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

Item	Design Criteria
(6) Activated sludge treatment process	Design criteria are summarized in the design covering the following facilities. Stormwater Sedimentation Basin Primary Sedimentation Basin Aeration Tank Secondary Sedimentation Basin Disinfection Tank Gravity Thickener Digestion Tank Mechanical Dewatering

SECTION 6 WASTEWATER COLLECTION SYSTEM

The alignments of main interceptors and pump stations in application of combined collection method were designed in the Master Plan for the target year of 2011. In the context of the Master Plan sub-main interceptors in the preliminary design area were additionally designed with the design flow for the final target year of 2011. The following are findings and counter-measures stemming from field investigations.

(1) There is no plan for road expansion and construction/improvement of klongs (DTCP and S.Ds). Existing public roads (refer to Data Report 2.6.1) are to be utilized for installation of interceptors. The routes along klongs are, in principle, avoided in the difficulty of area assurance for construction work and maintenance requirements.

(2) Locations of pump stations are to be arranged considering land availability including the space under elevated bridge.

Distribution of population and wastewater quantity was made in use of population density by land use type (refer to Supporting Report 2.6.1).

Alignments of interceptors and pump stations are shown in Figure 6.1 and their profiles in Figure 6.2(refer to hydraulic calculation in Supporting Report 2.6.1). The designs of eight(8) pump stations and four(4) inverted siphon are presented in Figures 6.3 and 6.4, respectively. Table 6.1 presents composition of collection facilities. Design fundamentals and specifications of pump stations and inverted siphon are included in Support-

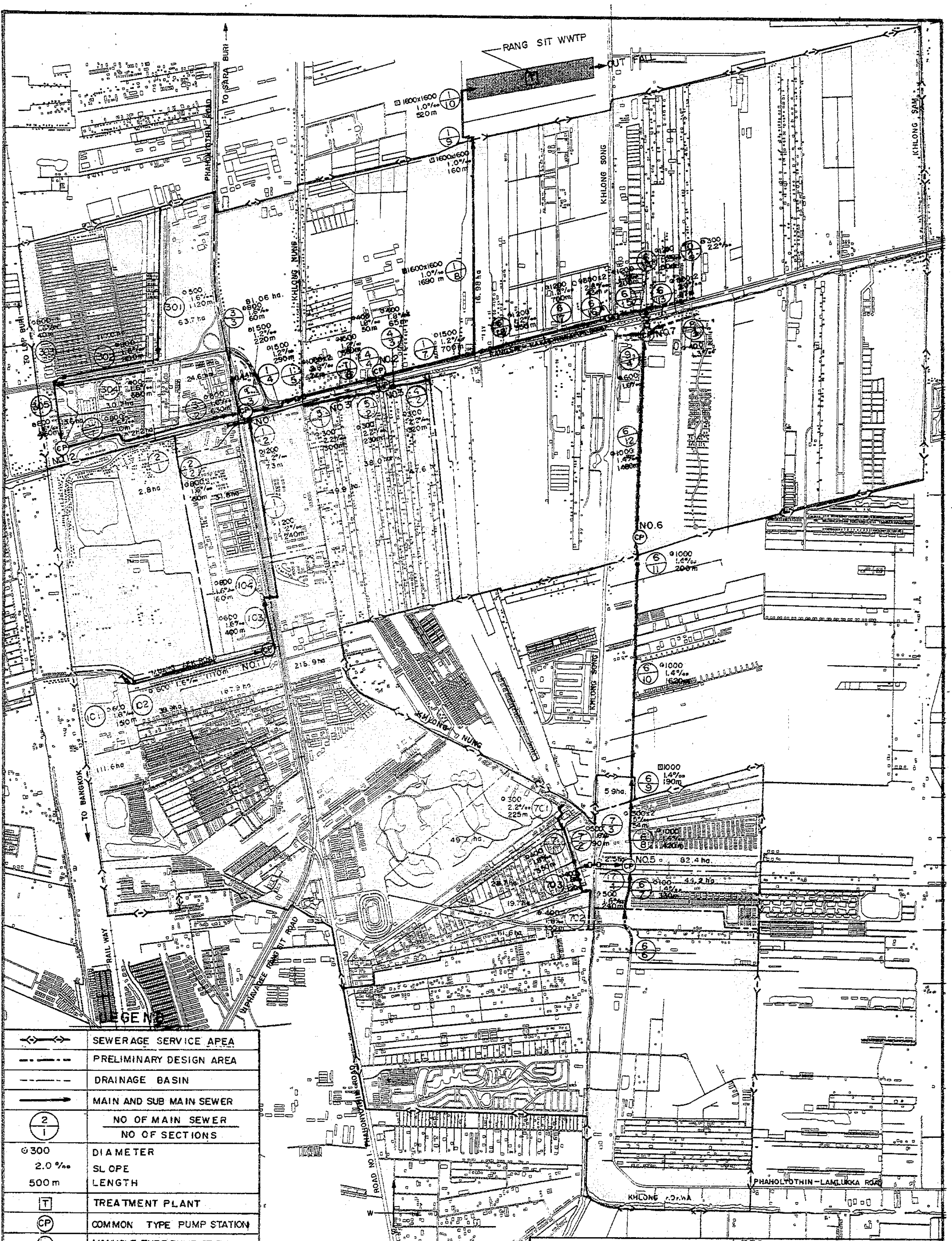
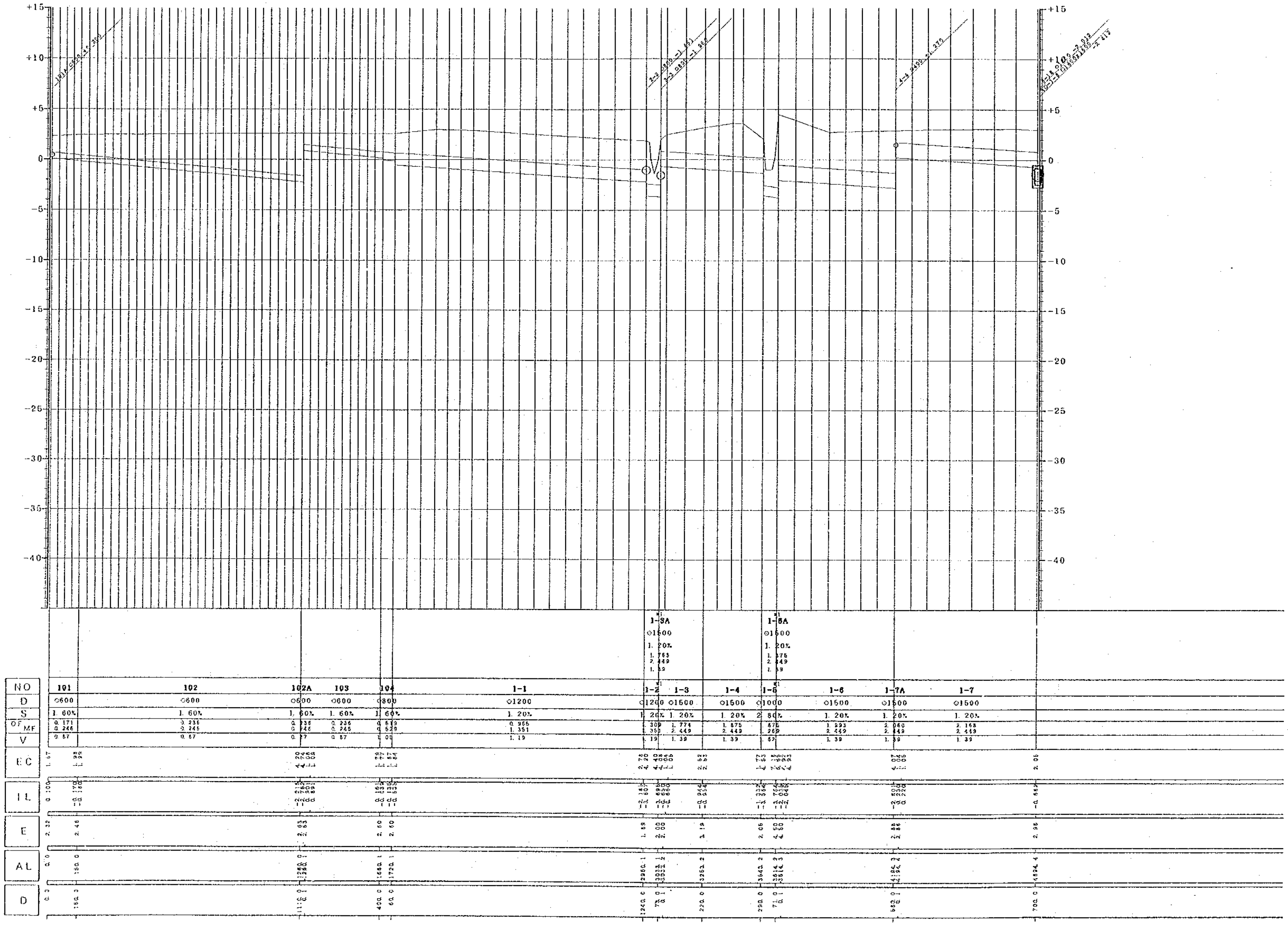


FIG. 6.1 PROPOSED SEWERAGE SYSTEM FOR PRELIMINARY DESIGN (RANGSIT AREA)

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

JAPAN INTERNATIONAL COOPERATION AGENCY



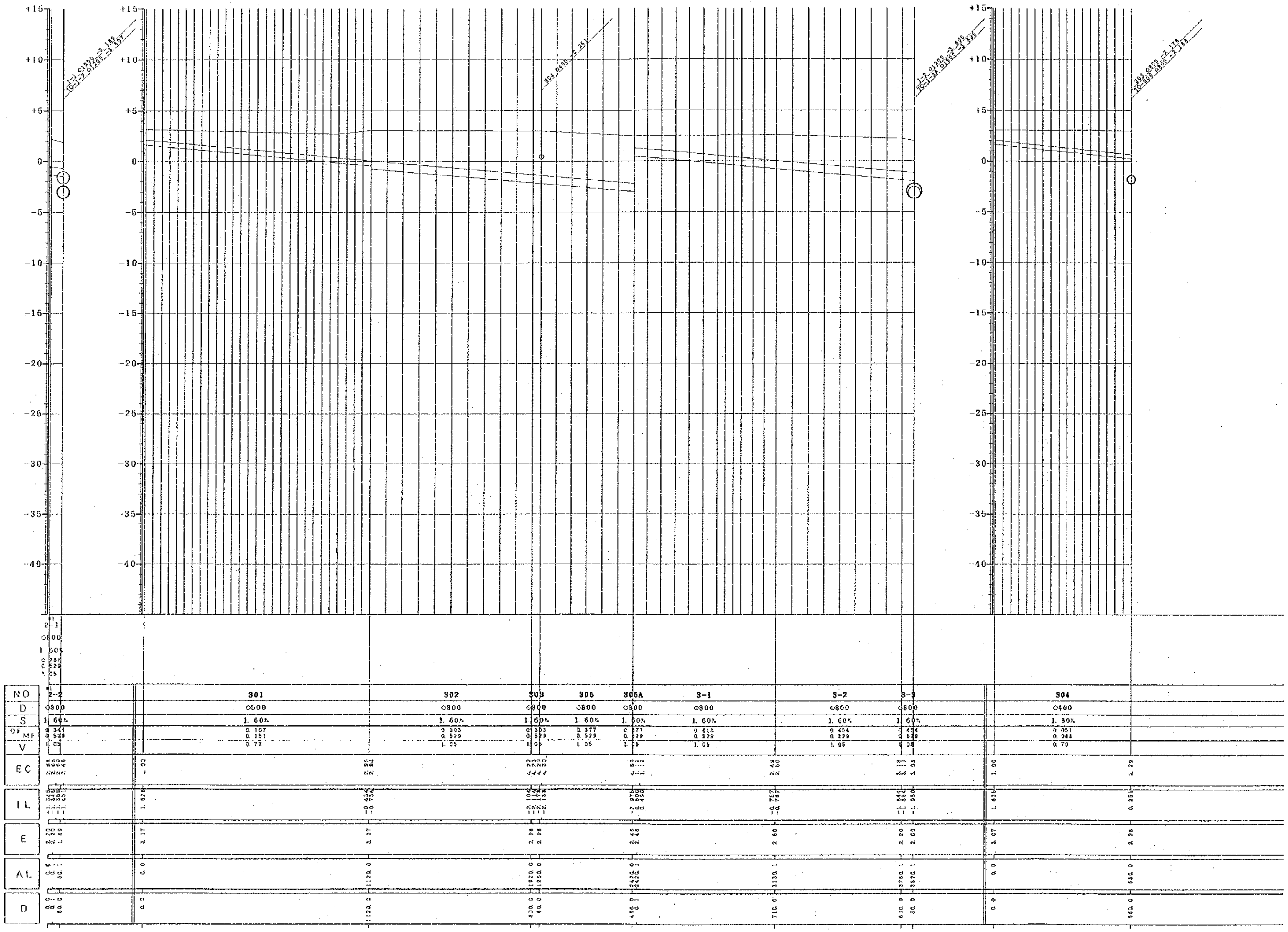
LEGEND

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

101	102	102A	103	104
1-1	1-2	1-3A	1-3	1-4
1-5	1-6A	1-6	1-7A	1-7

FIGURE 6.2 (1)	V 1:200
RANGSIT	H 1:10,000
PRELIMINARY DESIGN FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY	



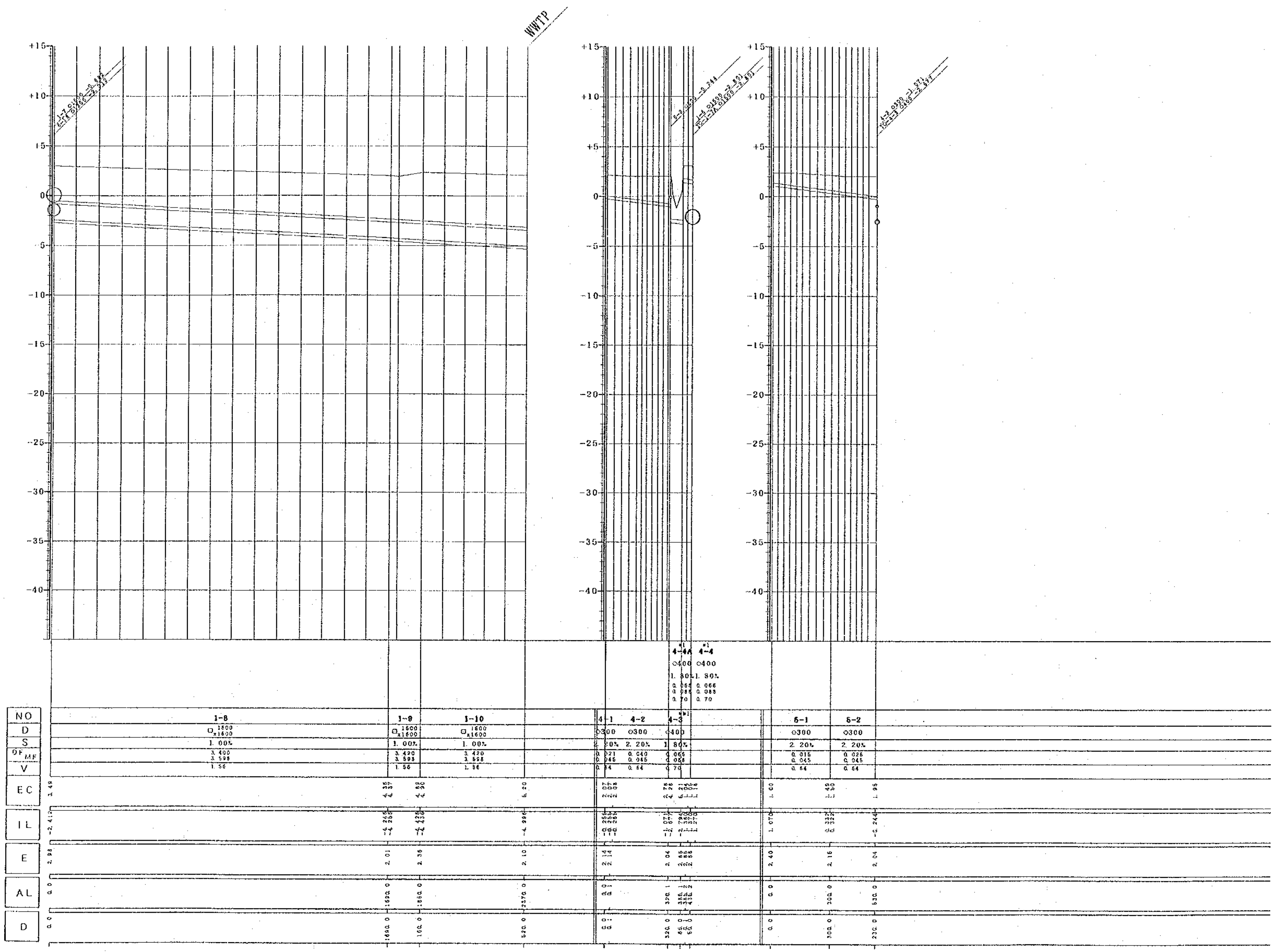
LEGEND

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

2-1	2-2	301	302	303
305	305A	3-1	3-2	3-3
304				

FIGURE 6.2 (2) RANGSIT	V 1:200 H 1:10,000
PRELIMINARY DESIGN 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

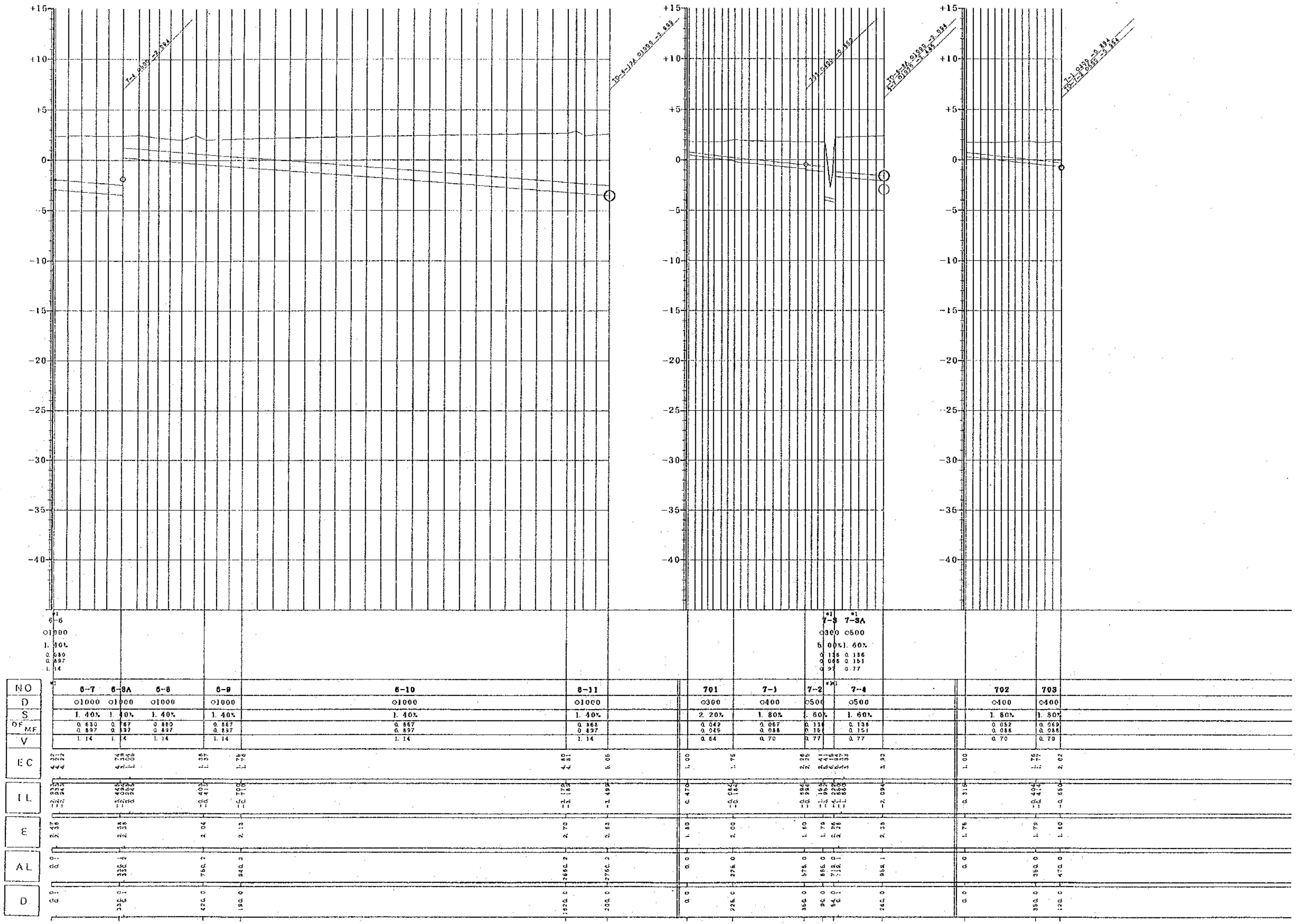
No. of Sewers

1-8	1-9	1-10	4-1	4-2
4-3	4-4A	4-4	5-1	5-2

FIGURE 6.2 (3)	V 1:200
RANGSIT	H 1:10,000

PRELIMINARY DESIGN FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY



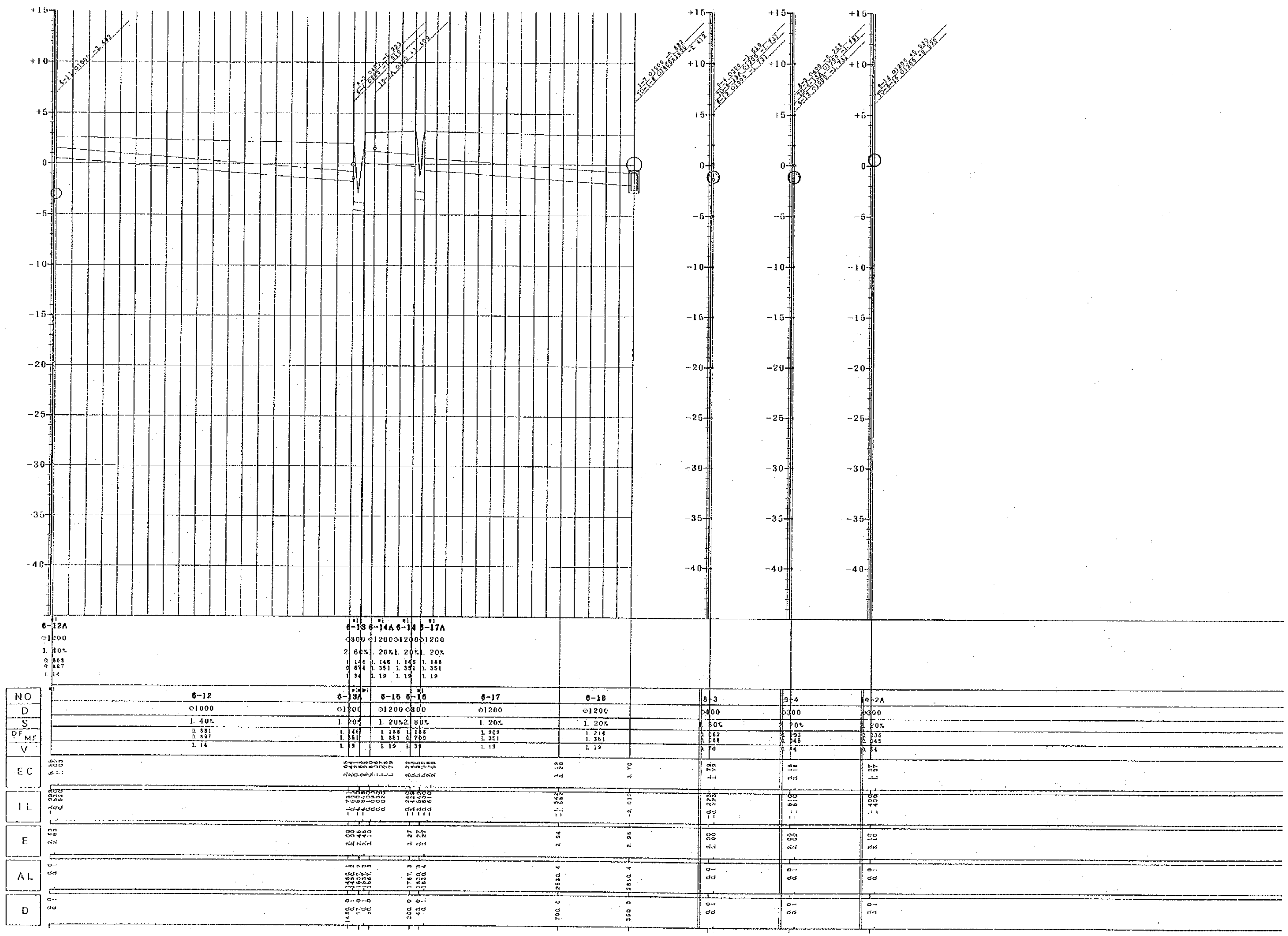
LEGEND

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

6-6	6-7	6-8A	6-8	6-9
6-10	6-11	701	7-1	7-2
7-3	7-3A	7-4	702	703

FIGURE 6.2 (4)	V 1:200
RANGSIT	H 1:10,000
PRELIMINARY DESIGN 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

