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-II

MAIN REPORT

JANUARY 1994

NIPPON JOGESUIDO SEKKEI CO., LTD.
PACIFIC CONSULTANTS INTERNATIONAL

JAPAM INTERNATIONAL COOPERATION AGENCY

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FOR

LOWER CHAO PHRAYA RIVER BASIN

VOLUME 2

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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
OUD	-	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, BOD5	-	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
H2S	-	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, ft3/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

PART II

SEWERAGE MASTER PLAN
FOR
THE EIGHT MUNICIPALITIES/AREAS

CHAPTER 1
INTRODUCTION

PART II SEWERAGE MASTER PLAN FOR THE EIGHT MUNICIPALITIES/AREAS

CHAPTER 1 INTRODUCTION

Sewerage Master Plan for the selected eight municipalities/areas was prepared based on data and information collected through the Stage I and II field work. The subject areas in the Lower Chao Phraya river basin cover Chai Nat, Sing Buri, Lop Buri, Ang Thong, Pa Mok, Sena, Rangsit and Bang Bua Thong.

Planning fundamentals and conditions/assumptions on the sewerage systems, which were discussed and agreed between JICA Study Team and PWD staff members are reflected in the study. In addition, recommendations on the sanitation improvement common to the eight study areas were made covering respective DTCP areas.

This Part II, Sewerage Master Plan, is arranged to consolidate eight plans simplifying the contents in provision of common conditions/assumptions and general approach and methodology in Chapter 2. Basic figures such as frame values and unit wastewater quantity and quality projected in the water pollution control plan in Part I are employed in principle after review of them through Stage II field work. Finally, This sewerage master plan was completed after Stage III field work.

CHAPTER 2
BASIC POLICY AND COMMON CONDITIONS TO THE AREAS FOR PREPARATION OF SEWERAGE MASTER PLAN

SECTION 1

PREVIOUS STUDIES RELEVANT TO SEWERAGE PROJECT

CHAPTER 2 BASIC POLICY AND COMMON CONDITIONS TO THE AREAS FOR PREPARATION OF SEWERAGE MASTER PLAN

This Chapter is intentionally arranged to cover major study items for sewerage master planning common to the eight study areas. Therefore, comparative studies for basic matters and methodologies with employed figures in the convenience of report organization are included covering technical, administrative, and financial and economic aspects.

SECTION 1 PREVIOUS STUDIES RELEVANT TO SEWERAGE PROJECT

The outline of existing/on-going sewage works and plans throughout Thailand is referred to in Chapter 4, Part I.

The areas covered for sewerage planning/design in the subject basin are three municipalities; Ayutthaya, Pathum Thani and Nonthaburi, and Rangsit area. Detailed design work for the industrial wastewater treatment plant in Rangsit area was completed at the end of 1992. Other projects are still under feasibility study stage waiting for the allocation of the budget form the central government.

Table 2.1.1 presents conditions and status of these projects. Major contents of these projects, entailing projections and design criteria are summarized in the Supporting Report 2.1.1 for reference purpose of the master planning.

Three agencies of the Thai government have been undertaking the sewerage planning/design under respective responsibilities; PWD-public sewerage projects, PCD-environmental protection and DIW-effluent quality control of factories.

General concepts and approach for planning/design are similar among them and still planning/design stage. PWD and PCD made arrangements to cover specific communities without overlapping in the study river basin for the sewerage projects.

Although plans and designs are prepared according to standard procedures and figures for planning fundamentals, the following seem to be

established/studied prior to the planning.

- Sewerage laws and regulations entailing the terms and conditions on combined collection of industrial wastewater and domestic sewage and effluent quality requirements for the discharge from wastewater treatment plants.

- Comprehensive water pollution control plan to achieve water quality standard in the public water body and seeking for effective and practical countermeasures among different wastewater sources.

- Augmentation of sewerage sector both in public and private systems to cover planning, design ,construction supervision, and operation and maintenance of the sewerage facilities.

Table 2.1.1 Conditions and Status of Relevant Sewerage Project (As of 1993)

Project Title	Objective of the Study	Study Area and Target years	Project Status
1. Lower Chao Phraya River Basin Water Pollution Control Master Plan	– Water Pollution control plan for Chao Phraya river and Tha Chin river – M/P for sewerage management	– Metro. Bangkok and its vicinity five provinces – Base year 1990 Target years 2000, 2010 and 2020	Study was completed and under review by PCD.
2. Comprehensive Study of Sewerage System for First Group Area	– M/P and F/S of sewerage systems for water pollution control and improvement of living standards	– M/P: DTCP area including future expansion area F/S: present municipality area – Base year 1991 Target years 2001, 2011 for M/P	Draft plan was completed in 1992. Further data collection is under way.
3. Flood Control, Drainage and Sewerage System for Nonthaburi Province	– M/P on flood protection and drainage systems F/S on sewerage system for Nontha buri and Pak kret	– M/P of flood protection and drainage systems: 246 km² F/S of flood protection and drainage system : 73.5 km² M/P of sewerage system : 73.5 km² F/S of sewerage system : 38.96 km²	Progress report was completed in May 1992 and under review by PWD
4. Pre–Feasibility Study of Domestic Wastewater Management for Pathum Thani	– F/S on the sewerage system – F/S on management of solid waste disposal	– Present municipality area of 7.1 km² – Base year 1991 Final target year 2011	Draft Final Report was prepared and under review by PCD.
5. Pre–Feasibility Study of Domestic Wastewater Management for Ayutthaya	–F/S on the sewerage system – F/S on management of solid waste disposal	– Ayutthaya municipality and its vicinity area – Base year 1991 Final target year 2011	Draft Final Report is under review by PCD.
6. Detailed Design of Wastewater Treatment Plant for Rangsit area	– Establishment of concept on sewerage system – Preparation of construction program of the facilities	– Rangsit area (about 200 factories exist in the study area)	Detailed design was finished and under review by DIW.

SECTION 2

WATER POLLUTION STATUS AND FUTURE PROSPECTS IN THE LOWER CHAO PHRAYA RIVER BASIN

SECTION 2 WATER POLLUTION STATUS AND FUTURE PROSPECTS IN THE LOWER CHAO PHRAYA RIVER BASIN

2.1 Present Status of Water Pollution

Present water pollution status represented by BOD in rivers, where the treated effluent from prospective wastewater treatment plants in the eight (8) subject municipalities/areas will be discharged, is shown in Figure 2.1.1. The maximum and minimum BOD figures during dry season are illustrated based on data collected from PCD and DOH as well as surveyed by JICA Study Team in four times.

Water pollution in Chai Nat area is not serious at present corresponding to relatively less pollution load being discharged from the municipality. However, the maximum BOD of 3.2 mg/l was observed in the survey as the direct influence of discharged pollution load from households located along with river banks.

Present water quality in the areas of Sing Buri, Ang Thong and Pa Mok is similar to each other and relatively better than the condition of Chai Nat area. Contribution of these areas to the water pollution at the water quality checking point downstream thereof in Chao Phraya river is likewise small.

As a whole, water quality meeting environmental standards is observed in the middle and upstream of Chao Phraya river, although there are cases that water quality exceeds the standards depending on river flow rate, etc.

With regard to water quality in major tributaries, the survey results of the Study Team is also exhibited in Figure 2.1.1, due to absence of existing data at agencies concerned. Present water quality nearby Lop Buri municipality ranges from 2.2 mg/l to 3.6 mg/l of BOD wherein wastewater discharged from the municipality has direct influence to water pollution. Although the self-purification effect is observed as water flows toward downstream, it is obvious that wastewater discharged from Lop Buri municipality is affecting water quality of Chao Phraya river in comparison with water quality surveyed between upstream and downstream of confluence point with main stream.

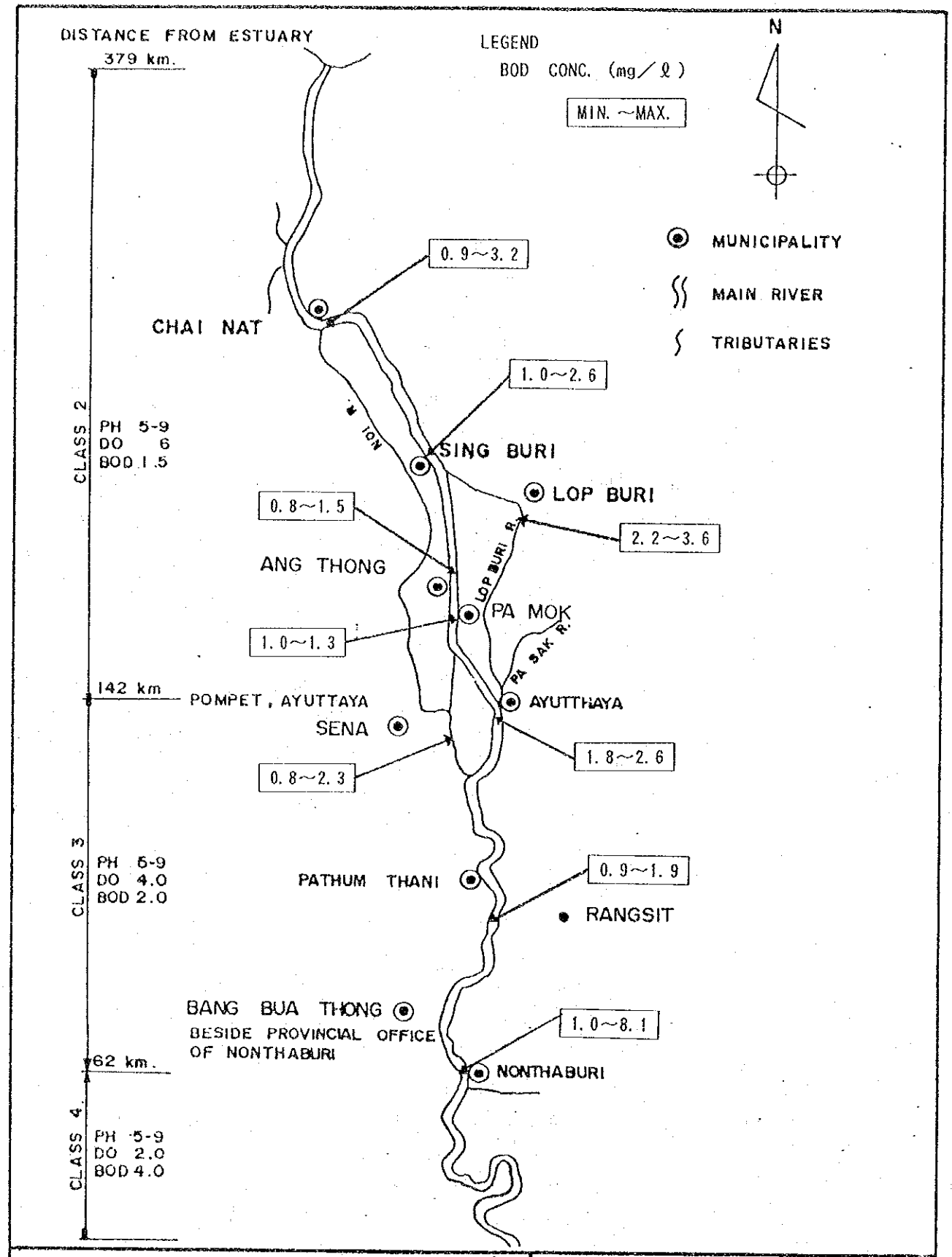

Figure 2.1.1 Present Water Pollution Status

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

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Sena municipality located downstream of Noi river has less influence of water pollution to Noi river.

Due to absence of water quality data nearby Rangsit and Bang Bua Thong in the downstream of Chao Phraya river, water quality observed nearby Pathum Thani and Nonthaburi is indicated in Figure 2.1.1 as substitute. The maximum BOD of 8.1 mg/l, which is about four times higher than the quality standard, is observed near Nonthaburi. The Study Team also determined 3.6 mg/l to 4.7 mg/l of daily average BOD. Likewise, water pollution in lower Chao Phraya river is becoming serious conditions. This water pollution condition is believed to be caused by the wastewater discharged from developed area including Rangsit and Bang Bua Thong, since considerably low BOD of 0.9 mg/l to 1.9 mg/l is observed near Pathum Thani in the upstream of these municipalities.

Based on the findings as mentioned above, present status of water pollution by sub-basin area is summarized as follows:

- Among 8 study areas, Bangkok Metropolitan area including Bang Bua Thong and Rangsit seems to be largely contributing to water pollution in the downstream of Chao Phraya river wherein water quality standard is not maintained. Khlongs and drainages being connected to the Chao Phraya river show serious water pollution conditions and urgent countermeasures for water pollution control is required.

