	North Area	South Area	Total
Area Coverage	669.6 ha	894.4 ha	1,564 ha
Present Population	32,732	13,058	45,800
Design Population	56,900	22,700	79,600

In the North area, the topography is flat with a gentle slope from west towards east. Three major khlongs exist in the area, which join the khlong located at the eastern boundary of the service area. While, in the South area, the central area has a lower land and gentle slope from west towards east.

The housing complexes are arranged on the uniform elevation. The wastewater treatment plant for the north area is located in the vicinity of the housing complex, while for South area in the agricultural area near a larger khlong.

8.6.2 Wastewater Collection System

Wastewater collection system in application of the combined collection method is proposed as shown in Figure 8.6.1.

Distribution of population and wastewater quantity was made based on population density assumed by land use type (refer to calculation table in Supporting Report 3.8.6).

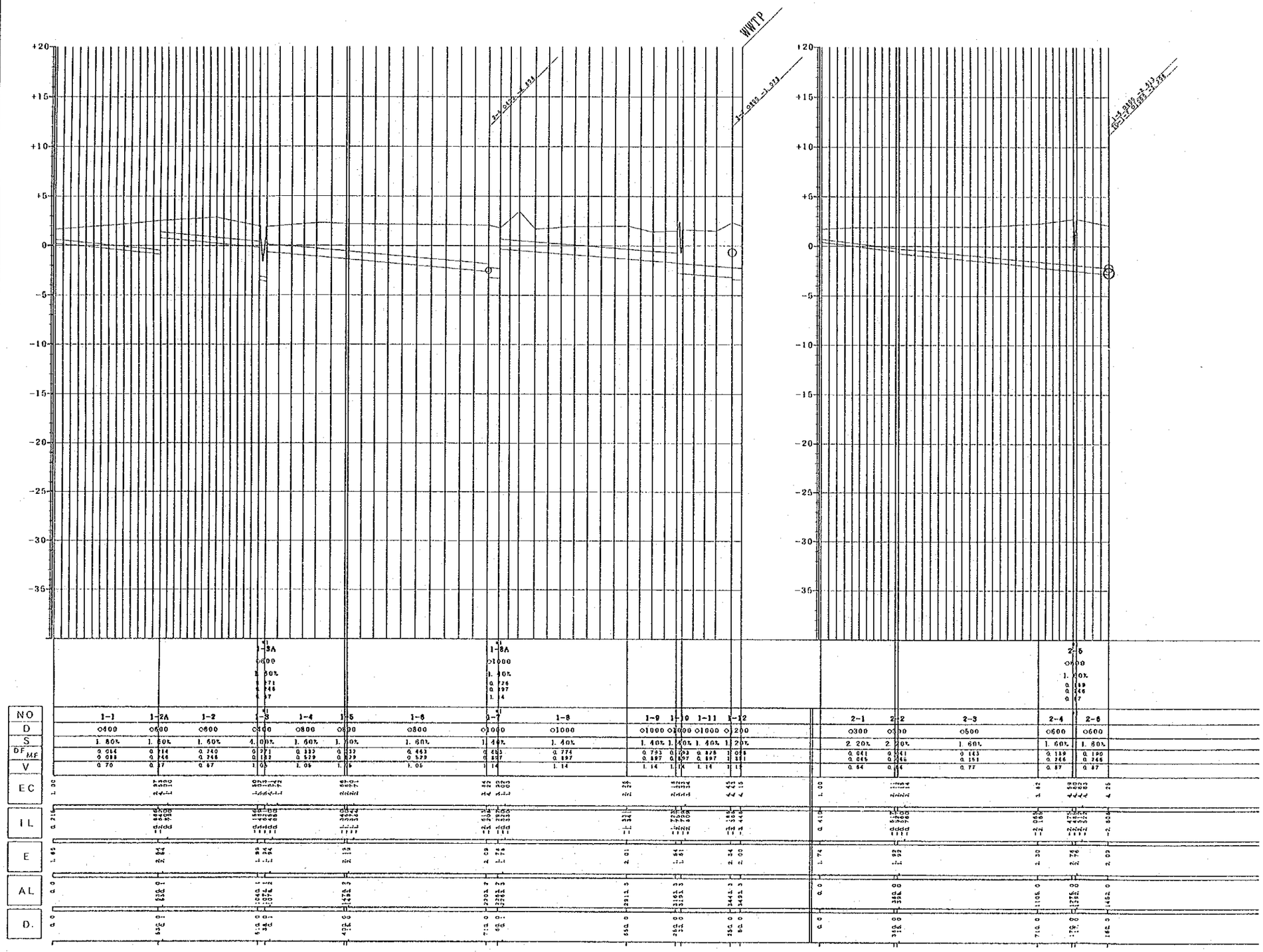
Alignments of main interceptors and pump stations are proposed in consideration of existing roads, drainage facilities as well as topographic conditions. The profile of sewers is shown in Figure 8.6.2. (refer to hydraulic calculation in Supporting Report 3.8.6). The following are descriptions on the sewer systems.

North Area

- A total of three (3) sewer systems are planned; 2 systems in the eastern portion and one system in the western portion.

- Interceptors 1/1 - 1/12 start from northeastern periphery of the service area and connect to WWTP via urban area.

- Interceptors 2/1 - 2/6 connect to 1/7



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

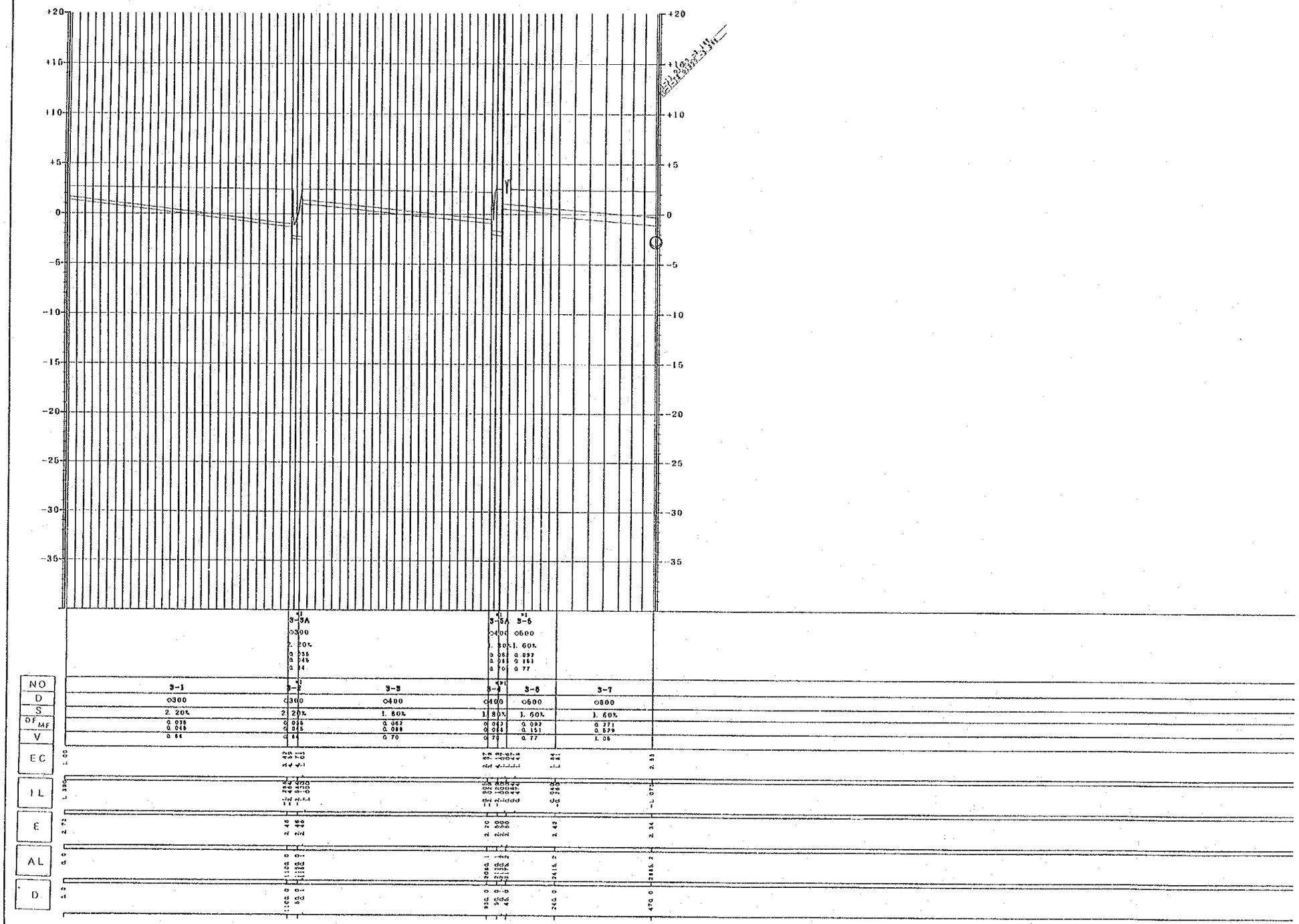
1-1	1-2A	1-2	1-3	1-3A
1-4	1-5	1-6	1-7	1-8A
1-8	1-9	1-10	1-11	1-12
2-1	2-2	2-3	2-4	2-5
2-6				

FIG. 8.6.2 (1)
BANG BUA THONG - NORTH (1)

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

3-1	3-2	3-3A	3-3	3-4
3-5A	3-5	3-6	3-7	

FIG. 8.6.2 (2)
BANG BUA THONG - NORTH (2)