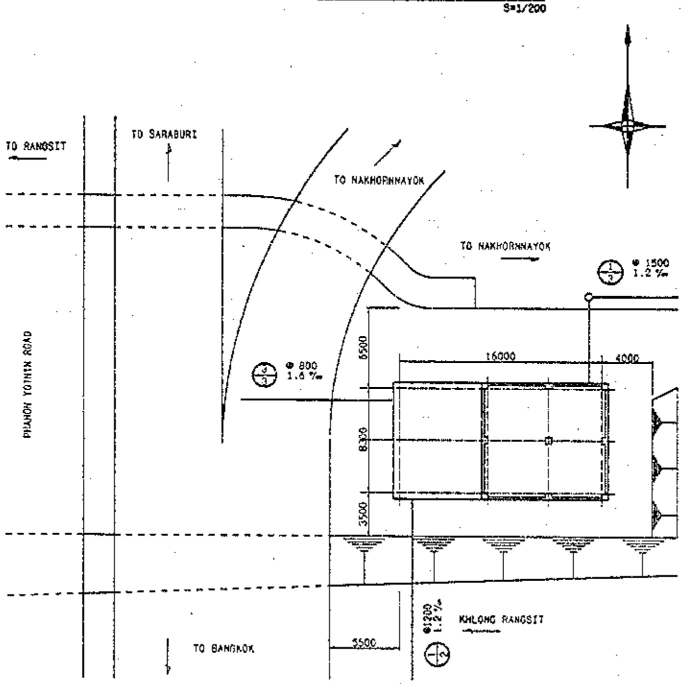
6-12A	6-12	6-13A	6-13	6-14A
6-14	6-15	6-16	6-17A	6-17
6-18	8-3	9-4	10-2A	

FIGURE 6.2 (5)	V 1:200
RANGSIT	H 1:10,000
PRELIMINARY DESIGN FOR THE SEWERAGE DEVELOPMENT PROJECT FOR LOWER CHAO PHRAYA RIVER BASIN	
JAPAN INTERNATIONAL COOPERATION AGENCY	

NO. 1 PUMP STATION

General Plan

S=1/200



Water Levels Diagram

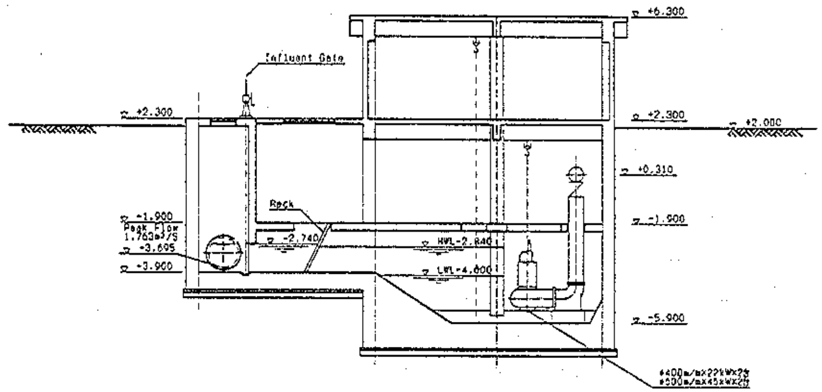


Figure 6.3. (1)-1
Preliminary Design of No. 1 Pump Station
Rang Sit Area

NO. 1 PUMP STATION

S=1/100

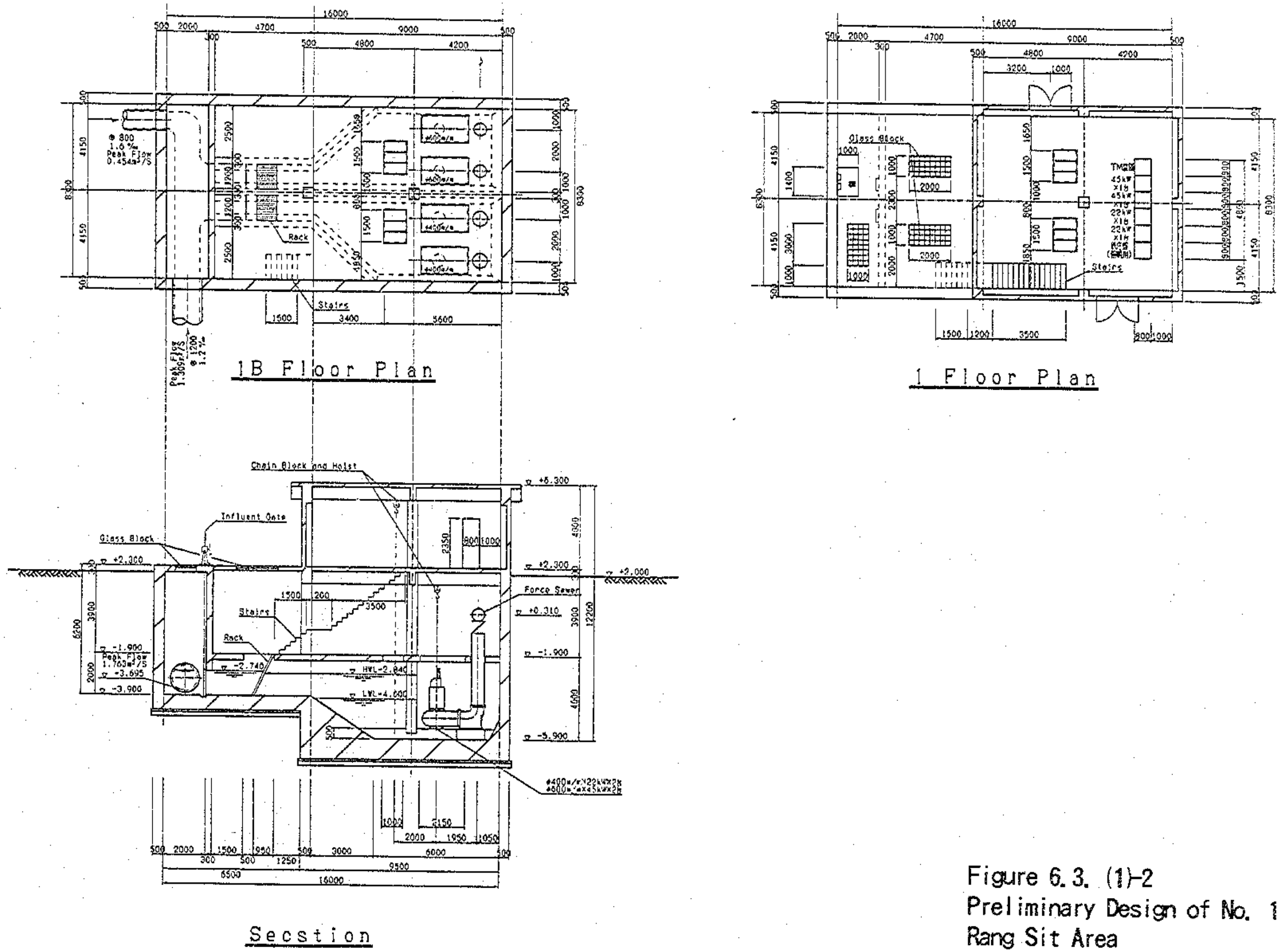
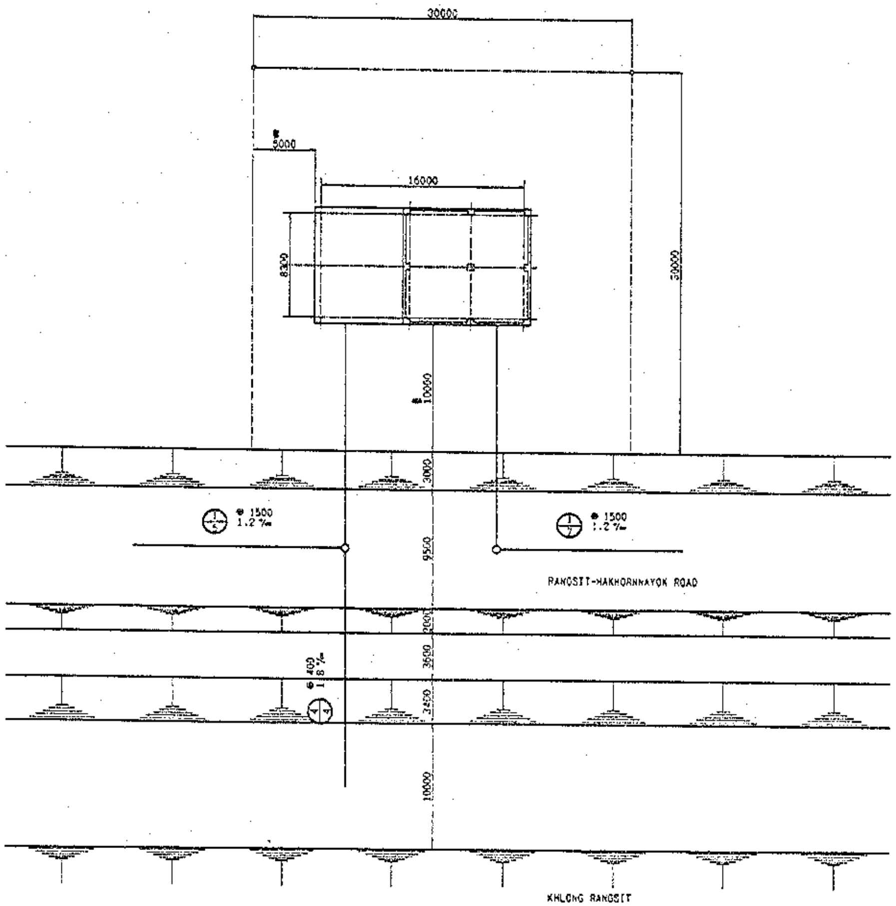


Figure 6.3. (1)-2
Preliminary Design of No. 1 Pump Station
Rang Sit Area

NO. 2 PUMP STATION

General Plan



Water Levels Diagram

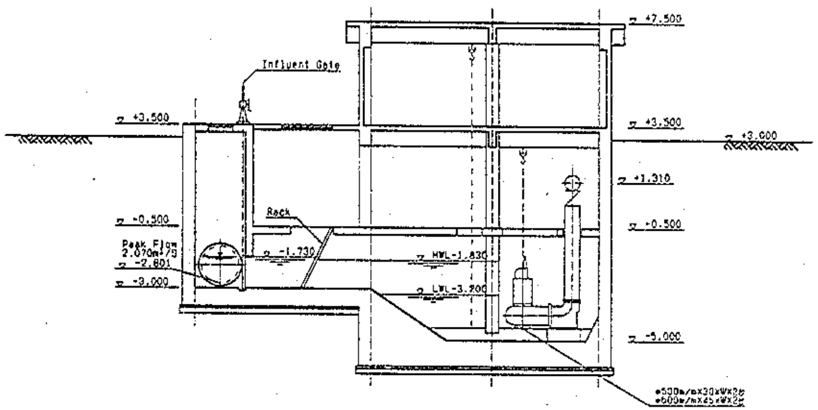


Figure 6.3. (2)-1
Preliminary Design of No. 2 Pump Station
Rang Sit Area

NO. 2 PUMP STATION

S=1/100

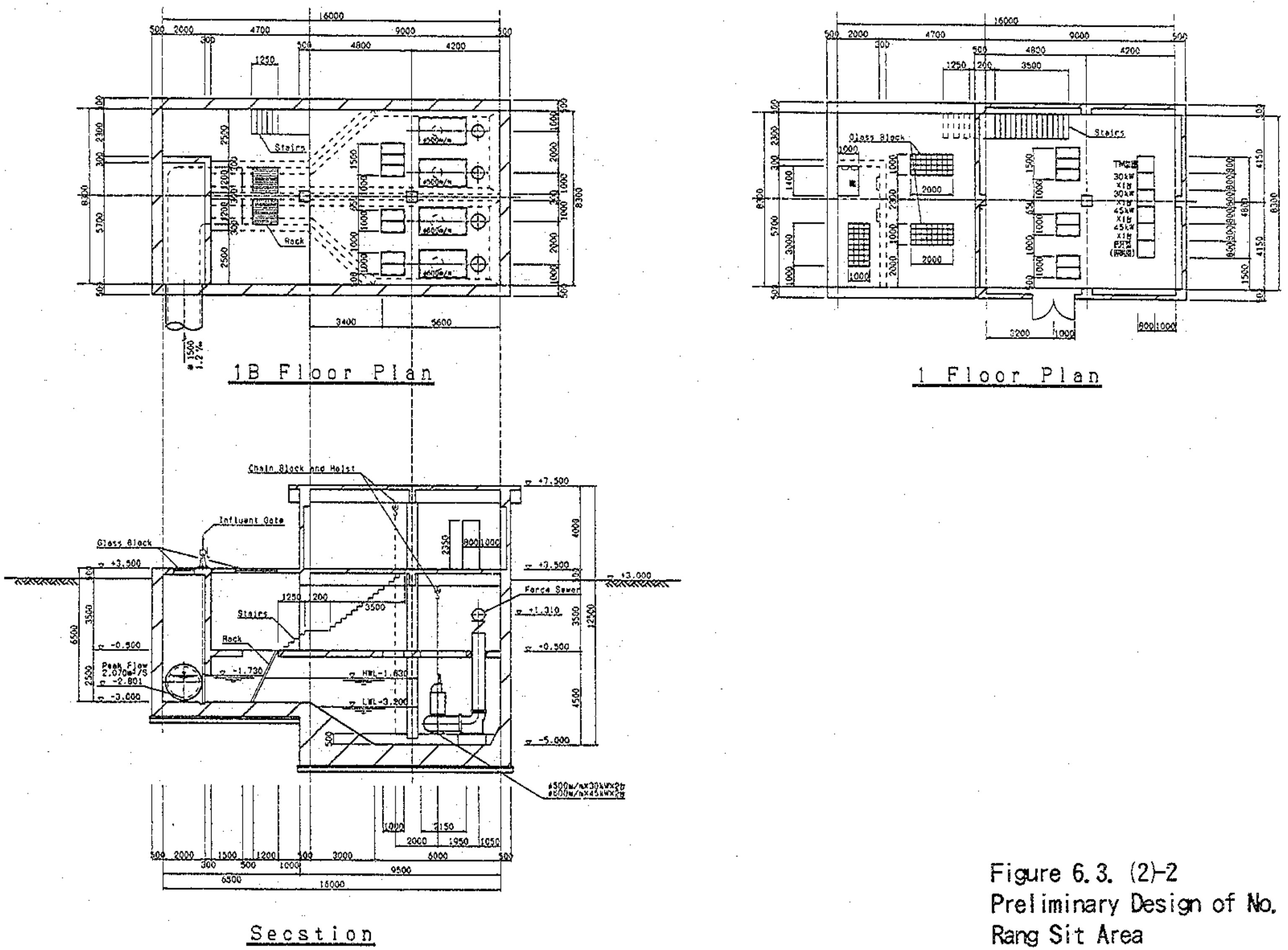
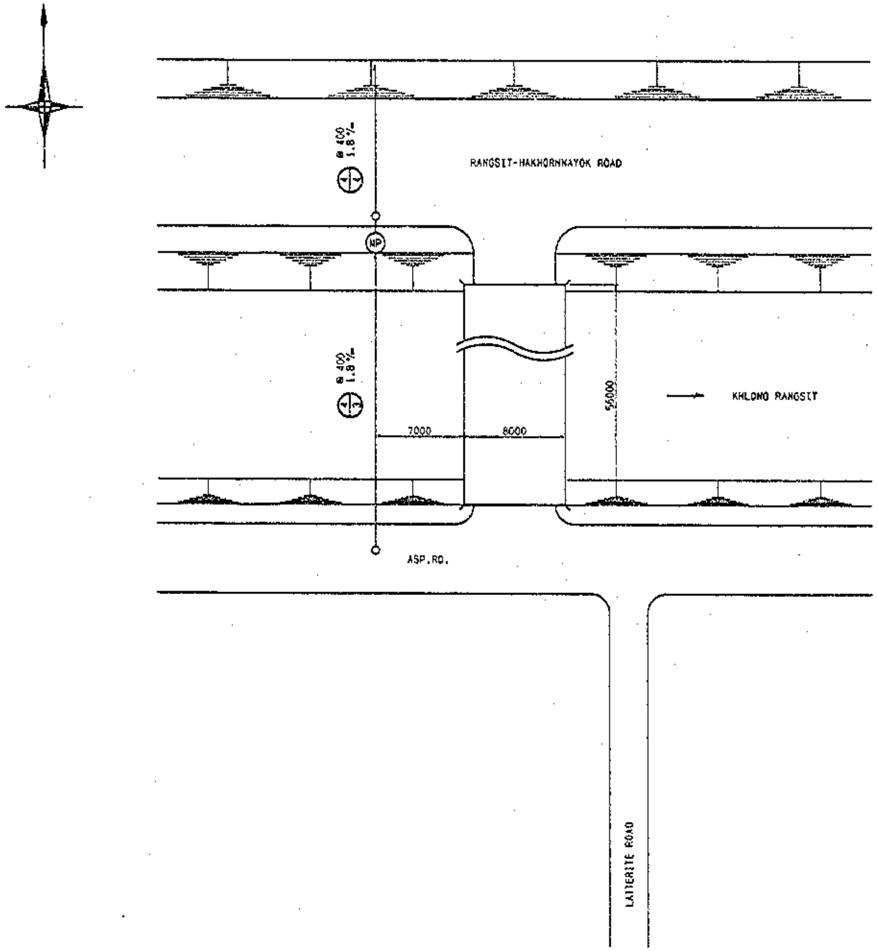


Figure 6.3. (2)-2
Preliminary Design of No. 2 Pump Station
Rang Sit Area

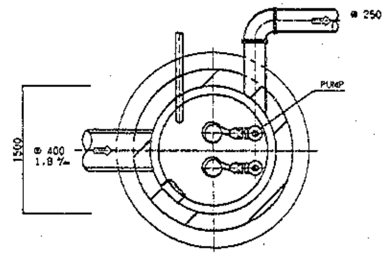
NO. 3 PUMP STATION

General Plan
S=1/200



Manhole Type
S=1/30

Plan



Cross Section

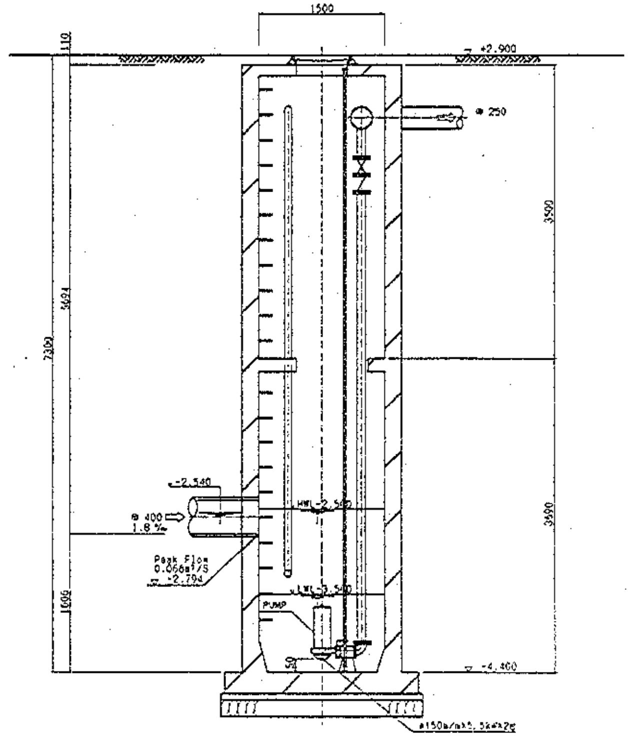
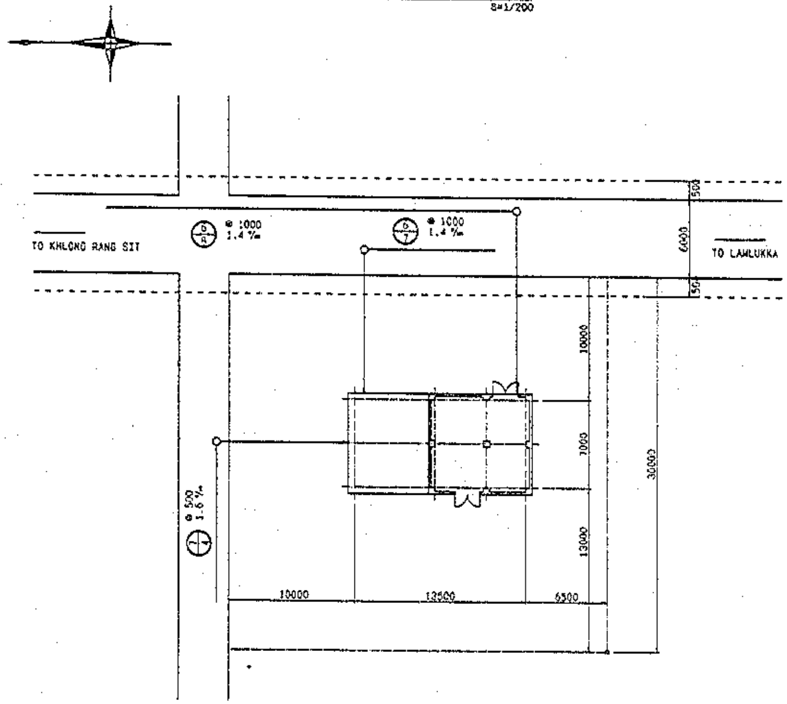