- The middle and upstream of Chao Phraya river is, on the other hand, still tolerable condition of water quality owing to effects of self-purification of the river and dilution of pollution load. But khlongs and drainages in respective municipalities are polluted by inflow of wastewater being discharged in the vicinity and therefore water quality is deteriorating annually. Countermeasures for water pollution control is thereby necessary, though priority is lower than the downstream area of Chao Phraya river.

2.2 Future Prospect of Water Pollution

Future water quality at major checking points in main stream of Chao Phraya river and its tributaries and concentrated pollution load (BOD in 2011) are

projected in the course of water pollution analysis. The results are exhibited in Figure 2.2.1. Water quality characteristics at each checking point are as follows:

(1) Chao Phraya river: R-0 to R-1

When the water quality standard of R-0 is assumed at 1.5 mg/l of BOD, water quality of R-1 is forecasted at 1.3 mg/l owing to self-purification effect to relatively low pollution load to be discharged from Chai Nat municipality.

(2) Chao Phraya river: R-1 to R-2

Within the drainage area between R-1 and R-2 checking points, there exist Sing Buri, Ang Thong and Pa Mok municipalities as target areas for sewerage development. BOD in the year 2011 at R-2 checking point is projected to be 1.5 mg/l which is equivalent to the water quality standard. The concentrated pollution load from these municipalities reaches to approximately 40% of the total amount in this section, however contribution of each municipality to water pollution is low.

(3) Noi River

Sena municipality situates within the Noi river basin. The concentrated BOD load from Sena is approximately 500 kg/d which is about 6% of the total amount as negligibly small amount. In the downstream of Noi river, considerably large amount of concentrated pollution load are being disposed of from municipalities other than Sena causing 3.6 mg/l of BOD in the future, while 1.3 mg/l is projected in the upstream.

(4) Lop Buri river and Pa Mok river

Lop Buri municipality situates in the river basin of Lop Buri river and Pa Sak river and is major source of pollution load together with Ayutthaya municipality. As high as 6.5 mg/l of BOD is projected at downstream of Lop Buri river. Water quality in the main stream of Chao Phraya river at downstream of the confluence point is likewise projected to be 2.0 mg/l, while upstream of confluence point is 1.5 mg/l.

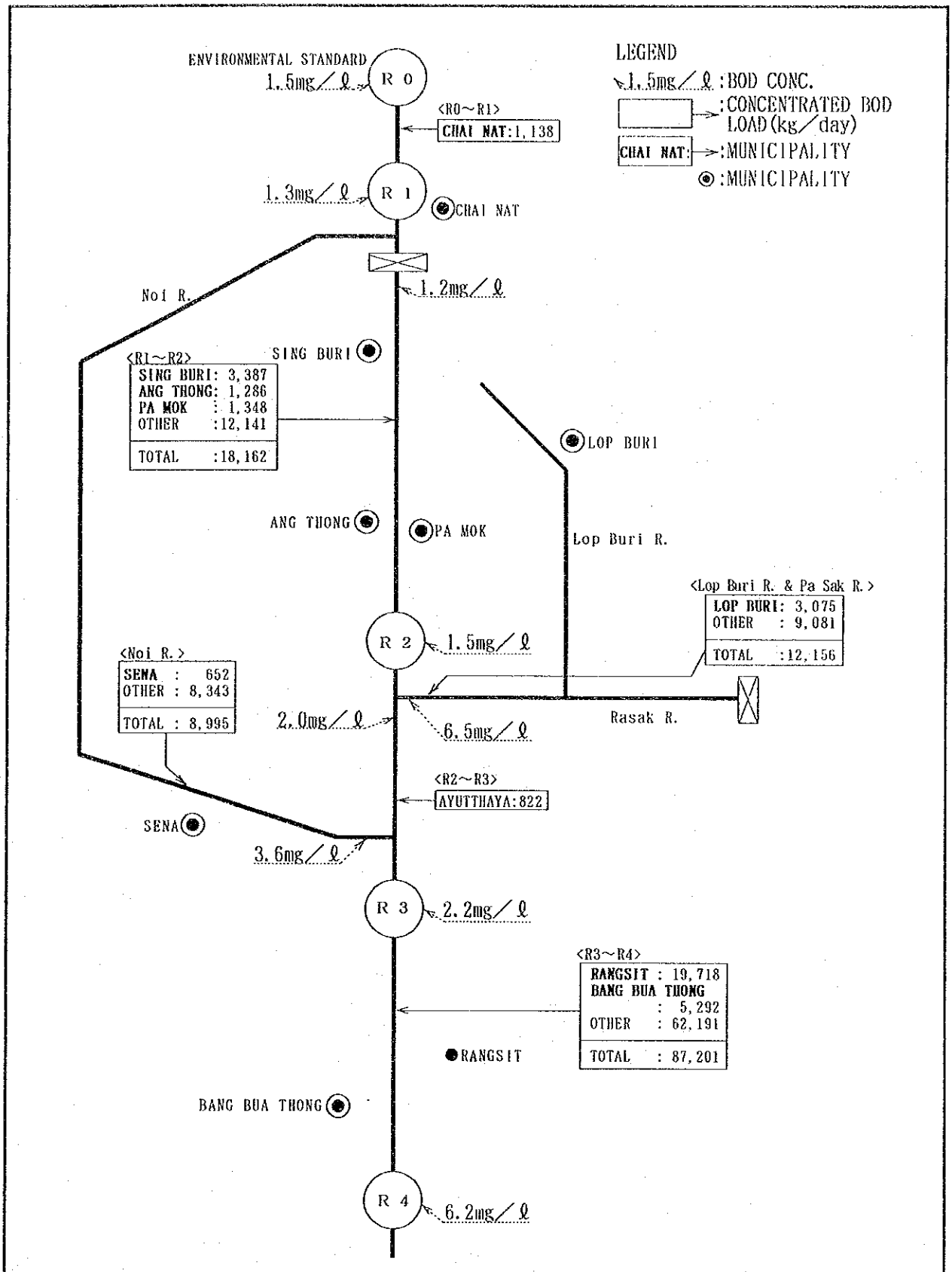

Figure 2.2.1 Relationship between Concentrated BOD Load and Projected BOD Concentration

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

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(5) Chao Phraya river: R-3 to R-4

Water quality at R-4 checking point, the lowest point in the study area, is projected to be 6.2 mg/l which is approximately 3 times of the water quality standard (2.0 mg/l). This water pollution is caused by discharge of pollution load within the drainage area of the section R-3 to R-4, especially Nonthaburi. Rangsit and Bang Bua Thong are also situated in the downstream area as pollution sources. Water pollution control measures in the drainage area, which is extension of the Bangkok Metropolitan area, are urgently required.

Aside from the influence of pollution loads discharged from major municipalities to the main rivers, deterioration of water quality in khlongs/drainages downstream of such municipalities will become much more serious than the present status. Countermeasures to reduce discharged pollution load are requisites to meet allowable environmental capacity of water bodies.

SECTION 3

DESIGN CONDITIONS, ASSUMPTIONS AND FUNDAMENTALS FOR SEWERAGE MASTER PLANNING

SECTION 3 DESIGN CONDITIONS, ASSUMPTIONS AND FUNDAMENTALS FOR SEWERAGE MASTER PLANNING

3.1 General

This section is arranged as a common portion of the study for the eight municipalities/areas to complete sewerage master plan followed by individual plans in Chapter 4.

Basic Conditions/assumptions and general approach by major study item are incorporated covering technical, financial and management aspects in accordance with study procedures for sewerage master planning. Thus, plan/design of wastewater collection and treatment facilities are presented in respective plans.

Sanitary sewage is the concern of the study excluding drainage plan with reference to applicable wastewater collection method and utilization of existing drainage facilities. Existing drainage systems will be fully used through the future in provision of rehabilitation and expansion of the facilities by respective local governments.

The study on the improvement of sanitation conditions in the study area (DTCP area) out of sewerage development area is also summarized in this section covering all municipalities/areas concerned.

3.2 Design Year and Area to be Sewered and/or in Provision of Sanitation Improvement

Study areas by study purpose are defined referring to present practices of the PWD as follows:

(1) Master Planning Area : DTCP area

(2) Sewerage Master Planning Area : Present municipality/S.D in addition to the area to be expanded in the near future

(3) Preliminary Design Area : Practical area within the present municipality/S.D areas together with expansion areas in the near future to realize effective investment for sanitation improvement and conservation of public water quality.

The base year and target years for the planning purpose are determined according to data availability and the target year of the Seventh National Economic and Social Development Plan of Thailand.

Base year : 1991
Intermediate year : 2001
Final target year : 2011

Composition of areas by study municipality/S.D for master plan target year of 2011 is shown in Table 3.2.1. DTCP area and sewerage master plan area are shown in Figure 3.2.1 - 3.2.8. Detailed descriptions for respective areas are referred to in the following Chapter.

3.3 Existing Sewerage/Sanitation and Flood Protection Facilities

3.3.1 Drainage Facilities

The existing drainage facilities are commonly installed in the limited urban areas. Furthermore, even if in such areas, the facilities are partial and wastewater discharged from houses does not necessarily reach to nearby channels/rivers.

In general, existing drainage facilities play a role to collect sullage and supernatant from pour-flush toilet and rain water in the service area, and discharge the wastewater into nearby rivers/khlongs.

Existing drainage pipe is mainly made of concrete with a diameter of 400-1,500 mm and usually installed along the boundary between roadway and sidewalk with a shallow earth cover. In addition, the slope of pipes is arranged to suit for flat topography. Accordingly, it seems that actual flow capacity of pipes is restricted in comparison with capable flow in application of an adequate slope under respective pipe diameters.

