3.6 Proposed Sewerage System

3.6.1 Service Area

The service area for sewerage planning consists of (1) present municipality area sub-divided into some areas by irrigation canals/khlongs flowing from north to south, (2) part of the DTCP area surrounded by khlongs/irrigation canals and (3) the cluster developed along western periphery of the municipality. The total area coverage is 1,023 ha with present and projected (2011) population of 48,800 and 61,300,respectively.

The topography in the service area is characterized with a gentle slope from northeast toward southwest. A single sewerage system is recommended covering the service area as shown in Figure 3.6.1.

Location of WWTP is recommended at the outside of the municipality to acquire required land area with cheaper cost. It is located in southwestern portion where some khlongs are joined. The site is presently low and swampy land to which wastewater flows from the municipality.

3.6.2 Wastewater Collection System

Wastewater collection system in application of the combined collection method is proposed taking into account of existing drainage facilities, topography and land availability for sewerage facilities.

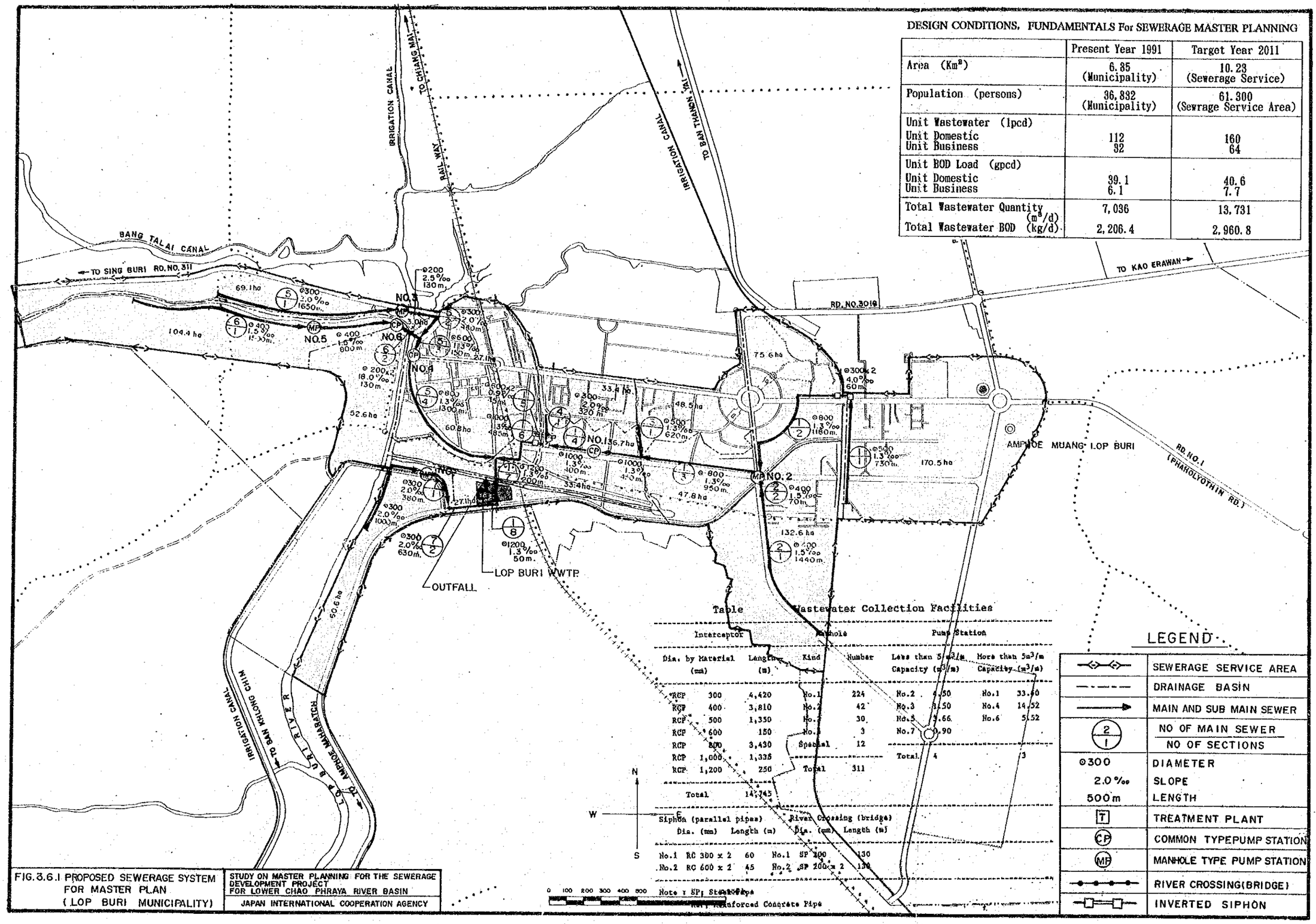
Distribution of population and wastewater quantity was made based on population density assumed by land use type (refer to calculation in Supporting Report 3.3.6).

Alignments of main interceptor and pump stations are proposed as shown in Figure 3.6.1. The profile of sewers is presented in Figure 3.6.2 (refer to hydraulic calculation in Supporting Report 3.3.6). The following are descriptions on the sewer systems.

- Considering the collection of wastewater via existing drains in the central area of the municipality, seven (7) sewer systems are planned.

DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991	Target Year 2011
Area (Km^2)	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	92	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



Note : SP; Steel Pipe
RCP; Reinforced Concrete Pipe

Table Wastewater Collection Facilities

Interceptor			Manhole		Pump Station			
Dia. by Material (mm)		Length (m)	Kind	Number	Less than $5m^3/s$ Capacity (m^3/s)		More than $5m^3/s$ Capacity (m^3/s)	
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 × 2	60	No.1	SP 300	130
No.2	RC 600 × 2	45	No.2	SP 200 × 2	130

LEGEND

	SEWERAGE SERVICE AREA
	DRAINAGE BASIN
	MAIN AND SUB MAIN SEWER
2/1	NO OF MAIN SEWER / NO OF SECTIONS
Ø300	DIAMETER
2.0‰	SLOPE
500m	LENGTH
T	TREATMENT PLANT
CP	COMMON TYPEPUMP STATION
MP	MANHOLE TYPE PUMP STATION
	RIVER CROSSING(BRIDGE)
	INVERTED SIPHON

FIG. 3.6.1 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (LOP BURI MUNICIPALITY)

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

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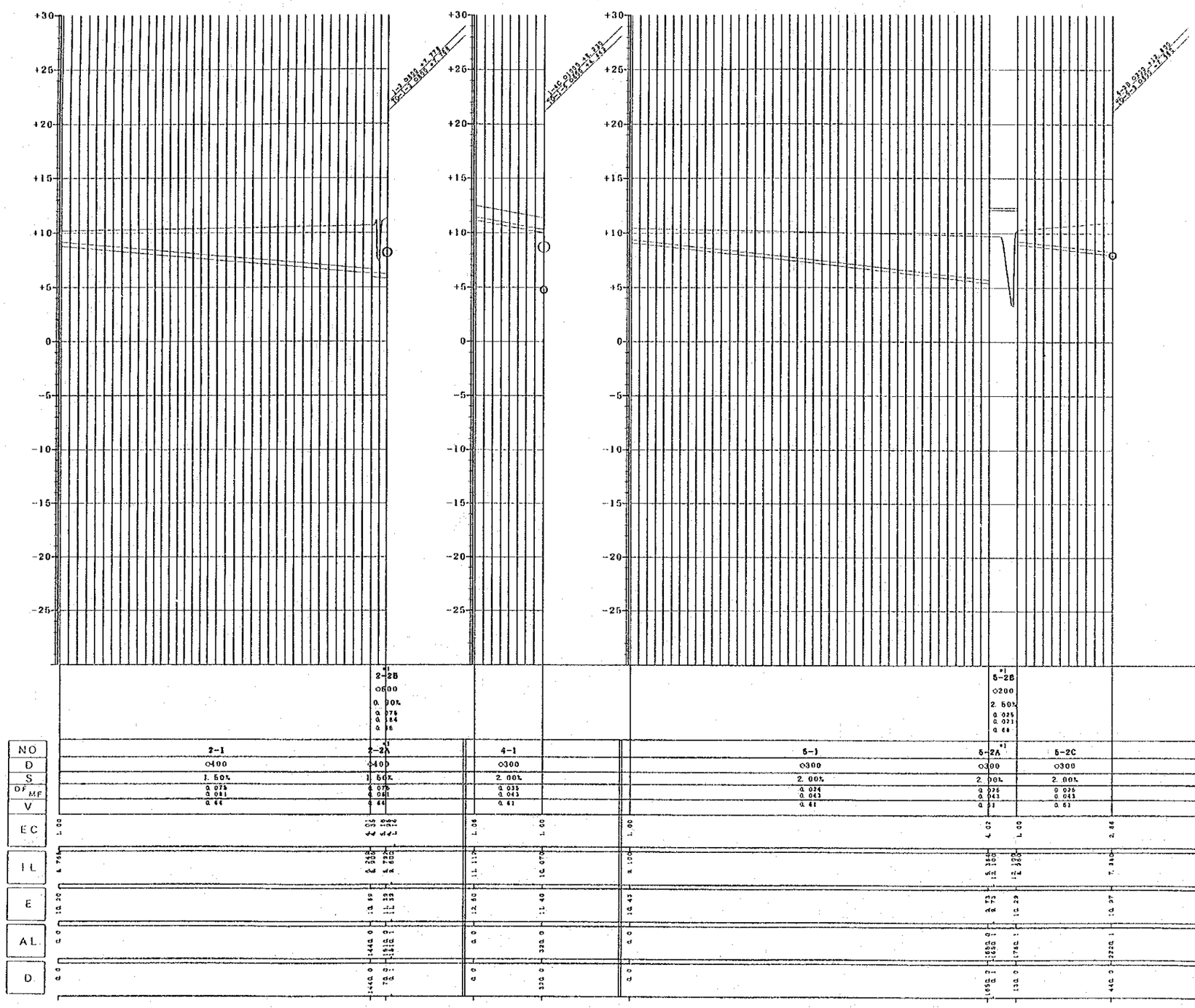

LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

2-1	2-2A	2-2B	4-1	5-1
5-2A	5-2B	5-2C		

FIG. 3.6.2 (1)
LOP BURI

V 1:200
H 1:10,000

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

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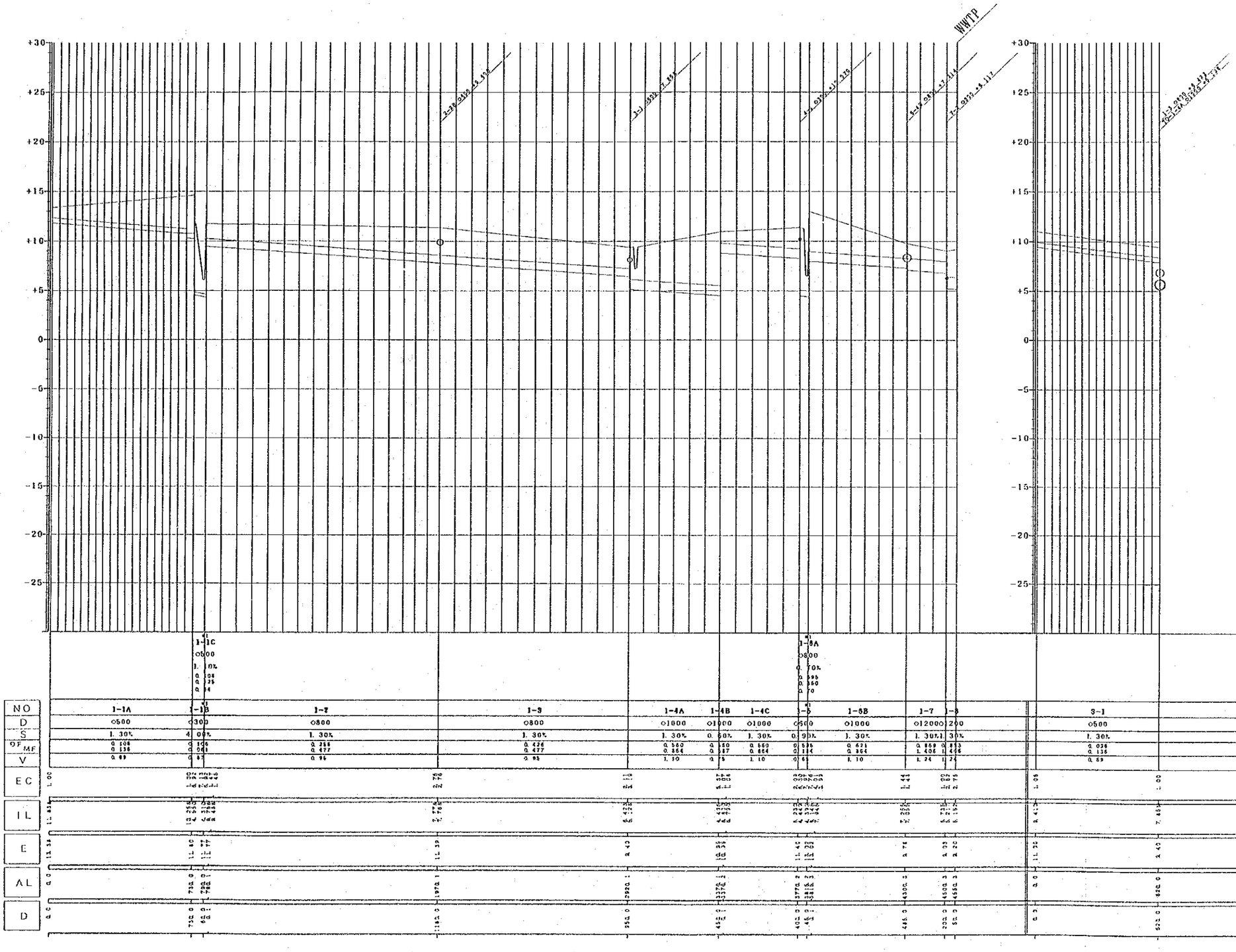


LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

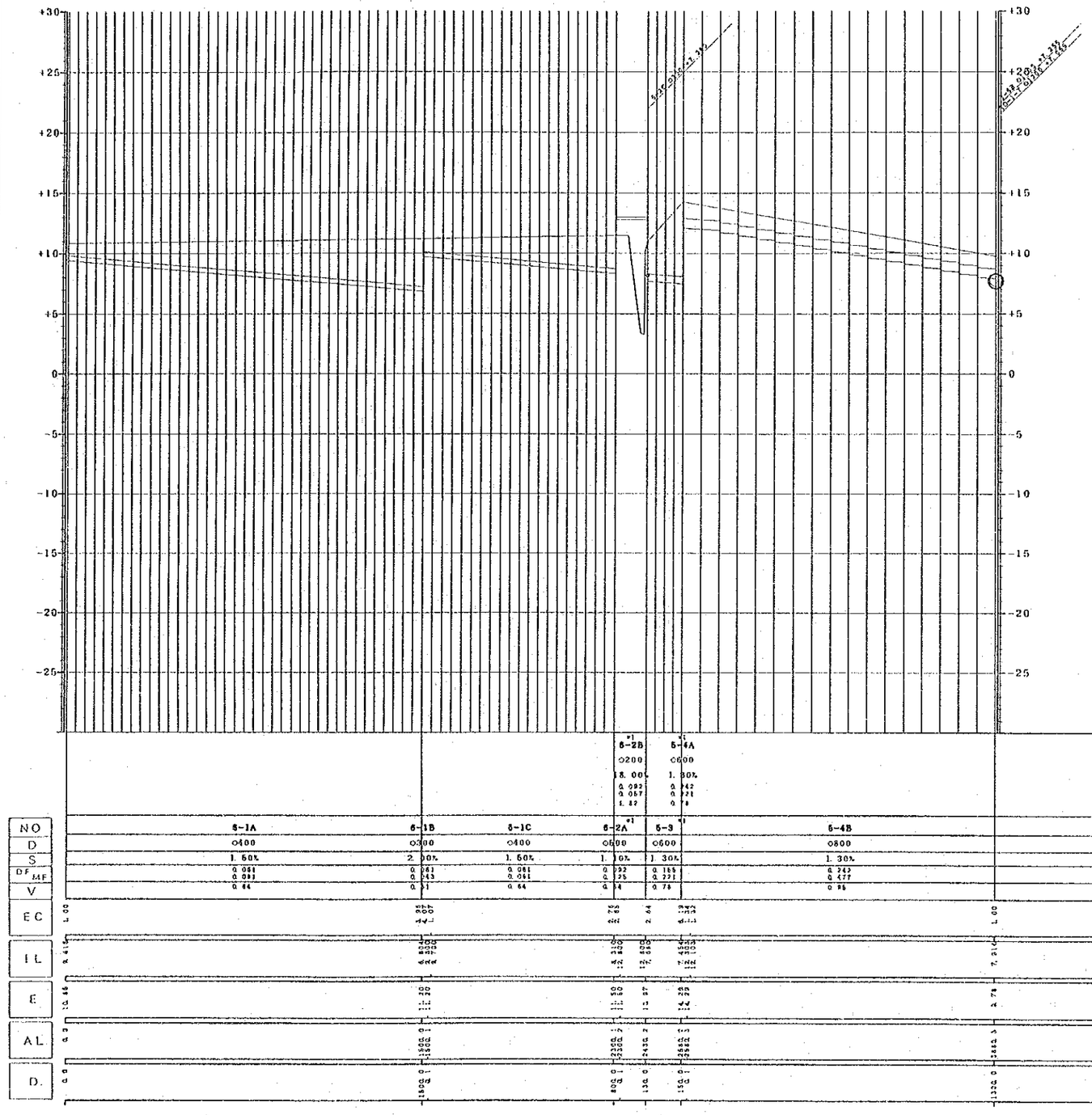
1-1A	1-1B	1-1C	1-2	1-3
1-4A	1-4B	1-4C	1-5	1-6A
1-6B	1-7	1-8	3-1	

FIG. 3.6.2 (2)
LOP BURI

V 1:200
H 1:10,000

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

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

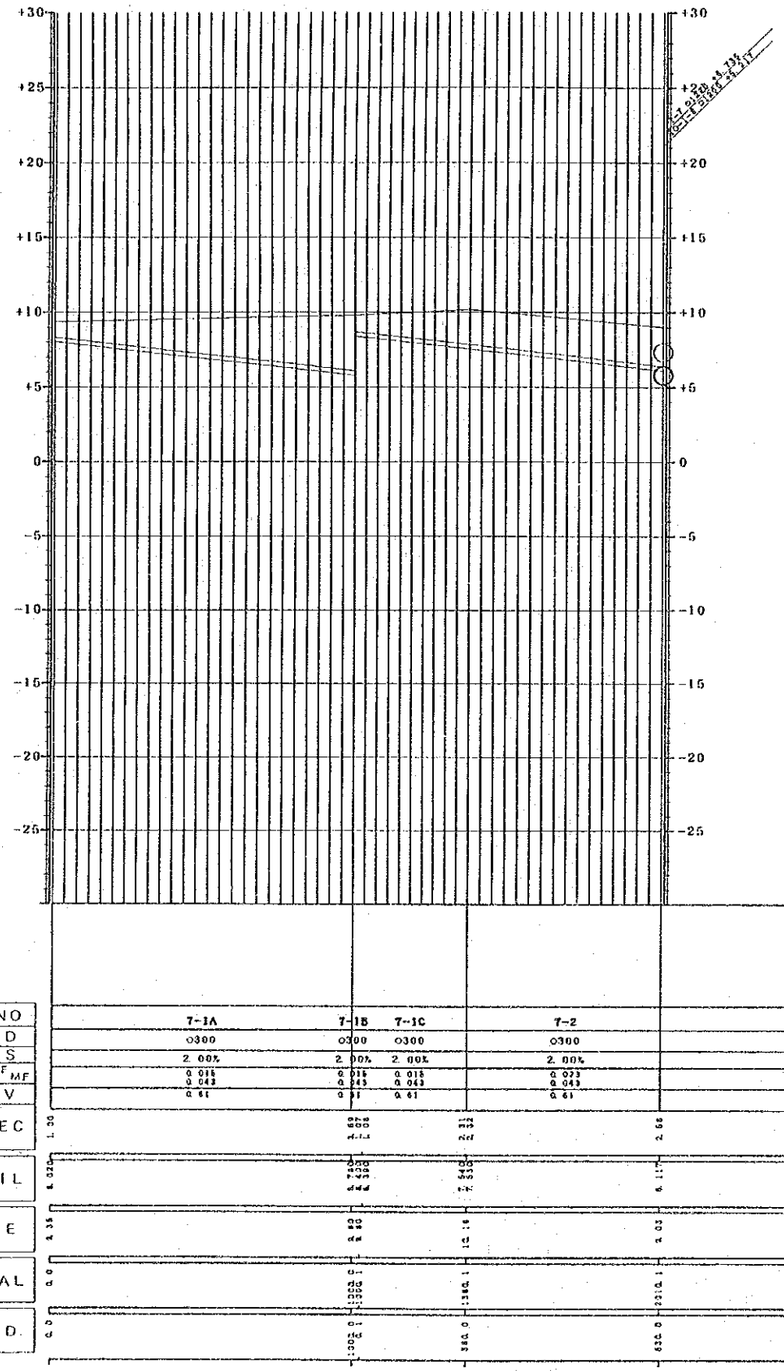
S-1A	S-1B	S-1C	S-2A	S-2B
S-3	S-4A	S-4B		

FIG. 3.6.2 (3)
LOP BURI

V 1:200
H 1:10,000

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

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

7-1A	7-1B	7-1C	7-2	

FIG. 3.6.2 (4) LOP BURI	V 1:200 H 1:10,000
MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY	

- Interceptors 1/1 - 1/8 are planned along irrigation canal against the slope (topography) to reach to WWTP.