Figure 6.3. (3)
Preliminary Design of No. 3 Pump Station
Rang Sit Area

NO. 5 PUMP STATION

General Plan

S=1/200



Water Levels Diagram

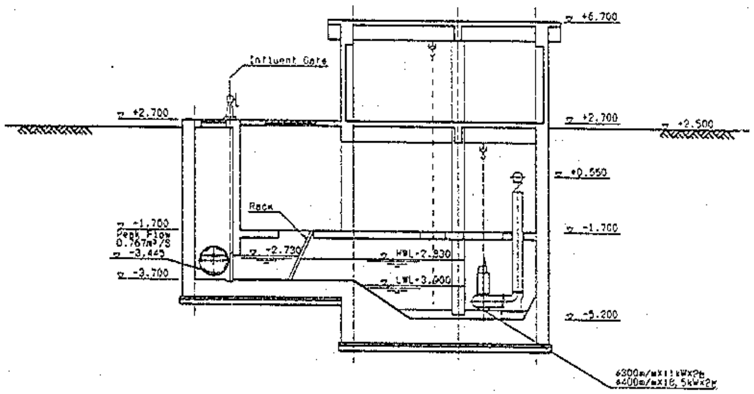


Figure 6.3. (4)-1
Preliminary Design of No. 5 Pump Station
Rang Sit Area

NO. 5 PUMP STATION

S=1/100

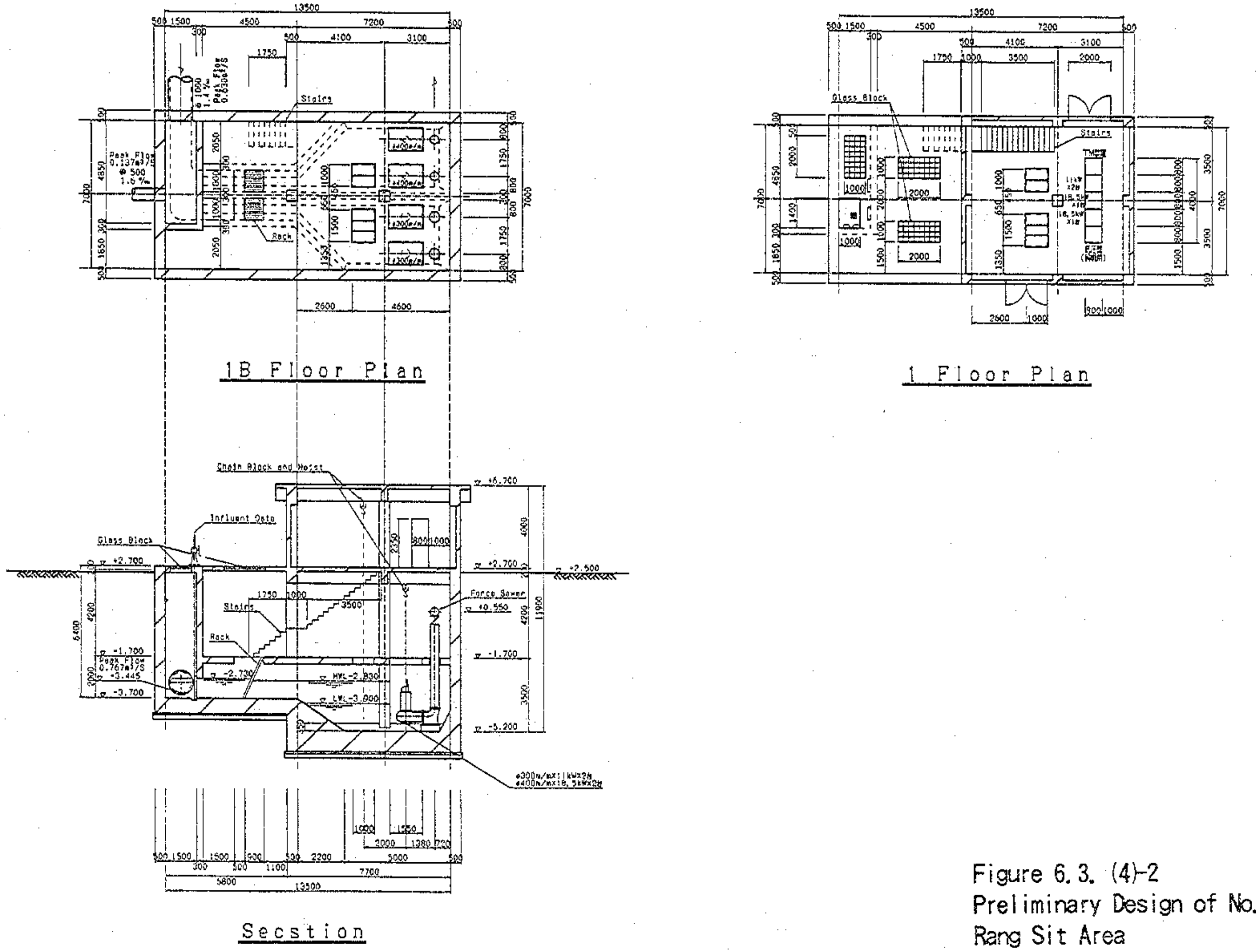
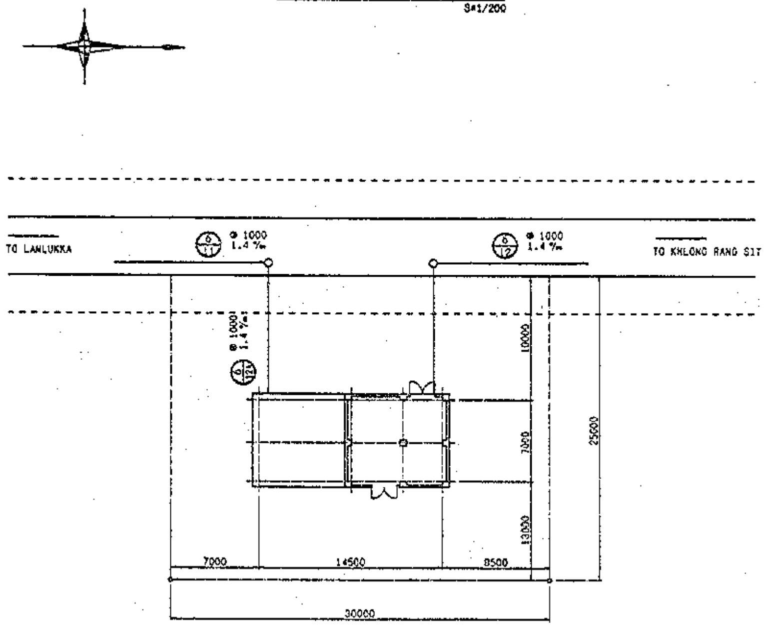


Figure 6.3. (4)-2
Preliminary Design of No. 5 Pump Station
Rang Sit Area

NO. 6 PUMP STATION

General Plan



Water Levels Diagram

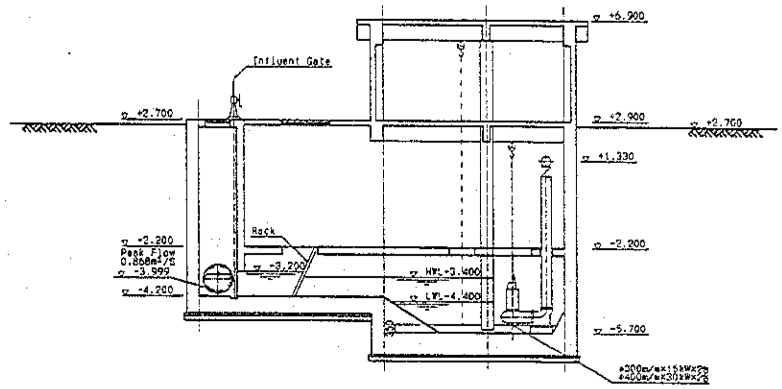


Figure 6.3. (5)-1
Preliminary Design of No. 6 Pump Station
Rang Sit Area

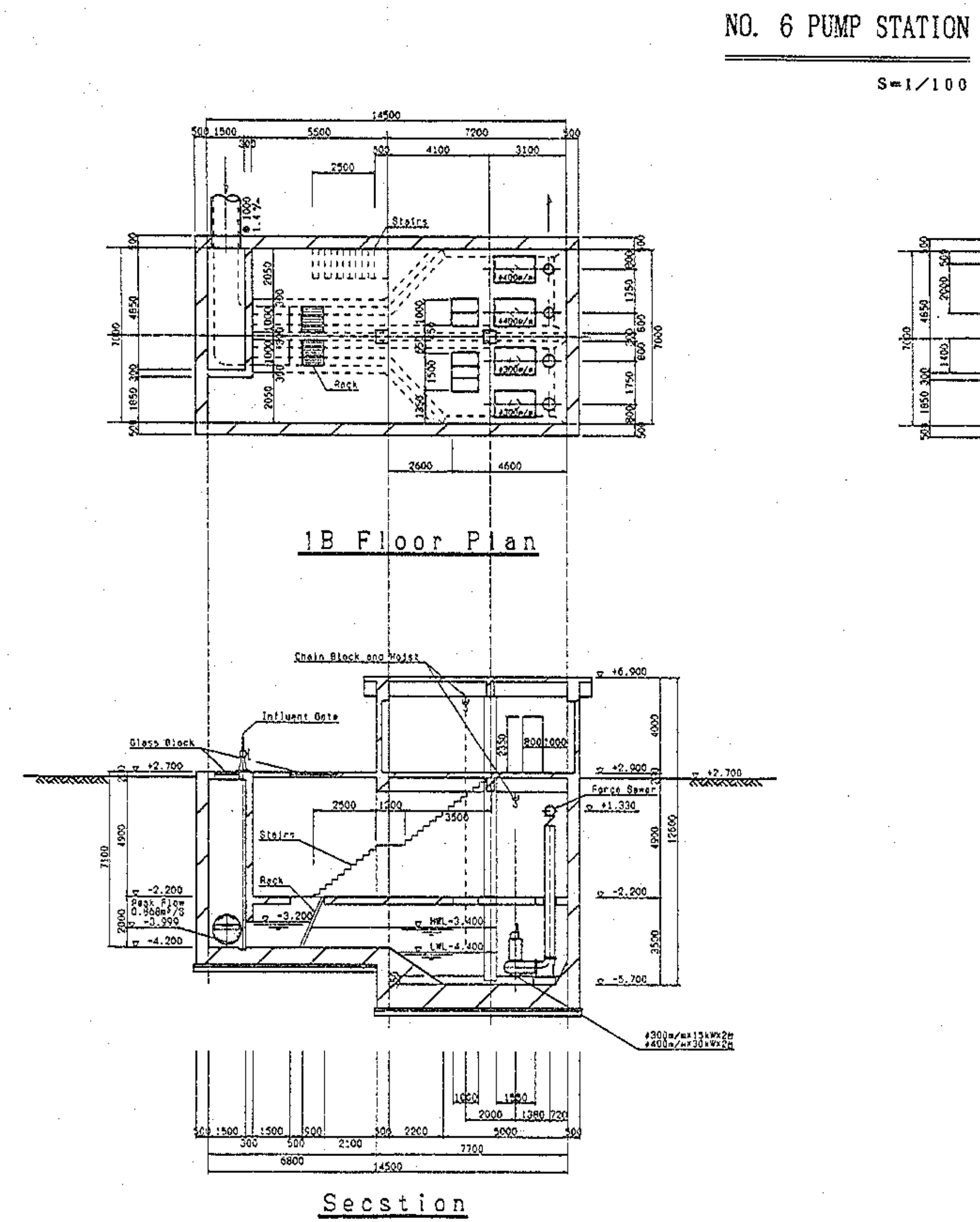
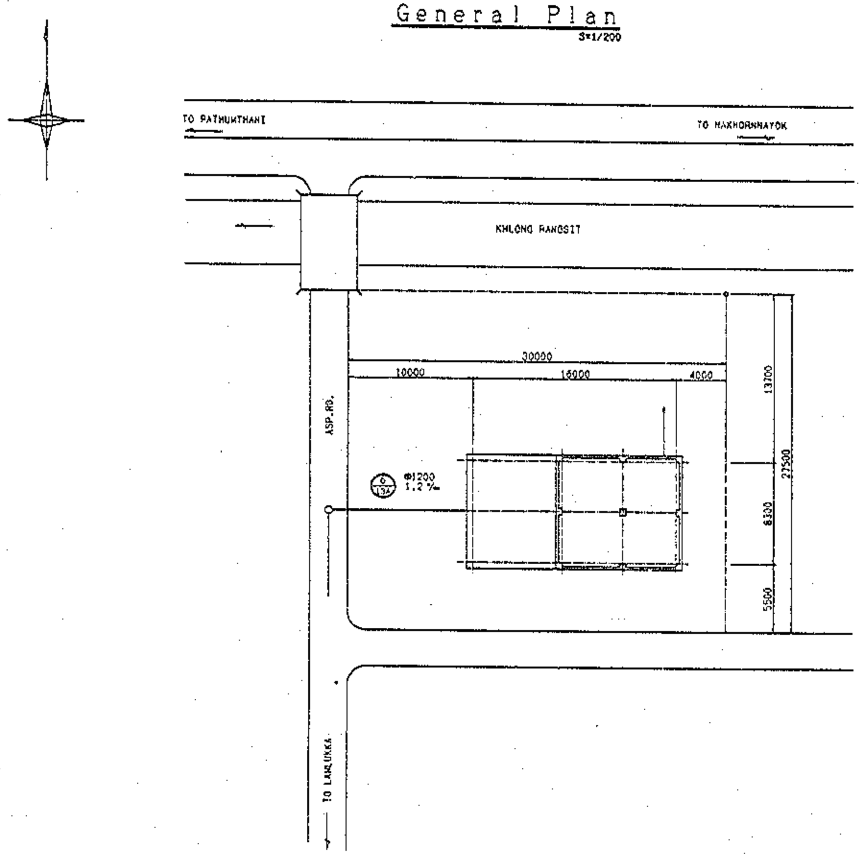


Figure 6.3. (5)-2
Preliminary Design of No. 6 Pump Station
Rang Sit Area

NO. 7 PUMP STATION

General Plan



Water Levels Diagram

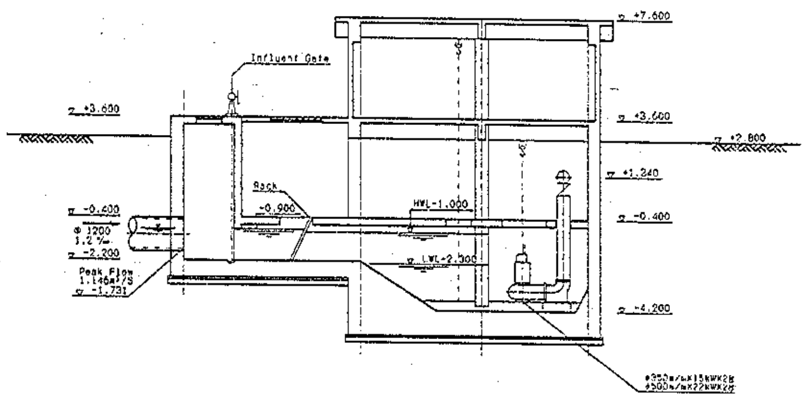


Figure 6.3. (6)-1
Preliminary Design of No. 7 Pump Station
Rang Sit Area

NO. 7 PUMP STATION

S=1/100

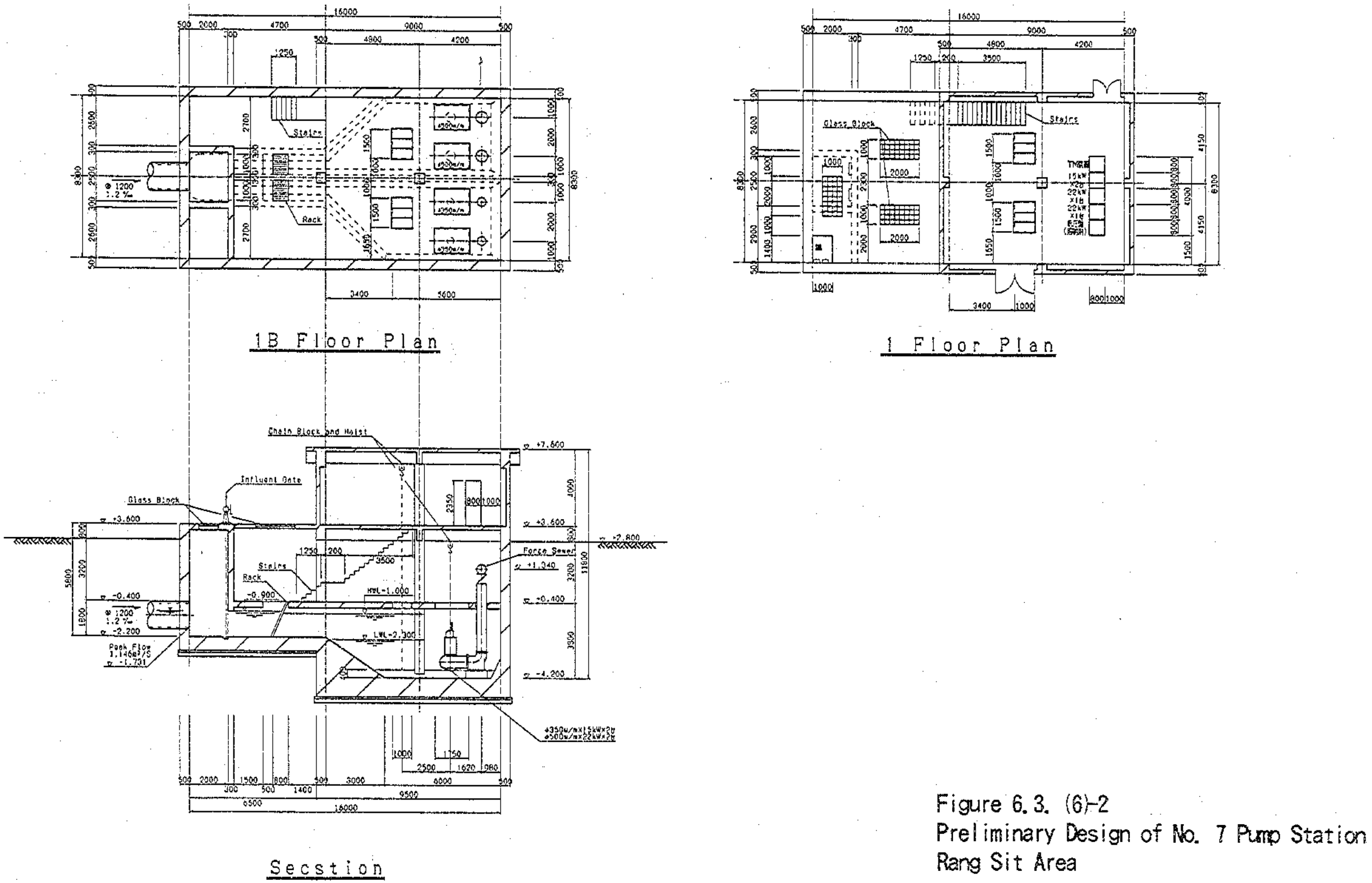
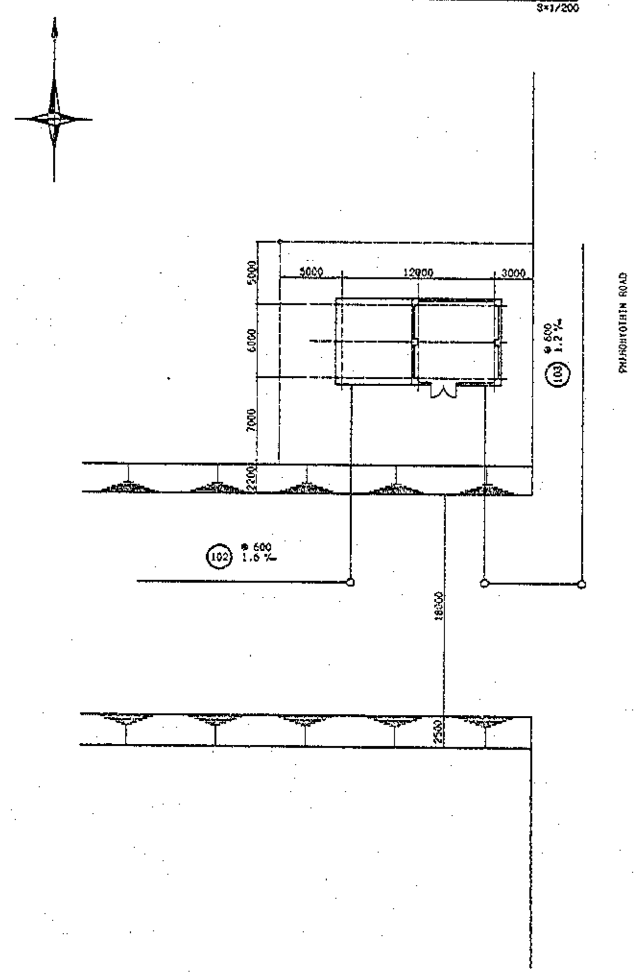


Figure 6.3. (6)-2
Preliminary Design of No. 7 Pump Station
Rang Sit Area

NO. 11 PUMP STATION

General Plan

S=1/200



Water Levels Diagram

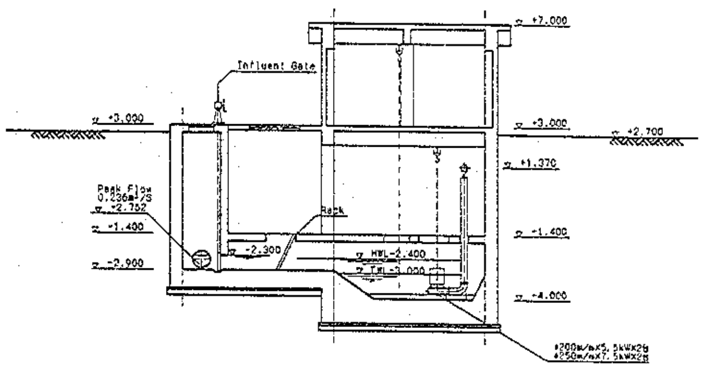


Figure 6.3. (7)-1
Preliminary Design of No. 11 Pump Station
Rang Sit Area

NO. 11 PUMP STATION

S=1/100

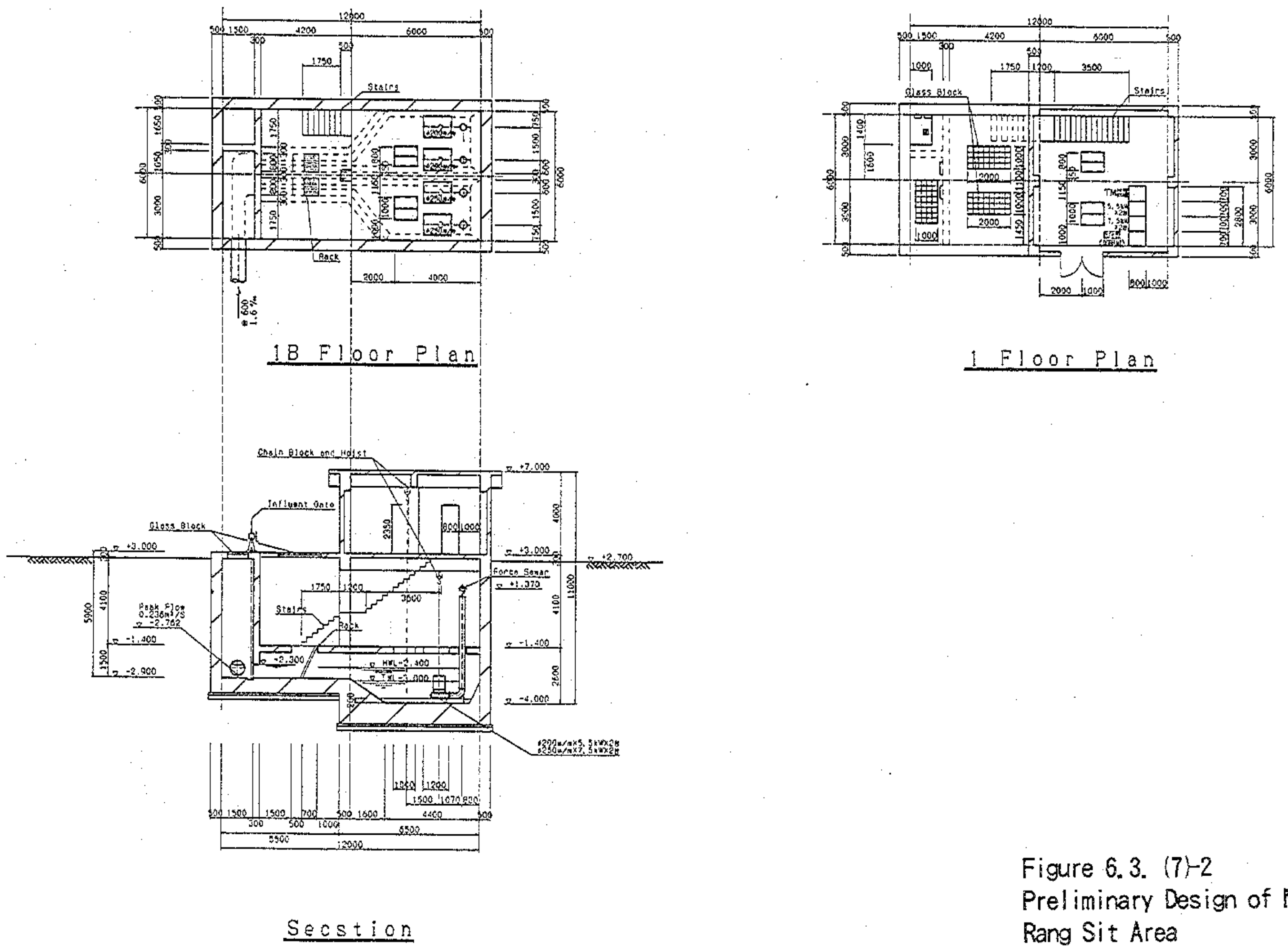
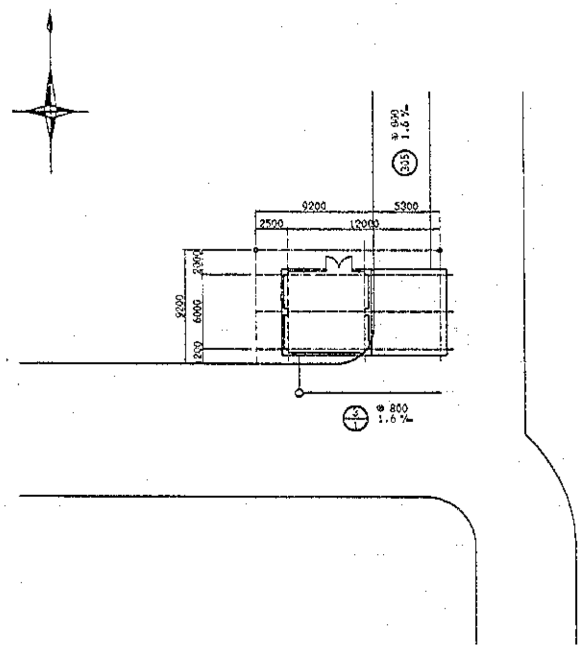


