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

2.1 General

There are four existing/on-going sewerage projects in the municipalities and areas of the subject basin, namely; the municipalities of Ayutthaya, Pathum Thani, Nonthaburi, and Rangsit area. Detailed design of WWTP for the industrial wastewater in Rangsit area was completed in 1992, while other projects are still under feasibility study stage. The following are the related reports.

(1) Lower Chao Phraya River Basin Water Pollution Control Master Plan

(2) Comprehensive Study of Sewerage System for the First Group Area (5 provinces)

(3) Flood Control, Drainage and Sewerage System for Nonthaburi Province

(4) Pre-feasibility Study of Domestic Wastewater Management for Pathum Thani Municipality

(5) Pre-feasibility study of Domestic Wastewater Management for Ayutthaya Municipality

(6) Detailed Design of Wastewater Treatment Plant for Rangsit area

General concepts and approach for planning/design are similar among the Thai government agencies undertaking sewerage planning and design activities. Most of these are still in the planning/design stage. Some recommendations are made on the requirements to be established/studied prior to planning.

2.2 Water Pollution Status and Future Prospects in the Lower Chao Phraya River Basin

Present water pollution status in the subject river basin is explained with reference to the eight study areas.

Range of BOD concentrations during dry season is illustrated along the river to analyze the relationship with the discharged pollution load from the study areas.

The following are the findings by sub-drainage area:

- Lower basin : Developed area of Bangkok Metropolitan extension including Bang Bua Thong and Rangsit causes water pollution since water quality standard is not maintained at the nearby water quality checking point. Klongs and drainage being connected to the Chao Phraya river show serious water pollution conditions.

- Middle and upper basin : Water quality at checking points are still tolerable in comparison with the standards due to assimilation capacity of the river, and comparatively smaller pollution load discharged in the drainage area. However, water pollution in Klongs and channels is considerable.

Future projection of BOD concentration (year 2011) is referred to using the study results in Part I of this report. Figure 2.1 shows the result of the projection in the course of water pollution analysis, that is , the relationship between BOD load and BOD concentration. The prospects by sub-drainage area are as follows:

(1) Chao Phraya river

R0-R1; Pollution load discharged from Chai Nat and its surrounding area does not seem to have a significant effect, with R1 point maintaining water quality standard.

R1-R2; Concentrated BOD load discharged from Sing Buri, Ang Thong and Pa Mok municipalities in the sub-drainage area is about 40% of

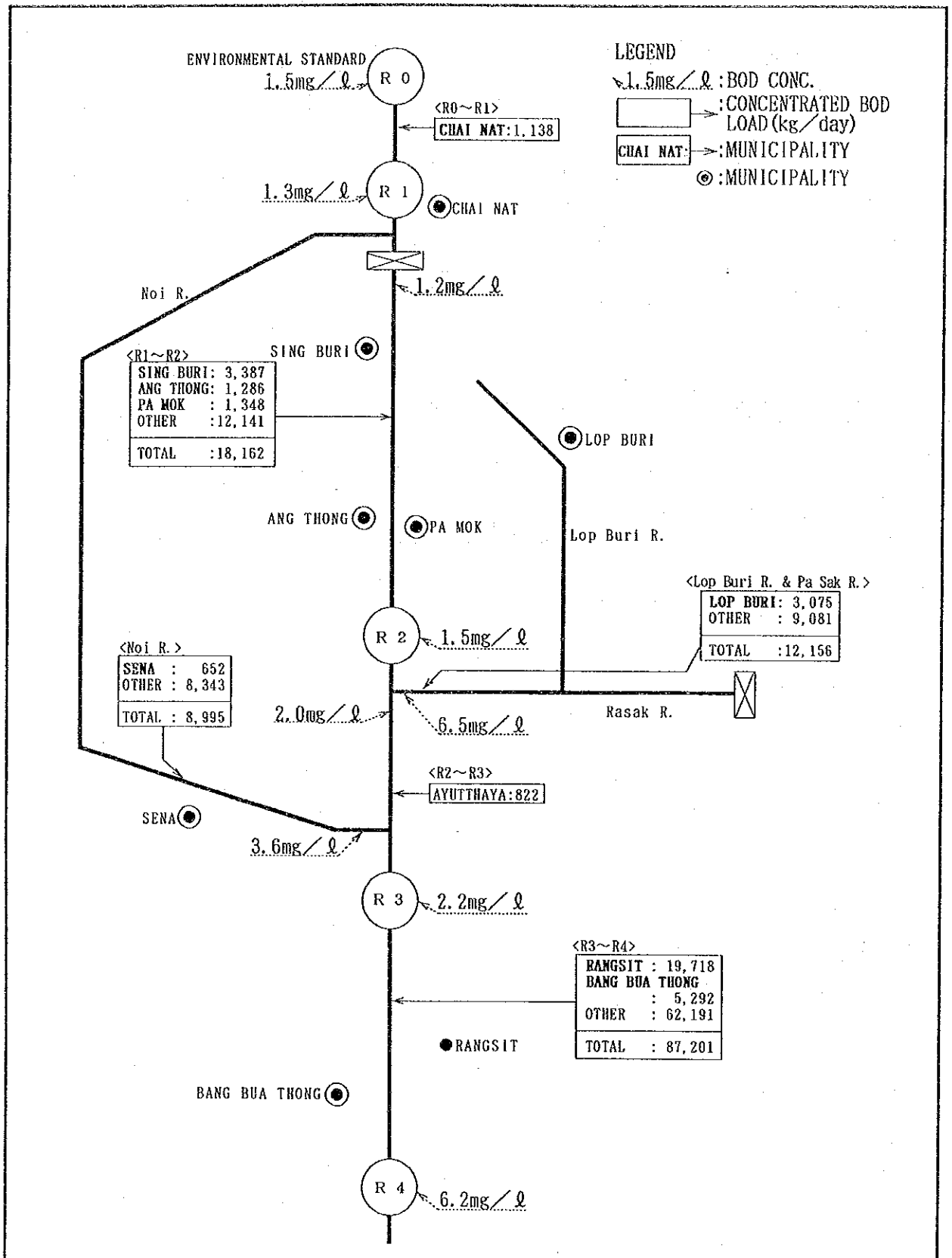

Figure 2.1 Relationship between Concentrated BOD Load and Projected BOD Concentration

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

JAPAN INTERNATIONAL COOPERATION AGENCY

the total concentrated load in this drainage area. However, contribution to the water pollution is low with reference to projected BOD concentration at R2 point (1.5 mg/l) equivalent to the standard.

R3-R4; BOD concentration at R4 point is projected at 6.2 mg/l, three times higher than the standard. Major pollution sources are identified to be discharged wastewater from the Bangkok extension area, Nonthaburi and its vicinity municipalities/S.Ds.

(2) Noi river

Sena municipality is located within the river basin, however its contribution to water pollution is rather small compared to other communities within the basin.

(3) Klongs and drainage

Direct pollution influence to the nearby Klongs and drainage caused by the discharge of wastewater from respective study municipalities/S.Ds is obvious, even if, to the main river, it is not considerable.

2.3 Design Conditions, Assumptions and Fundamentals for Sewerage Master Planning

Basic conditions/assumptions and general approach by major study item are presented covering technical, financial and management aspects in accordance with study procedures for sewerage master planning.

Sanitary sewage is the focus of the study. Drainage plan with reference to applicable wastewater collection method and utilization of existing drainage facilities is excluded.

(1) Design year and Area to be Sewered and Provision of Sanitation Improvement

Study areas by study purpose are defined referring to the 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; and 3) Preliminary Design Area- Practical area within the present municipality/SD areas.

The base year and target years for the planning purpose are determined as follows:

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

Table 2.2 shows the composition of areas by study municipality/SD for master plan target year of 2011.

Table 2.1 Study Area for Sewerage Master Plan

Subject Area		Present Municipality/S.D		Study Area (DTCP Area)
Province	Municipality/S/D	Area (sqkm)	Population	Area (sqkm)
Chai Nat	Chai Nat	6.06	13,983	56.49
Sing Buri	Sing Buri	9.02	22,570	31.33
Lop Buri	Lop Buri	6.85	36,832	12.85
Ang Thong	Ang Thong	3.73	9,607	23.98
Ang Thong	Pa Mok	6.89	10,686	26.86
Ayutthaya	Sena	1.20	4,607	26.10
Pathumtani	Rang Sit	33.30	100,600	33.30
Non Thaburi	Bang Buathong	1.60	45,786	13.50
Total		68.65	244,671	224.41

Note: (1) Rang Sit area covers Prachatipat and Ku Khot Sanitary Districts

(2) Existing Sewerage/Sanitation and Flood Protection Facilities

The existing drainage facilities partially installed in limited urban areas, serve as collection conduits for sullage and supernatant from pour-flush toilet and rainwater. These waters are discharged to nearby klongs or rivers. The concrete-made pipes with diameters of 400-1500mm are usually installed along boundaries between roadways and sidewalks with a shallow earth cover.

The flow capacities of pipes are limited due to designing of the pipe gradients following the generally flat terrain of the area.

Pour-flush latrines required for both houses and buildings are installed with soakway or septic tank and soakway. A standard design of septic tank provided with leaching tank is currently in use. Desludging services of cesspools or septic tanks once every 1 to 2 years by means of vacuum truck are provided either by the local government or private companies. The collected sludge is disposed of by dumping, and back filling or composting.

Overflow of wastewater from cesspool/septic tank may occur where permeability of the soil is low, especially during the rainy season. In this regard, collection of overflow water should be done by providing an overflow pipe as well as regular desludging.

Flood protection facilities have been constructed along the Chao Phraya river by RID. However, among the eight study areas, dikes have not been provided along the main river in Pa Mok and a portion in Sena. Flood control pump stations are installed only in Chai Nat and Sing Buri municipalities, but these facilities are not in operation for 20 years.

The present conditions allow for inundation hazards in the study area therefore, these pump stations should be maintained properly.

(3) Water Supply at Present and in the Future

Future water supply for domestic and industrial uses is analyzed in detail in Chapter 8, Part I. Water supplies for urban areas in the study areas are provided by the PWA, except for Bang Bua Thong municipality which is provided by the MWA. Water sources of these waterworks are either surface water or groundwater. Supplementary water supply systems in small sizes also exist in the rural areas.

Due to high land acquisition cost in the urban areas, industrial areas have been developed outside the municipality. Hence, industrial water consumption is considered only for Rang Sit area. Water consumption for cottage industries however, is considered as part of business water for all the study areas.

(4) 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 wastewaters were confirmed to be the subject wastewater sources (industrial wastewater for only Rang Sit area). The non-registered population of Rang Sit area is considered to meet the actual situation in an industrialized area. Table 2.3 summarizes the sewerage master planning area and design population by respective study areas.

The present land use is categorized into 6 types. DTCP's future land use plan for year 2005 is adopted for the target year 2011. Average population densities by land use type are assumed for the two classified group areas.

(5) Wastewater Collection Method

The plan and design of wastewater collection system differs depending on the employed collection method, that is, either the separate system and the combined system. There are no sanitary sewers in the study area. The storm water drainage systems are constructed and operated in the built-up areas under the responsibility of the municipalities. Night soil is separately disposed of at the generated site (fecal disposal), while sullage from the kitchen and shower is connected with a separate pipe to the storm water drainage system.

Major factors to be considered in the planning/design of wastewater collection system are: (1) utilization of existing drainage facilities to minimize construction cost; (2) staged improvements in the collection system; and (3) practical use of relevant existing facilities in consideration of (2).

After technical and socio-economic studies and discussions between the JICA Study Team and the Thai Government side, the combined wastewater collection system is adopted for all study areas. Supplementing the sewerage system, night soil should be disposed properly on-site. Furthermore, effluent from the septic tank shall be introduced to the interceptor as a future improvement as shown in Figure 2.2. This shall clearly illustrate the staged improvement of combined wastewater collection method.

TABLE 2.2 Sewerage Master Planning Area and Population

Project Area	Area & Population	Present Munici./SD	Future Exp. Area	Sewerage M/P Area	Study Area (DTCP Area)
1. Chai Nat	Area (km^2)	6.06	0.84	6.90	56.49
	Pop. in 1991	13,983	-	-	
	Pop. in 2011	19,765	2,035	21,800	
2. Sing Buri	Area (km^2)	9.02	2.89	11.91	31.33
	Pop. in 1991	22,570	-	-	
	Pop. in 2011	35,973	5,727	41,700	
3. Lop Buri	Area (km^2)	6.85	3.38	10.23	12.85
	Pop. in 1991	36,832	-	-	
	Pop. in 2011	49,320	11,980	61,300	
4. Ang Thong	Area (km^2)	3.73	1.45	5.18	23.98
	Pop. in 1991	9,607	-	-	
	Pop. in 2011	10,686	2,814	13,500	
5. Pa Mok	Area (km^2)	6.89	0.24	7.13	26.86
		(12.000)			
	Pop. in 1991	10,686	-	-	
	Pop. in 2011	12,857	443	13,300	
6. Sena	Area (km^2)	1.20	0.79	1.99	26.10
	Pop. in 1991	4,607	-	-	
	Pop. in 2011	7,790	1,610	9,400	
7. Rang Sit Prachatipat	Area (km^2)	33.30	0	33.30	33.30
	Pop. in 1991	100,600	-	-	
	Pop. in 2011	154,000	-	154,000	
8. Bang Bua Thong	Area (km^2)	1.60	11.90	13.50	13.50
	Pop. in 1991	45,786	-	-	
	Pop. in 2011	76,600	-	79,600	
Total	Area (km^2)	68.65	21.49	90.14	224.41
	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 Rang Sit area is estimated in consideration of non-registered population (30% of registered population)

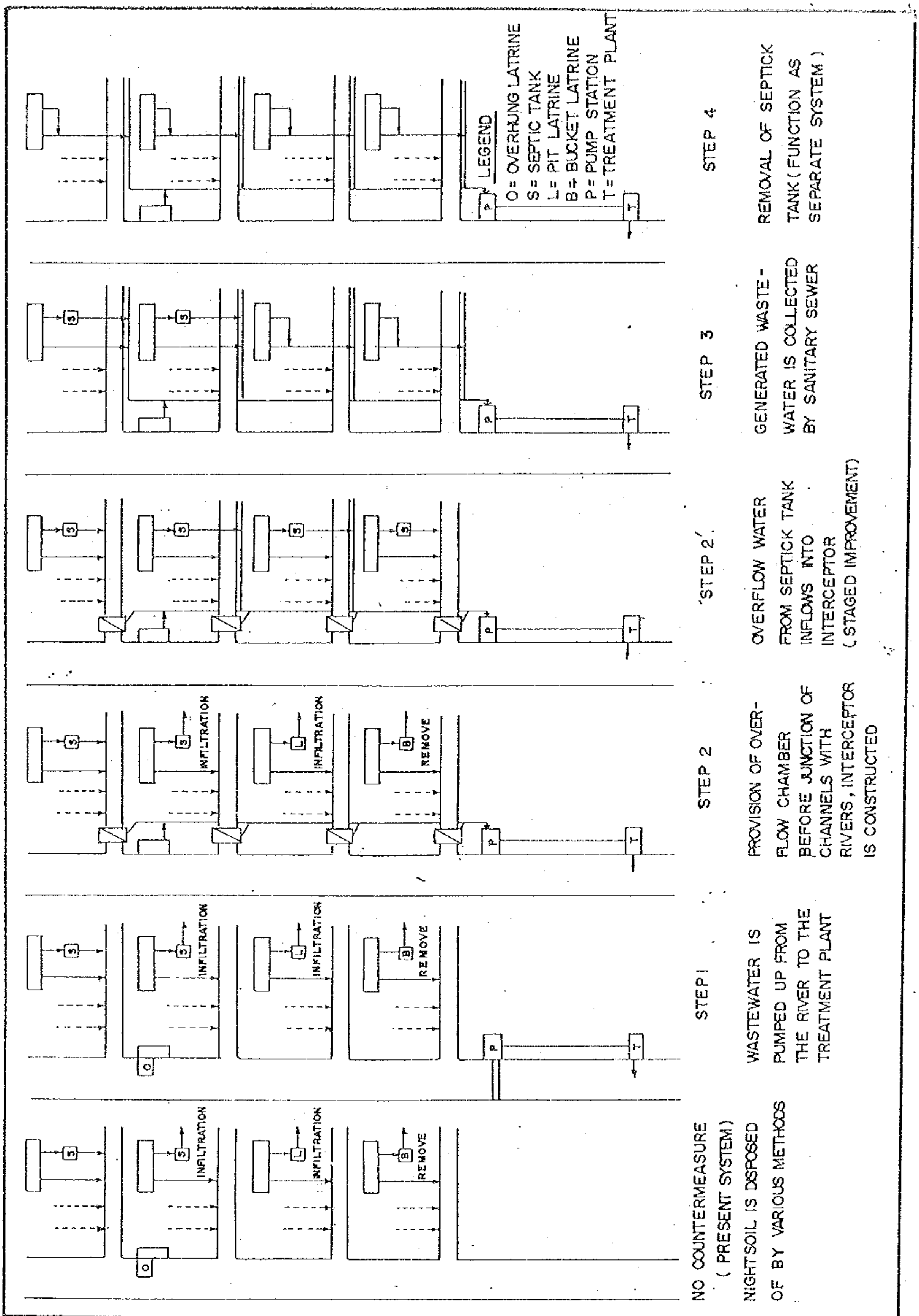

FIGURE 2.2	STAGED IMPROVEMENT OF COMBINED WASTEWATER COLLECTION METHOD	MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

(6) Concept for the Alignment of Major Sewerage Facilities

In the combined sewerage, intercepting sewer lines with more than 20ha collection area are, in principle, regarded as main sewer lines. Sub-main sewers with drainage area of more than 10ha are connected to the main sewers.

