWA for Rangsit.....	2-73
10.2.3 TP Staffing for Rangsit.....	2-74
CHAPTER 3	
SECTION 1	
1.1 Preliminary Design Area and Composition of Villages.....	3-2
1.2 Location of Existing Housing Estates.....	3-3
SECTION 3	
3.2.1 Future Land Use in the Preliminary Design Area (2011).....	3-7
SECTION 6	
6.1 Proposed Sewerage System for Preliminary Design	3-14
6.2(1) Preliminary Design for the Sewerage Development Project	
for Lower Chao Phraya River Basin.....	3-15
6.2(2) Preliminary Design for the Sewerage Development Project	
for Lower Chao Phraya River Basin.....	3-16
6.3(1)-1	
Preliminary Design of No.1 Pump Station Rang Sit Area.....	3-17
6.3(1)-2	
Preliminary Design of No.1 Pump Station Rang Sit Area.....	3-18

<u>Figure</u>	<u>Page</u>
6.3(2)-1	
Preliminary Design of No.2 Pump Station Rang Sit Area.....	3-19
6.3(2)-2	
Preliminary Design of No.2 Pump Station Rang Sit Area.....	3-20
6.4	
Preliminary Design Shphon.....	3-21
SECTION 7	
7.3.1 Wastewater Treatment Process.....	3-24
7.3.2 Mass Balance of SS in Rangsit Sewage Treatment Plant.....	3-27
7.3.3 Layout of Sewage Treatment Plant.....	3-33
7.3.4 Hydraulic Profile of Sewage Treatment Plant.....	3-34
SECTION 9	
9.3.1 Implementation Program for the First Stage Project.....	3-44

LIST OF ABBREVIATIONS

The following abbreviations have been adopted in this report.

Thai Government Organizations:

AIT	-	Asian Institute of Technology
ARD	-	Accelerated Rural Development Office
BOS or BS	-	Bureau of Sanitation, BMA
BMA	-	Bangkok Metropolitan Administration
BMR	-	Bangkok Metropolitan Region
CAO	-	Changwat Administrative Organization
CPD	-	City Planning Division, Office of Under Secretary of State for BMA
DIW	-	Department of Industrial Works
DPH	-	Department of Public Health
DOH	-	Department of Highways
DOI	-	Department of Industry, Ministry of Industry
DOLA	-	Department of Local Administration
DOR	-	Department of Religion
DTCP	-	Department of Town and Country Planning
DTEC	-	Department of Technical and Economic Cooperation
EPD	-	Environmental Promotion Department
EGAT	-	Electricity Generating Authority of Thailand
FRS	-	Foreign Relations Section, Office of Under Secretary of State for BMA
HWD	-	Highway Department, Ministry of Communication
IEAT	-	Industrial Estate Authority of Thailand
LD	-	Land Department
LTD	-	Land Transport Department
MD	-	Meteorological Department
MOA	-	Ministry of Agriculture
MOI	-	Ministry of Interior
NEB	-	Office of the Nation Environment Board
NESDB	-	National Economic and Social Development Board
NHA	-	National Housing Authority
NICA	-	National Institute of Coastal Aquaculture
NSO	-	National Statistical Office
OEPP	-	Office of Environmental Policy and Planning
OPP	-	Office of Policy and Planning
ONEB	-	Office of the National Environmental Board
ODD	-	Office for Urban Development
PAT	-	Port Authority of Thailand
PEA	-	Provincial Electricity Authority
PSU	-	Prince Songkhla University
PWA	-	Provincial Waterworks Authority
PWD	-	Public Works Department
RCDP	-	Regional Cities Development Project
RID	-	Royal Irrigation Department
RTG	-	Royal Thai Government
RTSD	-	Royal Thai Survey Department
TAT	-	Tourist Authority of Thailand
TISTR	-	Thailand Institute of Scientific and Technological Research
TOCD	-	Technical Office for Cities Development
UCR	-	Upper Central Region

Other Organizations:

ADB	-	Asian Development Bank
AIDAB	-	Australian International Development Assistance Bureau
IBRD	-	International Bank for Reconstruction and Development
JICA	-	Japan International Cooperation Agency
UNDP	-	United Nations Development Programme
WB	-	World Bank

Technical Term:

A/C	-	Asphaltic Concrete
AL	-	Aerated Lagoon
AS	-	Activated Sludge
BCR	-	Benefit/Cost Ration
B.E.	-	Buddhist Era
BOD, BODS	-	Biochemical Oxygen Demand
DF/R	-	Draft Final Report
CI	-	Castiron, grey
CIR	-	Cost Insurance and Freight
CL	-	Chloride Ion
COD	-	Chemical Oxygen Demand
DO	-	Dissolved Oxygen
DS	-	Dissolved Solids
DWF	-	Dry Weather Flow
EIRR	-	Economic Internal Rate of Return
FIRR	-	Financial Internal Rate of Return
F/R	-	Final Report
F/S	-	Feasibility Study
FY	-	Fiscal Year
GPP	-	Gross Provincial Product
H ₂ S	-	Hydrogen Sulfide
IC/R	-	Inception Report
IT/R	-	Interim Report
JSWA	-	Japan Sewage Works Agency
IRR	-	Internal Rate of Return
Klong	-	Canal (Thai word)
M/P	-	Master Plan
MPN	-	Most Probable Number
msl, MSL	-	Mean Sea Level
NPV	-	Net Present Value
O & M	-	Operating and Maintenance Costs
p.a.	-	Per Annum
pH	-	pH Value
PVC	-	Polyvinyl Chloride Pipe
SS	-	Suspended Solids
SW	-	Solid Waste
TOR	-	Terms of Reference
TP	-	Treatment Plant
TS	-	Total Solids
WS	-	Water Supply
WT	-	Water Temperature
WW	-	Wastewater

Units of Measurement:

฿, B	-	baht	-	Thai Currency
M฿, MB	-	million baht	-	Thai Currency
°C	-	degree Celsius	-	Temperature Unit
cfs, ft ³ /s	-	cubic foot per second	-	Flow Rate Unit
d	-	day	-	Time Unit
cm	-	centimeter	-	Length Unit
cms, m ³ /s	-	cubic meter per second	-	Flow Rate
ft	-	foot	-	Length Unit
gal	-	US gallon	-	Volume Unit
g, gm	-	gram	-	Weight or Mass Unit
gpcd	-	gram per capita per day	-	Loading Consumption Rate
gpm	-	US gallon per minute	-	Flow Rate
ha	-	hectare	-	Area Unit
h, hr	-	hour	-	Time Unit
HP	-	house power	-	Power Unit
Hz	-	hertz (cycle per second)	-	Frequency Unit
kg	-	Kilogram	-	Weight Unit
km	-	kilometer	-	Length Unit
kV	-	kilovolt	-	Electric Potential Unit
kW	-	kilowatt-hour	-	Energy Unit
l	-	liter	-	Volume Unit
lb	-	pound	-	Weight or Mass Unit
lpcd	-	liter per capita per day	-	Water Consumption Rate
m	-	meter	-	Length Unit
mm	-	millimeter	-	Velocity Unit
m/sec	-	meter per second	-	Velocity Unit
m ²	-	square meter	-	Area Unit
m ³	-	cubic meter	-	Volume Unit
m ³ /s, cms	-	cubic meter per second	-	Flow Rate
m ³ /day	-	cubic meter per day	-	Flow Rate
m ³ /min	-	cubic meter per minute	-	Flow Rate
m ³ /day/m ²	-	cubic meter per day per square meter	-	Surface Loading
m ³ /m ² /day	-	cubic meter per square meter per day	-	Surface Loading
mg	-	milligram	-	Weight or Mass Unit
mg/l	-	milligram per liter	-	Density Unit
ppt	-	part per thousand	-	Density Unit
Rai, rai	-	rai	-	Thai Unit Measurement of Area
rpm	-	revolution per minute	-	Angular Velocity
s, sec	-	second	-	Time Unit
sq km	-	square kilometer	-	Unit Measurement of Area
yr	-	year	-	Time Unit

GENERAL INTRODUCTION

1.1 Background of the Study

The Chao Phraya river flows from the Northern Valleys through the central plain and into the gulf of Thailand. The total length of the river is about 980 km with the basin area of 160,000 km² (32% of total land area of Thailand). The Chao Phraya River has been playing an important role for power supply, irrigation, water supply, navigations, fishing and wastewater disposal. However, water pollution of river, especially in the lower river basin, is considerable in recent years due to rapid urbanization and industrialization.

Water supply for the Bangkok Metropolitan area with a population of about 8 million is depending on the river for its water source (96.5%). The river water may not be maintained usable for the water supply purpose in the near future unless proper countermeasures are implemented. Under these critical situations in the water quality, the Government of the Kingdom of Thailand adopted water quality standards for the Chao Phraya River in 1986 and established several measures in 1988 in recognition of urgent needs of water pollution control.

The Government of Kingdom of Thailand requested the Japanese Government in August 1989 cooperation for preparation of Master Plan of the sewerage development project covering eight (8) municipalities/Sanitary Districts (S.Ds).

1.2 Objectives of the Study

The objective of the Study is to prepare a countermeasure plan for comprehensive water pollution control of the Chao Phraya River and to establish a master plan up to year 2011 for sewerage development along the river stretch between Chai Nat and Nontha Buri.

1.3 Study Area

The Study area shall cover lower Chao Phraya River basin between Chai Nat and Nontha Buri. The Master Planning for Sewerage development project shall

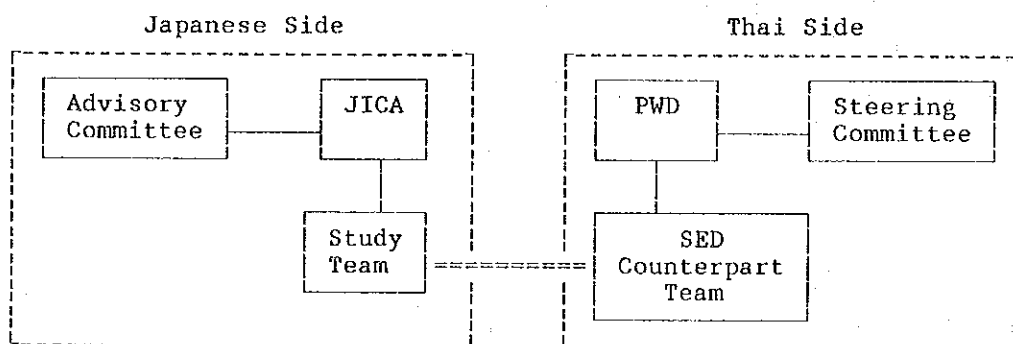
be done for the following municipalities/sanitary districts.

1. Chai Nat Municipality, Chai Nat Province
2. Sing Buri Municipality, Sing Buri Province
3. Lop Buri Municipality, Lop Buri Province
4. Ang Thong Municipality, Ang Thong Province
5. Pa Mok Municipality, Ang Thong Province
6. Sena Municipality, Ayutthaya Province
7. Prachatipat and Kukhot Sanitary Districts
(area so called Rang Sit), Pathum Thani Province
8. Bang Bua Thong Municipality, Nonthaburi Province

1.4 Study Organization

1.4.1 General Organization

The General organization for the Study is as shown below.



Note : JICA : Japan International Cooperation Agency
PWD : Public Works Department, Ministry of Interior
SED : Sanitary Engineering Division

1.4.2 Japanese Organization

The Japanese Organization consists of the Study Team under JICA headquarters and the Advisory Committee for JICA headquarters.

The members of the Study Team are as follows:

<u>Name</u>	<u>Field in charge</u>
1. Masatoshi Momose	Team Leader
2. Akio Takeuchi	Water Quality conservation /Sewerage Planning
3. Masami Kondo	Sewage Treatment Planning
4. Hiroshi Shiraishi	Facilities Design
5. Takafumi Kiguchi	Water Pollution Control
6. Chaisak Sripadungtham	Hydraulic/Hydrology
7. Kenji Kawada	Water Quality Analysis
8. Takamasa Katsuki	Construction Planning /Cost Estimate
9. Norihiro Noda	Organization/Management
10. Tatsuo Tsuchigane	Economist/Financial Analysis
11. Koichi Nakazato	Survey

The members of the Advisory Committee are as follows:

<u>Name</u>	<u>Field in Charge</u>	<u>Present Post</u>
Kunio Ichimura	Chairman	Director, Water Quality Control Dept., PWRI, MOC
Shigeru Miyahara	Sewerage Planning	Director, Sewage Works Bureau, The Municipal Government of Kurashiki Okayama Prefecture
Masatoshi Yamada	Water Pollution Analysis	Deputy Manager, Project Planning Dept., Japan Sewerage Works Agency

1.4.3 Thai Organization

The Thai organization consists of the SED Counterpart Team and the Steering Committee, operating in coordination with the Public Works Department of the Ministry of Interior.

The principal members of the counterpart Team are as follows:

<u>Agency</u>	<u>Name</u>	<u>Related Field</u>
PWD	Kreeta Soikeeree	Sanitary Engineering
PWD	Prenjit Honjunthanukula	Agricultural/Civil Engineering
PWD	Sekson Chorungsarit	Civil Engineering
PWD	Tepchai Sere-ummoi	Civil Engineering
PCD	Tawee Pienchalo	Environment
DIW	Kosol Jairungsee	Industry
RID	Virat Khao-Uppatum	Irrigation
DTCP	Somsanguan	City Planning

Note : PCD : Pollution Control Dept., Ministry of Science Technology
and Environment

DIW : Department of Industrial Works

RID : Royal Irrigation Department

DTCP : Department of Town and Country Planning

The members of the Steering committee are as follows:

<u>Name</u>	<u>Position</u>
Prajaya Sutabutr (Chairman)	Director General, Public Works Department
Sujin Channarong	Deputy Director General, Public works Department
Siritan Pairojboriboon	Deputy Director General, Pollution control Dept., Ministry of Science Technology and Environment
Vichan Vongvivat	Director, SED Public Works Department
Thossaporn Suddhajinda	Deputy Director, SED Public Works Department
Sakchai Suriyajantathong	Department of Industrial Works

1.5 Reports

The Study reports prepared are as follows:

- (1) Summary Report (Volume 1)

- (2) Main Report (Volume 2-1, Volume 2-2)
- (3) Supporting Report (Volume 3)
- (4) Data Report (Volume 4-1)
- (5) Drawings (Volume 4-2)

The Main report presents the results of the whole study. It consists of three Parts : Part (I) Water Pollution Control Plan, Part (II) Sewerage Master Plan for The Eight Municipalities/Areas, and Part (III) Preliminary Engineering Design of Sewerage Systems for Rang Sit Area and Bang Bua Thong Municipality.

