Chapter 7

INTERCEPTOR SEWER DEVELOPMENT

CHAPTER 7 INTERCEPTOR SEWER DEVELOPMENT

7.1 Introduction

Collection of wastewater in Tau Hu, Ben Nghe - Doi, Te (THBNDT) zone is proposed to utilize the existing combined sewer system as much as possible for reasons of economy. Then the interceptor sewer is required to collect the dry weather flow from the existing combined sewer system. This section describes the process for the selection of an optimum interceptor system for THBNDT zone from the technical and economical points of view.

Furthermore, the THBNDT zone borders the Nhieu Loc - Thi Nghe (NLTN) basin to the north. An environmental improvement project for the NLTN basin is currently being conducted by the World Bank as described in Section 2.4, Chapter 2, Vol. I, Main Report.

A wastewater treatment plant for the NLTN project was proposed at a site bordering on the north of the THBNDT WWTP site in JICA M/P study. However, the proposed site was about 9.5 km from the NLTN project area, thus requiring about 9.5 km of conveyance sewer and two (2) intermediate pumping station as proposed in the study. In order to reduce the construction cost of the conveyance sewer system, the NLTN project made a further effort and has found a possible site of its wastewater treatment plant closer to the collection are in District 2, which is about 7 km from its project area.

Consequently, the sewerage system for the THBNDT zone has not been integrated with the NLTN project and each project has been designed independently for the reasons of economy as described above.

7.2 Planning Concept and Design Criteria

7.2.1 Target Year to be Designed

Target year of the definitive plan is defined as the year of 2010. While, target year of the interceptor sewer design is proposed in the year 2020 same as the target year of Master Plan, because it is rather difficult to increase the sewer capacity by stepwise than other facilities as treatment plant and pumping stations. Therefore, interceptor sewers are proposed to design with the design wastewater discharge in the year 2020.

7.2.2 Design Criteria

The proposed design criteria in F/S are reviewed based on Vietnamese and Japanese Standard. As a result, the following is proposed for the criteria.

Pipe material: D<300mm - PVC pipe

	D>300mm - centrifugal concrete pipe
Unit Wastewater Discharge:	335 l/c/d (consisting of domestic, commercial, institutional and home industrial wastewater)
Design Flow:	Hourly maximum flow (1.4 times of daily average dry weather flow in year 2020) plus groundwater infiltration (10% of daily average dry weather flow)
Flow system:	Gravitation
Flow equation:	Manning equation n = 0.010 for PVC pipe n = 0.013 for concrete pipe
Minimum velocity:	0.7 m/s
Standard slope:	see Table 7.1
Minimum earth covering:	1.2 m
Manhole:	every 30m (pipe diameter $<$1200mm) every 50m (pipe diameter $>$1200mm)

The criteria may be adjusted upon a condition of soil and land if necessary.

7.3 Division of Sewerage Area

The sewerage area of 2,791.6 ha is separated by Tau Hu – Ben Nghe and Doi Te canals into three (3) areas; 1) left bank area of Tau Hu - Ben Nghe canal, 2)isolated area by Tau Hu - Ben Nghe and Doi Te canal, and 3) right bank area of Doi – Te canal. And these three (3) separated sewerage areas are further divided into 24 sub-zones as shown in Fig. 7.1 and listed in table below. The division is made based on existing combined sewer networks, canals, rivers, main roads and topography.

Sub-zone	Area (ha)	Covered District
(1) Tau Hu – Ben Nghe Canal Left Bank - East Area		
1. Sub-zone 1	132.4	1
2. Sub-zone 2	141.2	1, 3
3. Sub-zone 3	22.0	1
4. Sub-zone 4	72.9	1
5. Sub-zone 5	71.8	1, 3
6. Sub-zone 6	47.0	1
7. Sub-zone 7	232.1	1, 3, 5, 10
8. Sub-zone 8	44.9	1, 5
9. Sub-zone 9	40.4	5, 10
10. Sub-zone 10	23.7	5
Sub Total of East Area	828.4	
(2) Tau Hu – Ben Nghe Canal Left Bank - West Area		
11. Sub-zone 11	78.5	5, 10
12. Sub-zone 12	15.2	5
13. Sub-zone 13	277.1	5, 10, 11
14. Sub-zone 14	214.5	5, 6, 10, 11, Tan Binh
15. Sub-zone 15	168.6	5, 6, 11, Tan Binh
16. Sub-zone 16	111.1	6