The routes of interceptor lines shall be selected to allow for the gravity flow and full utilization of existing drainage facilities. The routes shall also be along and near the rivers/Klongs to allow for smooth discharge of overflow water. Existing roads are to be used for pipe laying.

Pump stations shall be constructed in cases where earth cover of pipes reaches more than 5 m . Depending on the flow rate, the type of pump facilities is determined; manhole type for less than $5m^3/m$ and common pump station for more than $5m^3/m$. The WWTP shall be situated in a site where depth of interceptor at WWTP entrance is within tolerable limit, receiving waterway for disposal of WWTP effluent is ensured, and will not cause adverse environmental effects. Ideally, it should also be within the service area. With due consideration to the above-stated criteria, the finalization of WWTP site was made through discussions with local officials with focus on land acquisition.

Wastewater and Sludge Treatment Methods

Experiences on wastewater treatment and sludge disposal in Thailand were studied entailing field inspections to come up with practical methods for this master planning. Common problem areas related to design, operation and maintenance of the existing wastewater treatment plants are identified and summarized.

The major wastewater treatment methods being used in Thailand are activated sludge, rotating biological contactor, stabilization pond, oxidation ditch and aerated lagoon.

The following conditions were considered in the final selection of the treatment methods: 1) condition of receiving water; 2) characteristics of the wastewater; 3) condition of the wastewater treatment plant site; 4) cost

for construction, operation and maintenance; and 5) engineering requirements for operation and maintenance.

General selection of wastewater treatment and disposal methods was made for the established two groups: 1) small and lower treatment level for the upper and middle basins; and 2) large scale and higher treatment level for the lower basin.

(7) Technical Design Criteria Common to the Eight Study Area

Capacity Calculation

It is assumed that discharged wastewater quantity is 80% of water consumption/generated wastewater. The unit domestic water consumption, broken down into sullage and night soil was obtained from the study results in Part I. Existing factories and their corresponding discharged wastewater in Rang Sit area were investigated.

A comparative study on the different factors used to estimate domestic wastewater quantity in terms of daily max. and hourly max. was made with reference to PWD standards, MWA experiences as well as PWA practices.

Considering groundwater infiltration, based on the present practices in Thailand, a 20% daily average wastewater is employed to estimate design flow.

Intercepting capacity is determined to ensure the most feasible measures in terms of economy of design and efficiency of water pollution abatement. After discussion between the JICA Study Team and the PWD staff, the standard intercepting capacity was determined to be three times the peak dry weather flow.

Daily average wastewater quantity is used for capacity calculation of treatment plant, except for activated sludge treatment process. This was used due to the comparatively long detention time in the design of potential treatment methods.

Design capacity of pump station during dry season is the design hourly max. wastewater flow; whereas, during the rainy season, it is three times the design hourly max. wastewater flow volume.

Influent and effluent of the treatment plant are set up as follows:

		BOD	SS
Influent		200 mg/l	170 mg/l
Effluent;	Category A	less than 40 mg/l	less than 40 mg/l
	Category B	less than 20 mg/l	less than 30 mg/l

Hydraulic Calculation

The Manning's Formula is used for sewers with small to medium size pipes. The slope of sewers is determined to have the following minimum flow velocities: 60 cm/sec for sanitary sewer, and 80 cm/sec for storm and combined sewer. Velocity shall not exceed 3.0 m/sec in any type of sewer to avoid pipe erosion.

Structural Design of Sewerage Facilities

Standards and conditions to be used in the design of interceptor, manhole, overflow chamber, siphon, pump station and wastewater treatment plant are studied. The study on wastewater treatment plant covers also its different treatment methods.

(8) Construction Materials and Methods

Basic information on natural conditions, labor, and availability of required machine and equipment was investigated to come up with construction materials and methods for this project. Reinforced concrete pipes will be used for sewer construction. Alternative construction methods for pump stations are also identified.

(9) Operation and Maintenance of Sewerage Facilities

Operation and maintenance of major sewerage facilities with preventive measures are included. In view of the adopted wastewater collection method and grade of the system, special emphasis is placed on the expansion and improvement of existing drainage systems.

(10) Cost Estimates

Construction Cost

Following the manner of cost estimation in previous projects in Thailand, construction cost for the project is estimated. Cost functions are prepared both for wastewater collection system and treatment plant. The base data are obtained from relevant authorities (PWD, PCD and BMA). Construction cost required for the year 2011 is summarized in Table 2.4.

Operation and Maintenance Cost

Experiences in Thailand on the required cost are referred to and cost functions are developed for large-size pump stations and different wastewater treatment processes. Table 2.5 presents the summary for the eight areas.

(11) Administrative and Financial Study

Administrative and Legislative Aspects

The Thai Government has become increasingly aware of the environmental deterioration (air. water. etc.) brought about by its expanding economy and urbanization. The Government expresses concern about its environment in the 7th Five Year Plan (1992-96) and aims to keep balance between economic development and environmental protection.

The Study Team found out that both central and local government organizations involved in this sector would need to be improved, because the present systems are rather too fragmented to deal with the increasing demands of sewerage. The sewerage development requires a wide range of expertise, strong financial supports and united efforts of central and local govern-

Table 2.3 Summary of Project Cost

(Unit : Million Baht)

	Chai Nat Muni.	Sing Buri Municipality			Lop Buri Muni.	Ang Thong Municipality			Pa Mok Municipality		
		Sing Buri East	Sing Buri West	Sub Total		Ang T. East	Ang T. West	Sub Total	Pa Mok East	Pa Mok West	Sub Total
1. Direct Cost											
1) Main Sewer	111.70	111.20	89.50	200.70	151.70	55.31	35.79	91.10	78.70	64.60	143.30
2) Pumping Station	4.70	12.10	8.90	21.00	57.20	4.86	3.14	8.00	--	--	--
3) Treatment Plant	8.91	4.53	20.17	24.70	38.06	3.31	2.15	5.46	2.86	2.41	5.27
Total of Direct Cost	125.31	127.83	118.57	246.40	246.96	63.48	41.08	104.56	81.56	67.01	148.57
2. Contingencies (Direct Cost x 20%)	25.06	25.60	23.70	49.30	49.40	12.70	8.20	20.90	16.30	13.40	29.70
Total of Construction Cost (1.+2.)	150.37	153.43	142.27	295.70	296.36	76.18	49.28	125.46	97.86	80.41	178.27
3. Engineering & Construction Supervision (Total of Construction Cost x 17%)	25.56	26.10	24.20	50.30	50.40	13.00	8.40	21.40	16.60	13.70	30.30
4. Land Acquisition											
1) Pumping Station	0.09	0.13	0.10	0.23	0.24	0.05	0.04	0.09	--	--	--
2) Treatment Plant	14.25	6.00	4.99	10.99	25.16	4.13	2.67	6.80	3.51	3.23	6.74
Total of Land Acquisition	14.34	6.13	5.09	11.22	25.40	4.18	2.71	6.89	3.51	3.23	6.74
Total of Project Cost	190.30	185.66	171.56	357.22	372.16	93.36	60.39	153.75	117.97	97.34	215.31

(Unit : Million Baht)

	Sena Muni.	Rangsit Area			Bang Bua Thong Municipality				
					Bang Bua Thong North			Bang Bua Thong South	Sub Total
		Prelim. Area	Other Area	Sub Total	Prelim. Area	Other Area	Sub Total		
1. Direct Cost									
1) Main Sewer	52.80	167.30	261.20	248.50	65.30	44.00	109.30	136.20	245.50
2) Pumping Station	--	58.50	91.30	149.80	13.40	9.10	22.50	30.00	52.50
3) Treatment Plant	3.77	233.74	365.01	598.75	108.30	72.96	181.26	47.71	228.97
Total of Direct Cost	56.57	459.54	717.51	1,177.05	187.00	126.06	313.06	213.91	526.97
2. Contingencies (Direct Cost x 20%)	11.30	91.90	143.50	235.40	37.40	25.20	62.60	42.80	105.40
Total of Construction Cost (1.+2.)	67.87	551.44	861.01	1,412.45	224.40	151.26	375.66	256.71	632.37
3. Engineering & Construction Supervision (Total of Construction Cost x 17%)	11.50	93.70	146.40	240.10	38.10	25.70	63.80	43.60	107.40
4. Land Acquisition									
1) Pumping Station	--	0.42	0.65	1.07	0.09	0.06	0.15	0.21	0.36
2) Treatment Plant	5.43	36.62	57.13	93.75	89.69	60.31	150.00	7.03	157.03
Total of Land Acquisition	5.43	37.04	57.78	94.82	89.78	60.37	150.15	7.24	157.39
Total of Project Cost	84.80	682.18	1,065.19	1,747.37	352.28	237.33	589.61	307.55	897.16

Table 2.4 Summary of Operation and Maintenance Cost

(Unit ; Thousand Baht)

	Chai Nat Muni.	Sing Buri Municipality			Lop Buri Muni.	Ang Thong Municipality			Pa Mok Municipality		
		Sing Buri East	Sing Buri West	Sub Total		Ang T. East	Ang T. West	Sub Total	Pa Mok East	Pa Mok West	Sub Total
1) Main Sewer	632	657	483	1,140	982	398	257	655	382	273	655
2) Pumping Station	190	559	411	970	2,850	213	137	350	--	--	--
3) Treatment Plant	130	70	630	700	1,070	55	35	90	50	40	90
Total of Annual O&M cost	952	1,286	1,524	2,810	4,902	666	429	1,095	432	313	745

(Unit ; Million Baht)

	Sena Muni.	Rangsit Area			Bang Bua Thong Municipality				
					Bang Bua Thong North			Bang Bua Thong South	
		Prelim. Area	Other Area	Sub Total	Prelim. Area	Other Area	Sub Total		Sub Total
1) Main Sewer	181	506	791	1,297	301	203	504	674	1,178
2) Pumping Station	--	3,502	5,468	8,970	638	430	1,068	1,427	2,495
3) Treatment Plant	60	15,115	23,595	38,710	7,250	4,890	12,140	4,650	16,790
Total of Annual O&M cost	241	19,123	29,854	48,977	8,189	5,523	13,712	6,751	20,463

ments. The country is still in its initial stage of sewerage development and therefore efforts have to be exerted in the collection of all relevant information, training of engineers, and information dissemination to all sectors or levels. Those efforts have to be extended to also overseas. Experiences of other countries shall be learned for Thailand to keep sustainable development.

The PWD of Ministry of Interior is primarily in-charge with the sewerage development nationwide, together with the Ministry of Science, Technology and Environment which is implementing some sewerage schemes. The Sanitary Engineering Division (SED) under the PWD is now in the process of planning, designing and implementing 21 sewerage systems, although at present, it has a limited number of staff. Office of Sewage works (OSW) was established in 1993 for the purpose to strengthen the Government's priority sector. However its staffing is now in process. The Study Team made a recommendation for the new organization.

Recommendations to improve the administration and management of the sewerage sector were drawn-up by the Study Team as follows:

(1) Strengthening of SED in PWD

A new division, the Office of Sewage Works (OSW) was established. The division should be well-organized and staffed with qualified engineers to deal with the increasing demand of sewerage implementation. The Study Team recommends that OSW be staffed to aim at more policy-oriented office. Guidelines and standards required for sewerage should be developed so that local governments can follow them to improve the environment in harmony with economic development.

(2) Creation of New Organization

Additional organizational streamlining to reinforce the newly created OSW is needed to deal with the ever increasing demands of sewerage. The Study Team therefore, recommends that a new sewerage organization, or National Sewage Works Authority (NSWA), be created to deal with ever increasing technical demands to implement sewerage systems nationwide. This new organization NSWA will be under the control of PWD, Ministry of Interior.

Corollary to this, local governments should be collaborated by creating a Local Sewage Works Authority (LSWA) with liaison to them.

(3) High quality of training courses

At present, there is no systematic training program for national and local officials/employees for sewage works because of knowledge lack and limited working systems. High quality training courses for both national and local levels should be developed and implemented.

(4) Rearrangement of legal system

Thailand has many environment controlling regulations. But it has no well-designed legal system for sewerage in terms of organization and management. Hence, it is necessary to develop a more responsive system with particular reference to other nations.

First of all, requisitions and laws shall be arranged to create NSWA and LSWAs. They can become an institutional vehicle to accelerate sewerage system.

Secondly the legal system shall be enforced by strengthening monitoring capability and punishment.

Financial Aspects

The Seventh Economic Plan suggests that construction cost and 75 % of land acquisition cost for the sewerage project be borne by the Central Government, the remaining 25 % of land acquisition cost by concerned municipality/sanitary district. Each municipality must bear O&M cost through user charges and connection fees.

The Central Government has three options for financing the project. One is from the central government either by subsidy or loan (10% interest rate with a payback period of 20 years.), and the second is from foreign lending institutions like the multilateral loans from the World Bank and ADB (8% and 10 % interest rates for 20 yrs. with 5 yrs. grace period) as well as bilateral loans from Germany, U.S., and Japan (3% to 5% interest rates for 20

yrs. or longer with grace period of 5 yrs. or longer). The third source can come from the so-called "Environmental Fund". A mixed grant-loan arrangement can be made available to the central government and local government agencies through this fund.

On the other hand, each municipality has two options to finance 25% of the local land acquisition. One is to utilize the "Municipal Development Fund", the second is the "Environment Fund" in the form of grant/loan.

Operation and maintenance cost must be shouldered by the beneficiaries of the sewerage project. Total revenue that will be generated by the project depends upon the number of beneficiaries (users) and the sewerage tariff structure. On the basis of the number of household users and the O&M cost by 2011, the variable cost-covering tariff rate was computed by municipality as shown in Table 2.6. However, it is expected that these O&M costs will increase between 1993 and 2011, with an average inflation rate of 5.7% and this will result to a corresponding increase in tariff rate. By that time, it is expected that household income has also increase by 5.7%.

Table 2.5 O&M Cost and Cost-Covering Tariff Rates

Municipality	No. of Household Users in 2011 (1)	O&M in 2011 (1000 baht) (in 1993 prices) (2)	Cost Covering Rate (baht/household (3) = (2)/(1)
Chai Nat	5,317	952	179
Sing Buri	10,170	2,810	276
Lop Buri	14,951	4,902	328
Ang Thong	3,292	1,095	333
Pa Mok	3,243	745	230
Sena	2,292	241	105
Rang Sit	37,560	48,977	1,304
Bang Bua Thong	19,414	20,463	1,054
Total	96,239	80,185	3,809
Average	12,029	10,023	833

The proposed wastewater tariff rate will be based on self-financing principle reflecting socio-economic conditions in the municipality. This princi-

ple may be translated into self-independent cost-covering revenue generation, i.e., a variable sewerage rate for each municipality.

In quantifying this, unit wastewater treatment cost (baht/cum) is obtained by using the O&M cost and treatment capacity for each municipality. The lowest rate was taken in Chai Nat at 0.44 baht/cum, and the highest rate in Bang Bua Thong at 2.18 baht/cum. Table 2.7 shows the unit treatment cost for each municipality.

As was stated, each municipality is obliged to commit 25% of the cost for land acquisition of the sewerage project. Table 2.8 indicates the degree of investment burden by municipality. Col(7) indicates the relative burden of land cost to total expenditures, ranging from 3.8% in Lop Buri to 25.4 % in Rangsit. For similar reason, the relative burden of land cost to total revenues is shown in col(8) with the lowest of 3.8% in Sena and with the highest of 18.2% in Rangsit.