- Interceptors 2/1 - 2/2 are arranged to intercept wastewater flowing down to the area, junction of road No. 3016 and service area boundary. The interceptor is connected to upstream of 1/3.

- Interceptor 3/1 connects 1/4 collecting wastewater from existing drains.

- Interceptor 4/1 is connected to upstream of 1/5.

- 5/1 - 5/4 interceptors collect wastewater from 5/2 - 5/4 and connect to upstream of 1/7.

- 6/1 - 6/2 interceptors are connected to upstream of 5/3.

- 7/1 - 7/2 interceptors are located in the western part of service area and connected to upstream of 1/8.

Table 3.6.1 summarizes planned collection facilities. Detailed on pump specifications and siphon are included in Supporting Report 3.A.6 - 3.C.6.

Table 3.6.1 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	4,420	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
RCP; Reinforced Concrete Pipe

3.6.3 Wastewater Treatment and Sludge Disposal System

(1) Wastewater Treatment and Disposal Methods

The wastewater discharge in the sewerage development area of Lop Buri municipality is estimated to be 13,731 m^3/d in the year of 2011. Groundwater infiltration is assumed to be 20% of discharged wastewater. The design wastewater at the treatment plant is estimated to be 16,500 m^3/d. The effluent quality is expected to be less than 40 mg/l as BOD.

The following three (3) treatment systems are applicable to meet the above requirements in quality and quantity.

1) Stabilization Pond
2) Aerated Lagoon
3) Oxidation Ditch

(2) Comparative Evaluation

The above three (3) treatment systems are compared in terms of required construction and O&M costs, required land area and easiness of O&M as shown below (Details are included in Supporting Report 3.1.6.2).

Evaluation Item	Stabilization Pond	Aerated Lagoon	Oxidation Ditch
(1) Construction Cost (million Baht)	26.2	38.06	99.64
(2) Land Cost (million Baht)	57.0	25.16	11.72
(3) O/M Cost (million Baht/year)	0.32	1.07	9.78
(4) Required Land Area (ha)	18.24	8.05	3.75
(5) Easiness of O/M			
- Adaptability of overload	A	A	B
- Required technology level	A	A	B
- Sludge disposal	A	A	C

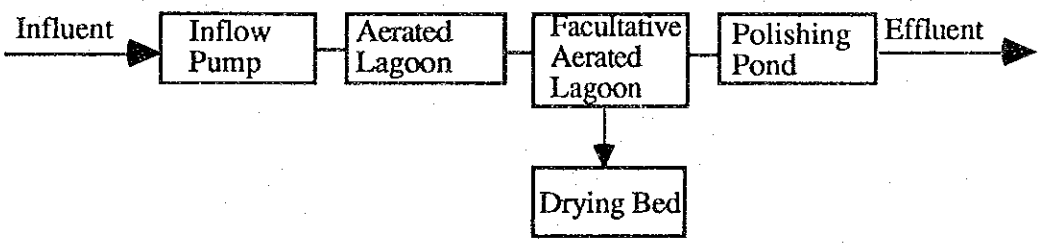
Note : 1) Construction cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical and others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge disposal : A: easy, B: medium, C: hard

Although stabilizartion pond is most economical in the comparison of NPV costs (refer to Supporting Report 3.1.6.3), aerated lagoon is selected due to land area limitation.

(3) Plan of Treatment Plant

The proposed treatment plant of aerated lagoon with a capacity of 16,500 m^3/d requires a net area of 8.05 ha. While the initially suggested waste-water treatment plant site by local government of Lop Buri is the swampy area with a total area of 3.8 ha (23.4 rai). Further land acquisition of 4.25 ha near the swampy area is required.

The flow sheet of aerated lagoon system and the capacity dimension and other relevant details of each treatment facility is shown below.



Flow of Aerated Lagoon System

Inflow Pump : Design capacity : 25,700 m^3/d (hourly max. dry)
: 77,100 m^3/d (hourly max. wet)
: Capacity : 17.85 $m^3/min.$ with 6.2 m hydraulic head (hourly max. dry)
: 53.54 $m^3/min.$ with 6.2 m hydraulic head (hourly max. wet)

Grit Chamber	: Surface loading	:	1,713 $m^3/m^2/d$ (dry weather)
			2,570 m^3 / m^2 /d (wet weather)
	: Retention time	:	30 sec (dry), 20 sec (wet)
	: Size	:	1.0 m(W) x 7.5 m(L) x 0.6 m(D)
			x 4 units
			(2 units for dry weather)
		:	Constructed with R.C

Aerated Lagoon	: Design capacity	16,500 m^3/day (daily ave. dry)
	: Pond capacity	49,980 m^3
	: Pond surface area	16,200 m^2
	: Retention time	3.03 days
	: Dimension	50 m(W) x 81 m(L) x 4.0 m(D)
		x 4 units
	: Embankment protected by masonry	

Facultative Aerated Lagoon	: Pond capacity	49,980 m^3
	: Pond surface area	16,200 m^2
	: Retention time	3.03 days
	: Dimension	50 m(W) x 81 m(L) x 4.0 m(D) x 4 units
	: Embankment protected by masonry	

Polishing Pond	: Pond capacity	16,640 m^3
	: Pond surface area	12,780 m^2
	: Retention time	1.0 days
	: Dimension	45 m(W) x 71 m(L) x 1.5 m(D) x 4 units
	: Embankment protected by masonry	

Drying Bed	: Drying area	1,600 m^2
	: Detention time	15 days
	: Dimension	5 m x 8 m x 40 units

The effluent is discharged to Lop Buri river through khlong. Layout of the treatment plant and hydraulic profile are shown in Figure 3.6.3 and Figure 3.6.4, respectively.

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
(Dry Season) ϕ 300m/m×8.4m^3/min×6.2"H×2units
(Wet Season) ϕ 400m/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

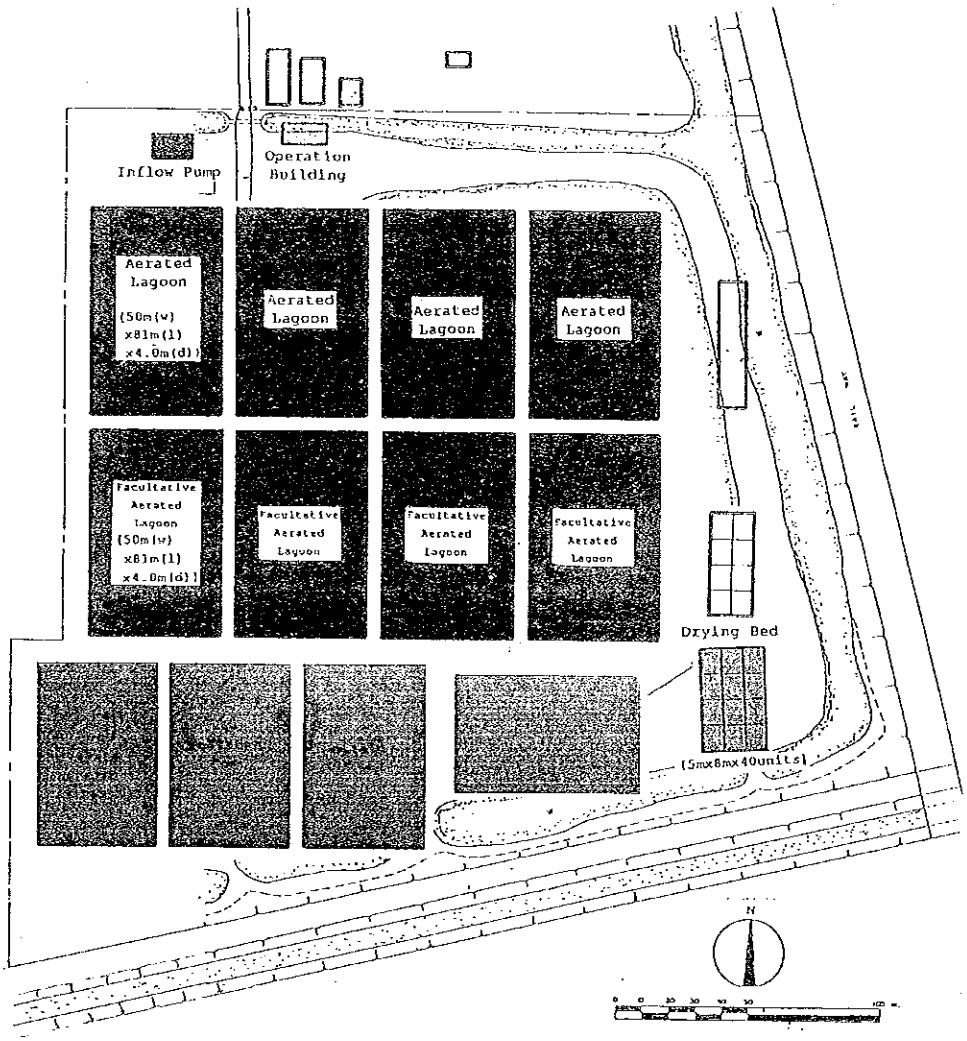


FIGURE 3.6.3 Layout of Sewage Treatment Plant (Lop Buri)

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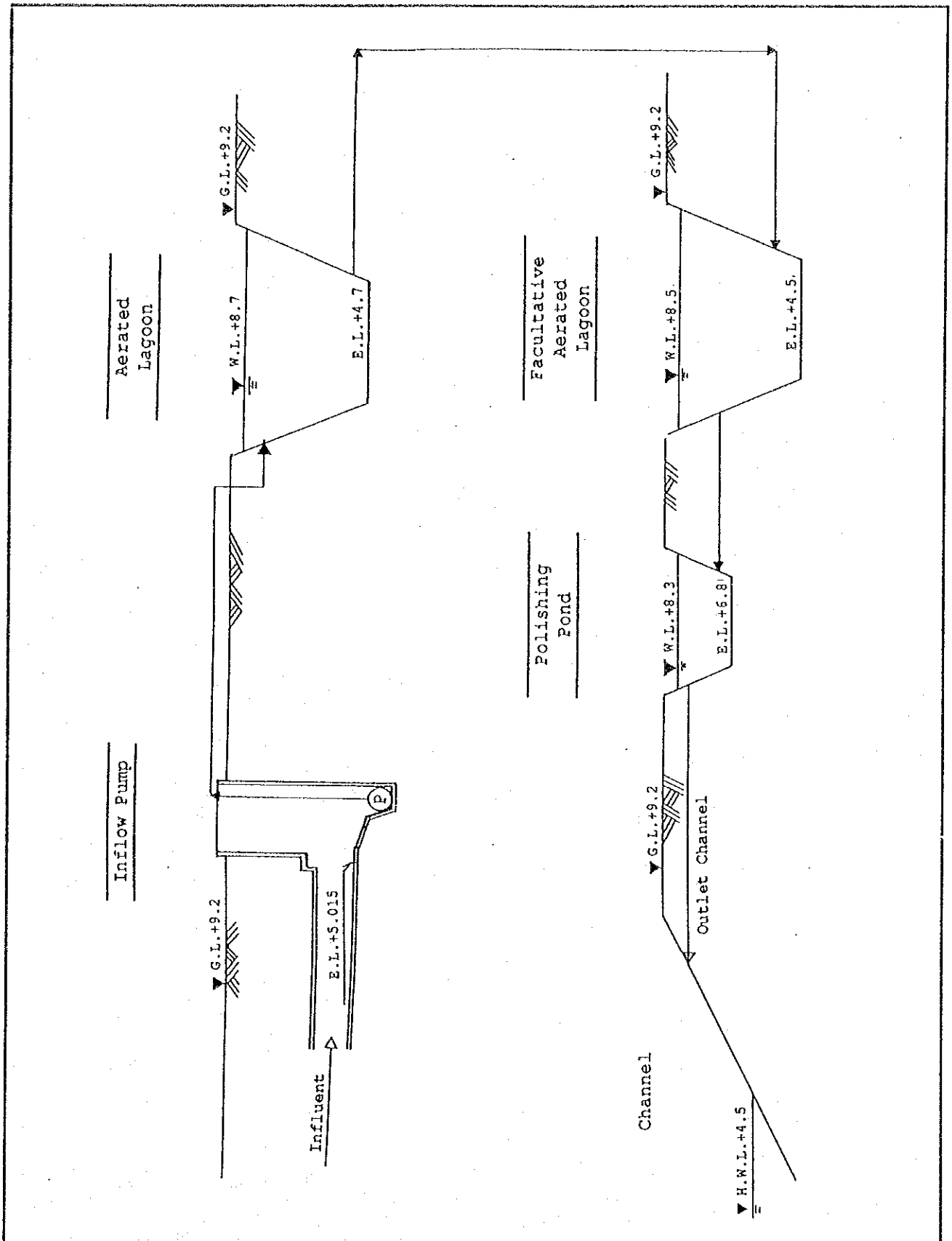

Figure 3.6.4 Hydraulic Profile of Sewage Treatment Plant (Lop Buri)

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

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3.7 Cost Estimates

3.7.1 Construction Cost

In the previous chapter, cost functions for interceptors, pump stations (more than 5 m^3/min.) and wastewater treatment plants are developed. Land acquisition cost is also considered to come up with the total construction cost. The following are cost requirements (million Baht) for the design year 2011.

(1) Direct Cost	
1) Interceptor	151.7
2) Pump Station	57.2
3) W.W.T.P.	38.06
Total of Direct Cost	246.96
(2) Contingency (20% of Direct Cost)	49.4
(3) Total of Construction Cost ((1)+(2))	296.36
(4) Engineering & Construction Supervision (17% of (3))	50.4
(5) Land Acquisition	
1) Pump Station	0.24
2) W.W.T.P.	25.16
Total of Land Acquisition	25.4
Grand Total (million Baht)	372.16

3.7.2 Operation and Maintenance Cost

Annual Operation and Maintenance cost (thousand Baht)is estimated using cost function/unit cost studied in the previous chapter.

(1) Interceptor	982
(2) Pump Station	2,850
(3) W.W.T.P.	1,070
Total of O&M Cost	4,902

3.8 Implementation Plan

The provision of a complete sewerage system for the entire study area with its increasing population, will require a great investments of capital fund as estimated in the previous section. Some areas within the study area is presently undeveloped land and environmental conditions of such area are different from built-up area. Although the study area needs to be sewered in early stage, the urgency of sewerage requirements is different depending on the land use features of areas.

Staged construction will be advantageous to minimize the excessive initial investment and capital expenditures. Implementation program is prepared for the first 20 years, dividing into 4 stages of five year each, taking the design period up to the year 2011 into account. The schedule is assumed giving priority to developed/being developed areas.

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

3.9 Administrative and Financial Study

3.9.1 General

This municipality is medium - sized with a total population of about 37,000 in 1991. The relationship of the central government is the same as other municipalities.

The equations of ministry of Interior decides detailed staffing and assignments of the municipalities, It is not equipped with technical expertise to deal with the proposed sewerage system.

3.9.2 Existing Administrative System

The existing organization of the municipality is shown in Figure 3.9.1. It has the following 5 divisions:

- Administration division
- Treasury division
- Health division
- Technical division
- Education division

This is a standard setup of this size municipality, regulated by the Municipal Government Act (1953).

The number of the present officials and employees of the municipality is 150, excluding about 200 teachers.

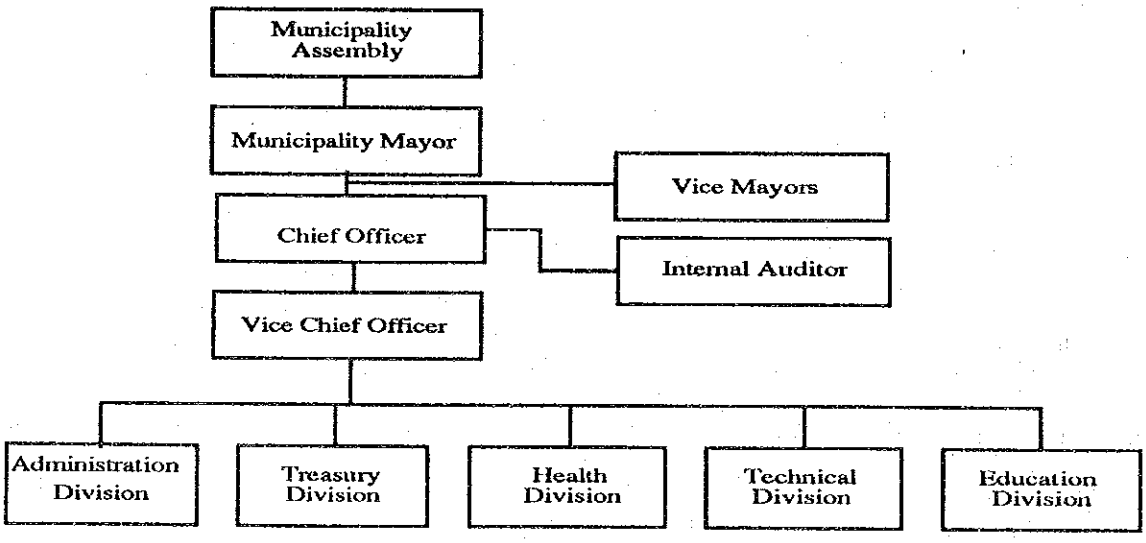


Figure 3.9.1 Administrative Structure of Municipality of Lop Buri

3.9.3 Recommendations

There are two possible options for management of the proposed sewerage system:

- (A) to integrate into the municipal organization (see Figure 3.9.2).
- (B) to create in independautly (see Figure 3.9.3).

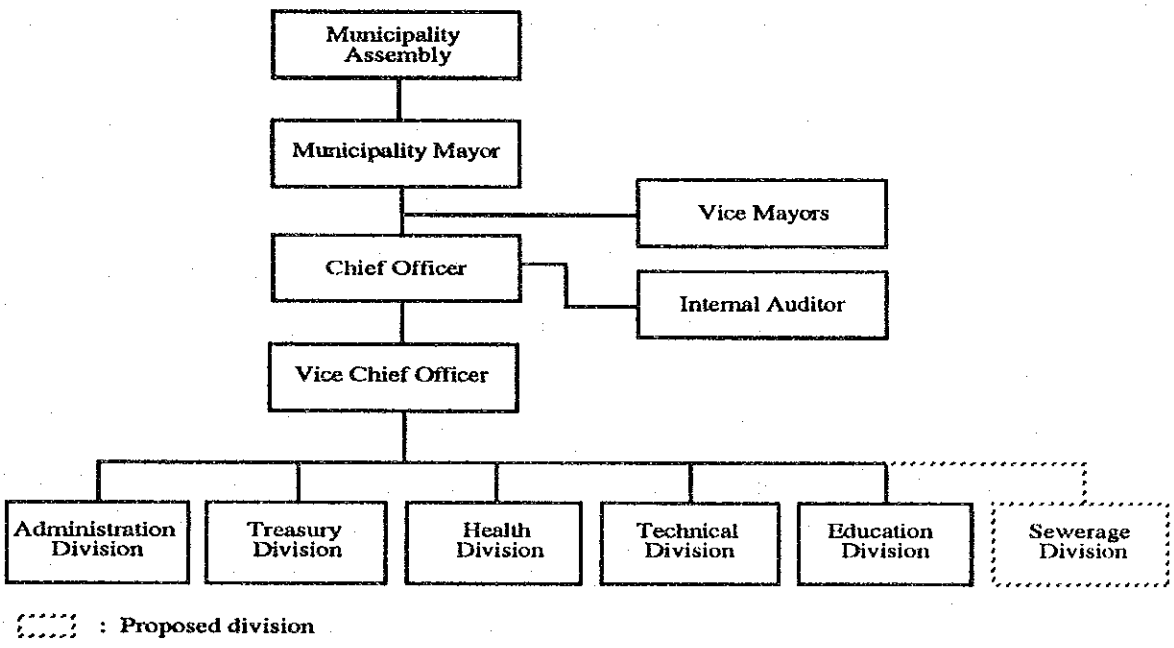


Figure 3.9.2 Option (A) for Municipality of Lop Buri

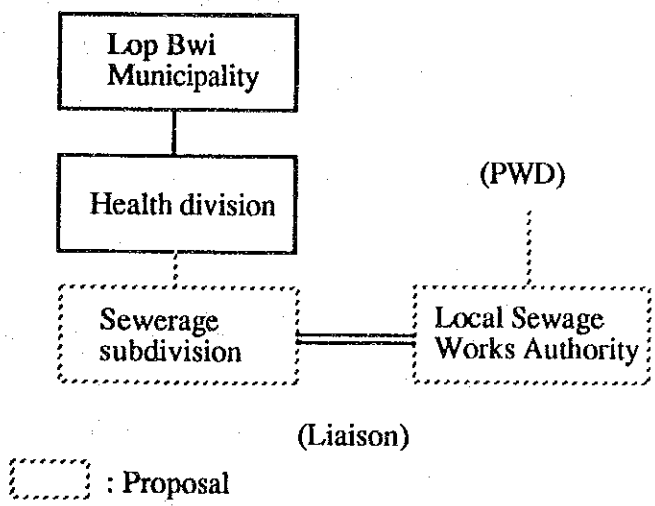


Figure 3.9.3 Option (B) for Municipality of Lop Buri

Based on the implementation plan, the staffing requirement is estimated as follows:

Stage	Period	Staffing requirement
1st	1991 - 1995	5
2nd	1995 - 2001	10
3rd	2002 - 2006	20
4th	2007 - 2011	40

The staff number of the municipality is now 150, excluding 200 teachers. This is large enough to integrate the sewerage management into the municipality.