Part (I) presents a water pollution analysis and recommendations on the required countermeasures for water pollution control in the Lower Chao Phraya River Basin. The findings and field measurement results conducted during the Stages I and II field work in Thailand formed the primary study base of this comprehensive basin-wide water pollution control plan. Some sectoral reports prepared by several agencies in Thailand were also fully reviewed in this study; the major portions of which were summarized in Volume IV - Data Report.

Part (II), Sewerage Master Plan, is arranged to consolidate eight separate plans and simplifies the contents with the provision of common conditions/assumptions, general approach and methodology in Chapter 2. Basic figures such as frame values and unit wastewater quantity and quality are projected in the water pollution control plan.

Part (III) presents a preliminary engineering design for Rang Sit area and Bang Bua Thong municipality which were selected among eight municipalities/areas.

PART I

WATER POLLUTION CONTROL PLAN

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 General

Part I of this report presents water pollution analysis and recommendations on the required countermeasures for water pollution control in the Lower Chao Phraya river basin. The findings and field measurement results taken during the conduct of Stages I and II field works in Thailand formed the primary study base of this comprehensive basin-wide water pollution control plan. Some sectoral reports prepared by different agencies in Thailand were also fully utilized in this Study, major reports of which were summarized in Volume IV - Data Report, Part I.

The existing general features of the river basin including its future state in terms of water pollution were described. Various water pollution sources both existing and projected were identified. Furthermore, the allocation of pollution load to be reduced by these different sources was determined and recommendations were formulated for the reduction of these pollution loads.

In developing the water pollution control plan for the lower part of the river basin, the following major activities were undertaken:

- (1) Establishment of fundamentals for water pollution analysis. This includes:
 - natural conditions and administrative composition;
 - laws and regulations relevant to water pollution control and water pollution status;
 - sanitation conditions and sewerage system at present and in the future;
 - socio-economic profile and present and future land uses;
 - population, and the existing and future profile of the industry, agriculture and fishery sectors;
 - present and future water uses and hydrological conditions of rivers; and
 - unit wastewater quantity and quality of various water pollution sources.

Available information on these parameters were gathered, assessed and analyzed. Surveys, ocular inspection and interviews of key informants were undertaken if no secondary information exist.

(2) Present water pollution analysis. This includes the formulation and determination of the following:

- run-off model of pollution load with water quality checking points;
- frame values and generated pollution load by administrative unit;
- frame values and generated/discharged pollution load by sub-area of water quality checking point/pollution load inflow point; and
- study on concentration and run-off ratios.

(3) Future water pollution analysis. This involves the following:

- determination of frame values and generated pollution load by administrative unit;
- frame values and generated/discharged pollution load by sub-area of water quality checking point/pollution load inflow point; and
- concentration and run-off load by sub-area of water quality checking point.

(4) Determination of pollution load to be reduced by pollution source. This includes the formulation and determination of the following:

- concepts and targets to reduce pollution load;
- allowable pollution load by pollution source at each water quality checking point;
- pollution load to be reduced by different pollution source by water quality checking point; and
- pollution load to be reduced by different pollution source by administrative unit.

5) Formulation of recommendations on the reduction of pollution load.

This will cover three major pollution sources, namely: domestic wastewater, industrial wastewater, and other water pollution sources.

Minutes of meeting exchanged every fieldwork between JICA Study Team and Thai side are included in Supporting Report 1-1.

CHAPTER 2
ADMINISTRATIVE COMPOSITIONS
AND NATURAL CONDITIONS

CHAPTER 2 ADMINISTRATIVE COMPOSITION AND NATURAL CONDITIONS

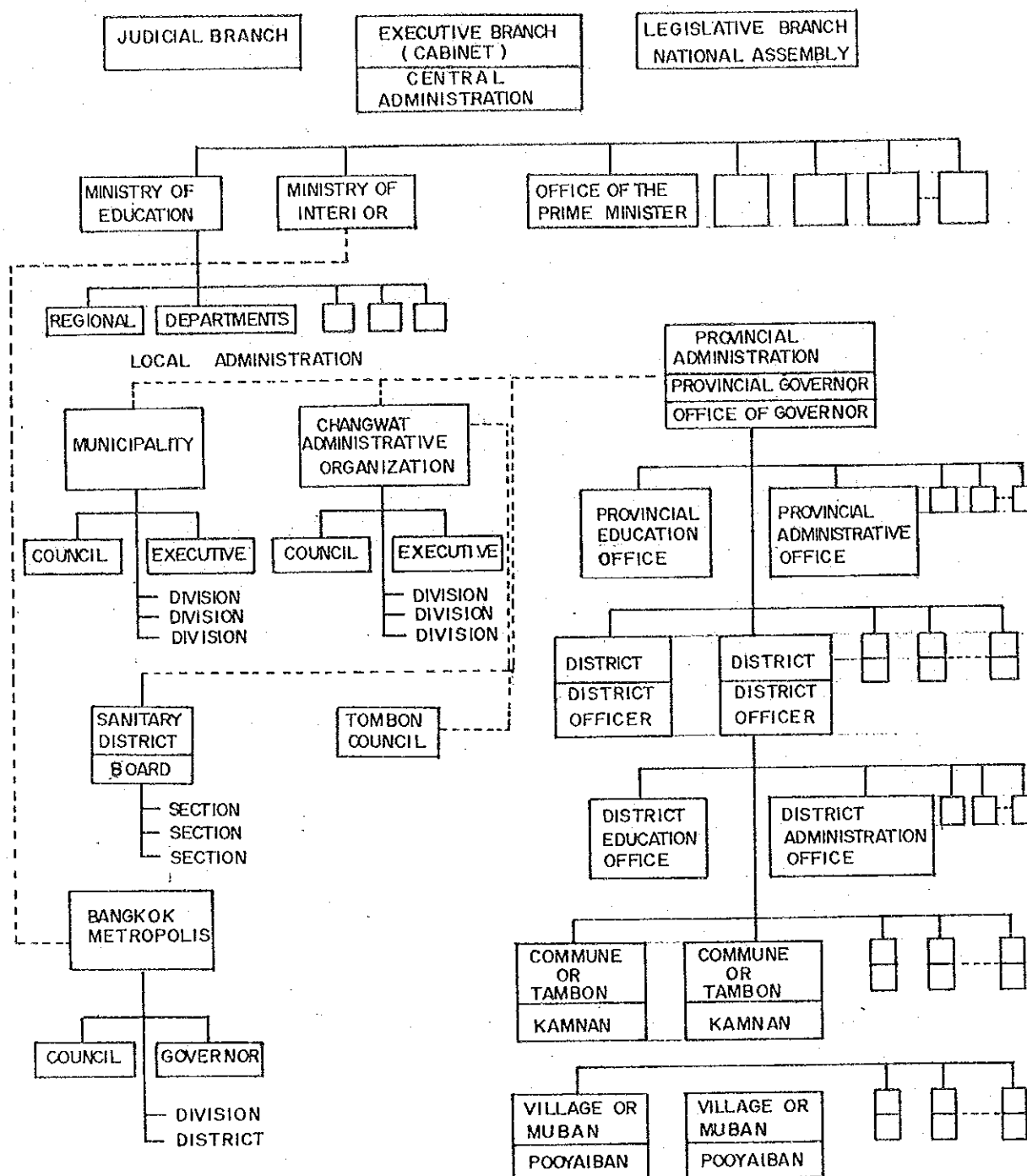
2.1 Outline of the Study Area

2.1.1 Local Administration Overview

Local administration in Thailand can be classified into two forms. One is the provincial or changwat administration, which can be considered as an extension of the national government through linkages like budget and general policies. The changwat administration consists of smaller political subdivisions: the districts or amphoes, the commune or tambon, and the village or muban (in the order of decreasing size). The other is the autonomous administration unit which consists of the following three bodies: the changwat administrative organization (CAO), the municipality, and the sanitary district. The delineation of the local administration system is shown in Figure 2.1.1. The three autonomous administration bodies are further described below.

(1) Municipality

A specific area meeting a certain degree of urbanization is usually administered under a municipality. A municipality may be further categorized according to general size, e.g., if it has fifty thousand or more inhabitants and an average density of three thousand persons/km², it is classified as a "nakhon (city) municipality" or if it has at least ten thousand inhabitants with the same aforementioned population density, it is classified as a "muang (town) municipality". An urban area may be classified as a "tambon (commune) municipality" if it fails to meet the above-mentioned criteria but nevertheless shows that it has the financial capacity to perform the designated functions of a municipality. The functions of each of the three municipal classes are shown in Table 2.1.1.



NOTE 1

—— DIRECT SUPERVISION

- - - - - SUPERVISION AND TECHNICAL ASSISTANCE GIVEN TO LOCAL ADMINISTRATION

----- COORDINATION AMONG THREE BRANCHES OF SOVEREIGNTY OF NATIONAL GOVERNMENT

SOURCE 1

REGIONAL DEVELOPMENT OF NAKHON RATCHESIMA
A COMPREHENSIVE PLANNING STUDY

FIG.2.1.1 ADMINISTRATIVE STRUCTURE OF THAILAND

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAY RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

Table 2.1.1 The Functions of Municipality

Nature of Functions	Tambon Municipality	Muang Municipality,	Nakhon Municipality
Compulsory	<ol style="list-style-type: none"> 1. Maintain peace 2. Provide and maintain roads and waterways 3. Keep road, sidewalks and public places clean including refuse and garbage disposal 4. Prevent and suppress communicable diseases 5. Provide fire fighting equipment 6. Provide people's education 7. Other activities as ordered by Ministry of Interior or as stated by law. 	<ol style="list-style-type: none"> 1-7 Same as Tambon Municipality 8. Provide clean water supply 9. Provide slaughterhouse 10. Provide and maintain medical centers 11. Provide and maintain drainage system 12. Provide and maintain public lavatories 13. Provide and maintain electricity or other lighting 	<ol style="list-style-type: none"> 1-13 Same as items 1-13 of Muang Municipality compulsory functions 14. Provide and maintain mother and child welfare 15. Provide other necessary activities for public health
Discretionary	<ol style="list-style-type: none"> 1. Provide clean water or water supply 2. Provide slaughterhouse 3. Provide markets, ferry and harbour facilities 4. Provide cemeteries and crematoria 5. Maintain and promote people's employment 6. Provide and maintain medical centers 7. Provide and maintain electricity or other lighting 8. Provide and maintain drainage system 9. Municipal commercial activities 	<ol style="list-style-type: none"> 1-3 Items 3, 4 & 5 of Tambon's discretionary functions 4. Provide and maintain mother and child welfare 5. Provide and maintain hospitals 6. Provide necessary public utilities 7. Provide other necessary activities for public health 8. Establish and maintain vocational school 9. Provide and maintain sports stadia and physical centers 10. Provide and maintain public parks, zoos and recreation places 11. Improve slum and keep city clean 12. Municipal commercial activities 	

Quoted from the Municipal Act, B.E. 2496

Source: JICA UCRS

(2) Sanitary District

A sanitary district (SD) is established in an urban area, which fails to meet the municipality definition criteria but nonetheless meet other set criteria of lesser proportions, e.g., minimum population of 1,500, etc. The principal functions of the SD are indicated in Table 2.1.2.

Table 2.1.2 The Functions of Sanitary District

-
1. Provide and maintain roads and waterways.
 2. Provide and maintain drainage system.
 3. Keep roads, sidewalks and public places clean.
 4. Refuse and garbage disposal.
 5. Provide clean water or water supply.
 7. Provide slaughterhouse.
 8. Provide market, ferry and harbor facilities.
 9. Provide cemeteries and crematory.
 10. Provide and maintain electricity or other lighting.
 11. Provide and relieve natural disasters.
 12. Provide fire fighting equipment.
 13. Provide and maintain medical centers.
 14. Promote people's education.
 15. Provide and promote people's employment.
 16. Provide and maintain sport, recreation facilities, public parks, zoos and people's meeting places.
 17. Promote religion, culture and ethics.
 18. Provide necessary public utilities.
 19. Provide commercial activities.
 20. Other necessary sanitary district activities for the benefit of people or duties stated by law.
-

Taken from the Sanitary District Act, B.E. 2495. Source: Jica UCRS

(3) Changwat Administrative Organization (CAO)

The Changwat Administrative Organization (CAO) covers all areas in the province except for the areas of jurisdiction of the municipalities and SDs. It is headed by the provincial governor and the Changwat council serves as the legislative arm. The CAO and the provincial administration are similar and overlap in many aspects. Their areas of jurisdiction overlap except for the municipal and SD areas. Moreover, the two bodies are both headed by the provincial governor and also, some provincial personnel hold positions in both organizations. Table 2.1.3 shows the principal functions of the CAO.

Table 2.1.3 The Functions of Changwat Administrative Organization

-
1. Maintain peace and order and foster goodwill of people.
 2. Provide education, maintain religion and promote culture.
 3. Provide necessary public utilities.
 4. Prevent and give treatment of diseases, establish and maintain medical centers.
 5. Provide and maintain roads and waterway.
 6. Provide and maintain drainage system.
 7. Keep roads, sidewalks and public places clean.
 8. Refuse and garbage disposal.
 9. Provide clean water or water supply.
 10. Provide slaughterhouse.
 11. Provide market, ferry and harbor facilities.
 12. Provide and maintain electricity or other lighting.
 13. Provide cemeteries and crematory.
 14. Provide and maintain sports, recreation facilities, public parks, zoos and people meeting places.
 15. Maintain and promote people's employment.
 16. Allocate money to local administration units as stated by law.
 17. Control and make profit from CAO properties.
 18. Prevent and relieve natural disasters.
 19. Provide commercial activities.
 20. Other necessary CAO activities for the benefit of the people or duties stated by law.
-

Quoted from the Changwat Administration Organization Act, B.E. 2498.