Table 2.6 O&M Cost and Unit Treatment Cost by Municipality

	O&M Cost (1000 baht/yr) (1)	Treatment Cap. (cum/day) (2)	Treatment Cost (baht/cum) (3)
Chai Nat	952	5,900	0.44
Sing Buri	2,810	11,200	0.69
Lop Buri	4,902	16,500	0.81
Ang Thong	1,095	3,700	0.81
Pa Mok	745	3,700	0.55
Sena	241	2,600	0.25
Rangsit	48,977	75,000	1.79
B.B. Thong	20,463	25,700	2.18

Col. (1) : In 1991 prices
Col. (2) : Treatment capacity (cum/day)
Col. (3) : Unit treatment cost = col (1)/[col(2)/365]

Table 2.7 Local Budgets and Sharing Burden of Land Acquisition by Municipality

(Million Baht)

Municipality	Total Revenue (1)	Central Support (2)	Total Exp (3)	Invest (4)	Land Exp (5)	Land/Inv % Share (6)	(5)/(3) % Share (7)	(5)/(1) % Share (8)
Chai Nat	24.5	10.0	22.1	1.21	3.59	296.7	16.2	14.6
Sing Buri	33.8	7.8	30.3	4.07	2.81	69.0	9.3	10.0
Lop buri	52.1	4.2	89.6	15.04	6.35	44.2	7.1	12.2
Ang Thong	23.1	10.1	22.8	13.47	1.72	12.8	7.1	7.4
Pa Mok	27.3	16.9	25.4	1.10	1.68	152.7	6.7	6.2
Sena	35.5	7.6	30.1	7.83	1.35	17.2	4.5	3.8
Rangsit	26.7	2.6	19.1	12.29	4.86	39.5	25.4	18.2
B.B. Thong	41.3	12.9	38.7	18.00	3.80	21.1	9.8	9.2

Source: Revenues and expenditures were obtained from each municipality Budget office, 1993.
(2) Central support is the fund allocated to each municipality from the Central Government.
(4) Investment expenditures indicates fixed investment allocated to public works, construction, facilities. Both local construction and construction designed by the Central Government are included.
(5) 25% Land Cost = 25% of land acquisition cost for the sewerage project.
(6) The share of 25% of land acquisition cost in fixed investment, the proportional burden sharing on each municipality.
(7) The ratio of 25% land cost to total expenditures in percent.
(8) The ratio of 25% land cost to total revenues in percent.

Aside from the 25% share for land acquisition by the local government, it will also have the responsibility of collecting O&M cost. There are two major issues that confront the local government: 1) the collection of sewerage revenues through affordable tariff rate; and 2) the revenue collection efficiency. This is defined as the proportion of total revenues collected to total bills for collection. Should this collection efficiency falls, the unpaid balance should either be locally finance, or be met by higher tariff rates.

In terms of tariff differentiation, households for each municipality are divided into 3 income groups: 1) high which constitutes 10%; 2) medium, 20%; and 3) low, 70%. The progressive tariff structure would be 1.0, 1.3, and 2.0 for low, medium, and high income households, respectively. This is based on the assumption of household water consumption of 150,200 and 300lpcd. Table 2.9 indicates the cost covering sewerage rate in 2011.

Table 2.8 Cost Covering Sewerage in 2011

Location	O&M Cost in 2011 (1000 Bt) (1)	H Users in 2011 (Number) (2)	Avg Rate H Users (Baht) (3)	Loan Cost H Users (Baht) (4)	Afford (3+4)/96571 (%) (5)
Chai Nat	952	5,317	179	63	0.25
Sing Buri	2,810	10,170	276	31	0.32
Lop Buri	4,902	14,951	328	40	0.38
Ang Thong	1,095	3,291	333	49	0.40
Pa Mok	745	3,243	230	48	0.29
Sena	241	2,292	105	54	0.16
Rangsit	47,247	37,560	1,258	12	1.31
B.B. Thong	17,583	19,414	906	18	0.96

Col(3) = col(1)/col(2)
Col(4) = Weighted average loan cost = 7%
50% local loan with 10% interest rate, 20 years
50% foreign loan with 4% interest rate, 20 years
Loan payment/household users = Loan Cost/H Users
Col(5) = [col(3) + col(4)]/96571 in percent
where 96,571 Baht is estimated income for low household income in 2011.

Affordability for sewerage rates that municipality would charge will fall under 1 percent of low household income in 2011 with the only exception of Rangsit. The affordability level was 1.31 percent, slightly over one percent. Thus the sewerage charging rate, whether it be the average household user rate or the progressive rate structure, would not be a problem for the sewerage project in all eight municipalities.

(12) Economic Analysis and Project Justification

Significant economic benefits to public health of the community can be derived from installation of an adequate sewerage system. The benefits to be derived from the sewerage systems as recommended in this Master Plan can be classified into three categories, (1) water qualitative improvement benefits, (2) private health and sanitation benefits, and (3) economic benefits attributable to the increase in land value.

The most significant benefits that may be derived from the sewerage project is water quality improvement of Chao Phraya River and the other channels.

The sewerage project also contributes to the reduction of private health

costs through improved health and sanitation, particularly through the reduction of water-borne diseases.

Table 2.10 shows a summary of the projection results in the year 2011 (water pollution control plan) reflecting the effects of sewerage projects in the lower Chap Phraya river basin.

Table 2.9 Effects of Sewerage Project

Water Quality Checking Point	Environmental Quality Standard (BOD mg/l)	Projected Water Quality	
		w/o sewerage system	with sewerage system
R1	1.5	1.3	1.3
R2	1.5	1.5	1.0
R3	2.0	2.2	1.9
R4	2.0	6.2	2.3

As shown in Table 3.14.3, it is obvious that the sewerage projects in the study area will contribute enormously for improvement of the water quality at the checking points, although water quality at R4 would be critical comparing with the environmental standard.

The benefits can be measured by the reduction of private health costs attributable to the incidence of the water-borne diseases.

The economic benefits to the community due to the reduction of the water-borne diseases is estimated. Quantification of health cost is determined through the direct relationship between the water-borne diseases and the cost of for treatment and care. For the purpose of this study, health cost is quantified, taking three factors into consideration; cost of medical treatment and care, income lost due to hospitalization, and out-patient consultation, it is expressed as the sum of these three factors:

The three factors are listed below:

a) medical cost of treatment and care per person at a hospital

b) medical cost of treatment and care per person per consultation

c) illness cost per person

Medical cost of a) and b) was 232.6 Baht in 1991, compared with illness cost of 99.4 Baht in 1991.

Then annual health cost was estimated at 8.7 million in 1991 and 12.9 million Baht in 2026 in this study area of eight sewerage projects.

An attempt was made to quantify economic benefits attributable to the increase in land price. Average Land price in the project service area is indicated as 17,545 Million Baht.

It is assumed that the Land price will increase at 15% per year from 1996 to 2000, and slow down the rate of increase at 7.5% between 2001 and 2011. The sewerage service area is assumed to contribute to 15% of the value of land increase. Net benefit of the increase of land value attributable to the sewerage project amounts to 2,658.0 million Baht during the period between 1996 and 2000. The factor of increase is 2.01 for 5 years at 15% compounded annually. [(17,545 x 2.01 - 17,545) x 0.15 = 2,658.0 million Baht], and to 1142.8 million Baht during the period between 2001 and 2005. [(17,720 x 1.43 - 17,720) x 0.15 = 1,142.8 million Baht]

An attempt to quantify economic benefits on the basis of the increase of land value and of the reduction of private health costs attributable to the sewerage project indicate that EIRR may be more than 10%. This figure appears reasonably high to justify the project on economic grounds. Other benefits such as economic benefits of groundwater pollution and the further development of housing and business establishments are not included.

(13) Interim Measures

Interim measures are recommended for effective and minimum capital investments in conformity with the future sewerage system. Periodic review and up-dating of the sewerage master plan are also required.

Based on the present pollution problems and future conditions, countermeasures to abate such problems and condition are recommended as follows:

- Improvement of nightsoil treatment facilities and promotion of desludging services;
- Improvement of refuse collection and disposal;
- Collection and treatment of sullage;
- Controlling measures to the discharge of industrial wastewater;
- Dredging and cleaning of klongs/drains; and
- Proper maintenance of existing treatment facilities and construction of treatment plant for new housing complexes

(14) Implementation Plan

Staged construction of sewerage systems is envisaged through the year 2011 considering the huge capital outlay requirement. Priority areas are identified for each respective sewerage system and an outline of the implementation plan is prepared as follows:

Stage	Period	Works with priority
1st	1991-1995	Preparatory work & design of facility
2nd	1996-2001	Construction for 1st priority area
3rd	2002-2006	Construction for 2nd priority area
4th	2007-2011	Construction for remaining area

(15) Environmental Impact by the Sewerage Projects and Recommended Counter measures

Adverse impact to nature and community caused by the construction of sewerage facilities are identified.

Considering the proposed methods/processes for the wastewater and sludge treatment in this master planning, possible adverse effects/impact were evaluated, and measures to mitigate such adverse impact/effects were described covering offensive odor, injurious insects and effluent quality. Table 2.11 indicates possible environmental problems and measures to control, if not to fully eliminate adverse environmental impact.

(16) Recommendations on the Sanitation Improvement in the DTCP Area

Improvement of public health and quality of life of the rural population in the DTCP area is another essential matter in the provision of improved water supply and sanitation. As required, the focus of the study is wastewater caused by nightsoil treatment and disposal.

Sequential improvement of nightsoil treatment was discussed. It is recommended that the ventilated improved pit latrine commonly used in the rural areas be up-graded to pour flush toilets with water seal, to keep pace with the increasing income of inhabitants.

Required improvement of septic tank currently in-used is also recommended with reference to the collection of overflow water. Furthermore, periodic control and desludging are emphasized as a basic need.

In the institutional aspect, community participation is important together with personal contacts and dialogue with inhabitants. Support from central and local governments is also indispensable, in addition to educational requirements.

Table 2.10 Environmental Problems and Countermeasures

Actions Affecting Environmental Resources and Valves	Damage to Environment	Recommended Feasible Protection Measures
A.Problems Related to Siting of Facilities		
1.Interference with other utilities/ Street, traffic/blocking of access to buildings	1.Nuisances/disturbances to public	1.Alignment of sewer routes to minimize interference with other utilities
2.Nuisance hazards to neighboring areas	2.Nuisances/hazards to worker and neighbors	2.Careful planning/design/O & M and adequate buffer areas
3.Inadequate resettlement provisions	3.Social inequities	3.Adequate planning and budgeting
4.Impairment of historical/cultural movements/areas	4.Loss or impairment of these values	4.Careful planning and offsetting measures
B.Problems During Design Stage		
1.Overflow/bypassing hazards	1.Pollution and flooding	1.Proper design/O & M and operation monitoring
2.Inadequate management of industrial wastewater discharge	2.Damage to sewers/treatment plants	2.Careful planning/design and operation monitoring
3.Hazards of sulfide corrosion	3. - do -	3. - do -
4.Odors and noise from treatment process or sludge disposal operations	4.Nuisance to public	4.Site treatment works only near compatible land use Select appropriate technology Include odor control and low-noise equipment
C.Problems During Construction Stage		
1.Silt runoff from construction operations	1.Soil erosion, damage to water quality /land values	1.Proper resurfacing and construction monitoring
2.Dust/odors/fumes	2.Hazards to workers and nearby residents	2.Appropriate controls
3.Prolonged periods of sewer construction	3.Traffic congestion/blocking of access to buildings	3.Careful construction scheduling
4.Noise and vibrations	4.Hazards to workers or nearby residents	4.Appropriate controls
D.Problems During Operation Stage		
1.Hazards to health/safety of workers	1.	1.Careful O & M and operation monitoring
a) Toxic gases in sewers and hazardous materials in sewage	a) Serious/health/safety hazards	a) Careful O & M program with of emergencies
b) Communicable disease hazards	b) - do -	b) Careful O & M program and monitoring
c) Sewer trench cave-in monitoring	c) - do -	c) - do -
2.Inadequate operation stage monitoring	2.O & M likely to depreciate	2.Losses in overall system functioning
3.Overflow from sewers	3.Nuisance/public health hazard	3.Routinely, inspect sewers for illegal connections and obstructions Clean sewers as required Provide monitoring system with alarms for pump station failure Educate public to prevent disposal of solid waste in sewers

CHAPTER 3. SEWERAGE MASTER PLAN FOR RESPECTIVE MUNICIPALITIES/AREAS

A sewerage master plan for each of the selected eight municipalities was prepared considering common conditions and assumptions prevailing to all areas as studied in the previous Chapter.

The summary of the sewerage master plan is presented consolidating background information regarding topography, socio-economic conditions, existing facilities, and others that formed the basis of the proposed sewerage system. Description of the proposed sewerage system, its estimated cost, and implementation plan are presented separately for each of the selected eight municipalities.

3.1 Description of the Study Area

All the eight areas are located along the Chao Phraya river between Chai-Nat and Nonthaburi. Terrain of most of the areas is flat and easily inundates during heavy rains even for areas with some flood protection facilities. The two major means of transportation are by river and by land. In some areas, a bridge is installed across the Chao Phraya river.

Cottage industries exist in most areas. There is at least a slaughterhouse and a fresh market in each of the selected municipalities. Most of the households are served with electric power supply. Table 3.1 outlines the general description of each area with regards to topography, means of transportation, and socio-economic conditions.

3.2 Existing Sewerage/Sanitation and Flood Protection Facilities

Existing Sewerage Facilities

Drainage facilities are installed in the urban areas and these presently serve as collection conduits for rainwater, as well as sullage and supernatant from pour-flush toilet. These waters are finally discharged to nearby rivers/klongs. The outline of the existing drainage facilities of each study area is presented in Table 3.2.

Table 3.1 Information on the Study Area

Area/ Municipality	Topography	Means of Transportation	Industries	Utility Services	Electric Power Supply	Telephone Service
1. Chai Nat	Plain Plateau	Land River bridge	Food & drinks, furniture, equipment repair shop & printing	1 Slaughterhouse 2 Fresh markets	Covers 99.37% of DTCP area	
2. Sing Buri	Flat terrain	Land	Food & beverages, car or motorcycle repair shops	1 Slaughterhouse 2 fresh markets 5 irrigation projects	By PEA covering quite a wide area	2,010 telophone lines plus limitted lines for long distance call
3. Lop Buri	Plain in the west and mostly mountainous terrain in the other parts	Land	Agricultural product, fishery, livestock raising	13 hotels 5 fresh markets 1 slaughterhouse	Covers all district areas	4 telephone centers with about 6,000 units
4. Ang Thong	Flat terrain	Land River bridge	Agriculture, livestock raising, freshwater fishery	3 fresh markets 1 slaughterhouse 18 schools	Supplied by the local electricity office	
5. Pa Mok	Flat terrain	Land River	Labor for production and construction, agriculture, fishery, brick manufacturing	1. Slaughterhouse		
6. Sena	Flat terrain	Land River	Jewelery factories, repair shops	2 hotels 2 fresh markets 1 slaughterhouses	Distributed through a local office	1,024 telephones
7. Rangsit Area Khu Khot S.D. & Prachatipat S.D.	Flat terrain	Land	Beverage shop, tailoring, mechanical works	1 Fresh market 17 public roads 11 housing projects 2 slaughterhouses	1,200 households; increase of users served per year	11,000 telephones
8. Bang Bua Thong	Flat terrain	Land		1 Slaughterhouse 1 fresh market	Supplied by EGAT in Bangkok	

Table 3.2 Outline of Existing Drainage System

Municipality	Size (mm)		Length (m)	Type	Drainage Area (ha)
Chai Nat	dia	1,000	5,100	RC. Pipe	45.8
	dia	600	4,150	RC. Pipe	42.4
	dia	500	1,250	RC. Pipe	8.6
	dia	400	2,550	RC. Pipe	19.4
Total			13,050		116.2
Sing Buri	dia	600	12,700	RC. Pipe	121.3
	dia	800	250	RC. Pipe	1.6
	dia	400	5,250	RC. Pipe	43.6
Total			18,150		166.5
Lop Buri	dia	1,000	2,800	RC. Pipe	39.6
	dia	800	2,400	RC. Pipe	26.5
	dia	600	5,350	RC. Pipe	69.6
Total			10,550		135.7
Ang Thong	dia	1,200	10	RC. Pipe	0.9
	dia	1,000	110	RC. Pipe	2.0
	dia	800	450	RC. Pipe	3.6
	dia	600	8,150	RC. Pipe	78.5
	dia	400	1,200	RC. Pipe	8.8
	width	500	580	U-shaped ditch	6.3
Total			10,500		100.1
Sena	dia	400-1,000	6,470	RC. Pipe	45.0
Pa Mok	dia	300	484	RC. Pipe	2.5
	dia	600	4,016	RC. Pipe	62.0
	dia	800	752	RC. Pipe	10.5
Total			5,252		75.0
Rang Sit	dia	400	400	RC. Pipe	5.0
	dia	600	43,900	RC. Pipe	785.0
	dia	800	10,100	RC. Pipe	150.0
	dia	1,000	650	RC. Pipe	7.0
	dia	1,500	20,100	RC. Pipe	467.0
Total			75,150		1,414.0
B.B. Thong	dia	400	130	RC. Pipe	--
	dia	600	5,491	RC. Pipe	--
Total			5,621		56.2

Existing Sanitation Facilities

Refuse collection service is usually provided by the municipal government. The absence of proper disposal of refuse causes clogging in the sewerage facilities, and aggravates flooding problems in the areas. The outline of the existing sanitation facilities of each study area is presented in Table 3.3. On-site treatment and disposal of nightsoil is common, either provided by septic tank or cesspool.