Sub Total of West Area	865.0	
Total of Left Bank	1,693.4	
(3) Islands between Tau Hu – Ben Nghe and Doi – Te Canals		
17. Khanh Hoi	350.2	4
18. Ong Kieu	3.9	4
19. Hung Phu	76.7	8
20. Tung Thien Vuong	82.0	8
21. Binh Dong	48.6	8
Sub Total of Island Area	561.4	
(4) Doi – Te Canal Right Bank		
22. Rach Ong	133.0	8
23. Pham The Hien	195.8	8
24. Binh Dang	208.0	8
Sub Total of Right Bank	536.8	
Grand Total	2,791.6	

Note : The following areas are excluded from the sewerage service area. The excluded area is estimated at 273.4 ha.
(1) Zoo = 20.6 ha in sub-zone 1
(2) Thong Nhat Palace = 12.6 ha in sub-zone 2
(3) Tao Dan Park = 19.7 ha in sub-zone 2
(4) Phu Tho Stadium = 24.4 ha in sub-zone 12 and 7.9 ha in sub-zone 13
(5) Saigon River = 59.5 ha, Tau Hu – Ben Nghe Canal = 46.5 ha, Doi – Te Canal = 66.8 ha, Other Rivers/Canals = 15.4 ha

The population by sub-zones in 1997, 2010 and 2020 are estimated as follows:

Sub-zone	1997		2010		2020	
	Covered Population	Population Density (person/ha)	Covered Population	Population Density (person/ha)	Covered Population	Population Density (person/ha)
(1) Tan Hu – Ben Nghe Canal Left Bank - East Area						
1. Sub-zone 1	19,933	151	19,871	150	19,823	150
2. Sub-zone 2	44,971	318	44,688	316	44,470	315
3. Sub-zone 3	12,543	570	12,428	565	12,340	561
4. Sub-zone 4	51,513	707	48,331	663	46,034	631
5. Sub-zone 5	32,333	450	32,041	446	31,820	443
6. Sub-zone 6	38,341	816	36,044	767	34,374	731
7. Sub-zone 7	163,247	703	159,187	686	156,189	673
8. Sub-zone 8	31,366	699	28,425	633	26,355	587
9. Sub-zone 9	25,949	642	25,038	620	24,363	603
10. Sub-zone 10	21,874	923	19,777	834	18,303	772
Sub total of East Area	442,070	534	425,830	514	414,071	500
(2) Tan Hu – Ben Nghe Canal Left Bank - West Area						
11. Sub-zone 11	62,892	801	61,771	787	60,936	776
12. Sub-zone 12	10,679	703	9,310	613	8,377	551
13. Sub-zone 13	153,275	553	147,211	531	142,958	516
14. Sub-zone 14	132,401	617	129,482	604	126,901	592
15. Sub-zone 14	88,578	525	89,250	529	89,308	530
16. Sub-zone 14	69,864	629	68,795	619	68,083	613
Sub total of West Area	517,689	598	505,819	585	496,563	574
Sub total	959,759	567	931,649	550	910,634	538

(3) Islands between Tan Hu – Ben Nghe and Doi – Te Canals						
17.Khanh Hoi	219,217	626	213,228	609	209,134	597
18.Ong Kieu	1,434	372	1,077	279	864	224
19.Hung Phu	67,220	876	59,739	779	54,806	714
20.Tung Thien Vuong	51,588	629	44,295	540	40,847	498
21.Binh Dong	21,369	440	19,952	411	18,926	390
Sub total of Island	360,828	643	338,291	603	324,577	578
(4) Doi – Te Canal Right Bank						
22.Rach Ong	68,615	523	67,480	515	66,778	509
23.Pham The Hien	40,361	219	42,796	232	44,768	243
24.Binh Dang	39,140	202	41,562	215	43,525	225
Sub total of Right	148,116	288	151,838	295	155,071	302
Grand Total	1,468,703	526	1,421,778	509	1,390,282	498