Source: JICA UCRS

2.1.2 Administrative Composition of the Study Area

The study area, the lower Chao Phraya river basin, essentially covers five (5) provinces in the Upper Central Region (UCR) and two (2) provinces in the Bangkok Metropolitan and its Vicinity Region (BMR). The provinces are Chai Nat, Sing Buri, Ang Thong, Lop Buri and Ayutthaya in the UCR and Pathum Thani and Nonthaburi in the BMR. The location of these subject provinces is presented in Figure 2.1.2.

Local autonomous administration units within the study area consist of 14 municipalities and 66 sanitary districts as of May 1992. The study area may also be subdivided into 57 districts or amphoes comprising of 587 tambons. Total population of the seven (7) provinces in 1990 was placed at 3,350,000, about 37.7% of which was residing within the urban areas (municipalities and sanitary districts). Table 2.1.4 shows the main local administration units by changwat and its corresponding areas and population.

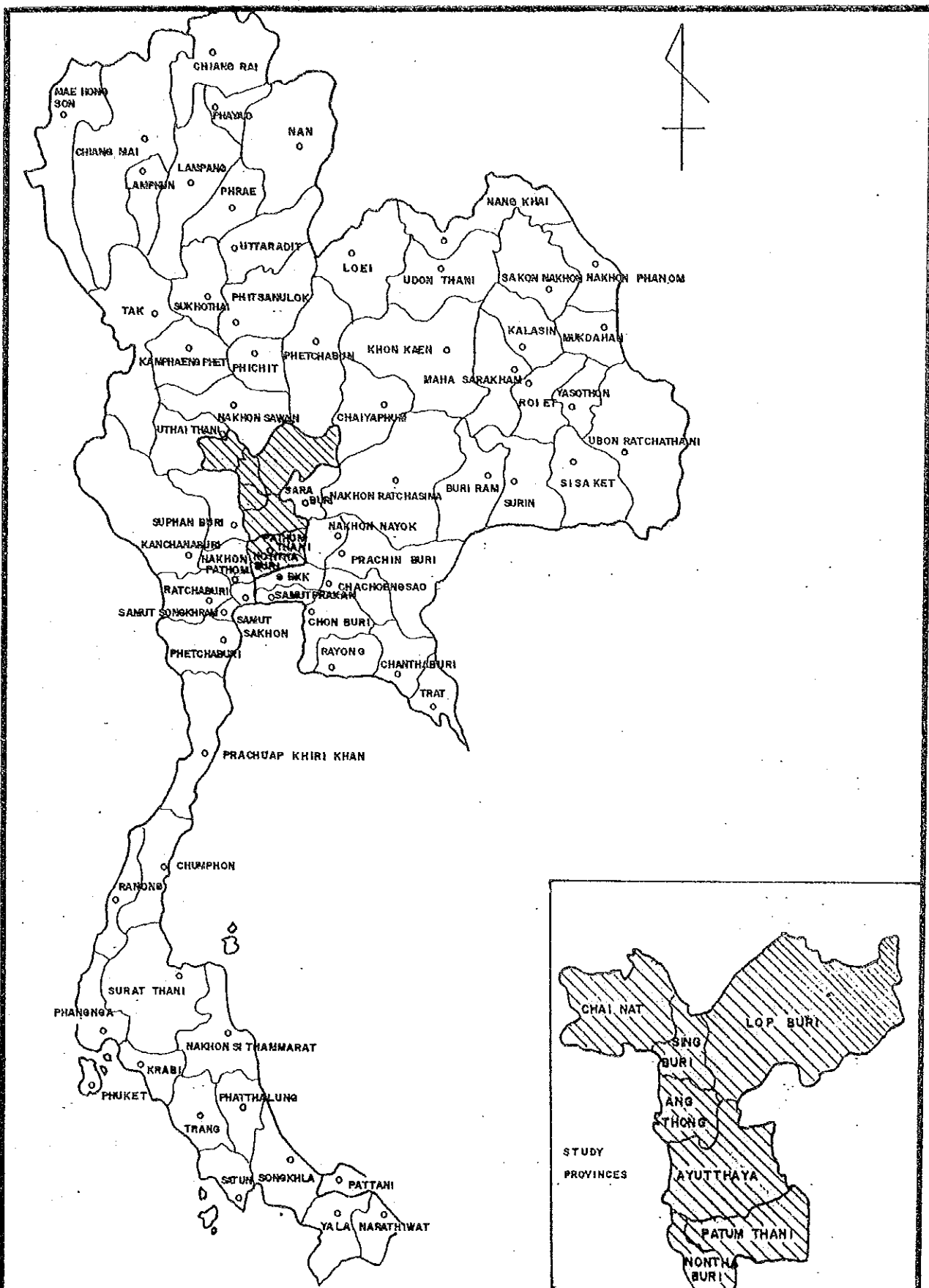


FIG. 2.1.2 LOCATION OF SUBJECT PROVINCES

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Table 2.1.4 Present Population and Area in the Study Area

Province		Amphoe		Municipality		Sanitary District		Others (Tambon & Thessaban)	
Name	Area Population (km ²)	Name	Area Population (km ²)	Name	Area Population (km ²)	Name	Area Population (km ²)	Number	Area Population (Tamb./Thes.) (km ²)
Chai Nat	2,469.7 355,151	TOTAL	2,469.75 355,151	TOTAL	8.06 18,705	TOTAL	9.53 17,297	Total	2,452.15 319,149
Number		Muang Chai Nat	255.38 73,110	Muang Chai Nat	6.06 14,506	-	-	9 / 67	249.32 58,604
Amphoe : 6		Mat Sing	606.32 45,154	Muang Mat Sing	2.00 4,199	-	-	11 / 75	604.32 40,955
Municipality : 2		Hanorom	225.64 35,453	-	-	Kung Sam Phao	1.83 2,892	7 / 39	223.82 32,561
San. District : 6		Sanphaya	228.28 52,888	-	-	Sanphaya	2.50 3,130	7 / 50	225.00 47,189
Tambon : 50						Pho Nang Dum	0.77 2,569		
Thessaban : 435		Sankaburi	354.80 68,684	-	-	Praek Sriracha	2.50 6,102	7 / 88	352.30 62,582
		Hankha	799.33 79,862	-	-	Hankha	0.58 539	9 / 116	797.40 77,258
						Sam Ngam Tha Bot	1.36 2,065		
Sing Buri	822.5 229,816	TOTAL	822.48 229,816	TOTAL	7.81 22,570	TOTAL	69.40 43,427	Total	745.27 158,819
Number		Muang Sing Buri	112.38 53,118	Muang Sing Buri	7.81 22,570	-	-	8 / 52	104.57 30,548
Amphoe : 5		In Buri	314.30 65,550	-	-	In Buri	4.00 6,724	10 / 105	310.30 58,825
Municipality : 1		Bang Rachan	190.55 38,984	-	-	Sing	22.80 21,541	8 / 75	167.75 17,443
San. District : 6		Phrom Buri	82.51 25,925	-	-	Bang Nam Chaeo	15.00 4,632	7 / 42	59.51 18,126
Tambon : 43		Tha Chang	34.35 16,059	-	-	Pak Bang	8.00 3,167		
Thessaban : 354		Kai Bang Rachan	88.40 30,180	-	-	Thon Sano	18.10 8,596	4 / 21	16.25 7,463
						Pho Sang Kho	1.50 3,767	6 / 59	86.90 26,413

...cont'd

Table 2.1.4 Present Population and Area in the Study Area (cont'd)

Table 2.1.4 Present Population and Area in the Study Area (cont'd)

Province		Amphoe		Municipality		Sanitary District		Others (Tambon & Thessaban)	
Name	Area (km ²)	Name	Area (km ²)	Name	Area (km ²)	Name	Area (km ²)	Number (Tamb./Thes.)	Area (km ²)
Ayutthaya (cont'n)									
Maha Rat	120.16	23,373	-	-	Maha Rat	5.84	2,773	12 / 58	114.32
Sena	205.57	59,918	Muang Sena	1.20	4,607	Hua Wiang	10.00	8,283	17 / 125
					Jao Jet	10.59	11,317		183.68
Bang Ban	135.31	34,599	-	-	Bang Ban	7.13	10,053	16 / 111	128.18
					Mahaphram				24,546
Pachi	104.51	29,444	-	-	Khoke Muang	5.00	6,515	8 / 72	99.51
Bang Pahan	121.87	36,649	-	-	Bang Pa Han	5.98	5,480	17 / 94	115.89
Bang Sai	150.76	19,553	-	-	Bang Sai	5.57	6,526	6 / 53	145.19
Bang Shai	219.68	43,836	-	-	Bang Shai	35.00	10,356	23 / 135	184.68
Tha Rua	106.19	51,434	Tambon The Rua	3.00	7,955	Tha Luang	2.50	13,994	10 / 83
Lad Bua Luang	199.93	32,632	-	-	Lad Bua Luang	3.80	2,181	6 / 56	196.13
Wang Noi	219.19	42,269	-	-	Lamtasao	19.50	11,090	10 / 68	199.69
Ban Praek	39.09	9,377	-	-	Ban Praek	8.00	2,835	5 / 27	31.09
									6,542
Pethum Thani	1,525.9	451,152	TOTAL	7.10	12,002	TOTAL	271.67	Total	1,233.30
		(448,431)							243,963
Number			M. Pathum Thani	7.10	12,002	Bang Luang	3.90	14 / 81	109.15
									73,174
Amphoe :	7		Sam Khok	94.97	38,947	Bang Tuel	12.29	11 / 58	82.68
Municipality :	1								30,518
San. District :	11		Lat Lum Kao	188.12	35,211	Raheang	18.22	7 / 61	169.90
Tambon :	60								29,683
...cont'd									

Table 2.1.4 Present Population and Area in the Study Area (cont'd)

Province		Amphoe		Municipality		Sanitary District		Others (Tambon & Thessaban)					
Name	Area Population (km ²)	Name	Area Population (km ²)	Name	Area Population (km ²)	Name	Area Population (km ²)	Number (Tamb./Thes.)	Area Population (km ²)				
Pathum Thani (cont'n)													
Thessaban : 529		Thanyaburi	112.12	85,046	* adjusted to be sum of S.D.s (82,325); recorded data is 82,325.	Thanyaburi	30.78	26,720	6 / 28	22.14	0		
						Sanurak	38.40	11,900					
						Prachathipat	20.80	46,426					
		Lam Luk Ka	297.71	82,831		Lam Luk Ka	11.45	6,975	8 / 126	270.14	40,221		
						Lam Sai	3.64	4,651					
						Khu Kot	12.48	30,984					
		Khlong Luang	299.15	78,817		Khlong Luang	105.94	46,870	7 / 106	179.44	31,947		
		Nong Sua	413.63	40,028		Nong Sua	13.78	1,608	7 / 69	399.85	38,420		
Nonthaburi													
622.3	652,462	TOTAL	622.30	652,462	TOTAL	40.50	248,661	TOTAL	57.28	177,957	Total	524.52	225,844
Number		M. Nonthaburi	77.02	286,560	Muang Nonthaburi	38.90	236,307	Bang Srimuang	6.36	17,438	10 / 32	31.76	30,815
Amphoe : 6		Bang Bua Thong	116.44	63,572	M. Bang Bua Thong	1.60	10,354				8 / 67	114.84	53,218
Municipality : 2													
San. District : 7		Bang Kruai	57.41	76,364				Wat Challow	4.90	13,572	9 / 60	50.98	44,441
Tambon : 52								Bang Kruai	1.53	18,351			
Thessaban : 369		Bang Yai	96.40	40,299				Bang Yai	7.23	4,055	6 / 65	87.50	30,370
								Bang Muang	1.67	5,874			
		Pak Kret	89.02	152,010				Pak Kret	34.59	116,415	12 / 85	54.43	35,595
		Sai Noi	186.02	33,657				Ratniyom	1.00	2,252	7 / 60	185.02	31,405
		Total	15,165.15	3,353,101		106.43	445,185		758.14	725,802		14,286.80	2,182,114

2.2 Topography, Geology and Hydrogeology in the Chao Phraya River Basin

2.2.1 Topography and Geology

Chao Phraya river basin is located between 14-20° N in longitude and 98-101° E in latitude and shaped as a long slip in the N-S direction. The basin occupies 162,000sqkm, about one-third of the whole country territory of 514,000sqkm. It is bounded by the Mekong basin on the north and east, Salween and Meklong basins on the west, and the Gulf of Thailand on the south. The basin can be divided into three: the upper basin of the northern highland, the middle basin in the middle flood plain and the lower basin of the Chao Phraya delta.

The upper portion of the study area has an average ground elevation of about 16 meters above mean sea water level (amsl) gradually sloping down toward Ayutthaya to a level of 2amsl. From the south portion of Ayutthaya to Nonthaburi, terrain is almost flat.

Active and former tidal flats of marine and brackish water deposits are found extensively in the southern central plain. Active tidal flats lie in a narrow strip along the coastline, while the former tidal flats are found in the immediate area of Bangkok. The soil in the latter area is poorly drained and gray colored hydromorphic alluvial soils with very fine clayey tropaquepts.

Former tidal flats of older brackish deposits exist in a large area extending from Ayutthaya to Bang Khen and Bangkok. The area is usually flooded especially during heavy rain periods. The soil is poorly drained and is composed of very fine textured hydromorphic alluvial soil.

Flood plains of recent river alluvium are found along the Chao Phraya river from Ayutthaya to Phitsanulok and Kamphaeng Phet. In the higher elevation area of these flood plains, the soil is moderately well drained with loamy alluvial soil, while in the lower portions, the soil is poorly drained with clayey hydromorphic alluvial soils.

Low alluvial terraces of semi-recent and old alluvium are found in both sides of the flood plains. The relief is flat and the soil in the low

portions of the terraces is poorly drained with fine loamy to clayey textured low humic gray soils. The higher portions are better drained with fine loamy and non-calcic brown soil.

Figure 2.2.1 shows the main land forms of the Chao Phraya river basin.