Figure 6.3. (7)-2
Preliminary Design of No. 11 Pump Station
Rang Sit Area

NO. 12 PUMP STATION

General Plan



Water Levels Diagram

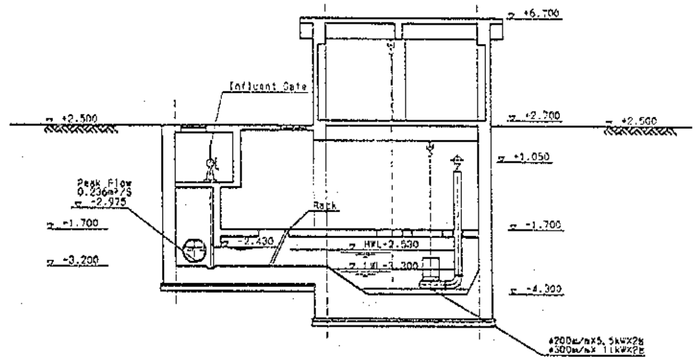


Figure 6.3. (8)-1
Preliminary Design of No. 12 Pump Station
Rang Sit Area

NO. 12 PUMP STATION

S=1/100

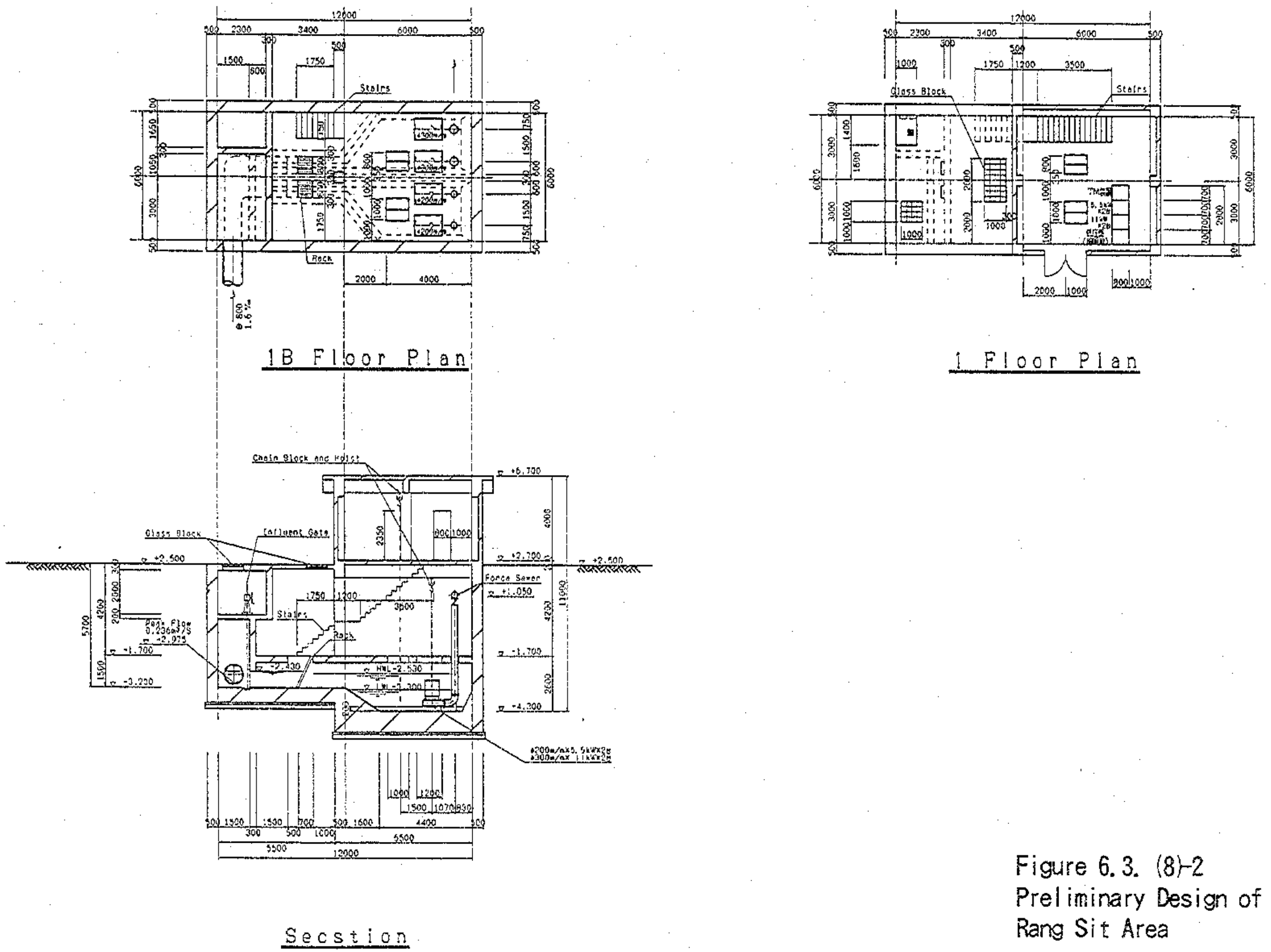


Figure 6.3. (8)-2
Preliminary Design of No. 12 Pump Station
Rang Sit Area

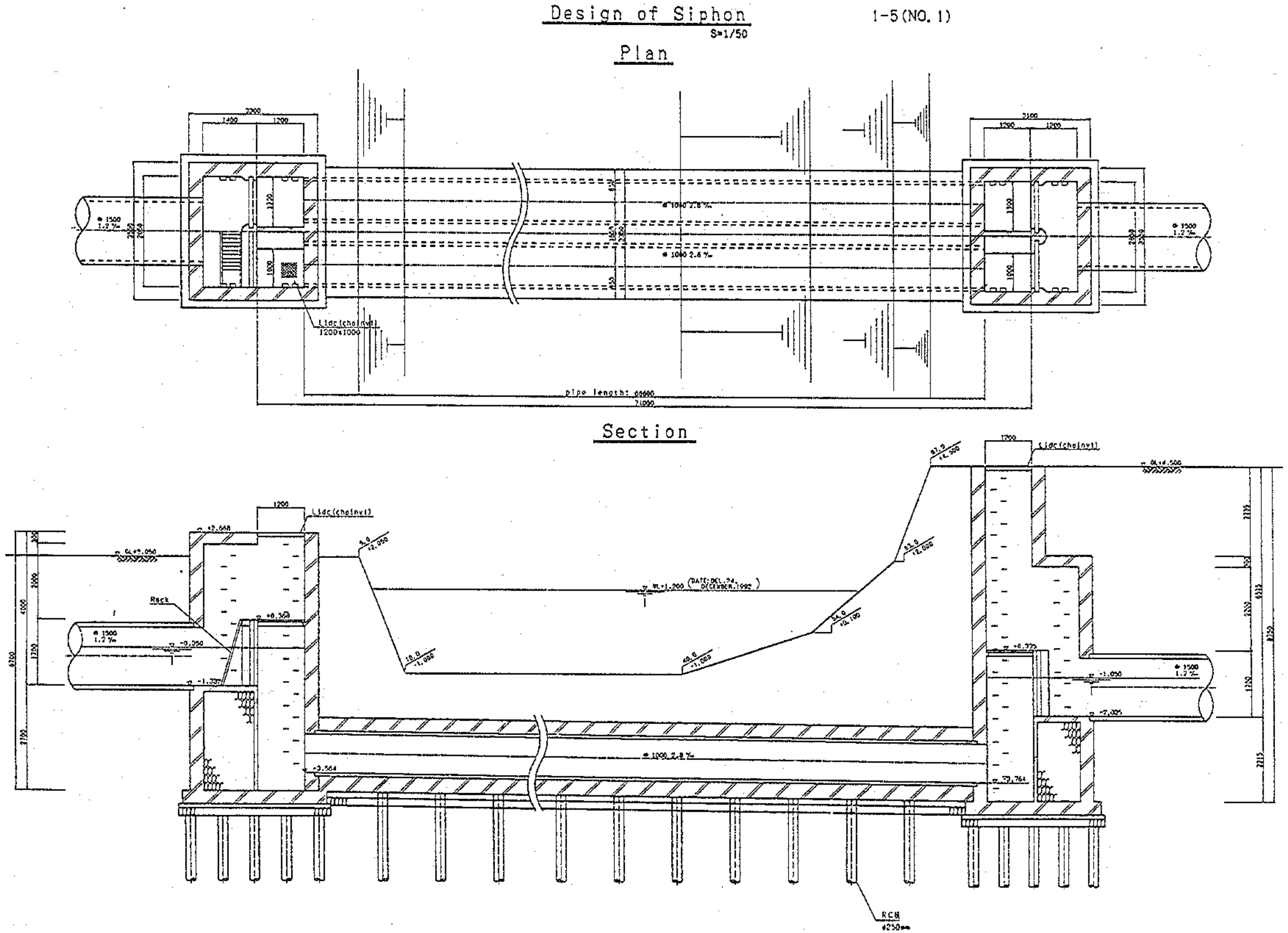


Figure 6.4.(1) Preliminary Design of Sihon

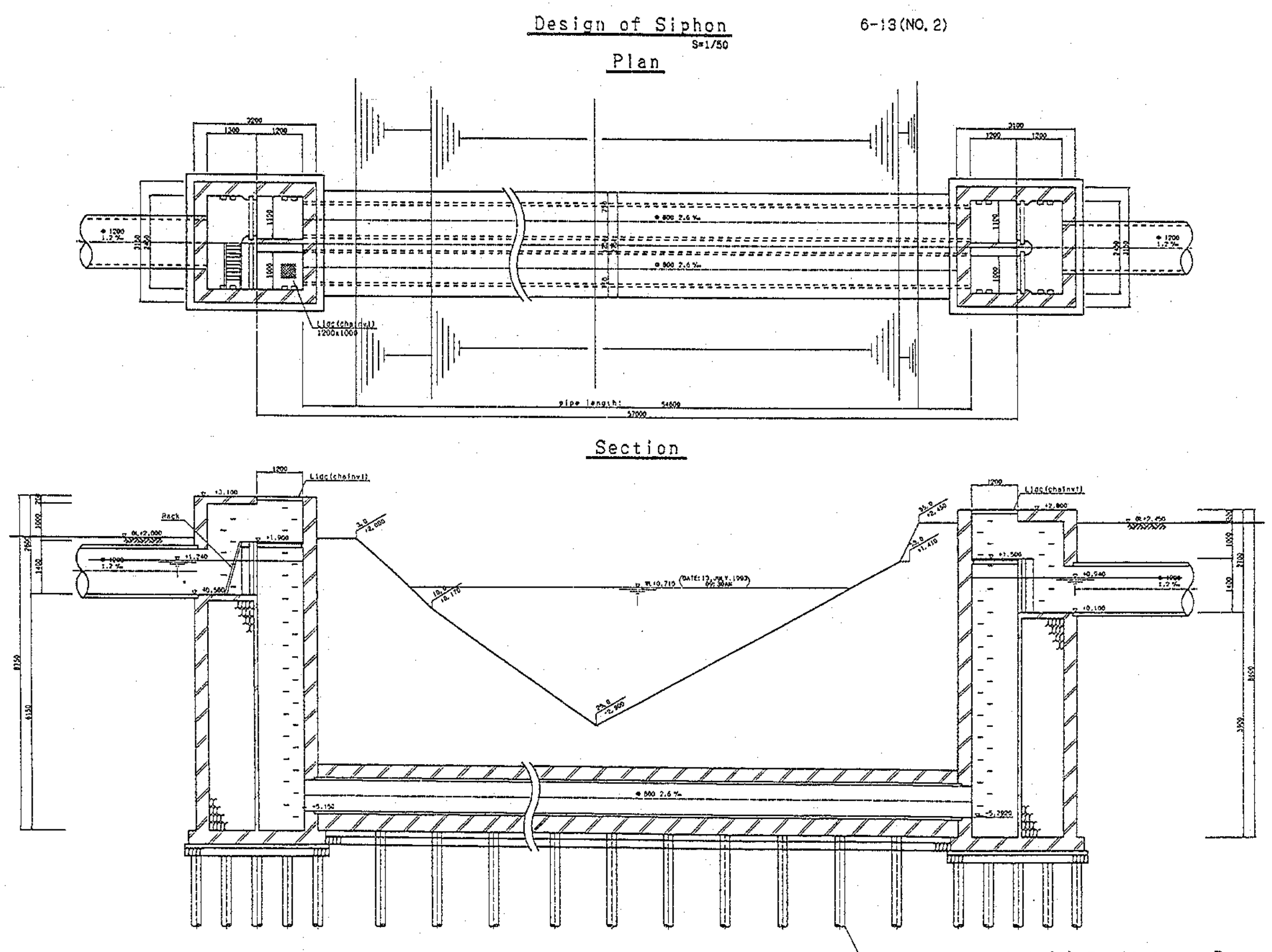


Figure 6.4.(2) Preliminary De:

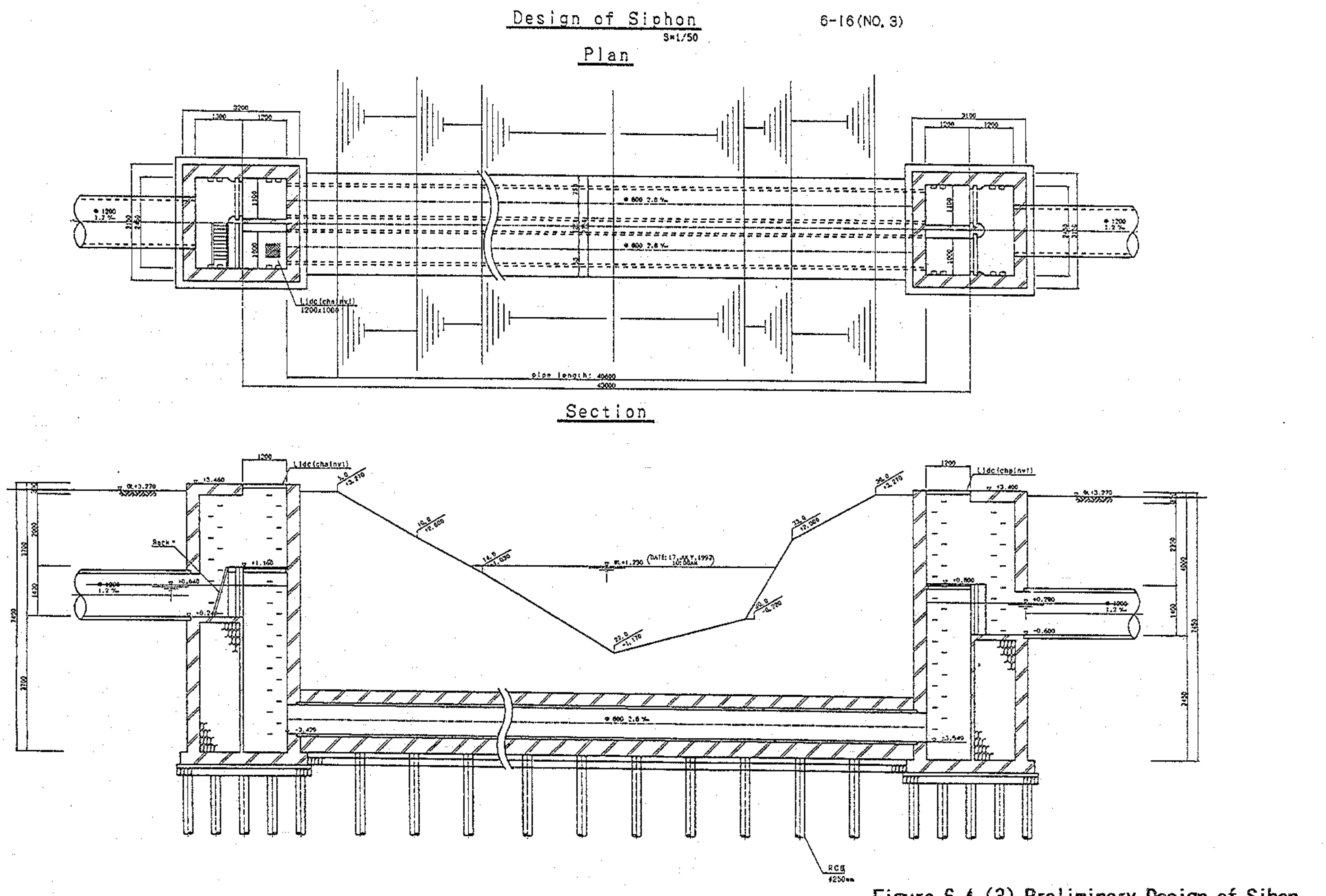


Figure 6.4.(3) Preliminary Design of Sihon

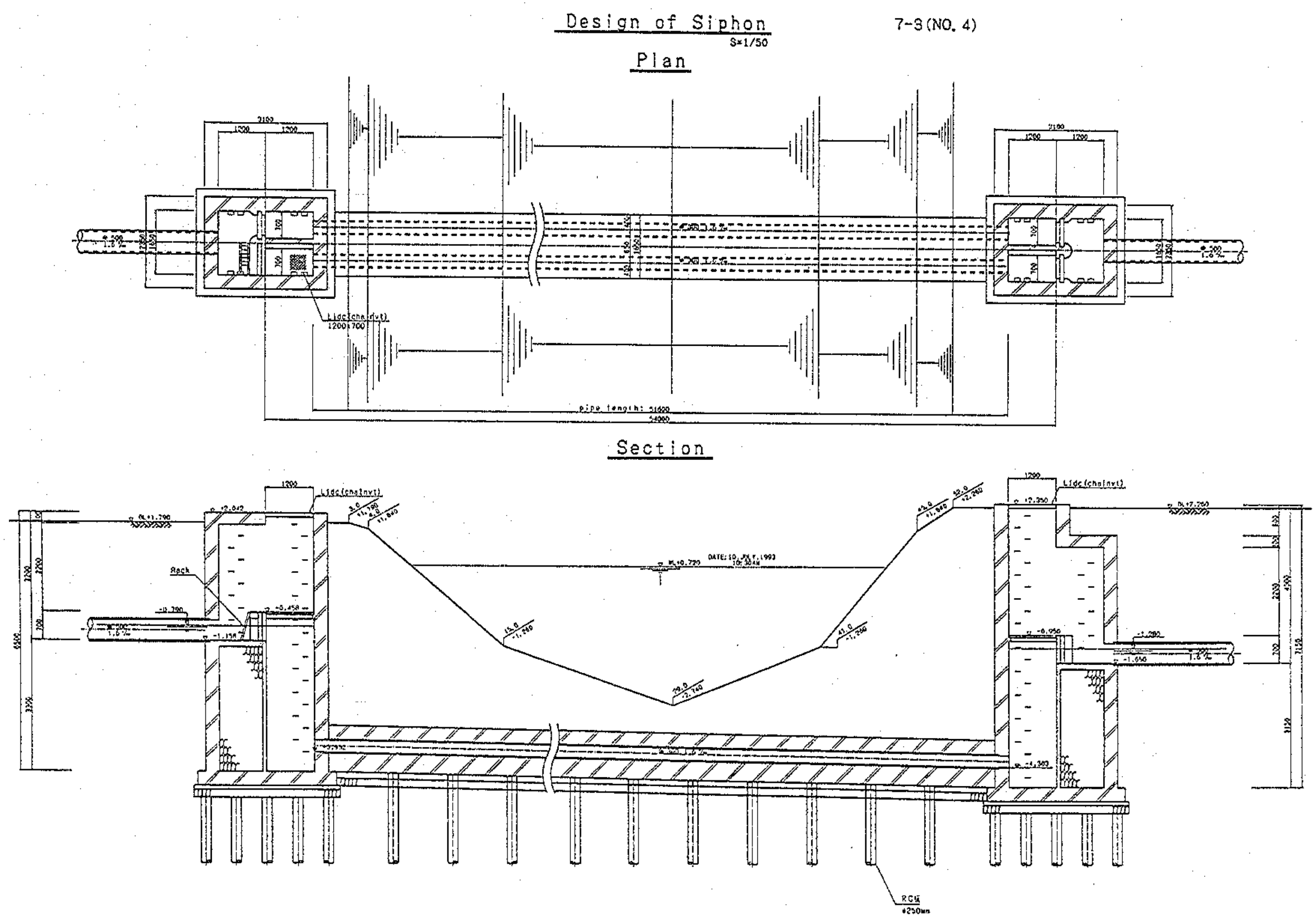


Figure 6.4.(4) Preliminary Design of Sihon

ing Report 2.6.2. Number of overflow chamber is also shown in the same Supporting Report.

Table 6.1 Wastewater Collection Facilities

Interceptor			Manhole		
Dia. (mm)	Length (m)	Are. Earth Cover (m)	Kind	Number	Ave. depth (m)
300	1,075	1.7	No.1	176	3.1
400	1,615	1.8	No.2	39	4.3
500	1,450	2.3	No.3	120	4.1
600	1,660	2.6	No.4	23	4.8
800	2,820	3.1	Total	358	
1,000	4,240	2.7			
1,200	2,613	2.6	Pump station : 6 stations		
1,500	1,790	2.7			
1,600x 1,600	2,370	4.2	Inverted siphon : 4 units		
Total	19,633				

SECTION 7 WASTEWATER TREATMENT AND SLUDGE DISPOSAL SYSTEM

7.1 Wastewater Treatment Plant Site

The proposed wastewater treatment plant site is located in Tambol Klong Nung, Klong Luang S.D. (refer to Figure 6.1, Section 6). The site is about 2 km north of Klong Rang Sit(potential area of 11.88ha, 1080 m x 110 m), currently being open land owned by the private sector, and encompassed by two klongs, klong Song and irrigation canal No9L. The land areas required for master plan and preliminary design are 7.5 ha and 3.0 ha, respectively. The adjacent area (1.92ha) of the proposed site, purchased by Prachatipat S.D. about 10 years ago, is used as a garbage dumping site of the S.D.

Ground elevation at the proposed site ranges from +1.3 m to +2.3 m with an average of +1.8 m amsl. The highest flood level is about 0.5 m above existing elevation based on the past flood records.

Soil conditions are obtained from boring test conducted at the site as follows:

The top surface layer of 0 - 13 m depth is composed of soft clay, with occasional organic materials and very fine sand. Soft to stiff silty clay layer is encountered at the depth of 14 - 18.5 m., followed by very to fine sand with coarse sand and gravel.

The N value of the subsoil are:
- Less than 10 at shallow depth less than 13 m.
- 23 - 52 at depth of 14 - 18.5 m
- Greater than 50 in deep layers(deeper than 19 m)

Details are included in Data Report 2.7.1. The supporting layer of the structures is proposed to be 15 m below existing ground level.

7.2 Design Wastewater Quantity and Quality

Wastewater quantity and quality on a daily average basis to be treated in 2001 and 2011 were studied in the master plan and previous section. Basic figures for design of sewerage facilities are discussed hereunder.

(1) Wastewater Quality

Conventional activated sludge treatment method is employed after comparative study of possible treatment methods in the Master Plan. Effluent quality requirements are less than 20 mg/l BOD and 30 mg/l SS. Design temperature is assumed to be 25°c. While influent BOD concentration flowing into the wastewater treatment plant is estimated using section 4.2, Chapter 2. Design influent quantity (daily maximum basis) is assumed as follows:

BOD : 175 mg/l (calculated from total BOD load and quantity)
SS : 150 mg/l (assumed referring to previous projects)

(2) Wastewater Quantity

The quantity of wastewater flowing into the treatment plant is summarized by design flow in its fluctuation through the day. Total wastewater quantity for capacity calculation includes the amount discharged from nine(9) housing estates. This is because of economical treatment of discharged wastewater in the design area at consolidated treatment plant, performing required effluent level for water quality conservation in the public water body.

In accordance with aforementioned design criteria; daily average, daily maximum and hourly maximum wastewater quantity for capacity calculation is summarized in comparison with those in the final target year. The required capacity for the preliminary design year (2001) is about 1/3 (35%) of that for final target year (2011).

Wastewater	Year 2001 (m^3/d)	Year 2011 (m^3/d)
Daily Average	21,350	62,500
Daily Maximum	25,700	75,000
Hourly maximum	33,300	97,500
Wet Weather Flow	100,000	292,500

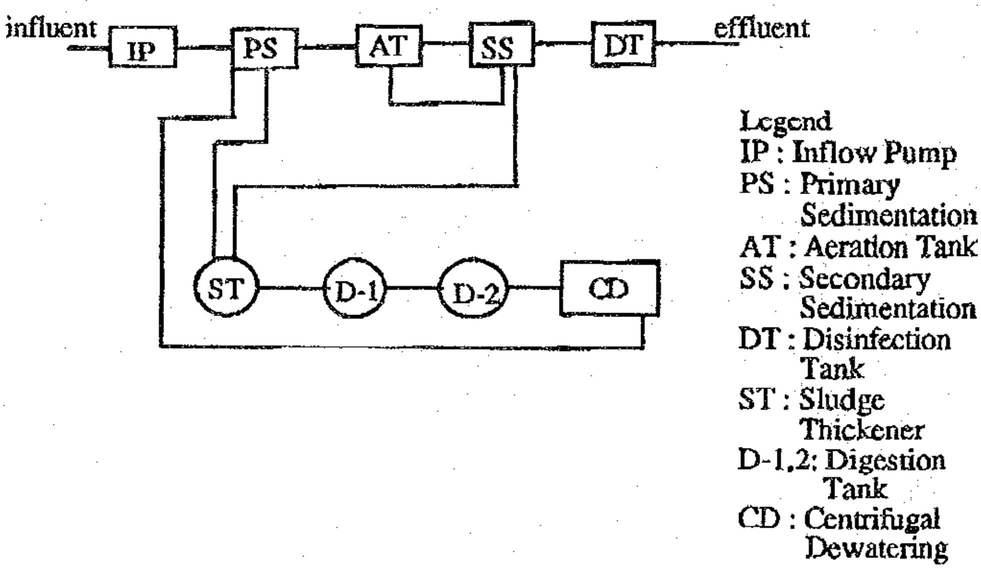
7.3 Design of Wastewater and Sludge Treatment Facilities

7.3.1 Design Considerations

Activated sludge treatment system comprises primary sedimentation basin, aeration tank and final sedimentation basin for wastewater treatment and sludge thickener and sludge digestion tank for sludge treatment. This system can save land area required comparing with other potential methods, while it is technically sophisticated both in construction and O & M of the facilities.