However as the sewerage system develops and a clear management is required in the future, Option (b) will be more practical.

3.9.4 Financial Considerations

The relative burden, as defined as the ratio of 25% land acquisition cost to fixed investment on land and construction, was 42%. While the amount of fixed investment varies with fiscal year, this figure of 42% was very high among eight municipalities.

Lop Buri has not yet developed social infrastructure, compared with that of Rangsit and Bang Bua Thong. The proportion of public fixed investment total expenditures was only 16.7% in 1991. This appears to reflect that the greater the portion of public fixed investment, the smaller the relative burden of land acquisition cost. For example, when public fixed investment increases to, say, 40% of total expenditures, the relative burden of land acquisition cost becomes also 40%. Thus, the relative burden of 42%, while very high, should be interpreted in a frame work not only of fixed investment but also of total expenditures.

Nevertheless, when the relative burden exceeds a certain figure, say, 10%, it will add substantial burden on local municipality. This is due to limited capability of increasing local revenues in financing a large public investment project as the sewerage project.

Lop Buri is no exception. financing options that are available are (1)

municipality development fund, (2) environment fund, or (3) increasing local Environmental fund is available to local agencies in the form of grant and/or loan. It is recommended that Lop Buri explore loan financing to allocate financial burden into the future, compared to raising local revenues or utilizing municipality development fund whose objectives are more general than those of environmental fund.

The average household user cost in item 4.3 of Table 3.9.1 is well below one percent of low household income ion 2011 for Lop Buri. the user cost, however, could be administratively increased by two factors, one is the interest rate of the local that Lop Buri would transfer to the user, and the other, the loss of the sewerage revenue collection that could be compensated for and would be included as part of the user charge.

The household users were estimated on the basis of the project service area in 2011. The household is assumed to have 4.1 persons on the average. We have also assumed that household users as sewerage users for simplicity. The average sewerage user cost was calculated on O&M cost divided by [(0.7+0.2x1.2+0.1x2)(number of household users)].

The average rate of non household users could be assumed to pay as high as the highest progressive rate of the household user rate structure. The progressive rate structure is 1.0 to 1.3 to 2.0 for low, medium, and high household income group respectively. A summary is shown in 4.4 of Table 3.9.1.

Finally, affordability will be considered. The affordability level is defined as the ratio of the average household user cost to low household income level of 96,571 Baht in 2011 in the Central Region. With available data on household income by Lop Buri, the figure indicated in 4.5 of Table 3.9.1 would then be updated and could also be modified with allocation of loan cost among the users.

Table 3.9.1 Selected indicators for Lop Buri

1.1	Service Pop in 2011	61,300
1.2	Household Users in 2011	14,951
2.1	Total Expenditures, 1991 (Thousand Baht)	89,611
2.2	Investment on Land & Const., 1991 (Thousand Baht)	15,042
2.3	Land Land Acquisition Cost (Thousand Baht)	6,350
2.4	Relative Burden (2.3/2.2) in %	42
2.5	Sanitation Expenditures, 1991 (Thousand Baht)	14
3.1	Total Revenues, 1991 (Thousand Baht)	85,559
3.2	Central Government Support, 1991 (Thousand Baht)	4,204
4.1	Treatment capacity (m3/d), in 2011	16,500
4.2	Unit O&M Cost of 4.1, in 2011	0.81
4.3	Household Users Cost/Year, in 2011 without loan	328
4.4	Progressive Rates: 1:1.3:2.0 in 2011	283 368 566
4.5	Loan Cost/H User/Year 50% Local, 50% Foreign Loan, 25 Years	36
4.6	Affordability (4.3 + 4.5) for Low Income Household, 96571 baht, 2011	0.38%

SECTION 4

ANG THONG MUNICIPALITY

SECTION 4 ANG THONG MUNICIPALITY

4.1 Description of the Study Area

The Chao Phraya river passes through the study area resulting in a municipality that is developed at both sides of the river. It is located about 108 km from Bangkok, covering an area of about 3.73 km^2. The Noi river lies to the west and there are several natural khlongs and irrigation canals within the study area. The topography is generally flat, with the elevation between 3.0-6.0 m above the mean sea water level making it susceptible to flooding from the Chao Phraya river during the rainy season. Summer and winter seasons are mild with average temperatures being 38°C and 12°C respectively.

Primary transportation is by land, with Highways No. 309, 3164 and 32 connecting Ang Thong to Ayutthaya, Sing Buri and Suphan Buri. The secondary mode of transportation is by boats, along the irrigation canals. Natural resource is mainly clay, which is used for brick production. With the presence of two rivers, Noi and Chao Phraya, the area has abundant water. Major water using industries are agriculture, livestock raising and freshwater fishery. Small scale car factory, machinery services and construction materials are the other industries found in the area.

In Tambol Talad Lunang, three fresh markets are located with two of them operated by the municipality and the other by a private company. There is one municipality-owned slaughterhouse near the Tonson Temple covering an area of one rai. About 3 cows, 30 pigs and a buffalo are slaughtered daily. The water for the slaughterhouse is supplied from a nearby well and the wastewater is directly discharged to the lowlands. There are no drainage facilities available in the area. The lone slaughter house has been in operation for about 30 years and its condition is deteriorating. There is a plan to move it to an outside town at Tambol Ban Hae, in Amphoe Muang Ang Thong.

Ang Thong is the center of electricity distribution for the central region of Thailand. There are two large scale distribution stations in the municipality, but the electricity used in the municipality is supplied by the local electricity office. About 7,596 households are supplied with electricity by this office.

The DTCP area has 18 schools and institutes mostly owned by the government, except one which is privately owned. Seven of the schools are located within the municipality.

4.2 Existing Sanitation/Sewerage and Flood Protection Systems

4.2.1 Existing Sanitation Facilities

The municipality operates only 1 truck, to collect 10 m^3 of refuse, 3 times per day and dispose them at a plain along Ang Thong-Pa Mok road covering an area of 3 rai. At present, the site is almost full to its capacity.

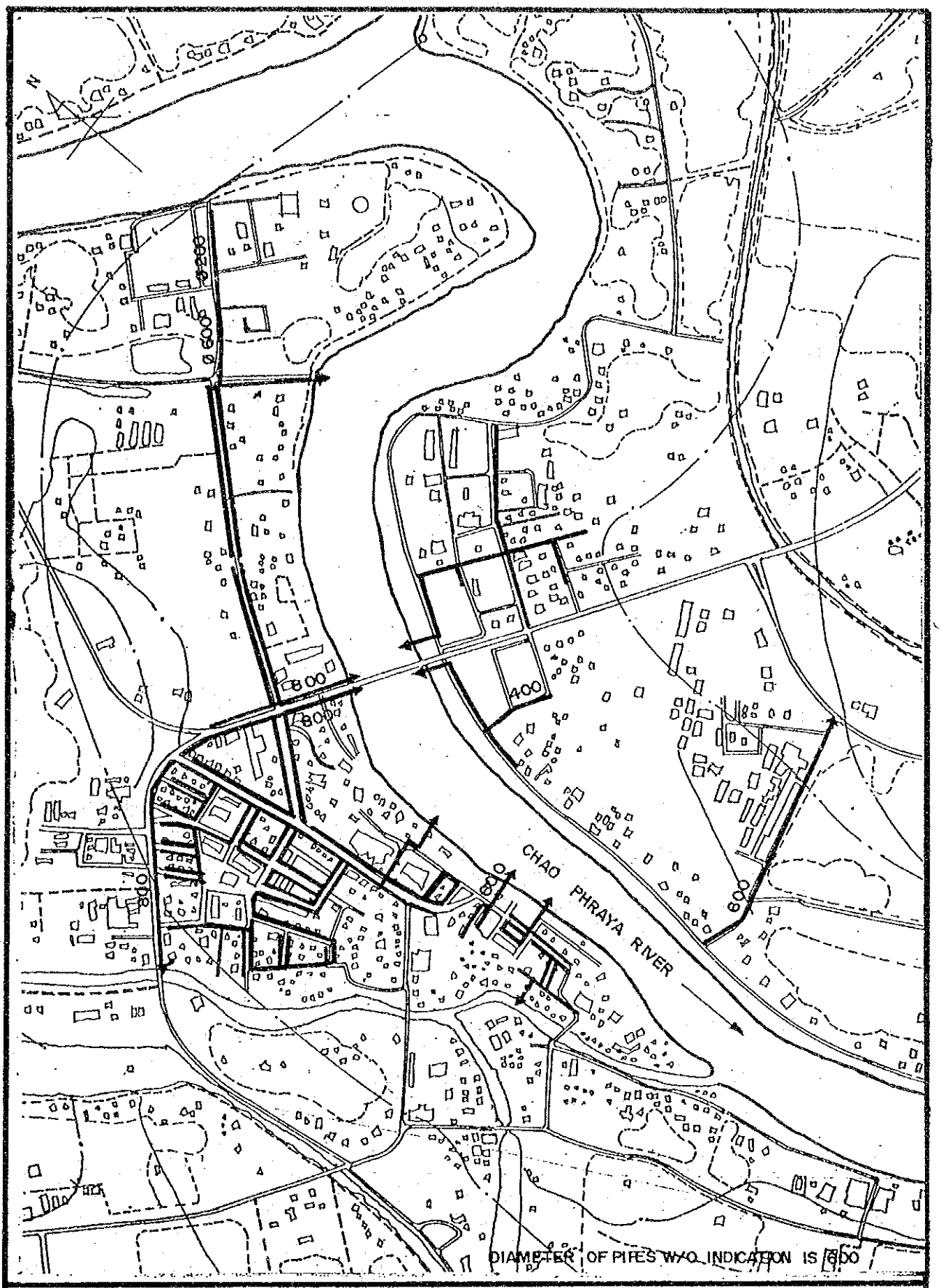
On-site treatment and disposal of nightsoil is practiced as mentioned in Section 3, Chapter 2.

4.2.2 Existing Sewerage Facilities

Combined sewers with diameters of 400 mm to 1,200 mm are provided to almost all parts of the municipality. The sewage is discharged to the Chao Phraya river and canals. However, underestimation in the size of the pipes and insufficient gradients cause problems of reverse flow from the Chao Phraya river during rise of its water level. Stagnation of the sewage spreads bad smell. The sewage is discharged into nearby khlongs. Composition of existing drainage facilities is summarized in Table 4.2.1. Area coverage and location of drains are shown in Figure 4.2.1.

Table 4.2.1 Existing Drainage Facilities

Size (mm)	Length (m)	Type	Drainage Area (ha)
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-shape ditch	6.3
Total	10,500		100.1



LEGEND : 600 DIAMETER (mm)
ORAINAGE PIPE ⟶ OUTFALL

SCALE 1:8,500

FIGURE 4.2.1 EXISTING DRAINAGE SYSTEM IN ANG THONG MUNICIPALITY

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4.2.3 Flood Protection Facilities

Dikes are built along both banks of the Chao Phraya river as a countermeasure against flood.

4.3 Water Supply

The waterworks of PWA at Tambol Taladluang, Amphoe Muang supplies water to the study area. It covers an area of 3.32 rai and uses water from the Chao Phraya river. Its total production capacity is 500 m^3/d. In addition, there are rural waterworks at Tambol Sala Daeng and Ban Hae to serve the villages. However, expansion of the waterworks is necessary to serve about 90% of the population. The water source will be sufficient even though it also serves 5 irrigation projects.

4.4 Population and Land Use

The population growth is 7-8% per year. Most of the population reside along the river due to the fact that in the past the river was the most important means of transportation. The communities are concentrated in the west bank of Chao Phraya river but government offices are located in the east bank area. The two parts are connected to each other by a 150 m long bridge across the river. Commercial area is around Highway 3164. Industrial areas are distributed both inside and outside of the municipality which accommodate small scale industries of car, machine service and construction materials. Most of the areas are still reserved for agriculture.

Land use at present and in the future (2011) is mentioned in Section 3, Chapter 2 and Figure 4.4.1 presents the projection in the year 2011.

Study area and population are as follows:

Area & Population	Present Municipality	Future Exp. Area	Sewerage M/P Area	Other Area	DTCP Area
Area(km^2)	3.73	1.45	5.18	18.80	23.98
Pop. in 1991	9,607	2,814	12,421		
Pop. in 2011	10,686	2,814	13,500		

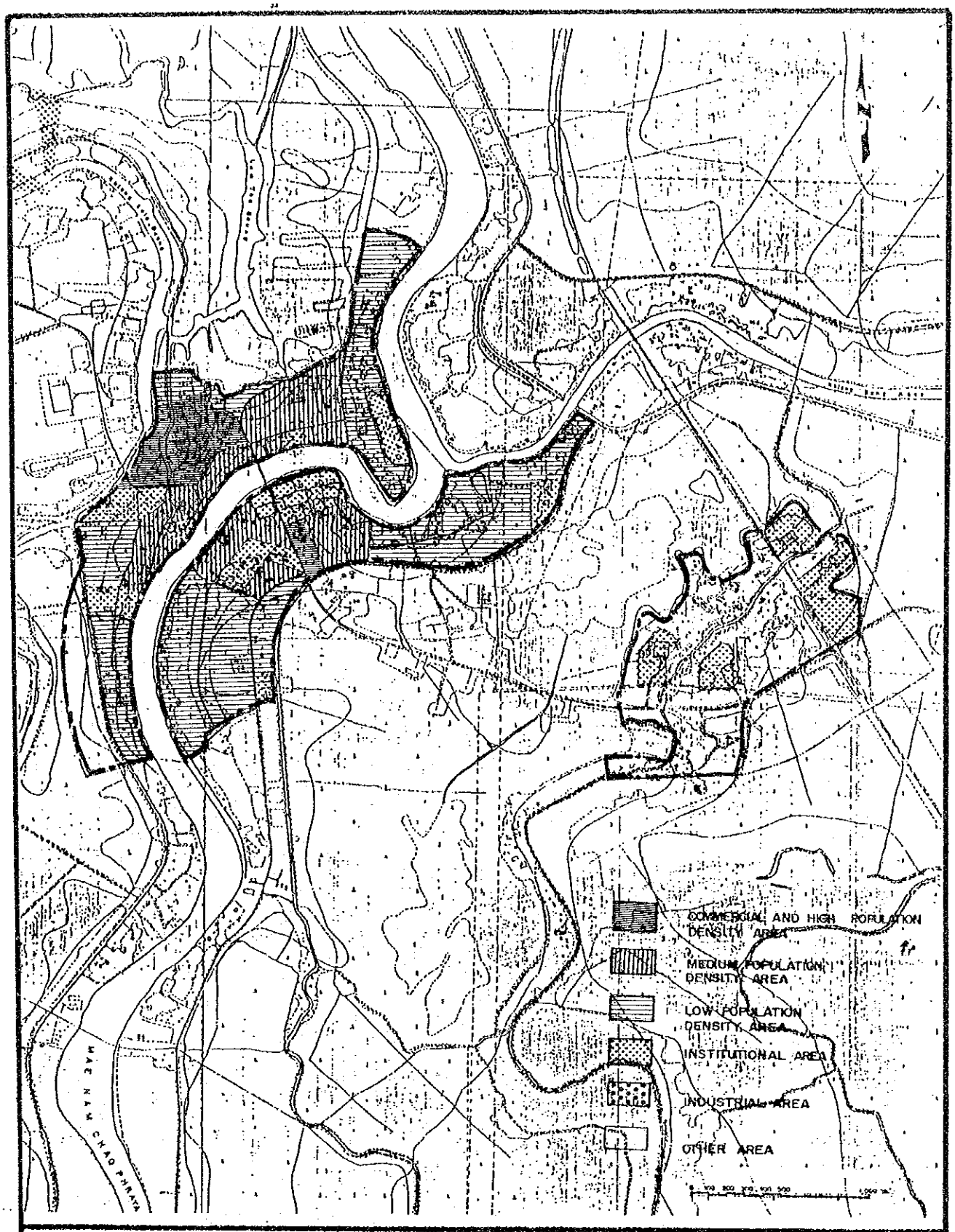

FIGURE 4.4.1 FUTURE LAND USE - YEAR 2011 (ANG THONG)

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4.5 Quality and Quantity of Wastewater

4.5.1 Unit Wastewater and Pollution Load on a Generation Basis

(1) Domestic Wastewater

Unit quality (BOD) and quantity on the daily average basis at present and in design year are tabulated breaking down into sullage and toilet waste.

Domestic wastewater discharge is assumed at 80% of water consumption. Toilet waste is treated by septic tank with assumed treatment efficiency of 50%.

Year	Unit Wastewater (lpcd)			Unit BOD Load (gpcd)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Present	100	12	112	33.6	5.5	39.1
Design Year (2011)	136	24	160	35.1	5.5	40.6

(2) Business Wastewater

Those for business wastewater (commercial and institutional) is assumed to be 30% and 40% of domestic wastewater for the present and design year (2011), respectively.

	Unit Wastewater (lpcd)	Unit Pollution Load (BOD gpcd)
Present	32	6.1
Design Year (2011)	64	7.7

4.5.2 Discharged Wastewater and BOD Load

(1) Domestic Wastewater

Wastewater quantity and BOD load based on a discharge basis are estimated for the present and design year (2011) multiplying service population by unit wastewater quantity/BOD load. The following are the estimation results.

Item	Present			Design Year (2011)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Wastewater Quantity (m^3/d)	1,244	149	1,393	1,836	324	2,160
BOD Load (kg/d)	417.3	68.3	485.6	473.9	74.3	548.2

(2) Business Wastewater

Discharged wastewater quantity and BOD load are estimated in the same procedure as domestic wastewater as shown below.

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	398	864
BOD Load (kg/d)	75.8	104.0

(3) Total Wastewater Quantity and BOD Load

Total discharged wastewater quantity and BOD load (daily average basis) at present and in the design year (2011) for Ang Thong Sewerage Development are figured out as shown below.

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	1,791	3,024
BOD Load (kg/d)	561.4	652.2

4.6 Proposed Sewerage System

4.6.1 Service Area

The service area covers 518 ha with present population of 12,400. The area consists of east and west bank areas of the Chao Phraya river with generally flat terrain. Population in the area is projected to be about 13,500 in 2011.

In the west bank area three sub-drainage areas may be considered; western portion of Khlong Sala Daeng, surrounded area by the Chao Phraya river and Khlong Sala Daeng, and urbanized area. In the east bank area; a total of three sub-drainage areas are also recommended; western portion of the irrigation canal along the Chao Phraya river, northern part of the provincial road toward National Road No. 32 and southern part thereof.

A single sewerage system is recommended and shown in Figure 4.6.1. This is because that wastewater collected in the east bank area may be transmitted by pumping across the Chao Phraya river through the bridge under some favorable conditions; major area is near the bridge, narrow width of the river and the bridge is durable for use of pipe crossing.

Location of WWTP is recommended in the west bank area where majority of population is concentrated. Selected site is north of Khlong Bang Ta Phaen connecting to Khlong Sala Daeng in view of immediate effect by the sewerage project.

4.6.2 Wastewater Collection System

Wastewater collection system employing combined collection method is proposed based on existing conditions including drainage facilities, topography and land availability for sewerage facilities.

Distribution of population and wastewater quantity was made in use of population density assumed by land use type (refer to calculation table in Supporting Report 3.4.6).

Alignments of main interceptors and pump stations are proposed as shown in Figure 4.6.1. The profile of sewers is presented in Figures 4.6.2.(1) and 4.6.2.(2) (refer to hydraulic calculation in Supporting Report 3.4.6). The following are brief descriptions on the sewer systems.

- Five (5) sewer systems cover both east and west bank areas. The largest trunk line starts from the isolated cluster in the east bank area (interceptors 1/1 - 1/6).

- Interceptor 2/1 is planned along existing irrigation canal to connect to upstream of 1/2).