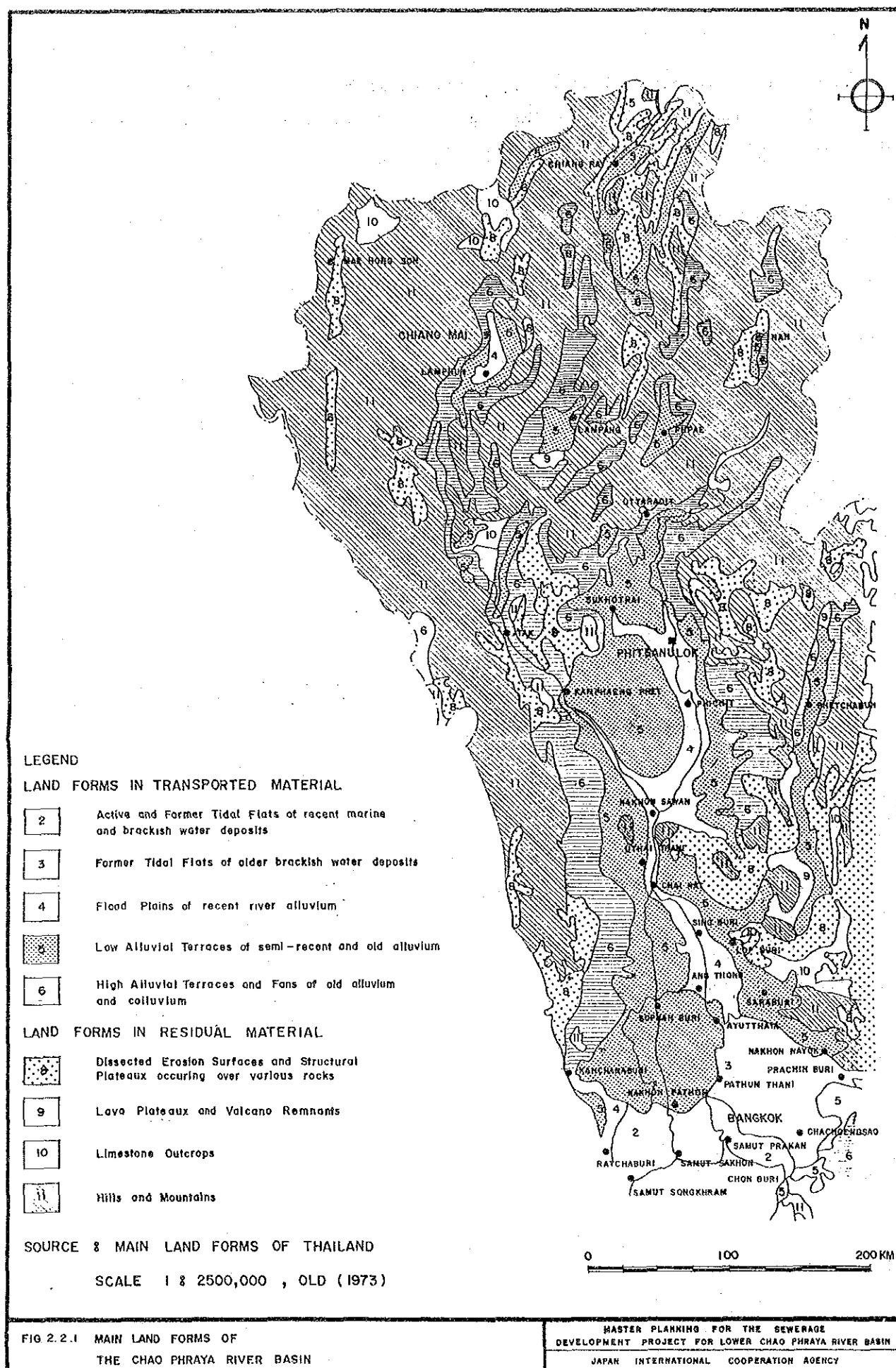
2.2.2 Hydrogeology

Most areas in Thailand have good groundwater resources. Terrace and recent alluvial aquifers, which are good water-bearing strata are found throughout the regions except in the northeast area.

The groundwater resources of the study area (north of Sing Buri) consist of both terrace and recent alluvial aquifers. Moreover, phreatic aquifers near the surface yield good quality water, which can be used for irrigation by means of deep and shallow wells.

At the lower portion of the study area, thick clay blankets exist extensively with a depth of 20 meters. Underneath, separated by layers of clay and/or sandy clay, are a number of layers of terrace and recent alluvium aquifers, which reach to the depth of around 650 meters.

This groundwater resource, however, has been overexploited: for Bangkok Metropolis alone, abstraction rate is estimated at 1.3 million cubic meter per day. This has resulted to the lowering of groundwater level more than 50 meters in some areas which in turn caused land subsidence and salt water intrusion problems. With these problems, water use for irrigation was deemed unfeasible. Figure 2.2.2 shows the hydrogeological profile of the lower Chao Phraya river basin.



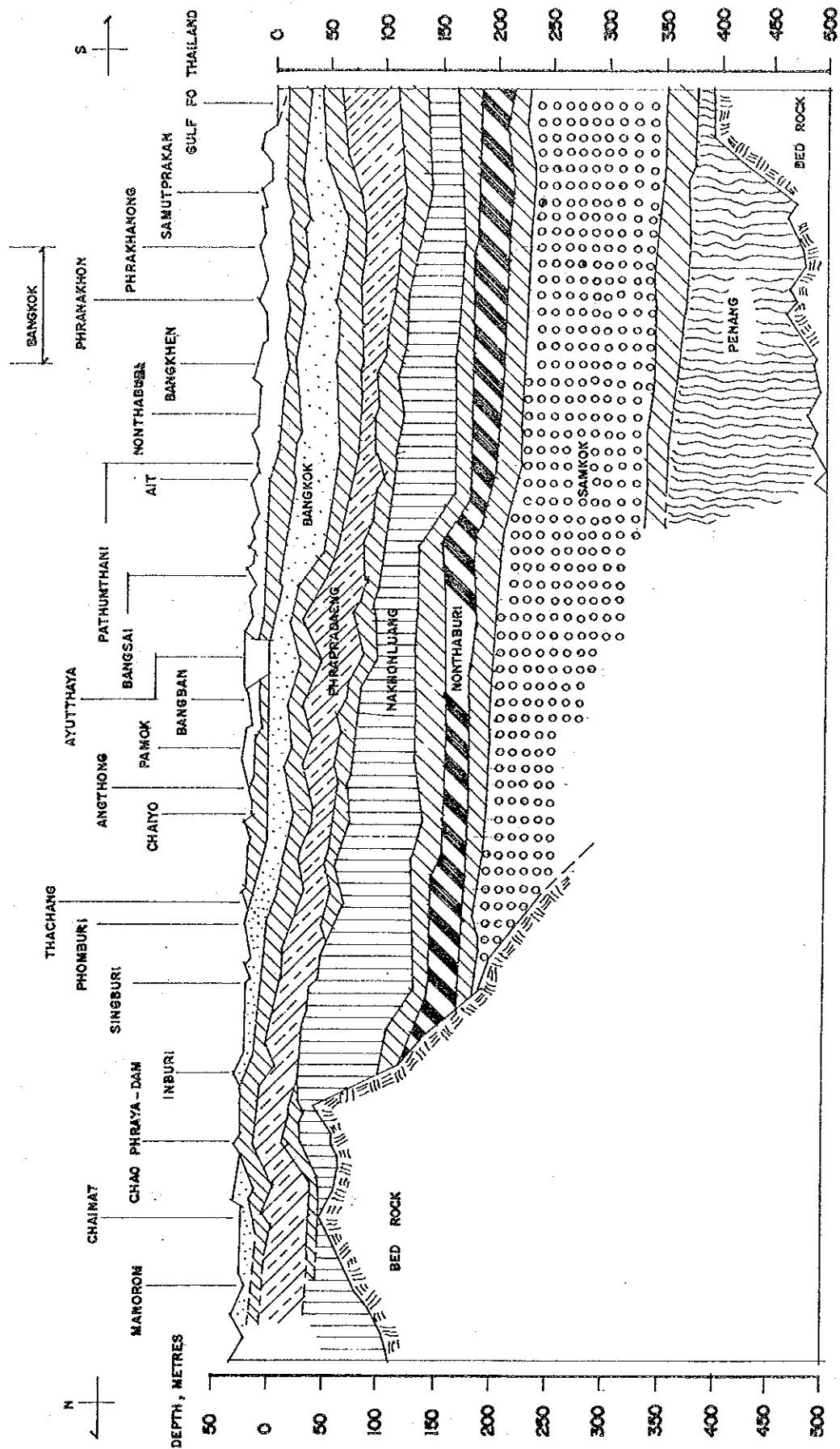


FIG.2.2.2 HYDROGEOLOGICAL PROFILE OF
CHAO PHRAYA RIVER BASIN

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

2.3 Meteorology and Characteristics of the Study Basin

2.3.1 Meteorology

The Chao Phraya river basin is located in a tropical monsoon region. Seasonal change of climate is affected by the southwest monsoon from the Indian ocean and northwest monsoon from the China mainland. Southwest monsoon is laden with moisture and warm air mass, while northwest monsoon, with dry cold air mass. Confrontation during the transition period causes high precipitation. About 85% of annual precipitation is by the southwest monsoon from May to September, while the northwest monsoon brings merely a little rainfall from October to April. In general, there are 3 seasons due to these monsoons as follows:

(1) Summer (between February and May):

The warmest period is April with an average highest temperature of about 35.5°C from past records.

(2) Rainy Season (from May to October):

This season is sometimes called as the wet season. Tropical cyclones often occur in the South Pacific Ocean and move into the basin, that cause torrential rains.

(3) Winter (from November to the middle of February):

The weather is dry and cold (dry season). Average lowest temperature is about 20°C.

The study area experiences an average annual rainfall of about 1,200mm as shown in Figure 2.3.1. Annual mean temperature is 28°C and annual mean relative humidity 70-75%. Table 2.3.1 shows the climatological data in Bangkok Area which may represent the study area.

Table 2.3.1 Climatological Data at Bangkok

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Pressure (*1000 or 900 mbs.)													
Mean	12.47	10.99	9.96	8.4	6.85	6.34	6.46	6.51	7.56	9.75	11.6	12.63	9.3
Ext. Max.	26.5	20.96	20.97	17.74	14.06	13	13.34	13.5	14.38	18.02	20.38	21.32	26.5
Ext. Min.	4.42	2.27	2.08	99.96	99.4	97.76	98.78	99.36	98.2	1.22	4.6	3.87	97.76
Mean daily range	4.81	4.8	48.5	4.83	4.46	3.8	3.75	3.93	4.39	4.43	4.28	4.51	4.4
Temperature (C)													
Mean	25.6	27.2	28.6	29.6	29.3	28.7	28.1	27.9	27.6	27.5	26.7	25.5	27.7
Mean Max.	31.9	32.8	33.9	34.9	34.2	33.1	32.6	32.4	32	31.8	31.5	31.4	32.7
Mean Min.	20.6	23.1	24.8	25.9	25.6	25.3	24.9	24.8	24.5	24.3	23	20.9	24
Ext. Max.	35.7	36.6	39.8	40	39.5	37.7	37.8	36.3	36	35.3	35.1	35.2	40
Ext. Min.	11.5	14.9	16.5	19.9	21.1	21.7	22.2	21.2	21.6	18.3	14.2	10.5	10.5
Relative Humidity (%)													
Mean	72.1	75.7	76	76	78.4	78.5	79.3	80.2	82.8	82.2	77.5	72.5	77.6
Mean Max.	90.6	92.2	91.6	90.7	92.2	91.5	91.8	93.2	94.8	94.3	92.5	90	92.1
Mean Min.	48.6	53.4	55.2	55.8	60.1	62.3	63.5	63.9	66	65.6	59.4	52.1	58.8
Ext. Min.	27	17	23	28	30	38	43	47	49	36	36	31	17
Dew Point (C)													
Mean	19.6	22.1	23.6	24.5	24.8	24.2	23.9	23.9	24.2	23.9	22.1	19.7	23
Mean - Pan	135.9	141.1	182.1	187.5	171.4	150.1	147.9	147.1	130.4	127.9	125.8	133.3	1780.5
Cloudiness(0 - 10)													
Mean	5.9	6.5	6.8	7	8.2	8.5	8.6	8.9	9	8.2	6.8	5.9	7.5
Sunshine Duration (hr.)													
Mean	276.6	252.2	270	256	222.4	178.5	169.1	159.4	152.6	202	242.6	266.1	2647.8
Visibility (km)													
0700 L.T.S	5.2	4.9	5.9	7.5	8.6	8.7	8.4	8.1	8	8	8.1	7.5	7.4
Mean	9.6	9.2	9.4	10.7	11.9	12.1	11.9	11.6	8.6	11.4	11.7	11.2	10.8
Wind (knots)													
Prevailing wind	NE	S	S	S	S	S	SW	SW	SW	SW	NE	NE	-
Mean wind speed	2.6	4.1	5	4.6	3.8	3.8	3.5	3.6	2.7	2.3	2.3	2.4	-
Max. wind speed	31 NNW	37 N	48 ENE	52 E, ESE	41 SSW	41 W	41 W, S	43 E	44 SSW	40 NE	37 SE, ESE	31 SE, NNE	52 E, ESE
Rainfall (mm)													
Mean	9.3	29.1	26.2	66.4	189.9	156.1	158.7	204.6	339.4	239.3	48.3	9.7	1477
Mean rainy days	1.3	2.9	3	6.4	15.7	16.7	18.1	20.6	21.5	17	5.9	1.3	130.4
Greatest in 24 hr	39.3	73	88.4	89.7	124.2	167.3	108.6	97.8	153.7	123.2	81.2	32	167.3
Day / Year	31/61	11/64	30/82	29/57	15/66	13/79	28/76	26/71	23/68	5/60	2/69	8/72	13/79
Number of days with:													
Haze	19.1	15.9	16.3	9.3	2.9	1.3	0.8	0.8	1	2.2	6.3	11.8	87.7
Fog	3.5	1.2	0.4	0	0.1	0	0.1	0	0	0.1	0.3	0.7	6.4
Rail	0	0	0	0	0	0	0	0	0	0	0	0	0
Thunderstorm	0.5	0.8	2.4	8.1	15.8	9.7	10.3	11	16.3	14.7	3.7	0.7	94
Squall	0	0	0	0.1	0	0	0	0	0.1	0	0	0	0.2