7.4 Design Wastewater Discharge

In the Project Area, the considerable portion of the toilet waste is treated by the individual septic tank. However, the sufficient treatment efficiency of the septic tank is not expected because of their insufficient maintenance. Hence, the treatment efficiency of the septic tank is ignored to determine the domestic wastewater quality and quantity. The wastewater discharge is defined as wastewater consisting both toilet waste and gray water.

Wastewater discharge for interceptor sewer design in each sub-zone is estimated as below.

Sub-zone	Design Wastewater Discharge (m^3/day) (2020)		
	Wastewater	Groundwater	Total
(1) Tau Hu – Ben Nghe Canal Left Bank – East Area			
1. Sub-zone 1	9,297	664	9,961
2. Sub-zone 2	20,856	1,490	22,346
3. Sub-zone 3	5,788	413	6,201
4. Sub-zone 4	21,589	1,542	23,131
5. Sub-zone 5	14,924	1,066	15,990
6. Sub-zone 6	16,121	1,152	17,273
7. Sub-zone 7	73,252	5,232	78,484
8. Sub-zone 8	12,361	883	13,244
9. Sub-zone 9	11,427	816	12,243
10. Sub-zone 10	8,585	613	9,198
Sub total of East	194,200	13,871	208,071
(2) Tau Hu – Ben Nghe Canal Left Bank – West Area			
11. Sub-zone 11	28,580	2,041	30,621
12. Sub-zone 12	3,928	281	4,209
13. Sub-zone 13	67,047	4,789	71,836
14. Sub-zone 14	59,517	4,251	63,768
15. Sub-zone 15	41,885	2,992	44,877
16. Sub-zone 16	31,931	2,281	34,212
Sub total of East	232,888	16,635	249,523

Sub Total of Left	427,088	30,506	457,594
(3) Islands between Tau Hu – Ben Nghe and Doi – Te Canals			
17. Khanh Hoi	98,084	7,006	105,090
18. Ong Kieu	405	29	434
19. Hung Phu	25,704	1,836	27,540
20. Tung Thien Vuong	19,158	1,368	20,526
21. Binh Dong	8,876	634	9,510
Sub Total of Island	152,227	10,873	163,100
(4) Doi – Te Canal Right Bank			
22. Rach Ong	31,319	2,237	33,556
23. Pham The Hien	20,996	1,500	22,496
24. Binh Dang	20,413	1,458	21,871
Sub Total of Right	72,728	5,195	77,923
Total	652,043	46,574	698,617

7.5 Outline of Each Sewerage Sub-Zone

As stated above, THBNDT zone is separated into three (3) sewerage areas. The existing land use condition of three (3) sewerage areas are as follows.

(1) Left Bank Area of Tau Hu – Ben Nghe Canal

The area has been developed as the central area of Ho Chi Minh City since French colonial era. Combined sewer system was also installed along the roads. In the East area covering District 1, 3 and 5 is fully developed with an adequate road networks, some potential roads can be installed interceptor sewer are along and parallel to the canals. While in West area consisting of District 6,10 and 11 is very congested area and China Town called "Cho Lon" is located along Tau Hu canal. In this West area, only Tran Van Kieu road along Tau Hu canal is recognized as the potential route of the interceptor sewer. From these different land use conditions, this left bank area of Tau Hu - Ben Nghe canal is further divided into two (2) sewerage zones as East zone and West Zone.

(2) Isolated Area by Tau Hu – Ben Nghe and Doi – Te Canals

In this area, roads are existed along both canals of Tau Hu – Ben Nghe and Doi – Te. There are no alternative routes for installation of the interceptor sewer except along the canals. This area is also further divided into four (4) small sewerage zone by canal as Khan Hoi, Hung Phu, Tung Thien Vuong and Binh Dong.