- Interceptor 3/1 is located along the Chao Phraya river against the slope to connect to upstream of 1/4.

- Interceptor 4/1 along the Chap Phraya river is connected to upstream of 1/4.

- Interceptors 5/1 - 5/3 are planned to collect wastewater from existing drains and connected to 1/5.

Table 4.6.1 summarizes planned collection facilities. Details on pump specifications and siphon are included in Supporting Report 3.A.6 - 3.C.6.

Table 4.6.1 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

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
- SLOPE
- LENGTH
- 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

STUDY ON MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN
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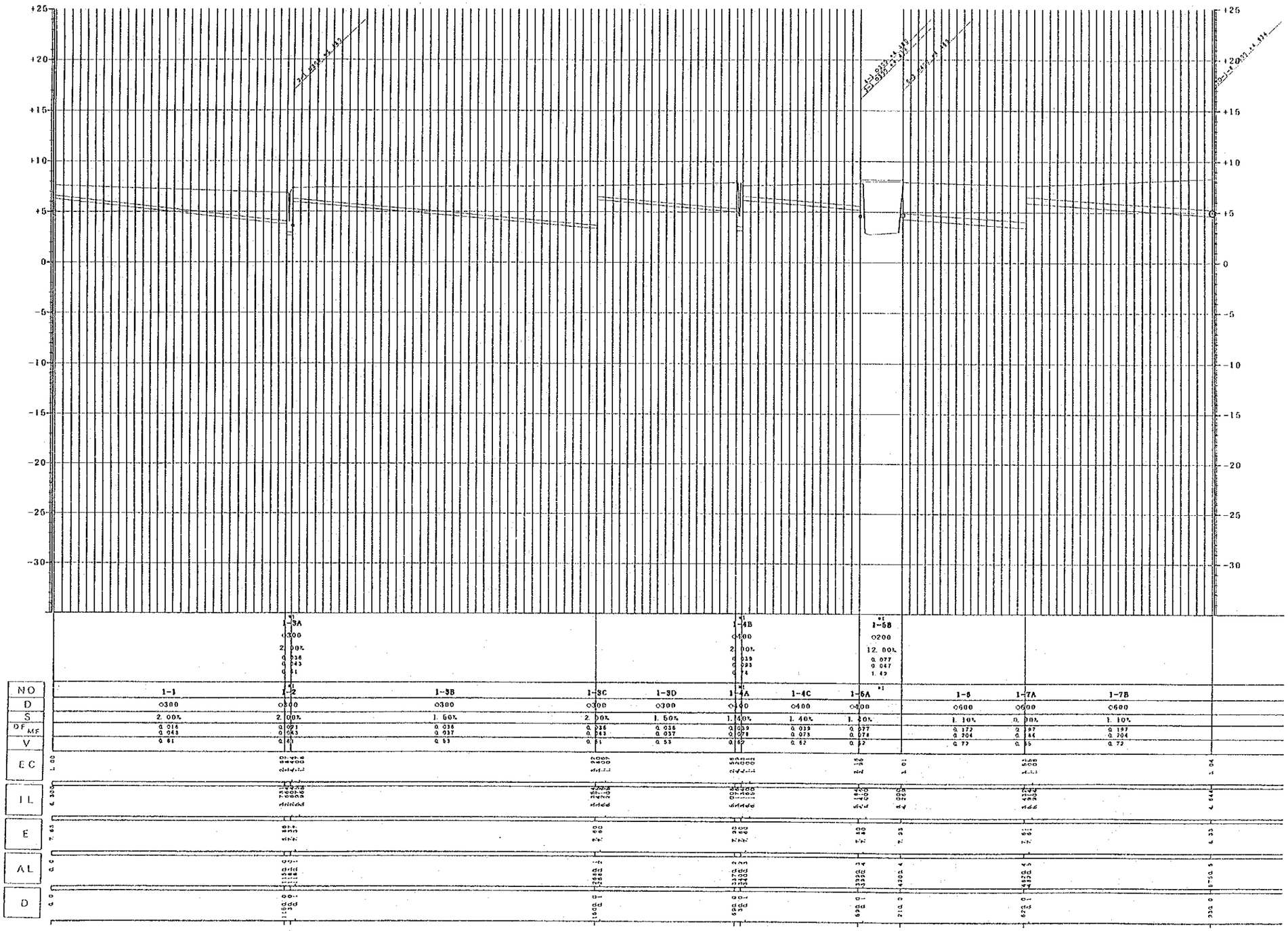
FIG. 4.6.1 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (ANG THONG MUNICIPALITY)



LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

1-1	1-2	1-3A	1-3B	1-3C
1-3D	1-4A	1-4B	1-4C	1-6A
1-5B	1-6	1-7A	1-7B	

FIG. 4.6.2 (1)
ANG THONG

V 1:200
H 1:10,000

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

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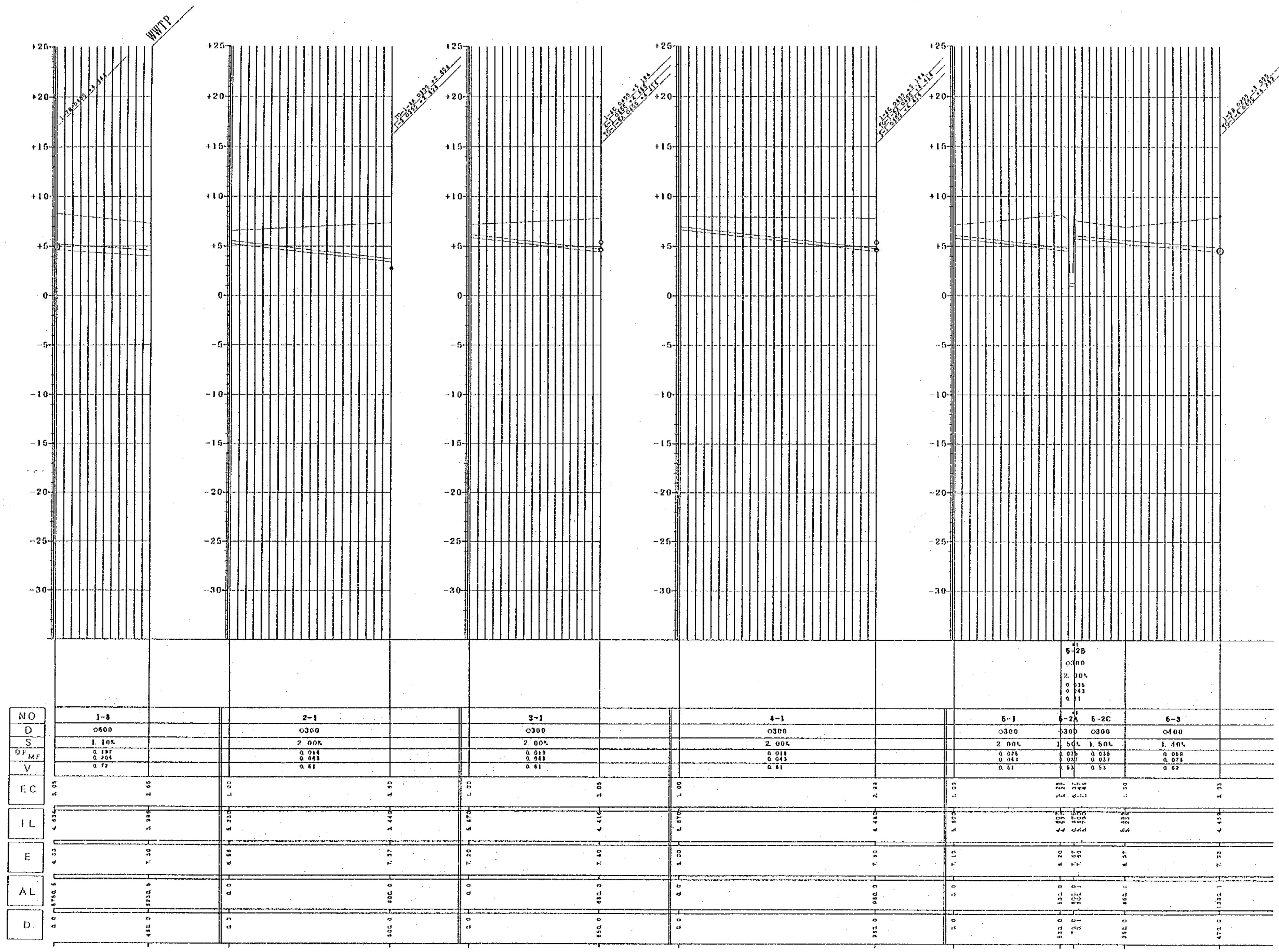

LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

1-8	2-1	3-1	4-1	5-1
5-2A	5-2B	5-2C	5-3	

FIG. 4.6.2 (2)	V 1:200
ANG THONG	H 1:10,000

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4.6.3 Wastewater Treatment and Sludge Disposal System

(1) Wastewater Treatment and Disposal Methods

The wastewater discharge in the sewerage development area of Ang Thong municipality is estimated to be 3,024 m^3/d in the year of 2011. Groundwater infiltration of 20% of wastewater discharge is assumed. The design wastewater to the treatment plant is estimated to be 3,700 m^3/d. The effluent quality is expected to be less than 40 mg/l as BOD_5.

The following three (3) treatment systems are applicable to meet the above requirements in quality and quantity.

1) Stabilization Pond
2) Aerated Lagoon
3) Oxidation Ditch

(2) Comparative Evaluation

The above three (3) treatment systems are compared in terms of required construction and O&M costs, required land space and easiness of O&M as shown below.

Evaluation Item	Stabilization Pond	Aerated Lagoon	Oxidation Ditch
(1) Construction Cost (million Baht)	5.46	9.79	22.34
(2) Land Cost (million Baht)	6.80	3.50	1.90
(3) O/M Cost (million Baht/year)	0.09	0.35	2.16
(4) Required Land Area (ha)	5.44	2.81	1.52
(5) Easiness of O/M			
- Adaptability of overload	A	A	B
- Required technology level	A	A	B
- Sludge disposal	A	A	C

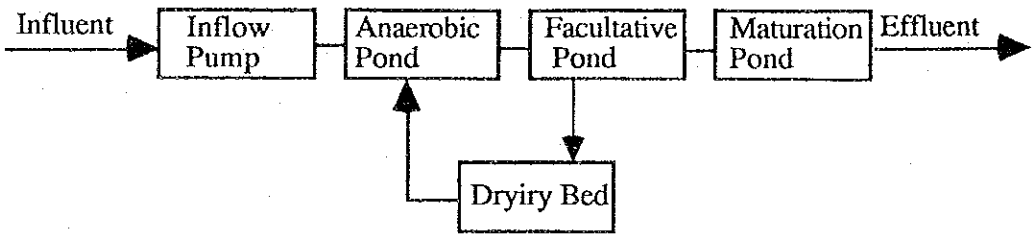
Note : 1) Construction cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical and others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge disposal : A: easy, B: medium, C: hard

As evident from cost comparison in NPV, stabilization pond system is the most economical (refer to NPV cost in Supporting Report 3.1.6.3).

(3) Plan of Treatment Plant

The proposed location of the wastewater treatment plant of Ang Thong is current of used as the paddy field in Tambol. The proposed treatment plant of stabilization pond with a capacity of 3,700 m^3/d requires a net land area of 5.44 ha.

The flow sheet of stabilization pond system and the capacity dimension and other relevant details of each treatment facility is shown below.



Inflow Pump : Design capacity 5,700 m^3/d (hourly max. dry)
17,100 m^3/d (hourly max. wet)
: Capacity 3.96 m^3/min. with 4.8 m hydraulic head (hourly max. dry)
11.88 m^3/min. with 4.8 m hydraulic head (hourly max. wet)

Grit Chamber : Surface loading 1,727 m^3/m^2/d (dry weather)
2,591 m^3/m^2/d (wet weather)
: Retention time 30 sec. (dry), 20 sec (wet)
: Size 0.6 m(W) x 5.5 m(L) x 0.6 m(D)
x 2 units
(1 unit for dry weather)
: Constructed with R.C

Anaerobic Pond	:	Pond capacity 18,530 m^3
	:	Pond surface area 6,200 m^2
	:	Retention time 5 days
	:	Dimension 50 m(W) x 62 m(L) x 4.0 m(D) x 2 units
	:	Embankment protected by masonry
Facultative Pond	:	Pond capacity 18,537 m^3
	:	Pond surface area 10,560 m^2
	:	Retention time 5 days
	:	Dimension 60 m(W) x 88 m(L) x 2.0 m(D) x 2 units
	:	Embankment protected by masonry
Maturation Pond	:	Pond capacity 18,662 m^3
	:	Pond surface area 14,200 m^2
	:	Retention time 5.04 days
	:	Dimension 50 m(W) x 71 m(L) x 1.5 m(D) x 4 units
	:	Embankment protected by masonry
Drying Bed	:	Required drying area 96 m^2
	:	Detention time 15 days
	:	Dimension 4 m x 6 m x 4 units

The effluent is discharged to Chao Phraya river through Khlong Lam Tha Daeng. Layout of the treatment plant and hydraulic profile are shown in Figure 4.6.3 and Figure 4.6.4, respectively. Further study on the employment of anaerobic pond shall be made during F/S stage to suit for sewage quality.

4.7 Cost Estimates

4.7.1 Construction Cost

In the previous chapter, cost functions for interceptors, pump stations (more than 5 m^3/min.) and wastewater treatment plants are developed. Land acquisition cost is also considered to come up with the total construction cost. The following are cost requirements (million Baht) broken down into east and west bank areas for the design year 2011.

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

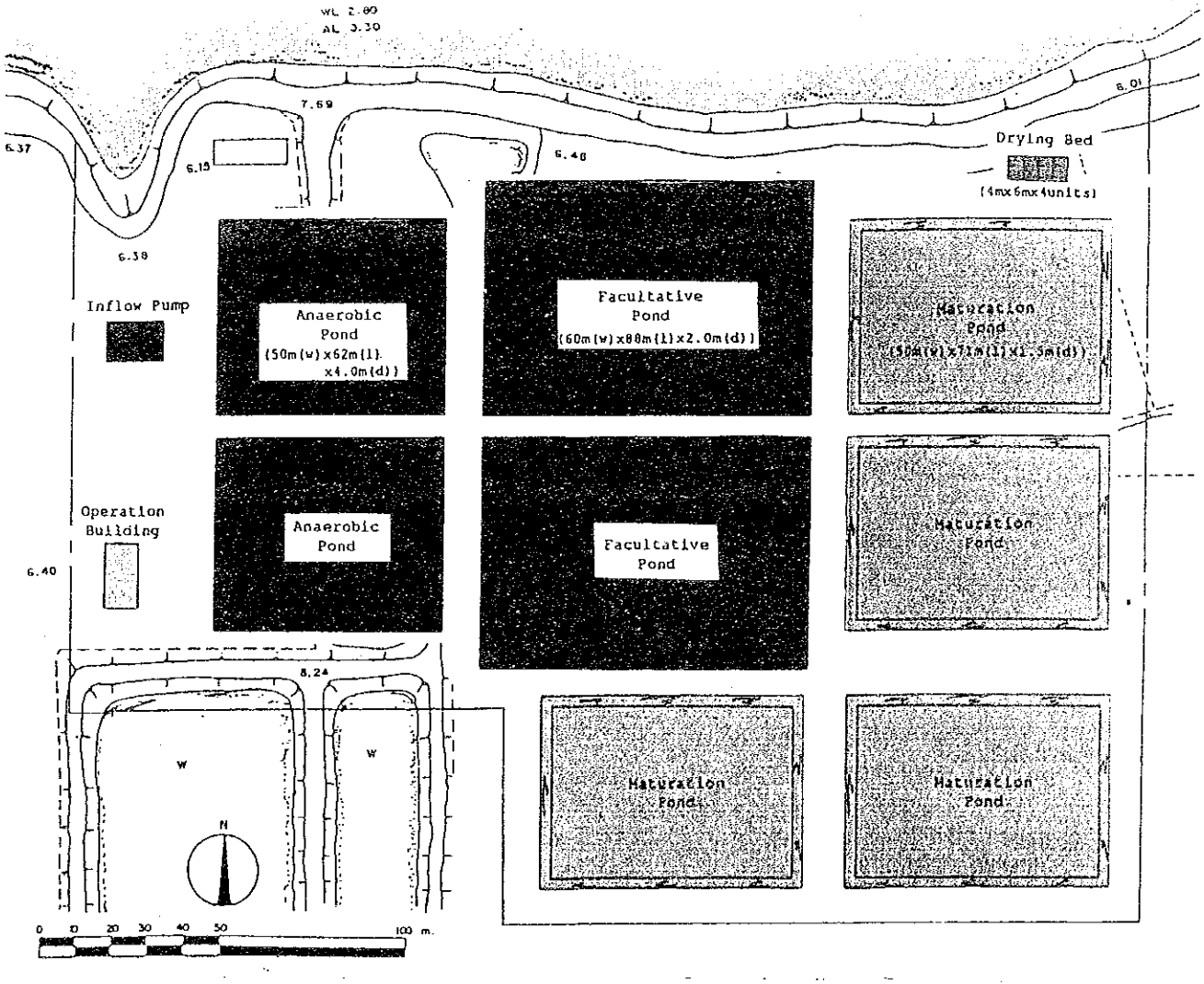


FIGURE 4.6.3 Layout of Sewage Treatment Plant (Ang Thong)

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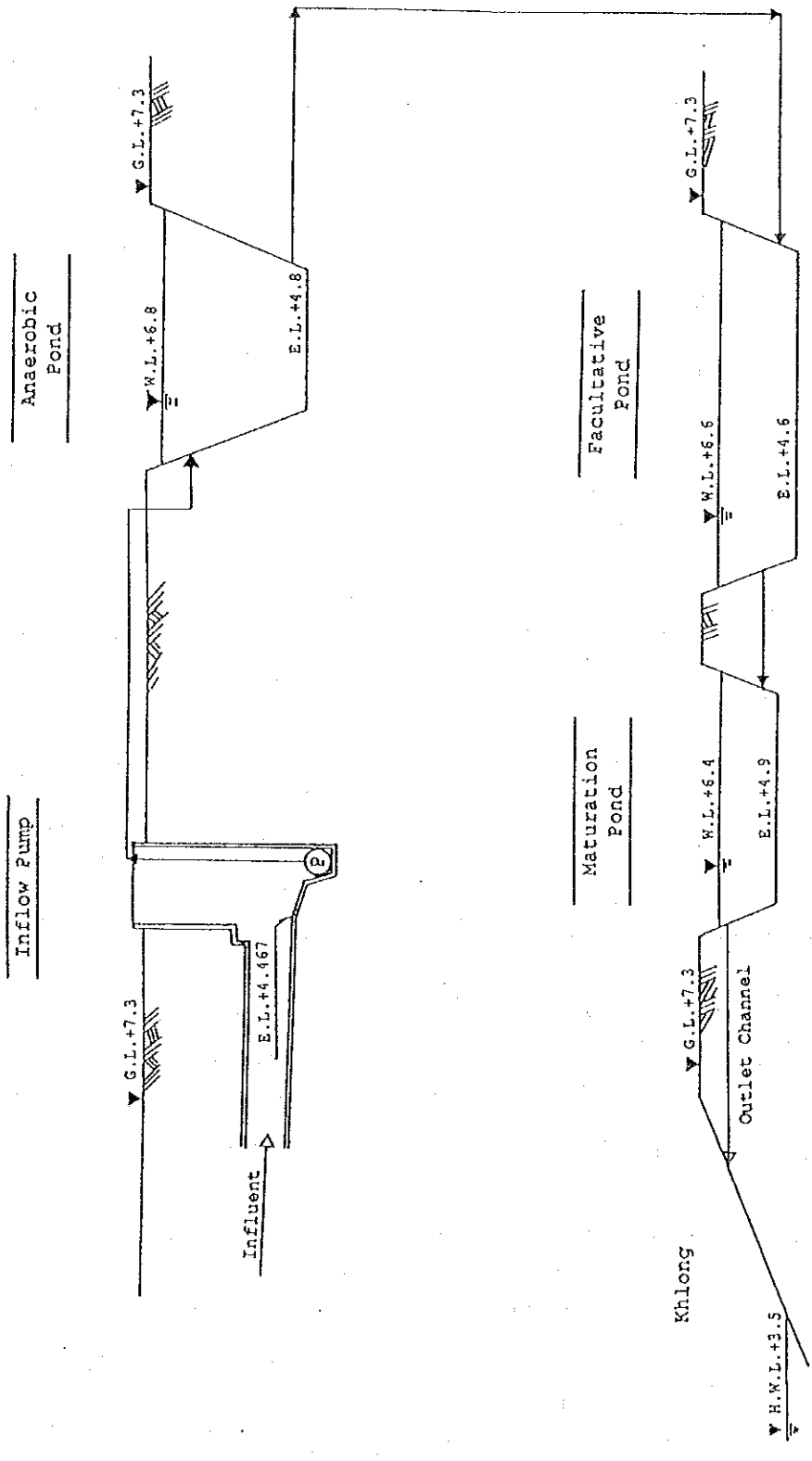


Figure 4.6.4	Hydraulic Profile of Sewage Treatment Plant (Ang Thong)	STUDY ON MASTER PLANNING FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY

Cost Item	Ang Thong East	Ang Thong West	Total
(1) Direct Cost			
1) Interceptor	55.31	35.79	91.1
2) Pump Station	4.86	3.14	8.0
3) W.W.T.P.	3.31	2.15	5.46
Total of Direct Cost	63.48	41.08	104.56
(2) Contingency (20% of Direct Cost)	12.7	8.2	20.9
(3) Total of Construction Cost ((1)+(2))	75.18	49.28	125.46
(4) Engineering & Construction Supervision (17% of (3))	13.0	8.4	21.4
(5) Land acquisition			
1) Pump Station	0.05	0.04	0.09
2) W.W.T.P.	4.13	2.67	6.8
Total of Land Acquisition	4.18	2.71	6.89
Grand Total (million Baht)	93.36	60.39	153.75

4.7.2 Operation and Maintenance Cost

Annual Operation and Maintenance cost (thousand Baht) is estimated in the previous Chapter.