V 1:200
H 1:10.000

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

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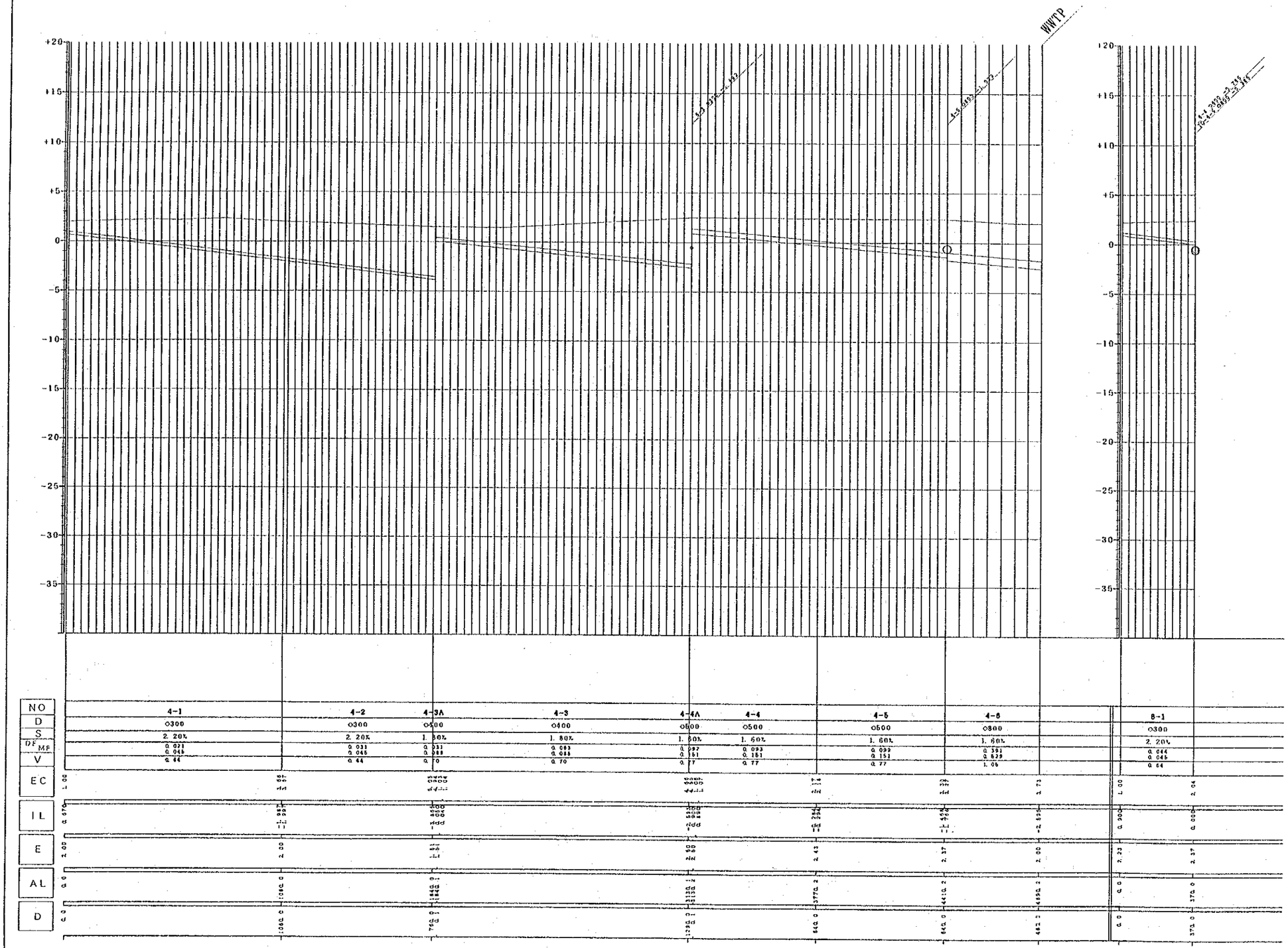


LEGEND

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

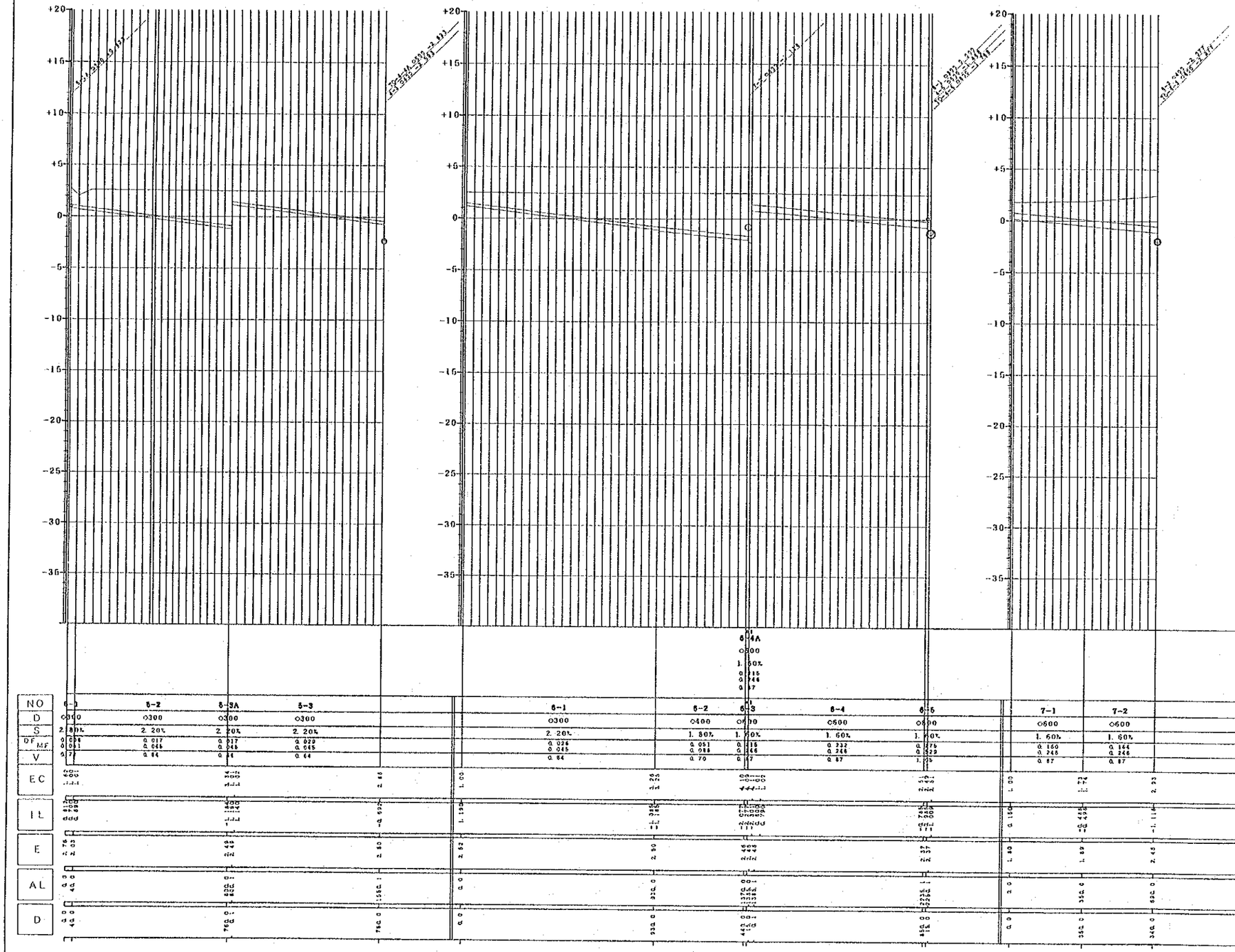
4-1	4-2	4-3A	4-3	4-4A
4-4	4-5	4-6	8-1	

FIG. 8.6.2 (3)
BANG BUA THONG - SOUTH (1)

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

5-1	5-2	5-3A	5-3	6-1
6-2	6-3	6-4A	6-4	6-5
7-1	7-2			

FIG. 8.6.2 (4)
BANG BUA THONG - SOUTH (2)

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 3/1 - 3/7 start from the northwestern of road No. 340 to connect to 1/12.

South Area

- Five (5) sewer systems are planned comprising one each for eastern and western areas, and two systems for central area.

- 4/1 - 4/6 interceptors start from the eastern part of the service area near WWTP and connect to WWTP.

- 5/1 interceptor starts from the southern periphery of the service area and connects to 4/4.

- 6/1 - 6/5 interceptors connect to 4/6 along road No. 3215.

- 7/1 - 7/2 interceptors conenct to 6/3.

- 8/1 interceptor starts at the northern periphery of the service area and connects to 6/5.

Table 8.6.1 summarizes planned collection facilities. Details on pump specifications and siphon are included in Supporting Report 3.A.6 - 3.C.6.

Table 8.6.1 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	6,175	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	2,005	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

8.6.3 Wastewater Treatment and Sludge Disposal System for Bang Bua Thong North Area

(1) Wastewater Treatment and Disposal Methods

The future wastewater discharge in the sewerage development area of Bang Bua Thong North area is estimated to be 16,388 m^3/d in the year of 2011. Groundwater infiltration at 20% of wastewater discharge is assumed. The daily average wastewater to the treatment plant becomes to be 19,700 m^3/d. The effluent quality is expected to be less than 20 mg/l as BOD_5.

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

1) Oxidation Ditch (OD)
2) Conventional Activated Sludge (AS)
3) Rotating Biological Contactor (RBC)

(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 referred to in Supporting Report 3.1.6.2).

Evaluation Item	Oxidation Ditch	ACtivated Sludge	RBC
(1) Construction Cost (million Baht)	142.71	181.26	226.0
(2) Land Cost (million Baht)	225.0	150.0	150.0
(3) O/M Cost (million Baht/year)	12.20	12.14	13.25
(4) Required Land Area (ha)	4.5	3.0	3.0
(5) Easiness of O/M			
- Adaptability of overload	A	C	C
- Required technology level	A	B	C
- Sludge disposal	B	B	B

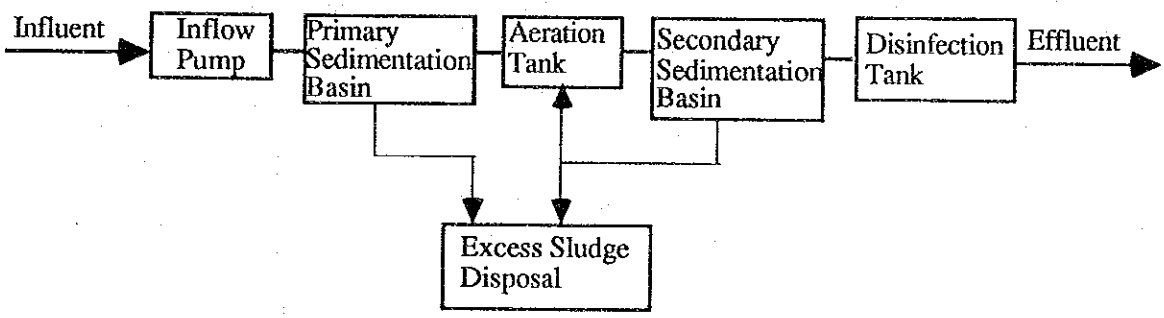
Note : 1) Construction cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical anc others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge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

From cost comparison in NPV (refer to Supporting Report 3.1.6.3), oxidation ditch system and Activated sludge system are economically on the same level. While the available land area is quite limited. Then the conventional activated sludge system is proposed for Bang Bua Thong North sewage treatment plant.

(3) Plan of Treatment Plant

The proposed location of the wastewater treatment plant of Bang Bua Thong North is the paddy field belonging to the temple. The proposed treatment plant of conventional activated sludge with a capacity of 23,600 m^3/d requires a net area of 3.0 ha.

The flow sheet of conventional activated sludge system and the capacity dimension and other relevant details of each treatment facility is shown below.