Table 3.3 Current Refuse Disposal Services

Area/Municipality	No. of Truck	Unit Capacity	Collection Volume	No. of Collection Per Day	Dumping Site	Area	Disposal Method	Municipality Service Percentage
1) Chai Nat	2		80 m3/d		Klao Phong Tambol Thapha	67 rai	Burning or Burying	53 %
2) Sing Buri	4	55 m3	110 m3/d	8 times	4 km away from the municipality	12 rai	landfill & Partial burning	
3) Lop Buri	7	10~15 m3	200 m3/d		Tambol Tale chubsorn, 2km away from the municipality	11.75 rai	Drying & burning	
4) Ang Thong	1		10 m3	3 times	Plain along Ang Thong Pa Mok road	3 rai	almost full to its capacity	
5) Pa Mok	1		5 ton/d	2~3 times	Sout-western part of the municipality	2.5 rai	Burning bad location	
6) Sena	2	10 m3	200~300m3/d	5~6 times	5 km from the municipality	4 rai	Burning	
7) Rang Sit Area a) Khu Khot S.D.	1 vacuum truck and 6 trucks		150 ton/d			80 rai		
b) Prachatipat S.D.	5		40 ton/d			12 rai		
8) Bang Bua Thong			100 ton/d			4 rai		

On site treatment and disposal of nightsoil is common either provided by septic tank or cesspool.

Flood Protection Facilities

Flood protection facilities have been constructed along the Chao Phraya river by RID. However, among the eight study areas, dikes have not been provided along the main river in Pa Mok municipality and part of Sena municipality. Flood control pump stations are installed only in Chai Nat and Sing Buri municipalities but these facilities have been non-operational for more than 20 years.

3.3 WATER SUPPLY

Present water supply for the study areas is covered by PWA or MWA, and supplemented by community water supply. Table 3.4 shows the present supply status. Water consumption rates range from 113 lpcd in Pa Mok to 280 lpcd in Lop Buri. Future consumption rates in 2011 are assumed for two groups; Rangsit and Bang Bua Thong (360 lpcd), and other areas (280 lpcd).

Table 3.4 Present Water Supply for the Study Areas

Province	Municipality / Sanitary District	Water Supply Agency	Population in Service Area	Population Served	Annual Water Sales (m^3/year)	No. of Connections	Consumption Rate lpcd
1. Chai Nat	1. Muang Chai Nat Mun.	PWA	14,500	10,960	714,650	2,739	179
2. Sing Buri	1. Muang Sing Buri Mun.	PWA	20,800	17,030	927,044	3,785	149
	2. Thon Sa Mo S.D	PWA	10,200				
3. Lop Buri	1. Muang Lop Buri Mun. and Military	PWA	-	-	10,219,627 * (4,580,000)	8,903	* (280)
4. Ang Thong	1. Muang Ang Thong Mun. and Surroundings	PWA	25,810	13,490	780,835	2,698	159
	2. Pa Mok Mun.	PWA					
	3. Sanchao Rong Thong S.D	PWA	10,900	4,360	179,682	872	113
5. Ayutthaya	1. Sena Mun.	PWA	13,600	6,680	487,311	1,671	200
6. Pathum T.	1. Rangsit Area S.Ds **	PWA	95,540	60,590	4,008,395	10,096	181
7. Nontha-buri	1. Muang Nonthaburi Mun.	MWA	258,037				
	2. Pak Kret Mun.	MWA	107,347		66,094,544	110,413	226
	3. Bang Bua Thong Mun.	MWA	35,342				

Note: * For Lop Buri, annual water sales in parenthesis is the figure excluding the use at military camp sites (more than 50% of total sales), then, the domestic consumption Rate is 280 lpcd.

** There are 4 S.Ds.

3.4 PROPOSED SEWERAGE SYSTEM FOR THE YEAR 2011

A total of 11 sewerage systems are proposed covering the 7 municipalities and two sanitary districts. Two systems are considered each for Sing Buri and Pa Mok due to topographic condition which are both separated by Chao Phraya river, and another 2 systems for Bang Bua Thong due to land availability for WWTP. Table 3.5 shows the proposed wastewater collection facilities for each of the municipalities/districts and Table 3.6 summarizes information on WWTPs including design capacity with treatment methods, land availability and cost requirements for both construction and annual O&M cost.

Required number of staff for O&M of WWTP is shown in Table 3.7. The number is dependent on the size of the WWTPs.

Implementation plan, and administrative and financial aspects are summarized in the previous chapter.

Table 3.7 Operators Requirements for O&M of Sewage Treatment

Municipaliry/S.D	Tratment Plant	Design Capacity (m3/d)	Operators Requirement	For each municipality
Chai Nat	T.P.	5,900	13	13
Sing Buri	East T.P.	3,100	11	
	West T.P.	8,200	16	27
Lop Buri	T.P.	16,500	21	21
Ang Thong	T.P.	3,700	11	11
Pa Mok	East T.P.	2,000	8	
	West T.P.	1,700	8	16
Sena	T.P.	2,600	9	9
Rangsit	T.P.	75,000	50	50
Bang Bua Thong	North T.P.	23,600	30	
	South T.P.	7,900	15	45

Sewerage Systems and layout plans of the treatment plants for respective project areas are presented in Figure 3.1 - 3.16. Although anaerobic pond is planned in the design of stabilization pond system, it may start from facultative pond with polishing pond. In this connection, further study shall be made during F/S stage to reflect updated information on sewage

characteristics associated with employed manner of sewage collection. Land area required for the WWTP may be more or less same in both cases with anaerobic pond and without anaerobic pond provided by polishing pond.

Table 3.5 Summary of Wastewater Collection Facilities

ITEM		CHAI NAT	SING BURI	LOP BURI	ANG THONG	PA MOK	SENA	RANGSIT	BANG BUA THONG
Interceptor (Type & Dia. mm)	RCP 300	4,750	8,700	4,420	6,660	3,615	1,258	3,460	6,175
	RCP 400	1,320	1,000	3,810	1,090	5,430	1,050	1,585	4,280
	RCP 500	1,560	1,630	1,350	----	820	----	760	2,005
	RCP 600	1,850	2,860	150	2,030	----	590	1,634	2,412
	RCP 800	590	2,693	3,430	----	----	----	2,190	2,090
	RCP 1,000	----	----	1,385	----	----	----	4,930	1,240
	RCP 1,200	----	----	250	----	----	----	2,613	50
	RCP 1,500	----	----	----	----	----	----	1,790	----
	RCB 1,600 x 1,600	----	----	----	----	----	----	2,370	----
	Total (m)	10,070	16,883	14,745	9,780	9,865	2,898	21,332	18,252
Manhole	NO. 1	238	350	224	242	266	75	183	329
	NO. 2	19	13	42	3	----	3	68	55
	NO. 3	3	25	30	----	----	----	61	35
	NO. 4	----	----	3	----	----	----	69	3
	Special	----	3	12	----	----	----	9	3
	Total	260	401	311	245	266	78	390	425
Pump Station	less than 5m³	0.78	0.72 4.56 0.66 0.78	4.50 1.50 3.66 0.90	2.16 2.16 2.34 4.62 2.10	2.76 2.34 4.62	2.16 1.44	3.96 2.94 2.16	2.10 3.72 1.86 1.02
	more than 5m³	9.12	8.76 21.90	33.60 14.52 5.52	11.82	----		105.84 123.54 12.42 46.02 52.02 68.70	12.84 43.56 5.52 12.90
	Number	2	6	7	6	3	2	9	8
Siphon (Type & Length)	Dia. (mm)	----	----	(1-1B) RC 300 x 2 x 60	----	----	----	RC 1,000 x 2 x 71m RC 800 x 2 x 57m RC 800 x 2 x 43m RC 300 x 2 x 54m RC 400 x 2 x 40m	(1-3A) RC 400 x 2 x 38 m
	Length (m)			(1-5) RC 600 x 2 x 45					
	Number	----	----	2	----	----	----	5	1
River Crossing	Length (m)	----	----	(5-2B) SP 200 x 130 m (6-2B) SP 200 x 2 x 130 m	(1-5B) SP 200 x 210 m	----	(1-1C) SP 200 x 80 m	----	----
	Number	----	----	2	1	----	1	----	----

Table 3.6 Summary of Construction and Annual O&M Cost of Sewage Treatment Plant

Name of Treatment Plant	Design Capacity (m^3/day)	Initially Projected Land Area by Local Government (ha)	Treatment Plant		Required Land Area (ha)	Project Cost (Million Baht)			Annual O&M Cost (Million Baht)
			Treatment Method *	Sludge Dewatering **		Construction Cost	Land Acquisition	Sub-Total	
Chai Nat	5,900	11.0	SP	DB	7.60	8.91	14.25	23.16	0.13
Sing Buri East	3,000	6.5	SP	DB	4.80	4.53	6.00	10.53	0.07
Sing Buri West	8,200	4.5	AL	DB	4.70	20.17	4.99	25.16	0.63
Lop Buri	16,500	3.8	AL	DB	8.05	38.06	25.16	63.22	1.07
Ang Thong	3,700	6.0	SP	DB	5.44	5.46	6.80	12.26	0.09
Pa Mok East	2,000	10.0	SP	DB	3.74	2.86	3.51	6.37	0.05
Pa Mok West	1,700	20.0	SP	DB	3.44	2.41	3.23	5.64	0.04
Sena	2,600	6.7	SP	DB	4.34	3.77	5.43	9.20	0.06
Rang Sit	75,000	11.9	AS	DU	7.50	598.75	93.75	692.50	38.71
B.B.Thong N.	23,600	3.2	AS	DU	3.00	181.26	150.00	331.26	12.14
B.B.Thong S.	7,900	9.0	OD	DB	2.25	47.71	7.03	54.64	4.65

Note * : SP: Stabilization Pond
AL: Aerated Laggon
OD: Oxidation Ditch
AS: Activated Sludge

Note **: DB: Drying Bed
DU: Dewatering Unit

DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991	Target Year 2011
Area (Km²)	6.06 (Municipality)	6.90 (Sewerage Service)
Population (persons)	13,983 (Municipality)	21,800 (Sewrage Service Area)
Unit Wastewater (lpcd)	144	224
Unit Domestic	112	160
Unit Business	32	64
Unit BOD Load (gpcd)	45.2	48.3
Unit Domestic	39.1	40.6
Unit Business	6.1	7.7
Total Wastewater Quantity (m^3/d)	2,307	4,883
Total Wastewater BOD (kg/d)	724	1,053

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station	
Dia. by Material (mm)		Length (m)	Kind	Number	Less than 5 m^3/m Capacity (m^3/m)	More than 5m^3/m Capacity (m^3/m)
RCP	300	4,750	No.1	238	No.2 0.78	No.1 9.12
RCP	400	1,320	No.2	19		
RCP	500	1,560	No.3	3	Total 1	1
RCP	600	1,850	No.4	-		
RCP	800	590	Special	-		
	Total	10,700	Total	260		

Note : RCP; Reinforced Concrete Pipe

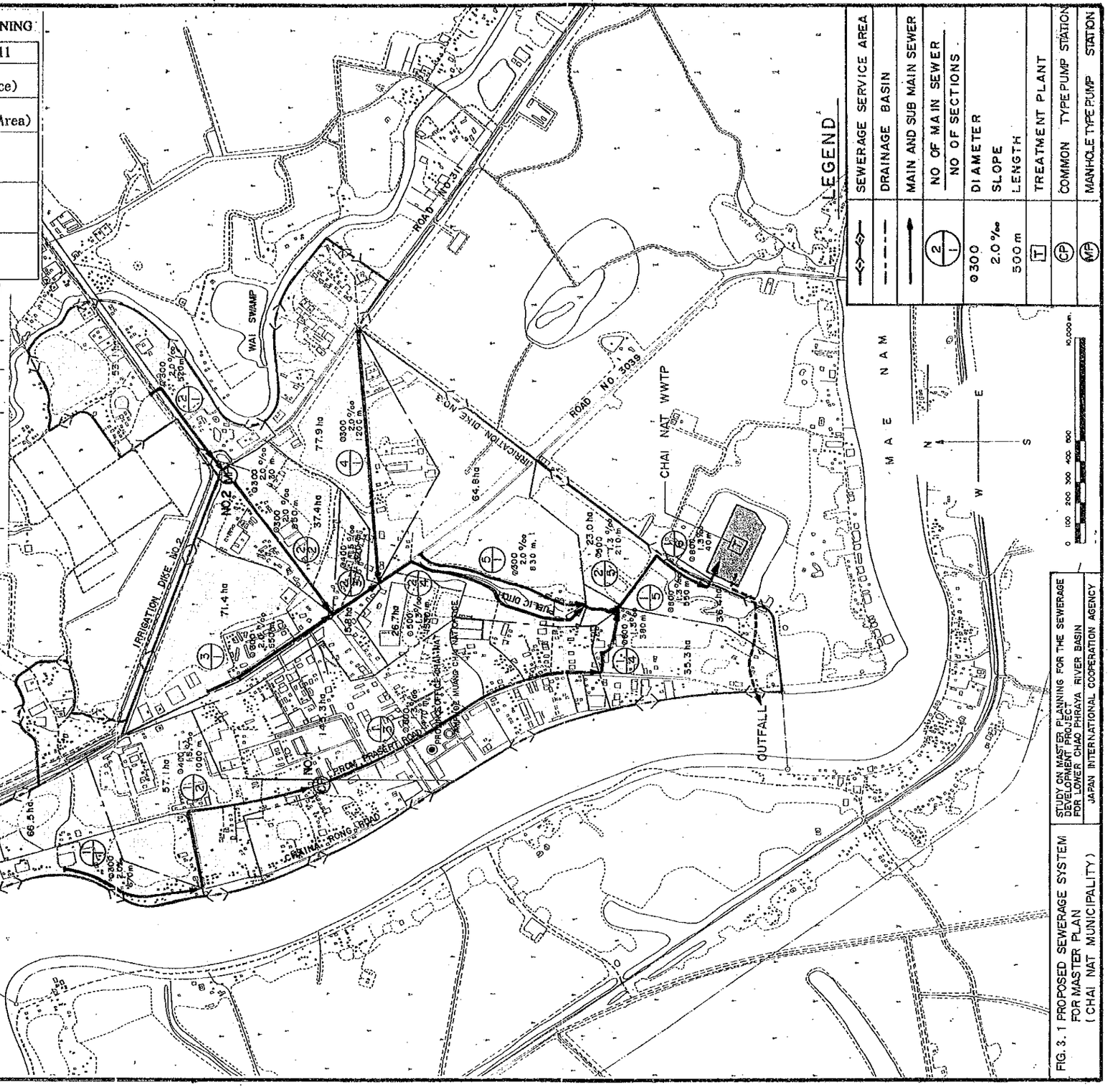

FIG. 3.1 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (CHAI NAT MUNICIPALITY)

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

Wastewater Treatment Plant

Wastewater Treatment method	Stabilization Pond System
Plant Space Area (ha)	7.6
Treatment Capacity (m^3/d) (inclusive of G.W)	5,900
Discharge Point	Chao Phraya River

Main Facilitie's

1)	Inflow Pump	Submerged Pump
	(Dry Season)	ø200m/mx3.0m^3/minx7.6^{m}Hx2units
	(Wet Season)	ø250m/mx6.0m^3/minx7.6^{m}Hx2units
2)	Grit Chamber	Constructed with R.C. Size 0.8^{m}Wx6.5^{m}Lx0.6^{m}Dx2units (1 unit for dry weather)
3)	Anaerobic Pond	Enbankment protected by masonry Dimension 60^{m}Wx80^{m}Lx4.0^{m}Dx2units Retention Time 5 days
4)	Facultative Pond	Enbankment protected by masonry Dimension 70^{m}Wx120^{m}Lx2.0^{m}Dx2units Retention Time 5 days
5)	Maturation Pond	Constructed with R.C. Dimension 63^{m}Wx83^{m}Lx1.5^{m}Dx4units Retention Time 5 days
6)	Drying Bed	Dimension 6^{m}x8^{m}x4units Detention Time 15 days