Cost Item	Ang Thong East	Ang Thong West	Total
(1) Interceptor	398	257	655
(2) Pump Station	213	137	350
(3) W.W.T.P.	55	35	90
Total of O&M Cost	666	429	1,095

4.8 Implementation Plan

The provision of a complete sewerage system for the entire study area with its increasing population, will require a great investments of capital fund as estimated in the previous section. Some areas within the Study area is

presently undeveloped land and environmental conditions of such area are different from built-up area. Although the study area needs to be sewered in early stage, the urgency of sewerage requirements is different depending on the land use features of areas.

Staged construction will have advantages to minimize the excessive initial investment and capital expenditures. Implementation program is prepared for the first 20 years, dividing into 4 stages of five year each, taking the design period up to the year 2011 into account. The schedule is assumed giving priority to developed/being developed areas.

Stage	Period	Works with Priority
1st	1991-1995	Preparatory work & design facilities
2nd	1996-2001	Construction for west bank area
3rd	2002-2006	Construction for east bank area
4th	2007-2011	Construction for east bank area (isolated area)

4.9 Administrative and Financial Study

4.9.1 General

The municipal organization is strictly controlled y regulations of ministry of Interior. The present staff are not technically capable to deal with the proposed sewerage system.

Therefore new staff members shall be recruited or proper trainings should be given to the existing staff.

4.9.2 Existing Administrative System

The present organization of the municipality is shown in Figure 4.9.1. The work forces are as follows:

- 50 officials
- 43 teachers
- 24 employees (permanent)
- 116 employees (temporary)

The staff number is decided by the city size. A large number of the staff are allocated by DOLA. In the municipality there are 20 vacancies for officials.

The original number of officials is supposed to be 70. The administrative structure is the same as the other municipalities.

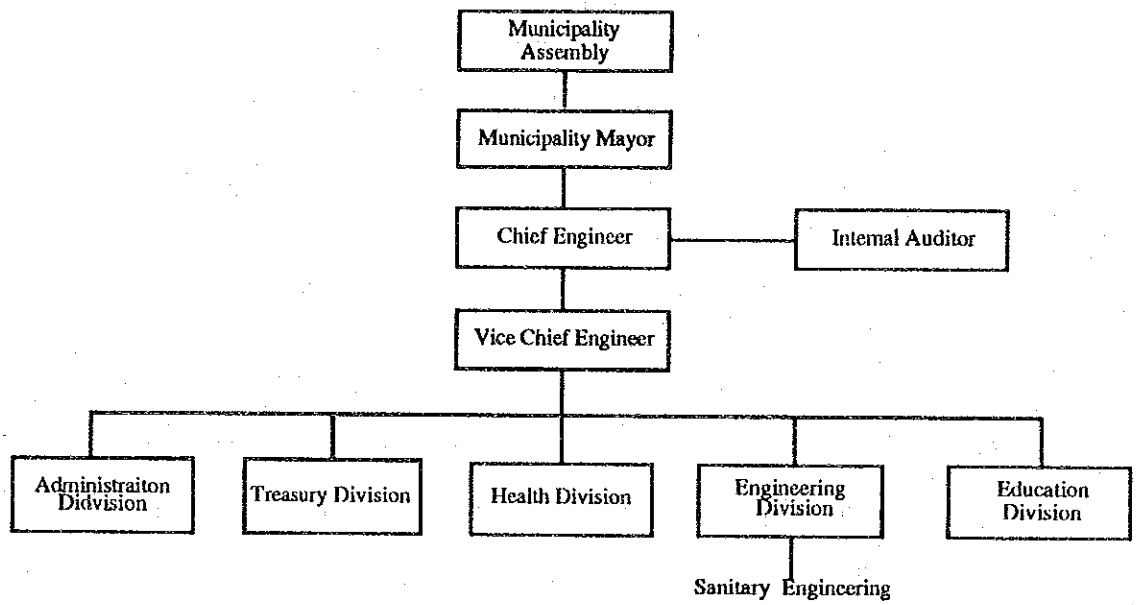


Figure 4.9.1 Administrative Structure of Municipality of Ang Thong

4.9.3 Recommendations

Two options can be considered for sewerage management:

- (A) to integrate it into the municipal organization (see Figure 4.9.2)
- (B) to create an independent organization with liaison to the municipality (see Figure 4.9.3).

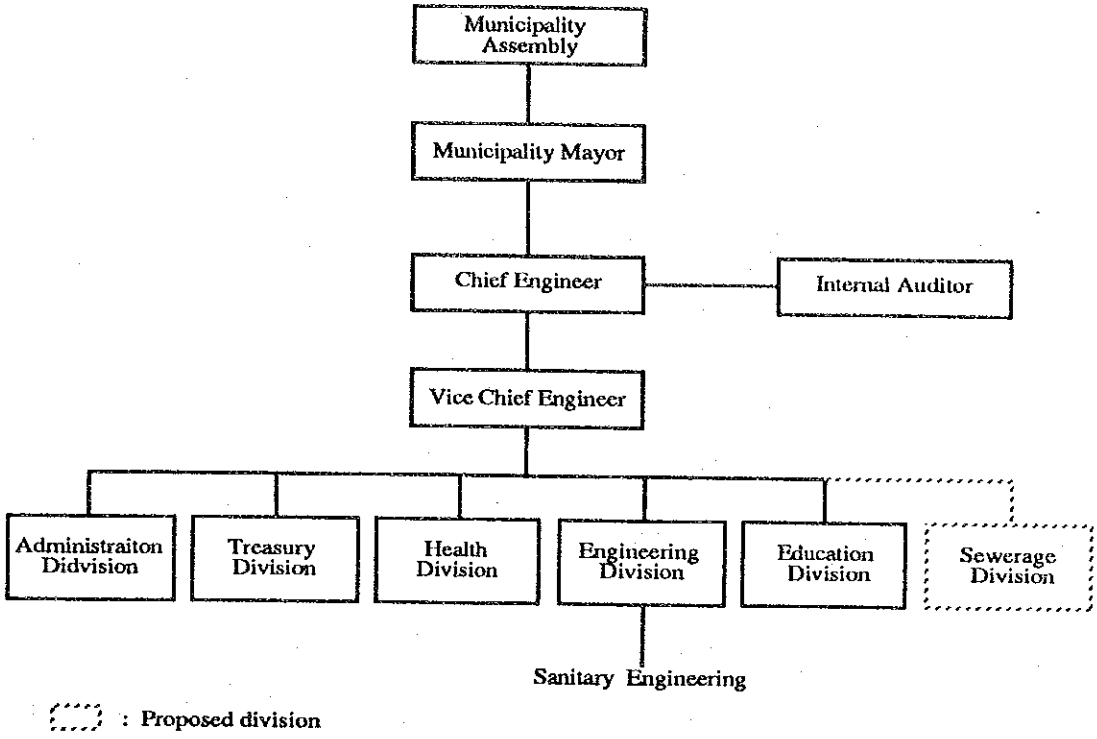


Figure 4.9.2 Option (A) for Municipality of Ang Thong

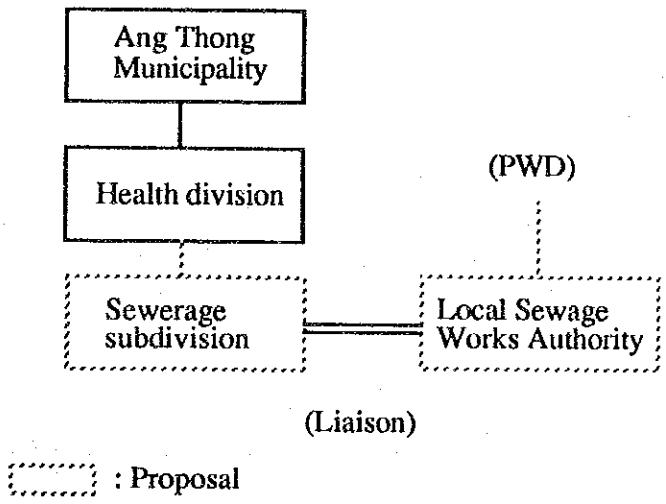


Figure 4.9.3 Option (B) for Municipality of Ang Thong

Based on the implementation plan, the staffing requirement is estimated as follows:

Stage	Period	Staffing requirement
1st	1991 - 1995	3
2nd	1995 - 2001	5
3rd	2002 - 2006	10
4th	2007 - 2011	20

The final staffing requirement is estimated at 20, while the interim one is estimated at 5 in 2001. Therefore option (A) is more practical that option (B), because of the size to the existing municipal officials of 50 at present.

However option (B) is to be considered in the future, when the nation wide sewerage authority is established.

4.9.4 Financial Considerations

The relative burden, as defined as the ratio of 25% land acquisition cost to fixed investment on land and construction, was 13%. While the amount of fixed investment varies with fiscal year, this figure of 13% was not high among eight municipalities.

Ang Thong has not yet developed social infrastructure, compared with that of Rangsit and Bang Bua Thong. The proportion of public fixed investment to total expenditures was only 6.1% in 1991. This appears to reflect that the greater the portion of public fixed investment, the smaller the relative burden of land acquisition cost. For example, when public fixed investment increases to, say, 10% of total expenditures, the relative burden of land acquisition cost becomes also 10%. Thus, the relative burden of 12% while a little high, should be interpreted in a frame work not only of fixed investment but also of total expenditures.

Nevertheless, when the relative burden exceeds a certain figure, say, 10%, it will add substantial burden on local municipality. This is due to limited capability of increasing local revenues in financing a large public investment project as the sewerage project.
Ang Thong is no exception. Financing options that are available are (1) municipality development fund, (2) environment fund, or (3) increasing local

revenues.

Environmental fund is available to local agencies in the form of grant and/or loan. It is recommended that Ang Thong explore loan financing to allocate financial burden into the future, compared to raising local revenues or utilizing municipality development fund whose objectives are more general than those of environmental fund.

The average household user cost in item 4.3 of Table 4.9.1 is well below one percent of low household income in 2011 for Ang Thong. The user cost, however, could be administratively increased by two factors, one is the interest rate of the local that Ang Thong would transfer to the user, and the other, the loss of the sewerage revenue collection that could be compensated for and would be included as part of the user charge.

The household users were estimated on the basis of the project service area in 2011. The household is assumed to have 4.1 persons on the average. We have also assumed that household users as sewerage users for simplicity. The average sewerage user cost was calculated on O&M cost divided by [(0.7+0.2x1.2+0.1x2)(number of household users)].

The average rate of non household users could be assumed to pay as high as the highest progressive rate of the household user rate structure. The progressive rate structure is 1.0 to 1.3 to 2.0 for low, medium, and high household income group respectively. A summary is shown in 4.4 of Table 4.9.1.

Finally, affordability will be considered. The affordability level is defined as the ratio of the average household user cost to low household income level of 96,571 Baht in 2011 in the Central Region. With available data on household income by Ang Thong, the figure indicated in 4.5 of Table 4.9.1 would then be updated and could also be modified with allocation of loan cost among the users.

Table 4.9.1 Selected indicators for Ang Thong

1.1	Service Pop in 2011	13,500
1.2	Household Users in 2011	3,292
2.1	Total Expenditures, 1991 (Thousand Baht)	28,373
2.2	Investment on Land & Const., 1991 (Thousand Baht)	13,465
2.3	Land Acquisition Cost (Thousand Baht)	1,722
2.4	Relative Burden (2.3/2.2) in %	12
2.5	Sanitation Expenditures, 1991 (Thousand Baht)	2
3.1	Total Revenues, 1991 (Thousand Baht)	29,747
3.2	Central Government Support, 1991 (Thousand Baht)	na
4.1	Treatment capacity (m3/d), in 2011	3,700
4.2	Unit O&M Cost of 4.1, in 2011	0.81
4.3	Household Users Cost/Year, in 2011 without loan	333
4.4	Progressive Rates: 1:1.3:2.0 in 2011	287 373 574
4.5	Loan Cost/H User/Year 50% Local, 50% Foreign Loan, 25 Years	44
4.6	Affordability (4.3 + 4.5) for Low Income Household, 96571 baht, 2011	0.40%

SECTION 5

PA MOK MUNICIPALITY

SECTION 5 PA MOK MUNICIPALITY

5.1 Description of the Study Area

The DTCP area extending about 26.86 km^2 covers the present municipality area of 12.0 km^2 and its surrounding tambols; Sai Thong, Rong Chang, Bang Sadet, Pong Pang, Aekrach and Norasingh. The study area is about 98 km far from Bangkok and located in the south of Ang Thong. The municipality area is divided by the Chao Phraya river into east and west bank area.

The climate and topography of the study area are quite similar to Ang Thong municipality. The topography is flat with an average elevation of 6.0 m above mean sea water level. There are no mountains or forests present giving rise to a mild climate, without extreme summers or winters with temperature between 16.5°C and 39°C throughout the year. During the rainy season the flow from the Chao Phraya river inundates the area up to a level of 1.0-2.5 m above the ground. The annual rainfall is 1,142 mm/year. The soil type found in the area is predominantly clayey sand and clay.

The two major means of transportation in the area are by river and on land. The Chao Phraya river which passes through the middle part of Pa Mok and dividing it into eastern and western parts is the major river for transportation. There are ships and boats transporting about 4,500 to 5,000 persons/day across the river. There is no direct bridge to cross the Chao Phraya river in Pa Mok. It is necessary to utilize land transportation through Highway No. 309 which goes up to Ang Thong and use the bridge located there. This highway passes through the eastern part of the river and connects not only to Ang Thong but also to Ayutthaya. In the western side, there are some roads along irrigation canals and these connect Pa Mok to Amphoe Muang Ang Thong, Amphoe Bang Ban and Ayutthaya. The roads in the commercial area are 6.00 to 15.00 m wide and are mostly paved with concrete.

The source of living is mainly by labor for production and construction. About 39.23% of the population are engaged in occupations related to this. The second one is agriculture and fishery which employs about 22.82% of the population. Commercial and industrial activities rank third with about 14.74% of the work force. The rest are technicians, office workers, etc. The main industry is bricks manufacturing.

There is a 5.5 rai slaughterhouse inside the municipality in the western part of the Chao Phraya river. According to the 1990 records, about 2 cows, 2 buffaloes and 9 pigs are slaughtered daily. It uses about 1.0 m^3 of water a day. The wastewater is drained directly to the drainage pipes without prior treatment. A new slaughterhouse is planned to be built outside the residential area, most probably near Khlong Bang Pla Kad. This is expected to have a wastewater treatment facility, located at a reasonable distance from the city.

5.2 Existing Sanitation/Sewerage and Flood Protection Systems

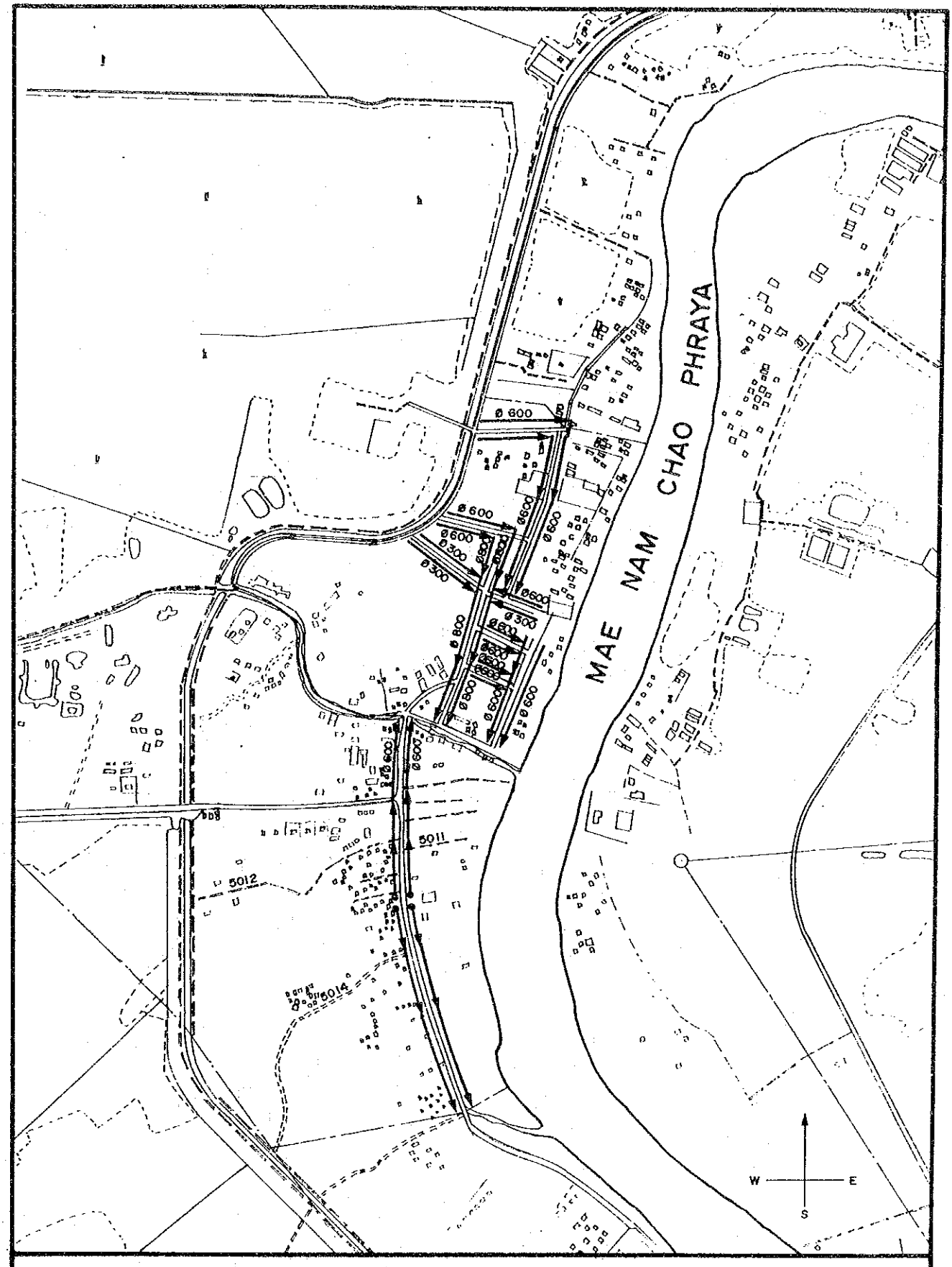
5.2.1 Existing Sanitation Facilities

The municipality operates only one truck to collect 5 ton of refuse daily, 2-3 times/day and dispose them at a dumping site in the south-western part of the municipality. The site is about 2 km away from an irrigation canal outside the municipality and has an area of 2.5 rai. The dumping site is owned by the mayor of the municipality. The disposal method is burning. However, the dumping site is not in a very good location, since the wind blow the offensive smell from the site to the center of the municipality. A new dumping site which will be accessible when the construction of the bridge across the Chao Phraya river from Pa Mok is completed, has been considered in the north western part near Amphoe Pak Hai. It will occupy an area of at least 75 rai employing sanitary landfill disposal method. Four trucks with a capacity of 3.5 ton each will collect waste twice/day. It is assumed that this will be sufficient for a municipality for a projected population of 26,000 people.

On-site treatment and disposal of nightsoil is common either provided by septic tank or cesspool as described in Section 3, Chapter 2.

5.2.2 Existing Sewerage Facilities

Combined sewerage facilities (ϕ300, ϕ600, and ϕ800 mm) are provided only in the residential and commercial area in the western part. The wastewater is drained to Khlong Bang Pla Kad, irrigation canals and to the Chao Phraya river. Those areas with existing drainage pipes are sometimes experiencing temporary flooding due to insufficient gradients. Composition of existing drainage facilities is summarized in Table 5.2.1. Area coverage and location of drains are shown in Figure 5.2.1.



DIAMETER (mm.)