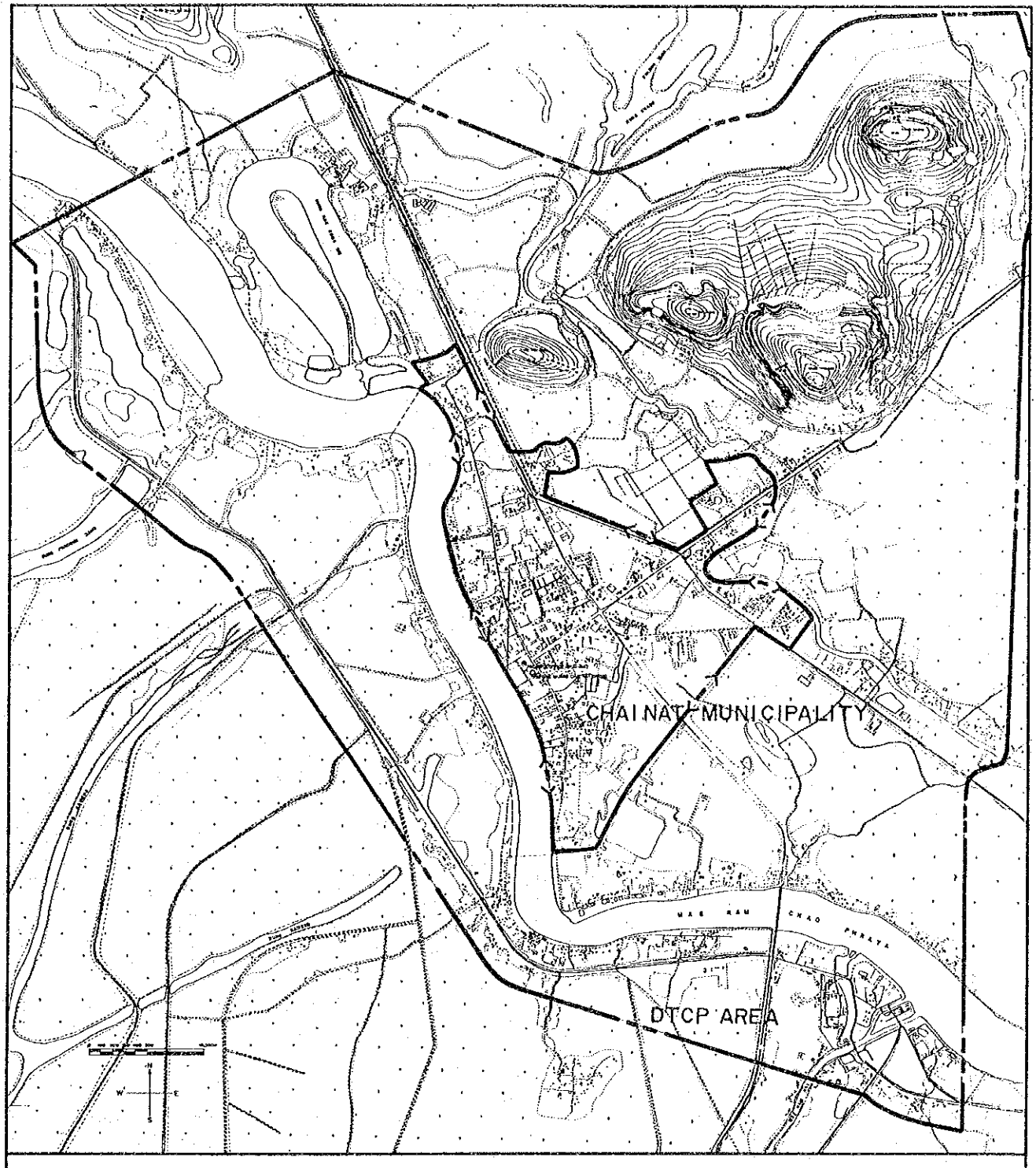

FIGURE 3.2.1 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN CHAI NAT

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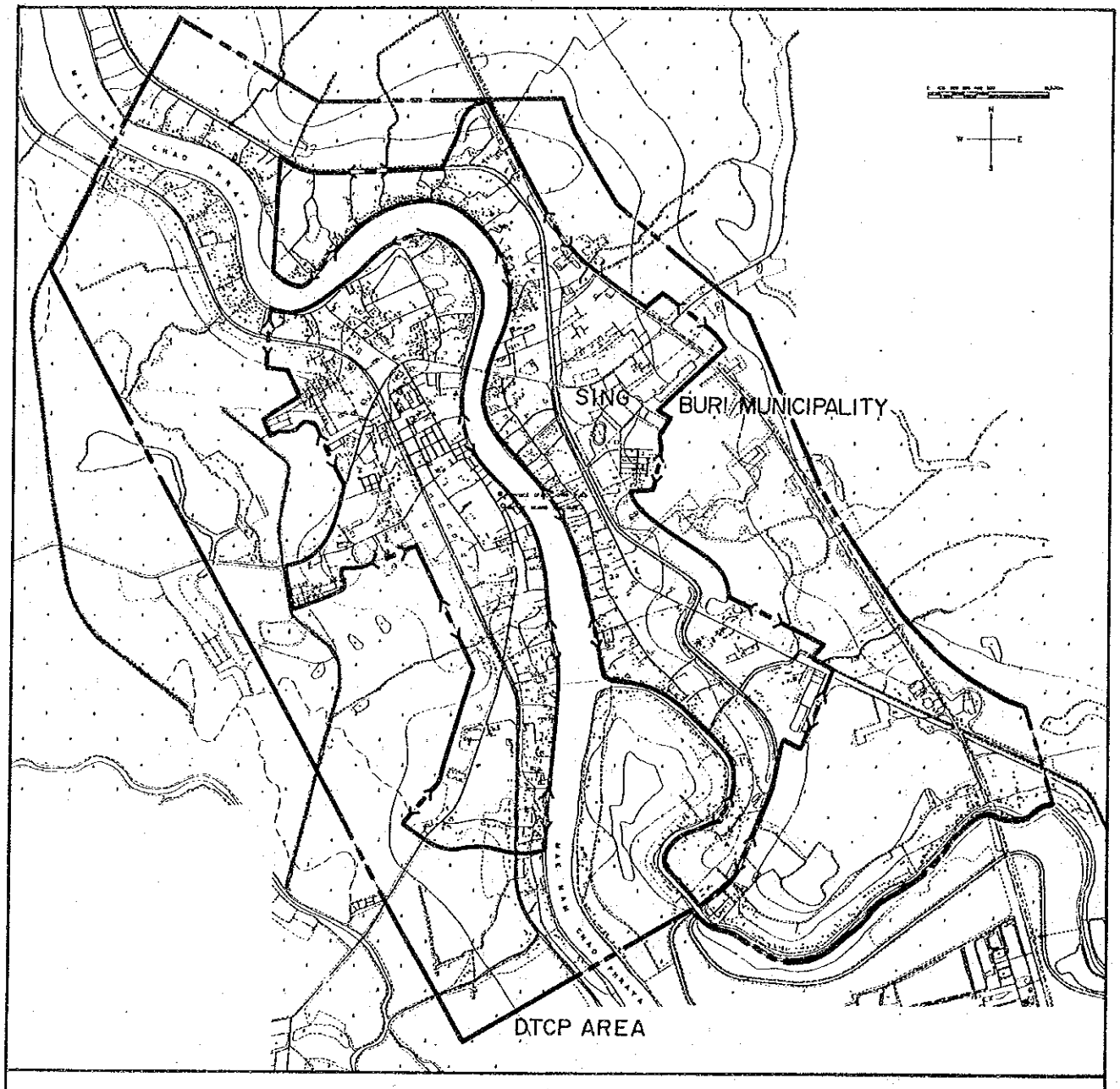

FIGURE 3.2.2 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN SING BURI

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JAPAN INTERNATIONAL COOPERATION AGENCY

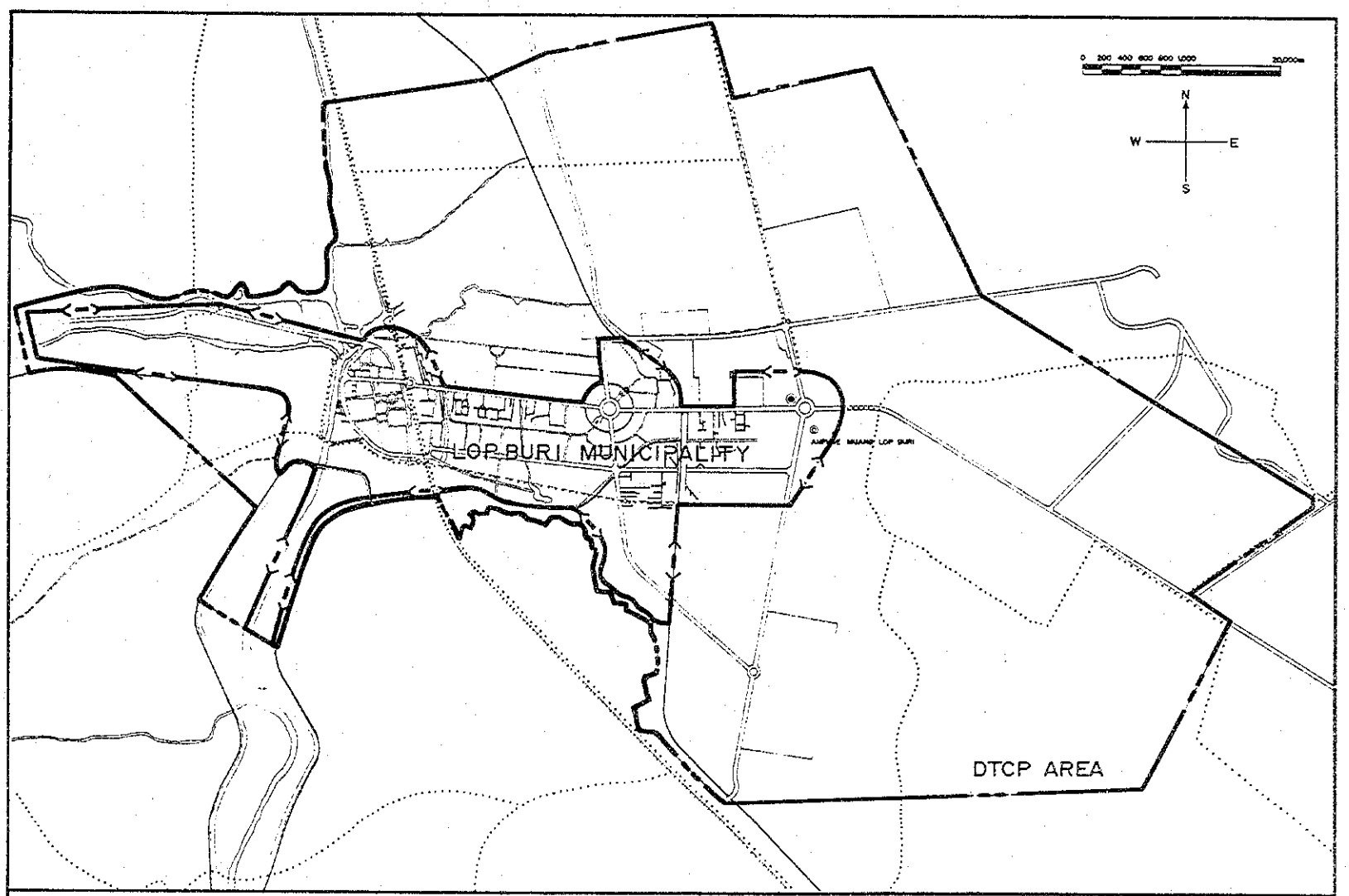

FIGURE 3.2.3 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN LOP BURI

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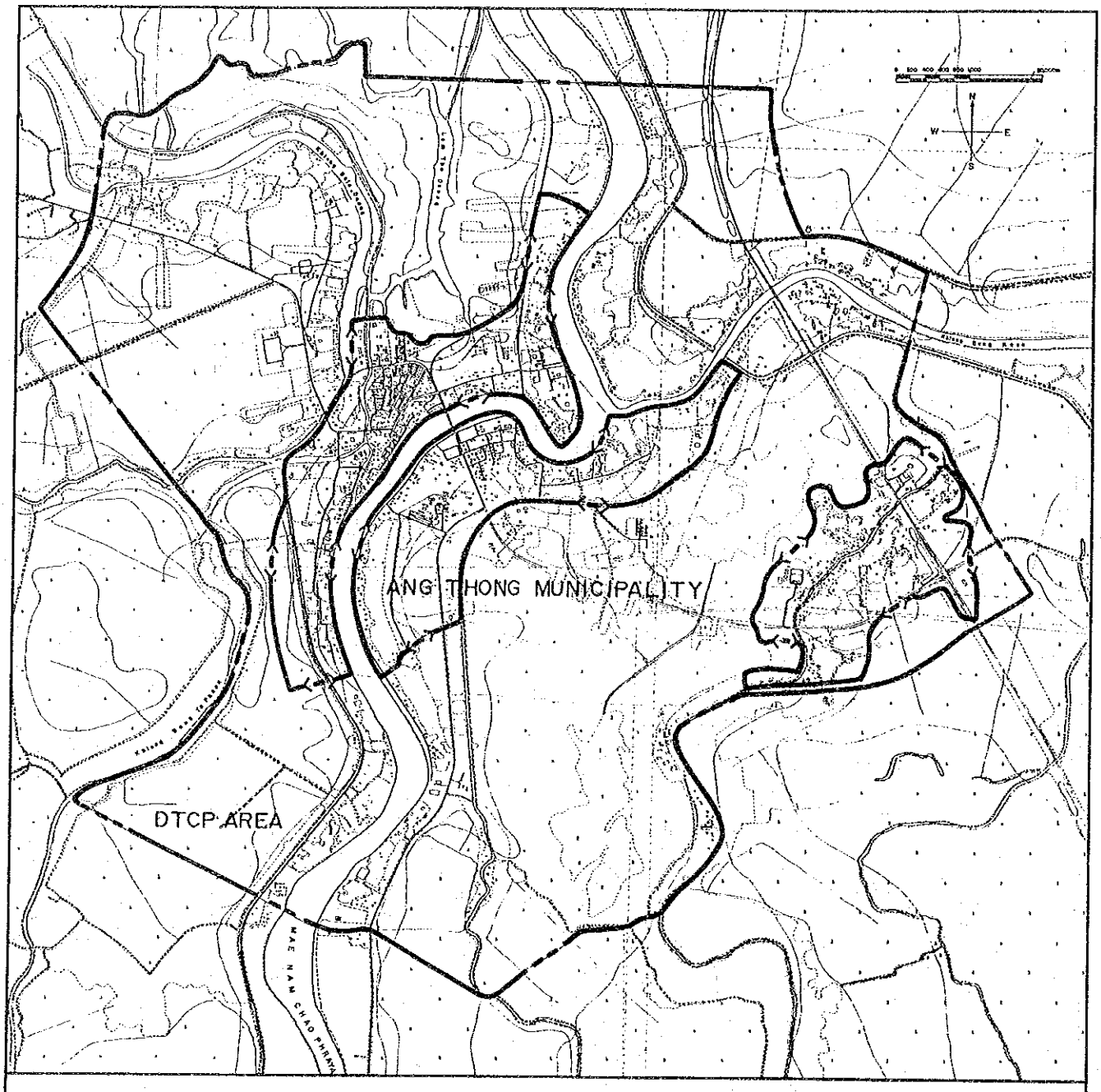