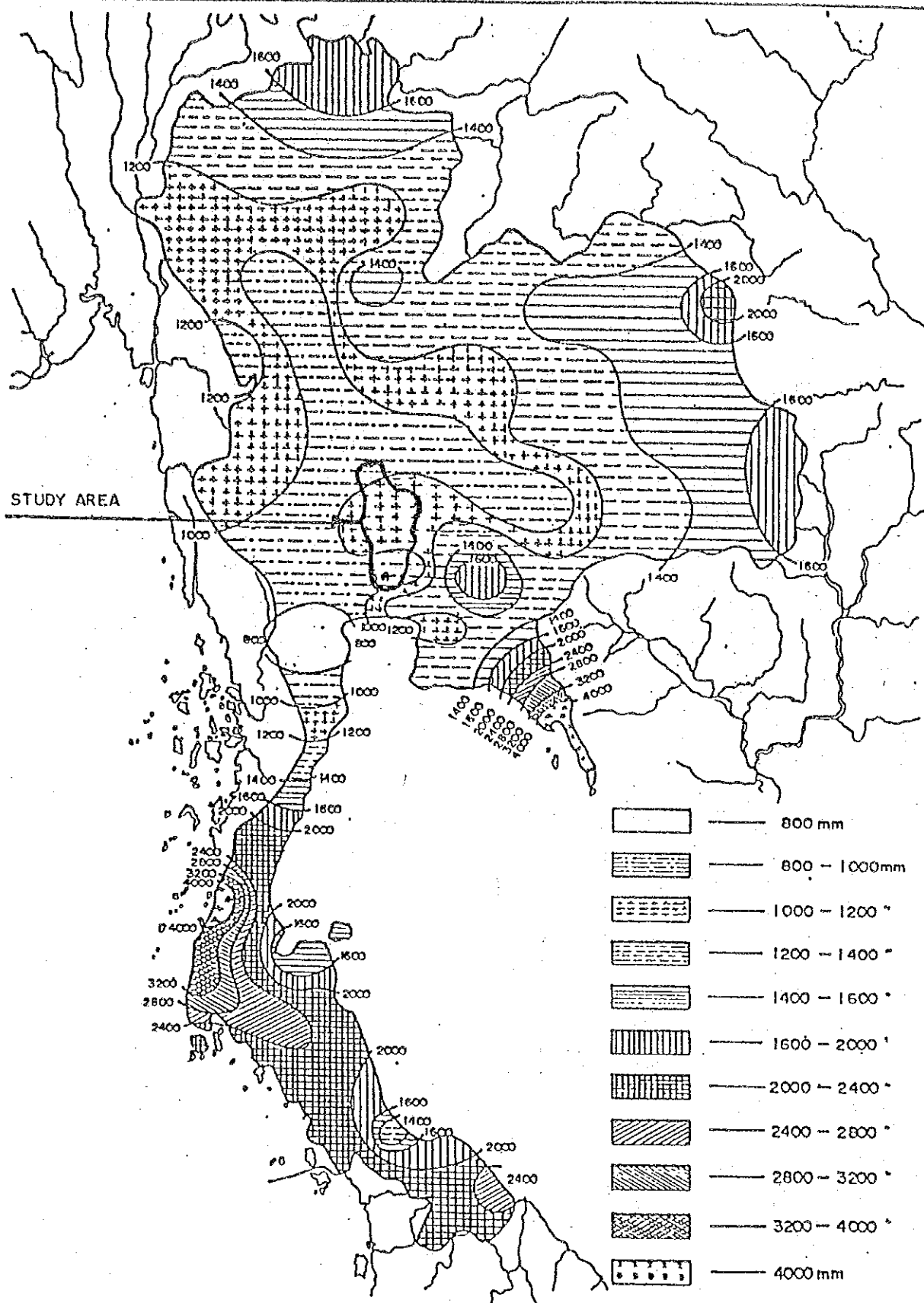


FIG.23.1 RAINFALL DISTRIBUTION MAP
OF THAILAND

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

2.3.2 Characteristics of the Study Basin

The Chao Phraya river, which originates from the mountain area in the north, is composed of 4 main upstream rivers, namely: Ping, Wang, Yom, and Nan. It runs through Nakhon Sawan and flows down to the Gulf of Thailand. The river has a total length of about 380km and covers a drainage basin of about 162,000sqkm. The basin is divided into two sub-basins: the upstream area of Nakhon Sawan with 106,500sqkm, and the down stream area with 55,000sqkm. Annual discharge from the basin is about 30,000cum and flow rate is more than 1,000cum/2. Width of the river at Bangkok area is about 180m and the depth is 20m.

The upper portion of the tributaries up to Nakhon Sawan are still natural rivers, while those in the lower reaches are converted artificially to meet the requirements of irrigation, hydropower generation and municipal water supply.

The upper basin covers the majority of the northern region, where the area is mountainous and hilly with wide sloping valleys running along the basin. The forest covers about 55% of the drainage area in the upper basin.

In the central valley consisting of the northern hilly area and the central valley, an alluvial plain has been formed by the Chao Phraya river system. The upper plain in the central valley located north of Chai Nat is formed by the lower river valley of the Ping, Yom and Nan rivers. An alluvial plain called the Bangkok plain lies south of Chai Nat.

During flooding period, the delta area is completely inundated. The greater part of the Bangkok plain is covered by a layer of so-called Bangkok dark heavy clay with a thickness of approximately 2m. This soil, under the conditions of yearly flooding and consolidation, is extremely suitable to rice production.

In the downstream area from Chai Nat, the main river branches into several tributaries: the Noi, Lop Biro and Pasak rivers. The river meanders as a single channel from Ayutthaya southwards until the Gulf of Thailand. The lower stretch is affected by ocean tides up to Pa Mok in Ang Thong (about 160km from river mouth). In the downstream section from Chai Nat to Ayut-

thaya, the river has a slope of 5-6cm/km, while from Bang Shai to the river mouth, it has a milder slope of 2cm/km.

The boundary of the basin in the study area is delineated referring to the watershed map prepared by RID. However, it is limited to the drainage area during dry season under natural topographic/hydraulic conditions, while the area coverage of the RID is larger (especially in the lower part of the basin) because it includes areas covered for irrigation. The total area of the lower Chao Phraya river basin for this study arrived at 6,037.4sqkm.

The overall Chao Phraya river basin and composition of provinces in the basin are shown in Figures 2.3.2 and 2.3.3 respectively.

2.4 Inundation and Flood Control

2.4.1 Inundation and Flood Control Damage

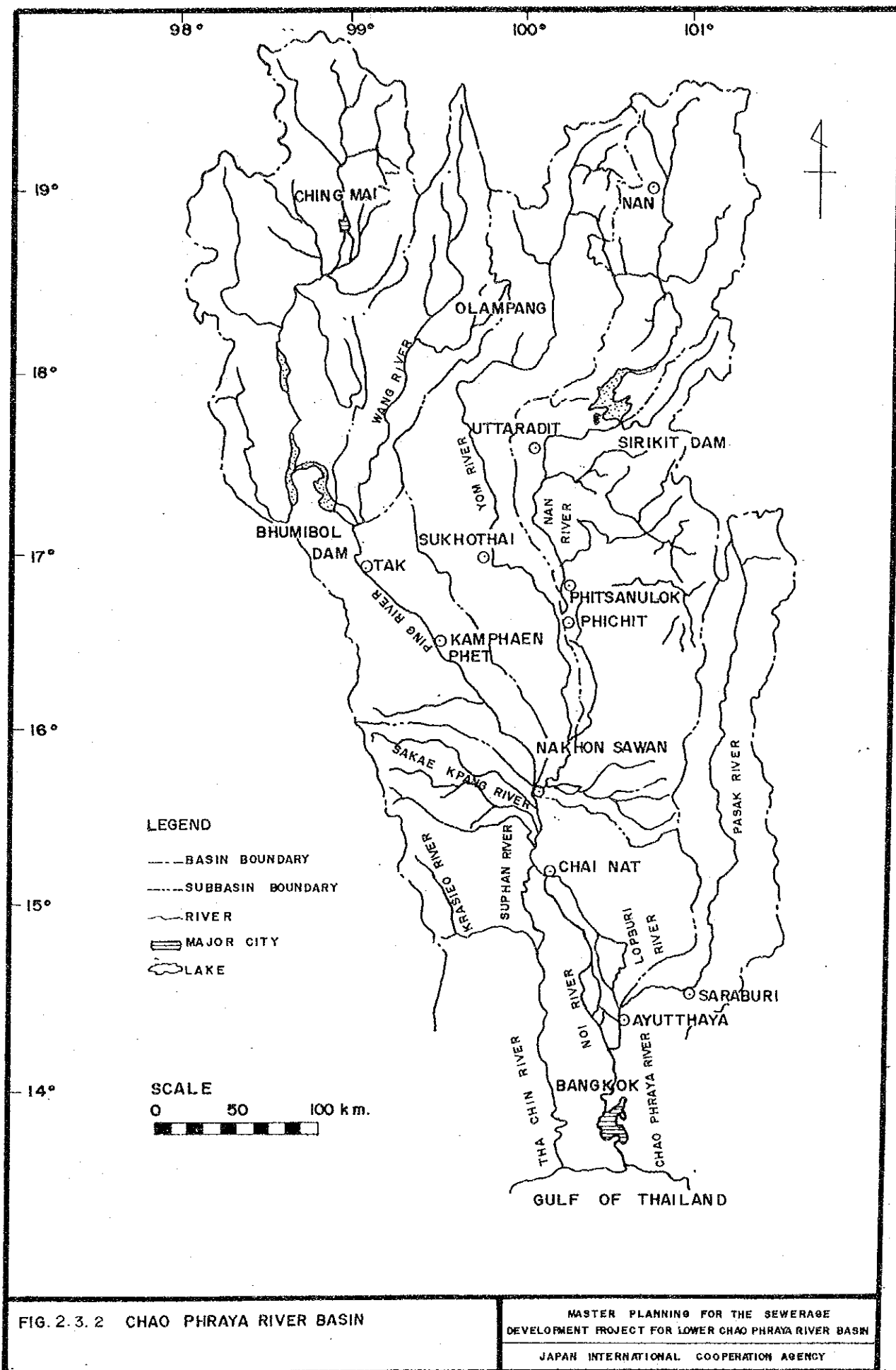
Major flood damages along the Chao Phraya river are caused by overflow of the main river and its major tributaries during the rainy season, but in some areas, inundation is caused by torrential rainfall. Generally, flood problems occur both in lower and upper basins from Nakhon Sawan.

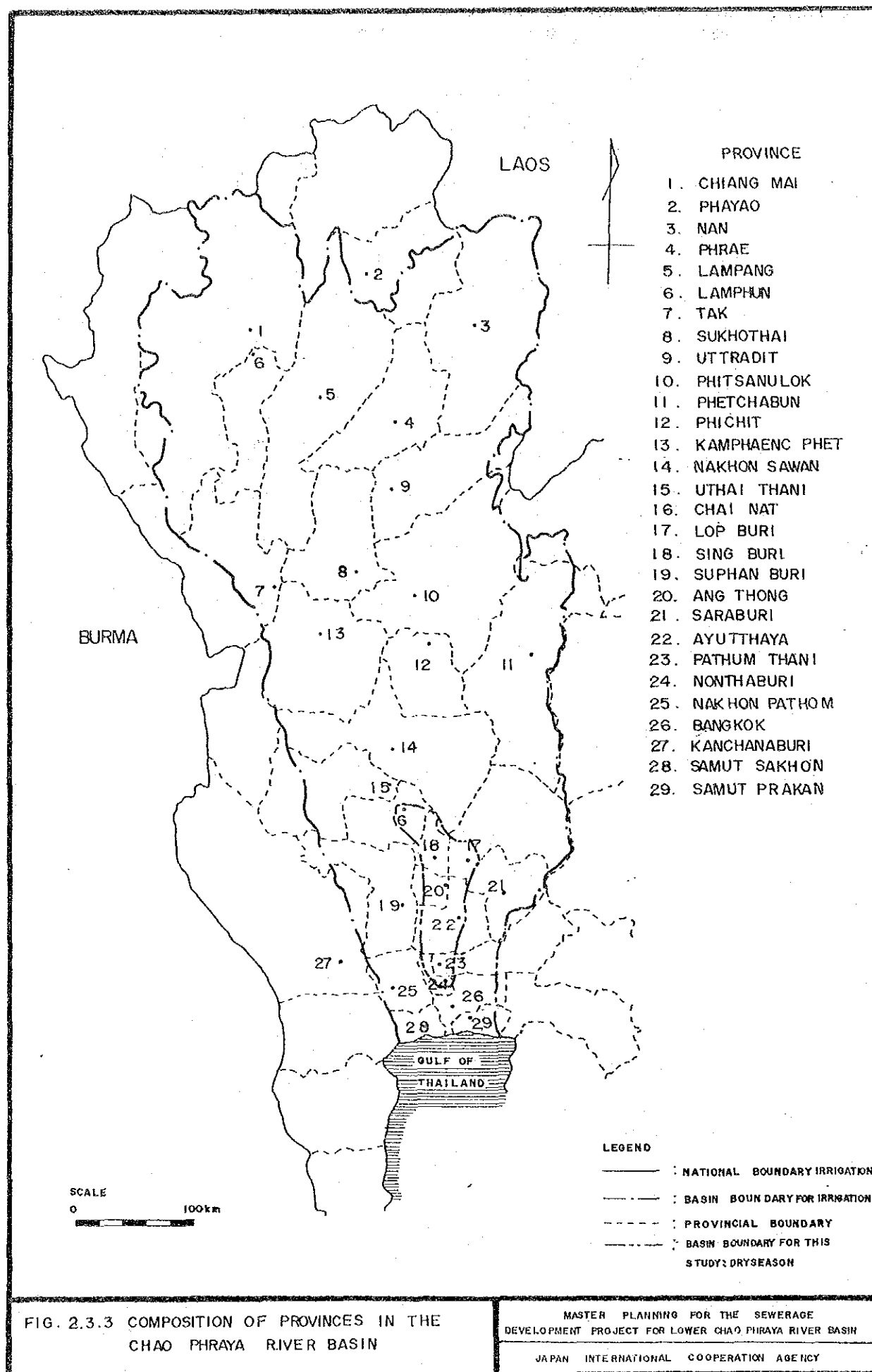
Upper Basin from Nakhon Sawan

Flood records show that there were 400,000 casualties for the period 1976-1985. The records also revealed that floods had affected a total area of 33,000ha. Section 2.4 of Volume IV-Data Report presents flood records taken from the questionnaire survey.