Flow of Conventional Activated Sludge System

Inflow Pump :	Design capacity	30,700 m^3/d (hourly max. dry)
		92,100m^3/d (hourly max. wet)
	: Capacity	21.3 $m^3/min.$ with 8.0 m
		hydraulic head (hourly max. dry)
		64.0 $m^3/min.$ with 8.0 m
		hydraulic head (hourly max. wet)
Grit Chamber :	Surface loading	1,706 m^3/m^2 day
		(dry weather)
		2,132 $m^3/m^2/d$
		(wet weather)
	: Retention time	20 sec (dry), 16 sec (wet)
	: Size	1.0 m(W) x 9 m(L) x 0.4 m(D)

x 2 units

(2 units for dry weather)

1.4 m(W) x 9 m(L) x 0.4 m(D)

x 2 units

: Constructed with R.C

Stormwater Sedimentation Basin: Design discharge 68,500 m^3/d

(hourly max. wet - daily max. dry)

: Dimension ϕ 14 m x 3 m (D) x 6 units

: Surface loading 74.2 $m^3/m^2/day$

: Sedimentation time 1.0 hr

: Constructed with R.C

Primary sedimentation basin: Design wastewater 23,600 m^3/d

(daily max. dry)

: Dimension ϕ 15 m(W) x 4 m(D) x 4 units

: Surface loading 43.5 $m^3/m^2/day$

: Sedimentation time 2.2 hours

: Constructed with R.C

Aeration Tank: Design wastewater 23,600 m^3/d

(daily max. dry)

: Dimension 12.0 m(W) x 36.0 m(L) x 3.0 m(D)

x 4 units

: Aeration time 5.3 hours

: BOD-SS loading 0.32 kg-BOD/kg-SS/day

: MLSS 1,478 mg/l (25% return sludge)

: Constructed with R.C

Secondary sedimentation basin: Design wastewater 23,600 m^3

: Dimension ϕ 17.0 m x 2.5 m(D) x 4 units

: Retention time 2.3 hours

: Surface loading 26.0 $m^3/m^2/d$

: Constructed with R.C

Sludge thickener: Design sludge volume 419 m^3/d

(4.01 ton-DS/d)

: Dimension of tank ϕ 6.0 m x 4.0 m(D) x 2 units

: Detention time 13.0 hours

Sludge digestion tank	:	Design sludge volume	107 m^3/d
	:	Dimension of tank	ϕ 12.0 m x 5.0 m(D) x 4 units
			ϕ 8.5 m x 5.0 m(D) x 4 units
Centrifugal	:	Design digested	79 m^3/d
Dewatering	:	Operation time	6 hours x 6 days per week
	:	Capacity	4 ~ 5 m^3/hr x 1 unit
			7 ~ 8 m^3/hr x 2 units

The effluent is discharged to Khlong Bang Bua Thong through Khlong Ban Klual. Layout of the treatment plant is shown in Figure 8.6.3.(1) and Figure 8.6.4.(1), respectively.

8.6.4 Wastewater Treatment and Sludge Disposal System for Bang Bua Thong South Area

(1) Wastewater Treatment and Disposal Methods

The future wastewater discharge in the sewerage development area of Bang Bua Thong South Sewerage Development area is estimated to be 6,538 m^3/d in the year of 2011. Groundwater infiltration at 20% at wastewater discharge is assumed. The daily average wastewater to the treatment plant becomes to be 7,900 m^3/d. The effluent quality is expected to be less than 20 mg/l as BOD_5.

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

1) Oxidation Ditch (OD)
2) Conventional Activated Sludge (AS)
3) Rotating Biological Contactor (RBC)

(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 referred to in Supporting Report 3.1.6.2).

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) Chlorination 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.
	1.0"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

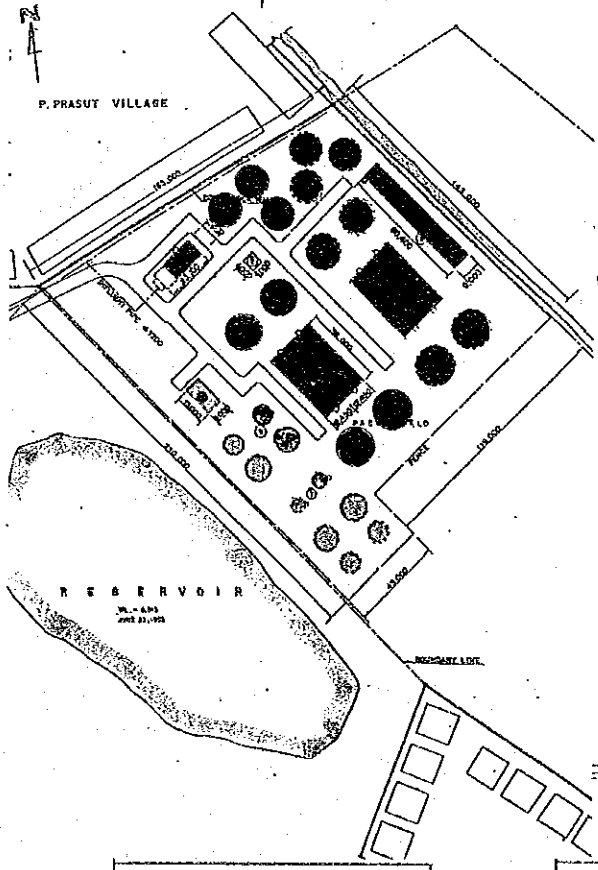


Figure 8.6.3 (1) Layout of Sewage Treatment Plant (Bang Bua Thong North)

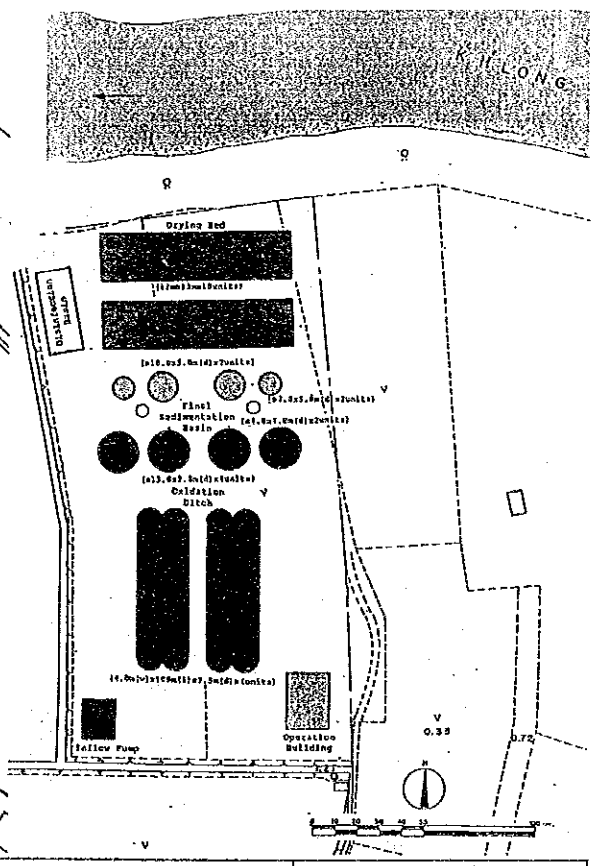


FIGURE Layout of Sewage Treatment Plant (Bang Bua Thong South) 8.6.3 (2)

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HYDRAULIC PROFILE

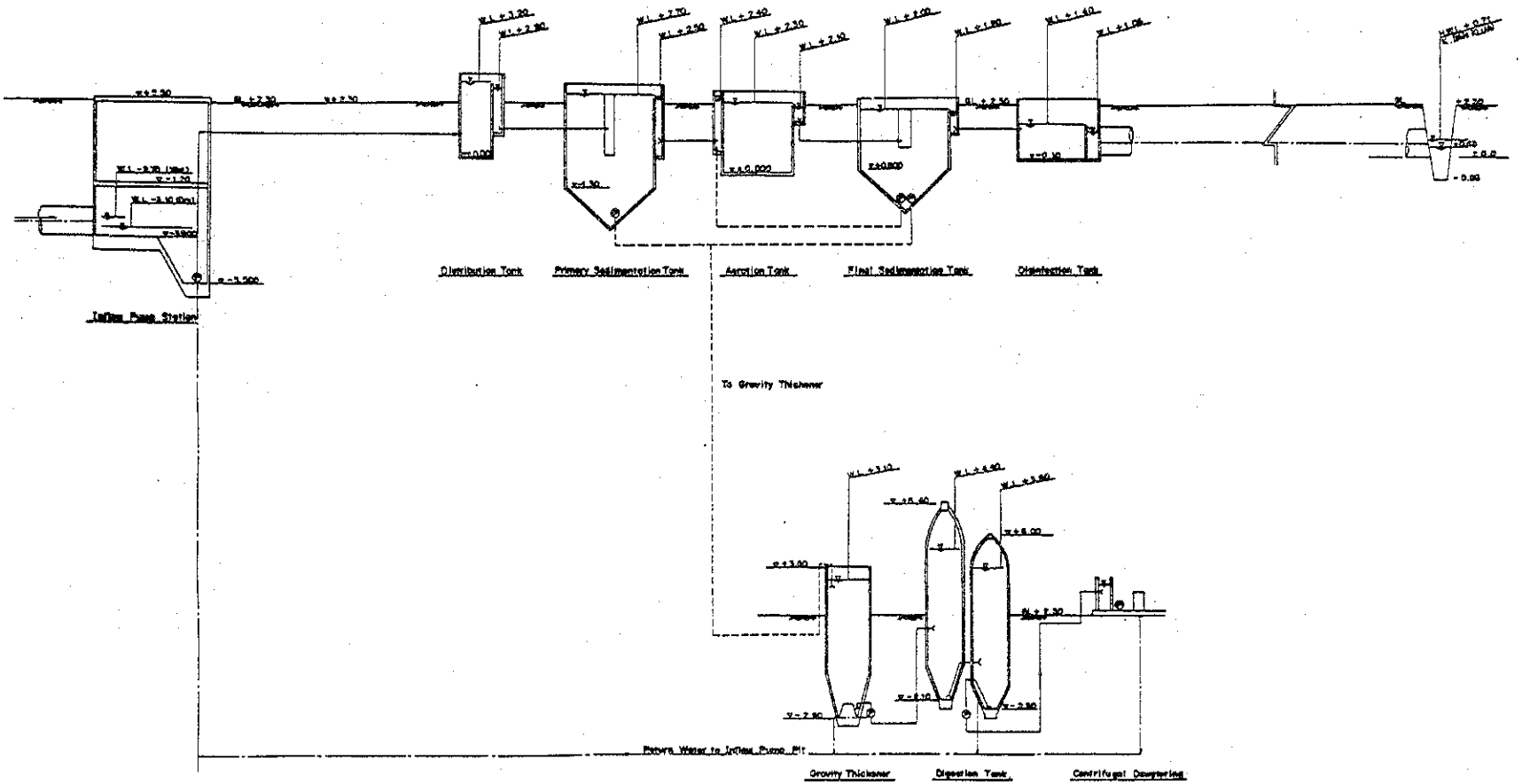

Figure: 8.6.4 (1) Hydraulic Profile of Sewage Treatment Plant (Bung Bua Thang North)

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

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Evaluation Item	Oxidation Ditch	Activated Sludge	RBC
(1) Construction Cost (million Baht)	47.71	65.42	74.52
(2) Land Cost (million Baht)	7.03	2.50	2.50
(3) O/M Cost (million Baht/year)	4.65	4.68	5.14
(4) Required Land Area (ha)	2.25	0.80	0.80
(5) Easiness of O/M			
- Adaptability of overload	A	C	C
- Required technology level	A	B	C
- Sludge disposal	A	B	B

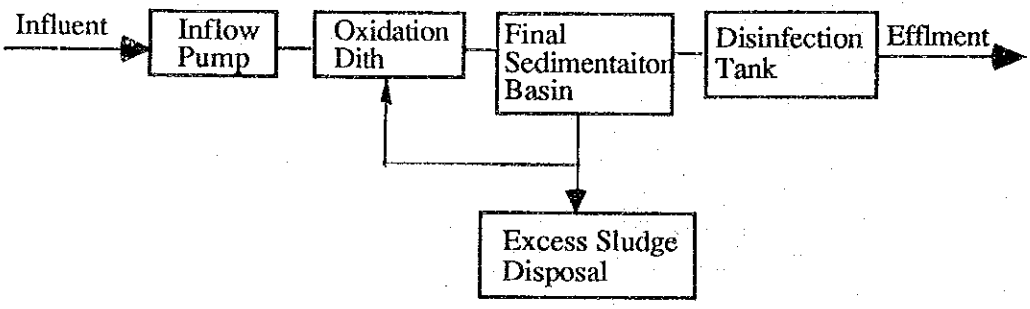
Note : 1) Construction cost : direct construction cost excluding land acquisition, engineering and administration costs
2) O/M cost : wages, electric charge, chemical anc others
3) Adaptability of overload : A: high, B: middle, C: low
4) Required technology level : A: low, B: middle, C: high
5) Sludge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

As evident from cost comparison in NPV (refer to Supporint Report 3.1.6.3), oxidation ditch system is the most eonomical.