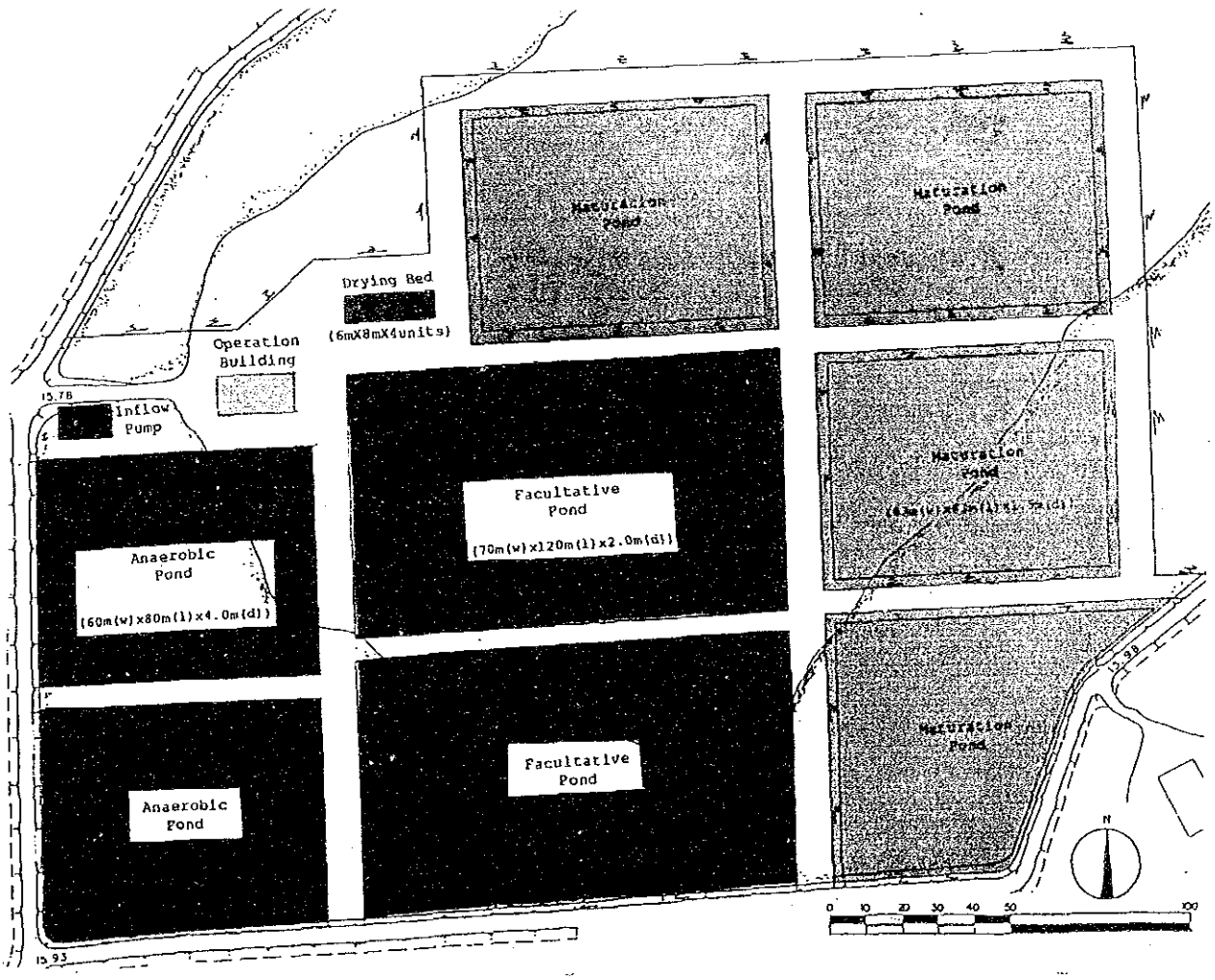

FIGURE 3.2 Layout of Sewage Treatment Plant (Chai Nat)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

DESIGN CONDITIONS. FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991			Target Year 2011		
	East Area	West Area	Total	East Area	West Area	Total
Area (Km^2)	4.17	4.85	9.02	6.859	5.051	11.91
Population (persons)	6,120	16,450	22,570	11,300	30,400	41,700
Unit Wastewater (lpcd) Unit Domestic Unit Business	112 32			160 64		
Unit BOD Load (gpcd) Unit Domestic Unit Business	39.1 6.1			40.6 7.7		
Total Wastewater Quantity (m^3/d)	1,106	2,976	4,082	2,531	6,810	9,341
Total Wastewater BOD (kg/d)	346.6	932.4	1,279	545.8	1,468.1	2,013.9

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station	
Dia. by Material (mm)	Length (m)		Number		Less than 5 m^3/m Capacity (m^3/m)	More than 5 m^3/m Capacity (m^3/m)
RCP 300	8,700	No.1	350	No.1	0.72	No.3 8.76
RCP 400	1,000	No.2	19	No.2	4.56	No.6 21.60
RCP 500	1,630	No.3	35	No.4	0.66	
RCP 600	2,860	No.4	-	No.5	0.78	
RCP 800	2,693	Special	3			
Total	16,883	Total	401	Total		

Note : RCP; Reinforced Concrete Pipe

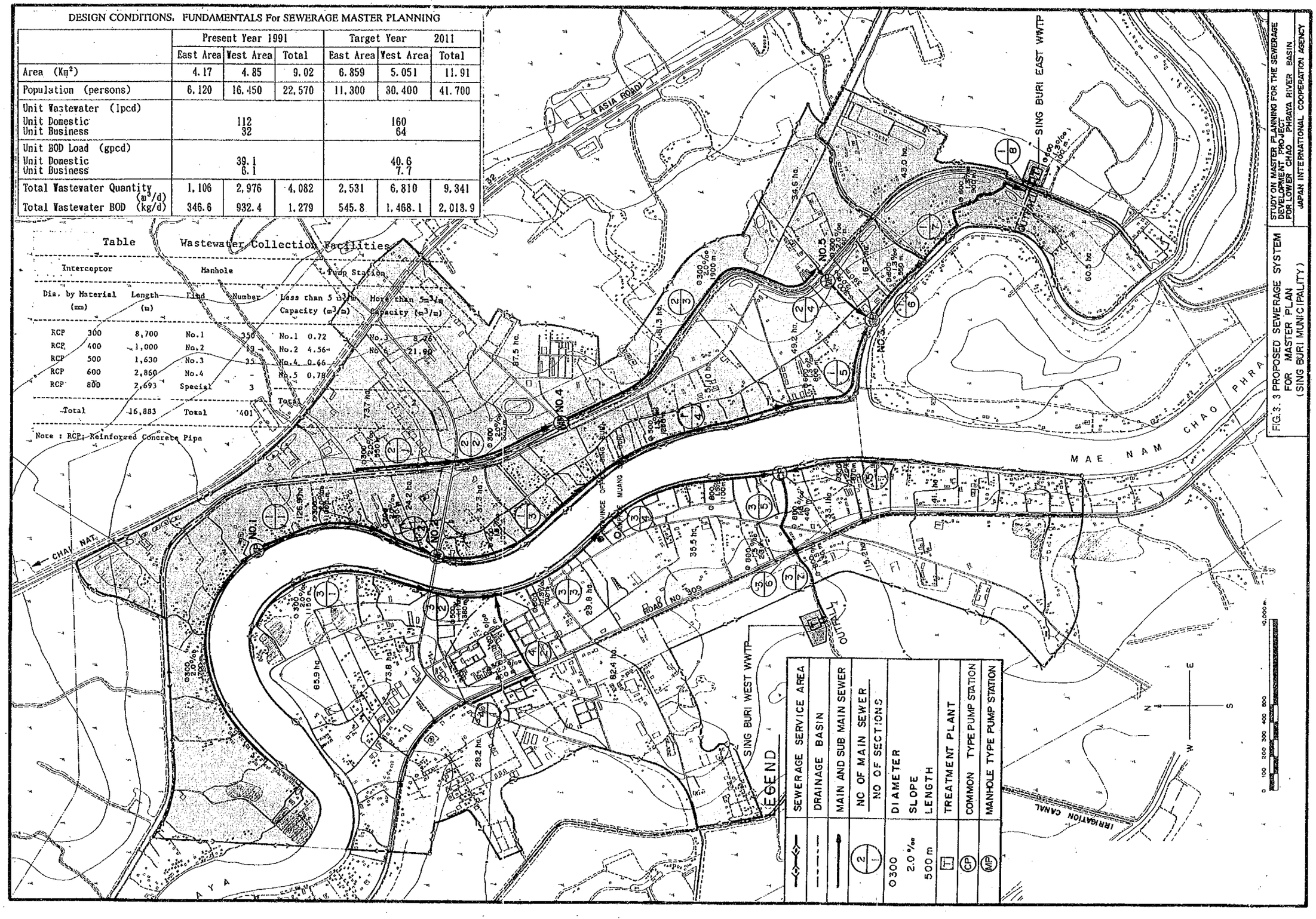

FIG. 3. 3 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (SING BURI MUNICIPALITY)

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

Wastewater Treatmentplant

	East T.P.	West T.P.
Wastewater Treatment method	Stabilization Pond System	Aerated Lagoon System
Plant Space Area (ha)	4.8	9.85
Treatment Capacity (m³/d) (inclusive of G.W)	3,000	8,200
Discharge Point	Irrigation Canal	Khlong

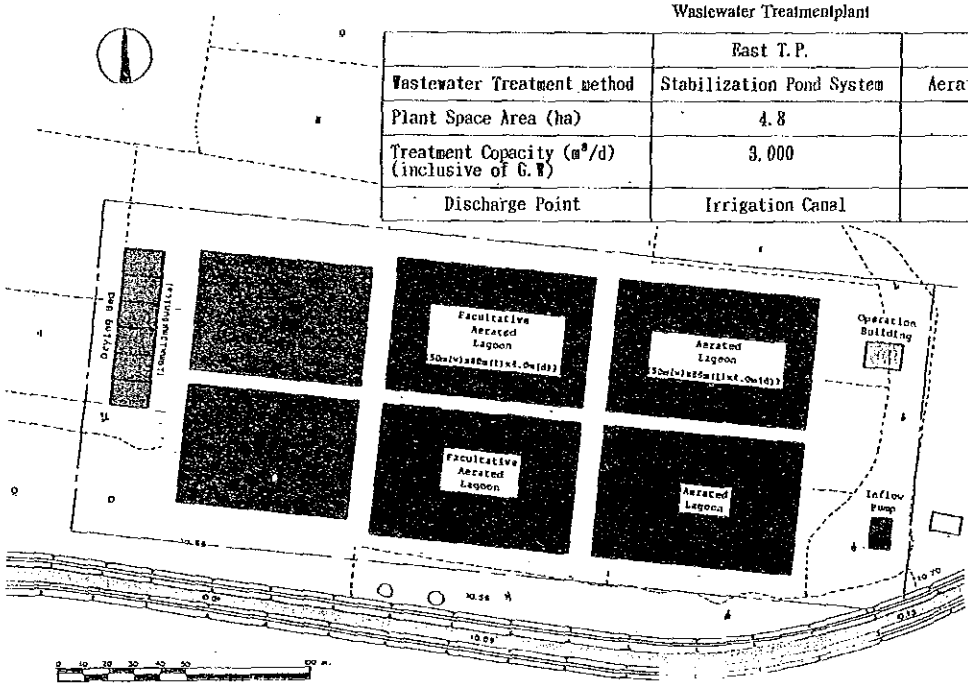

FIGURE 3.4(b) Layout of Sewage Treatment Plant (Sing Buri West)

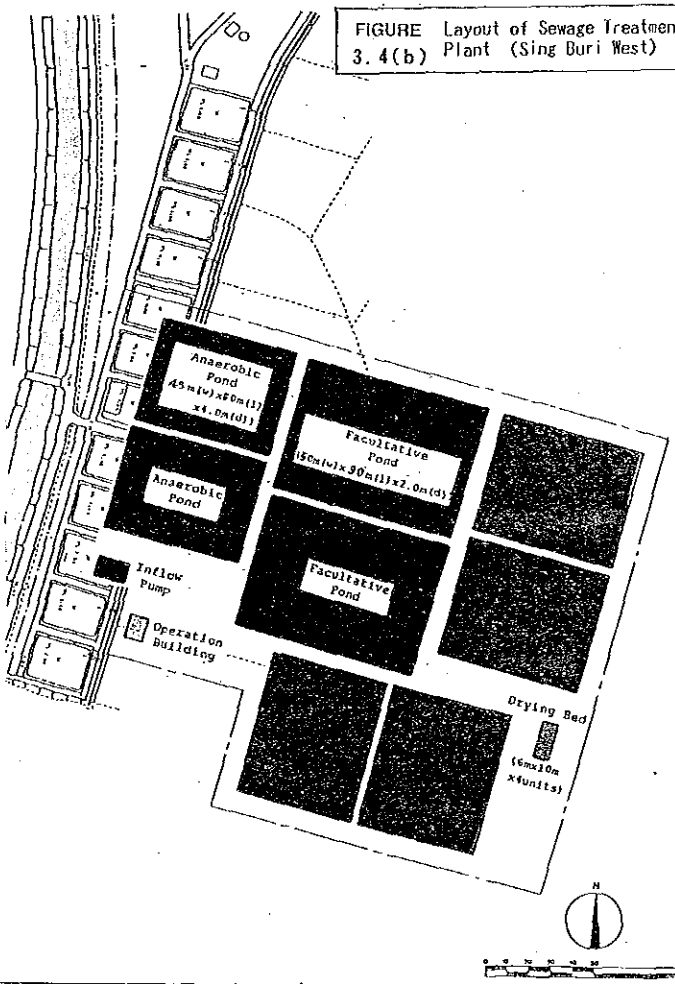

FIGURE 3.4(a) Layout of Sewage Treatment Plant (Sing Buri East)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Main Facilitie's

	West T.P.
1)Inflow Pump	Submerged Pump
(Dry Season)	ϕ 200m/m×4.15m³/min×4.8"H×2units
(Wet Season)	ϕ 300m/m×8.4m³/min×4.8"H×2units
2)Grit Chamber	Constructed with R.C.
	Size
	1.0"W×7.5"L×0.6"D×2units
	(1unit for dry weather)
3)Aerated Lagoon	Enbankment protected by masonry
	Dimension
	50"W×80"L×4.0"D×2units
	Retention Time 3 days
4)Facultative Aerated Lagoon	Enbankment protected by masonry
	Dimension
	50"W×80"L×4.0"D×2units
	Retention Time 3 days
5)Polishing Pond	Enbankment protected by masonry
	Dimension
	45"W×70"L×1.5"D×2units
	Retention Time 1 days
6)Drying Bed	Dimension
	10"×15"×6units
	Detention Time 15 days

Mai Facilitie's

	East T.P.
1)Inflow Pump	Submerged Pump
(Dry Season)	ϕ 150m/m×1.6m³/min×8.5"H×2units
(Wet Season)	ϕ 200m/m×3.2m³/min×8.5"H×2units
2)Grit Chamber	Constructed with R.C.
	Size
	0.6"W×5.0"L×0.6"D×2units
	(1unit for dry weather)
3)Anaerobic Pond	Enbankment protected by masonry
	Dimension
	45"W×60"L×4.0"D×2units
	Retention Time 5 days
4)Facultative Pond	Enbankment protected by masonry
	Dimension
	50"W×90"L×2.0"D×2units
	Retention Time 5 days
5)Maturation Pond	Enbankment protected by masonry
	Dimension
	40"W×75"L×1.5"D×4units
	Retention Time 5 days
6)Drying Bed	Dimension
	6"×10"×4units
	Detention Time 15 days

DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991	Target Year 2011
Area (Km²)	6.85 (Municipality)	10.23 (Sewerage Service)
Population (persons)	36,832 (Municipality)	61,300 (Sewrage Service Area)
Unit Wastewater (lpcd)		
Unit Domestic	112	160
Unit Business	32	64
Unit BOD Load (gpcd)		
Unit Domestic	39.1	40.6
Unit Business	6.1	7.7
Total Wastewater Quantity (m^3/d)	7,036	13,731
Total Wastewater BOD (kg/d)	2,206.4	2,960.8

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station			
Dia. by Material (mm)		Length (m)	Kind	Number	Less than 5 m^3/m		More than 5 m^3/m	
					Capacity (m^3/m)		Capacity (m^3/m)	
RCP	300	4,420	No.1	224	No.2	4.50	No.1	33.60
RCP	400	3,810	No.2	42	No.3	1.50	No.4	14.52
RCP	500	1,350	No.3	30	No.5	3.66	No.6	5.52
RCP	600	150	No.4	3	No.7	0.90		
RCP	800	3,430	Special	12				
RCP	1,000	1,335			Total	4		3
RCP	1,200	250	Total	311				
Total		14,745						

Siphon (parallel pipes)			River Crossing (bridge)		
	Dia. (mm)	Length (m)		Dia. (mm)	Length (m)
No.1	RC 300 x 2	60	No.1	SP 200	130
No.2	RC 600 x 2	45	No.2	SP 200 x 2	130

Note : SP; Steel Pipe
RC; Reinforced Concrete Pipe

LEGEND

	SEWERAGE SERVICE AREA
	DRAINAGE BASIN
	MAIN AND SUB MAIN SEWER
(2/1)	NO OF MAIN SEWER / NO OF SECTIONS
⌀300	DIAMETER
2.0‰	SLOPE
500m	LENGTH
T	TREATMENT PLANT
CP	COMMON TYPE PUMP STATION
MP	MANHOLE TYPE PUMP STATION
	RIVER CROSSING(BRIDGE)
	INVERTED SIPHON

FIG. 3. 5 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (LOP BURI MUNICIPALITY)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Wastewater Treatmentplant

Wastewater Treatment method	Aerated Lagoon System
Plant Space Area (ha)	8.05
Treatment Copacity (m^3/d) (inclusive of G.W)	16,500
Discharge Point	Khlong

Main Facilitie's

1) Inflow Pump	Submerged Pump
(Dry Season)	ϕ300m/m×8.4m^3/min×6.2"H×2units
(Wet Season)	ϕ400m/m×16.8m^3/min×6.2"H×2units
2) Grit Chamber	Constructed with R.C.
	Size
	1.0"W×7.5"L×0.6"D×4units
	(2units for dry weather)
3) Aerated Lagoon	Enbankment protected by masonry
	Dimension
	50"W×81"L×4.0"D×4units
	Retention Time 3 days
4) Facultative Aerated Lagoon	Enbankment protected by masonry
	Dimension
	50"W×81"L×4.0"D×4units
	Retention Time 3 days
5) Polishing Pond	Enbankment protected by masonry
	Dimension
	45"W×71"L×1.5"D×4units
	Retention Time 1.0 days
6) Drying Bed	Dimension
	5"×8"×40units
	Detention Time 15 days