The flow diagram of the wastewater treatment process is shown in Figure 7.3.1.

Figure 7.3.1 Wastewater Treatment Process



The following two conditions shall be taken into account for designing.

- Preventive measures against power cut without provision of generator set
- Inundation at the WWTP site during rainy season caused by back flow or overflow of the main river

(1) Ground elevation at the WWTP site

An average G.L of the road facing the WWTP is 2.1 m amsl. Water level of the receiving waterway is 1.15 m amsl during rainy season. Flood level experienced was about 50 cm higher than existing G.L. Thus, planned G.L at the WWTP is 2.5 m amsl.

(2) Wastewater treatment facilities

1) Inflow pump : Submersible type against power cut and inundation problems

dry season; control by means of number of pump units (each pump has same capacity)

rainy season; larger capacity pump unit, but smaller number of units

2) Wastewater treatment process

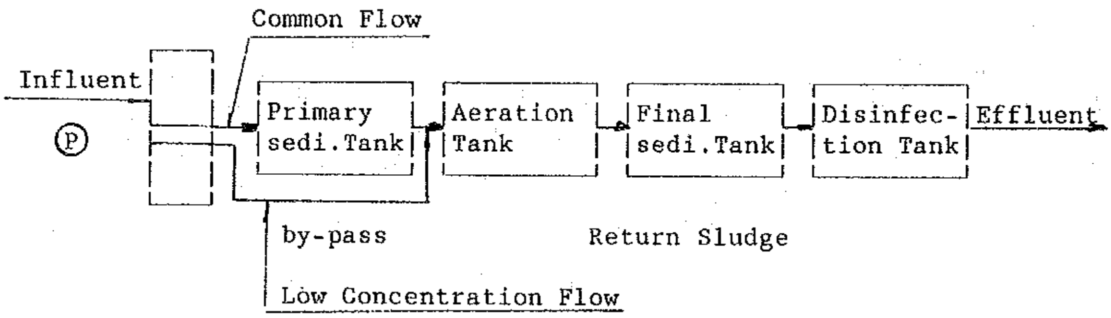
1) Wet weather flow: Hourly max.flow is discharged after passing sedimentation basin provided for the flow. Remaining wastewater in the basin after raining shall be introduced into aeration tank at a constant flow rate.
2) Low concentration of influent quality (BOD & SS) : flow from inlet pump chamber shall be by-passed to aeration tank.
3) Aerator: mechanical type aerator shall be provided. Maintenance of diffuser is difficult in case of power cut.
4) Shape of sedimentation basin: Circle type basin shall be used to ensure sedimentation efficiency to the wastewater with low concentration.
5) Disinfection of effluent : Calcium hypochloride dosing shall be adopted for the procurement in Thailand.

(3) Sludge treatment facilities : Drying bed is advantageous in O & M, but mechanical equipment may be used in the difficulty of land acquisition. Centrifugal type is favorable.

Design of treatment facilities is usually prepared in assumption of various kind of design conditions for the target year based on the experiences and present status. It may arise some discrepancies at the operation stage of the facilities. We have such experiences in Japan. The following are recommendations on the countermeasures based on the experience in Japan referring to the conditions in Thailand.

(1) Low concentration of influent quality into WWTP

Generally, influent quality in the initial stage of plant operation is lower than planned. The possibility of lower BOD inflow was confirmed through the investigation at existing treatment plants in Thailand. Some modification in operation of treatment facilities may be necessary. In addition, the quality of combined wastewater differs area by area affected by the combination of rain water and wastewater as well as size of collection area. The following are illustrations of the flow system both for common treatment process and in case that influent is more or less 100 mg/l. In the latter case, the treatment shall be done without sedimentation process at primary sedimentation basin.



(2) Dissolved Oxygen

Existing drainage facilities are to be utilized for the project. A lack of dissolved oxygen in the influent especially during dry season may be a common problem under the existing hydraulic profile with gentle slope of sewers. It is recommended to provide aeration facility prior to primary sedimentation basin for about 30 -60 minutes. Wastewater with insufficient D.O may arise deterioration and upflow of sludge in the primary sedimentation tank. Furthermore it may affect activated sludge treatment process and sludge treatment system.

(3) Low BOD concentration and small volume of influent

There is a possibility of influent during dry season either with low BOD concentration and small volume or with design BOD concentration and small volume. In this case influent shall be by-passed to aeration tank and application of extended aeration may be done. sludge without adequate moisture content may be produced under the above conditions.

Design conditions for the treatment facilities are summarized in Table 7.3.1.

Table 7.3.1 Design Conditions for the Treatment Facilities

Item	Conditions					
Design Flow (m^3/d)	Daily Ave.		Daily Max.	Hourly Max.		
	21,350		25,700	33,300		
Removal Ratio (%)	Influent Quality(mg/l)		Primary Sedi.	Effluent from Sedi. (mg/l)	Final Sedi.	Effluent Quality (mg/l)
	BOD	175	30	122.5	83.7	20
	SS	150	35	97.5	69.2	30

Item				
Sludge Conditions (%)	Return sludge density	0.7	Thickened sludge organic material ratio	60
	Return sludge ratio	25	Efficiency of Digestion Tank	90
	Raw sludge density	2	Digestion ratio	50
	Excess sludge density	0.7	Efficiency of Dewatering (centrifugal)	95
	Thickened sludge Den.	3	Dewatered sludge moisture content	79
	Digested sludge Den.	3	Dosing ratio	1.1
	Efficiency of thickener	80		

The following are outline of unit treatment facilities.

(1) Wastewater treatment

1) Inflow Pump Station

Raw wastewater firstly flows into this facility and is pumped up to the primary sedimentation basin. Coarse materials and sand in the wastewater are removed in provision of a screen and grit chamber to protect the pump units and reduce loads to the succeeding facilities.

2) Primary Sedimentation Basin

The function of the primary sedimentation basin is to remove suspended solids, organic and/or inorganic, by gravitational sedimentation, which decrease BOD and SS substances to be loaded into the biological treatment process. Originating from its role, the primary sedimentation process is the preliminary treatment process in the biological treatment process.

For quick removal of settled sludge, a sludge rake and sludge pump are provided in the basin.

3) Aeration Tank

This facility is highly important in the biological treatment process. Aeration is the method of propagating various kinds of aerobic bacteria with organic matter in the sewage being the source of nutrition. This activated sludge process is to remove organic matter by coagulating suspended solids and colloidal matter through bacterial metabolism. The clarifying functions of the activated sludge process are summarized below.

(1) Absorption of organic matter
(2) Oxidation and Assimilation of absorbed organic matter
(3) Formation of a floc for quick sedimentation

Aerated effluent separates solids from liquid in the secondary sedimentation basin in the next process, and the supernatant water flows out, while the settled sludge is returned to the aeration tank as activated sludge, and again employed in the sewage treatment process. The surplus sludge is treated by the sludge treatment process.

4) Final Sedimentation Basin

Aeration tank effluent separates solids from liquid in the basin and the liquid flows out to the next process.

In the basin, sludge rake, sludge pump and scum collector are

provided as the primary sedimentation basin.
Return sludge to the aeration tank and excess sludge to the sludge treatment process are returned from the final sedimentation basin.

5) Disinfection Tank
This facility is designed to remove bacterium from the effluent, Calcium hypochlorite dosing to the effluent is adopted as the disinfecting agent.

(2) Sludge treatment
The flow diagram of the proposed sludge disposal system is shown in Figure-7.3.2 including mass balance of suspended solid. The mass balance for the final target year is shown in Supporting Report 2.7.3.1. Table 7.3.2 presents required capacity of major facilities both for preliminary design and final target year.

Table 7.3.2 Design Capacity of Sludge Treatment Facilities

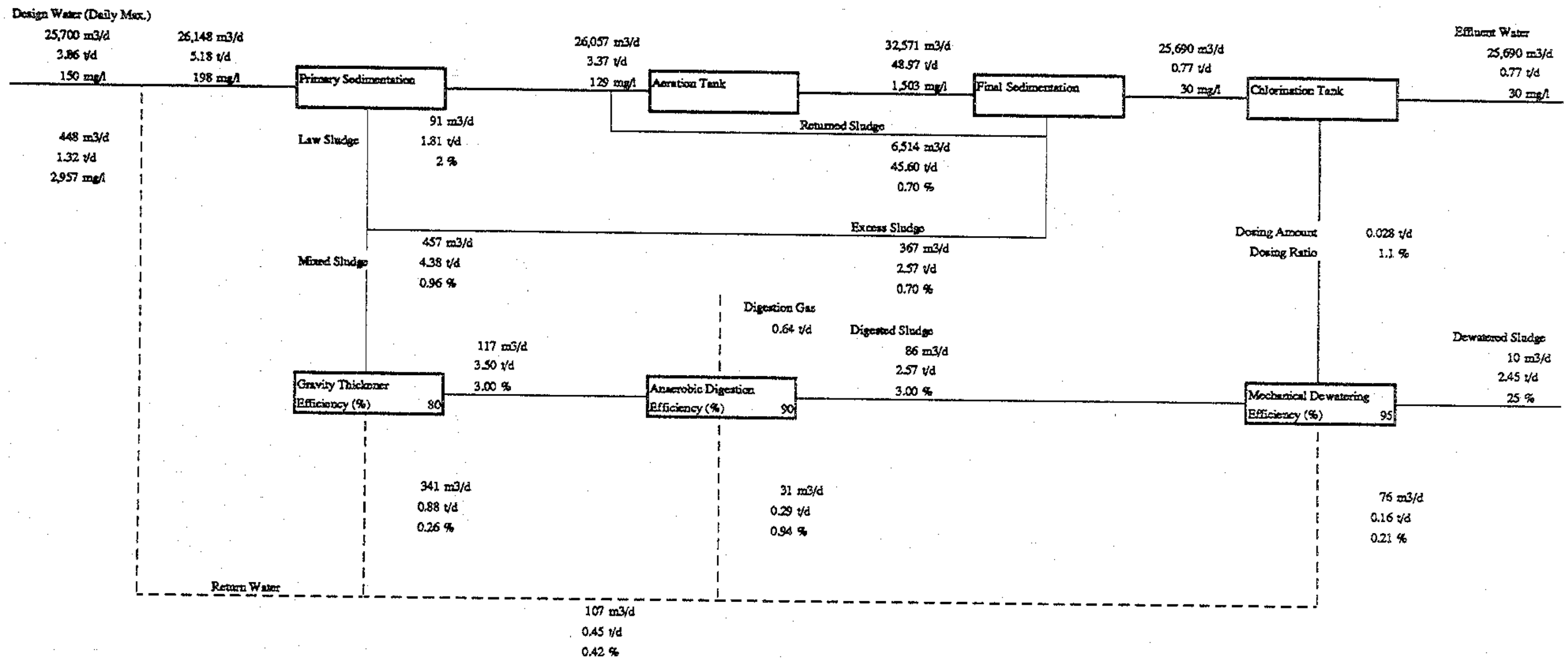
Facility	Preliminary Design	Final Target Stage (2011)
Gravity Type Thickener	$457m^3/d$, 4.38t/d	$1,332m^3/d$, 12.76t/d
Anaerobic Digestion Tank	$117m^3/d$, 3.50t/d	$340m^3/d$, 10.21t/d
Centrifugal Dewatering	$86m^3/d$, 2.57t/d	$250m^3/d$, 7.51t/d

The following are the outline of sludge treatment facilities.

1) Gravity Thickener
Gravity thickening is accomplished in a tank similar in design to a conventional sedimentation basin. Mixed sludge is fed to a center feed well. The feed sludge is allowed to settle and compact, and thickened sludge is withdrawn from the bottom of the tank.

2) Anaerobic Digestion Tank
Anaerobic digestion of sludge is classified into four(4) from its different operation system as standard-rate, single-stage high-rate, two-stage and separate system. Two-stage digestion system is proposed as the optimum sludge digestion process for this project.

Figure 7.3.2 Mass Balance of SS in Rangsit Sewage Treatment Plant



3) Centrifugal Dewatering

The following four(4) mechanical dewatering processes are considered as alternatives for this project.

- Belt Filter Press
- Filter Presses
- Vacuum Filtration
- Centrifugal Dewatering

These four(4) mechanical dewatering processes are compared from technical and economical view points. Centrifugal dewatering process is selected as an optimum dewatering process for this project, because of the low density of SS of influent wastewater to the Treatment plant.

Solid bowl type is selected from other two(2) centrifugal dewatering process of disc-nozzle and basket types.

7.3.2 Design of Facilities

Capacity calculation and determination of dimensions for respective treatment units are made. Detailed calculation results are included in Supporting Report 2.7.3.2.

The composition of treatment system was established considering design flow (daily max. basis) for the final target year, 75,000 m^3/d and this design flow, 25,700 m^3/d. A total of six(6) treatment unit systems are planned with a capacity of 12,500 m^3/d for each unit system. Two unit systems with the joint capacity of 25,000 m^3/d are designed for the first stage program.

Table 7.3.3 Shows design of facilities for the first stage project.

Layout plan and hydraulic profile of the treatment system are shown in Figure 7.3.3 and 7.3.4.

Table 7.3.3 (1) Specifications of Wastewater Treatment Plant

Item	Specifications
1) Grit Chamber	
(Dry Weather)	
Numbers	1 units
Dimension	(W) 1.6 m x (L) 11.0 m
Effective Depth	(H) 0.7 m
Retention Time	32.0 sec.
Surface Loading	1,892 m3/m2/day
(Wet Weather)	
Numbers	1 units
Dimension	(W) 1.6 m x (L) 11.0 m
Effective Depth	(H) 0.7 m
Retention Time	16.0 sec.
Surface Loading	3,790 m3/m2/day
3) Primary Sedimentation Tank	
Type of Tank	Circular
Numbers	4 units
Diameter	(D) 16.0 m
Effective Depth	(H) 4.0 m
Retention Time	3.0 hr.
Surface Loading	32 m3/m2/day
Weir Loading	128 m3/m/day
4) Stormwater Sedimentation Tank	
Type of Tank	Circular
Numbers	4 units
Diameter	(D) 18.5 m
Effective Depth	(H) 3.0 m
Retention Time	1.0 hr.
Surface Loading	69 m3/m2/day
Weir Loading	320 m3/m/day
5) Aeration Tank	
Type of Tank	Rectangular
Numbers	2 units
Dimension	(W) 15.0 m x (L) 75.0 m
Effective Depth	(H) 3.0 m
BOD - SS Loading	0.32 kg/kg/day
Aeration Time	6.3 hr
BOD Volumetric Load	0.47 kg/m3/day
Sludge Age	3.97 days

Table 7.3.3 (2) Specifications of Wastewater Treatment Plant

Item	Specifications
6) Secondary Sedimentation Tank	
Type of Tank	Circular
Numbers	4 units
Diameter	(D) 18.5 m
Effective Depth	(H) 2.5 m
Retention Time	2.5 hr
Surface Loading	24 m3/m2/day
Weir Loading	111 m3/m/day
7) Disinfection Tank	
Numbers	1 units
Dimension	(W) 2.0 m x (L) 180.0 m
Effective Depth	(H) 2.0 m
(Dry Weather)	
Contact Time	40.3 min.
(Wet Weather)	
Contact Time	10.4 min.
8) Gravity Thickener	
Numbers	2 units
Diameter	(D) 6.0 m
Effective Depth	(H) 4.0 m
Solids Loading	77.4 kg/m2 day
Thickening Time	11.9 hr
9) Digester	
(1st Digester)	
Numbers	2 units
Diameter	(D) 17.5 m
Effective Depth	(H) 5.0 m
Digestion Time	20.6 days
(2nd Digester)	
Numbers	2 units
Diameter	(D) 12.0 m
Effective Depth	(H) 5.0 m
Digestion Time	9.7 days

Table 7.3.3 (3) List of Major Mechanical and Electrical Equipment for Wastewater Treatment Plant

Item	Specifications		Quantity
1) Grit Chamber			
- Manual Coarse Bar Screen	1,600 mm(W) x 3,000 mm(H)		6
- Manual Fine Bar Screen	1,600 mm(W) x 3,200 mm(H)		6
- Sand Pump and Washing Equipment	∅ 100 mm x 1.0 m3/min. x 15m	5.5 kw	1
2) Inflow Pump Station			
- Submersible Pump	∅ 350 mm x 11.55 m3/min.	45 kw	2
- Submersible Pump (Stormwater)	∅ 800 mm x 23.15 m3/min.	110 kw	1
3) Primary Sedimentation Tank			
- Sludge Scraper (Center Drive)	∅ 16.0 m x 3.8 m(H)	0.4 kw	4
- Sludge Draw off Pump	∅ 100 mm x 0.12 m3/min. x 6 m	5.5 kw	4
- Inlet Value	∅ 400 mm Sluice Manual		4
4) Aeration Tank			
- Surface Aerator (Bridge Mount Type)		11 kw	6
- Surface Aerator (Bridge Mount Type)		22 kw	4
- Inlet Value	∅ 400 mm Sluice Manual		4
5) Final Sedimentation Tank			
- Sludge Scraper (Center Drive)	∅ 18.5 m x 2.3 m(H)	0.75 kw	4
- Sludge Recirculation Pump	∅ 150 mm x 1.04 m3/min. x 5 m	15 kw	4
- Inlet Value	∅ 500 mm Sluice Mannual		4
- Excess Sludge Draw off Pump	∅ 100 mm x 0.12 m3/min. x 6 m	5.5 kw	4
6) Disinfection Tank			
- Dosing Pump	0 ~ 3 l/min. x	0.4 kw	2
- Hypochlorite Storage Tank	4 m3		2
- Inlet Gate	1,000 mm(W) x 1,000 mm(H)		1
- Outlet Gate	1,000 mm(W) x 1,000 mm(H)		2
7) Gravity Thickener			
- Sludge Draw off Pump	∅ 100 mm x 0.15 m3/min. x 6 m	5.5 kw	2
8) Digester			
- Sludge Draw off Pump	∅ 100 mm x 0.14 m3/min. x 6 m	5.5 kw	2
- Agitation Blower	2.8 m3/min. x 7 m	15 kw	2
- Desulfurizer	3,000 m3/d Dry Type		1
- Waste Gas Burner	2 m3/min.		1
- Gas Transfer Blower	2 m3/min. x 6 m	7.5 kw	2
9) Dewatering Unit			
- Sludge Feeding Pump	0 ~ 5 m3/hr. x	2.2 kw	2
- Polymer Dosing Pump	0 ~ 20 l/min. x	0.4 kw	2
- Centrifuge Type	8 ~ 10 m3/hr.	(15 kw/2.2kw)	1
- Centrifuge Type	15 ~ 18 m3/hr.	(30 kw/5.5kw)	1
- Beltconveyor & Hopper	10 m3	0.75 kw	2
10) Laboratory Equipments			
- BOD Measurement Kit			1
- COD Measurement Kit			1
- SS Measurement Kit			1
- DO / Temperature Meter			1
- PH Meter			1
- Coliform Group Counting Kit			1

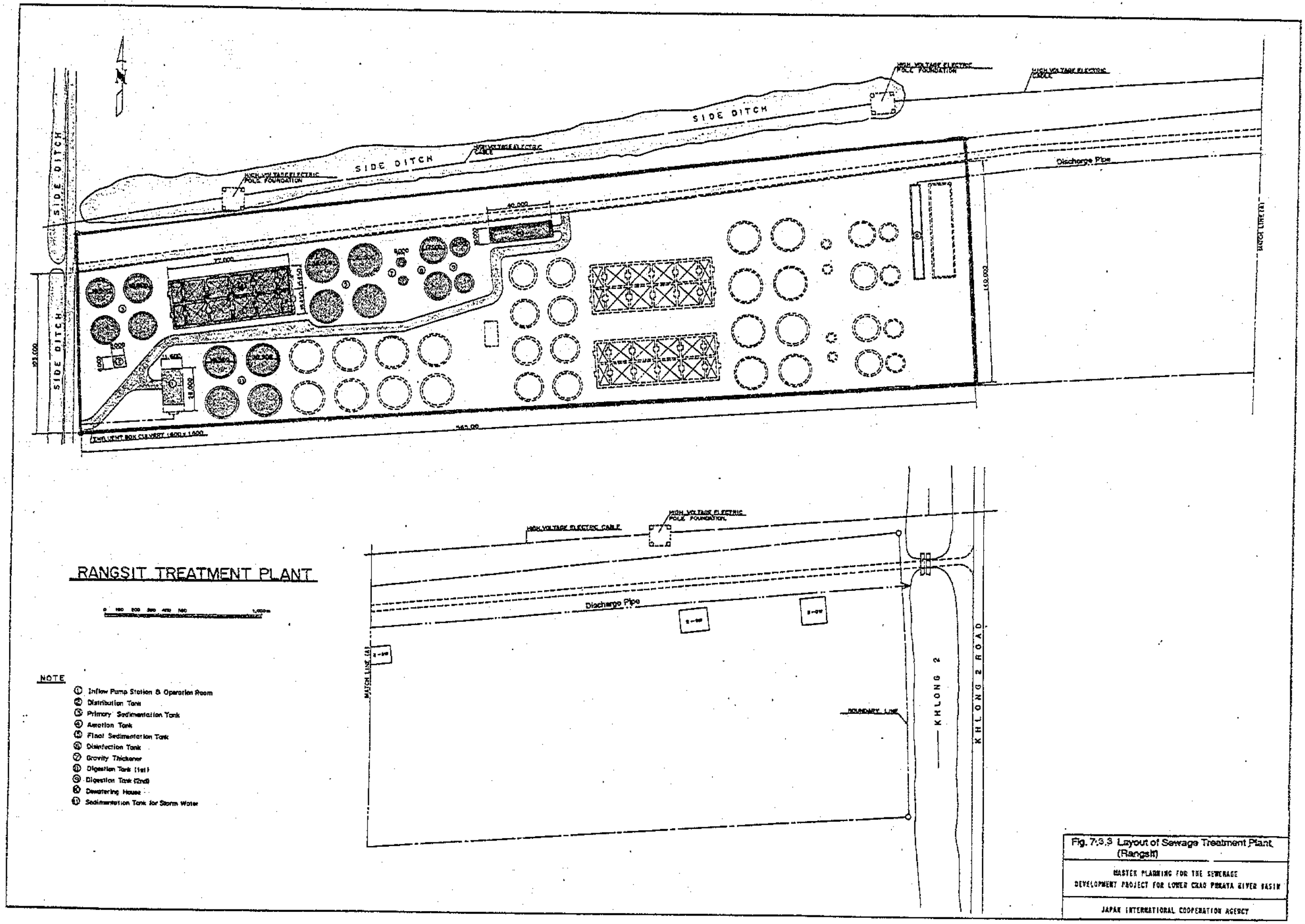


Fig. 7.3.3 Layout of Sewage Treatment Plant (Rangsit)

HYDRAULIC PROFILE

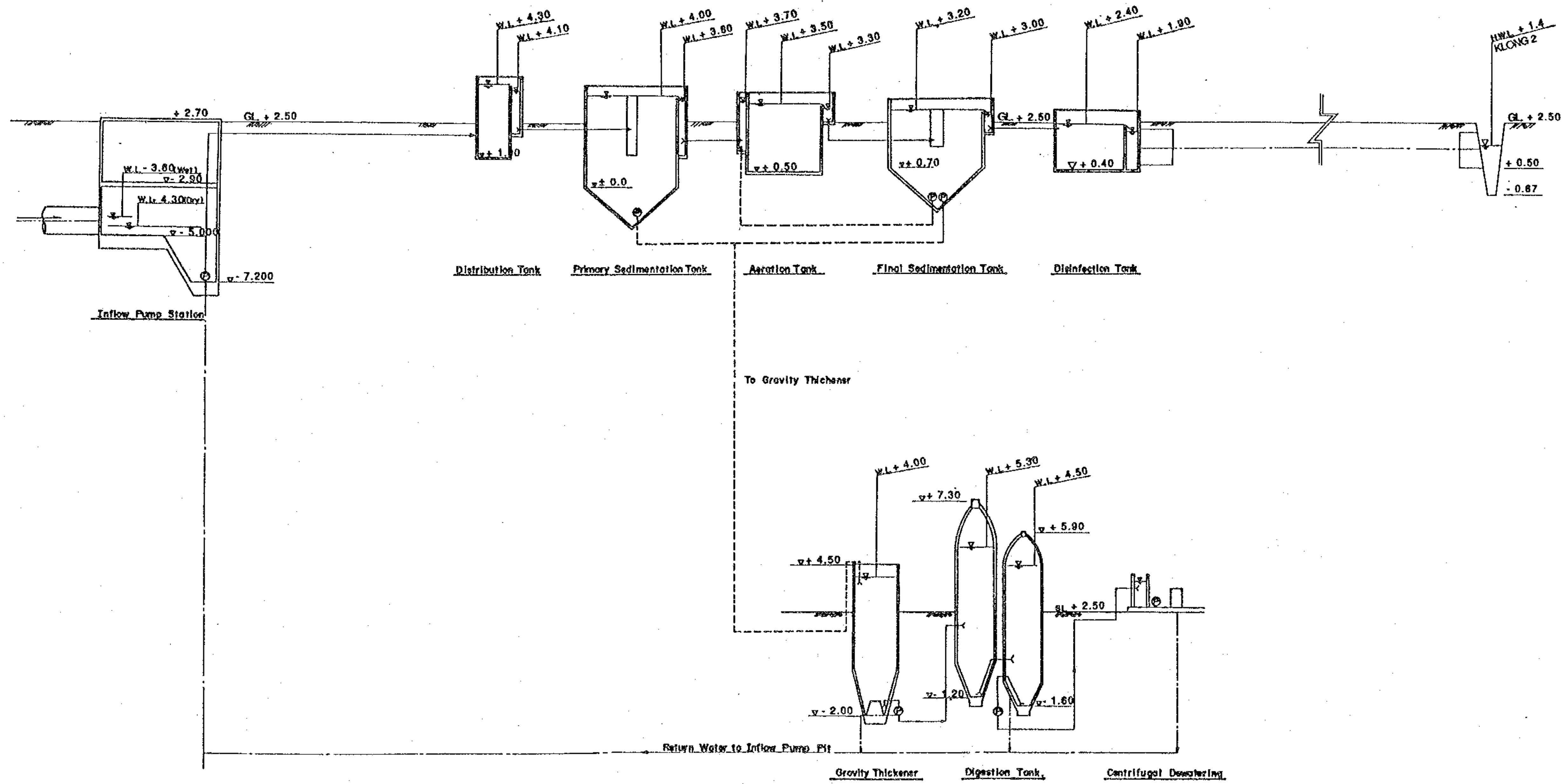


Fig. 7.3.4 Hydraulic Profile of Sewage Treatment Plant (Rangsit)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

SECTION 8 CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE OF THE FACILITIES

8.1 Construction plan, and Operation and Maintenance

Construction methods for major sewerage facilities including sewers, pump stations and treatment plant are discussed in the Master Plan. Additional descriptions for overflow chamber, inverted siphon and pump stations (manner of pump operation) are included in this Section.