(3) Plan of Treatment Plant

The proposed location of the wastewater treatment plant of Bang Bua Thong South is currently the open space. The proposed treatment plant of oxidation ditch with a capacity of 7,900 m^3/d requires a net area of 2.25 ha.

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



Flow of Oxidation Ditch System

Inflow Pump	:	Design capacity	12,400 m^3/d (hourly max. dry)
			37,200 m^3/d (hourly max. wet)
	:	Capacity	8.61 m^3/min. with 7.0 m hydraulic head (hourly max. dry)
			25.8 m^3/min. with 7.0 m hydraulic head (hourly max. wet)
Grit Chamber:		Surface loading	1,653 m^3/m^2/d (dry weather)
			2,480 m^3/m^2/d (wet weather)
	:	Retention time	31 sec (dry), 21 sec (wet)
	:	Size	1.0 m(W) x 7.5 m(L) x0.6 m(D) x 2 units (1 unit for dry weather)
	:	Constructed with R.C	
Oxidation Ditch:		Design wastewater	7,900 m^3/d (daily ave. dry)
basin	:	Dimension	4 m(W) x 100 m(L) x 2.5 m(D) x 4 units
	:	Aeration time	12.2 hours
	:	Constructed with R.C	
Final sedimentation:		Design wastewater	7,900 m^3
basin	:	Dimension	ϕ13.0 m x 2.6 m(D) x 4 units
	:	Retention time	4.2 hours
	:	Surface loading	14.9 m^3/m^2/d
	:	Constructed with R.C	
Sludge thickener:		Design sludge volume	158 m^3/d (1.106 ton-DS/d)
	:	Dimension of tank	ϕ4.0 m x 4.0 m(D) x 2 units
	:	Detention time	15.3 hours
Sludge digestion tank:		Design sludge volume	36.8 m^3/d
	:	Dimension of tank	ϕ10.0 m x 5.0 m(D) x 2 units
			ϕ7.0 m x 5.0 m(D) x 2 units
Drying Bed	:	Drying area	1,800 m^2
	:	Detention time	15 days
	:	Dimension	12 m x 15 m x 10 units

The effluent is discharged to Chao Phraya river through Khlong Bang Bua Thong. Layout of the treatment plant and hydraulic profile are shown in Figure 8.6.3.(2) and Figure 8.6.4.(2), respectively.

8.7 Cost Estimates

8.7.1 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 priority area in North area (F/S area), remaining area in North area and South area, for the design year 2011.

Cost Item	F/S Area in North Area	Remaining Area in North Area	South Area	Total
(1) Direct Cost				
1) Interceptor	65.3	44.0	136.2	245.5
2) Pump Station	13.4	9.1	30.0	52.5
3) W.W.T.P.	108.30	72.96	47.71	228.97
Total of Direct Cost	187.0	126.06	213.91	526.97
(2) Contingency (20% of (1))	37.4	25.2	42.8	105.4
(3) Total of Construction Cost ((1)+(2))	224.4	151.26	256.71	632.37
(4) Engineering & Construction Supervision (17% of (3))	38.1	25.7	43.6	107.4
(5) Land Acquisition				
1) Pump Station	0.09	0.06	0.21	0.36
2) W.W.T.P.	89.69	60.31	7.03	157.03
Total of Land Acquisition	89.78	60.37	7.24	157.39
Grand Total (million Baht)	352.28	237.33	307.55	897.16

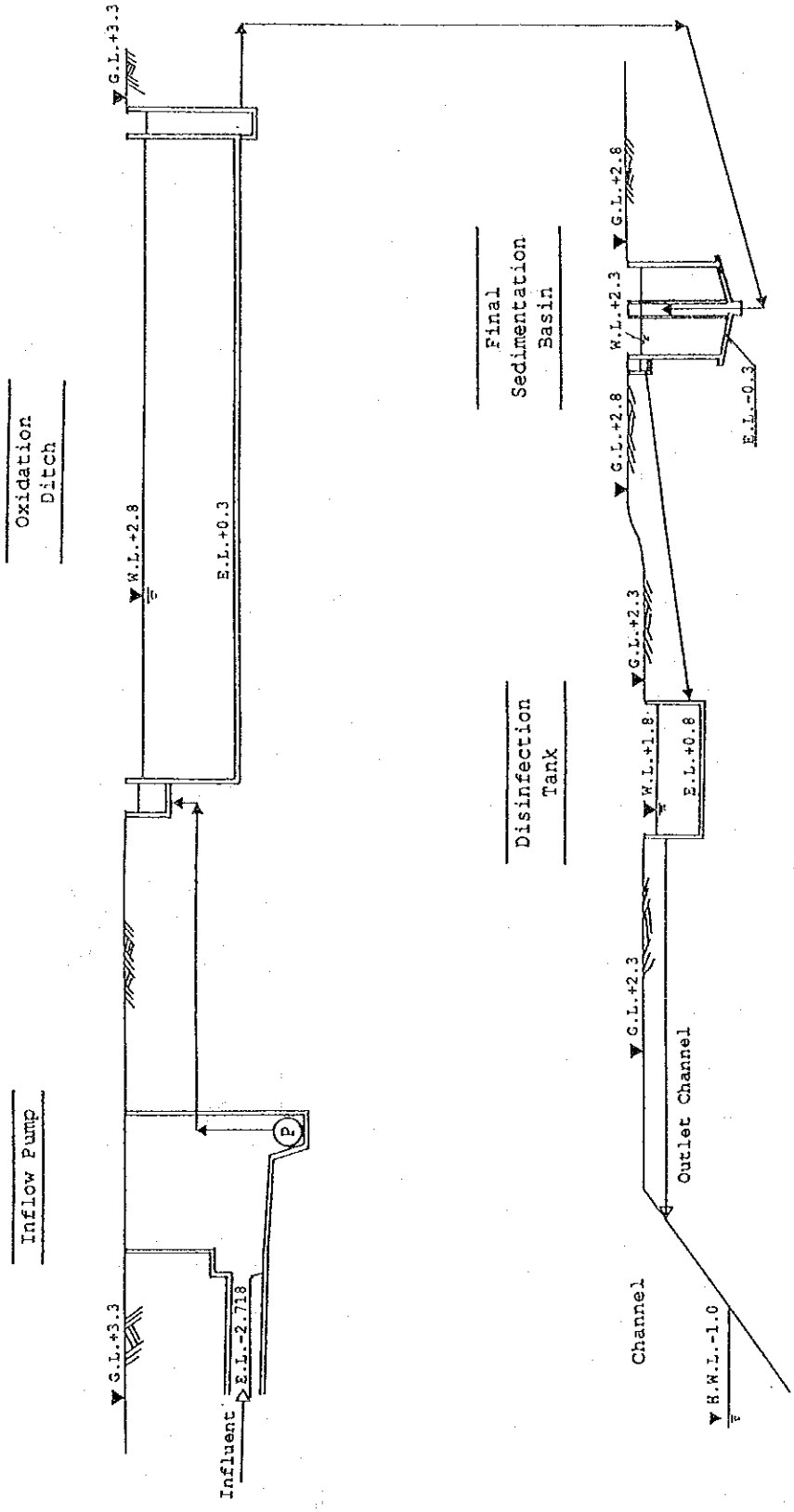


Figure 8.6.4.(2) Hydraulic Profile of Sewage Treatment Plant (Bang Bua Thong South)

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

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8.7.2 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	F/S Area in North Area	Remaining Area in North Area	South Area	Total
(1) Interceptor	301	203	674	1,178
(2) Pump Station	638	430	1,427	2,495
(3) W.W.T.P.	7,250	4,890	4,650	16,790
Total of O&M cost	8,189	5,523	6,751	20,463

8.8 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 with 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 of facilities
2nd	1996-2001	Construction for F/S area in North area
3rd	2002-2006	Construction for remaining area in North area and central area in South area
4th	2007-2011	Construction for South area

8.9 Administrative and Financial Study

8.9.1 General

Thailand is politically a centralized country where the central government is controlling the local governments. The strongest tool of the central government for the purpose is the Ministry of Interior. This ministry is almost controlling all the aspects of local governments from budgeting to staffing and capital investment.

The ministry of Interior has the following three departments among others to control local governments:

- Department of Local Administration (DOLA)
- Department of Town and Country Planning (DTCP)
- Department of Public Works (PWD)

Their functions are explained in the forgone section. PWD is the counterpart office of the Project.

In this background the local governments are generally not equipped with funds nor with expertise for large scale projects like sewerage one. This s feet by the Study Team during its field visit and interviews.

The size of staffing itself is relatively small for only daily administration. This is rigidly regulated by the laws. On the top of this, most of the high ranking officials are dispatched by the central government. They are morning from one local government to another nationwide in a relatively short term of a couple of years. This means that, though the got accustomed with the local conditions after some time, they have to moue to another local government. Low ranking, or locally recruited officials and part-time workers are left to work for the residents under even changing management. This kind of administration is so conservative as to only repeat the same jobs on a minimum level. They are not progression nor innovative.

However a sewerage project is a new challenge in Thailand, which will require both funds and expertise.

The centralized system has the following advantages as well as disadvantages:

Advantages:

- Uniform policy on the country
- Allocation of limited human resources
- Efkctine dissemination of information

Disadvantages:

- Elimination of local characteristics
- Ignorance of local conditions
- Lack of long-term development policy

The decentralized system has the opposite aspects of the above-mentioned.

The reality is between the two systems. Thailand is a monarchy country, and needs to be centralized to some degree, considering local conditions.