LEGEND : 600 DRAINGE PIPE ⟶ OUTFALL SCALE 1 : 10,000

FIGURE 5.2.1 EXISTING DRAINAGE SYISTEM IN PA MOK MUNICIPALITY

Table 5.2.1 Existing Drainage Facilities

Size (mm)	Length (m)	Type	Drainage Area (ha)
dia. 300	484	RC pipe	2.50
600	4,016	RC pipe	62.00
800	752	RC pipe	10.50
Total	5,252		75.00

5.2.3 Flood Protection Facilities

During heavy rains, over flow from the Chao Phraya river inundates both the eastern and the western parts of Pa Mok. In 1983, there was a big flood with water levels rising to 6.50 m above ground level. The ground level in the area is between 5.30 and 6.00 m above mean sea water level. The municipality was almost totally submerged. For flood countermeasures, dikes should be built about 6.80 m high, though it is extremely expensive.

5.3 Water Supply

The water supply for Pa Mok municipality is carried out by PWA in the eastern part and by the municipality in the western part. The two water supply systems are described in Table 5.3.1.

In the future, the waterworks under the operation by the municipality will be transferred to the responsibility of PWA after the completion of the construction of the bridge across the Chao Phraya river.

Table 5.3.1. Water supply in Pa Mok Municipality

Feature	Eastern Part	Western Part
Supplier	PWA	Municipality
Location of the waterworks	Tambol Pa Mok	Tambol Bang Pla Kod
Area	8 rai	1 rai
Water sources	groundwater	groundwater
Number of wells	2	
Depth of well	120 m	
Production capacity	1,920 m^3/d	1,500 m^3/d
Type of tank	filtering tank (35 m far from well)	storage tank (21.65 m above G.L.)
Capacity of the tank	150 m^3/hr	120 m^3/hr
Supply rate	800 m^3/d	1,000 m^3/d
No. of registered users	798 households	358 households
Consumption	200 lpcd	

5.4 Population and Land Use

The different land use type and its location are summarized below. The population, about 10,700 in 1990, is concentrated on the limited west bank area (less than 100 ha).

Land use type	Location
Residential area	along the Chao Phraya river bank
Commercial area	in the western part
Industrial area	in the municipality (also in the western part)

Land use at present and in the future (2011) is referred to in Section 3, Chapter 2 and Figure 5.4.1 presents the projection in the year 2011.

Study area and population are as follows:

Area & Population	Present Municipality	Future Exp. Area	Sewerage M/P Area	Other Area	DTCP Area
Area (km^2)	6.89	0.24	7.13	19.73	26.86
Pop. in 1991	10,686	443	11,129		
Pop. in 2011	12,857	443	13,300		

5.5 Quality and Quantity of Wastewater

5.5.1 Unit Wastewater and Pollution Load on a Generation Basis

(1) Domestic Wastewater

Unit quality (BOD) and quantity on the daily average basis at present and in design year are tabulated breaking down into sullage and toilet waste.

Domestic wastewater discharge is assumed at 80% of water consumption. Toilet waste is treated by septic tank with assumed treatment efficiency of 50%.

Year	Unit Wastewater (lpcd)			Unit BOD Load (gpcd)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Present	100	12	112	33.6	5.5	39.1
Design Year (2011)	136	24	160	35.1	5.5	40.6

(2) Business Wastewater

Those for business wastewater (commercial and institutional) is assumed to be 30% and 40% of domestic wastewater for the present and design year (2011), respectively.

	Unit Wastewater (lpcd)	Unit Pollution Load (BOD gpcd)
Present	32	6.1
Design Year (2011)	64	7.7

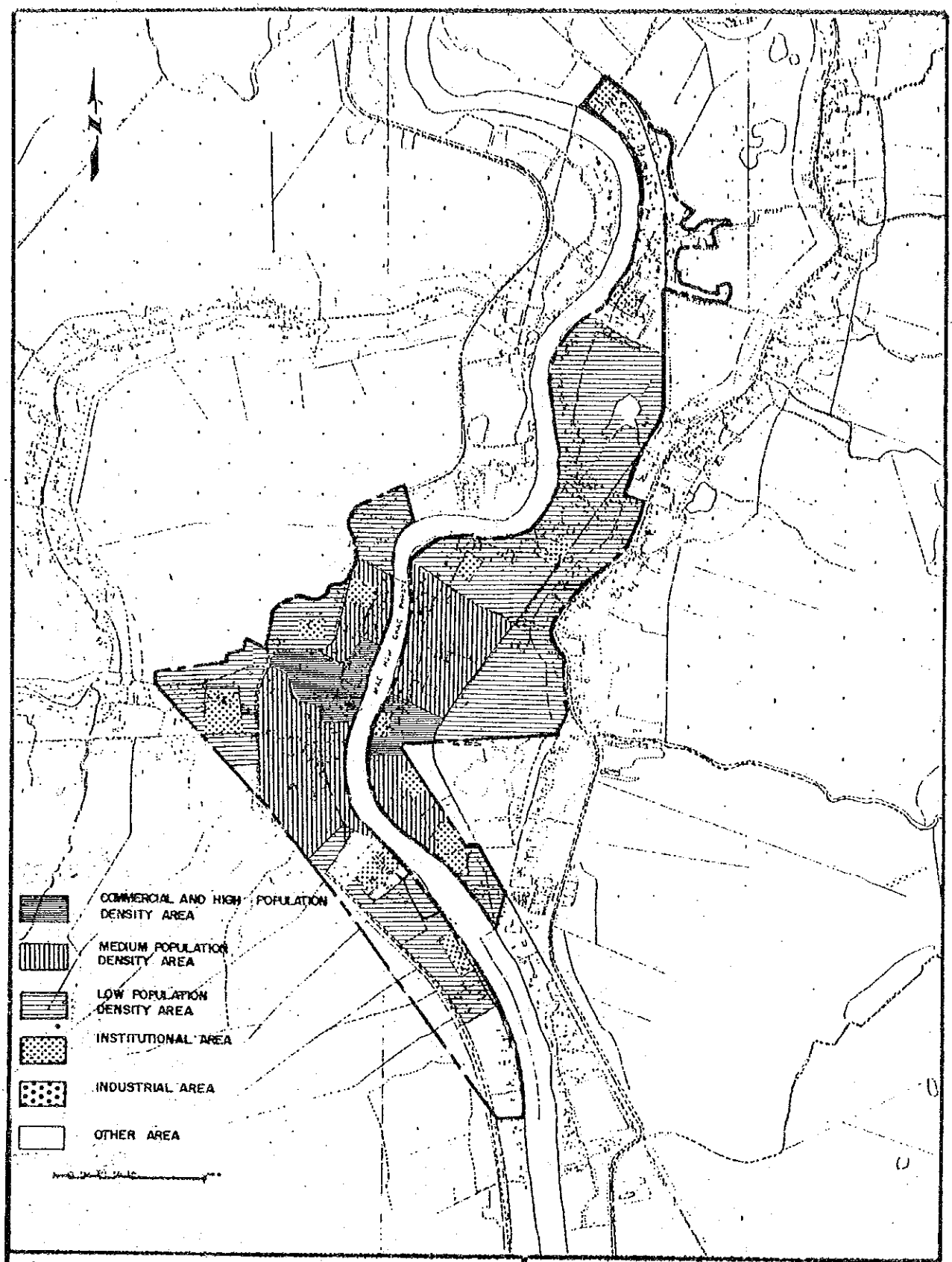


FIGURE 5.4.1 FUTURE LAND USE - YEAR 2011 (PA MOK)

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5.5.2 Discharged Wastewater and BOD Load

(1) Domestic Wastewater

Wastewater quantity and BOD load based on a discharge basis are estimated for the present and design year (2011) multiplying service population by unit wastewater quantity/BOD load. The following are the estimation results.

Pa Mok East Area

Item	Present			Design Year (2011)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Wastewater Quantity (m^3/d)	611	73	684	993	175	1,168
BOD Load (kg/d)	205.2	33.6	238.8	256.2	40.2	296.4

Pa Mok West Area

Item	Present			Design Year (2011)		
	Sullage	Toilet Waste	Total	Sullage	Toilet Waste	Total
Wastewater Quantity (m^3/d)	502	60	562	816	144	960
BOD Load (kg/d)	168.7	27.6	196.3	210.6	33.0	243.6

(2) Business Wastewater

Discharged wastewater quantity and BOD load are estimated in the same procedure as domestic wastewater as shown below.

Pa Mok East Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	195	467
BOD Load (kg/d)	37.3	56.2

Pa Mok West Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	161	384
BOD Load (kg/d)	30.6	46.2

(3) Total Wastewater Quantity and BOD Load

Total discharged wastewater quantity and BOD load (daily average basis) at present and in the design year (2011) for Pa Mok East/West Sewerage Development are figured out as shown below.

Pa Mok East Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	879	1,635
BOD Load (kg/d)	276.1	352.6

Pa Mok West Area

Item	Present	Design Year (2011)
Wastewater Quantity (m^3/d)	723	1,344
BOD Load (kg/d)	226.9	289.8

5.6 Proposed Sewerage System

5.6.1 Service Area

A total service area covers 713 ha with present population of about 11,100 consisting of east and west bank areas of the Chao Phraya river. The area along the Chao Phraya river at the upstream of the urban area in the west bank may be considered as an individual system. While for the east bank area, about 50-60 ha expanded from present residential area (40 ha) is included in the

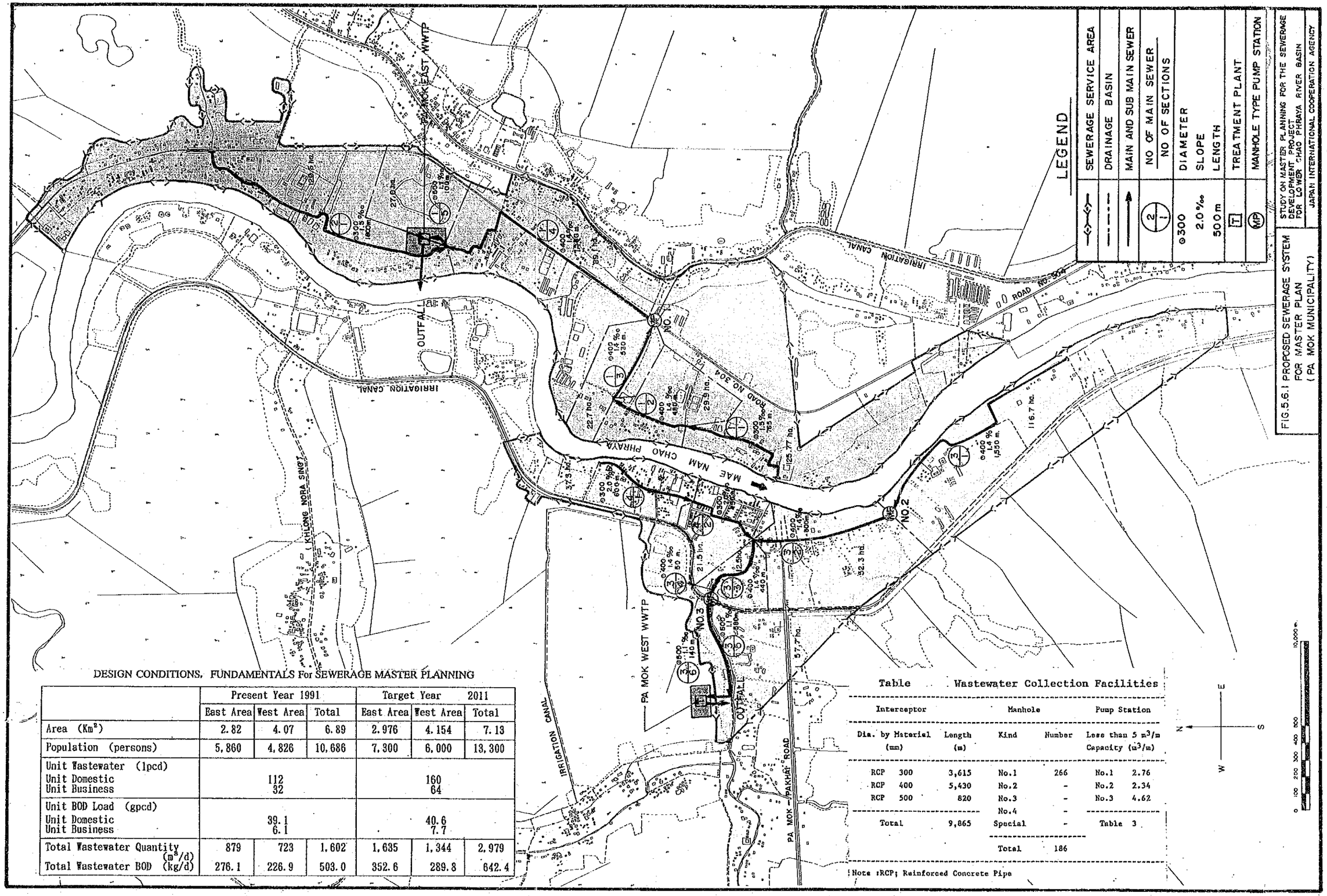


FIG.5.6.1 PROPOSED SEWERAGE SYSTEM FOR MASTER PLAN (PA MOK MUNICIPALITY)

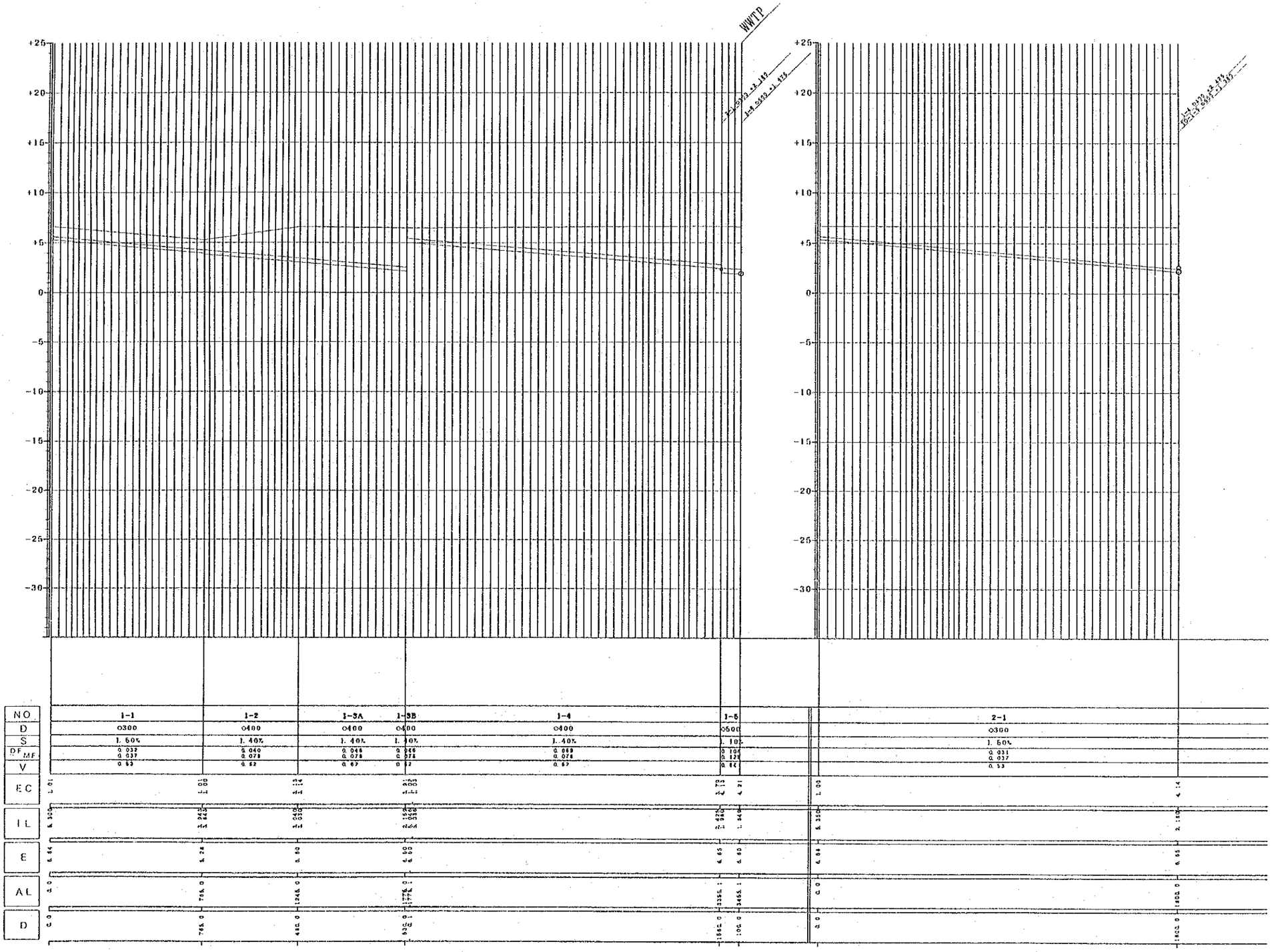
DESIGN CONDITIONS, FUNDAMENTALS For SEWERAGE MASTER PLANNING

	Present Year 1991			Target Year 2011		
	East Area	West Area	Total	East Area	West Area	Total
Area (Km^2)	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 (m^3/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 m^3/m Capacity (m^3/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



LEGEND

Item	Description
NO	NO. of Sewers
D	Diameter
S	Slope
DF MF	Design Flow Maximum Flow for Pipe
V	Velocity
EC	Earth Cover
IL	Invert Level
E	Elevation
AL	Accumulated Length
D	Distance

No. of Sewers

1-1	1-2	1-3A	1-3B	1-4
1-5	2-1			

FIG. 5.6.2 (1)
PA MOK - EAST/WEST

V 1:200
H 1:10,000

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DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN

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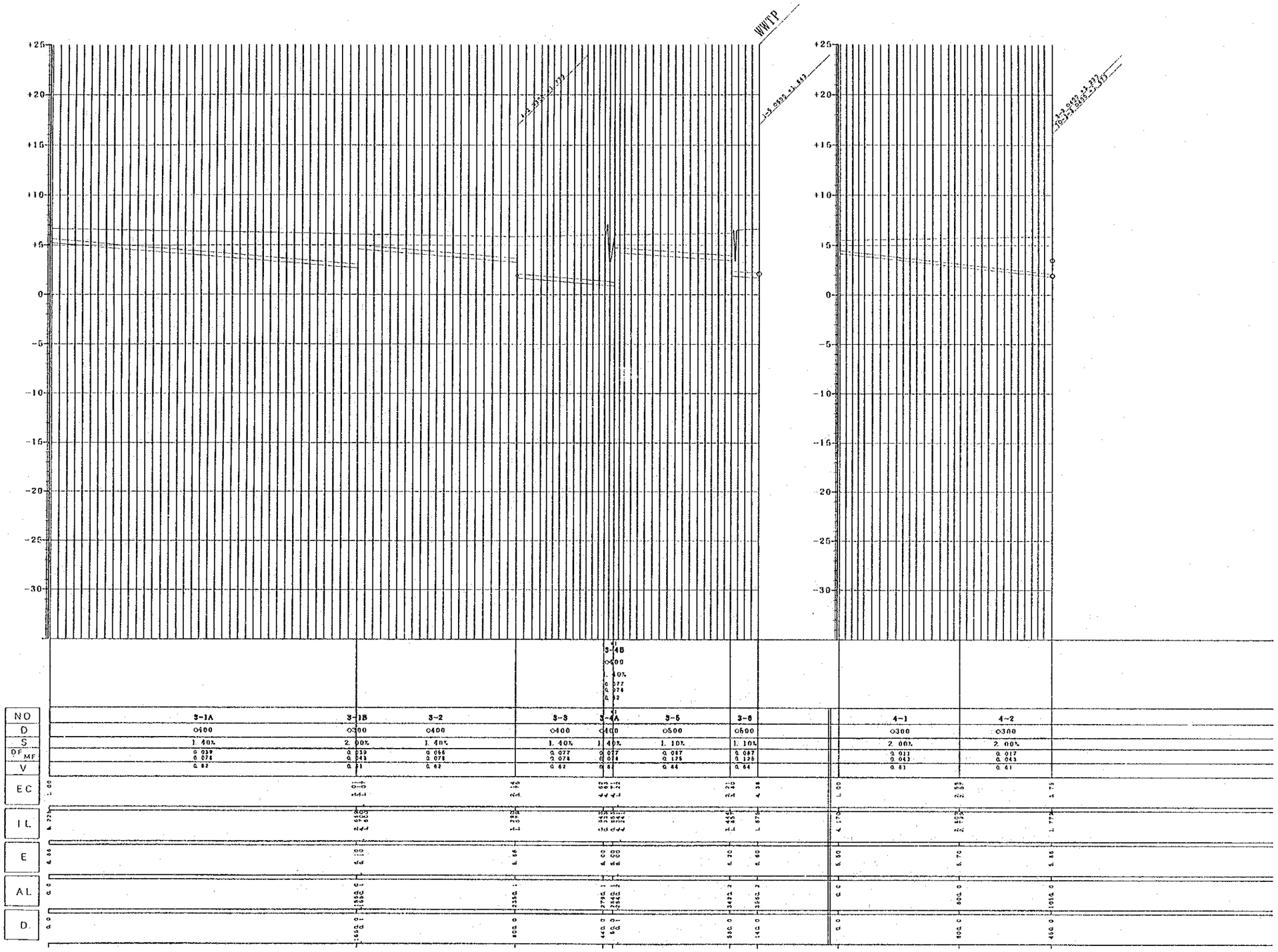

LEGEND

Item	Description
N O	NO. of Sewers
D	Diameter
S	Slope
D F M F	Design Flow Maximum Flow for Pipe
V	Velocity
E C	Earth Cover
I L	Invert Level
E	Elevation
A L	Accumulated Length
D	Distance

No. of Sewers

3-1A	3-1B	3-2	3-3	3-4A
3-4B	3-5	3-6	4-1	4-2

FIG. 5.6.2 (2)
PA MOK - EAST/WEST

V 1:200
H 1:10,000

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

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system. Other clusters along the Chao Phraya river may be arranged separately.