(1) Interceptors

Open trench method is employed for pipe laying in provision of sheet pile for the excavation of more than 2 m deep. The excavation is done either by means of man-power or backhoe.

(2) Overflow Chamber

The overflow chamber shall be installed under public roads. In case of wastewater collection discharged from housing estates, the facility shall be placed at the junction of the pipe from estates and public road/drainage along the road.

In construction of the chamber at the drainage along the road, consolidation of inflow drainages thereto shall be made to design the neighboring chambers with a distance of about 500 m.

(3) Inverted Siphon

The parallel pipes in application of open cut method shall be installed crossing klong provided with chambers at both inlet and outlet parts. Drain pits with a depth of about 1.0 m and stop boards are necessary at the chambers. If the depth of the chamber exceeds 5 m, drain pump facility is necessary. In principle, pile foundation shall be adopted in consideration of the soil consolidation. The pipes shall be covered with reinforced concrete and installed at least 0.5 m below the river bet (There is no plan on dredging/improvement of klongs). The cover installed on the top at the chamber, upstream of the inverted siphon, shall be arranged to release wastewater upon receipt of abnormal pressure.

(4) Pump Station

Ground elevation at the pump station shall be determined taking into account of those in the surrounding area and levee. A large pump station will require pile foundation because of sub-soil condition with bearing strata at about 15 m below ground surface. Sheet piling may be applicable for excavation.

Pump type shall be submersible one without grit chamber prior to pump pit. A bar screen with 75 mm mesh shall be provided. A generator set is not considered, however, central monitoring and local control shall be provided.

Number of pump units are as follows:

- The number of units is more than two.
- Four (4) units shall be provided for comparatively large pump station. Number of units by pump diameter is:
  - a) Two(2) units with each capacity of 1/2 hourly max.
  - b) Two(2) units with each capacity of hourly max.
  - c) Four(4) units as the total of item a) and b) shall be operated for wet weather flow.

Operation of pump units shall be done according to flow fluctuation.

a) Daily average wastewater

Under common condition during dry season, two(2) units of pump with a capacity of 1/2 hourly max. each shall be used. During the repair period of these units, either one of the two units with a capacity of hourly max. each shall be operated.

b) Daily max. wastewater

Operation of pump unit/s shall be done in the same procedure as item a).

c) Hourly max. wastewater

Under common condition, 2 units of pump with a capacity of 1/2 hourly max. each shall be used. Either one of two units with a capacity of hourly max. each can be operated, if the abovementioned units are broken down.

d) Wet weather wastewater
Four units of pump shall be operated at one time.

(5) Wastewater Treatment Plant
Pile foundation is required for construction of treatment facilities.

In any cases, for a) to c), the pump units shall be operated alternatively.

8.2 Mitigating Measures against Potential Negative Impact

Potential environmental problems caused by sewerage projects and countermeasures thereto are discussed in Section 3.16, Chapter 2, Part II covering different stages from designing to operation and maintenance of major sewerage facilities. Further descriptions on the preliminary design area are included in this section. Countermeasures to be considered during design stage are reflected in the previous section of this plan. Those for construction, and operation and maintenance stages are discussed hereunder.

(1) Construction Stage

Interceptor

Interferences with klongs and national roads are major concern for installation of interceptors. A parallel sewers are planned along both sides of Rang sit - Hakhorn Nayok road. Houses are located along the road. Traffic congestion/blocking of access to houses/buildings are to be minimized. Careful construction schedule and arrangements to get cooperation from inhabitants are requisites. Crossing the road shall also be done ensuring partial traffic using open cut method for pipe laying. The work crossing klong Rang Sit along above mentioned road shall be managed to minimize interference with river transportation (small boat).

The construction of inverted siphon shall be done using sheet pile ensuring a half water way for traffic convenience during the work.

In principle, only day time work is recommended to minimize vibration and noise problems caused by the construction work. Road damages are to be restored immediately after completion of pipe laying.

Wastewater treatment plant

With regard to the construction of wastewater treatment plant, traffic congestion at the junction of access road to the treatment plant and Rang sit-Hakhorn Nayok road shall be managed. Adequate buffer areas surrounding the treatment plant shall also be ensured, although the land is currently open area and far from residential areas.

(2) Operation and Maintenance Stage

Interceptors and pump stations

Routine inspection work shall be done along sewer routes for preventive countermeasures with attentions to sewer trench cave-in, manhole structure and overflow of wastewater from sewers. Maintenance at the chamber of inverted siphon (overflow, etc.) and discharge pipe (effect by adverse flow from main river) shall be carefully done. Periodic removal of deposit at overflow chamber is essential to keep functioning the sewerage systems.

A quick action to the pump accident for maintenance of pump stations shall be done in full use of a central monitoring system. Inspection of sewers for illegal connections to interceptors and obstructions is necessary. Dissemination of information on the maintenance of sewerage systems is important in addition to prevent disposal of solid waste in sewers.

Wastewater treatment plant

Common problems to wastewater treatment plants such as odor and noise are to be minimized through careful operation and maintenance, and operation monitoring. The control of effluent quality shall be done to meet fluctuation of wastewater quantity and quality according to yearly increase of service area and its water consumption. Depending on the concentration of organic substances, modified arrangements of treatment facilities shall be made.

Investigations on industrial wastewater both in quantity and quality shall be conducted periodically not only for treatment reference but also adequate sewerage charge collection.

SECTION 9 COST ESTIMATES AND CAPITAL INVESTMENT PROGRAM

9.1 Construction Cost

The project cost on 1993 price level consists of direct cost, indirect cost, contingency and engineering fee. Assumed percentages for major factors are as follows:

- Contingency : 20 % of direct cost
- Engineering fee(design and construction supervision) :
  17 % of total construction cost including contingency

Currency exchange rates are set for calculation of cost requirements in Baht: 1 US$ = 25 Baht = 105 yen

Data base is those collected in Thailand; market price for materials and equipment, and construction unit in the similar projects.

(1) Direct cost for construction of sewerage facilities

Direct cost including tax covers those for interceptors with accessories, pump stations and treatment facilities. Most of construction materials and equipment are available in Thailand except for mechanical and electrical equipment. Unit prices of basic materials and equipment are referred to in the Master Plan.

<u>Cost estimates on unit cost base</u>

Unit construction cost per meter was estimated for installation of interceptors. The standard costs in terms of pipe diameter and earth cover are included in Supporting Report 9.1.1. Likewise unit construction costs for manhole, overflow chamber connected to existing drainage pipe were prepared as shown in supporting Report 9.1.1. While, costs for inverted siphon, pump station and treatment plant are estimated by each facility.

(2) Total Construction Cost

Direct construction costs for interceptors, manhole, inverted siphon, overflow chambers and pump stations are estimated. Detailed calculation results are included in Supporting Report 9.1.2. Table 9.1.1 summarizes project cost. Land acquisition cost is estimated based on local information. The costs are divided into domestic and foreign (imported materials and equipment) portions.

Table 9.1.1 Project Cost on 1993 Price Level

(Unit: Million Baht)

Description	Domestic Portion	Foreign Portion	Total
1. Direct Cost			
1.1 Collection System			
(1)Interceptor	229.0	-	229.0
(2)Manhole	6.0	-	6.0
(3)Overflow Chamber	0.4	-	0.4
(4)Inverted Siphon	9.2	0.9	10.1
(5)Pump Station	42.2	60.2	102.4
Sub-Total	286.8	61.1	347.9
1.2 Treatment Plant			
(1)Civil & Architec. Facilities	61.5	-	61.5
(2)Mechanical Facility			
(3)Electrical Facility	-	187.6	187.6
Sub-Total	61.5	187.6	249.1
Total of item 1	348.3	248.7	597.0
2. Contingency	69.7	49.7	119.4
3. Total of Construction Cost (1 + 2)	418.0	298.4	716.4
4. Engineering Cost	121.8	-	121.8
5. Land Acquisition Cost	76.9	-	76.9
Grand Total	616.7	298.4	915.1

Note : 1.1(1) includes maintenance equipment / car
1.2(2) includes P.S monitoring facility

9.2 Operation and Maintenance Cost

Annual operation and maintenance cost for the year 2001 by major facility was estimated using data collected in Thailand.

(1) Interceptors and accessories

Inspection of sewer routes is a routine work for maintenance of sewers. Cleaning of sewers shall be done at least twice a year. Mechanical methods are to be employed as discussed in the Master Plan. Unit cost required per meter was estimated at 21.5 Baht in assumption of the followings.

Annual cost required is 847.1 x 10^3 Baht(21.5 Baht/m x 19,700 m x 2 times)

(2) Pump station

Cost requirements include those for labor, electric power, fuel and repairment of facilities.

1) Labor Cost

Staff composition and cost requirements to cover eight(8) pump stations were estimated as follows:

Staff Member & No.		Unit Cost/Month (x 10^3 Baht)	Annual Cost (x 10^3 Baht)
Technician	1	5	60.0
Labor	2	2.35	56.4
Total	3		116.4

2) Operation and Maintenance Cost

Item		Unit Cost /percentage	Consumption /initial cost(x10^3Baht/year)
Operation:	Power	1.65 B/KWH	3,834
Maintenance:	Civil/archi. structure	1 % of construction cost	422
	Mechanical and Electrical equip.	3 % of construction cost	1,806
	Total		6,062

(3) Wastewater Treatment Plant

Labor cost and, operation and maintenance cost were estimated by major item.

1) Labor Cost

Staff Member & No.		Unit Cost/month (x 10^3 Baht)	Annual Cost (x 10^3 Baht)
Manager	1	12	144.0
Mecha. Eng.	2	8.2	196.8
Elect. Eng.	1	8.2	98.4
Operator	4	5.0	240.0
Labor	2	2.35	56.4
Total	10		735.6

Note: Inclusion of night shift

2) Operation and Maintenance Cost

Item		Unit Cost /percentage	Consumption /initial cost (x10^3Baht/year)
Operation:	Power	1.65 B/KWH	8,317
	Chlorine	16 B/kg	164
Mainte-nance:	Civil/archi. structure	1 % of construction cost	615
	Mechanical and Electrical equip.	3 % of construction cost	5,628
	Total		14,724

The following are the summary of annual O & M cost for the capacity of 2001 covering above mentioned items.

Item	cost Requirement (x10^3 Bhat)
1.Interceptors & accessories	847
2.Pump Stations	
(1) Labor	116
(2) O & M	6,062
Sub Total	6,178
3.Wastewater T.P	
(1)Labor	736
(2)O & M	14,724
Sub Total	15,460
4.Total Cost	22,485

9.3 Capital Investment Program

The first stage program was established starting from 1994 to complete by the 1997 under the following assumptions.

(1) Detailed Engineering Design: One(1) year period
(2) Construction period of wastewater treatment plant: two(2) years
(3) Budgetary arrangement and approval procedures: as required for consulting services and construction works

Figure 9.3.1 shows implementation schedule and manners of implementation by item are enumerated.

(1) Budgetary arrangement and relevant procedures for project implementation

Arrangements by the Government in either use of domestic or foreign assisted finances shall be done timely both for consulting services and construction of sewerage facilities. Tendering and approval by related agencies are requisites with some months: For consulting service it is necessary to be performed at the beginning of 1994. During 1995, arrangements for construction work is also required.

(2) Land acquisition

Prior to the construction work, land area shall be purchased or ensured for right-of-way (interceptor routes). The activities shall be done during the years 1995 and 1996. The land acquisition covers eight(8) pump stations and treatment plant site.

(3) Construction of sewerage facilities

Interceptors with accessories including overflow chambers and inverted siphon are planned to be constructed during 1996 and 1997 (1.5 years) before completion of treatment plant.

Pump stations are also to be completed by 1997(1.5 years). The longest construction period of years is assumed for the treatment plant starting from the beginning of 1996. Procurement of a maintenance vehicle and laboratory equipment shall be done by the end of 1997.

Figure 9.3.1 Implementation Program for the First Stage Project

year Item	1994	1995	1996	1997
1.Budgetary arrangement & other procedures				
1.1 Budgetary Arrangement	——	——		
1.2 Tendering	—	——		
1.3 Approval procedure	—	— —		
2.Land Acquisition				
2.1 Right-of-way for Interceptors(19.7km)		------	----	
2.2 Pump Station (8st.)		------	----	
2.3 Treatment Plant		---------		
3.Construction Work				
3.1 Interceptors w/ accessories			———	————
3.2 Pump Stations			———	————
3.3 Treatment Plant			————	————
4.Consulting Services				
4.1 Engineering Design	————	—		
4.2 Const. Supervision			————	————

(4)Consulting Services

Detailed design of sewerage facilities is assumed to be conducted by the beginning of 1995. Construction supervision shall be done during the construction period by experienced engineers.

Table 9.3.2 shows capital investment program between 1994 and 1997.

SECTION 10 ORGANIZATION AND MANAGERIAL ASPECTS

10.1 General

Well scheduled preparations shall be conducted at both national and local levels in a due and timely manner. Local preparations of management will be discussed in the next section.

The national preparations shall be conducted:

Table 9.3.2 Capital Investment Program for First Stage Project

(Unit: Million Baht)

Year / Item	1994			1995			1996			1997			Total		
	Dom.	Foreign	Total	Dom.	Foreign	Total	Dom.	Foreign	Total	Dom.	Foreign	Total	Dom.	Foreign	Total
1. Interceptors W/Accessories							73.4	0.3	73.7	171.2	0.6	171.8	244.6	0.9	245.5
2. Pump Stations							12.7	18.1	30.8	29.5	42.1	71.6	42.2	60.2	102.4
3. Treatment Plant							30.8	93.8	124.6	30.7	93.8	124.5	61.5	187.6	249.1
Sub-Total (item 1-3)							116.9	112.2	229.1	231.4	136.5	367.9	348.3	248.7	597.0
4. Contingency							23.4	22.4	45.8	46.2	27.3	73.5	69.7	49.7	119.4
5. Consulting Fee															
(1) Detailed Design	82.3		82.3	9.1		9.1							91.4		91.4
(2) Supervision							15.2		15.2	15.2		15.2	30.4		30.4
6. Land Acquisition				75.9		75.9	1.0		1.0				76.9		76.9
Sub-Total (item 4-6)	82.3		82.3	85.0		85.0	39.6	22.4	62.0	61.4	27.3	88.7	268.4	49.7	318.1
Total	82.3		82.3	85.0		85.0	156.5	134.6	291.1	292.8	163.8	456.6	616.7	298.4	915.1

Note : Dom.; Domestic portion
Foreign; Foreign portion
Procurement of maintenance car is included in item 1.
Laboratory equipment is considered in item 3.

(1) Strengthening of PWD and OSW

A new office for sewage works which was created in 1993 is called as Office of Sewage Works (OSW). The Sanitary Engineering Division (SED) staff have been dealing with wide duties covering solid waste management, nightsoil disposal and drainage. The staff of OSW need to be reinforced to concentrate themselves on sewage works. It is also recommended that OSW staff be involved with more policy-oriented direction.

The organization of OSW is recommended by the Study Team, shown in Figure 10.1.1

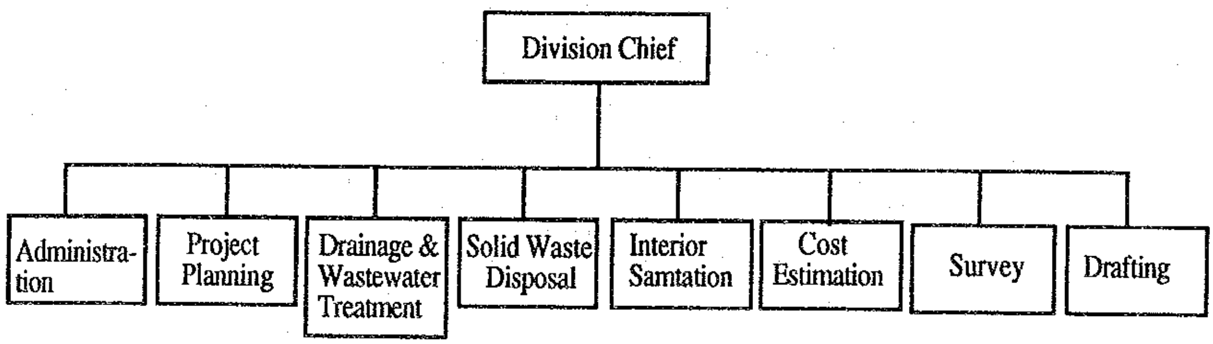


Figure 10.1.1 Organization of Office of Sewage Works (OSW)

(2) Creation of NSWA

It is predicted that the demands for sewerage system will continue to increase through the future. But sanitary engineers who can work for sewerage system are rather limited, because of the historical and social background of Thailand. One of the solutions for this will be to create a new organization out of the central government, but with close relationship of PWD. This new organization can be National Sewage Works Authority (NSWA) as temporally named, in analogy with Metropolitan or Provincial Water Works Authority for water supply.

The new organization should be basically self-sufficient, in balance between revenue and expenditure, though it may be financed from outside in the initial stage. It should have the following functions:

- Managerial/Financial Capability
- Technical Capability
  . Planning/design Capability
  . Construction and supervision capability
  . Operation and maintenance
- Training capability
- Archives/Statistics capability

If a new organization is created, legal arrangements will be required accordingly. The contents of the new organization will be as follows:

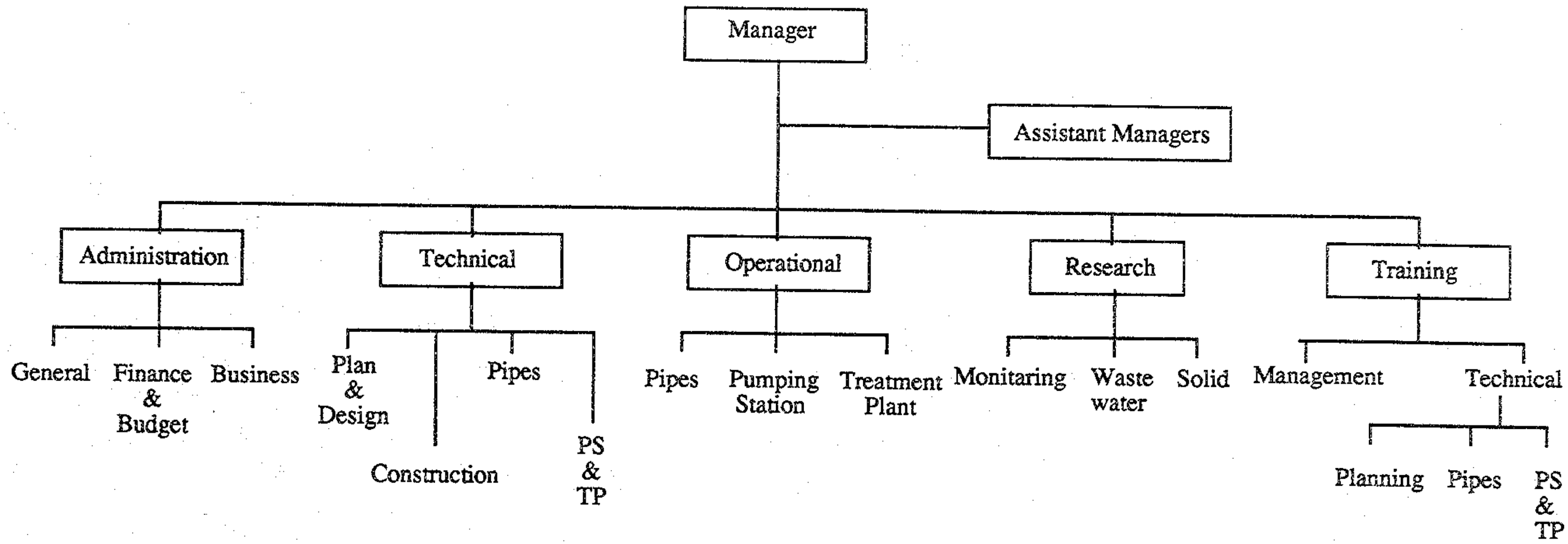
1) General
2) Establishment
3) Management
4) Business
5) Finance and Accounting
6) Supervision
7) Penalty
8) Others

The organization of NSWA is proposed in Figure 10.1.2

(3) Legal arrangement

The laws and standards for environmental pollution control have been well developed in Thailand. They are aimed at air, noise, water and tonic wastes. However the problem is how to enforce these laws and standards in order to realize the people's welfare and amenity. If there is no capacity to monitor a pollution, though there is a standard, it is almost useless. It means only a symbol of pollution control. This is why a real mechanism of legal enforcement should be developed. For the purpose effective trainings are one tool, and public education is also useful.

However there is no sewage works law in Thailand, which is supposed to aim at sound development of cities, improvement of public health and



Note : PS = Pumping Station
TP = Treatment Plant

Figure 10. 1. 2 Organization of National Sewage Works Authority (NSWA)

conservation of public water quality. Pollution control is a tool, but passive.

What is now needed in Thailand is an active mechanism to realize such above goals. Japan has the following three laws related to wastewater management, which can be referred to in the Study.

- Sewage Works Law (1958)
- Emergency Law for sewage Works Implementation (1967)
- Law of Japan Sewage Works Agency (1972)

The first law was aimed at establishing the concept of sewage works and giving the frame to be developed. The second one was intended to accelerate the implementation of sewage works by planning and financing the sewage works. This law facilitates the implementation of sewage works by phasing the plan, such as the Five-Year Sewage Works Plan. Now the 7th Five Year Plan is in progress. The third one is a organizational vehicle to promote the sewage works plan.

This kind of legal arrangements shall be conducted to create NSWA and LSWAs and to ensure financial supports for sewerage development.

(4) Financial arrangement

The sewerage system is expensive in capital and O/M. The capital costs can be fully or partly subsidized from the central government, but the O/M costs should be basically born at users' expenses as currently practiced in Thailand. Appropriate tariff should be studied and decided, taking into account users' affordability.

(5) Establishment of training courses

Effective trainings should be scheduled and given at national and local levels. Lecturers and materials should be basically supplied from inside, but in the initial stage they can be found from outside.

. Management courses
  - Management

- Finance/Accounting
- Tariff/Cost control

. Technical courses
- Pipe lines
- Pumping stations
- Treatment plans

Coordination with the Environmental Research and Training Center (ERTC) will augment the training activities.

10.2 Local Management

It is scheduled that all the sewerage system of the First Stage will be completed by 1997 and brought into Operation in 1998. Necessary arrangements shall be conducted along with the design and construction phase.