The sewerage is such a system. It should be centralized to ensure:

- Technical uniformity like guidelines
- Fund allocation
- Effective use of expertise

On the other hand it should consider

- Local conditions
- Long-term operators

8.9.2 Existing Administrative System

The organization of the municipality is shown in Figure 8.9.1, which is divided into six (6) divisions: Administrative, Treasury, Health, Technical, Education, and Fire Fighting Divisions.

The total number of the municipality is 162, consisting of 58 officials and 104 employees in March, 1993. The most officials are recruited by ministry

of Interior and seconded to the municipality. They are supposed to have passed the examination for government officials. There are also some employees who have been recruited by other ministries.

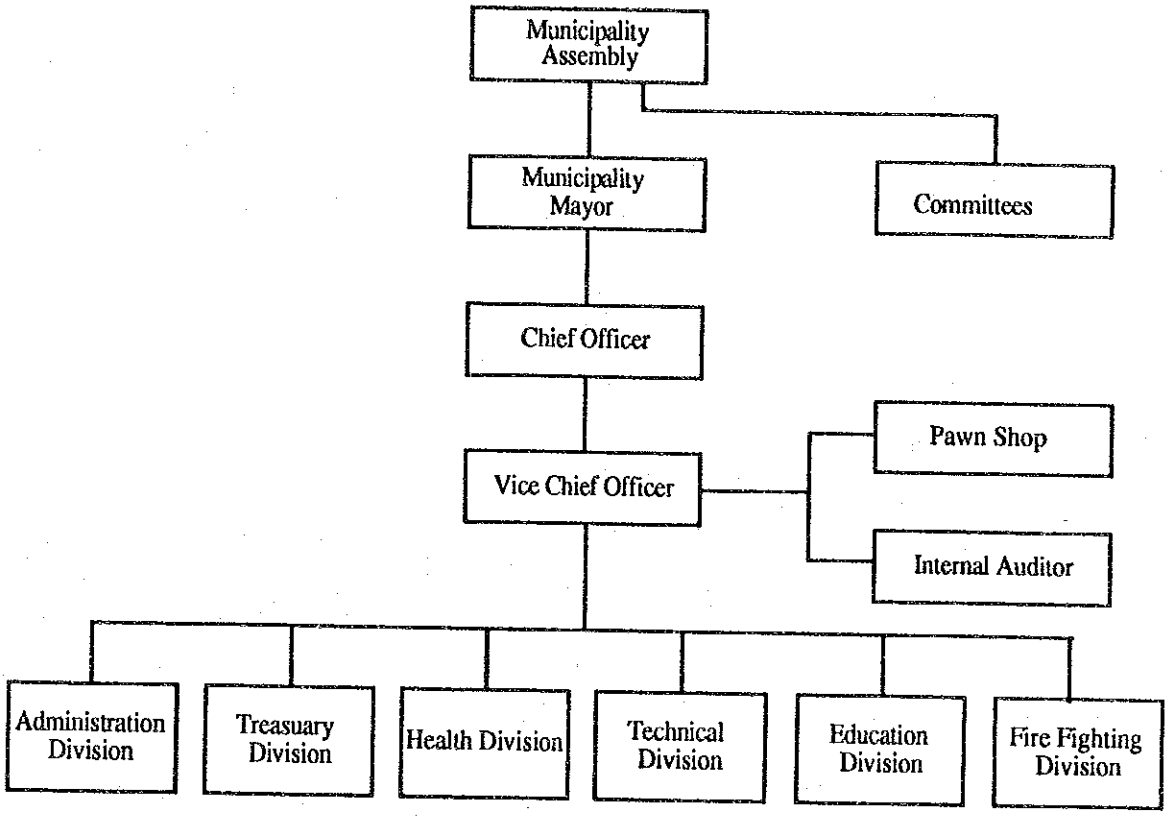

Figure 8.9.1 Administrative Structure of Municipality of Bang Bua Thong

There are two types of employees: permanent ones and temporary ones. The permanent employees are recruited on a relatively long-term basis of about five (5) years, while the temporary ones are recruited on a short-term basis of daily to one year. These employees, both types, are subject to lay-off, dependent upon the needs. The recruitment of employees is to be approved by the municipality assembly.

There are some officials who are stationed in a municipality on a relatively long period. But higher-ranking officials are rotating quickly nation-wide from one municipality to another, based upon the enrollment of the central government. The municipality has the following functions:

- Administration
- Tax collection
- Health affairs
- Maintenance of basic infrastructures
- Fire Fighting

The Health Division is in charge with garbage disposal and sanitation. When the municipality has a sewerage system, additional employees are necessary. The number of the required employees is estimated at about 43, or 27% increase of the present personnel.

Since there is no sewerage system, most houses and buildings are installed with on-site sanitation facilities. These facilities are relatively easy and tough, but need to be maintained properly. When they are stopped or fulfilled, the users ask the municipalities for help. the municipality is equipped with a vacuum truck and sends it to house to empty the sanitation facility. The desludging usually takes place once for one or two years. In the rainy season the demands of desludging increase, because storm water can fulfill it.

8.9.3 Existing Relevant Regulations

The municipality is under direct control of DOLA (Department of local Administration), MOI. There is no special regulation referred to the municipality. The general relationships between central and local governments are mentioned above. The duties and functions of the municipality are regulated by the Municipal Government Act (1953).

8.9.4 Recommendations

At present there is no sewerage system in Bang Bua Thong, so no organization exists for the purpose.

In order to establish a new organization for sewerage there are two options:

- (A) to attach it to the existing organization of the municipality (see Figure 8.9.2)
- (B) to create it independently, but with liaison to the municipality (see Figure 8.9.3)

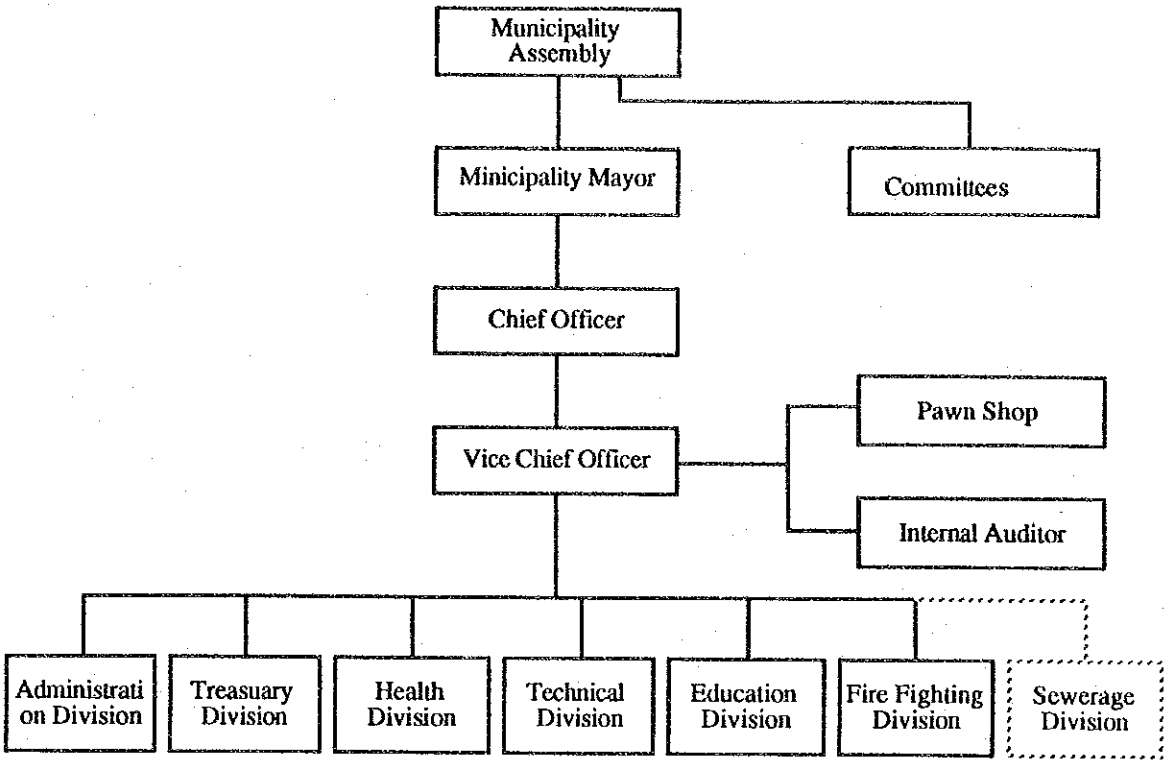

Figure 8.9.2 Option (A) : Attachment

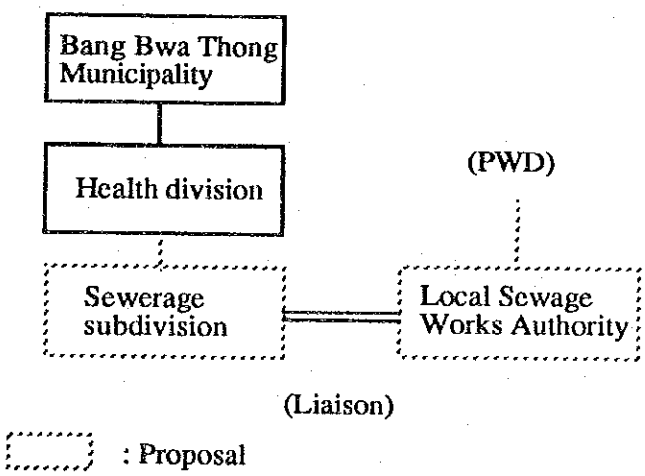

Figure 8.9.3 Option (B) : Independent

The two options have both advantages and disadvantage, as summarized in Table 8.9.1. The implementation plan is explained in 8.8.

Table 8.9.1 Comparisons of Two Options

Options / Items	(A) Attachment	(B) Independent
(1) Main Power	Rigid, within regulations	More flexible
(2) Budget	Stable with general account	Instable (Tariff)
(3) Technical	Indirect through municipality	Direct from PWD
(4) Policy adjustment	Easy	Needs efforts for adjustment
(5) Operation	Similar sectors . garbage disposal . right soil dislodging	Similar Organization . water supply

The operation and maintenance of sewerage system require a large size of manpower. The final stage of sewerage system for Bang Bua Thong will collect and treat wastewater of 2300 m^3/d (2011) in two treatment plants. This will require about 43 operators. About half of this will be required for operation and maintenance of pumping stations and collection pipes.

Beside this, some more staff will be required for tariff collection, budgeting, contracting and general administration.

The size of staffing for sewerage system will be nearly about 100 in full capacity.

The present staffing of the municipality is 162, which will naturally increase in the future. But it can be assumed that the staffing for sewerage system will be about half of the municipal staffing. This is rather imbalanced.

This is the reason why the study Team recommends that the sewerage organization be established independently. But it should have liaison function wat the municipality. The proposed organization is shown in Figure 8.9.4.