FIGURE 3.2.4 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN ANG THONG

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

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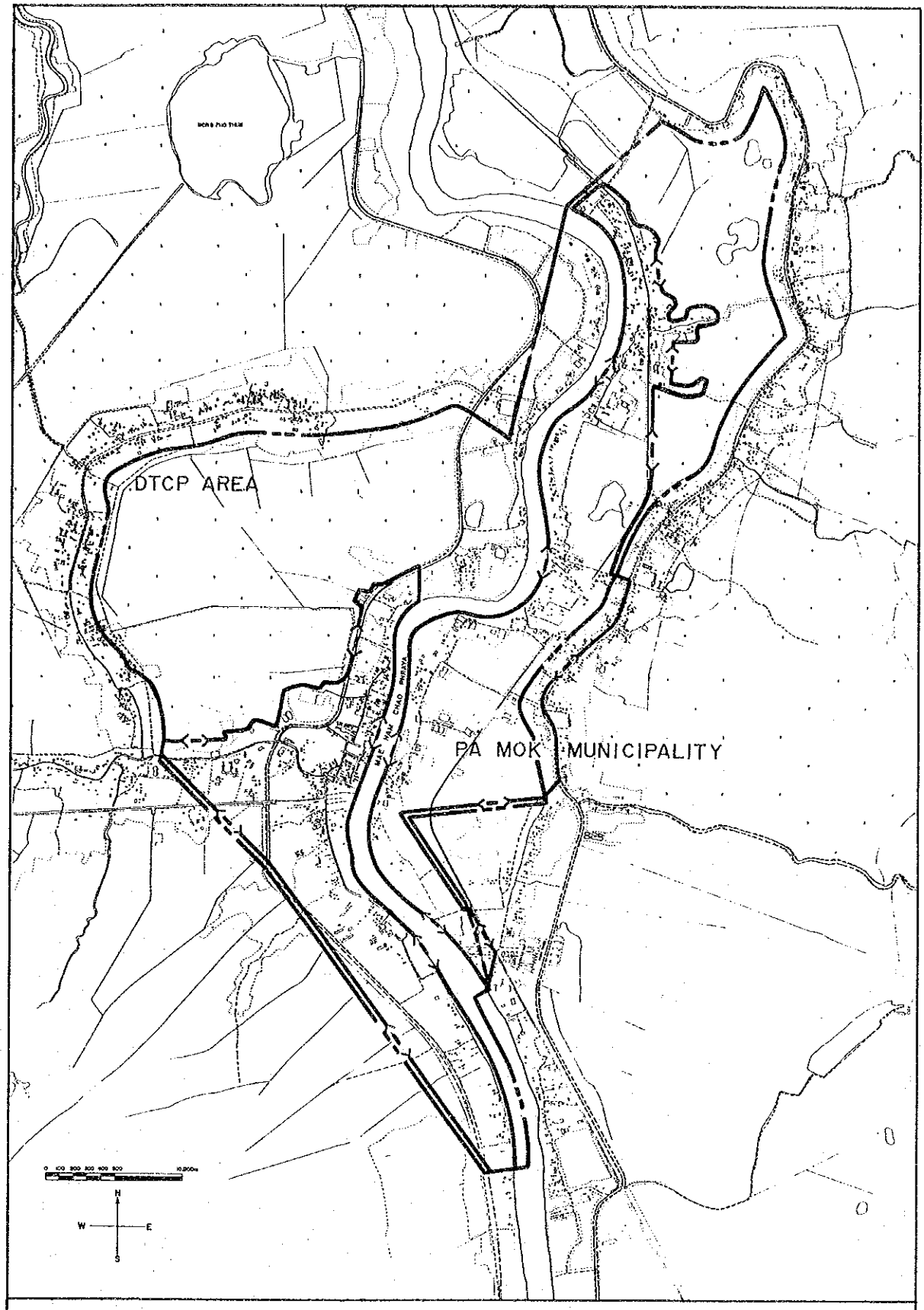


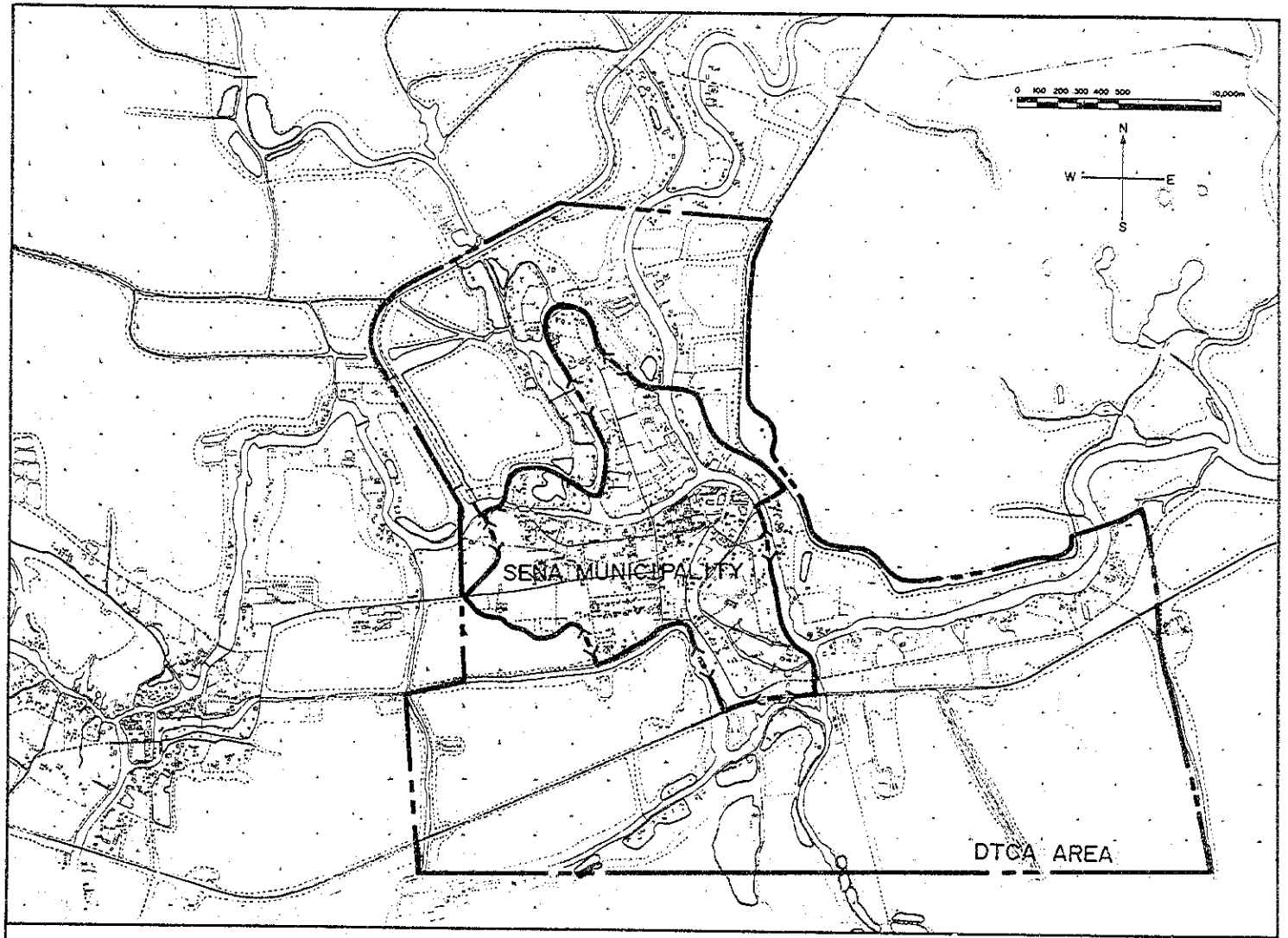
LEGEND
—— - - —— DTCP AREA
—<->—<->— SEWERAGE MASTER PLAN AREA