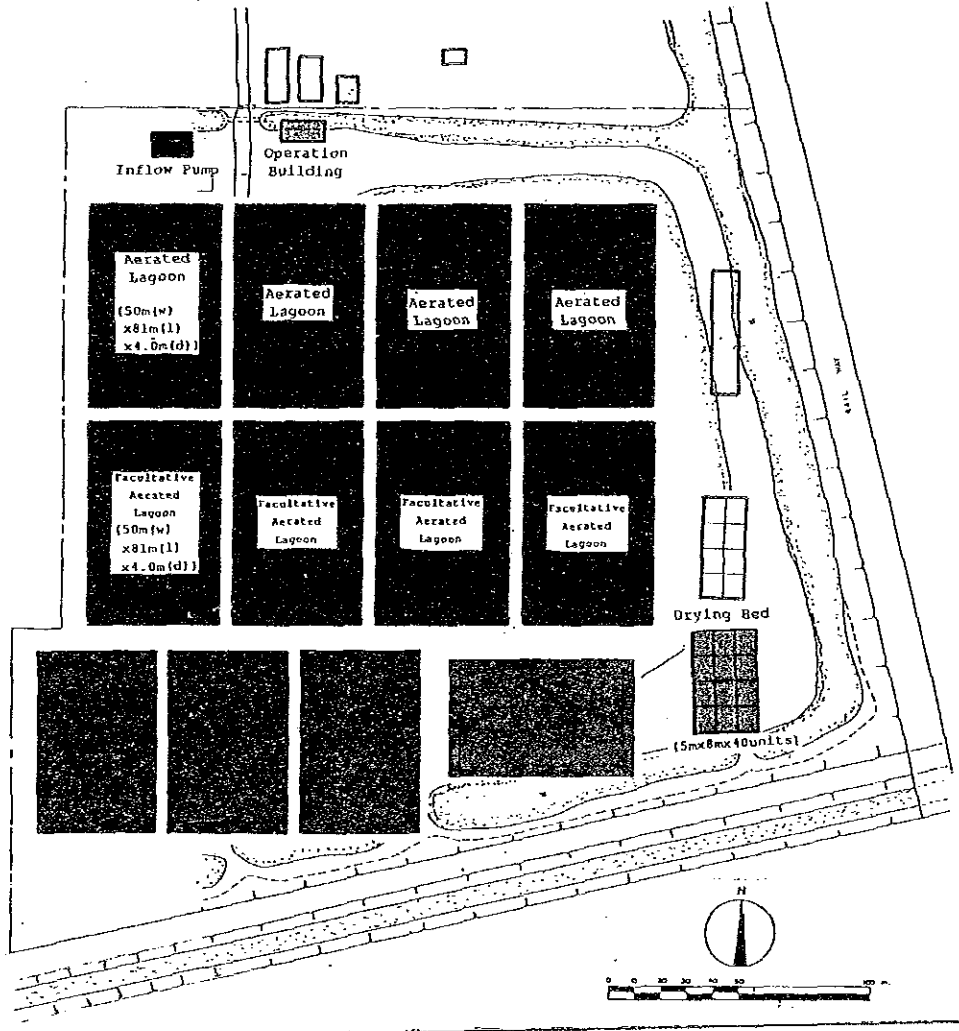

FIGURE 3.6 Layout of Sewage Treatment Plant (Lop Buri)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station			
Dia. by Material (mm)		Length (m)	Kind	Number	Less than 5 m^3/m Capacity (m^3/m)		More than 5m^3/m Capacity (m^3/m)	
RCP	300	6,660	No.1	242	No.1	2.16	No.5	11.82
RCP	400	1,090	No.2	3	No.2	2.16		
RCP	500	-	No.3		No.3	2.34		
RCP	600	2,030	No.4		No.4	4.62		
			Special		No.6	2.10		
Total		9,780						
			Total	245	Table 5			1

River Crossing (Bridge)

Dia. (mm)	Length (m)
SP 200	210

Note ; SP; Steel Pipe
RCP; Reinforced Concrete Pipe

LEGEND

- SEWERAGE SERVICE AREA
- DRAINAGE BASIN
- MAIN AND SUB MAIN SEWER
- NO OF MAIN SEWER / NO OF SECTIONS
- DIAMETER ⌀300
- SLOPE 2.0‰
- LENGTH 500m
- TREATMENT PLANT
- COMMON TYPEPUMP STATION
- MANHOLE TYPE PUMP STATION
- RIVER CROSSING(BRIDGE)

DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991	Target Year 2011
Area (Km^2)	3.73 (Municipality)	5.18 (Sewerage Service)
Population (persons)	9,607 (Municipality)	13,500 (Sewrage Service Area)
Unit Wastewater (lpcd)		
Unit Domestic	112	160
Unit Business	32	64
Unit BOD Load (gpcd)		
Unit Domestic	39.1	40.6
Unit Business	6.1	7.7
Total Wastewater Quantity (m^3/d)	1,791	3,024
Total Wastewater BOD (kg/d)	561.4	652.2

FIG.3.7 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (ANG THONG MUNICIPALITY)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Wastewater Treatment Plant

Wastewater Treatment method	Stabilization Pond System
Plant Space Area (ha)	5.44
Treatment Capacity (m^3/d) (inclusive of G.W)	3,700
Discharge Point	Khlong Lam Tha Daeng

Main Facilitie's

1)	Inflow Pump	Submerged Pump
	(Dry Season)	ø150m/mx1.9m^3/minx4.8^{m}Hx2units
	(Wet Season)	ø200m/mx3.8m^3/minx4.8^{m}Hx2units
2)	Grit Chamber	Constructed with R.C. Size 0.6^{m}Wx5.5^{m}Lx0.6^{m}Dx2units (1 unit for dry weather)
3)	Anaerobic Pond	Enbankment protected by masonry Dimension 50^{m}Wx62^{m}Lx4.0^{m}Dx2units Retention Time 5 days
4)	Facultative Pond	Enbankment protected by masonry Dimension 60^{m}Wx88^{m}Lx2.0^{m}Dx2units Retention Time 5 days
5)	Maturation Pond	Enbankment protected by masonry Dimension 50^{m}Wx71^{m}Lx1.5^{m}Dx4units Retention Time 5 days
6)	Drying Bed	Dimension 4^{m}x6^{m}x4units Detention Time 15 days

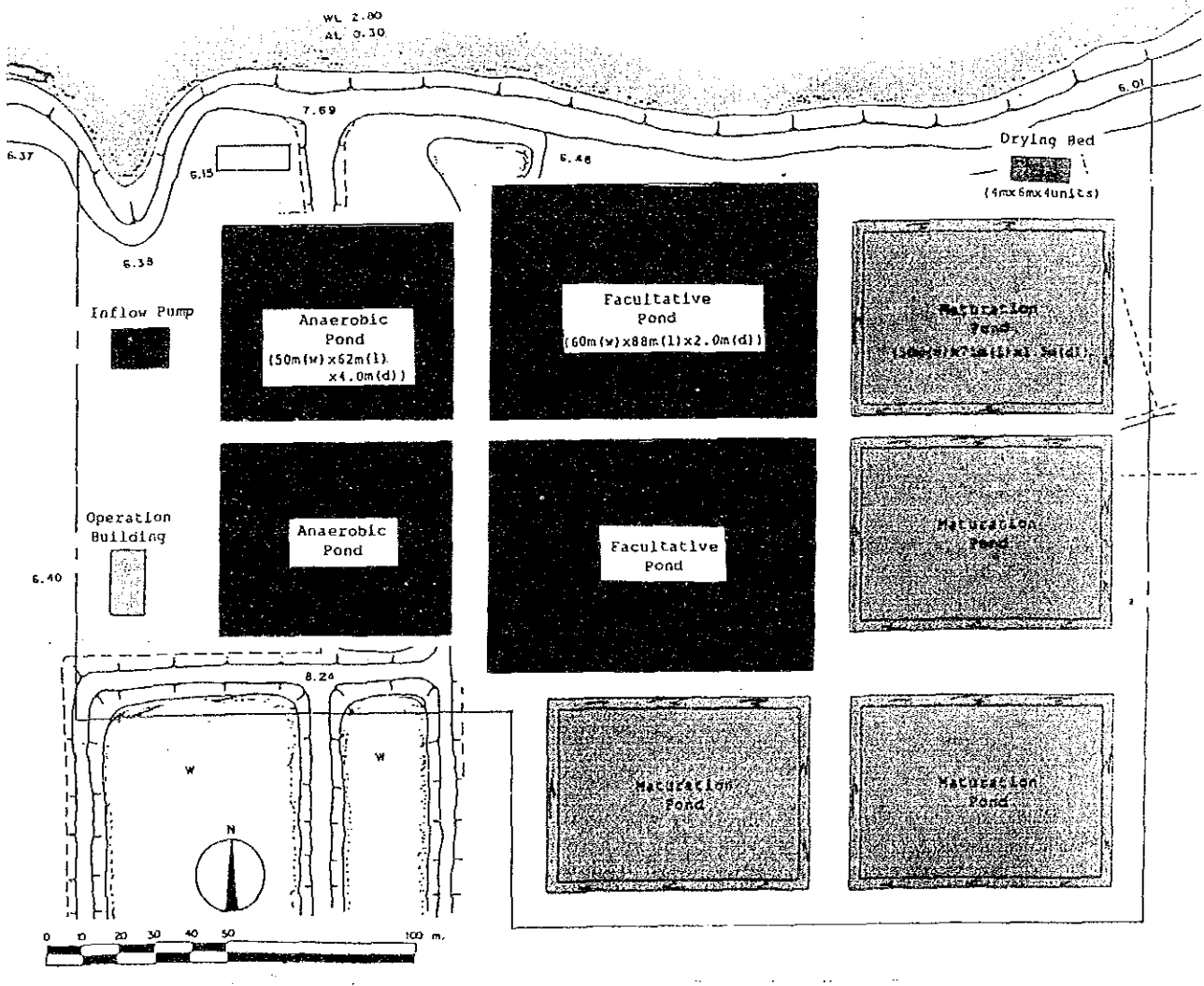

FIGURE 3.8 Layout of Sewage Treatment Plant (Ang Thong)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

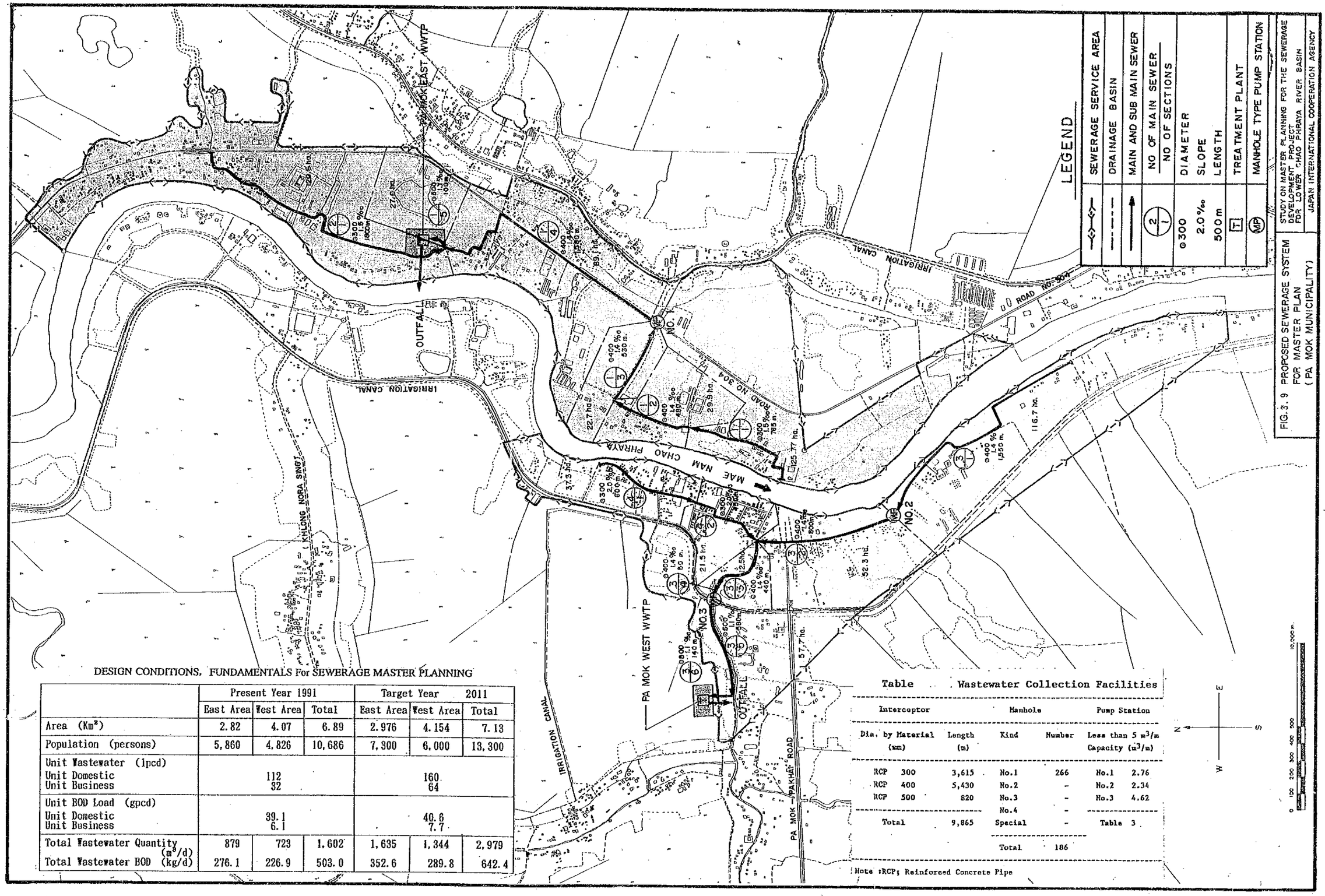

FIG. 3. 9 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (PA MOK MUNICIPALITY)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991			Target Year 2011		
	East Area	West Area	Total	East Area	West Area	Total
Area (Km²)	2.82	4.07	6.89	2.976	4.154	7.13
Population (persons)	5,860	4,826	10,686	7,300	6,000	13,300
Unit Wastewater (lpcd)						
Unit Domestic	112			160		
Unit Business	32			64		
Unit BOD Load (gpcd)						
Unit Domestic	39.1			40.6		
Unit Business	6.1			7.7		
Total Wastewater Quantity (m³/d)	879	723	1,602	1,635	1,344	2,979
Total Wastewater BOD (kg/d)	276.1	226.9	503.0	352.6	289.8	642.4

Table Wastewater Collection Facilities

Interceptor		Manhole		Pump Station	
Dia. by Material (mm)	Length (m)	Kind	Number	Less than 5 m³/m Capacity (m³/m)	
RCP 300	3,615	No.1	266	No.1	2.76
RCP 400	5,430	No.2	-	No.2	2.34
RCP 500	820	No.3	-	No.3	4.62
		No.4	-		
Total	9,865	Special	-	Table 3	
		Total	186		

Note :RCP; Reinforced Concrete Pipe

Wastewater Treatment Plant

Wastewater Treatment method	Stabilization Pond System	
	East T.P.	West T.P.
Plant Space Area (ha)	3.74	3.44
Treatment Capacity (m^3/d) (inclusive of G.W)	2,000	1,700
Discharge Point	Chao Phraya River	Khlong

Main Facilitie's — East T.P.

1) Inflow Pump	Submerged Pump
(Dry Season)	ø150m/mx1.1m^3/minx7.6^{m}Hx2units
(Wet Season)	ø150m/mx2.1m^3/minx7.6^{m}Hx2units
2) Grit Chamber	Constructed with R.C. Size 0.6^{m}Wx3.0^{m}Lx0.6^{m}Dx2units (1 unit for dry weather)
3) Anaerobic Pond	Enbankment protected by masonry Dimension 35^{m}Wx53^{m}Lx4.0^{m}Dx2units Retention Time 5 days
4) Facultative Pond	Enbankment protected by masonry Dimension 45^{m}Wx67^{m}Lx2.0^{m}Dx2units Retention Time 5 days
5) Maturation Pond	Enbankment protected by masonry Dimension 40^{m}Wx50^{m}Lx1.5^{m}Dx4units Retention Time 5 days
6) Drying Bed	Dimension 5^{m}x6^{m}x2units Detention Time 15 days

Main Facilitie's — West T.P.