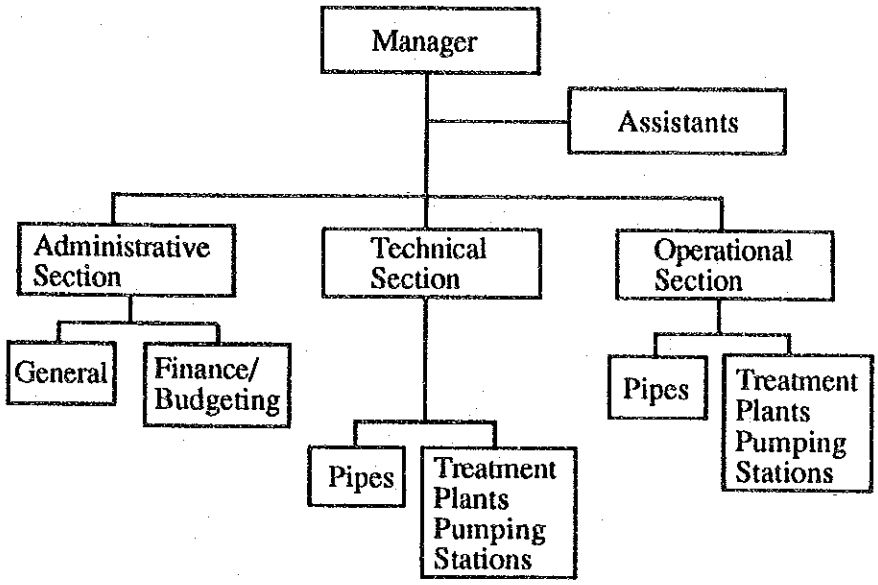

Figure 8.9.4 Proposed Sewerage Organization for Bang Bua Thong

For operation and maintenance several special vehicles and machines are required: pipe cleansing, pumping station and treatment plant. Those vehicles and machines are to be maintenanced in workshop. Enough spare parts are to be stored in stock.

Some countermeasures should be taken for emergency like pipe clogging or pump breakage, because of 24 hrs operation. They can be done by in-force laborers or contracts. these will require some more administrate capability.

Staff requirements are summarized as follows.

Stage	Period	Staffing requirement
1st	1991 - 1995	15
2nd	1995 - 2001	33
3rd	2002 - 2006	60
4th	2007 - 2011	100

8.9.5 Financial Consideration

The relative burden, as defined as the ratio of 25% land acquisition cost to fixed investment on land and construction, was 21%. While the amount of fixed investment varies with fiscal year, this figure of 13% was not high among eight municipalities.

Bang Bua 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 25% 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, 30% of total expenditures, the relative burden of land acquisition cost becomes also 30%. 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.

Bang Bua 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 Bang Bua 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 8.9.2 is well below one percent of low household income in 2011 for Bang Bua Thong. The user cost, however, could be administratively increased by two factors, one is the interest rate of the local that Bang Bua 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 8.9.2.

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 Bang Bua Thong, the figure indicated in 4.5 of Table 8.9.2 would then be updated and could also be modified with allocation of loan cost among the users.

Table 8.9.2 Selected indicators for Bang Bua Thong

1.1	Service Pop in 2011	79,600
1.2	Household Users in 2011	19,414
2.1	Total Expenditures, 1991 (Thousand Baht)	38,736
2.2	Investment on Land & Const., 1991 (Thousand Baht)	17,995
2.3	Land Acquisition Cost (Thousand Baht)	3,800
2.4	Relative Burden (2.3/2.2) in %	21
2.5	Sanitation Expenditures, 1991 (Thousand Baht)	3
3.1	Total Revenues, 1991 (Thousand Baht)	41,300
3.2	Central Government Support, 1991 (Thousand Baht)	10,688
4.1	Treatment capacity (m3/d), in 2011	27,600
4.2	Unit O&M Cost of 4.1, in 2011	1.75
4.3	Household Users Cost/Year, in 2011 without loan	906
4.4	Progressive Rates: 1:1.3:2.0 in 2011	781 1015 1562
4.5	Loan Cost/H User/Year 50% Local, 50% Foreign Loan, 25 Years	17
4.6	Affordability (4.3 + 4.5) for Low Income Household, 96571 baht, 2011	0.96%

PART III

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

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

Among eight (8) municipalities/areas for sewerage master planning, Rang Sit area and Bang Bua Thong Municipality were selected for preparation of sewerage preliminary design. The selection is attributable to the needs for the effective water pollution control of the lower Chao Phraya river as identified in the basin-wide water pollution control plan in Part I.

Preliminary design of the sewerage systems for the first stage program with a target year of 2001 is prepared within the context of the previous sewerage master plan. In this connection, information and study results included in the master plan are not repeated, but summary was presented, as required, with reference to the master plan.

Detailed information for this design of sewerage systems was collected through the third field work in Thailand entailing topographic survey along planned sewer routes, investigation on existing drainage pipes and soil boring tests at the treatment plant sites.

CHAPTER 2

RANG SIT AREA

CHAPTER 2 RANG SIT AREA

SECTION 1 STUDY AREA FOR FIRST STAGE SEWERAGE PROGRAM

In the master planning area of 33.30 km^2, priority area for first stage sewerage project was selected taking into account of current land use, especially with reference to a higher population density. The identified area of 1,288ha consists of administrative two S.Ds, Prachatipat and Khu Khot, which are located western and southern part of the master plan area. The preliminary design area comprises twelve (12) election zones. Table. 2.1.1 shows the composition of related administrative area and sewerage design area by election zone. Figure 2.1.1 presents the area coverage for the preliminary design.

Table 2.1.1 Administrative and Sewerage Design Area by Election Zone

Sanitary District	Election Zone	Administrative Area (ha)	Design Area (ha)
Prachatipat	Prachatipat-1	304	120.8
	Prachatipat-2	309	267.2
	Prachatipat-3	354	159.7
Khu Khot	Khu Khot-5	148	108.8
	Khu Khot-7	154	154
	Khu Khot-8	89	89
	Khu Khot-9	70	70
	Khu Khot-10	71	48.5
	Khu Khot-13	68	68
	Khu Khot-14	57	57
	Khu Khot-15	55	55
	Khu Khot-16	90	90
Total		1,769	1,288

In Rang sit area there exist fourteen (14) housing estates(Date Report 2.1.1) developed by private sector, of which nine (9) estates are located in the design area(refer to Table 2.1.2 and Figure 2.1.2.).