Under the topographic condition in the service area and non existence of an appropriate bridge crossing the Chao Phraya river, two (2) sewerage systems are proposed as shown in Figure 5.6.1; east bank area, 297.6 ha and west bank area 415.4 ha. Design population in 2011 is projected for east and west bank areas to be about 7,300 and 6,000, respectively.

The topography in the service areas is generally flat with a mild slope towards the Chao Phraya river from urban areas of the both bank areas.

The treatment plant sites are selected from the view of possible land acquisition; east bank area - north of urban area and west bank area - west of urban area near the boundary of service area.

5.6.2 Wastewater Collection System

Wastewater collection system in application of the combined collection method is proposed for the two sewerage systems. A full utilization of existing drainage facilities is considered. Thus, the major provincial road connected Ang Thong municipality is planned for the principal sewers in the west bank area.

Distribution of population and wastewater quantity was made based on population density assumed by land use type (refer to calculation table in Supporting Report 3.5.6).

Alignments of main interceptors and pump stations are proposed as shown in Figure 5.6.1. The profile of sewers is presented in Figure 5.6.2 (refer to hydraulic calculation in Supporting Report 3.5.6). The following are descriptions on the sewerage systems.

<u>East Bank Area</u>

- Two (2) sewer systems are planned along the Chao Phraya river, since WWTP is located in the central part of the service area.

- Interceptors 1/1 - 1/5 are planned from south to north to connect to 1/5.

- Interceptors 2/1 - 2/2 connect to 1/5 in the same direction of the river.

West Bank Area

- To meet locational arrangement of WWTP in the central part of the service area, two (2) sewer systems are planned.

- 3/1 - 3/6 interceptors from south (downstream of the river) to reach north WWTP.

- 4/1 - 4/2 interceptors along the Chao Phraya river connect to 3/3 interceptor.

Table 5.6.1 summarizes planned collection facilities. Details on pump specifications and siphon are included in Supporting report 3.A.6 - 3.C.6.

Table 5.6.1 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)	
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	-	Total	3
		Total	186		

Note :RCP; Reinforced Concrete Pipe

5.6.3 Wastewater Treatment and Sludge Disposal System for Pa Mok East Area

(1) Wastewater Treatment and Disposal Methods

The future wastewater discharge in the sewerage development area of Pa Mok East Sewerage Development area is estimated to be 1,635 m^3/d in the year of 2011. Groundwater infiltration of 20% of wastewater discharge is assumed. The design wastewater to the treatment plant becomes to be 2,000 m^3/d. The effluent quality is expected to be less than 40 mg/l as BOD.

The following three (3) treatment systems are applicable to meet the above requirements in quality and quantity.

1) Stabilization Pond
2) Aerated Lagoon
3) Oxidation Ditch

(2) Comparative Evaluation

The above three (3) treatment systems are compared in terms of required construction and O&M costs, required land area and easiness of O&M as shown below (Details are included in Supporting Report 3.1.6.2).

Evaluation Item	Stabilization Pond	Aerated Lagoon	Oxidation Ditch
(1) Construction Cost (million Baht)	2.86	5.60	12.08
(2) Land Cost (million Baht)	3.51	1.97	1.14
(3) O/M Cost (million Baht/year)	0.05	0.22	0.73
(4) Required Land Area (ha)	3.74	2.10	1.22
(5) Easiness of O/M			
- Adaptability of overload	A	A	B
- Required technology level	A	A	B
- Sludge disposal	A	A	C

Note : 1) Construction cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical and others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge disposal : A: easy, B: medium, C: hard

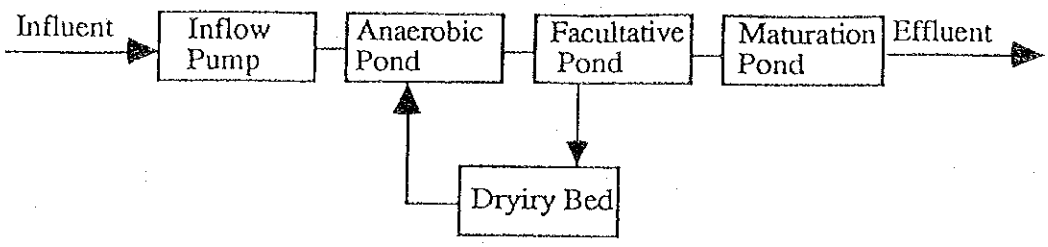
As evident from the cost comparison in NPV (refer to Supporting Report 3.1.6.3), stabilization pond system is the most economical.

(3) Plan of Treatment Plant

The proposed wastewater treatment plant site of Pa Mok East is currently an open space. The proposed treatment plant of stabilization pond with a capacity of 2,000 m^3/d requires a net area of 3.74 ha.

The flow sheet of stabilization pond system and the capacity dimension and

other relevant details of each treatment facility is shown below.



Flow of Stabilization Pond System

Inflow Pump	: Design capacity	: 3,100 m^3/d (hourly max. dry)	
		: 9,300 m^3/d (hourly max. wet)	
	: Capacity	: 2.16 m^3/min. with 7.6 m hydraulic head (hourly max. in dry)	
		: 6.46 m^3/min. with 7.6m hydraulic head (hourly max. in wet)	
Grit Chamber	: Surface loading	: 1,722 m^3/m^2/d (dry weather)	
		: 2,583 m^3/m^2/d (wet weather)	
	: Retention time	: 30 sec(dry), 20 sec (wet)	
	: Size	: 0.6 m(W) x 3 m(L) x 0.6 m(D) x 2 units (1 unit for dry weather)	
	: Constructed with R.C		
Anaerobic Pond	:	: Design capacity 2,000 m^3/d	
	: Pond capacity	10,010 m^3	
	: Pond surface area	3,710 m^2	
	: Retention time	5.01 days	
	: Dimension	35 m(W) x 53 m(L) x 4.0 m(D) x 2 units	
	: Embankment protected by masonry		

Facultative Pond	:	Design capacity	2,000 m^3/d
	:	Pond capacity	10,125 m^3
	:	Pond surface area	6,030 m^2
	:	Retention time	5.06 days
	:	Dimension	45 m(W) x 67 m(L) x 2.0 m(D) x 2 units
	:	Embankment protected by masonry	
Maturation Pond	:	Design capacity	2,000 m^3/d
	:	Pond capacity	10,059 m^3
	:	Pond surface area	8,000 m^2
	:	Retention time	5.03 days
	:	Dimension	40 m(W) x 50 m(L) x 1.5 m(D) x 4 units
	:	Embankment protected by masonry	
Drying Bed	:	Drying area	60 m^2
	:	Detention time	15 days
	:	Dimension	5 m x 6 m x 2 units

The treated water is discharged to Chao Phraya river. Layout of the treatment plant and hydraulic profile are shown in Figures 5.6.3.(1) and 5.6.4.(1), respectively. Further study on the application of anaerobic pond shall be made during F/S stage to meet updated information on sewage quality.

5.6.4 Wastewater Treatment and Sludge Disposal System for Pa Mok West Area

(1) Wastewater Treatment and Disposal Methods

The future wastewater discharge in the sewerage development area of Pa Mok West Sewerage Development area is estimated to be 1,344 m^3/d in the year of 2011. Groundwater infiltration at 20% of wastewater discharge is assumed. The design wastewater to the treatment plant becomes to be 1,700 m^3/d. The effluent quality is expected to be less than 40 mg/l as BOD_5.

The following three (3) treatment systems are applicable to meet the above requirements in quality and quantity.

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

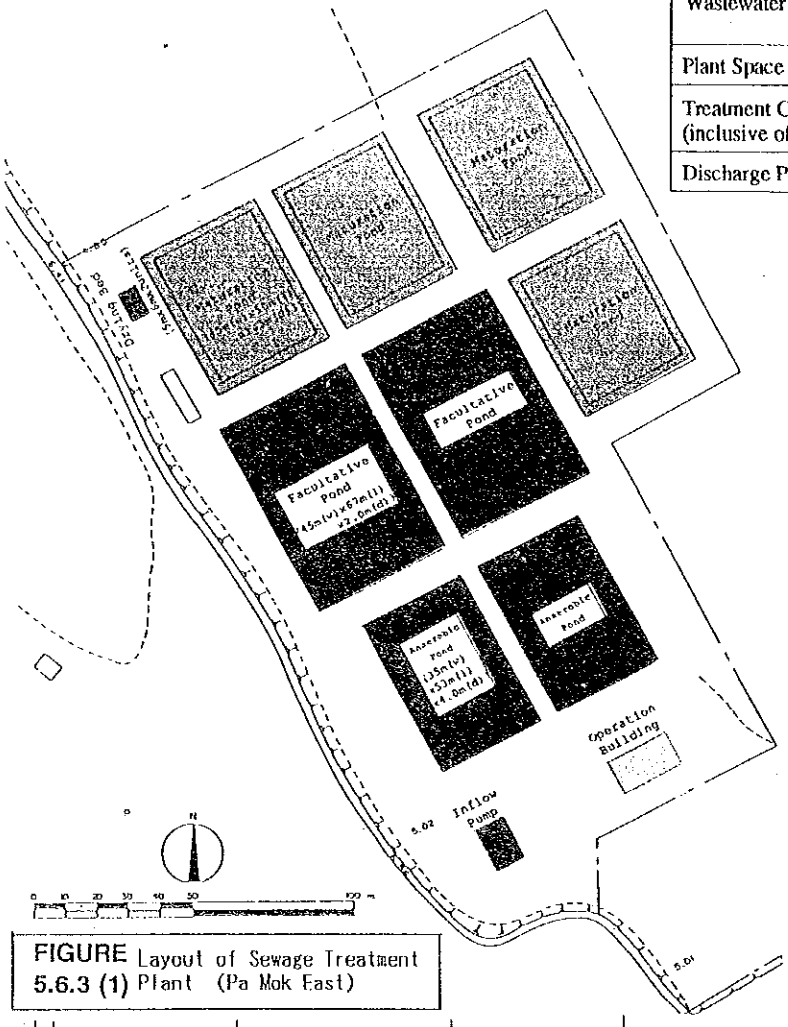


FIGURE 5.6.3 (1) Layout of Sewage Treatment Plant (Pa Mok East)

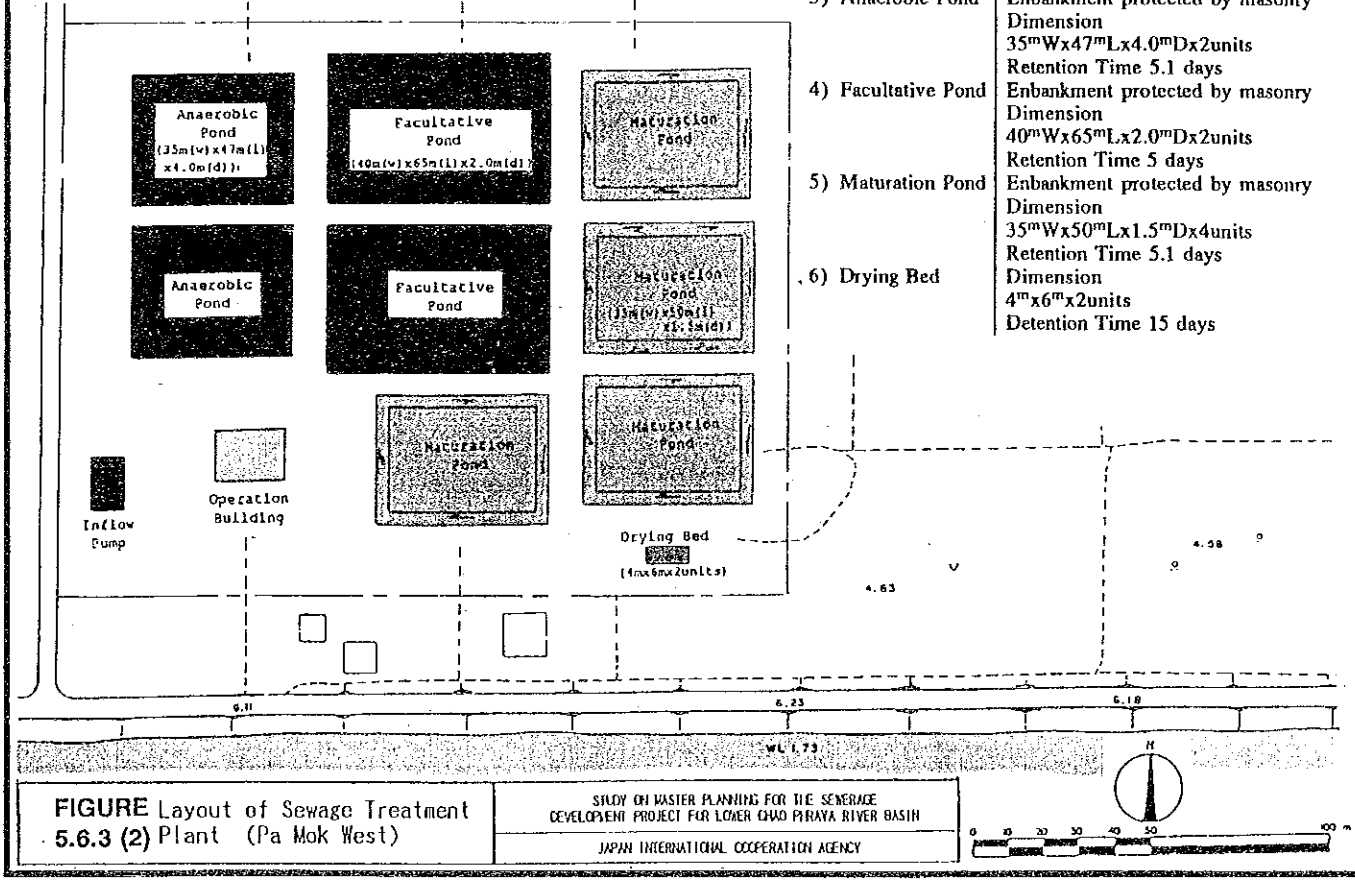


FIGURE 5.6.3 (2) Layout of Sewage Treatment Plant (Pa Mok West)

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

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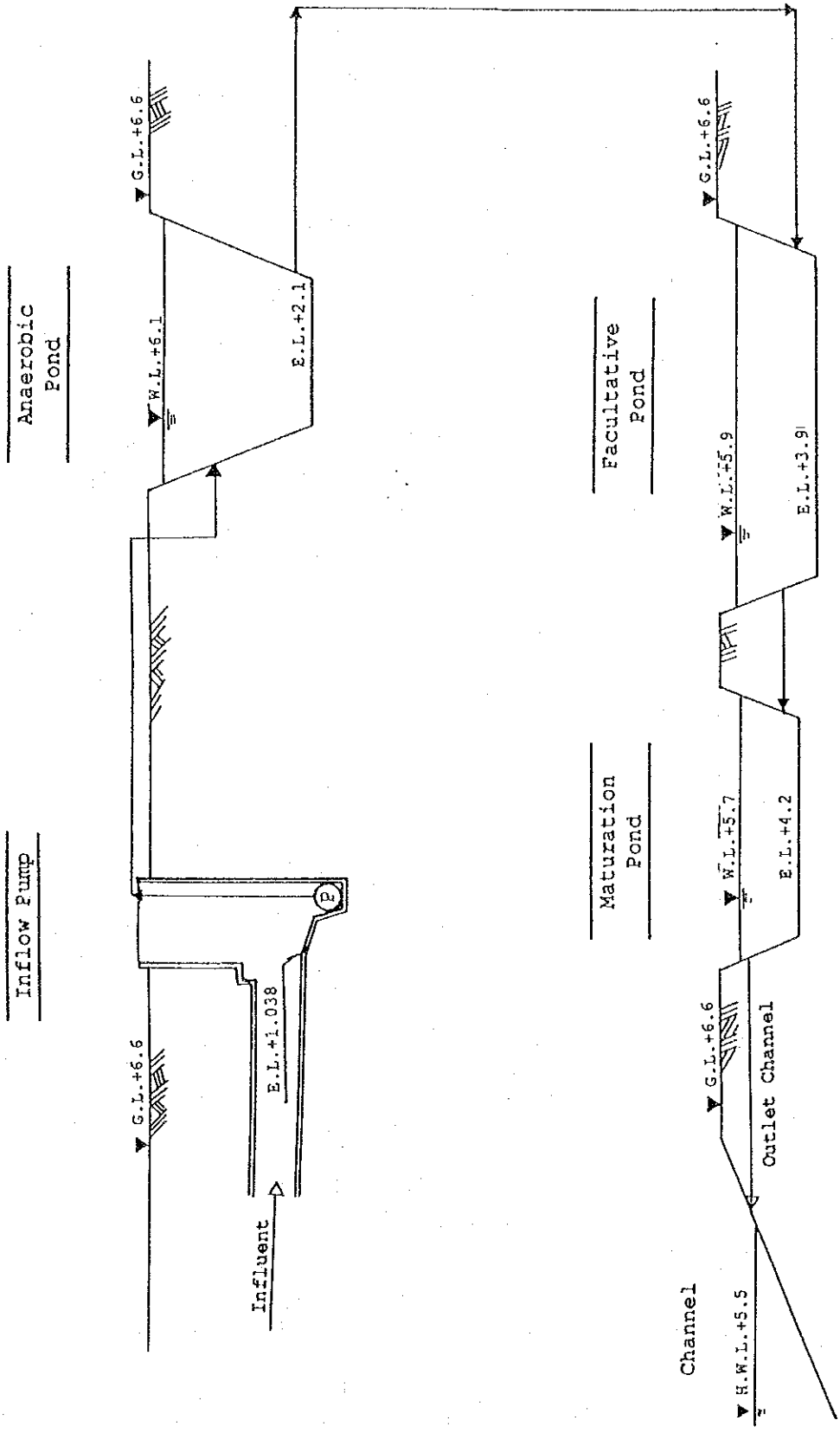

Figure 5.6.4.(1) Hydraulic Profile of Sewage Treatment Plant (Pa Mok East)

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

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1) Stabilization Pond

2) Aerated Lagoon

3) Oxidation Ditch

(2) Comparative Evaluation

The above three (3) treatment systems are compared in terms of required construction and O&M costs, required land area and easiness of O&M as shown below (Details are included in Supporting Report 3.1.6.2).

Evaluation Item	Stabilization Pond	Aerated Lagoon	Oxidation Ditch
(1) Construction Cost (million Baht)	2.41	4.83	10.27
(2) Land Cost (million Baht)	3.23	1.86	1.10
(3) O/M Cost (million Baht/year)	0.04	0.20	0.99
(4) Required Land Area (ha)	3.44	1.98	1.17
(5) Easiness of O/M			
- Adaptability of overload	A	A	B
- Required technology level	A	A	B
- Sludge disposal	A	A	C

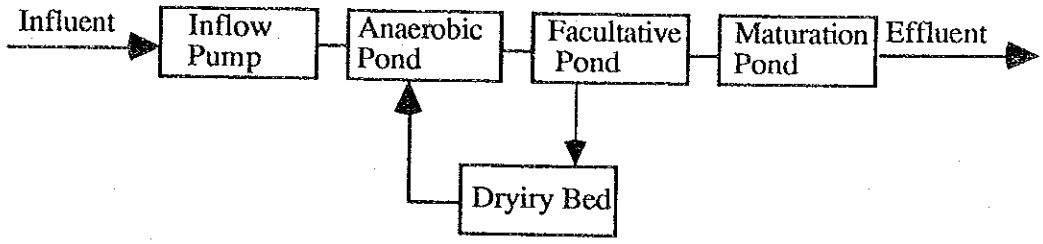
Note : 1) Construction Cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical and others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge disposal : A: easy, B: medium, C; hard

As evident from cost comparison in NPV (refer to Supporting Report 3.1.6.3), stabilization pond system is the most economical.

(3) Plan of Treatment Plant

The proposed location of the wastewater treatment plant of Pa Mok West is currently the open land. The proposed treatment plant of stabilization pond with a capacity of 1,700 m^3/d requires a net area of 3.44 ha.

The flow sheet of stabilization pond system and the capacity dimension and other relevant details of each treatment facility is shown below.