(1) Creation of Local Sewage Works Authority (LSA)

The Study Team recommends that a local sewage works authority be created in Rangiest after comparative study of two options. LSWA is expected to work better than an attached division of the municipality, because it can be to some degree free from regulations of Ministry of Interior. But LSWA shall have a highly qualified manager and maintain contact with the municipality through liaison to Sewerage subsection under Health division of the municipality.

The F/S phase has two stages:
- 1st Stage (1991-1997)
- 2nd Stage (1998-2001)

The 1st stage is a period to prepare the management. The organization at this stage is shown in Figure 10.2.1. The staff number is estimated at 15.

Each duty during the preparation is as follows:

- Manager to control the overall organization
- Administrative chief and staff to be responsible for general and financial affair
- Technical chief and staff to be responsible for planning and technical affairs
- Operational chief and staff to be responsible for operation and maintenance of the sewerage system. They are to coordinate with the construction team.

After completion of the system the organization shall be expanded to operational shifting, as shown in Figure 10.2.2. The staff number is estimated to be 33.

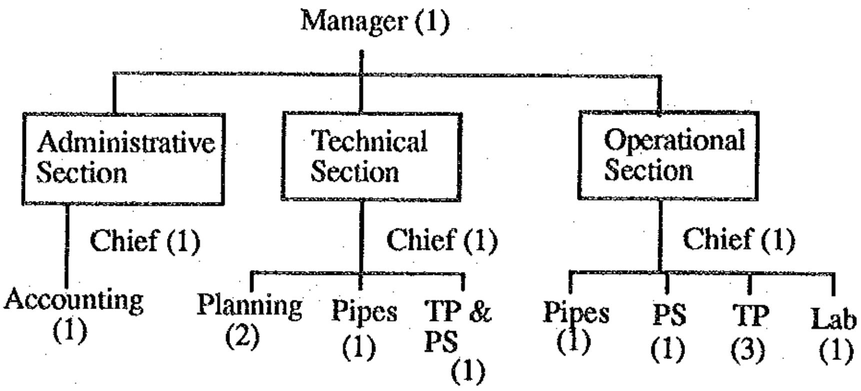
Each duty is the same as that in preparation, but is to be expanded to include the operation.

The sewerage facilities shall be operated and maintained as follows:

- Pipes to be dredged and kept free from deposits of soil and sand. This shall be contracted to outside and supervised by of two engineers.

- Pumping stations to be operated by three operators (head and two operators) is two shifts.

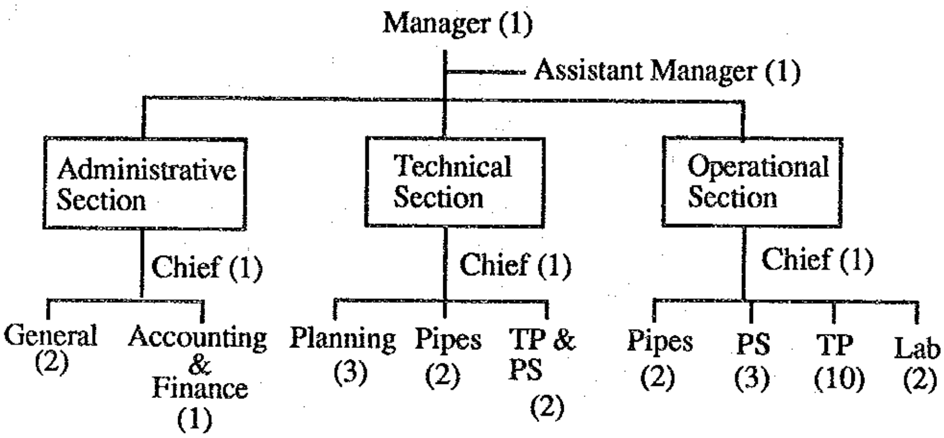
- Treatment plant to be operated by the staff shown in Figure 10.2.3.



Total Staff = (15)

Note : TP = Treatment Plant
PS = Punping Station
Lab = Laboratory
( ) = Staff number

Figure 10. 2. 1 Organization of LSWA for Rangsit
(1st Stage = 1991 - 1997)



Total Staff = (33)

Note : TP = Treatment Plant
PS = Punping Station
Lab = Laboratory
( ) = Staff Number

Figure 10. 2. 2 Organization of LSWA for Rangsit
(2nd Stage = 1998 - 2001)

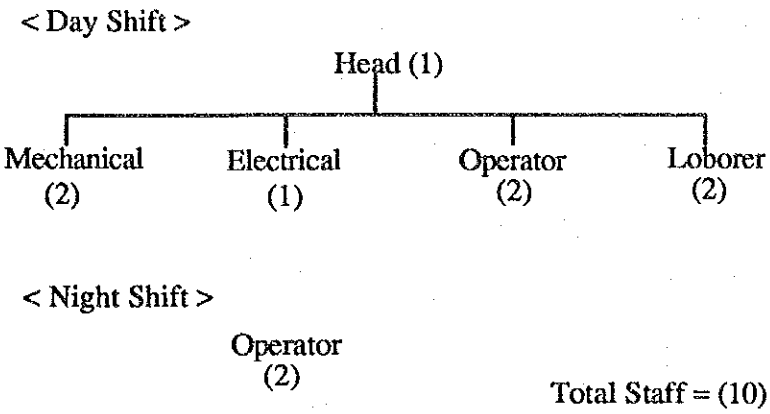


Figure 10. 2. 3 TP Staffing for Rangsit

There will be two shifts: 8 for day shift and 2 for night shift. Inspections and repairs shall be done by day shift. Night shift shall be only to operate the system.

(2) Training

At present there is no specialist for sewerage system in the municipality. So technical training and dissemination are quite important to ensure success of the proposed sewerage system. For the purpose the various training courses shall be designed for the Managers and operators.

First of all mobilization (recruitment and assignment) will be essential, because there are only limited number of expertise in Thailand. The problem is low to find and recruit sewerage specialists (technical, administrative and financial).

At national level National Sewage Works Authority (NSWA) shall be established. It shall be responsible for the trainings required for the municipality level. The number of trainees is small at municipal level. It is better to concentrate those trainees in the center of the country. NSWA is expected to organize different training courses.

The operators shall be made available on the schedule shown in Table 10.2.1.

Table 10.2.1 Operations' Schedule for Rangsit

Year / Staff	1994	1995	1996	1997	1998	1999	2000	2001
Manager		1	1	1	1	1	1	1
Assistant manager					1	1	1	1
Administrative staff		1	2	2	5	5	5	5
Technical staff		1	5	5	6	8	8	8
Operational staff		1	7	7	18	18	18	18
Total		4	13	13	33	33	33	33

Four key members (1 manager and 3 section chiefs) shall be recruited and assigned by the end of 1994. From 1995 they shall work together with the construction team and have trainings as well.

New staff members shall be recruited based on Table 10.2.1 and have trainings.

The following training courses shall be organized:

(A) Management courses

i) Financial management

ii) System management

iii) Record management

(B) Technical courses

i) Training for TP operators

ii) Training for PS operators

iii) Training for pipe maintenance

SECTION 11 FINANCIAL PLANNING

11.1 Financing the Project Cost: Central Government

There are two sewerage projects under preliminary design. The Rangsit project cost was estimated at 915.1 million Baht in 1993 prices. The cost was divided into the local (616.7) and the possible foreign(298.4) portion. The Bang Bua Thong project was also estimated at 459.5 million Baht in 1993 prices. The cost comprises the local(338.1) and the foreign(121.4) portion in the same view of Rangsit.

Aside from local budgeting totally, two options of financing the above two projects may be considered. One is arrangement through loan in the foreign portion of the project cost(419.8 million Baht), the remaining is government budget. The other is to finance the entire project cost by foreign and local loans. The foreign portion of the loan is 419.8 and the local portion, 954.8 million Baht for the two projects. This means that the weighted average capital cost becomes 8.1%[.32*0.04+.68*0.1=0.081] for 25 years with five years of grace period.

(1) Option 1 : Partial Loan Financing by Foreign Loan

The Central Government assumes 75% of the land acquisition cost (170.55) while the remaining 25% is borne by local municipalities.

Col(1) of Table 11.1.1 indicates the project cost without the land acquisition cost. Col(2) is 75% of the land acquisition cost. Col(3) is O&M cost. Total amount of foreign loan is 419.8 million Baht. The household users in Rangsit and Bang Bua Thong were estimated on the basis of Table 3.5.1 Sewerage Master Planning Area and Population. The average number of persons per household was 4.1 persons. The household population is expected to increase at 2.2% in Rangsit and 2.4% in Bang Bua Thong between 1993 and 2024. The result is shown in col(5).

Col(6) is the break even loan cost per household between 1999 and 2024. Col(4) divided by col(5) gives col(6).

Net income in Col(7) is the net revenue generated from the household users. During the period between 1994 and 1998, no revenues will be generated. Thus the net income shows negative figure of col(4). Here O&M cost in col(3) is excluded because O&M cost will be borne by household users in local municipalities.

Col(7) is derived from col(5) multiplied by col(6) and further multiplied by a factor of 1.5. This factor of 1.5 is required to make the FIRR sound and feasible in financial administration. There is no definite figure to be maintained, but in view of the capital opportunity cost of, say, 10 to 12%, the FIRR should be closer to the opportunity cost and be higher than the capital cost used in this example.

The last column (8) is the real cost on the part of the household users. This is derived from col(6) multiplied by a factor of 1.5. The loan cost per household user becomes 893 Baht in 1999 and decreases to 510 Baht toward the year 2024.

FIRR of Table 11.1.1 turned out 11.8%, reflecting the opportunity cost the capital.

In the Master Plan, it was estimated that the household income in highly industrialized municipalities of Rangsit and Bang Bua Thong would reach 430,670 Baht in 2011. This is the average figure and the low household income in these two area would be much less, say, one third or less. Using the figure of one third of 430,670 Baht, the level of income would become 143,556 Baht.

(2) Option 2 : Full Loan financing by Foreign and Local Loans

Table 11.1.2 shows the loan cost per household user when the entire project cost is financed by foreign and local loans. Each column in Table 11.1.2 is the same as that in Table 11.1.1. Only exception is the amount of loan and the interest rate. The loan cost per household user would become 4,136 Baht per year in 1999 and drops to 2,363 in 2024. The FIRR would also drop to 8.6%, much lower than the capital opportunity cost.

Should the entire project cost be financed, the financial burden on the part of household users would be too high and the household users would be able to pay that amount. On the basis of 143,556 Baht as the low household income in 2011, 4,135 Baht would be equivalent of 2.8% of household income, much too high to bear.

Table 11.1.1 Cash Flow of the Sewage Project by Central Gov't for Rangsit and Bang Bua Thong, 1994-2024

Year	ProjCost Exc Land (Mil Bt) (1)	LandCost 75%Share (Mil Bt) (2)	O&M Cost (Mil Bt) (3)	LoanCost F&L Loan (Mil Bt) (4)	H User (5)	H User Cost (4)/(5) (Baht) (6)	Net Income (Mil Bt) (7)	H User Cost/Yr (Baht) (8)
1994	112.6		32.185	16.79	39919		-16.792	
1995	11.0	170.55	32.185	16.79	40823		-16.792	
1996	445.8		32.185	16.79	41746		-16.792	
1997	577.7		32.185	16.79	42691		-16.792	
1998			32.185	16.79	43657		-16.792	
1999			32.185	26.59	44646	596	13.295	893
2000			32.185	26.59	45656	582	13.295	874
2001			32.185	26.59	46689	570	13.295	854
2002			32.185	26.59	47746	557	13.295	835
2003			32.185	26.59	48827	545	13.295	817
2004			32.185	26.59	49932	533	13.295	799
2005			32.185	26.59	51063	521	13.295	781
2006			32.185	26.59	52219	509	13.295	764
2007			32.185	26.59	53401	498	13.295	747
2008			32.185	26.59	54610	487	13.295	730
2009			32.185	26.59	55846	476	13.295	714
2010			32.185	26.59	57111	466	13.295	698
2011			32.185	26.59	58404	455	13.295	683
2012			32.185	26.59	59726	445	13.295	668
2013			32.185	26.59	61079	435	13.295	653
2014			32.185	26.59	62462	426	13.295	639
2015			32.185	26.59	63877	416	13.295	624
2016			32.185	26.59	65323	407	13.295	611
2017			32.185	26.59	66803	398	13.295	597
2018			32.185	26.59	68316	389	13.295	584
2019			32.185	26.59	69863	381	13.295	571
2020			32.185	26.59	71446	372	13.295	558
2021			32.185	26.59	73064	364	13.295	546
2022			32.185	26.59	74719	356	13.295	534
2023			32.185	26.59	76412	348	13.295	522
2024			32.185	26.59	78143	340	13.295	510

Col(3) = O&M Cost is borne by H Users FIRR 0.11822
Col(4) = 4% Interest rate,25 Year, Loan = 419.8 Million Baht (foreign loan only),5 Years of Grace Period
Col(5) = H Users increase at 2.2 in Rangsit, 2.4% in B.B.Thong
Col(6) = Break Even H User Cost = col(4)/col(5)
Col(7) = Income from H Users = col(5)*col(6)*1.5
Col(8) = Col(6)*1.5 = co (6)*1.5

Table 11.1.2 Cash Flow of the Sewage Project by Central Gov't for Rangsit and Bang Bua Thong, 1994-2024

Year	ProjCost Exc Land (Mil Bt) (1)	LandCost 75%Share (Mil Bt) (2)	O&M Cost (Mil Bt) (3)	LoanCost F&L Loan (Mil Bt) (4)	H User (5)	H User Cost (4)/(5) (Baht) (6)	Net Income (Mil Bt) (7)	H User Cost/Yr (Baht) (8)
1994	112.6		32.185	106.73	39919		-106.73	
1995	11.0	170.55	32.185	106.73	40823		-106.73	
1996	445.8		32.185	106.73	41746		-106.73	
1997	577.7		32.185	106.73	42691		-106.73	
1998			32.185	106.73	43657		-106.73	
1999			32.185	123.09	44646	2757	61.546	4136
2000			32.185	123.09	45656	2696	61.546	4044
2001			32.185	123.09	46689	2636	61.546	3955
2002			32.185	123.09	47746	2578	61.546	3867
2003			32.185	123.09	48827	2521	61.546	3781
2004			32.185	123.09	49932	2465	61.546	3698
2005			32.185	123.09	51063	2411	61.546	3616
2006			32.185	123.09	52219	2357	61.546	3536
2007			32.185	123.09	53401	2305	61.546	3458
2008			32.185	123.09	54610	2254	61.546	3381
2009			32.185	123.09	55846	2204	61.546	3306
2010			32.185	123.09	57111	2155	61.546	3233
2011			32.185	123.09	58404	2108	61.546	3161
2012			32.185	123.09	59726	2061	61.546	3091
2013			32.185	123.09	61079	2015	61.546	3023
2014			32.185	123.09	62462	1971	61.546	2956
2015			32.185	123.09	63877	1927	61.546	2891
2016			32.185	123.09	65323	1884	61.546	2827
2017			32.185	123.09	66803	1843	61.546	2764
2018			32.185	123.09	68316	1802	61.546	2703
2019			32.185	123.09	69863	1762	61.546	2643
2020			32.185	123.09	71446	1723	61.546	2584
2021			32.185	123.09	73064	1685	61.546	2527
2022			32.185	123.09	74719	1647	61.546	2471
2023			32.185	123.09	76412	1611	61.546	2416
2024			32.185	123.09	78143	1575	61.546	2363

Col(3) = O&M Cost is borne by H Users FIRR 0.08572
Col(4) = 4% Interest rate,25 Year, Loan = 1,317.7 Million Baht (foreign and domestic loans),5 Years of Grace Period
Col(5) = H Users increase at 2.2 in Rangsit, 2.4% in B.B.Thong
Col(6) = Break Even H User Cost = col(4)/col(5)
Col(7) = Income from H Users = col(5)*col(6)*1.5
Col(8) = Col(6)*1.5 = co (6)*1.5

11.2 Cash Flow and Household Burden of O&M and Local Land Acquisition Cost

As indicated in the Master Plan, the ratio of land acquisition cost to fixed investment was high, thereby putting too much burden upon Rangsit. this would suggest that Rangsit would apply for loan financing.

While the capital construction cost is borne by the Central Government, the acquisition cost of land is not totally included. Local municipality must acquire the land for sewerage facility with 25% of the cost.

Should the entire land acquisition cost be financed by the 50% foreign land and 50% local loan with the weighted average capital cost of 7% for 25 years with the grace period of 5 years, the break even cost per household user becomes 109 Baht per year in 1999 and drops to 63 Baht in 2024. However, the real burden on the household user becomes 437 Baht in 1999 and decreases to 254 in 2026. This is because the FIRR should be maintained in such a level that the local financial project be feasible. The FIRR should be somewhere greater than 7%, but less than the prevailing capital market cost of, say, 12%. The FIRR turned to be 7.38% in Rangsit. The above figure would indicate the maximum burden on the household user should Rangsit be financed entirely by the combination of foreign and local loans. Should Rangsit obtain through official procedures, subsidy and grant, the real burden on the household user would be smaller.

The cash flow is indicated in col(6) of Table 11.2.1. Col(6) is equal to col(4) multiplied by col(5) and further multiplied by a factor of 4.

Table 11.2.1 Rangsit : Cash Flow and Household User Cost
Pop in 1991 = 45,786, 2.4% Increase

Year	25%Land Cost Million (1)	O&M Cost Million (2)	Loan Cost 25%Land Million (3)	H User (4)	H User Br'kEv'n (3)/(4) Baht (5)	Net Income Million (7)	H User Cost Baht (8)
1994		22.49	2.63	26192		-25.13	
1995	37.63	22.49	2.63	26768		-25.13	
1996		22.49	2.63	27357		-25.13	
1997		22.49	2.63	27959		-25.13	
1998		22.49	2.63	28574		-25.13	
1999		22.49	3.19	29203	109	12.76	437
2000		22.49	3.19	29845	107	12.76	428
2001		22.49	3.19	30502	105	12.76	418
2002		22.49	3.19	31173	102	12.76	409
2003		22.49	3.19	31858	100	12.76	401
2004		22.49	3.19	32559	98	12.76	392
2005		22.49	3.19	33276	96	12.76	383
2006		22.49	3.19	34008	94	12.76	375
2007		22.49	3.19	34756	92	12.76	367
2008		22.49	3.19	35521	90	12.76	359
2009		22.49	3.19	36302	88	12.76	351
2010		22.49	3.19	37101	86	12.76	344
2011		22.49	3.19	37917	84	12.76	337
2012		22.49	3.19	38751	82	12.76	329
2013		22.49	3.19	39604	81	12.76	322
2014		22.49	3.19	40475	79	12.76	315
2015		22.49	3.19	41365	77	12.76	308
2016		22.49	3.19	42275	75	12.76	302
2017		22.49	3.19	43205	74	12.76	295
2018		22.49	3.19	44156	72	12.76	289
2019		22.49	3.19	45127	71	12.76	283
2020		22.49	3.19	46120	69	12.76	277
2021		22.49	3.19	47135	68	12.76	271
2022		22.49	3.19	48172	66	12.76	265
2023		22.49	3.19	49231	65	12.76	259
2024		22.49	3.19	50315	63	12.76	254

Col(1) = Loan financed by 50% foreign and 50% Local, with 7% interest 25 years, with 5 years of grace period

FIRR = 0.0738

Col(7) = Col(6)*col(5)*4 for 1999 to 2024
Col(8) = Col(6)*4 for 1999 to 2024

11.3 Affordability

In the Master Plan, it was estimated that the household income in highly industrialized Municipality of Rangsit would reach 430,670 Baht in 2011. This is the average figure and the low household income in Rangsit would be much less, say, less than one third. Using the figure of one third of 430,670 give 143,556 Baht. In the case of Rangsit, the relative cost of household user would become 437 Baht in 1999, 0.3% of household income of 143,556 Baht. Should the project loan cost by the Central Government be added to Rangsit household users, this figure would increase to 1,330 in 1999 and 764 Baht in 2024, respectively.

11.4 Recommendations

It is generally agreed upon that the burden on the household user be 1% or less. Should the household income in Rangsit and Bang Bua Thong be in the neighborhood of 150,000 Baht in 2011, the relative burden on household users would not a be problem.

With respect to local financing, each municipality will be advised to utilize a combination of foreign and local loans to the extent that their local financial resources will not be too much burdened. This study has provided one practical and feasible solution as 50% foreign loan and 50% local loan. There are other combinations of foreign and local loans also.

Some serious effort of obtaining a portion of land acquisition cost will highly be recommended because it shows strong local determination on the part of the sewerage project, portraying the image of joint project between the Central Government and the local municipality.

Finally, if not the last, public education and persuasion effort will highly be valuable for the dissemination of the value of this project throughout the country.

11.5 Financial Sensitivity Analysis

When the loan amount is fixed, the cash flow depends upon the revenue generated from the expected household user. As in most cases, the revenue collection efficiency, defined as the ration of the expected revenues to the actual revenues collected. When the collection efficiency drops to, say 80%, the expected FIRR also drops accordingly.

Three scenarios are assumed: The first is 80% revenue collection efficiency and the second, 70%, and the third, 60%, respectively both in Rangsit and Bang Bua Thong. A summary of the three scenarios is presented in Table 11.5.1.

Table 11.5.1 Sensitivity Analysis of Financial Returns

FIRR	Bang Bua Thong (%)
Scenario 1: 80% Revenue Collection	5.4
Scenario 2: 70% Revenue Collection	4.4
Scenario 3: 60% Revenue Collection	3.2

As indicated above, the FIRR is highly sensitive to a change of revenue collection efficiency.

SECTION 12 BENEFITS OF THE PROJECT

12.1 Economic Benefits

Significant economic benefits to public health of the community can be derived from installation of an adequate sewerage system. The benefits to be derived from the sewerage systems as recommended in this Master Plan can be classified into three categories, (1) water qualitative improvement benefits, (2) health and sanitation improvement benefits, and (3) economic benefits attributable to the increase of land value, tax income, and of business activities, and (4) upgrading of living standard.

(1) Water Quality Improvement of Chao Phraya River

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

Table 12.1.1 shows a summary of the projection results reflecting the effects of sewerage projects in the lower Chao Phraya river basin.

Table 12.1.1 Effects of Sewerage Projects

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

As shown in Table 12.1.1, it is obvious that the sewerage projects in the study area will contribute enormously for improvement of the water quality at the checking points,although water quality at R4 would be critical comparing with the environmental standard.

(2) Health and Sanitation Improvement Benefits

(a) Private Health and Sanitation Benefits

The sewerage project also contributes to the reduction of private health costs through improved health and sanitation, particularly through the reduction of water-borne diseases.

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

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

The three factors are listed below:

a) medical cost of treatment and care per person at a hospital
b) medical cost of treatment and care per person per consultation
c) illness cost per person

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

Then annual health cost was estimated at 3.7 million in 1994 and 5.3 million Baht in 2024 in this study area of Rangsit sewerage project.

(b) Public Health Improvement Benefits Increase of opportunity in different water uses:

Improvement of water quality in the main river/klongs enables residents to use water for recreational purpose and others. In addition, contribution to the Chao Phraya river is expected to achieve water quality standard.

(c) Mortality and morbidity of the inhabitants would be reduced. The people use water in klongs for multiple purposes, even if for bathing being exposed to polluted water. In this connection, it is expected for the sewerage system to diminish the chance of communicable diseases.

(3) **Improvement of Land Use**

(a) The sewerage service help promote effective land use such as expansion of residential area and commercial activities.

(b) Increase of tax income: Tax revenues from the increase of property (land and buildings, structures, etc.) and of business activities may be expected.

(c) Development of employment opportunity and markets for construction materials and equipment. Construction of sewerage system, and operation and maintenance work will contribute to the local economy through the increase of employment opportunity and expansion of markets relevant to the sewage works.

(d) A quantitative attempt to measure property value attributable to the sewerage factor:

An attempt to quantify economic benefits attributable to the increase in land price. Average Land price in the project service area is indicated as 46,605 Million Baht in 1993, as shown in Table 12.1.2.

Table 12.1.2 Land Value in the Project Service Area in Rangsit,1993

Land Use Type	Rangsit hector (1)	Price (2)	Value (3)
Commercial Area	144	6000	8640
Medium Density Area	411	4000	16440
Low Density Area	251	3000	7530
Institutional Area	56	2000	1120
Industrial Area	107	1000	1070
Other Area	2361	500	11805
Total Value of Land			46605

It is assumed that the land price will increase at 5% per year from 1993 to 2000. The sewerage service area is assumed to contribute to 5% of the value of land increase. Net benefit of the increase of land value attributable to the sewerage project indicated in col(5) of Table 12.1.3.