(3) Right Bank Area of Doi – Te Canal

This area has not been fully developed yet. Road networks are not sufficient to develop the sewer system, however, this area will be developed in near future. The sewerage system needs to be also developed hormonally with the land development. The Vietnamese standards stipulate that the sewerage development for newly developed area must be covered by separate sewer system. Hence the separate sewer system is proposed in this right bank area of Doi – Te canal.

7.6 Construction Method

Construction method of pipe installation is reviewed. According to geological condition and cost consideration, the following method is most appropriate:

Trench depth (m)	method
0 - 4	open cut without sheet pile
4 - 10	open cut with sheet pipe
10 <	pipe jacking

In general, sheet pile can be applied up to a trench depth of 10m. For a deeper than 10m-trench, pipe jacking or shield tunneling method is considered. Shield tunneling method is more expensive than pipe jacking method in general. In addition, pit for pipe jacking method should be installed roughly every 300 m for this study area. The pit is used for the connection between the secondary and primary interceptor. Therefore, pipe jacking method is proposed. After geological survey is done, more detail review will be carried out.

7.7 Proposed Interceptor Sewers and Construction Cost

Sewerage development in seven sub zone is described in this section.

(1) East Area of Left Bank of Tau Hu - Ben Nghe Canal

Main and Secondary Interceptor is shown in Fig. 7.2.

Route	: Main Interceptor	⇒	along Ton Duc Thang – Ham Nghi – Tran Hung Dao streets and reaches the intermediate wastewater pumping station
Route	: Secondary Interceptor	⇒	under the streets perpendicular to Ben Chuong Duong street

Diversion chamber, mentioned in the next section, is installed at existing drainage pipe before Ben Nghe Canal and Saigon River. All wastewater is collected by the chamber. Then wastewater is carried through Secondary Interceptor to Main Interceptor.

The following is summarized main characteristic of the interceptors.

Length	:	Main	6,538 m
		Secondary	5,639 m
Interceptor Diameter	:	Main	ϕ 300 mm ~ ϕ 2,200 mm

		Secondary	ϕ 225 mm ~ ϕ 800 mm	
Trench Depth	:	Main	4.4 ~ 9.7 m	
		Secondary	2.0 ~ 4.8 m	
Construction Method	:	Main	Open Cut Method	2,671 m
			Pipe Jacking Method	3,867 m
		Secondary	Open Cut Method	5,637 m
Construction Cost	:	Main	136 billion VND	
		Secondary	20 billion VND	
		Total	156 billion VND	

(2) West Area of Left Bank of Tau Hu - Ben Nghe Canal

The interceptor for West Area of Left Bank of Tau Hu - Ben Nghe Canal is proposed under the operation/maintenance road for the Tau Hu - Ben Nghe Canal, and connects to the main interceptor sewer coming from the East Area before crossing Tau Hu Canal (Fig. 7.1). The following is summarized main characteristic of the interceptors.

Main Features

Total Length	:	3,885 m		
Interceptor Diameter	:	ϕ 500 mm - ϕ 2,000 mm		
Trench Depth	:	5.6 - 9.6 m		
Construction Method	:	Open Cut Method	:	1,580 m
		Pipe Jacking Method	:	2,305 m
Construction Cost	:	131 billion VND		

(3) Khanh Hoi Sub-Zone

Two (2) lines of interceptor sewer are proposed under Ben Van Don and Ton That Thuyet roads running along the Ben Nghe and Te canals, respectively. The interceptor sewer along the Ben Van Don road joins the other one running along Tong That Thuyet road and the merged interceptor sewer finally joins the main sewer installed in Rach Ong sub-zone after crossing Te canal.