NOT TO SCALE

FIGURE 3.2.5 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN PA MOK

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

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

—— - - —— DTCP AREA

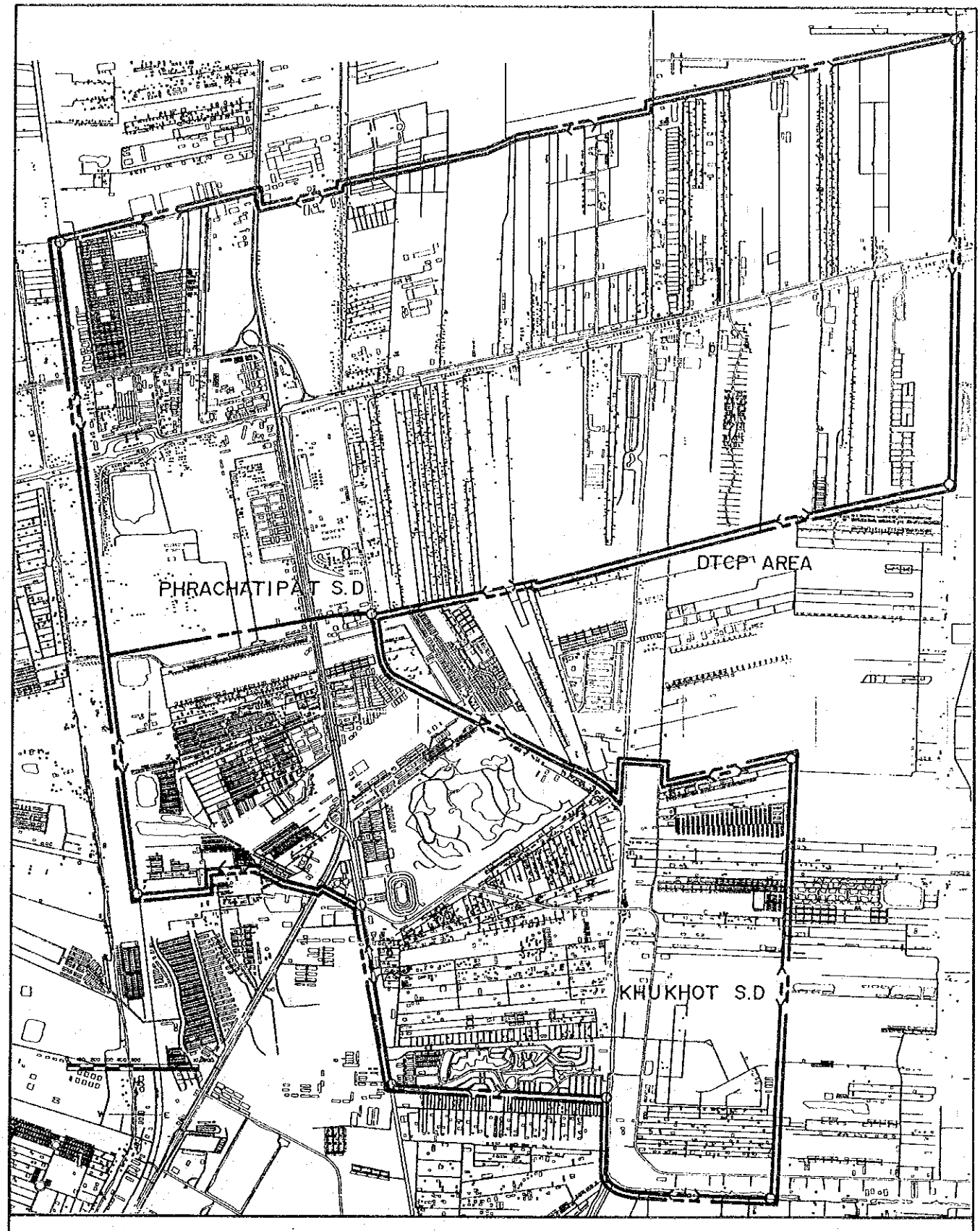
—<->—<->— SEWERAGE MASTER PLAN AREA

NOT TO SCALE

FIGURE 3.2.6 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN SENA

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

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

—— - - —— DTCP AREA

—<->—<->— SEWERAGE MASTER PLAN AREA

NOT TO SCALE

FIGURE 3.2.7 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN RANG SIT

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

JAPAN INTERNATIONAL COOPERATION AGENCY

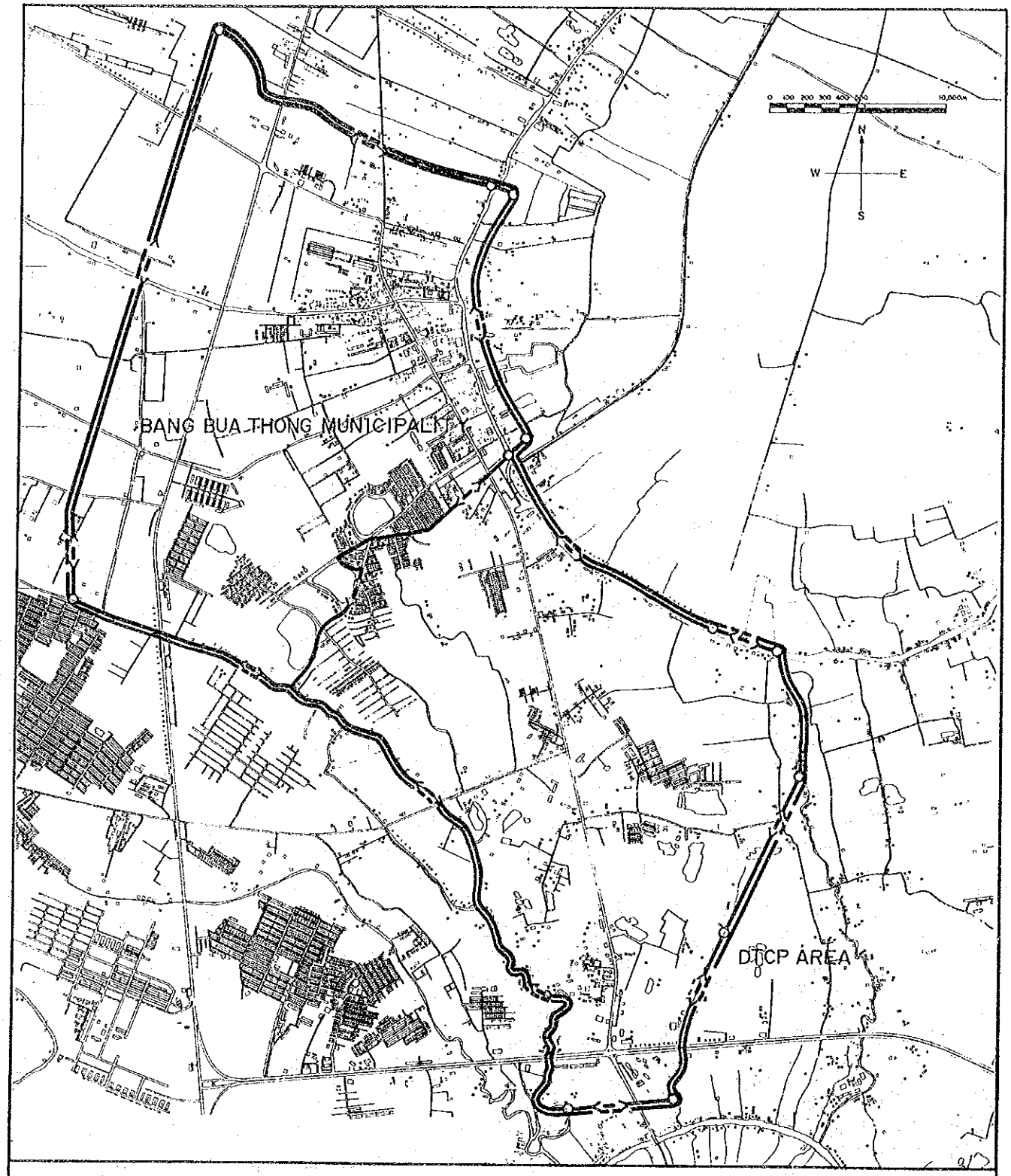


FIGURE 3.2.8 DTCP AREA AND SEWERAGE MASTER PLAN AREA IN BANG BUA THONG

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A general drainage system in the surrounding area of the house is illustrated in Figure 3.3.1 (1) and Figure 3.3.1 (2).

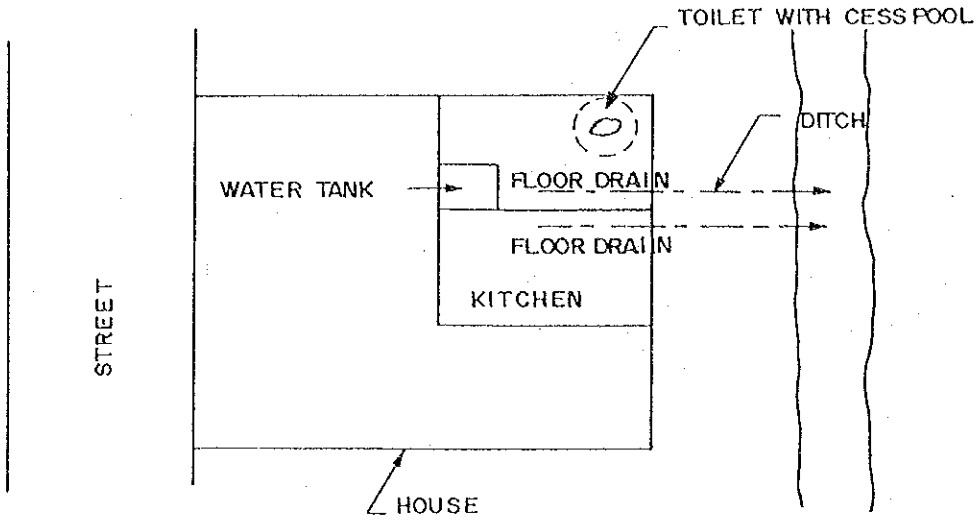
Table 3.2.1 SUB-STUDY AREAS BY PROJECT AREA

Project Area	Area & Population	Present Munici./SD	Future Exp. Area	Sewerage M/P Area	Other Area	DTCP Area
1. Chai Nat	Area (km2)	6.06	0.84	6.90	49.54	56.49
	Pop. in 1991	13,983	-	-		
2. Sing Buri	Area (km2)	9.02	2.89	11.91	19.42	31.33
	Pop. in 1991	22,570	-	-		
3. Lop Buri	Area (km2)	6.85	3.38	10.23	2.62	12.85
	Pop. in 1991	36,832	-	-		
4. Ang Thong	Area (km2)	3.73	1.45	5.18	18.80	23.98
	Pop. in 1991	9,607	-	-		
5. Pa Mok	Area (km2)	6.89 (12.000)	0.24	7.13	19.73	26.86
	Pop. in 1991	10,686	-	-		
6. Sena	Area (km2)	1.20	0.79	1.99	24.11	26.10
	Pop. in 1991	4,607	-	-		
7. Rangsit Prachatipat Ku Khot	Area (km2)	33.30	0	33.30	0	33.30
	Pop. in 1991	100,600	-	-		
8. Bang Bua Thong	Area (km2)	1.60	11.90	13.50	0.00	13.50
	Pop. in 1991	45,786	-	-		
Total	Area (km2)	68.65	21.49	90.14	134.27	224.41
	Pop. in 1991	244,671	0	0	0	0

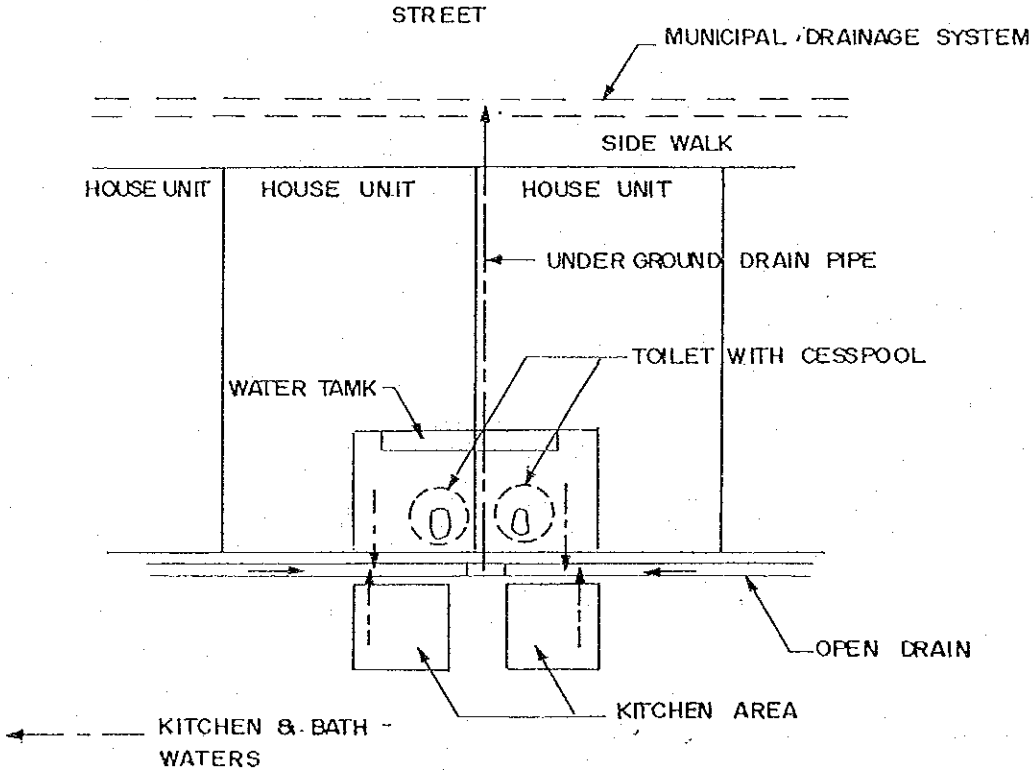
1) Present population out of the municipality area is estimated based on the current population density (20 persons/ha).
2) Population in Rangsit area is estimated in consideration of non-registered population (30 % of registered population).
3) Other area : Subject area for sanitation improvement without sewerage systems.

3.3.2 Toilet Facilities, Safe Water Supply and Refuse Disposal

Pour-flush latrines are obligatory for houses and buildings. A common toilet facilities installed at each house are pour-flush latrine with soakaway or pour-flush toilet with septic tank and soakaway as shown in Figure 3.3.1.



SMALL SINGLE HOUSE UNIT WASTEWATER DRAIN SYSTEM



ROW HOUSING WASTEWATER DRAIN SYSTEM

FIGURE 3.3.1(1) TYPICAL DOMESTIC WASTEWATER DRAIN SYSTEM

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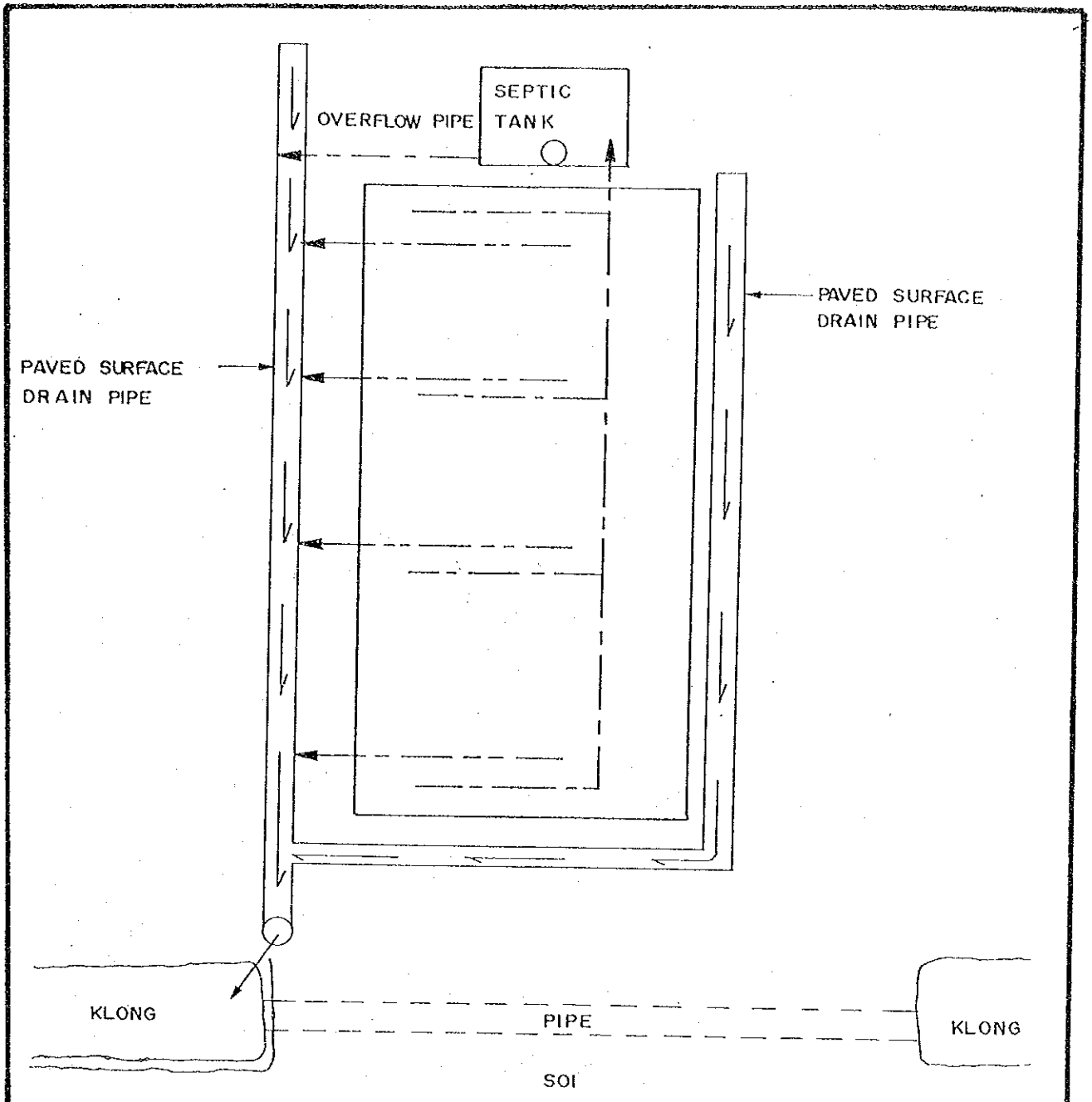

FIGURE 3.3.1(2) APARTMENT HOUSE WASTEWATER DRAIN SYSTEM

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While, a standard septic tank provided with leaching tank is recently enforced by the Government, as shown in Figure 3.3.2 (1), to the newly constructed houses. This type of toilet facilities basically employ same treatment and on-site disposal methods as the old prevalent type shown in Figure 3.3.2 (2), although some improvement may be expected in its effluent/leaching water quality. Accumulated sludge is usually removed by means of vacuum car for both types. Present installation status (1991) of such toilets by respective study areas in addition to the information on safe water supply and refuse collection is referred to in Chapter 4 Part I.