Table 12.1.3 Economic Benefits and Economic Rate of Return (Million Baht)

Year	Project Cost (1)	O&M Cost (2)	LandValue (3)	5% Inc of land '94-2010 (4)	Sewage Factor 5% (5)	PvtH'lth Benefit (6)	Total Benefit (5)+(6) (7)	Net Cash Flow (7)-(2) (8)
1994	82.3	9.700	48,935	2,330	117	3.7	120.2	37.9
1995	85.0	9.700	51,382	2,447	122	3.7	126.1	41.1
1996	291.1	9.700	53,951	2,569	128	3.8	132.2	(158.9)
1997	616.7	9.700	56,649	2,698	135	3.8	138.7	(478.0)
1998		9.700	59,481	2,832	142	3.9	145.5	145.5
1999		9.700	62,455	2,974	149	3.9	152.6	152.6
2000		9.700	65,578	3,123	156	4.0	160.1	160.1
2001		9.700	68,857	3,279	164	4.0	168.0	168.0
2002		9.700	72,300	3,443	172	4.1	176.2	176.2
2003		9.700	75,915	3,615	181	4.1	184.8	184.8
2004		9.700	79,710	3,796	190	4.1	193.9	193.9
2005		9.700	83,696	3,986	199	4.2	203.5	203.5
2006		9.700	87,881	4,185	209	4.3	213.5	213.5
2007		9.700	92,275	4,394	220	4.3	224.0	224.0
2008		9.700	96,888	4,614	231	4.3	235.0	235.0
2009		9.700	101,733	4,844	242	4.4	246.6	246.6
2010		9.700	106,820	5,087	254	4.5	258.8	258.8
2011		9.700	106,820	0	0	4.5	4.5	4.5
2012		9.700	106,820	0	0	4.6	4.6	4.6
2013		9.700	106,820	0	0	4.6	4.6	4.6
2014		9.700	106,820	0	0	4.7	4.7	4.7
2015		9.700	106,820	0	0	4.7	4.7	4.7
2016		9.700	106,820	0	0	4.8	4.8	4.8
2017		9.700	106,820	0	0	4.8	4.8	4.8
2018		9.700	106,820	0	0	4.9	4.9	4.9
2019		9.700	106,820	0	0	5.0	5.0	5.0
2020		9.700	106,820	0	0	5.0	5.0	5.0
2021		9.700	106,820	0	0	5.1	5.1	5.1
2022		9.700	106,820	0	0	5.1	5.1	5.1
2023		9.700	106,820	0	0	5.2	5.2	5.2
2024		9.700	106,820	0	0	5.3	5.3	5.3
							EIRR =	0.3078

Shadow Price: 40% Foreign and 60% Local contents are assumed
Project cost = Foreign portion[.4 *1.2]+ Local[0.6(0.2*1.0 + 0.8*0.8)]
Foreign capital cost = 1.2, Local capital cost = 1.0, Local labor = 0.8
Local capital = 20% of local portion, labor = 80% of local portion
Shadow price factor = 0.984 [0.4*1.2+0.6*0.2*1.0+0.6*0.8*0.8]
Col(1) and Col (2) adjusted by 0.984
Land Value = 46,605 Million Baht in 1993.,5% Increase from 1994-2010
O&M Cost is borne by H Users

(4) Upgrading of Living Standard

Improvements of water quality of public water body and its surrounding environment are to be expected.

conservation of natural conditions:

The sewerage system will help recover natural stream, especially for major klongs in terms of offensive odor, appearance(color) and ecological system.

12.2 Economic Justifications

Socio-economic benefits derived from sewerage project are qualitatively discussed in the Master Plan. In the preliminary design, the benefits are also described qualitatively.

Nevertheless, a quantitative trial measurement on (2) and (3) is attempted as an index of economic benefits.

An attempt to quantify economic benefits on the basis of the increase of land value and of the reduction of private health costs attributable to the sewerage project indicate that EIRR becomes 31%. This figure appears reasonable to justify the project on economic grounds. However, as will be indicated in 12.3 sensitivity analysis, this figure of EIRR should be interpreted with caution. Underlying assumptions and conditions may be subject to change and are sometimes difficult to foresee some fundamental changes of the socio-economic environment.

In view of qualitative improvement and quantitative measurement, the realization of sewerage project will bring about substantial advantages. Further deterioration of water quality in the public water body is indispensable without provision of sewerage project. The future opportunity cost is bound to increase should the project be delayed any further.

Thus, there exist stronger and constructive reasons for justifying the sewerage project on qualitative and quantitative grounds both.

12.3 Economic Sensitivity Analysis

The EIRR of 30.8% appear high enough to justify the project on economic grounds. However, the key is the land value and its increase.

However, the major contributing factor to the value of EIRR is the assumptions made under land value and land value increase. Should the assumptions indicated may change, the value of EIRR will also be altered. Thus it the value of EIRR should be interpreted with caution.

When the volume of land transactions decreases by 50%, then the EIRR drastically drops from 31% to 6.8%. Similarly when the volume of transactions decreases to one third, then EIRR will become 6.7%. The worst scenario that one fourth of land transactions is generated, then the EIRR becomes a negative of 2.2%, as shown in Table 12.3.1.

Table 12.3.1 Sensitivity Analysis of Economic Returns

	EIRR (%)
Scenario 1: Land Transactions Reduced into Half	6.8
Scenario 2: Land Transactions Reduced into One Third	6.7
Scenario 3: Land Transactions Reduced into One Quarter	-0.2

CHAPTER 3

BANG BUA THONG MUNICIPALITY

CHAPTER 3 BANG BUA THONG MUNICIPALITY

SECTION 1 STUDY AREA FOR FIRST STAGE SEWERAGE PROGRAM

Of the two service areas planned in the sewerage master plan, Bang Bua Thong North area covering 438 ha was selected as the priority area for the first stage program. The design area is currently developed with a higher population density including municipal center and housing complexes. Administratively the area comprises two villages, Pimol Ratch 3 and 5, and the part of Sano Loy and Bang Bua Thong 2 in Nonthaburi province. Table 1.1 shows the composition of administrative areas and sewerage design area. Figure 1.1 presents the area coverage for the preliminary design.

Table 1.1 Administrative and Sewerage Design Area

Village	Administrative Area (ha)	Design Area (ha)
Sano Loy	160	149.4
Bang Bua Thong 2	108	72.6
Pimol Ratch 3	65	65.0
Pimol Ratch 5	151	151.0
Total	484	438.0

There are seven(7) housing estates in the master planning area including those under construction and planned as shown in Data Report 3.1.1. Table 1.2 and Figure 1.2 present those estates located in the design area.

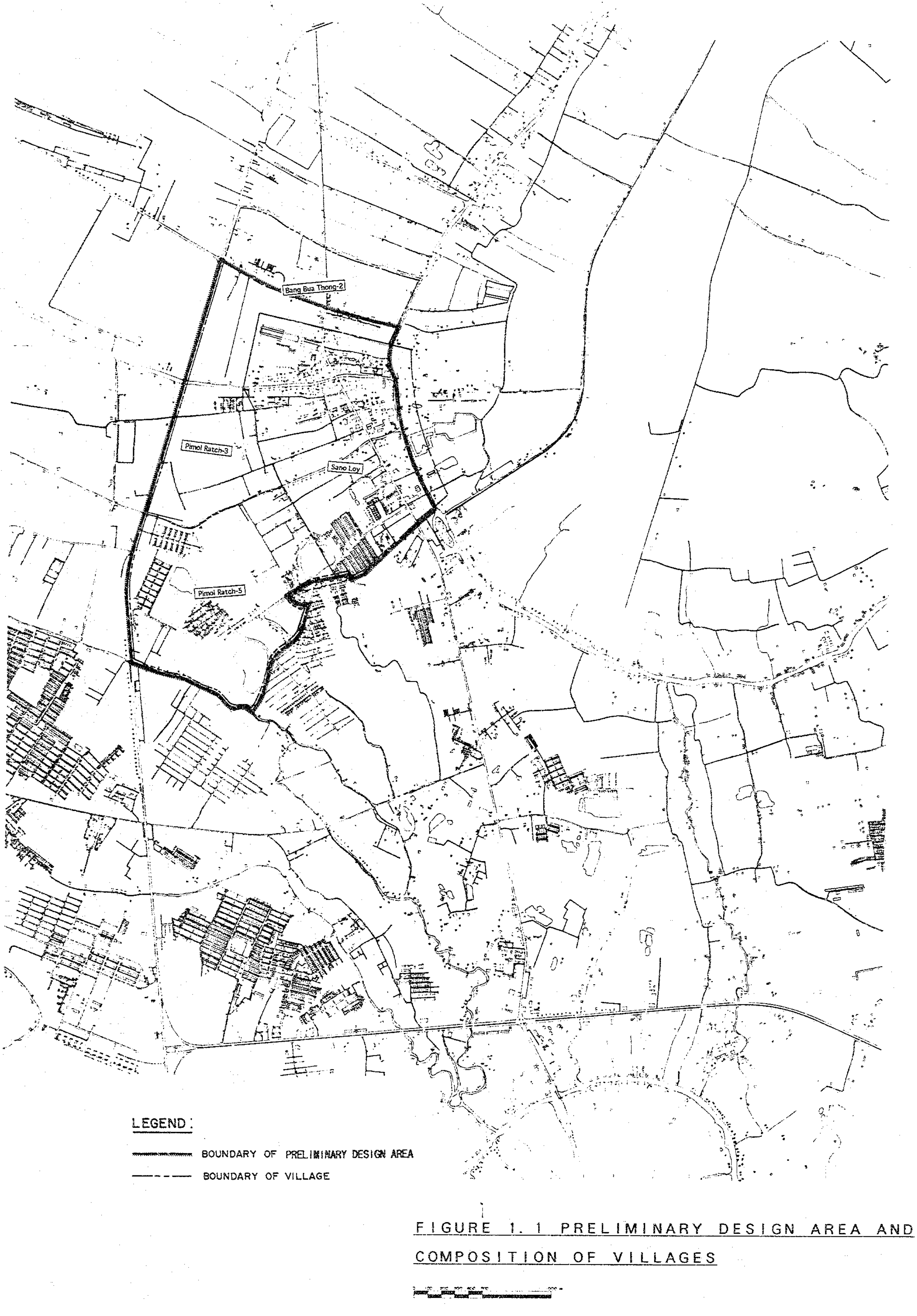


FIGURE 1. 1 PRELIMINARY DESIGN AREA AND COMPOSITION OF VILLAGES

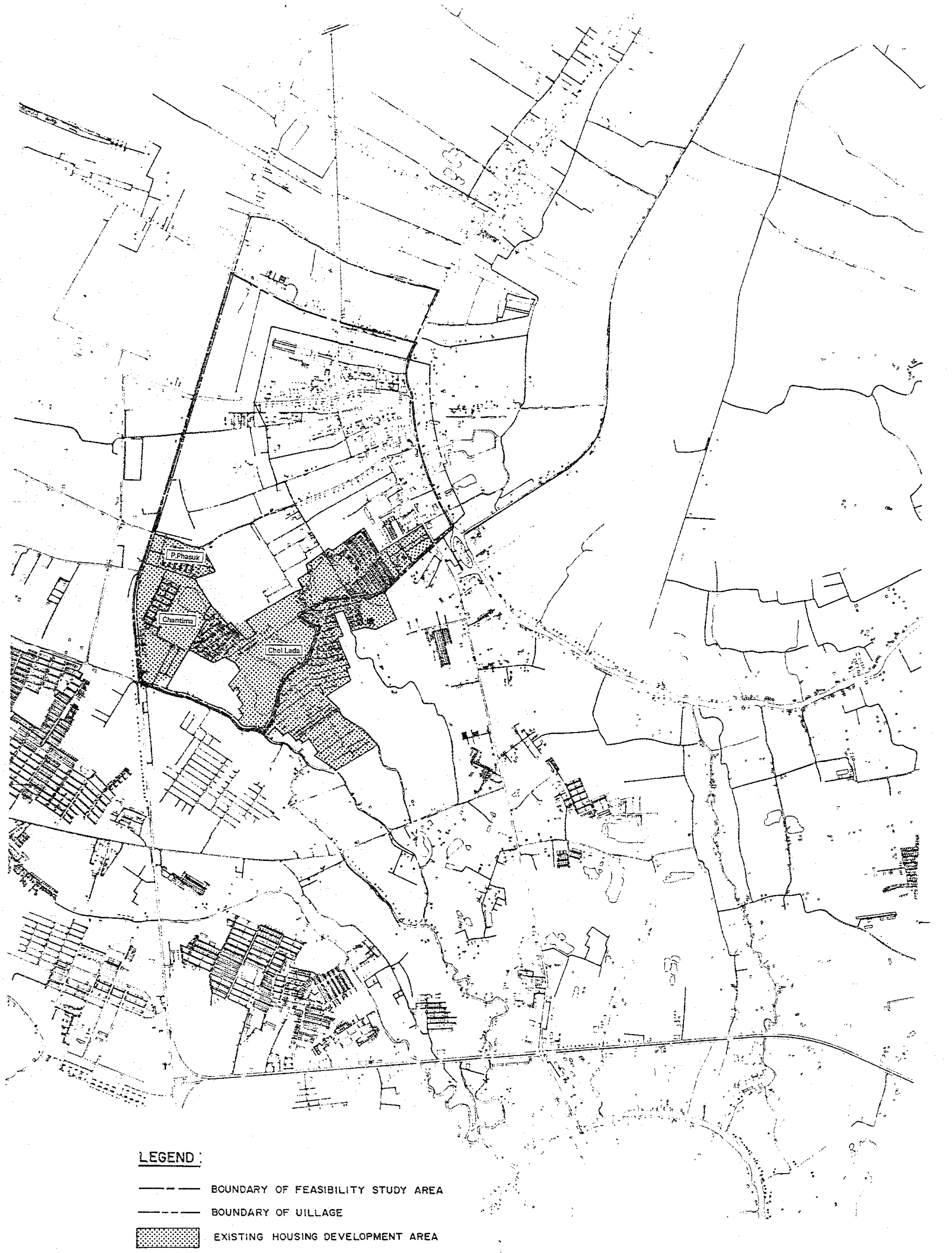


FIGURE 1. 2 LOCATION OF EXISTING HOUSING ESTATES

Table 1.2 Housing Estates in the Design Area

Name	Area (ha)	No.of House	Population		Location	Treatment Plant Maintenance
		Plan	Present	Plan		
Chol Lada	74.0	1,350	2,630	5,400	Sano Loy and Pimol Ratch 5	Good
P.Phasuk	9.6	700	840	2,800	Pimol Ratch 5	Poor
Chantima	19.2	1,000	1,200	4,000	Pimol Ratch 5	Poor
Busa Korn	4.8	336	0	1,350	Bang Bua Thong 2	
Total	107.6	3,386	4,670	13,550		

Note: Chol Lada housing estate is developed bestriding four(4) villages. bout 74 ha of Chol Lada housing estates (67% of total area of 109.9 ha) is covered by the design Area. Sano Loy : 20 ha, Pimol Ratch 5 : 54 ha

SECTION 2 EXISTING SANITATION/SEWERAGE FACILITIES IN THE STUDY AREA

Existing drainage facilities are installed facing klong Pra Pimol in the urbanized area. On-site treatment and disposal of nightsoil is practiced in the design area.

Three housing estates have respective wastewater treatment facilities as shown in Table 1.2. However, only Chol Lada estate is currently operating the facilities in comparatively good condition. 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 3.2.1

Major klongs in the subject area are klong Phra Phimon and klong Ban Klual, which are connected to klong Bang Bua Thong. The depth of these klongs were rather shallow. 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. Mamhole cover is made of thick concrete making it diffecult 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 (discharge pipes were covered with grass).

SECTION 3 POPULATION AND LAND USE

3.1 Present Population

Present population data were collected at Bang Bua Thong District Office covering four administrative areas/villages both in administrative and preliminary design area. Table 3.1.1 shows the population in 1992.

Table 3.1.1 Population in 1992

Village	Administrative Area (Registered)	Design Area
Sano Loy	10,587	9,886
Bang Bua Thong 2	391	263
Pimol Ratch 3	3,332	3,332
Pimol Ratch 5	492	492
Total	14,802	13,973

The population in Table 3.1.1 does not include those in the housing estates located in the design area as described in Section 1. Present population by relevant three estates, Chol Lada, P. Phasuk and Chantima was estimated using information collected from housing developers. Population distribution by the estate to relevant villages was made in assumptions and conditions of the followings:

- P. Phasuk and Chantima housing estates are located in Pimol Ratch 5.

- Chol Lada is developed bestriding four villages, Sano Loy, Pimol Ratch 5, Pimol Ratch 5, Bang Pak Pattana 5 and Bang Pak Pattana 6. In the design area, Chol Lada housing estate comprises Sano Loy 20 ha and Pimol Ratch-5 54 ha (a total of 74 ha of the planned estate area 109.9 ha) with the planned population of 5,400. Planned population for Sano Loy (1,440) and Pimol Ratch-5 (3,960) was allocated according to area proportion.

- Current occupancy ratio by housing estate was assumed based on field investigation in villages Sano Loy and Pimol Ratch-5 as follows:

  Sano Loy ; 100 % in Chol Lada estate
  Pimol Ratch-5 ; 30 % in three estates

Table 3.1.2 summarizes total population in the design area.

Table 3.1.2 Present Population by Village

Village	Registered	Housing estate	Total
Sano Loy	9,886	1,440	11,326
Bang Bua Thong 2	263	-	263
Pimol Ratch 3	3,332	-	3,332
Pimol Ratch 5	492	3,230	3,722
Total	13,973	4,670	18,643

Note: Pimol Ratch 5 housing estate population

Chol Lada	3,960 x 0.3 =	1,190
P. Phasuk	2,800 x 0.3 =	840
Chantima	4,600 x 0.3 =	1,200
Total		3,230

3.2 Design Population and Land Use

Design population for the year 2001 is estimated by interpolating those in 1992 and 2011. The population in 2011 by village 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 3.2.2 shows projected design population in 2001, which arrived by interpolating those in 1992 and 2011.

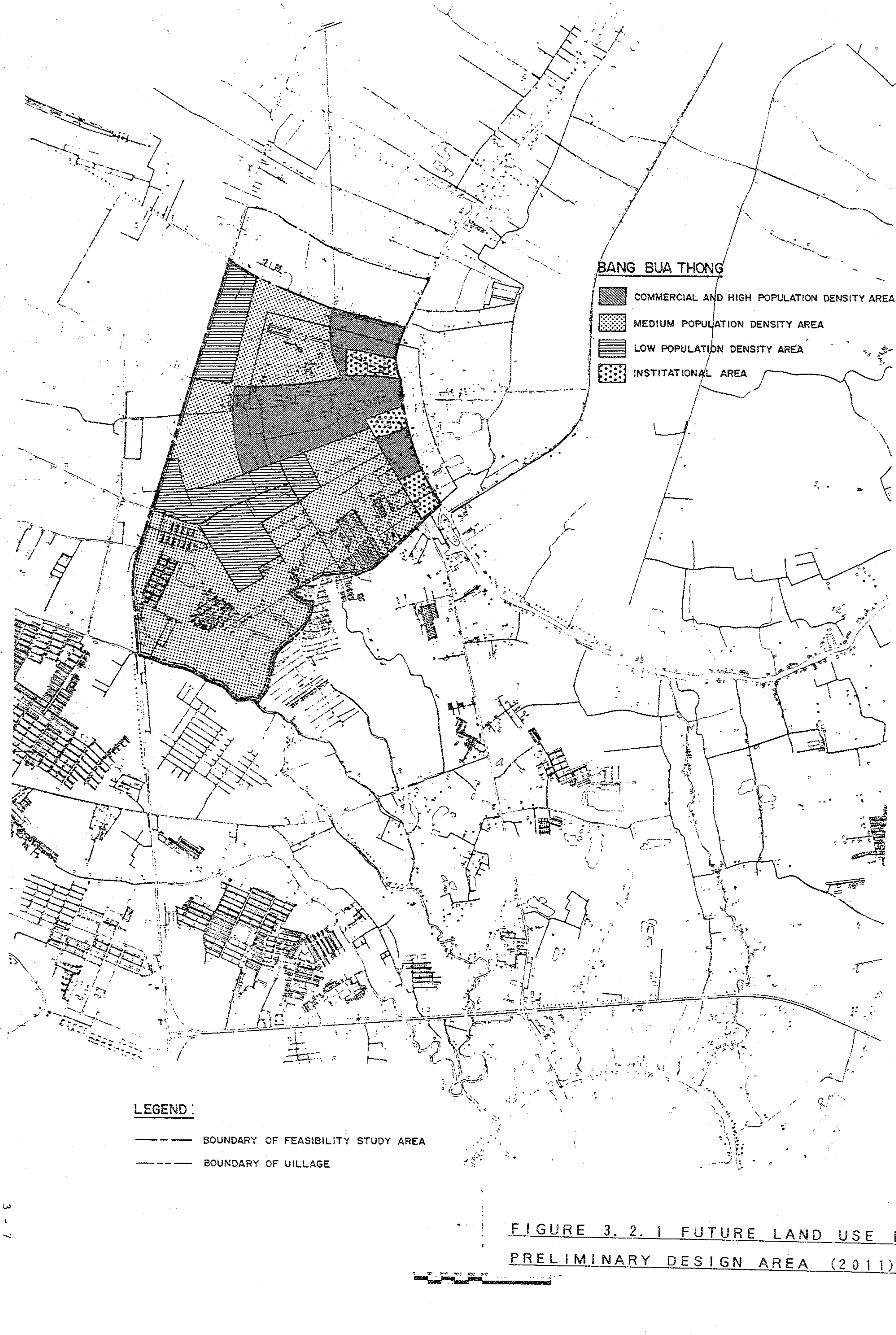


FIGURE 3. 2. 1 FUTURE LAND USE IN THE PRELIMINARY DESIGN AREA (2011)

Table 3.2.1 Land Use and Population in 2011

Village	Commerc.	Land Use (ha)				Population in 2011
		Med.Pop.	Low.Pop.	Insti.	Total	
Sano Loy	66.9	60.6	7.3	14.6	149.4	19,660
Bang Bua Thong 2	9.0	49.0	14.6	0.0	72.6	7,140
Pimol R.3	19.5	29.1	16.4	0.0	65.0	7,300
Pimol R.5	0.0	120.8	30.2	0.0	151.0	12,990
Total	95.4	259.5	68.5	14.6	438 0	47,090

Note: Population density
Commercial area 200 person/ha
Med. Pop. area 100 person/ha
Low. Pop. area 30 person/ha

Table 3.2.2 Design Population in 2001

Village	Design Area (ha)	Population		
		1992	2001	2011
Sano Loy	149.4	11,326	15,270	19,660
Bang Bua Thong 2	72.6	263	3,520	7,140
Pimol Ratch 3	65.0	3,332	5,210	7,300
Pimol Ratch 5	151.0	3,722	8,110	12,990
Total	438.0	18,643	32,110	47,090

SECTION 4. QUANTITY AND QUALITY OF WASTEWATER

Wastewater quantity and quality (BOD 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 employed from those studied in pollution control plan and sewerage master plan.

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/septick tank (BOD removal ratio) is expected to be 50 percent. unit figures on a daily average basis for the year 2001 are summarized below.

Unit Wastewater Quantity (lpcd)			Unit BOD Load (gpcd)		
Sullage	Toiletwaste	Total	Sullage	Toiletwaste	Total
132	24	156	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 basis 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)
78.4	9.4

4.2 Wastewater Quantity and Quality for Design of Sewerage Facilities

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

(1) Domestic wastewater

The total wastewater quantity and BOD load were obtained using unit wastewater quantity and projected population.

Wastewater quantity: 0.156 m^3/c.d. x 32,110 = 5,009 m^3/d
BOD load : 0.0398 kg/c.d x 32,110 = 1,278 kg/d

(2) Business wastewater

The total quantity and BOD load were estimated in the same manner as domestic wastewater.

Wastewater quantity: 0.0784 m^3/c.d. x 32,110 = 2,517 m^3/d
BOD load : 0.0094 kg/c.d x 32,110 = 302 kg/d

(3) Groundwater infiltration

It is assumed that 20 percent of wastewater quantity discharged from domestic and business sources could coincide with groundwater infiltration.

(4) Design wastewater quantity and quality

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

Type of sources	Wastewater Quantity (m^3/d)	BOD Load (kg/d)
Domestic wastewater	5,009	1,278
Business wastewater	2,517	302
Groundwater	1,505	-
Total	9,031	1,580

Table 4.2.1 summarizes quantity and quality of wastewater by source type covering four villages.

Table 4.2.1 Design Wastewater Quantity and BOD Load

Village	Wastewater Quantity (m^3/d)					BOD Load (kg/d)		
	Domestic	Busi.	Sub-T	Groundwater	Total	Domestic	Busi.	Total
Sano Loy	2,382	1,197	3,579	716	4,295	608	144	752
Bang Bua Thong 2	549	276	825	165	990	140	33	173
Pimol R.3	813	408	1,221	244	1,465	207	49	256
Pimol R.5	1,265	636	1,901	380	2,281	323	76	399
Total	5,009	2,517	7,526	1,505	9,031	1,278	302	1,580

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 Industrial W.W	 80 % of water consumption 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
(6) Pump station capacity	Dry season: design hourly max. Rainy season: three times design hourly max.
Hydraulic Calculation (1) Equation for flow calculatin	 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)