Main Features

Total Length	:	6,513 m (including canal crossing)		
Interceptor Diameter	:	ϕ 300 mm - ϕ 1,200 mm		
Trench Depth	:	2.3 - 7.9 m		
Construction Method	:	Open Cut Method		
Canal Crossing	:	Canal Name	:	Te Canal
		Length	:	179 m
		Construction Method	:	Pipe Jacking Method
		System	:	Siphon with ϕ 900 mm x 2 lines
Construction Cost	:	38 billion VMD		

(4) Hung Phu Sub-Zone

Two (2) lines of interceptor sewer are proposed under the Ben Ba Dinh and Ben Nguyen Duy roads on both sides of sub-zone along the canals. After joining both interceptor sewers at the intersection of Chanh Hung and Ben Nguyen Duy roads, the merged interceptor sewer connects to the main sewer with a diameter of ϕ2200 mm coming from the Left Bank of Tau Hu - Ben Nghe Canal.

Main Features

Total Length	:	4,435 m
Interceptor Diameter	:	ϕ 300 mm - ϕ 900 mm
Trench Depth	:	1.9 - 11 m
Construction Method	:	Open Cut Method
Construction Cost	:	19 billion VMD

(5) Tung Thien Vuong Sub-Zone

Two (2) lines of interceptor sewer are proposed under the Ben Binh Dong and Ben Nguyen Duy roads on both sides of sub-zone along the canals. After joining both interceptor sewers, the merged interceptor sewer connects to the interceptor sewer for Hung Phu Sub-Zone.

Main Features

Total Length	:	4,739 m
Interceptor Diameter	:	ϕ 300 mm - ϕ 600 mm
Trench Depth	:	1.9 - 8 m
Construction Method	:	Open Cut Method
Construction Cost	:	22 billion VMD

(6) Binh Dong Sub-Zone

Interceptor sewers are proposed under roads surrounding Binh Dong sub-zone. Collected wastewater by the interceptor sewers is transferred to the main sewer in Tung Thien Vuong sub-zone. Crossing under Ngang No.1 canal by pipe jacking method is proposed near by the bridge.

Main Features

Total Length	:	2,543 m (including canal crossing)		
Interceptor Diameter	:	ϕ 300 mm - ϕ 400 mm		
Trench Depth	:	2.0 m - 5.1 m		
Construction Method	:	Open Cut Method		
Canal Crossing	:	Canal Name	:	Ngang 1 Canal
		Length	:	42 m

		Construction Method	:	Open Cut Method
		System	:	Siphon with ϕ 300 mm x 2 lines
Construction Cost	:	6 billion VMD		

(7) Rach Ong, Pham The Hien, and Binh Dang Sub-Zone

The interceptors for Rach Ong, Pham The Hien, and Binh Dang are planned to connect the interceptors from the area isolated by Tau Hu – Ben Nghe and Doi – Te Canal. In addition, the interceptor is collected sanitary sewer in Rach Ong, Pham The Hien, and Binh Dang. The characteristic of the interceptor is as follows:

Main Features

Total Length	:	6,154 m		
Interceptor Diameter	:	ϕ 400 mm - ϕ 1,500 mm		
Trench Depth	:	1.9 - 11 m		
Construction Method	:	Open Cut Method	:	3,350 m
		Pipe Jacking Method	:	2,804 m
Construction Cost	:	139 billion VMD		

7.8 Diversion Chamber

7.8.1 Introduction

Purpose of diversion chamber is to intercept wastewater from combined sewer. The diversion chamber is installed nearby outlet of the existing combined sewer under the existing road or sidewalk. All existing combined sewers are affected by tide from canals. Therefore, high water level must be considered to design diversion chamber.

Diversion chamber is needed as follows:

East Area of Left Bank of THBN Canal	28
West Area of Left Bank of THBN Canal	12
Khanh Hoi	29
Hung Phu	7
Tung Thien Vuong	21
Binh Dong	2
Total	99

7.8.2 Design Condition

The proposed typical diversion chamber is shown in Fig. 7.3. Typical plane internal dimension is proposed as 2m x 2.2m. The orifice is designed to divert the wastewater to the interceptor sewer. The size of orifice is designed by the design flowrate in each existing pipe. A flap gate is installed at the center of the diversion chamber.

Based on the sewage flow conditions in the combined sewer and water level conditions of receiving water bodies, following four (4) cases should be taken into consideration to divert the design wastewater to the interceptor sewer.