Desludging services of cesspool/septic tank once one-two year are provided either by local government units or private companies by means of each one-two units of vacuum truck.

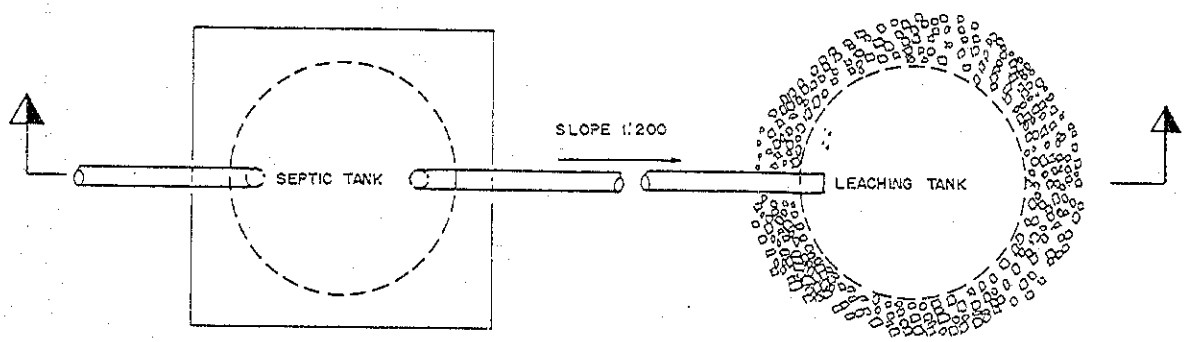
- Health Division of Municipality : five (5) municipalities, Chai Nat, Sing Buri, Lop Buri, Sena and Bang Bua Thong

- Private companies : Ang Thong, Pa Mok and Rangsit area (Khu Khat and Prachatipat)

Desludging charges are collected in different two manners; sludge amount removed with a pay of 100 Baht/m^3 - 200 Baht/m^3 and every desludging work base with the pay ranging from 200 Baht to 400 Baht.

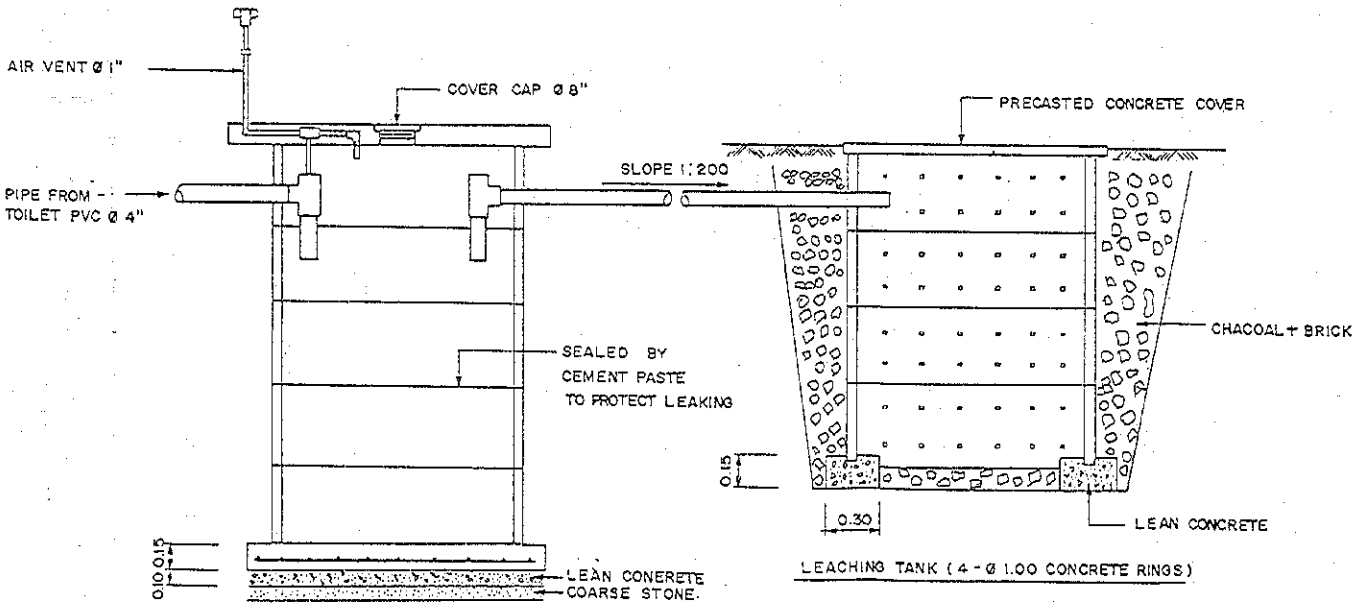
Dumping and backfilling are adopted as the final disposal of the collected sludge for three (3) municipalities of Chai Nat, Sena and Bang Bua Thong. Composting system is applied for municipalities of Sing Buri and Lop Buri and the sludge is sold to farmers in the Prachatipat S.D. While in Khu Khot S.D., collected sludge is disposed of at the pond in Pathum Thani municipality which is 20 km far from the center of the S.D.

Table 3.3.1 shows the existing desludging and disposal conditions of toilet sludge in each municipality and sanitary district.



DETAILS OF SEPTIC TANK AND LEACHING TANK

SCALE 1 : 25



SECTION OF SEPTIC TANK AND LEACHING TANK

SCALE 1 : 25

Figure 3.3.2 (1) STANDARD DRAWING OF SEPTIC TANK WITH SOAKAWAY

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

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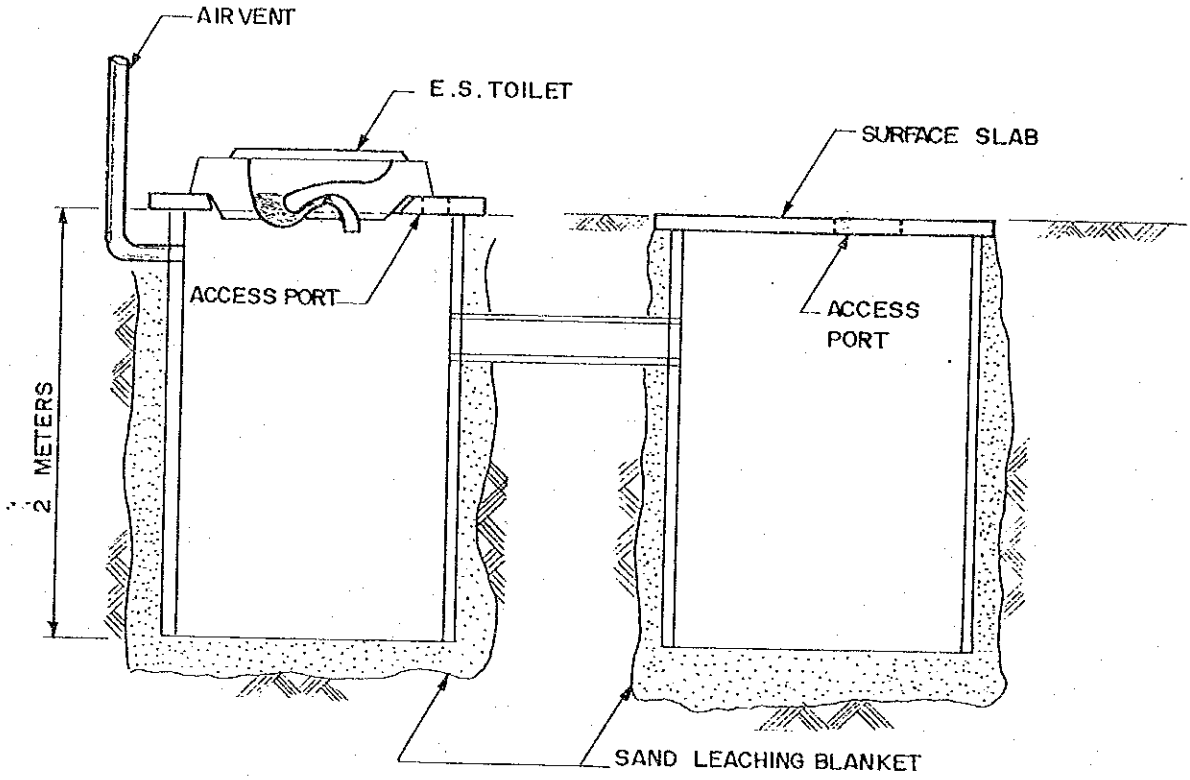

Figure 3.3.2 (2) TYPICAL POUR - FLUSH TOILET WITH SOAKAWAY

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

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Table 3.3.1 Existing conditions of Desludging and Disposal of toilet sludge

	Chai Nat	Sing Buri	Lop Buri	Ang Thong	Pa Mok (*1)	Sena	Rangsit		Bang Bua Thong
							(Khu Kot)	(Prachatipat)	
Desludging Services Conducted by	Health Section of Municipality	Health & Enviroment Section	Municipality	Private company		Municipality	Private company	Private company	Health Division of Municipality
Service Area	Include outside of municipality area	781 ha	Include outside of municipality area	Municipality area only		1,000	1,248	Municipality area only	160
Served Population	14,660	22,000	40,000	N.A		20,000	30,984	46,430	10,350
Desludging Volume (m3/day)	4 ~ 5 hours/day	30	6.25	10 hours/month		N.A	N.A	N.A	N.A
Frequency	Once/1 ~ 2 year	?	Once/1 ~ 2 year	Twice a year		Every 2 years	Once/1 ~ 2 year	Once/1 ~ 2 year	Once/1 ~ 2 year
Service Charge	100 Baht/m3(*2) 200 Baht/m3	150 Baht/m3	200 Baht/m3	125 Baht/m3		400 Baht/desludge	200 Bhat/desludge	200 Bhat/desludge	300 Bhat/desludge
Vacuum Truck Number	1	1	2	2		1	1	1	1
Capacity (m3)	3	3	2	4		4	3	2	3
No. of Workers	3 workers/truck	3 workers/truck	3 workers/truck	4 workers/truck		3 workers/truck	3 workers/truck	3 workers/truck	3 workers/truck
Disposal Site Location	Kao Khyai (50 rai)	N.A	Inside of Municipality area	Outside of Municipality area		3 km from city Center (*3)	20 km from Khu Kot (Pond)	N.A	Garbage dumping Site
Method	Dumping & backfilling	Composing	Composing	N.A		Dumping & Backfilling	Dipose to pond	Selling to farmers	Dumping & Backfilling
Annual Revenue & Expences (Bath/year) Revenue	N.A	310,000	36,000	6,000		16,000	N.A	N.A	N.A
Expenditure	144,000	138,000	376,100	0		1,968,000	N.A	N.A	N.A

(*1) : Desludging works in municipality Pa Mok is handled by the same private company of municipality Ang Thong.
(*2) : Service charge of 100 Baht per m3 is applied for inside of municipality area and 200 Baht per m3 for outside of municipality.
(*3) : Sludge disposal site is the same as garbage dumping site located outside of municipality area.
N.A : Data not available

3.3.3 Flood Protection Facilities

It is concluded that flood problems are mainly caused by water releases from the upstream dams, torrential rainfall under insufficient drainage facilities and tidal effect.