In the upper basin, major flood areas are:

- 1 Wang river basin: Along Wang river near the confluence with Ping river.
- (2) Yom river basin: The lower part of the Yom river between Sukhotai and the confluence with Nam river.
- (3) Nan river basin: The area along several tributaries of Nan river.





Lower Basin from Nakhon Sawan

In the lower basin, records showed that there were around 1,452,000 flood casualties and the flooded area extended up to 171,000ha.

The recent serious flood problems were recorded in 1975, 1978, 1980 and 1983. Major causes of these floods were torrential rains and low flow capacity of river courses.

Inundation occurs mostly in the west middle part of the lower reaches from Sing Buri to Ayutthaya. This is probably because of the existence of natural rivers without provision of an appropriate embankment. The capacities of these rivers are also inadequate to carry torrential rainfall and high discharge from the main river.

Another cause of inundation is the tidal effects on the lower part of the basin. The big flood experienced in 1983 was the result of this phenomenon given the allowable flow rate of the main river.

A summary of the recorded peak discharge by river is shown in Table 2.4.1.

Table 2.4.1 Discharge Rate by River

River	Drainage (sqkm)	Peak Discharge (cum/s)		
		1978	1980	1983
Ping-Wang	42,700	1,178	905	1,439
Yom	21,415	480	732	465
Nan	32,878	1,430	1,520	673
Chao Phraya				
Nakhon Sawan	110,569	3,540	4,320	2,290
Chai Nat	120,693	3,740	3,795	3,290
Pasak	14,374	3,206	886	851

It can be concluded that one of the main causes of floods in the Chao Phraya river basin is excess discharges/overflow from the river. Although the amount of water released downstream is controlled at the dams in the upper basin, it is sometimes unavoidable to release water beyond the capacity of the river to ensure structural stability of the dams. In the lower basin from Ayutthaya to the river mouth, the tidal effect is also an essential

cause of flooding. During low tide, flow velocity decreases gradually and under constant flow rate there is a rise of water level, sometimes over the river bank. Water releases from the upstream dams, torrential rainfall and tidal effect are, therefore, considered as major reasons of flood problems.

2.4.2 Flood Control

Hydraulic structures in the Chao Phraya river are categorized into 4 types according to their functions and structures as follows:

- (1) Dams and reservoirs on main tributaries in the upper part
- (2) Diversion weirs or barrages across main river
- (3) Regulators or gates on main canals
- (4) Flood protection dike along the main river

The main functions of these structures are to control the amount of water for various purposes, i.e., hydropower generation, irrigation, flood control, flood mitigation, salt water intrusion control, and navigation.

Major hydraulic structures in the basin are as follows:

- (1) Dam and Reservoirs

Bhumipol Dam and Sirikit Dam are major dams in the upper basin located on natural tributaries. Controlled discharges at these dams affect flow rate of the main river at Nakhon Sawan.

- (2) Diversion Dams/Weirs/Barrages

Major dams/weirs/barrages in the lower basin are described below and location of these facilities is shown in Figure 2.4.1.

- 1) Chao Phraya Dam/Barrage

Chao Phraya Dam/Barrage is located in the uppermost part of Chao Phraya river in Chai Nat province. This barrage has multifunctions, i.e., irrigation, navigation, municipal water supply, salinity and flood control. The dam is composed of 16 units of

DISTANCE FROM ESTUARY AND
WATER QUALITY STANDARD

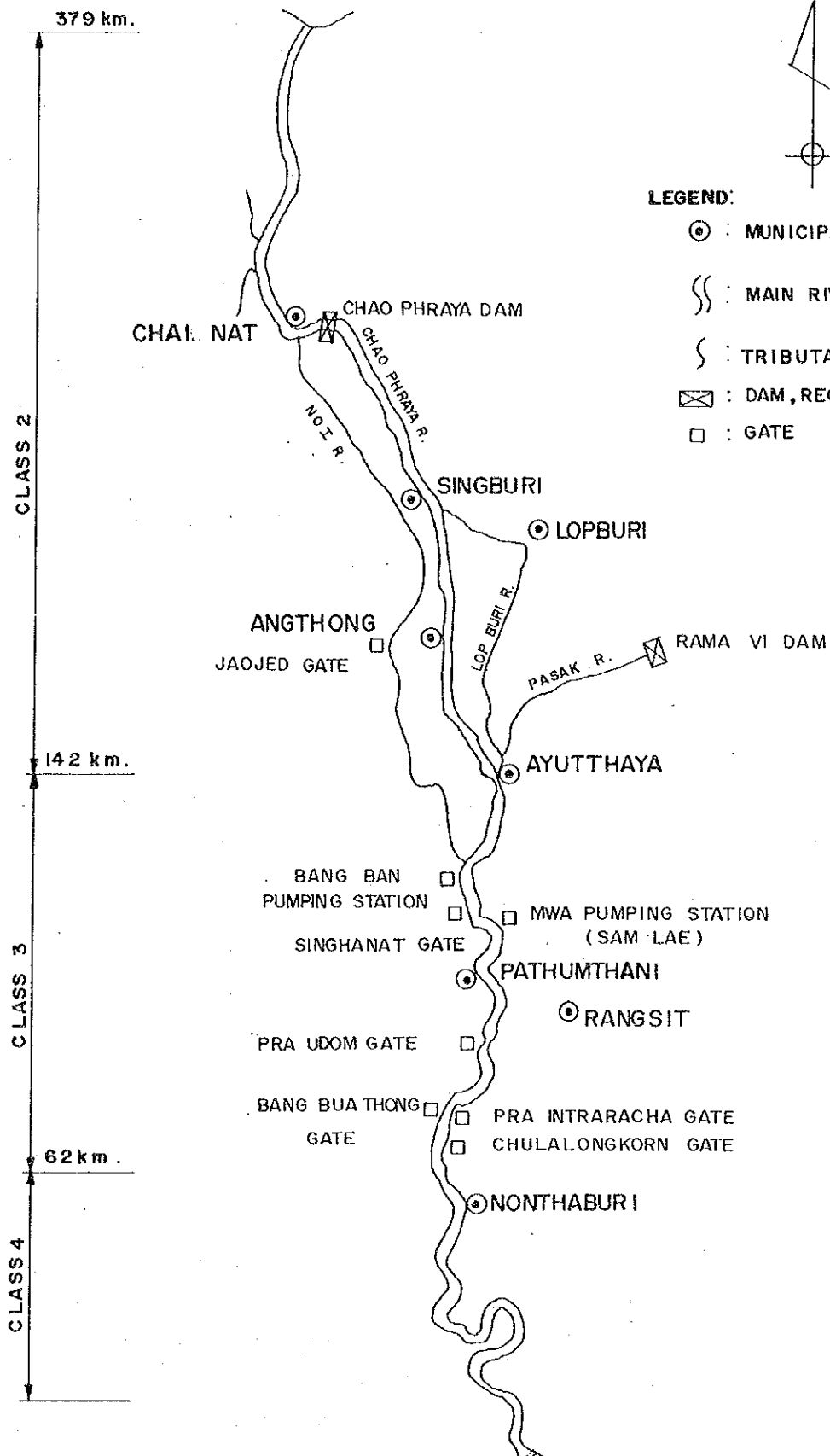


FIG. 2.4.1 HYDRAULIC STRUCTURES LOCATED ALONG
CHAO PHRAYA RIVER AND ITS TRIBUTARIES

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DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

12.5m wide radial gates and a 14.0m wide lock with a miter gate. An emergency spillway of 1,000m long with a crest elevation of +17.00m (amsl) is located on the left bank. Design peak discharge is 3,300cum/s.

Some important operational regulations of the dam are as follows:

- a) Water level behind the dam is kept at +16.50m (amsl) for controlling flow rate to lower water courses.
- b) Water head between upstream and downstream portions of the dam is controlled to be less than 9.5m to maintain structural stability.
- c) Minimum discharge is set at 50 m³/s for the purpose of navigation, salinity control and municipal water supply during dry season.

2) Rama VI Dam/Barrage

Rama VI barrage located on Pasak river in Ayutthaya province was constructed and completed in 1924 with 6 units of 12.5m wide and 7.5m high slide gates. The function of the barrage is basically for irrigation in the Pasak river basin. This barrage also plays a crucial role for flood control together with Chao Phraya Dam in the Chao Phraya river basin. However, operational regulations are still not clear and discharge during dry season is nil.

3) Major Regulators and Gates

There are several regulators and gates along Chao Phraya river and its tributaries. Main purposes of these regulators are for irrigation and navigation manually controlling the discharge through the gates. Flow capacities of these regulators are commonly designed with less than 20 m³/s. Most of the regulators including Bang Ban Pump Station, Singhanat Gate, Phra Udom Gate,

Bang Bua Thong Gate, Chulalongkorn Gate and Pra Intraracha Gate are located from Ayutthaya to Nonthaburi provinces to cope with the large agricultural land.

4) Flood Protection Dike along Major Rivers

Flood protection dikes were constructed mostly along the Chao Phraya river and the lower portion of Pasak river to prevent flood damage in the surrounding agricultural areas. The height of dike was designed for a 25 year return period with free board of 0.5m. After that big flood in 1983, the height of the dike was raised consequently, increasing the height of free board from 0.5m to 1.0m. In the area of Bangkok Metropolis, circle levees or dikes were constructed not only to prevent overflow from the Chao Phraya river, but also inflow from the north and east areas. In the urban area of the west bank, the feasibility of a polder system is being studied.

During rainy season, river flow is controlled for flood prevention, but occasionally due to torrential rainfall, discharge volume goes beyond the capacity of the dams and excess water has to be released to the drainage basin resulting to flood problems. On the other hand, during dry season, the flow is mainly controlled for irrigation use, saltwater intrusion control and navigation purposes. Discharges from dams and barrages during rainy season are arranged at a minimum level so that enough water is stored for paddy cultivation, since run-off from rainfall is negligible during dry season.

CHAPTER 3

LAWS AND REGULATIONS RELEVANT TO WATER POLLUTION CONTROL AND WATER POLLUTION STATUS

CHAPTER 3 LAWS AND REGULATIONS RELEVANT TO WATER POLLUTION CONTROL AND WATER POLLUTION STATUS

3.1 Administrative/Institutional Set-up Related to Water Pollution Control

Environmental problems are becoming more and more serious in Thailand due to the rapid growth in its economy and urbanization. In the past, the Public Works Department (PWD) was the main organization in charge of water pollution control. Later, due to the rapid growth of Bangkok Metropolis, the Bangkok Metropolitan Authority (BMA) was established and it took over the responsibility of water pollution control. The Office of the National Environment Board (ONEB) was also established to carry out the main responsibility of environmental management in Thailand.

Due to the urgency and difficulty of solving water pollution problems, countermeasures are being provided through the cooperation of several agencies/offices including the Pollution Control Department (PCD) (re-organized from ONEB), BMA, PWD, Department of Industrial Works (DIW), Department of Health (DOH), Royal Irrigation Department (RID), and others. The Central Government agencies involved in water environmental management are indicated in Figure 3.1.1 and are described as follows:

(1) National Economic and Social Development Board (NESDB)

The NESDB is the central economic planning agency of Thailand and it is under the Office of the Prime Minister. The NESDB methodology in drawing up environmental plans and policies includes, in addition to internal studies and analysis, consultation and coordination with other government agencies, working groups/committees (inter-agency on otherwise), the academy and other consultants/experts. Aside from its planning tasks, the NESDB screens/evaluates and monitors plans and projects of sectoral agencies.

(2) Department of Industrial Works (DIW)

The DIW is under the Ministry of Industry and its principal function in environmental management is to enforce the Factory Act and other

OFFICE OF THE PRIME MINISTER

- THE OFFICE OF THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT BOARD

MINISTRY OF AGRICULTURAL AND COOPERATIONS

- ROYAL IRRIGATION DEPARTMENT
- DEPARTMENT OF AGRICULTURE
- ROYAL FORESTRY DEPARTMENT
- LAND DEVELOPMENT DEPARTMENT
- DEPARTMENT OF FISHERIES
- DEPARTMENT OF LIVESTOCK DEVELOPMENT
- AGRICULTURAL LAND REFORM OFFICE

MINISTRY OF INTERIOR

- DEPARTMENT OF LOCAL ADMINISTRATION
- DEPARTMENT OF PUBLIC WORKS
- DEPARTMENT OF PUBLIC WELFARE
- DEPARTMENT OF TOWN AND COUNTRY PLANNING
- DEPARTMENT OF LANDS
- METROPOLITAN WATER WORKS AUTHORITY
- PROVINCIAL WATER WORKS AUTHORITY
- BANGKOK METROPOLITAN AUTHORITY
- OFFICE OF ACCELERATED RURAL DEVELOPMENT

MINISTRY OF PUBLIC HEALTH

- DEPARTMENT OF HEALTH

MINISTRY OF INDUSTRY

- DEPARTMENT OF MINERAL RESOURCES
- DEPARTMENT OF INDUSTRIAL WORKS

MINISTRY OF TRANSPORT AND COMMUNICATIONS

- HARBOUR DEPARTMENT
- METEOROLOGICAL DEPARTMENT
- THE PORT AUTHORITY OF THAILAND

MINISTRY OF SCIENCE, TECHNOLOGY AND ENVIRONMENT

- OFFICE OF ENVIRONMENTAL POLICY AND PLANNING (OEPP)
- POLLUTION CONTROL DEPARTMENT (PCD)
- ENVIRONMENTAL PROMOTION DEPARTMENT (EPD)
- THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

MINISTRY OF DEFENCE

- ROYAL THAI ARMY

FIG. 3.1.1 GOVERNMENT AGENCIES INVOLVED
IN ENVIRONMENTAL MANAGEMENT

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DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

acts pertinent to industrial operations. One of its specific functions is to oversee industrial activities with environmental implications. The organizational chart of DIW is shown in Figure 3.1.2. Among others, its activities in environmental management are the following:

- 1) Issuance of licenses prior to construction of factories;
DIW reviews treatment system design and/or measures for pollution control prior to the construction.
- 2) Issuance of licenses prior to operation of facilities;
DIW inspects treatment facilities vis-a-vis approved design.
- 3) Factory Monitoring;
DIW regularly monitors wastewater treatment efficiency and issues all necessary instructions/orders to remedy any system deficiencies (within its powers under the Factory Act).
- 4) Renewal of Licenses;
DIW inspects factories, if necessary, when licenses are to be renewed every three years.
- 5) Industrial Complaints;
When complaints related to industrial pollution are received, DIW inspects the facilities, and under the Factory Act, issues all necessary instructions.
- 6) Issuance of Factory Expansion License;
DIW reviews the existing wastewater treatment system and determines its viability/effectiveness vis-a-vis the proposed expansion.
- 7) Treatment Facility Design;
DIW designs treatment facilities for factories with small production capacities, without charging any fee.
- 8) Central Wastewater Treatment Facilities;
DIW has constructed central wastewater treatment plants for the

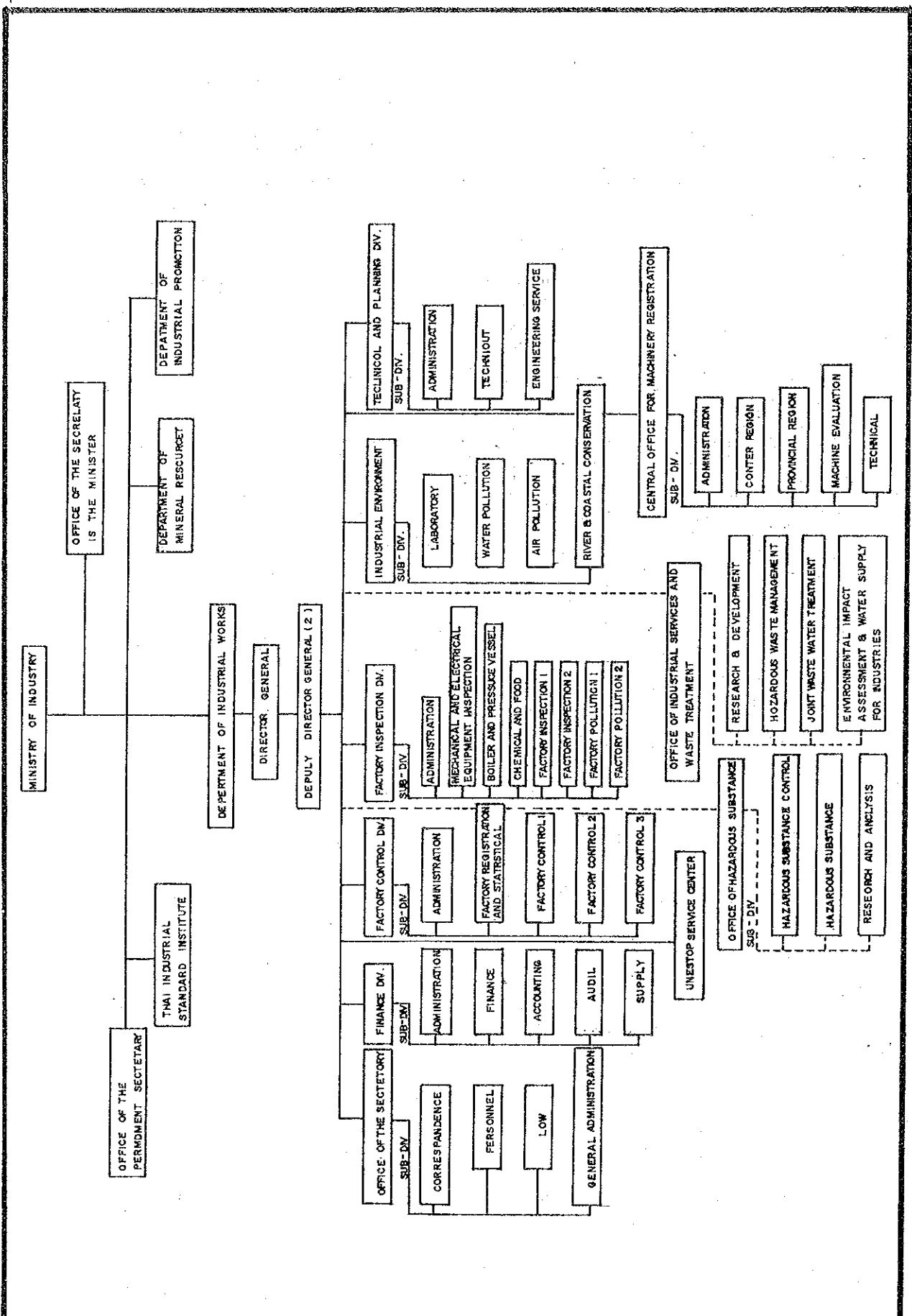


FIG. 3.1.2 ORGANIZATION CHART OF DEPARTMENT
OF INDUSTRIAL WORKS

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

wastewater generated at the sugar refineries in Ratchaburi and Kanchanaburi provinces and for hazardous wastes treatment at Bangkhuntien.

- 9) Training for Treatment Operations;
DIW conducts training courses for operators/technical staff in operation of industrial wastewater facility.

(3) Department of Health (DOH)

The DOH is under the Ministry of Public Health and conducts environmental monitoring.

(4) Public Works Department (PWD)

The PWD is under the Ministry of Interior. PWD's main areas of responsibilities comprise the following:

- 1) Technical Services;
These services include planning and design works, construction supervision of both government and private projects, construction of public utilities and supply of equipment, etc.
- 2) Legal Aspect;
Primarily enforcement of building codes.
- 3) Urban Area Development;
Providing solutions to basic problems, e.g. traffic, water supply, wastewater treatment, solid waste disposal, etc.
- 4) Rural Development;
Construction/provision of basic infrastructures like roads, water and power supply, and other public utilities.

PWD has regional administration offices which are directly under the central office. The regional offices manage a total of 72 provincial offices. Among the divisions of the PWD, the Sanitary Engineering Division (SED) is in charge of water pollution control. Its main

functions are planning and design of flood protection, drainage, solid waste disposal and sewerage works for municipalities and sanitary districts, etc. Other responsibilities include application and research activities, such as standardization and improvement of sanitary works. The organizational chart of the PWD is shown in Figure 3.1.3.

- (5) OEPP, PCD and EPD of the Ministry of Science, Technology and Environment

The ONEB which was established in 1974 as the lead environmental agency in Thailand has been re-organized in April 1992 into three new offices, as follows :

- 1) Office of Environmental Policy and Planning (OEPP)
- 2) Pollution Control Department (PCD)
- 3) Environmental Promotion Department (EPD)

Main tasks of each office are as follows :

- 1) Office of Environmental Policy and Planning (OEPP)
 - to develop the alternatives of environmental policy
 - to formulate the management system, implementation programs, and long-term and short-term plans of Pollution Control together with PCD and EPD
 - to follow-up activities of the government agencies, state enterprises and private sectors in compliance with the national environmental quality standards, including the prevention of pollution from industry, energy and agriculture.
- 2) Pollution Control Department (PCD)
 - to supervise the works in planning, design and operation of development projects in the country to ensure the appropriateness of these projects with reference to measures for

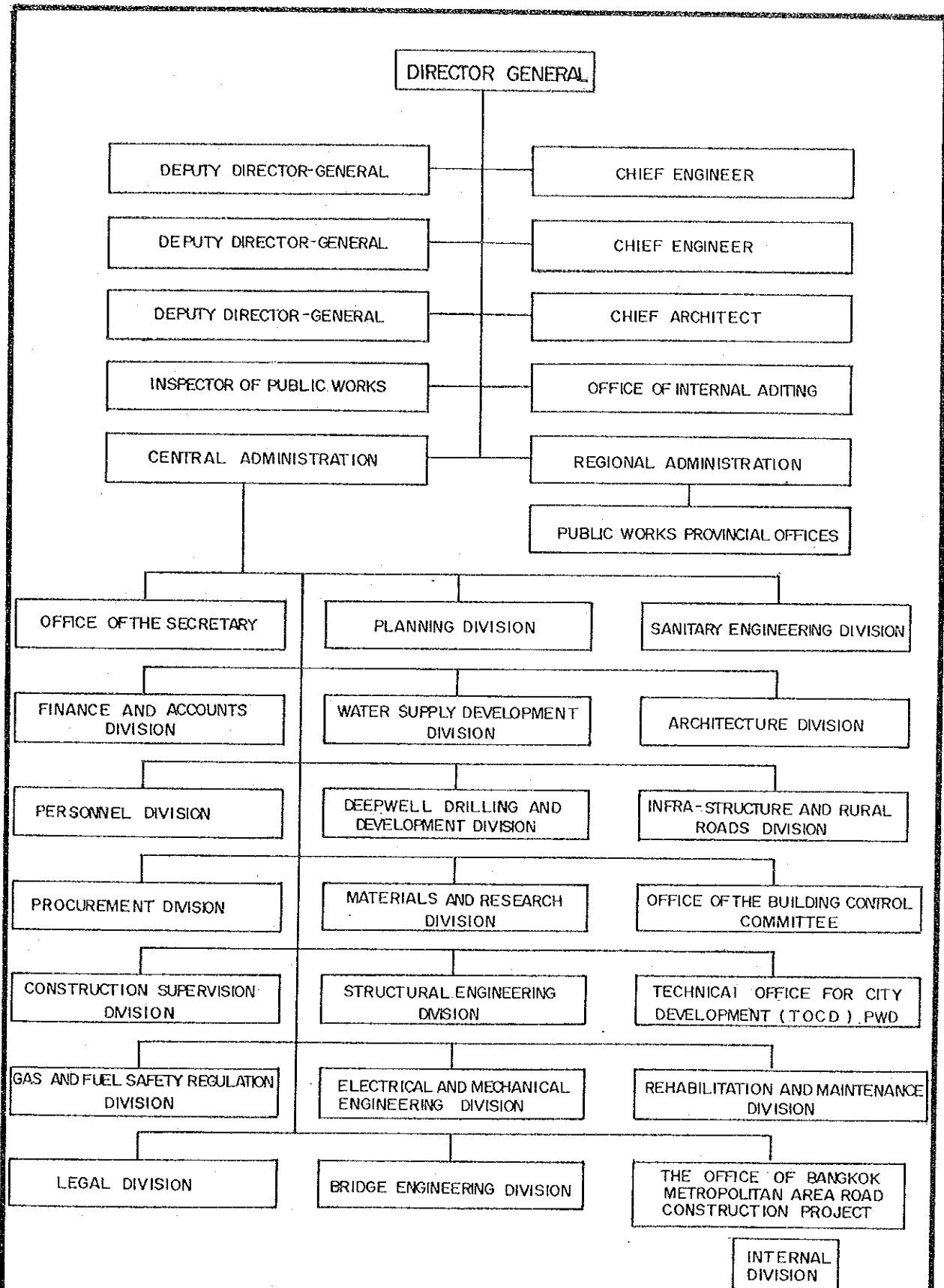


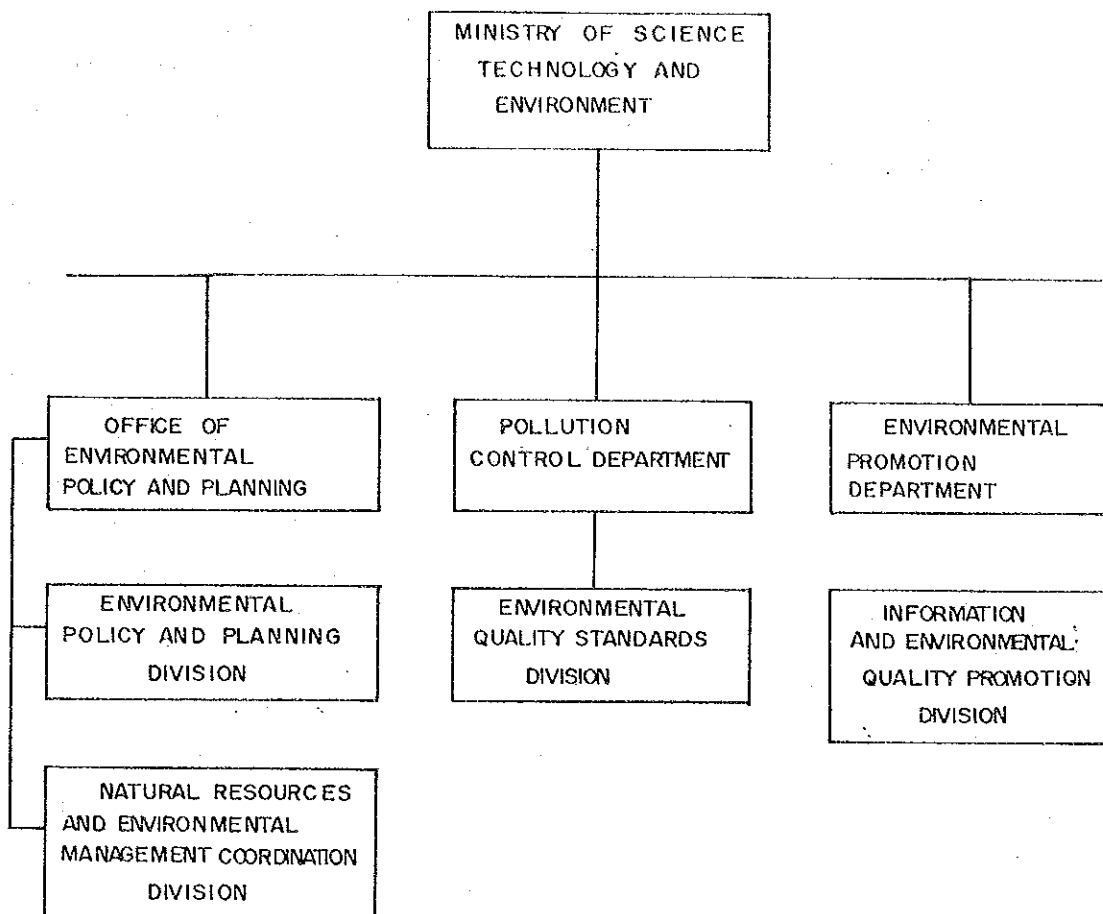
FIG. 3.1.3 ORGANIZATION CHART OF THE
PUBLIC WORKS DEPARTMENT

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DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

conservation of the natural resources

- to implement the Environmental Impact Statement (EIS) program, including the provision of technical guidelines and advises for the preparation of the EIS reports by the project proponents.
 - to carry out special studies and researches needed for establishment of environmental protection plans, for specially sensitive regions including Chao Phraya river, Mae Khlong river, the Songkla Lake, the beach resorts of Pattaya and Phuket, the Khao Yai Park and other special resource areas
 - to monitor the environmental quality and record the data for effective use in conservation of the environmental quality
 - to recommend the minimum criteria or standards needed for assuring the reasonable protection of natural resources such as water, land, air, etc.
 - to undertake studies/projects on special environmental problems in cooperation with other government agencies
- 3) Environment Promotion Department (EPD)
- to serve as a center for coordination and public relations in the promotion of environmental quality improvements within the country and with foreign countries
 - to prepare official documents and information materials, and publish and distribute journals,
 - to carry out environmental education, training, etc.