Case	Flow Condition	Water level of Down Stream
A	Dry weather flow	Low tide
B	Wet weather flow	Low tide
C	Dry weather flow	High tide
D	Wet weather flow	High tide

Hydraulic condition of diversion chamber under the different four (4) cases mentioned above are explained in Fig. 7.4 and Fig. 7.5.

Design highest water level of receiving water bodies is applied at +1.4 m above mean sea level at Mui Nai based on tidal data between 1993 and 1997.

7.8.3 Preliminary Design

According to hydraulic condition in each case, wastewater and rain water flow described as follows:

Case	flow to outlet	flow to orifice
Case A	none	design flowrate
Case B	yes	design flowrate or more
Case C	none	design flowrate
Case D	yes	more than design flowrate

Size of orifice is determined in the condition of Case A and C. To avoid attaching solid waste or other garbage, a size of orifice is designed as big as possible. To do so, upper edge of orifice is set just below the invert level of drainage pipe (Fig. 7.3).
A size of orifice is determined by a capacity of the design flowrate in each drainage pipe in dry weather. Design flowrate is estimated by a computer simulation of MOUSE released by Danish Hydraulic Institute. Fig. 7.2 shows a size of orifice at secondary interceptor.

In Case D, flowrate to orifice is the largest. Total volume flowing to interceptor is 3 times higher than design flow. The design concept of interceptor is not allowed to flow over design flowrate. Therefore, it is proposed that a gate be installed at a diversion chamber.

A reduction of the flowrate by gate is proposed to be daily average wastewater flowrate as a safety. From a result of MOUSE, nine diversion chambers should be installed gate to be a hourly average wastewater flowrate in an interceptor. Diversion chamber selected an installation of gate is shown in Fig. 7.2.

To control gate, maintenance person should stay near the diversion chamber with gate for 24 hr. For safe and effective operation, a relationship of water volume and water level should be investigated after the installation.

TABLE 7.1 STANDARD SLOPE FOR DESIGN CRITERIA

Diameter (mm)	Slope, I (‰)	Vfull (m/s)	Qfull (m3/s)	Design Criteria in Vietnam	
				Vmin	Imin (‰)
300	2.3	0.7	0.05	0.8	4.0
350	2.2	0.7	0.07	0.8	4.0
400	2.1	0.8	0.10	0.8	2.5
450	2.0	0.8	0.13	0.9	-
500	2.0	0.9	0.17	0.9	-
600	1.9	0.9	0.27	1.0	-
700	1.7	1.0	0.38	1.0	-
800	1.5	1.0	0.51	1.0	-
900	1.5	1.1	0.70	1.15	-
1000	1.4	1.1	0.90	1.15	-
1100	1.3	1.2	1.11	1.15	-
1200	1.2	1.2	1.35	1.15	-
1300	1.2	1.3	1.67	1.3	-
1500	1.2	1.4	2.45	1.3	-
1600	1.2	1.4	2.91	1.5	-
1800	1.2	1.6	3.98	1.5	-
2000	1.2	1.7	5.27	1.5	-
2500	1.0	1.8	8.73	1.5	-
3000	0.9	1.9	13.47	1.5	-