1) Inflow Pump	Submerged Pump
(Dry Season)	ø150m/mx0.9m^3/minx4.9^{m}Hx2units
(Wet Season)	ø200m/mx1.75m^3/minx4.9^{m}Hx2units
2) Grit Chamber	Constructed with R.C. Size 0.6^{m}Wx3.0^{m}Lx0.6^{m}Dx2units (1 unit for dry weather)
3) Anaerobic Pond	Enbankment protected by masonry Dimension 35^{m}Wx47^{m}Lx4.0^{m}Dx2units Retention Time 5.1 days
4) Facultative Pond	Enbankment protected by masonry Dimension 40^{m}Wx65^{m}Lx2.0^{m}Dx2units Retention Time 5 days
5) Maturation Pond	Enbankment protected by masonry Dimension 35^{m}Wx50^{m}Lx1.5^{m}Dx4units Retention Time 5.1 days
6) Drying Bed	Dimension 4^{m}x6^{m}x2units Detention Time 15 days

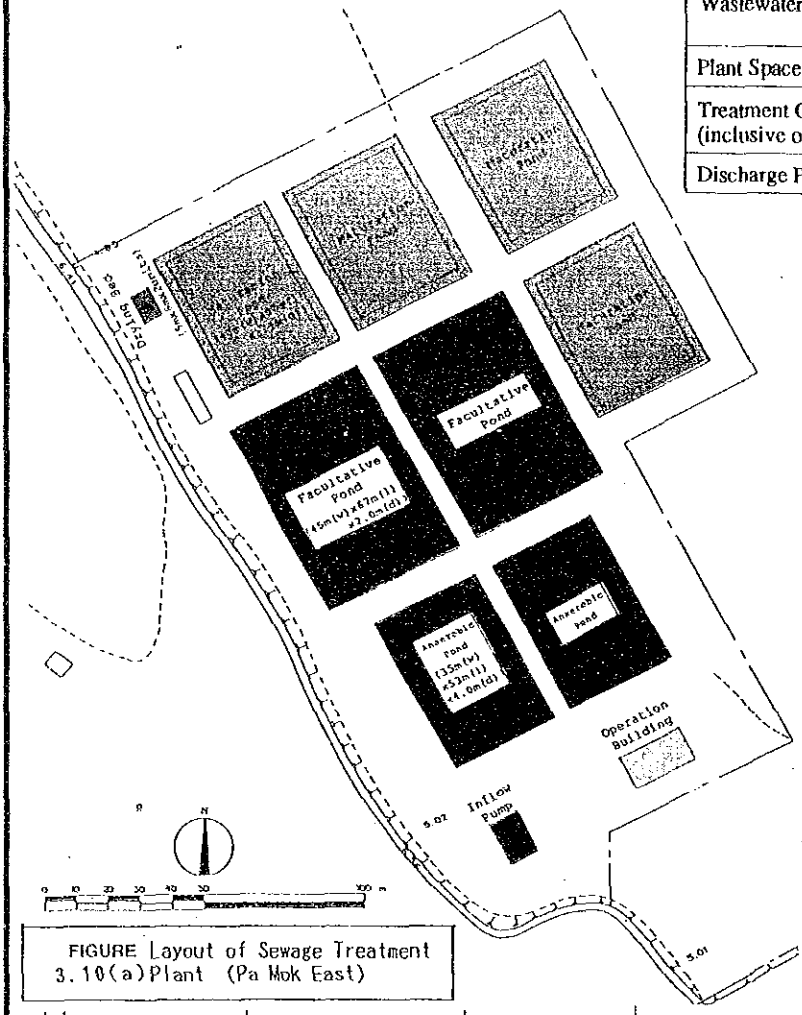

FIGURE Layout of Sewage Treatment 3.10(a) Plant (Pa Mok East)

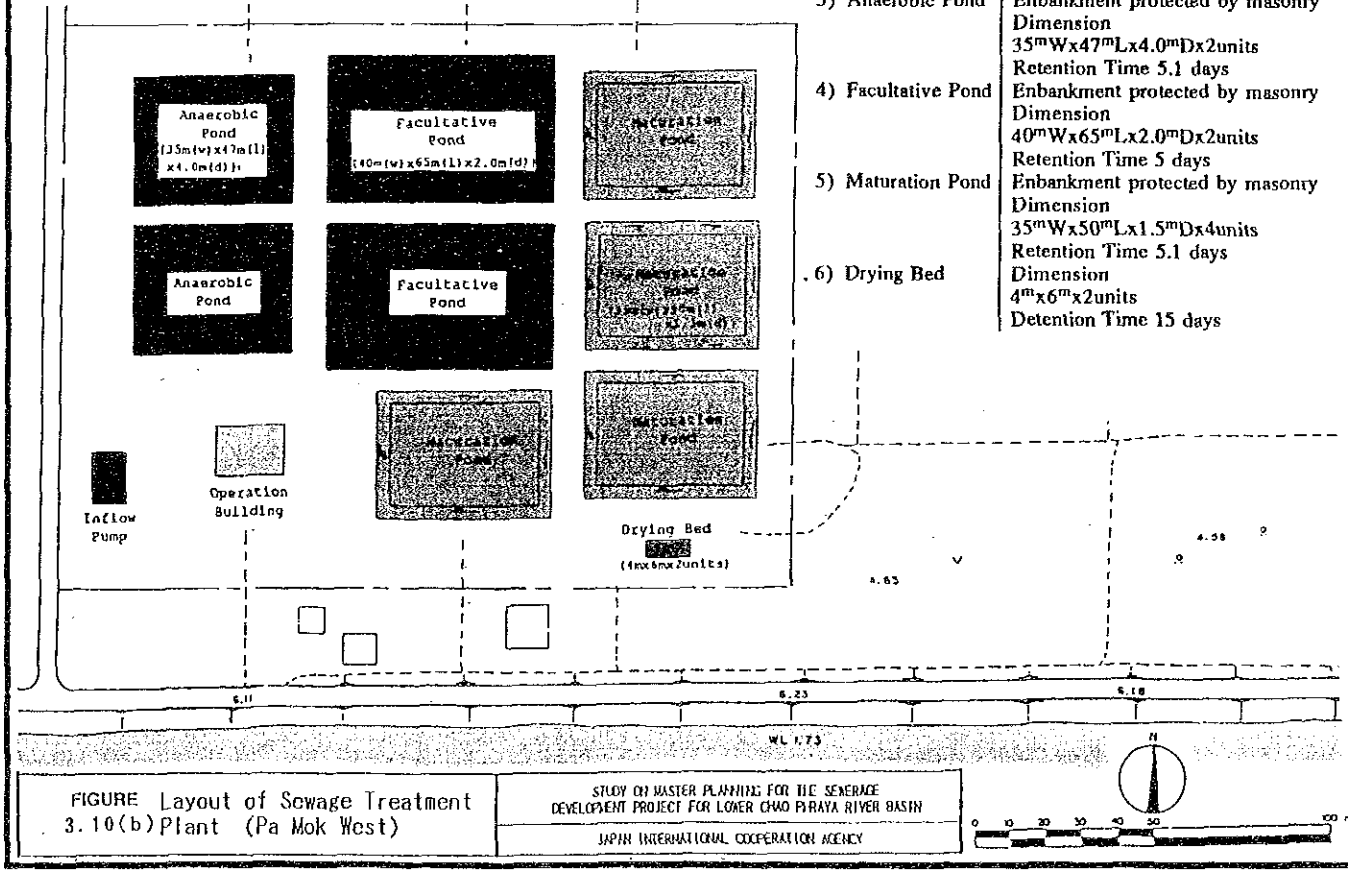

FIGURE Layout of Sewage Treatment 3.10(b) Plant (Pa Mok West)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

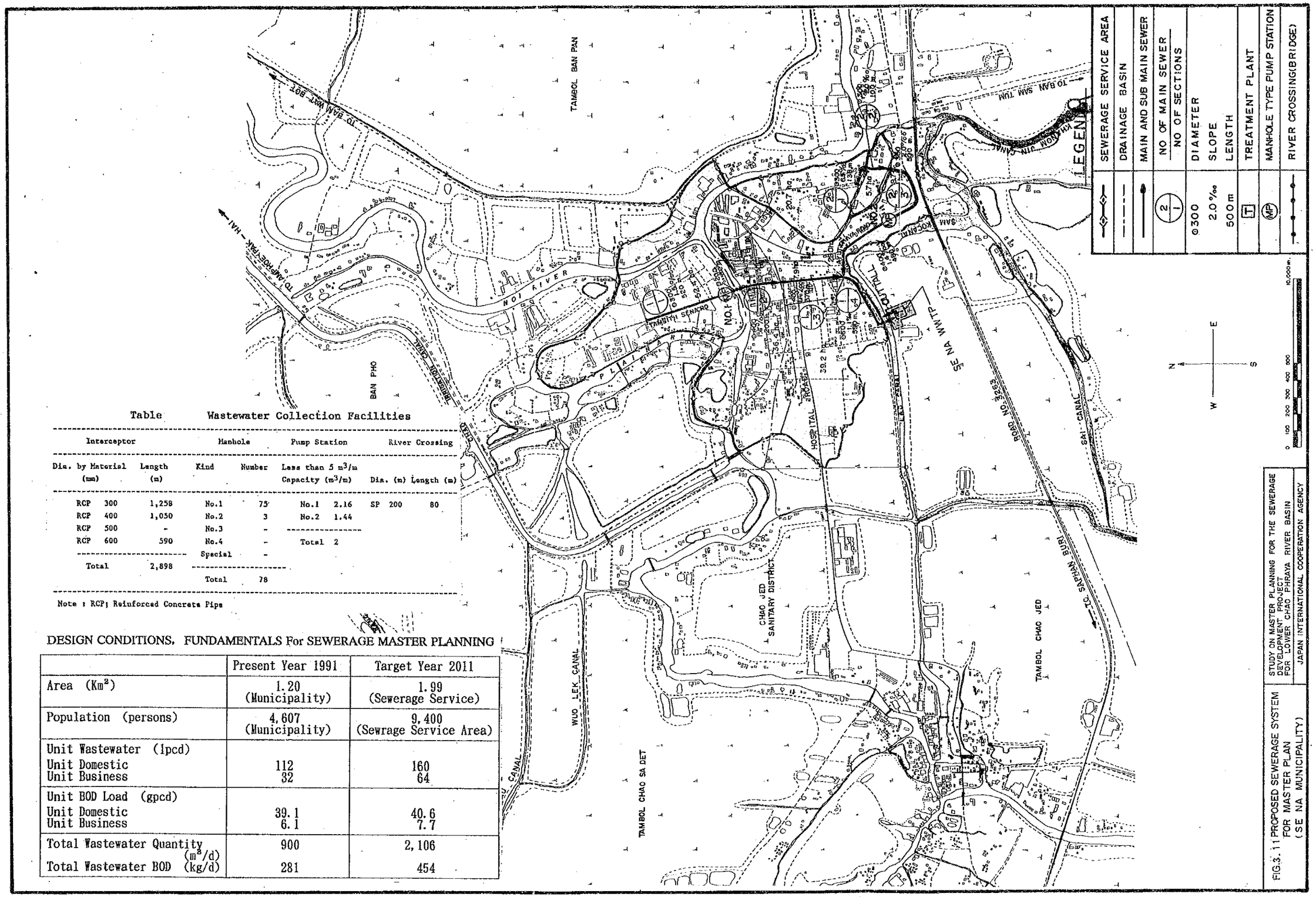

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station		River Crossing	
Dia. by Material (mm)	Length (m)	Kind	Number	Less than 5 m^3/m Capacity (m^3/m)	Dia. (m)	Length (m)		
RCP 300	1,258	No.1	75	No.1 2.16	SP 200	80		
RCP 400	1,050	No.2	3	No.2 1.44				
RCP 500	-	No.3	-					
RCP 600	590	No.4	-	Total 2				
		Special	-					
Total	2,898							
		Total	78					

Note : RCP; Reinforced Concrete Pipe

DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991	Target Year 2011
Area (Km^2)	1.20 (Municipality)	1.99 (Sewerage Service)
Population (persons)	4,607 (Municipality)	9,400 (Sewrage Service Area)
Unit Wastewater (lpcd)		
Unit Domestic	112	160
Unit Business	32	64
Unit BOD Load (gpcd)		
Unit Domestic	39.1	40.6
Unit Business	6.1	7.7
Total Wastewater Quantity (m^3/d)	900	2,106
Total Wastewater BOD (kg/d)	281	454

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

FIG.3.11 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (SE NA MUNICIPALITY)

Wastewater Treatmentplant

Wastewater Treatment method	Stabilization Pond System
Plant Space Area (ha)	4.34
Treatment Capacity (m^3/d) (inclusive of G.W)	2,600
Discharge Point	Samko Canal

Main Facilitie's

1) Inflow Pump	Submerged Pump
(Dry Season)	ϕ 150m/m×1.4m^3/min×6.2"H×2units
(Wet Season)	ϕ 200m/m×2.65m^3/min×6.2"H×2units
2) Grit Chamber	Constructed with R.C.
	Size
	0.6"W×4.0"L×0.6"D×2units
	(1unit for dry weather)
3) Anaerobic Pond	Enbankment protected by masonry
	Dimension
	40"W×57.5"L×4.0"D×2units
	Retention Time 5 days
4) Facultative Pond	Enbankment protected by masonry
	Dimension
	50"W×75"L×2.0"D×2units
	Retention Time 5 days
5) Maturation Pond	Enbankment protected by masonry
	Dimension
	40"W×65"L×1.5"D×4units
	Retention Time 5.1 days
6) Drying Bed	Dimension
	4"×5"×4units
	Detention Time 15 days

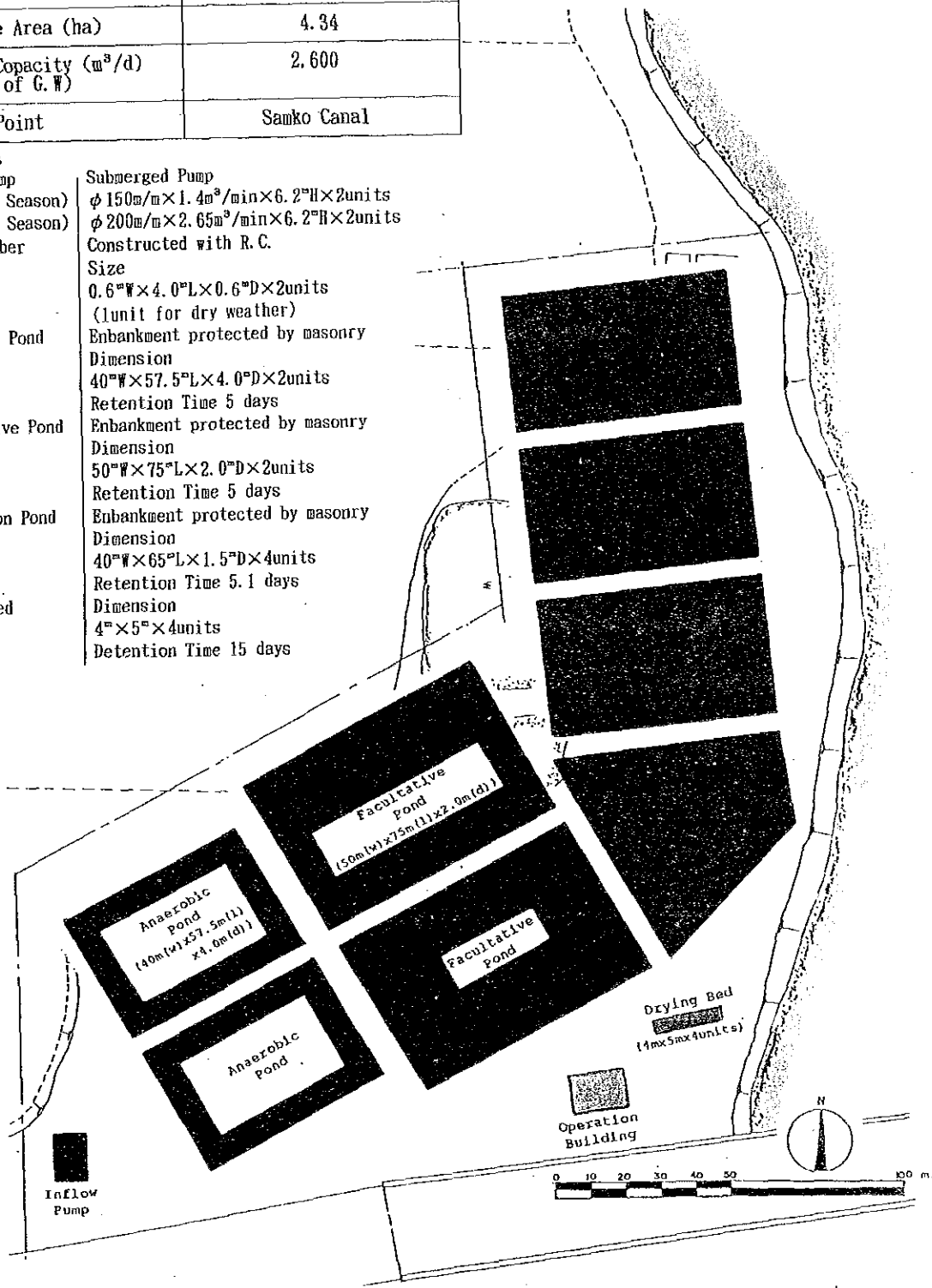

FIGURE 3.12 Layout of Sewage Treatment Plant (Sena)