The organizational chart of the OEPP, PCD, and EDD is shown in Figure 3.1.4.



NOTE : ONLY SHOWS OFFICES / DEPARTMENTS UNDER THE MSTE
WHICH ARE INVOLVED IN ENVIRONMENTAL MANAGEMENT

FIG.3.1.4 ORGANIZATION STRUCTURE OF ENVIRONMENTAL
MANAGEMENT OFFICES / DEPARTMENTS
UNDER THE MSTE

MASTER PLANNING FOR THE SEWERAGE
DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

(6) Royal Irrigation Department (RID)

The RID is under the Ministry of Agriculture and Cooperatives. The main function of the RID is to manage all hydrology related works for the whole country with special attention to the Chao Phraya river basin. Major activities of the department are:

- 1) Collection of meteorological and hydrological data
- 2) Planning, study and design of the water resources/irrigation facilities
- 3) Operation and maintenance of the river for irrigation use, flood control, salt water intrusion control, navigation, etc.
- 4) Liaison with other agencies on activities for hydropower, waste-water treatment, etc.

Relevant divisions of the department which have important roles/functions in the Chao Phraya River basin are:

1) Hydrology Division

This Division has three field investigation offices in the Chao Phraya river basin located at Chiang Mai, Phitsanulok and Chai Nat.

The work of the division entails hydrological observation, and data filing for the analysis/study of hydrological phenomenon in the river basins, especially on the Chao Phraya River. Other functions include observation of intake water for irrigation use, daily collection of weather forecast maps from the Meteorology Department as well as maintenance of recording gauges.

2) Operation and Maintenance Division

This division is in charge mainly of the operation and maintenance of constructed river structures and water flow controls in

agricultural areas. The division also collects hydrological data from regional irrigation offices to analyze them.

The organization chart of the RID is shown in Figure 3.1.5.

(7) Local Administration

Local administration also plays an important role in water pollution control, although it may be restricted due to limited mandate and technical expertise at the present time.

For example, municipalities undertake various environmental management works within its jurisdiction. Such works are principally handled by the Sanitation and Environmental Department, and these are broken down as follows:

- 1) Garbage disposal
- 2) Maintenance of existing drainage and sewers
- 3) Control and monitoring of wastes generated by factories
- 4) Maintenance of cleanliness
- 5) Control and monitoring of wastewater generated by slaughterhouses
- 6) Liaison with related agencies for environmental planning and implementation of the projects therefrom.

Figure 3.1.6 presents a typical organization of a municipality as represented by Ayutthaya Municipality.

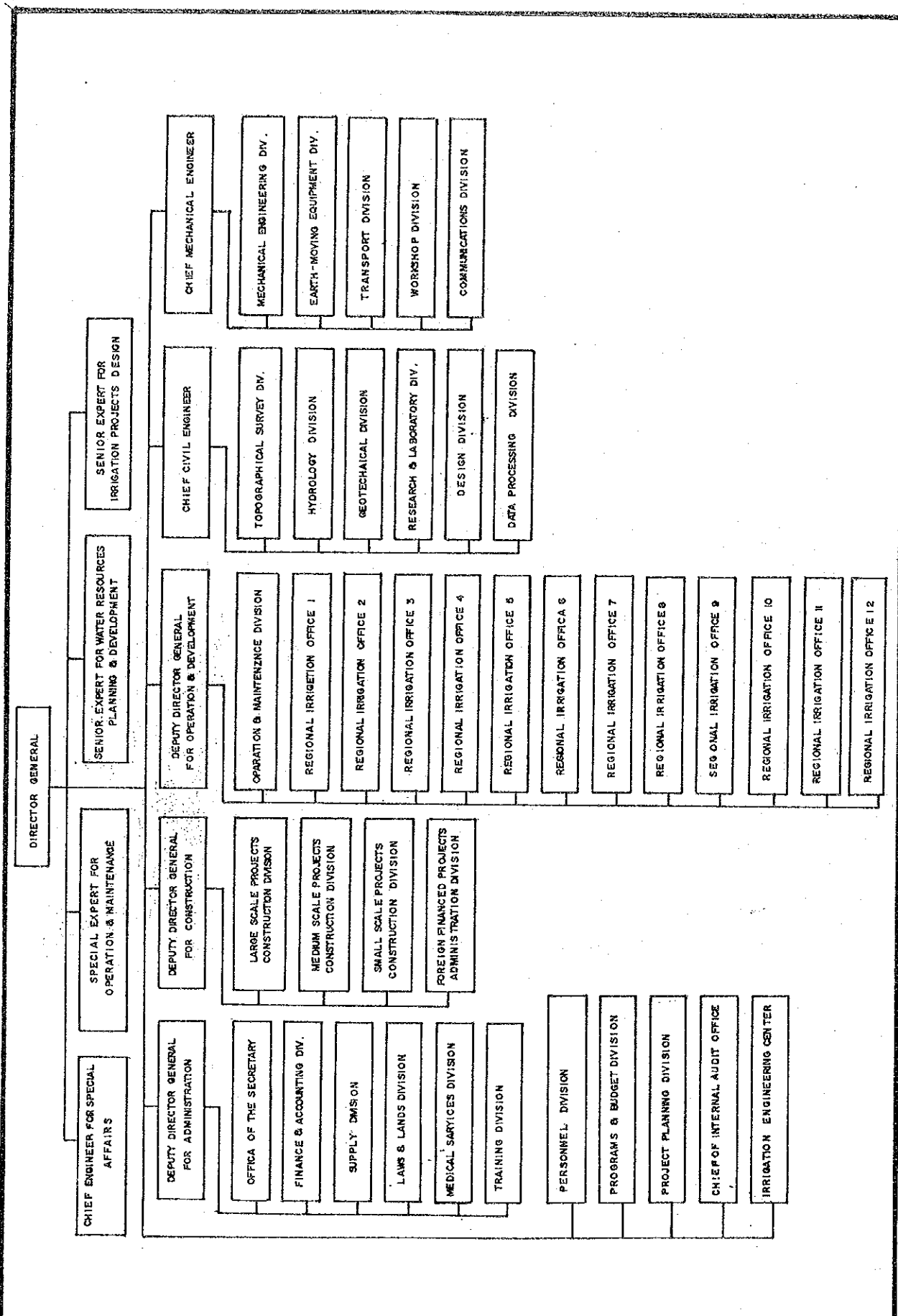


FIG. 3.1.5 ORGANIZATION OF ROYAL IRRIGATION DEPARTMENT

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DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

AYUTTHAYA MUNICIPALITY

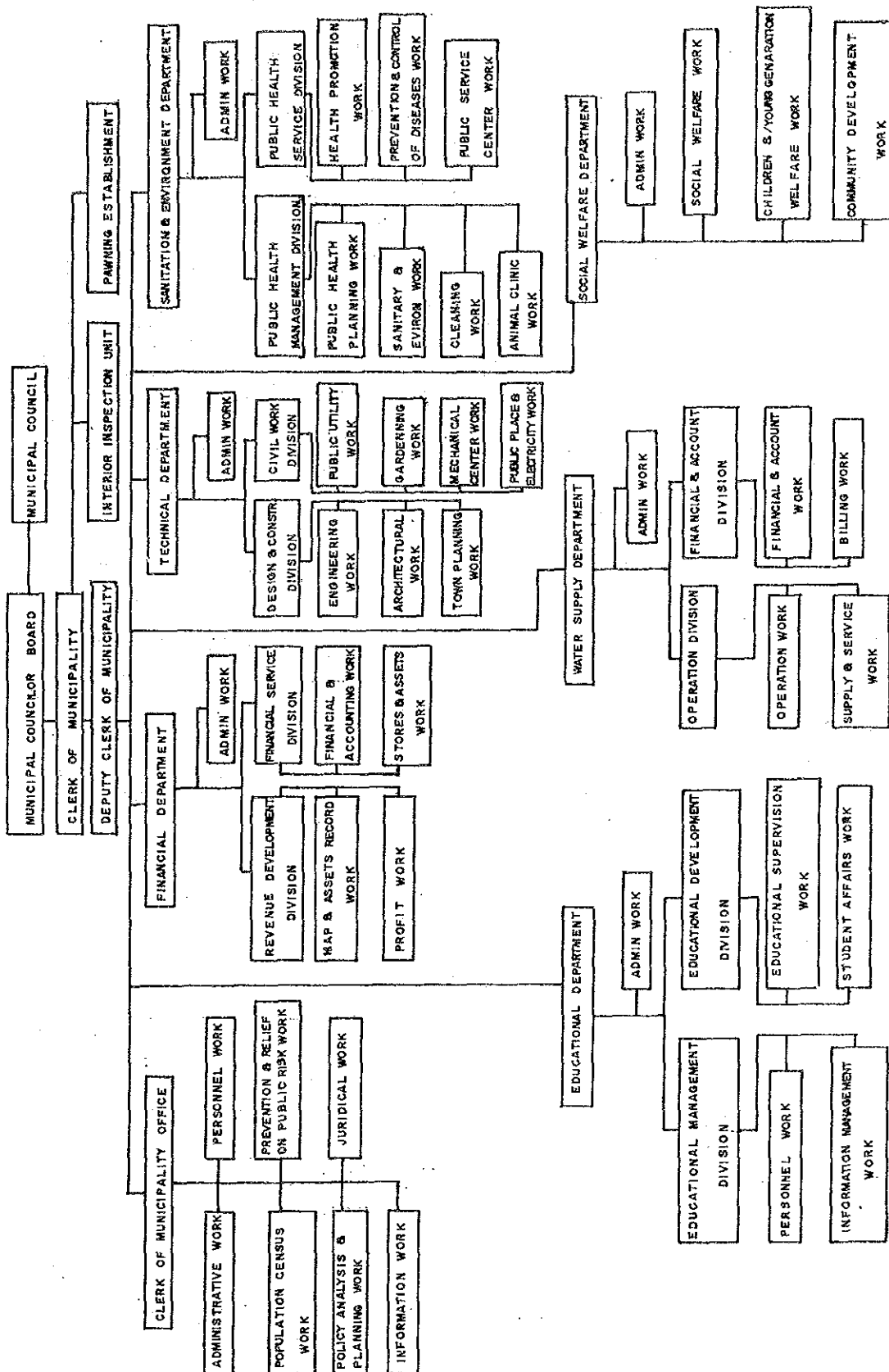


FIG. 3.1.8 ORGANIZATION CHART OF AYUTTHAYA MUNICIPALITY

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DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY

3.2 Present Policies and Countermeasures for Water Pollution Control

Policies and countermeasures have been formulated for environmental management purposes including water pollution control. These are embodied in the 7th National Economic and Social Development Plan (NESDP). More specific policies and countermeasures are formulated by bodies like the Special Committee for the Formulation of Policies and Countermeasures to Control Water, Air and Noise Pollution in Thailand and others.

3.2.1 The Seventh National Economic and Social Development Plan (NESDP)

One of the main development objectives of the 7th NESDP is the upgrading of the quality of the environment and natural resource management and corollary to this is the plan target for environmental development. Specifically, it calls for the reduction of BOD load of wastewater discharged to the lower part of the Chao Phraya river (from the estuary to 100km upstream) with not more than 4 mg/l. The following guidelines/policies pertinent to water pollution were formulated to attain the objectives and targets set in the 7th Plan.

(1) Reduction of Water Pollution Load Generated by Communities, and Industrial and Agricultural Activities by:

- 1) Supporting relocation of pollution-generating industries within Bangkok Metropolis and vicinity towns to designated areas;
- 2) Enforcing the effluent standards for all buildings based on the building control act or other existing laws, and livestock and agriculture farms;
- 3) Collecting water fees from agricultural and industrial activities as well as levying effluent charges to encourage economical use of water and to stimulate application of appropriate technology;
- 4) Encouraging use of wastewater treatment technology in production/business operations;
- 5) Encouraging waste recycling and promotion of use of treated wastewater;
- 6) Controlling and supervising reduction of pollution level particularly in locations outside the target zones of wastewater

treatment systems.

- (2) Enforcement of Control Measures and Prevention of Additional Effluent Discharges to Public Water Bodies (Currently facing critical problem) by:

- 1) Controlling construction/expansion of factories which generate water pollution load, as well as the location and expansion of communities near the target water resources;
- 2) Encouraging establishment of industrial estates/zones;
- 3) Designating land use zones for livestock and aquaculture farms, supporting business operations in the form of estates, grouping, associations which have a system of basic facilities, i.e., wastewater treatment system, etc.; and
- 4) Separating sanitary sewerage systems from drainage systems in new communities/industrial areas to increase pollution control efficiency.

- (3) Investment in Wastewater Treatment Systems, in particular:

- 1) Construction of comprehensive wastewater treatment systems for communities and industrial plants in target areas e.g. Bangkok Metropolis, vicinity towns, regional urban centers, tourist destination, etc.; and
- 2) Conduct of feasibility studies for the construction of wastewater treatment systems in other areas, in the order of priority.

In addition to the above, other significant environmental management policies in the 7th Plan are:

- (1) Promotion of the "polluter-pays-principle" (to ensure that polluters shoulder the burdens of treatment and disposal of wastewater);
- (2) Establishment of an environmental fund for investments in environmental management;
- (3) Promotion of private sector investments in environmental management