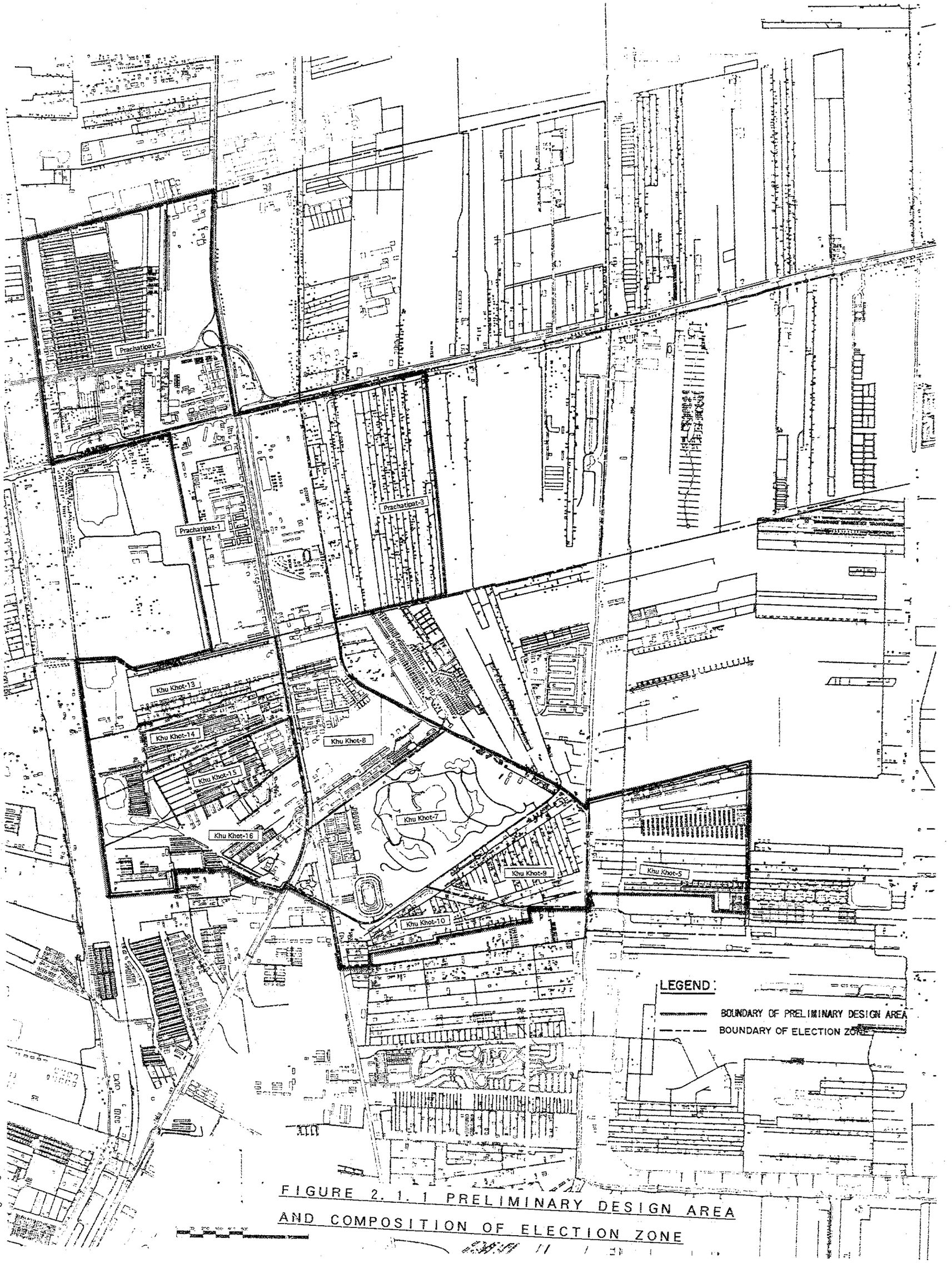

FIGURE 2.1.1 PRELIMINARY DESIGN AREA AND COMPOSITION OF ELECTION ZONE

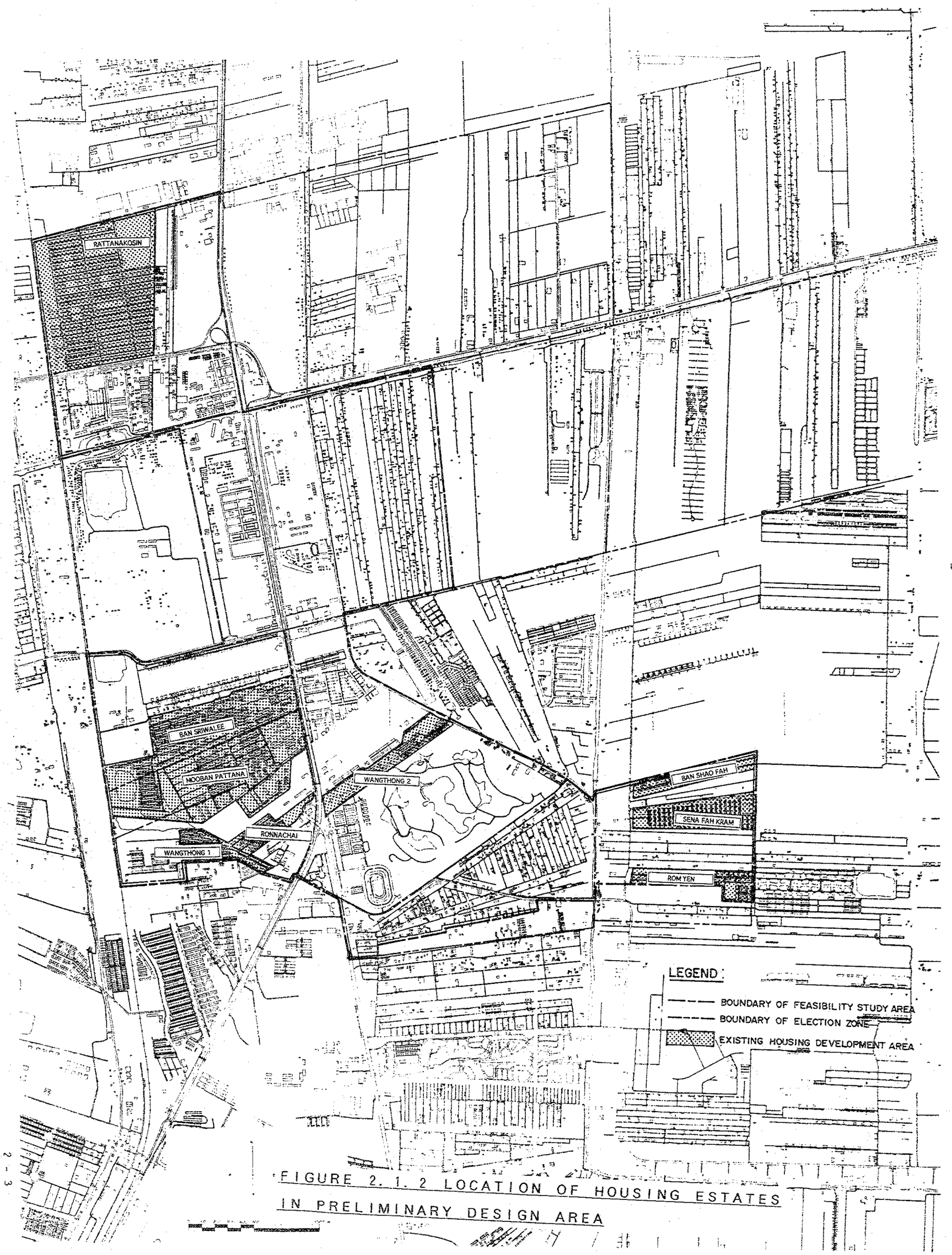

FIGURE 2.1.2 LOCATION OF HOUSING ESTATES IN PRELIMINARY DESIGN AREA

Table 2.1.2 Existing Housing Estates in The Design Area

Name	Area (ha)	No.of Houses	Population		Location	Treatment Plant Mainte.
		Plan	Present	Plan		
RATTANAKOSIN	85.6	3,000	12,000	12,000	Prachatipat-2	Poor
SENA FAH KRAM	24	700	720	2,400	Khu Khot-5	No plant
ROM YEN	11.2	700	2,000	2,800	Khu Khot-5	poor
CHO FAH	12	500	1,200	2,000	Khu Khot-5	Poor
WANGTHONG 2	4	300	400	1,200	Khu Khot-8	No plant
SRIWALEE	32	800	1,600	3,200	Khu Khot-14	Good
RATTANA	32	2,000	4,800	8,000	Khu Khot-15	Good
RONNACHAI	4.8	150	600	600	Khu Khot-16	No plant
WANGTHONG 1	4.8	300	1,200	1,200	Khu Khot-16	No plant
TOTAL	73.6	3,250	8,200	13,000		

SECTION 2 EXISTING SANITATION/SEWERAGE FACILITIES IN THE STUDY AREA.

On-site treatment and disposal of nightsoil is practiced in the study area. While five housing estates of the existing nine ones are provided with wastewater treatment facilities. Only two of them are being operated on a comparatively good level as shown in Table 2.1.2.

Existing conditions of sewerage facilities were investigated during stage III field work including the followings:

- Cross-sectional survey of ditches/channels
- Measurement of existing drainage pipes/conduits entailing survey of discharge pipes
- Cross-sectional survey of klongs and waterways

The findings/measurement results are incorporated in Data Report 2.2.1

Major klongs in the subject area are klong Rang Sit, klong Nung and klong song. The depth of klong Rang Sit, the deepest among them, was 1.0 - 2.0 m and others were rather shallower. It was noticed that deposit of solids

(sand and garbage) was common problems and water was stagnant. Solid deposit at manholes revealed insufficient maintenance practices. Manhole cover is made of thick concrete making it difficult to remove and some of them were damaged. There exist many small discharge pipes/conduits into channels/klongs, however, proper maintenance seemed not to be provided (pipes were covered with grass).

SECTION 3 POPULATION AND LAND USE

3.1 Present Population

Present population (1991) in the preliminary design area was estimated using available information covering a total of 12 election zones of the two S.Ds. Administrative population in 1991 arrived at 57,900 and 42,700 for Phrachatipat S.D and Khu Khot S.D, respectively. These figures include non-registered population at 30 % of registered as shown below.

S.D	Registered Pop.	Estimated Pop.
Phrachatipat	44,600	57,900
Khu Khot	32,810	42,700
Total	77,410	100,600

Estimated present population by S.D was distributed to each election zone in proportion to the number of electorates over 20 years old as shown in Table 3.1.1. The total population in the preliminary design area arrived at 68,892 (Prachatipat 43,318 and Khu Khot 25,574).

Further distribution of the population to the preliminary design area was made for the election zones where some areas are out of the design area. The following are assumptions/conditions for the calculation based on field observation.

1) Assumption of population percentage to the total of election zone

Prachatipat-1 60 %

Prachatipat-2 80 %

Prachatipat-3 25 %

2) Proportional percentage of subject area to the election zone

Khu Khot - 9 zones

Table 3.1.1 Population Distribution to each Election Zone

Sanitary District	Area	Election Zone	No. of Electorates	Population
Prachatipat	P.D. area	Prachatipat-1	5,550	11,417
		Prachatipat-2	11,694	24,055
		Prachatipat-3	3,814	7,846
		Sub Total	21,058	43,318
	Others		7,089	14,582
	Total		28,147	57,900
Khu Khot	P.D. area	Khu Khot-5	1,834	3,719
		Khu Khot-7	928	1,882
		Khu Khot-8	1,851	3,754
		Khu Khot-9	1,524	3,091
		Khu Khot-10	1,620	3,285
		Khu Khot-13	1,440	2,920
		Khu Khot-14	1,159	2,350
		Khu Khot-15	1,477	2,995
		Khu Khot-16	778	1,578
		Sub Total	12,611	25,574
	Others		8,444	17,126
	Total		21,055	42,700
		Grand Total	49,202	100,600

Note: P.D area - Preliminary design area
Total population in the preliminary design area : 68,892

The calculation results for respective zones are summarized in Table 3.1.2. The total population in the design area arrived at 51,604.

3.2 Design Population and Land Use

Design Population for the year 2001 is estimated by interpolating those in 1991 and 2011. The population in 2011 by election zone was calculated using land use plan and population density by land use type. Table 3.2.1 presents land use plan and total population in the design area. Figure 3.2.1 shows land use in 2011.

Table 3.1.2 Population Distribution in the Preliminary Design Area

Sanitary District	Election Zone	Design Area (ha)	Population
Prachatipat	Prachatipat-1	120.8 (0.60)	6,850
	Prachatipat-2	267.2 (0.80)	19,244
	Prachatipat-3	159.7 (0.25)	1,962
Khu Khot	Khu Khot-5	108.8 (0.74)	2,734
	Khu Khot-7	154 (1.00)	1,882
	Khu Khot-8	89 (1.00)	3,754
	Khu Khot-9	70 (1.00)	3,091
	Khu Khot-10	48.5 (0.68)	2,244
	Khu Khot-13	68 (1.00)	2,920
	Khu Khot-14	57 (1.00)	2,350
	Khu Khot-15	55 (1.00)	2,995
	Khu Khot-16	90 (1.00)	1,578
Total		1,288	51,604

Note: ( ) population percentage to administrative population

Table 3.2.1 Land Use and Population in 2011

Sanitary District	Land Use(ha)							Popu. in 2011
	Com.	Med.Pop.	Low Pop.	Insti.	Indus.	Other	Total	
Pracha -1	61.6	0.0	6.4	29.2	15.0	8.6	120.8	7,520
-tipat -2	137.0	130.2	0.0	0.0	0.0	0.0	267.2	24,250
-3	0.0	0.0	111.5	3.6	0.0	44.6	159.7	2,320
Sub Total	198.6	130.2	117.9	32.8	15.0	53.2	547.7	34,090
Khu Khot-5		108.8					108.8	6,530
-7		41.7			14.7	97.6	154.0	2,500
-8	17.0	42.6	0.0		27.4	2.0	89.0	4,600
-9		58.3			11.7		70.0	3,500
-10		48.5					48.5	2,910
-13	19.8	33.7	14.5				68.0	4,690
-14	17.0	31.7	3.6	4.7			57.0	4,010
-15	19.0	29.0	7.0				55.0	4,160
-16	33.0	48.0	9.0				90.0	7,020
Sub Total	105.8	442.3	34.1	4.7	53.8	99.6	740.3	39,920
Total	304.4	572.5	152.0	37.5	68.8	152.8	1,288	74,010

Note: Population density

Commercial area	120 person/ha
Med. population area	60 person/ha
Low population area	20 person/ha