Flood protection facilities along the Chao Phraya river are managed by the RID in provision of Chao Phraya Dam, Rama VI barrage, regulators and gates and dike along the Chao Phraya river (details on such facilities are referred to in Section 2.4, Chapter 2 Inundation and Flood Control, Part I). However among eight study areas, dike is not provided along the main river for Pa Mok and part of Sena municipalities (Bang Bua Thong and Rangsit areas are not faced directly to the main river).

The dike of irrigation canals under the control by the RID are designed and constructed referring to the water level of the Chao Phraya river.

Pump stations for the purpose of flood control is only installed in Chai Nat and Sing Buri municipalities. However, the facilities have not been operated for the last 20 years.

3.4 Water Supply at Present and in the Future

Water Supply for domestic and industrial uses in the future is studied in Chapter 8, Unit wastewater quality and quantity, Part I. The following are the summary of the study results.

Domestic water is defined in a broad sense comprising those for household, business, institutional and cottage industry uses.

The urban areas of the study areas excepting Bang Bua Thong municipality are served by the PWA (Bang Bua Thong is under service by the MWA). Water sources of these waterworks are either surface water or groundwater. Supplementary water supply systems in small size also exist in the rural areas.

Unit water consumption rates at present and in the year 2011 by classification of municipality/S.D are projected as follows:

Class	Present	2011	Municipality/S.D
Class A	280	360 (50%)	Rangsit area and Bang Bua Thong
Class B	180	280 (40%)	Chai Nat, Sing Buri, Lop Buri, Ang Thong, Pa Mok and Sena
Class C	120	220 (20%)	None in the study area

Note: unit water consumption rate; lpcd on an average base
( ) ; percentage of other water consumption to household water consumption

With regard to industrial water consumption, unit quantity per employee was projected by categorized type of industry in the water pollution control plan. However, industrial areas have been developed out of the municipal areas excepting Rangsit area. Due to high land acquisition cost in the urban area, factories seem to be located out of the municipal area through the future. In this connection, water consumption rate only for Rangsit area is studied in the following section. While, water consumption for cottage industries is considered for all study areas as a part of business water.

3.5 Frame Values and Land Use for Sewerage Master Planning

Frame values of the identified wastewater sources to be accepted by the public sewerage systems are requisites for estimation of design flow. Domestic and industrial wastewater (limited to Rangsit area) was confirmed to be subject wastewater sources. Accordingly, population and number of employees only for Rangsit area are studied.

Registered population is the basis for the projection of seven study areas except for Rangsit area. Non-registered population is considered for Rangsit area to meet the actual situation in the industrialized area. Table 3.5.1 summarizes sewerage master planning area and design population by respective study areas. (Number of employees for Rangsit area is referred to in its sewerage plan)

Table 3.5.1 Sewerage Master Planning Area and Population

Study Area	Area & Population	Present Munici./SD	Future Exp. Area	Sewerage M/P Area
1. Chai Nat	Area (km2)	6.06	0.84	6.90
	Pop. in 1991	13,983	-	-
	Pop. in 2011	19,765	2,035	21,800
2. Sing Buri	Area (km2)	9.02	2.89	11.91
	Pop. in 1991	22,570	-	-
	Pop. in 2011	35,973	5,727	41,700
3. Lop Buri	Area (km2)	6.85	3.38	10.23
	Pop. in 1991	36,832	-	-
	Pop. in 2011	49,320	11,980	61,300
4. Ang Thong	Area (km2)	3.73	1.45	5.18
	Pop. in 1991	9,607	-	-
	Pop. in 2011	10,686	2,814	13,500
5. Pa Mok	Area (km2)	6.89	0.24	7.13
		(12.000)		
	Pop. in 1991	10,686	-	-
	Pop. in 2011	12,857	443	13,300
6. Sena	Area (km2)	1.20	0.79	1.99
	Pop. in 1991	4,607	-	-
	Pop. in 2011	7,790	1,610	9,400
7. Rangsit Prachatipat Ku Khot	Area (km2)	33.30	0	33.30
	Pop. in 1991	100,600	-	-
	Pop. in 2011	154,000	-	154,000
8. Bang Bua Thong	Area (km2)	1.60	11.90	13.50
	Pop. in 1991	45,786	-	-
	Pop. in 2011	76,600	-	79,600
Total	Area (km2)	68.65	21.49	90.14
	Pop. in 1991	244,671	0	0
	Pop. in 2011	369,991	24,609	394,600

1) Present population out of the municipality area is estimated based on the current population density (20 persons/ha) and assumed to be constant through the future

2) Population in Rangsit area is estimated in consideration of non-registered population (30 % of registered population)

(1) Present Land Use

Existing land use map and its relevant data/report covering study eight municipalities/S.Ds were prepared by the DTCP between 1985 and 1992. In the information, land use is categorized into six (6) types; (1) commercial and high population density area, (2) medium population density area, (3) low population density area, (4) institutional area (government office, school, religious space and hospital), (5) industrial area and (6) other area (paddy field, open space, river area, etc.).

The area and composition of land use types at present and the year 2011 are summarized for the eight (8) areas in Tables 3.5.2 (1) and (2).

Features of the land use are enumerated below:

The shares of land use for commercial and high population density area range from 1.92% in Pa Mok to 6.12% in Bang Bua Thong with an average of 4.27%.

Commercial and high population density area is mainly located at the center of each municipality area and sanitary district.

Shares of residential use consisting of high, medium and low population density areas range from 23.49% of Prachatipat to 41.71% of Sena with an average of 30.29%.

Institutional use shares from 0.77% of Khu Khot to 14.95% of Lop Buri with an average of 4.36%.

Industrial area exists only in Sena and Rangsit areas. The industrial use occupies 0.72% in Sena, 3.5% in Prachatipat and 2.74% in Khu Khot.

Shares of other area range from 48.39% of Sena to 71.1% of Khu Khot with an average of 61.54%.

Table 3.5.2 (1) Area and Share of Existing Land Use Pattern of Sewerage Development Area in 1984

(Land Use)

Sewerage Area	Commercial & High Population Density		Medium Population Density Area		Low Population Density Area		Instutional Area		Industrial Area		Other Area		Total	
	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)
Chai Nat	25.7	3.72	76.4	11.07	107.9	15.64	50.0	7.25	–	0.00	430.0	62.32	690.0	100
Sing Buri	36.1	3.03	123.1	10.34	292.2	24.53	72.8	6.11	8.6	0.72	658.2	55.26	1,191.0	100
Lop buri	67.7	6.62	182.1	17.80	91.4	8.93	152.9	14.95	–	0.00	528.9	51.70	1,023.0	100
Ang Thong	20.5	3.96	47.8	9.23	118.0	22.78	48.5	9.36	–	0.00	283.2	54.67	518.0	100
Pa Mok	13.7	1.92	87.2	12.23	212.7	29.83	32.7	4.59	–	0.00	366.7	51.43	713.0	100
Sena	11.5	5.78	25.3	12.71	46.2	23.22	19.7	9.90	–	0.00	96.3	48.39	199.0	100
Rangsit	144.0	4.32	410.7	12.33	251.3	7.55	56.1	1.68	107.1	3.22	2,360.8	70.89	3,330.0	100
(Prachatipat)	97.6	4.69	190.7	9.17	200.3	9.63	46.5	2.24	72.8	3.50	1,472.1	70.77	2,080.0	100
(Khu Kot)	46.4	3.71	220.0	17.60	51.0	4.08	9.6	0.77	34.3	2.74	888.7	71.10	1,250.0	100
Bang Bua Thong	95.4	7.07	187.5	13.89	307.2	22.76	18.6	1.38	–	0.00	741.3	54.90	1,350.0	100
Total	414.6	4.60	1,140.1	12.65	1,426.9	15.83	451.3	5.01	115.7	1.22	5,465.4	60.63	9,014.0	100

Table 3.5.2 (2) Area and Share of Future Land USe Pattern of Sewerage Development Area in 2011

(Land Use)

Sewerage Area	Commercial & High Population Density		Medium Population Density Area		Low Population Density Area		Instutional Area		Industrial Area		Other Area		Total	
	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)	Area (ha)	Share (%)
Chai Nat	54.7	7.93	161.2	23.36	278.2	40.32	66.8	9.68	–	0.00	129.1	18.71	690.0	100
Sing Buri	64.9	5.45	158.0	13.27	430.9	36.18	124.7	10.47	44.9	3.77	367.6	30.86	1,191.0	100
Lop buri	131.8	12.88	276.8	27.06	242.0	23.66	122.9	12.01	–	0.00	249.5	24.39	1,023.0	100
Ang Thong	34.7	6.70	94.4	18.22	183.8	35.48	82.8	15.98	–	0.00	122.3	23.61	518.0	100
Pa Mok	19.7	2.76	104.9	14.71	232.1	32.55	60.7	8.51	–	0.00	295.6	41.46	713.0	100
Sena	11.3	5.68	40.3	20.25	103.7	52.11	37.0	18.59	–	0.00	6.7	3.37	199.0	100
Rangsit	512.8	15.40	1,270.0	38.14	813.2	24.42	55.7	1.67	120.0	3.60	558.3	16.77	3,330.0	100
(Prachatipat)	347.5	16.71	584.8	28.12	680.1	32.70	46.1	2.22	96.9	4.66	347.4	16.70	2,080.0	100
(Khu Kot)	165.3	13.22	685.2	54.82	133.1	10.65	9.6	0.77	23.1	1.85	256.8	20.54	1,250.0	100
Bang Bua Thong	95.4	7.07	393.0	29.11	707.3	52.39	14.6	1.08	–	0.00	139.7	10.35	1,350.0	100
Total	925.3	10.27	2,498.6	27.72	2,991.2	33.18	565.2	6.37	164.9	1.83	1,868.8	20.73	9,014.0	100

(2) Future Land Use

The latest land use plans for the target year of 2005 were obtained from the DTCP covering study areas, which were prepared between 1985 and 1992. These plans in terms of land use pattern in 2005 may be used for those in 2011. Population densities in 2011 by land use type for the study areas are figured out referring to land area by land use type in the year 2005 and projected population in 2011.

Land Use Type	Pop. Density by Group	
	A	B
Commercial & High population density area	200	120
Medium population density area	100	60
Low population density area	30	20

Note:
Group A : Sing Buri, Lop Buri, Sena, and Bang Bua Thong
Group B : Chai Nat, Ang Thong, Pa Mok and Rangsit

The composition by land use type at present and for the year 2011 is summarized in Table 3.5.2 (3) and (4). Salient features of the future land use in eight (8) study areas are summarized as follows:

1) The share of residential use consisting of commercial & high population density area, medium population density area and low population density area of each study area increases up to an average of 69.78% from the present average of 30.29%.

   The highest share of the residential use of 70.83% is projected in Sena, while the lowest of 50.02% in Pa Mok.

2) The share of institutional land use of 5.98% is not much different from the 4.36% at present.

3) Development of industrial area is limited to Sing Buri and Rangsit area.