Flow of Stabilization Pond System

Inflow Pump : Design capacity 2,600 m^3/d (hourly max. dry)
7,800 m^3/d (hourly max. wet)
: Capacity 1.81 m^3/min. with 4.9 m hydraulic head (hourly max. dry)
5.42 m^3/min. with 4.9 m hydraulic head (hourly max. wet)

Grit Chamber : Surface loading : 1,444 m^3/m^2 day (dry weather)
: 2,167 m^3/m^2/d (wet weather)
: Retention time : 36 sec (dry), 24 sec (wet)
: Size : 0.6 m(W) x 3 m(L) x 0.6 m(D) x 2 units (1 unit for dry weather)
: Constructed with R.C

Anaerobic Pond : Design capacity 1,700 m^3/d (daily ave. dry)
: Pond capacity 8,690 m^3
: Pond surface area 3,290 m^2
: Retention time 5.11 days
: Dimension 35 m(W) x 47 m(L) x 4.0 m(D) x 2 units

: Embankment protected by masonry

Facultative Pond : Pond capacity 8,591 m^3
: Pond surface area 5,200 m^2
: Retention time 5.05 days
: Dimension 40 m(W) x 65 m(L) x 2.0 m(D)
x 2 units
: Embankment protected by masonry

Maturation Pond : Pond capacity 8,672 m^3
: Pond surface area 7,000 m^2
: Retention time 5.10 days
: Dimension 35 m(W) x 50 m(L) x 1.5 m(D)
x 4 units
: Embankment protected by masonry

Drying Bed : Drying area 48 m^2
: Detention time 15 days
: Dimension 4 m x 6 m x 2 units

The effluent is discharged to Chao Phraya river through khlong. Layout of the treatment plant and hydraulic profile are shown in Figure 5.6.3.(2) and Figure 5.6.4.(2), respectively.

5.7 Cost Estimates

5.7.1 Construction Cost

In the previous chapter, cost functions for interceptors, pump stations (more than $5m^3$/min.) and wastewater treatment plants are developed. Land acquisition cost is also considered to come up with the total construction cost. The following are cost requirements (million Baht) broken down into the sewerage systems for the design year 2011.

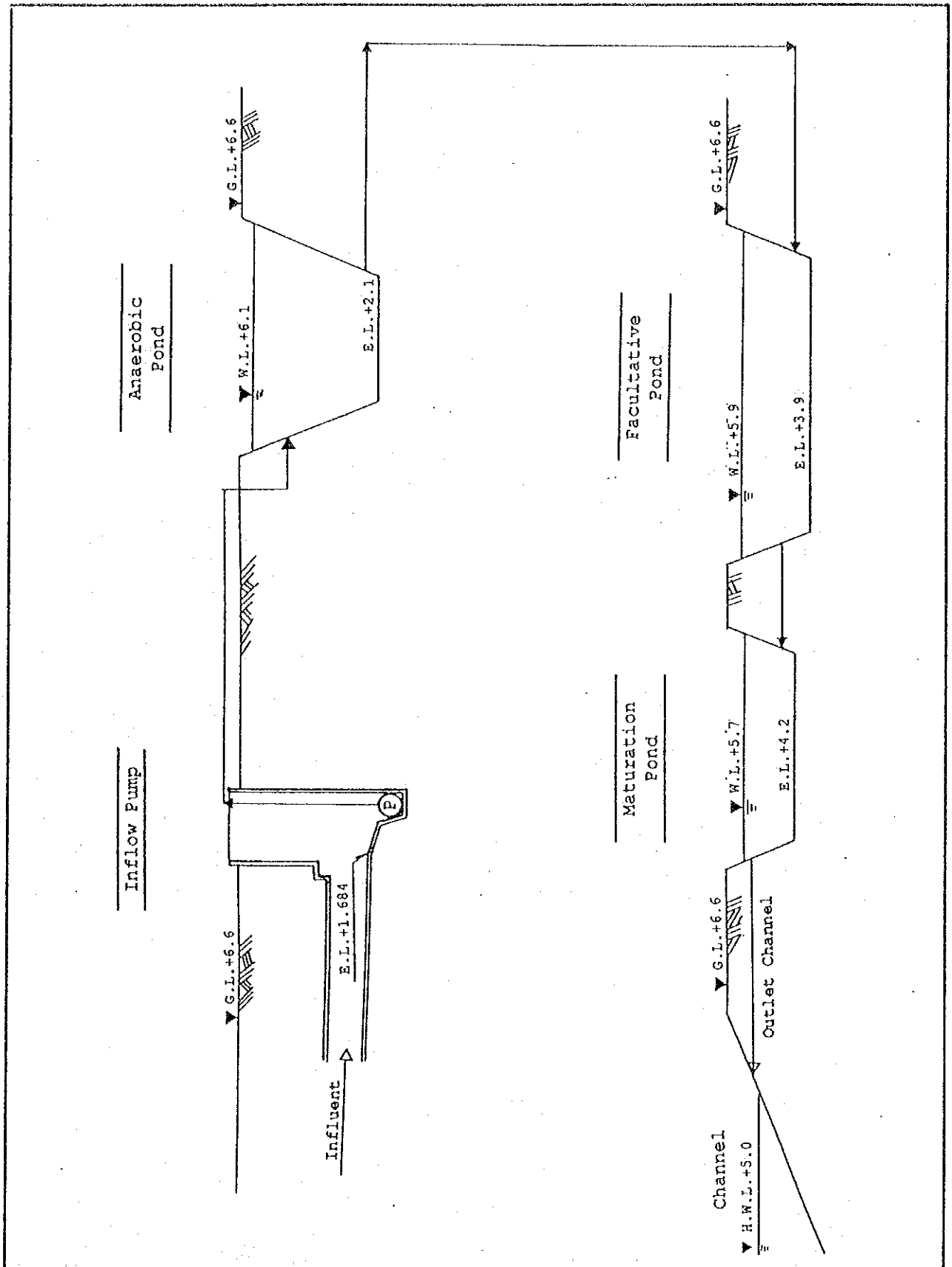


Figure 5.6.4.(2) Hydraulic Profile of Sewage Treatment Plant (Pa Mok West)

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Cost Item	Pa Mok East	Pa Mok West	Total
(1) Direct Cost			
1) Interceptor	78.7	64.6	143.3
2) Pump Station	—	—	—
3) W.W.T.P.	2.86	2.41	5.27
Total of Direct Cost	81.56	67.01	148.57
(2) Contingency (20% of Direct Cost)	16.3	13.4	29.7
(3) Total of Construction Cost ((1)+(2))	97.86	80.41	178.27
(4) Engineering & Construction (17% of (3))	16.6	13.7	30.3
(5) Land Acquisition			
1) Pump Station	—	—	—
2) W.W.T.P.	3.51	3.23	6.74
Total of Land Acquisition	3.51	3.23	6.74
Grand Total (million Baht)	117.97	97.34	215.31

5.7.2 Operation and Maintenance Cost

Annual Operation and Maintenance cost (thousand Baht) is estimated using cost functions/unit cost studied in the previous Chapter.

Cost Item	Pa Mok East	Pa Mok West	Total
(1) Interceptor	382	273	655
(2) Pump Station	—	—	—
(3) W.W.T.P.	50	40	90
Total of O&M Cost	432	313	745

5.8 Implementation Plan

The provision of a complete sewerage system for the entire study area with its increasing population, will require a great investments of Capital fund as estimated in the previous section. Some areas within the study area is

presently undeveloped land and environmental conditions of such area are different from built-up area. Although the study area needs to be sewered in early stage, the urgency of sewerage requirements is different depending on the land use features of areas.

Staged construction will be advantageous to minimize the excessive initial investment and capital expenditures. Implementation program is prepared for the first 20 years, dividing into 4 stages of five year each, taking the design period up to the year 2011 into account. The schedule is assumed giving priority to developed/being developed areas.

Stage	Period	Works with Priority
1st	1991-1995	Preparatory work & design of facilities
2nd	1996-2001	Construction for Pa Mok West
3rd	2002-2006	Construction for Pa Mok East (northern area)
4th	2007-2011	Construction for Pa Mok East (southern area)

5.9 Administrative and Financial Study

5.9.1 General

The municipal structure and staffing are strictly regulated by regulations of Ministry of Interior in the centralized context of Thailand.

There is very little room for the municipality to play in including sewerage management. Nor the existing staff are technically capable to handle the system.

5.9.2 Exisitng Administrative Ssytem

The administrative structure regulated by the Municipal Government Act (1953) is the same as the other municipalities with following major functions (see Figure 5.9.1):

- Administration
- Treasury (Tax collection)
- Engineering (Maintenance of infrastructures)
- Health and Environment affairs
- Education

There are six (6) schools and 84 teachers are assigned for them. The total number of municipality staff is 166.

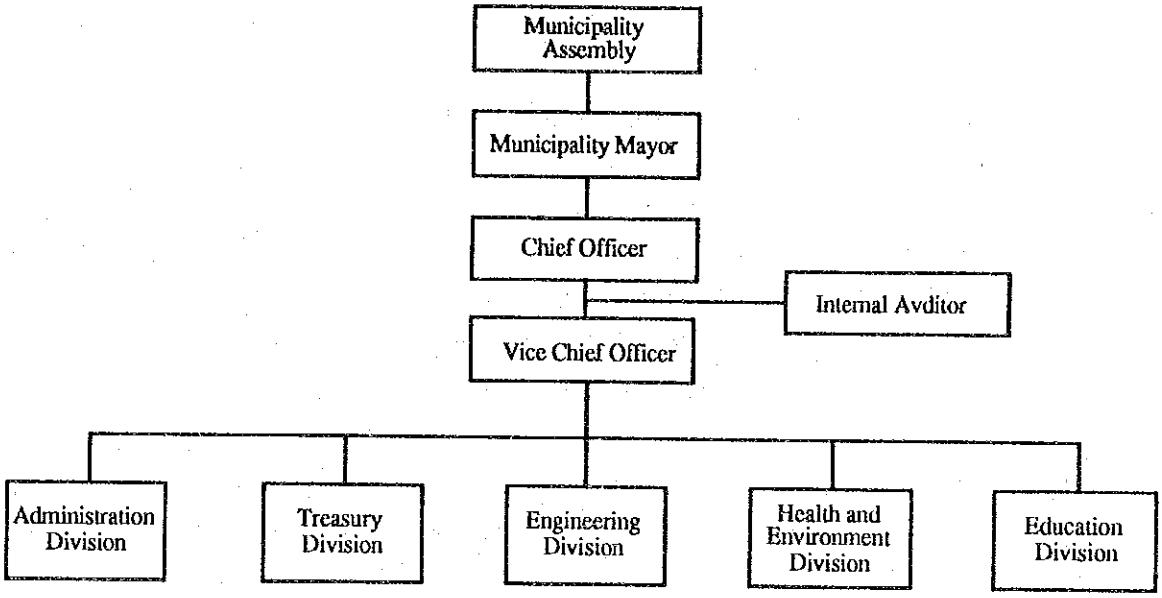

Figure 5.9.1 Administrative Structure of Municipality Pa Mok

5.9.3 Recommendations

According to the Master Plan of the Study it is recommended that two (2) treatment plants (East and West) be constructed.

In the municipality there is no sewerage system at present. In estchlishing the system there are two options for management:

- (A) to integrate it into the municipal organization (see Figure 5.9.2)
- (B) to create an independent organizaion (see Figure 5.9.3)

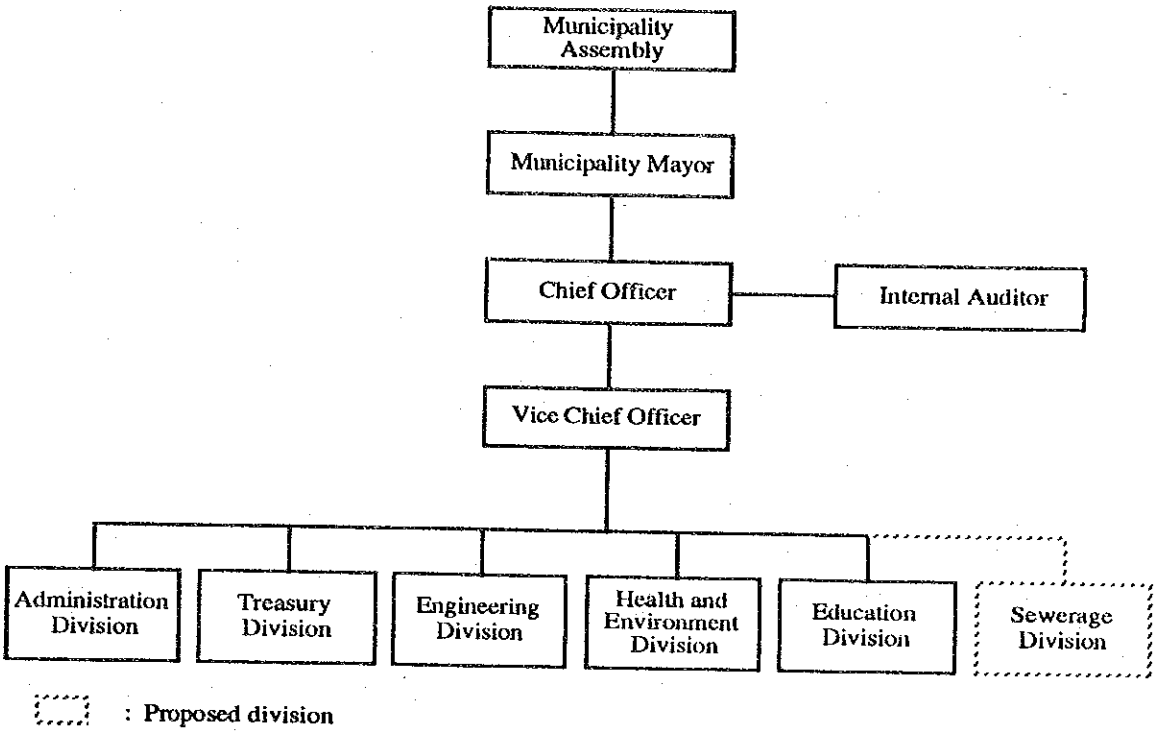

Figure 5.9.2 Option (A) for Municipality of Pa Mok

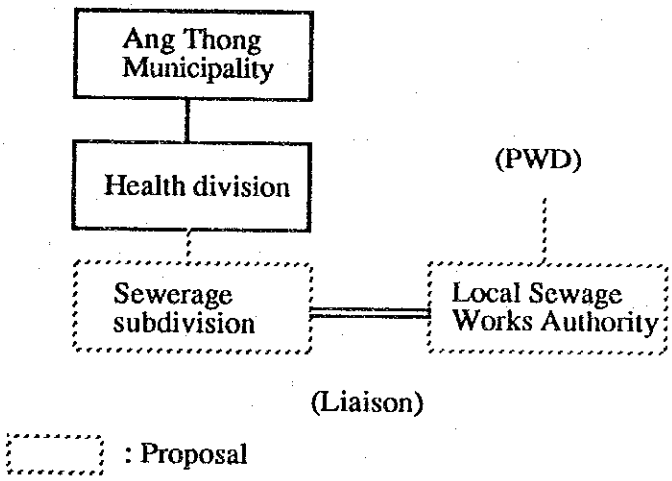

Figure 4.9.3 Option (B) for Municipality of Pa Mok

Based on the implementation plan, the staffing requirement is estimated as follows:

Stage	Period	Staffing requirement
1st	1991 - 1995	3
2nd	1995 - 2001	5
3rd	2002 - 2006	10
4th	2007 - 2011	20

The present staff of the municipality is 82, excluding teachers. This is large enough to integrate the staff of sewerage system.

The Study Team recommends that Option (A) be considered to be more feasible than Option (B). However it suggests that Option (B) be open for the future, when a nationwide system is established.

5.9.4 Financial Considerations

The relative burden, as defined as the ratio of 25% land acquisition cost to fixed investment on land and construction, was 154%. While the amount of fixed investment varies with fiscal year, this figure of 154% was not high among eight municipalities.

Pa Mok has not yet developed social infrastructure, compared with that of Rangsit and Bang Bua Thong. The proportion of public fixed investment to total expenditures was only 6.3% in 1991. This appears to reflect that the greater the portion of public fixed investment, the smaller the relative burden of land acquisition cost. For example, when public fixed investment increases to, say, 10% of total expenditures, the relative burden of land acquisition cost becomes also 10%. Thus, the relative burden of 168% while a little high, should be interpreted in a frame work not only of fixed investment but also of total expenditures.

Nevertheless, when the relative burden exceeds a certain figure, say, 10%, it will add substantial burden on local municipality. This is due to limited capability of increasing local revenues in financing a large public investment project as the sewerage project.

Pa Mok is no exception. Financing options that are available are (1) municipality development fund, (2) environment fund, or (3) increasing local revenues.

Environmental fund is available to local agencies in the form of grant and/or loan. It is recommended that Pa Mok explore loan financing to allocate financial burden into the future, compared to raising local revenues or utilizing municipality development fund whose objectives are more general than those of environmental fund.

The average household user cost in item 4.3 of Table 5.9.1 is well below one percent of low household income in 2011 for Pa Mok. The user cost, however, could be administratively increased by two factors, one is the interest rate of the local that Pa Mok would transfer to the user, and the other, the loss of the sewerage revenue collection that could be compensated for and would be included as part of the user charge.

The household users were estimated on the basis of the project service area in 2011. The household is assumed to have 4.1 persons on the average. We have also assumed that household users as sewerage users for simplicity. The average sewerage user cost was calculated on O&M cost divided by [(0.7+0.2x1.2+0.1x2)(number of household users)].

The average rate of non household users could be assumed to pay as high as the highest progressive rate of the household user rate structure. The progressive rate structure is 1.0 to 1.3 to 2.0 for low, medium, and high household income group respectively. A summary is shown in 4.4 of Table 5.9.1.

Finally, affordability will be considered. The affordability level is defined as the ratio of the average household user cost to low household income level of 96,571 Baht in 2011 in the Central Region. With available data on household income by Pa Mok, the figure indicated in 4.5 of Table 5.9.1 would then be updated and could also be modified with allocation of loan cost among the users.

Table 5.9.1 Selected indicators for Ang Thong

1.1	Service Pop in 2011	13,300
1.2	Household Users in 2011	3,243
2.1	Total Expenditures, 1991 (Thousand Baht)	26,752
2.2	Investment on Land & Const., 1991 (Thousand Baht)	1,097
2.3	Land Acquisition Cost (Thousand Baht)	1,685
2.4	Relative Burden (2.3/2.2) in %	168
2.5	Sanitation Expenditures, 1991 (Thousand Baht)	na
3.1	Total Revenues, 1991 (Thousand Baht)	27,691
3.2	Central Government Support, 1991 (Thousand Baht)	18,913
4.1	Treatment capacity (m3/d), in 2011	3,700
4.2	Unit O&M Cost of 4.1, in 2011	0.55
4.3	Household Users Cost/Year, in 2011 without loan	230
4.4	Progressive Rates: 1:1.3:2.0 in 2011	198 258 397
4.5	Loan Cost/H User/Year 50% Local, 50% Foreign Loan, 25 Years	44
4.6	Affordability (4.3 + 4.5) for Low Income Household, 96571 baht, 2011	0.29%

SECTION 6

SENA MUNICIPALITY

SECTION 6 SENA MUNICIPALITY

6.1 Description of the Study Area

The DTCP area extending about 26.1 km^2 covers two communities; Sena municipality and Chao Jet S.O and its surrounding Tambols; Ban Pan, Ban Pho, Bang Nom Kho, Chao Fed, Chao Saded, Ran Jorakhe, Samkho and Ban Taew. The Sena municipality which has an area of 1.20 ha is located 22 km west of Amphoe Muang and 37 km from Pathum Thani.

There are about 37 government offices in DTCP area with 2 hotels in the municipality. The community is expanding towards south of municipality along Thamasit Sena road and along Highway No. 3263. Roads are being connected to Ayutthaya, Suphan Buri and Pathum Thani.

The business area is concentrated in Sena municipality. There is one municipal and one private fresh food market. The slaughterhouse is located at Tamasitti Sena covering an area of 4 rai and uses water from Noi river. Cottage industry is also existing and has an average of 7.5 employees mainly engaged in jewelry factories and repair shops.

There are 1,024 telephones in the area, with 9 public phones. An area of one rai is occupied by a transmission station, although the telephone office is located in Ayutthaya Province.

The south-west monsoon affects the area with a longer rainy season. Two types of soils, clayey and sandy soils are predominant in the area.

The DTCP area is bounded by the Noi river in the east, Jao-Jet to Pak Hai canal in the West and Ayutthaya to Ban-Sali Mooban (village) in the south. The municipality is developed in the western part of the Noi river, adjoining Pathunam canal. Commercial area with a high population density is located in the southern part of the Pathunam canal which leads to a concentration of infrastructures there.

Both river and land transportation modes are used in the study area. The most important means of transportation route used to be the river connecting Bangkok-Sena-Suphan Buri, but at present road transportation is preferred.