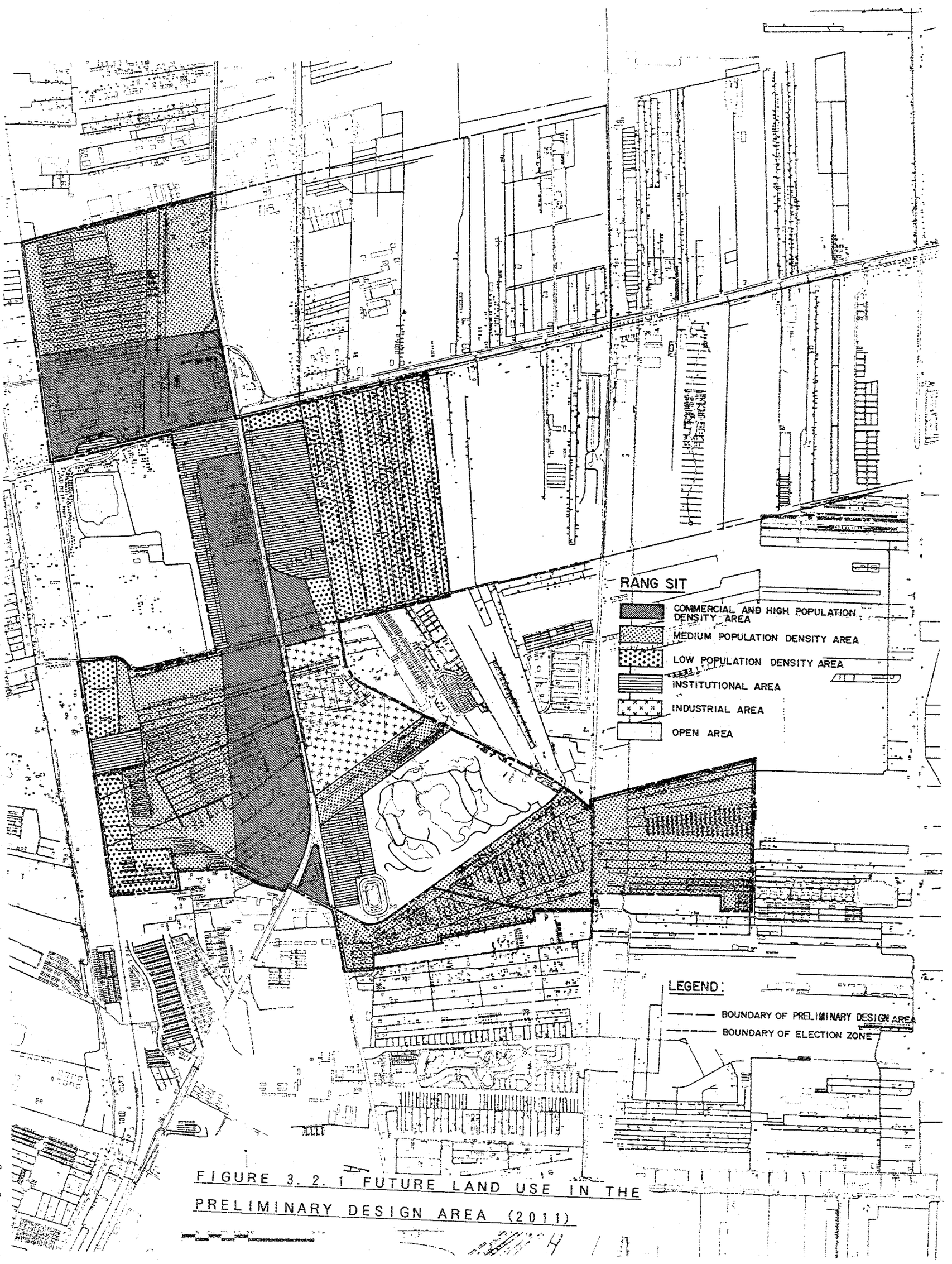

FIGURE 3.2.1 FUTURE LAND USE IN THE PRELIMINARY DESIGN AREA (2011)

Table 3.2.2 shows projected design population in 2001, which is proportionately calculated between those in 1991 and 2011. The total population for design purpose arrived at 62,830. Population in the aforementioned housing estates is included in the design population.

Table 3.2.2 Design Population in 2001

Sanitary District	Election zone	Population		
		1991	2001	2011
Prachatipat	Prachatipat-1	6,850	7,190	7,520
	-2	19,244	21,750	24,250
	-3	1,962	2,140	2,320
	Sub Total	28,056	31,080	34,090
Khu Khot	Khu Khot-5	2,734	4,630	6,530
	-7	1,882	2,190	2,500
	-8	3,754	4,180	4,600
	-9	3,091	3,300	3,500
	-10	2,244	2,580	2,910
	-13	2,920	3,810	4,690
	-14	2,350	3,180	4,010
	-15	2,995	3,580	4,160
	-16	1,578	4,300	7,020
	Sub Total	23,548	31,750	39,920
	Total	51,604	62,830	74,010

SECTION 4 QUANTITY AND QUALITY OF WASTEWATER

Wastewater quantity and quality (BDD load) to be collected and treated for the preliminary design area were calculated in the same procedure as sewerage master planning. Major assumptions for unit wastewater quantity and quality by pollution source are basically utilized from water pollution

control plan and sewerage master plan. Industrial wastewater generated at present in the design area is assumed to be constant from present to the design year.

4.1 Unit Wastewater Quantity and Quality on a Discharged Base

(1) Domestic wastewater

Discharged rate against generated quantity /water consumption is assumed to be 80 percent. Treatment efficiency of nightsoil treatment facilities/septic tank (BOD removal ratio) is expected to be 50 percent. Unit figures on a daily average base for the year 2001 are summarized below.

Unit Wastewater Quantity (lpcd)			Unit BOD Load (gpcd)		
Sullage	Toiletwaste	Total	Sullage	Toiletwaste	Total
120.8	24	144.8	34.3	5.5	39.8

(2) Business wastewater

Unit wastewater quantity and quality on the discharged base are calculated under the same assumptions as domestic wastewater. Generated base of the wastewater is from the study result of water pollution control plan (Chapter 8, Part I). Adopted figures on a daily average base for design purpose are as follows:

Unit Wastewater Quantity (lpcd)	Unit BOD Load (gpcd)
72	8.6

4.2 Wastewater Quantity and Quality for Design of Sewerage Facilities

Design quantity and quality were estimated covering domestic, business and industrial wastewater as well as groundwater infiltration.

(1) Domestic wastewater

The total wastewater quantity and BOD load were obtained from the unit wastewater figures and projected population as follows:

Wastewater quantity: 0.1448 m^3/c.d. x 62,830 = 9,098 m^3/d
BOD load : 0.0398 kg/c.d x 62,830 = 2,500 kg/d

(2) Business wastewater

Design figures for business wastewater were calculated in the same procedure as that of domestic wastewater.

Wastewater quantity: 0.072 m^3/c.d. x 62,830 = 4,524 m^3/d
BOD load : 0.086 kg/c.d x 62,830 = 540 kg/d

(3) Industrial wastewater

Under the assumption that present wastewater discharged in the design area will be constant through the future, wastewater quantity and BOD load were summed up using data investigated by the DIW as referred to in the Master Plan, Part II.

Wastewater quantity: 4,173 m^3/d
BOD load : 1,457 kg/d

(4) Groundwater infiltration

In addition to the wastewater discharged from domestic, business and industrial sources, 20 percent of groundwater quantity to the wastewater is considered.

(5) Design Wastewater quantity and quality

The total wastewater quantity and quality in the preliminary design area are estimated taking into account of the abovementioned factors. The following are the total quantity and quality.

Type of sources	Wastewater Quantity (m^3/d)	BOD Load (kg/d)
Domestic wastewater	9,097	2,500
Business wastewater	4,525	540
Institutional wastewater	4,174	1,457
Groundwater	3,559	-
Total	21,355	4,497

Table 4.2.1 summarizes quantity and quality of wastewater by source type covering 12 election zones.

SECTION 5 DESIGN CRITERIA

Design criteria for design of sewerage facilities are studied in sewerage master plan, Section 3.9 Chapter 2, Part II. A summary of technical design criteria are included in this section in terms of capacity calculation, hydraulic calculation and structural design of facilities(refer to Table 5.1).

Table 5.1 Design Criteria for Sewerage Facilities

Item	Design Criteria
Capacity calculation	
(1) Daily ave. wastewater quantity	
Domestic and business W.W	80 % of water consumption
Industrial W.W	100 % of effluent volume
(2) Daily Max. and Hourly Max. W.W	
Domestic and business W.W (Daily ave. water consumption : Q)	Daily max./Daily ave. = 1.2 Hourly max./Daily max. = 1.3 Hourly max./Daily ave. = 1.56 Daily ave.W.W. quantity = 0.8Qx1.2
(3) Groundwater infiltration	20 % of daily average wastewater
(4) Intercepting capacity	3 times of hourly max.wastewater
(5) Wastewater treatment plant	Effluent quality: BOD less then 20mg/l SS less than 30mg/l Water temperature : 25 °c

Table 4.2.1 Quantity and Quality of Wastewater

Name of Election Zone	Pre. Design Area		Wastewater Discharge (m3/day)				Groundwater Infiltration (m3/day)	Wastewater Total (m3/day)	Pollution Load Discharge (kg-BOD/day)			
	Service Area (ha)	Population in 2001	Domestic	Commerce & Institutional	Industrial	Total			Domestic	Commerce & Institutional	Industrial	Total
Pracha-1	120.8	7,190	1,041	518	333	1,892	378	2,270	286	62	111	459
Pracha-2	267.2	21,750	3,149	1,566	1,181	5,896	1,179	7,075	866	187	433	1,486
Pracha-3	159.7	2,140	310	154	762	1,226	245	1,471	85	18	302	405
Khu-5	108.8	4,630	670	333	46	1,049	210	1,259	184	40	14	238
Khu-7	154.0	2,190	317	158	6	481	96	577	87	19	1	107
Khu-8	89.0	4,180	605	301	1,839	2,745	549	3,294	166	36	595	797
Khu-9	70.0	3,300	478	238	7	723	145	868	131	28	1	160
Khu-10	48.5	2,580	374	186	0	560	112	672	103	22	0	125
Khu-13	68.0	3,810	552	274	0	826	165	991	152	33	0	185
Khu-14	57.0	3,180	460	229	0	689	138	827	127	27	0	154
Khu-15	55.0	3,580	518	258	0	776	155	931	142	31	0	173
Khu-16	90.0	4,300	623	310	0	933	187	1,120	171	37	0	208
Total	1,288.0	62,830	9,097	4,525	4,173	17,795	3,559	21,355	2,500	540	1,457	4,497

Table 5.1 Design Criteria for Sewerage Facilities (cont'd)

Item	Design Criteria
(6) Pump station capacity	Dry season: design hourly max. Rainy season: three times design hourly max.
Hydraulic Calculation (1) Equation for flow calculation	Manning's Formula
(2) Roughness coefficient	R.C pipe : 0.013 Steel pipe : 0.012
(3) In-pipe velocity	Minimum velocity Sanitary sewer:60 cm/sec. Storm and combined sewer:80 cm/sec. Maximum velocity:3.0 m/sec.
Structural Design of Facilities (1) Interceptor	Starting point:drainage area of 20ha Alignment: under the existing public roads (full use of existing drainage pipes) Minimum dia. of sewer: RC 300 mm Force main crossing waterways: less than 200mm in dia. Earth cover: max.5.0 m below G.L min.1.0 m below G.L
(2) Manhole	Manhole type: Japanese standard Manhole spacing: Pipe dia. — Max.spacing less than 600 mm — 40 m 800 - 1200 mm — 80 m more than 1200 mm — 120 m
(3) Overflow chamber	Installation type Open channel/U type drain without a cover channel/U type drain with a cover Drainage pipe/conduit Weir type: submerged weir Screen: bar type(75 mm) sand deposit: 30 cm below invert level of sewer
(4) Siphon	River crossing:parallel installation velocity: 20-30 % up at upstream to downstream
(5) Pump station	Manhole type: less than 5.0 m^3/min. Common type: more than 5.0 m^3/min.