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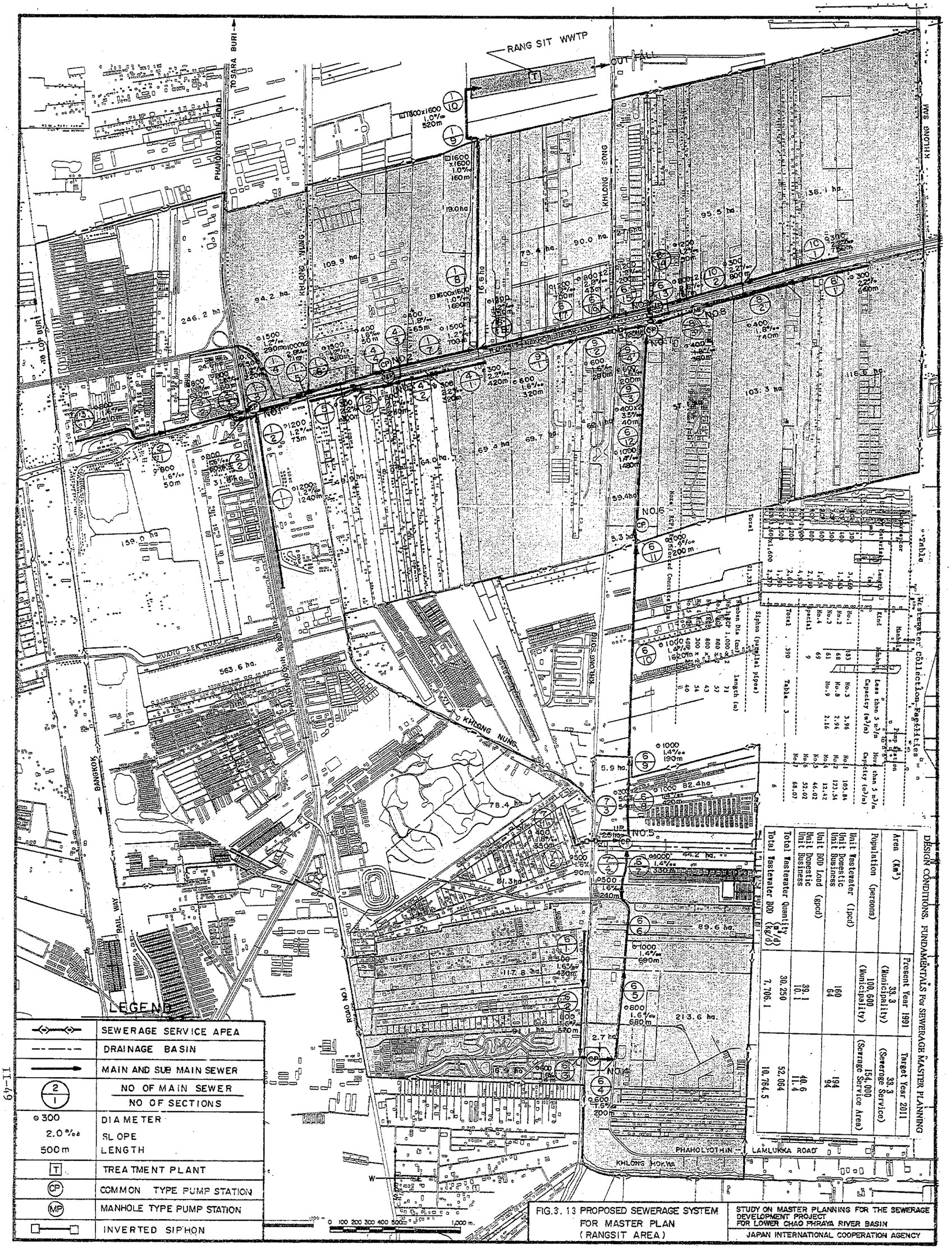
JAPAN INTERNATIONAL COOPERATION AGENCY



DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991	Target Year 2011
Area (km²)	33.3 (Municipality)	33.3 (Sewerage Service)
Population (persons)	100,600 (Municipality)	154,000 (Sewerage Service Area)
Unit Wastewater (lpcd)		
Unit Domestic	160	194
Unit Business	64	94
Unit BOD Load (gpcd)		
Unit Domestic	39.1	40.6
Unit Business	10.1	11.4
Total Wastewater Quantity (m³/d)	30,250	52,064
Total Wastewater BOD (kg/d)	7,706.1	10,764.5

FIG.3.13 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (RANGSIT AREA)

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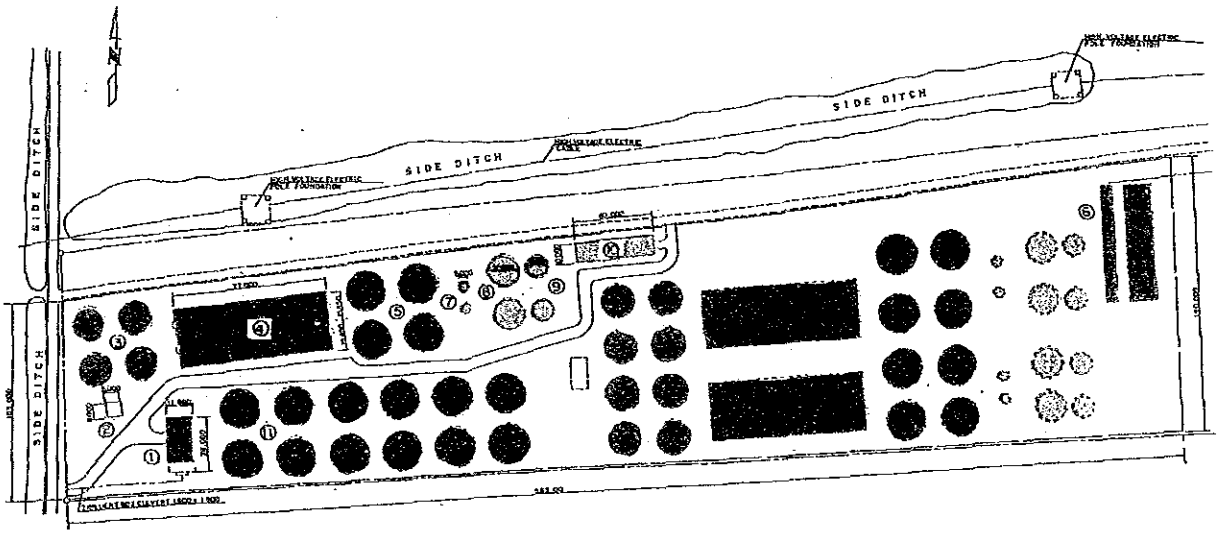
JAPAN INTERNATIONAL COOPERATION AGENCY

Wastewater Treatmentplant

Wastewater Treatment method	Conventional Activated Sludge System
Plant Space Area (ha)	7.5
Treatment Capacity (m^3/d) (inclusive of C.W)	75,000
Discharge Point	Khlong Song

Main Facilitie's

1) Inflow Pump	Submerged Pump
(Dry Season)	ϕ 350m/m×11.6m^3/min×7.3"H×2units
	ϕ 500m/m×23.2m^3/min×7.3"H×2units
(Wet Season)	ϕ 800m/m×66.9m^3/min×7.3"H×2units
2) Grit Chamber	Constructed with R.C.
	Size
	1.6"W×11"L×0.7"D×6units
	(3units for dry weather)
3) Primary Sedimentation Tank	Constructed with R.C.
	Dimension
	ϕ 16.0"×4.0"D×12units
	Retention Time 3.1 hr.
4) Aeration Tank	Constructed with R.C.
	Dimension
	15"W×75"L×3"D×6units
	Retention Time 5.9 hr.
5) Secondary Sedimentation Tank	Constructed with R.C.
	Dimension
	ϕ 18.5"×2.5"D×12units
	Retention Time 2.6 hr.
6) Chloriration Tank	Constructed with R.C.
	Dimension
	2"W×180"L×2"D×3units
	Contact Time 10 min.
7) Sludge Thickener	Constructed with R.C.
	Dimension
	ϕ 6.0"×4"D×6units
	Thickening Time 12.2 hr.
8) Anaerobic Digention Tank	Constructed with R.C.
	Dimension
	ϕ 17"×5"D×6units
	ϕ 12"×5"D×6units
	Digestion Time 1st stage 20 days
	2nd stage 10 days
9) Mechanical dewatering	Centrifugal dehydrator
	8~10m^3/hr - 2 units
	15~18m^3/hr - 2 units



NOTE

① Inflow Pump Station & Operation Room
② Distribution Tank
③ Primary Sedimentation Tank
④ Aeration Tank
⑤ Final Sedimentation Tank
⑥ Disinfection Tank
⑦ Gravity Thickener
⑧ Digestion Tank (1st)
⑨ Digestion Tank (2nd)
⑩ Dewatering House
⑪ Sedimentation Tank for Storm Water

Figure 3.14	Layout of Sewage Treatment Plant (Rangsit)	STUDY ON MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station			
Dia. by Material (mm)		Length (m)	Kind	Number	Less than 5 m^3/m Capacity (m^3/m)		More than 5m^3/m Capacity (m^3/m)	
RCP	300	6,175	No.1	329	No.3	2.10	No.1	12.84
RCP	400	4,280	No.2	55	No.4	3.72	No.2	43.56
RCP	500	2,305	No.3	35	No.5	1.86	No.6	5.52
RCP	600	2,412	No.4	3	No.6	1.02	No.8	12.90
RCP	800	2,090	Special	3				
RCP	1,000	1,240			Total	4		4
RCP	1,200	50	Total	425				
Total		18,252						

Siphon (Parallel pipes)

Dia. (mm)	Length (m)
RC 400 x 2	38

Note ; RCP; Reinforced Concrete Pipe

LEGEND

- SEWERAGE SERVICE AREA
- DRAINAGE BASIN
- MAIN AND SUB MAIN SEWER
- NO OF MAIN SEWER / NO OF SECTIONS
- DIAMETER ø300 / SLOPE 2.0 ‰ / LENGTH 500m
- T TREATMENT PLANT
- CP COMMON TYPE PUMP STATION
- MP MANHOLE TYPE PUMP STATION
- INVERTED SIPHON

DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991			Target Year 2011		
	North Area	South Area	Total	North Area	South Area	Total
Area (Km^2)	1.55	0.05	1.6	6.70	8.94	15.64
Population (persons)	32,700	13,086	45,786	56,900	22,700	79,600
Unit Wastewater (lpcd)						
Unit Domestic	160			194		
Unit Business	64			94		
Unit BOD Load (gpcd)						
Unit Domestic	39.1			40.6		
Unit Business	10.1			11.4		
Total Wastewater Quantity (m^3/d)	7,333	2,925	10,258	16,388	6,538	22,926
Total Wastewater BOD(kg/d)	1,610.4	642.4	2,252.8	2,058.9	1,180.5	4,139.4

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

JAPAN INTERNATIONAL COOPERATION AGENCY

FIG. 3.15 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (BANG BUA THONG MUNICIPALITY)

Wastewater Treatmentplant

	North T.P.	South T.P.
Wastewater Treatment method	Conventional Activated Sludge System	Oxidation Ditch System
Plant Space Area (ha)	3.0	2.25
Treatment Capacity (m^3/d) (inclusive of G.W)	23,600	7,900
Discharge Point	Khlong Bang Kluai	Khlong Bang Bua Thong

Main Facilitie's North T.P.	
1) Inflow Pump	Submerged Pump
(Dry Season)	ϕ250m/m×4.9m^3/min×8.0"H×2units
	ϕ350m/m×11.5m^3/min×8.0"H×1units
(Wet Season)	ϕ450m/m×21.4m^3/min×8.0"H×2units
2) Grit Chamber	Constructed with R.C.
	1.0"W×9"L×0.4"D×2units
	(2units for dry weather)
	1.4"W×9"L×0.4"D×2units
3) Primary Sedimentation Tank	Constructed with R.C.
	Dimension
	ϕ15.0"4.0"D×4units
	Sedimentation Time 2.2 hr.
4) Aeration Tank	Constructed with R.C.
	Dimension
	12"W×36"L×3"D×4units
	Retention Time 5.3 hr.
5) Secondary Sedimentation Tank	Constructed with R.C.
	Dimension
	ϕ17"×2.5"D×4units
	Sedimentation Time 2.3 hr.
6) Chloriration Tank	Constructed with R.C.
	Dimension
	2"W×60"L×1.5"D×3units
	Contact Time 8 min.

Main Facilitie's South T.P.	
1) Inflow Pump	Submerged Pump
(Dry Season)	ϕ200m/m×4.0m^3/min×7.0"H×2units
	ϕ300m/m×8.0m^3/min×7.0"H×2units
2) Grit Chamber	Constructed with R.C.
	1.6"W×7.5"L×0.6"D×2units
	(1unit for dry weather)
3) Oxidation Ditch	Constructed with R.C.
	Dimension
	4"W×100"L×2.5"D×4units
	Aeration Time 12.2 hours
4) Final Sedimentation Tank	Constructed with R.C.
	Dimension
	ϕ13"×2.6"D×4units
	Retention Time 4.2 hours
5) Drying Bed	Dimension
	12"×15"×10units
	Detention Time 15 days

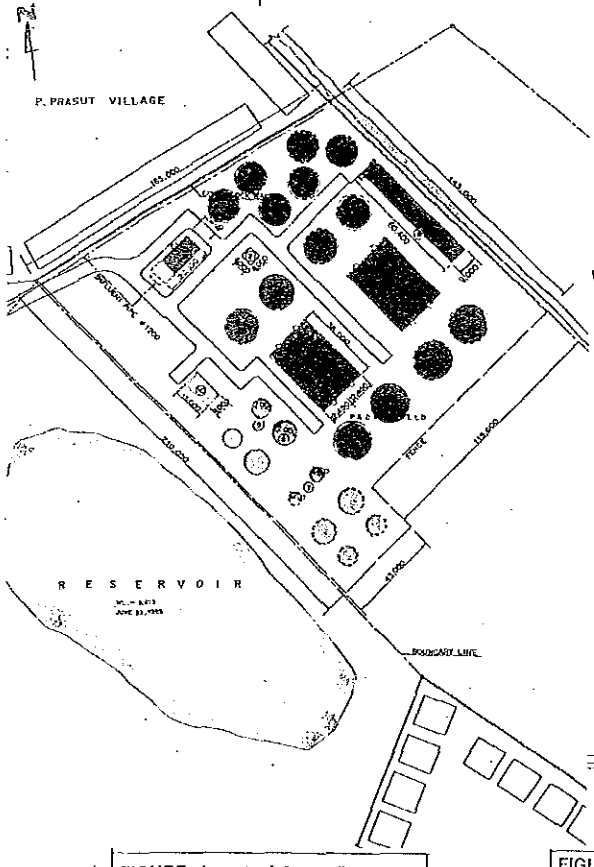


FIGURE 3.16(a) Layout of Sewage Treatment Plant (Bang Bua Thong North)

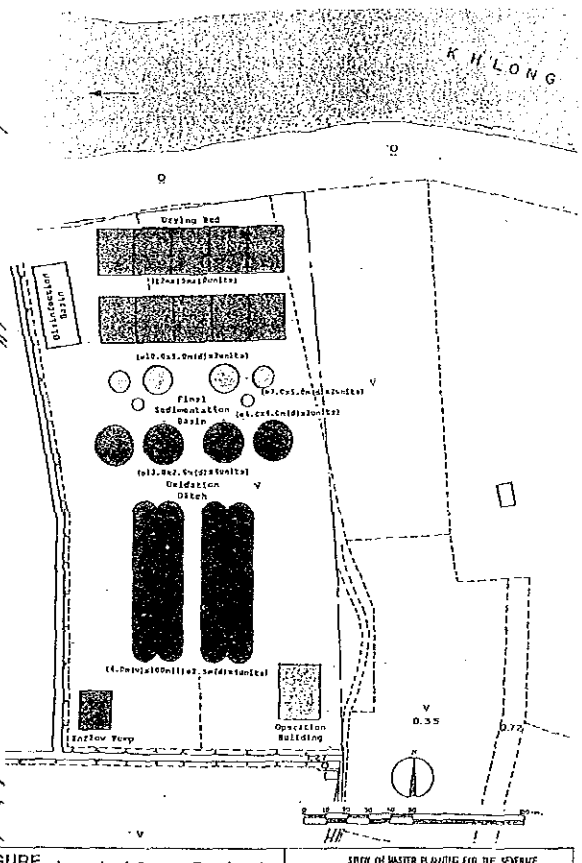


FIGURE 3.16(b) Layout of Sewage Treatment Plant (Bang Bua Thong South)

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

PART 3

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

PART III PRELIMINARY ENGINEERING DESIGN OF SEWERAGE SYSTEMS FOR RANGSIT AREA AND BANG BUA THONG MUNICIPALITY

CHAPTER 1 INTRODUCTION

Of the study eight (8) municipalities/areas of the sewerage master plan, the area of Rang Sit and the municipality of Bang Bua Thong were selected to be prepared for the preliminary sewerage design. These two (2) areas were selected because of their applicability to the need to implement effective water pollution control for the lower Chao Phraya river. The details of the basin-wide pollution control plan are identified in Part I.

The preliminary design of the sewerage system for the first stage program has a target year of 2001, and is prepared within the context of the previous sewerage master plan. To avoid redundancy, information from the study results included in the master plan are not repeated. Instead, a summary was presented, as required, with reference to the master plan.

The detailed information for this sewerage system design was collected in the third field expedition to Thailand, which entailed topographic surveys along the planned sewer routes, investigations as to the existing drainage pipes, and soil boring tests at the treatment plant sites.