Table 3.5.2 (3) Sewerage Service Area and Service Population in Each Classified Land Use Pattern in 1991

Sewerage Area	Commercial & High Population Density		Medium Population Density Area		Low Population Density Area		Instutional Area		Industrial Area		Other Area		Total	
	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population
Chai Nat	25.7	4,823	76.4	7,107	107.9	1,088	50.0	0	0.0	0	430.0	0	690.0	16,018
Sing Buri West	36.1	8,808	68.1	5,924	196.4	5,897	29.8	0	8.6	0	166.1	0	505.1	20,629
Sing Buri East	0.0	0	55.0	4,798	95.8	2,870	43.0	0	0.0	0	492.1	0	685.9	7,668
Lop buri	67.7	20,990	182.1	22,041	91.4	5,781	152.9	0	0.0	0	528.9	0	1,023.0	48,812
Ang Thong	20.5	3,828	47.8	5,211	118.0	3,382	48.5	0	0.0	0	283.2	0	518.0	12,421
Pa Mok East	7.6	1,105	43.1	2,611	71.3	1,305	22.7	0	0.0	0	152.9	0	297.6	5,021
Pa Mok West	6.1	870	44.1	2,661	141.4	2,577	10.0	0	0.0	0	213.8	0	415.4	6,108
Sena	11.5	1,495	25.3	2,665	46.2	2,057	19.7	0	0.0	0	96.3	0	199.0	6,217
Rangsit	144.0	40,198	410.7	49,777	251.3	10,625	56.1	0	107.1	0	2,360.8	0	3,330.0	100,600
Bang Bua Thong North	95.4	10,976	153.0	17,982	90.0	3,774	18.6	0	0.0	0	352.0	0	709.0	32,732
Bang Bua Thong South	0.0	0	34.5	4,050	217.2	9,008	0.0	0	0.0	0	389.3	0	641.0	13,058
Total	414.6	93,093	1,140.1	124,827	1,426.9	51,364	451.3	0	115.7	0	5,465.4	0	9,014.0	269,284

Table 3.5.2 (4) Sewerage Service Area and Service Population in Each Classified Land Use Pattern in 2011

Sewerage Area	Commercial & High Population Density		Medium Population Density Area		Low Population Density Area		Instutional Area		Industrial Area		Other Area		Total	
	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population	Area (ha)	Population
Chai Nat	54.7	6,564	161.2	9,672	278.2	5,564	66.8	0	0.0	0	129.1	0	690.0	21,800
Sing Buri West	64.9	12,980	87.3	8,730	289.7	8,690	51.1	0	0.0	0	12.1	0	505.1	30,400
Sing Buri East	0.0	0	70.7	7,070	141.2	4,230	73.6	0	44.9	0	355.5	0	685.9	11,300
Lop buri	131.8	26,360	276.8	27,680	242.0	7,260	122.9	0	0.0	0	249.5	0	1,023.0	61,300
Ang Thong	34.7	4,160	94.4	5,664	183.8	3,676	82.8	0	0.0	0	122.3	0	518.0	13,500
Pa Mok East	11.0	1,320	51.8	3,120	77.8	1,560	45.7	0	0.0	0	111.3	0	297.6	6,000
Pa Mok West	8.7	1,040	53.1	3,180	154.3	3,080	15.0	0	0.0	0	184.3	0	415.4	7,300
Sena	11.3	2,260	40.3	4,030	103.7	3,110	37.0	0	0.0	0	6.7	0	199.0	9,400
Rangsit	512.8	61,536	1,270.0	76,200	813.2	16,264	55.7	0	120.0	0	558.3	0	3,330.0	154,000
Bang Bua Thong North	95.4	19,080	319.8	31,980	253.0	7,590	14.6	0	0.0	0	26.2	0	709.0	
Bang Bua Thong South	0.0		73.2	7,320	454.3	13,629	0.0	0	0.0	0	113.5	0	641.0	22,700
Total	925.3	135,300	2,498.6	184,646	2,991.2	74,653	565.2	0	164.9	0	1,868.8	0	9,014.0	394,600

4) Other areas are still remained in each study area. The shares of other areas range from 3.37% of Sena to 43.38% of Ang Thong with an average of 22.96%.

3.6 Wastewater Collection Method

Plan and design of wastewater collection systems are different depending on the employed collection method. Two alternative collection systems; separate and combined systems are comparatively studied. The characteristics of the two systems are summarized as follows;

(1) Separate System

A Separate system has parallel collection systems for sanitary sewage and stormwater run-off, respectively. This system is advantageous to the surrounding sanitation environment and water pollution control. It is also recommendable in the areas where conventional drainage facilities are maintained in relatively good conditions, and only collection and treatment of sanitary sewage are required for completion of a sewerage system. On the contrary, the collection of sanitary sewage needs construction of house connections and lateral sewers.

(2) Combined System

A combined system refers to a system to collect sanitary sewage and storm water run-off by means of combined sewers. This system may be employed to extend sewerage service areas in low cost investment under the following conditions.

1) Discharge of wastewater into public water body is acceptable during rainy season.

2) Existing drainage/channels presently collecting rain water and sullage can be used as combined sewers and or receiving water courses for the overflow water from diversion chamber.

There is no sanitary sewers in the study area. The stormwater drainage systems are constructed and operated in the built-up areas under the responsibility of the municipalities. However, construction activities are limited to annual budget available.

Nightsoil is separately disposed of at the generated site (fecal disposal), while sullage from kitchen and shower is connected with a separate pipe to the stormwater drainage system. Under these conditions, major factors to be taken into account for selection of wastewater collection method are as follows:

1) Utilization of existing drainage facilities to achieve low cost construction under the current wastewater (sanitary sewage and stormwater) collection method

2) In consideration of staged construction of the system and prevailing countermeasures/facilities, practical use of relevant existing facilities

3) Staged improvement in collection method setting up final target system

In addition to the principal factors mentioned above and findings through exchange of opinions between JICA study team and officials concerned in Thailand, major considerations are enumerated below.

1) With reference to sewerage projects in Thailand, investment priority is given to drainage facilities. There is no idea to construct sanitary sewers in ahead of drainage, even if in the area where no drainage facilities exist at present.

2) Saving of construction cost for sewer networks is a major concern of the Government, utilizing existing channels in the built-up area.

3) Separate on-site disposal of nightsoil from the sullage is governmental policy and such facilities are widespread in the study area.

4) Combined wastewater collection method sometimes with a partial separate method is employed for most of existing sewerage systems except for those in the resort beach. Thus, construction of interceptor is major concern of the PWD.

5) Although under the combined collection system, water pollution in the channels caused by the discharge of sullage from houses would not be improved in use of current drainage system, water quality in the main rivers/khlongs downstream of the built-up area will be considerably improved. During dry season wastewater reached to the rivers/khlongs can be intercepted for treatment and substantial dilution of wastewater is expected in tropical rainy season (strong intensity and short time duration). Therefore, direct contribution to the sanitation improvement can be expected in the rivers/khlongs where people use water for multiple purposes (especially bathing and washing).

With an emphasis on the low cost construction to realize sanitation/water quality improvements on the service level affordable at the present time in Thailand, the following are recommended. However, periodic review and modifications of the master plan are requisites in the future to upgrade sewerage systems for further improvement of sanitation conditions in the service area. Collection of generated wastewater (Step 3 and step 4 in Figure 3.6.1) may be future targets to meet future needs supported by economic development and policy.

(1) In general, combined wastewater collection method shall be adopted using existing drainage systems in the built-up areas. Interceptors shall be constructed and overflow water shall be discharged into existing rivers/khlongs during rainy season.

(2) Nightsoil shall be disposed of at generated sites. For the future improvement, effluent from septic tank may be introduced to the interceptor. Figure 3.6.1 shows illustrated staged improvement in use of existing channels applying combined collection method.

Design of the collection system for the master plan aims at Step 2, but Step 2' may be taken into account for future improvement.

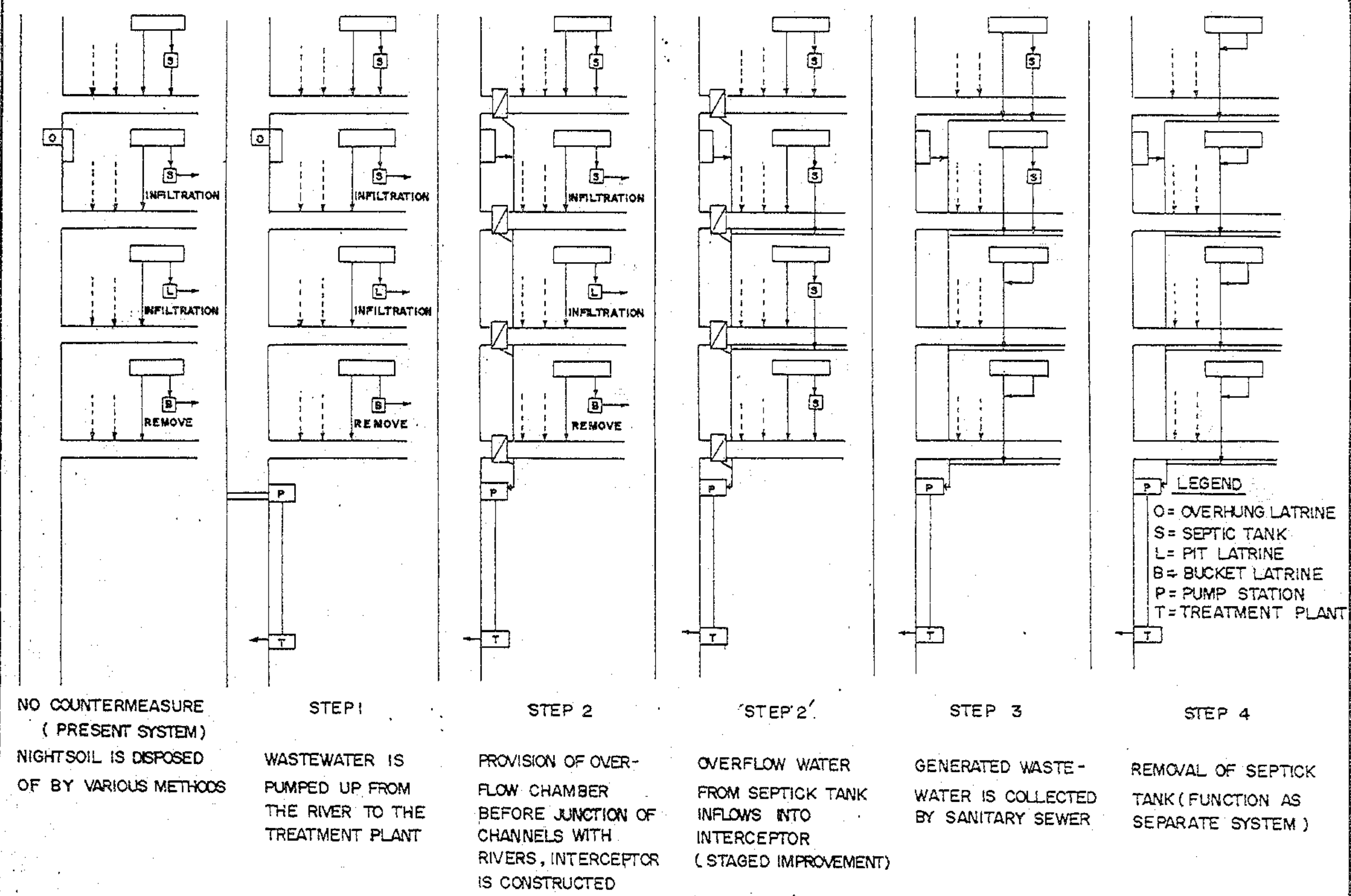

FIGURE 3.6.1 STAGED IMPROVEMENT OF COMBINED WASTEWATER COLLECTION METHOD

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Limitations to utilize existing drainage systems, and problem areas and required countermeasures in application of the selected method is discussed as follows:

(1) Limitations on the utilization of existing nightsoil and drainage systems

1) Separate treatment and disposal of nightsoil (on-site)

a) The invert level of existing drainage is too shallow to receive wastewater from existing toilet facilities without change of household drainage systems.

2) Utilization of existing drainage facilities limited to lateral sewers collecting rainwater and sullage.

a) The slope of existing pipes is quite minimal due to the economical arrangements under flat terrain, resulted in limited flow capacity and velocity with a natural water level in the pipes; requirements of newly construction of intercepting pipes.

b) Structural conditions of street sewer/drainage do not allow for introduction of nightsoil, especially with reference to its shallow installation and without a cover on the connection box thereof causing offensive odor.

(2) Problem area and required countermeasures to supplement/complete recommended systems

1) Improvement and expansion of existing drainage systems

Existing khlongs and channels are functioning as drainage facilities, although these are not necessarily sufficient at the present time against stormwater run-off. Such waterways may be used as the receiving water bodies of overflow water from diversion chamber in the sewerage service areas. However, improvement (dredging and widening of channels/khlongs, etc.) and expansion of existing drainage facilities shall be done in accordance with the arrangements by the local

government units as practiced in Thailand. Plans for staged construction are requisites to be prepared by each municipality.

2) Proper operation and maintenance of septic tank/cesspool and solid waste disposal

The adopted sewerage system cannot be completed without proper treatment and disposal of nightsoil. Information dissemination and legislative measures to the inhabitants on the design and construction of the facilities are requisites for the local government units. Arrangements on desludging from the facilities shall also be provided properly as well as sound disposal of sludge. In addition, refuse collection and disposal at present shall be improved to cover sewerage service areas and to perform sanitary landfill/composting.

3) Maintenance of overflow/diversion chamber to keep the function of adopted sewerage systems

Aside from design of the contrived chambers, periodic maintenance of the facilities, especially systematic solid waste removal is essential. The function of the sewerage system is depending on adequate arrangements by concerned agencies and cooperation of the beneficiaries.

4) Provision of house connections to connect to overflow pipes of nightsoil treatment facilities

With reference to planned grade of sewerage facilities, it is difficult for the beneficiaries to realize upgrading of living conditions resulted in the difficulty of sewage charge collection. Collection and treatment of overflow water from septic tank/cesspool could contribute to the improvement of water quality of channels/khlongs in the urban area/sewerage service area. Giving priority to specialized areas in the sewerage service area, installation of such connection pipes to interceptors shall be proceeded through the future to help promote collection of sewage charges.