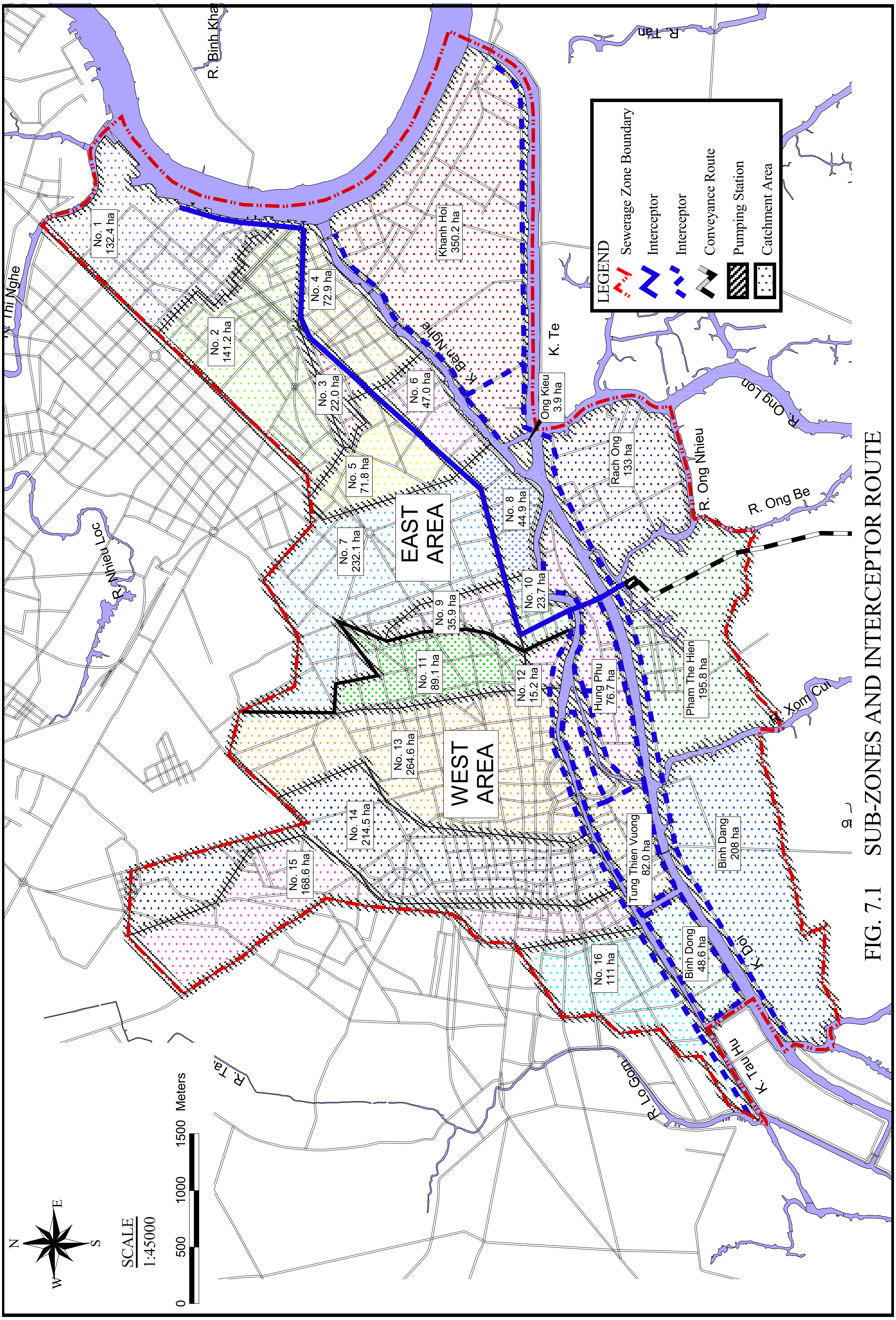


FIG. 7.1 SUB-ZONES AND INTERCEPTOR ROUTE

Secondary Interceptor

No	Length (m)	Diameter (m)	Orifice at diversion chamber		Discharge (m3/s)
			width (m)	depth (m)	
1	175	225	0.1	0.1	0.002
2	220	225	0.1	0.1	0.014
3	270	300	0.1	0.1	0.014
4	365	300	0.1	0.1	0.014
5	550	600	0.3	0.25	0.182
6	625	300	0.15	0.15	0.039
7	580	400	0.2	0.15	0.059
8	580	300	0.15	0.15	0.039
9	570	300	0.15	0.1	0.026
10	500	400	0.2	0.2	0.079
11	505	800	0.3	0.3	0.218
12	425	400	0.2	0.2	0.079
13	345	400	0.2	0.2	0.079
14	320	300	0.15	0.15	0.039
15	400	600	0.3	0.25	0.166
16	340	1,200	0.5	0.5	0.783
17	220	400	0.25	0.2	0.099
18-1	40	300	0.2	0.15	0.051
18-2	20	300	0.15	0.15	0.039
18-3	220	400	-	-	0.099

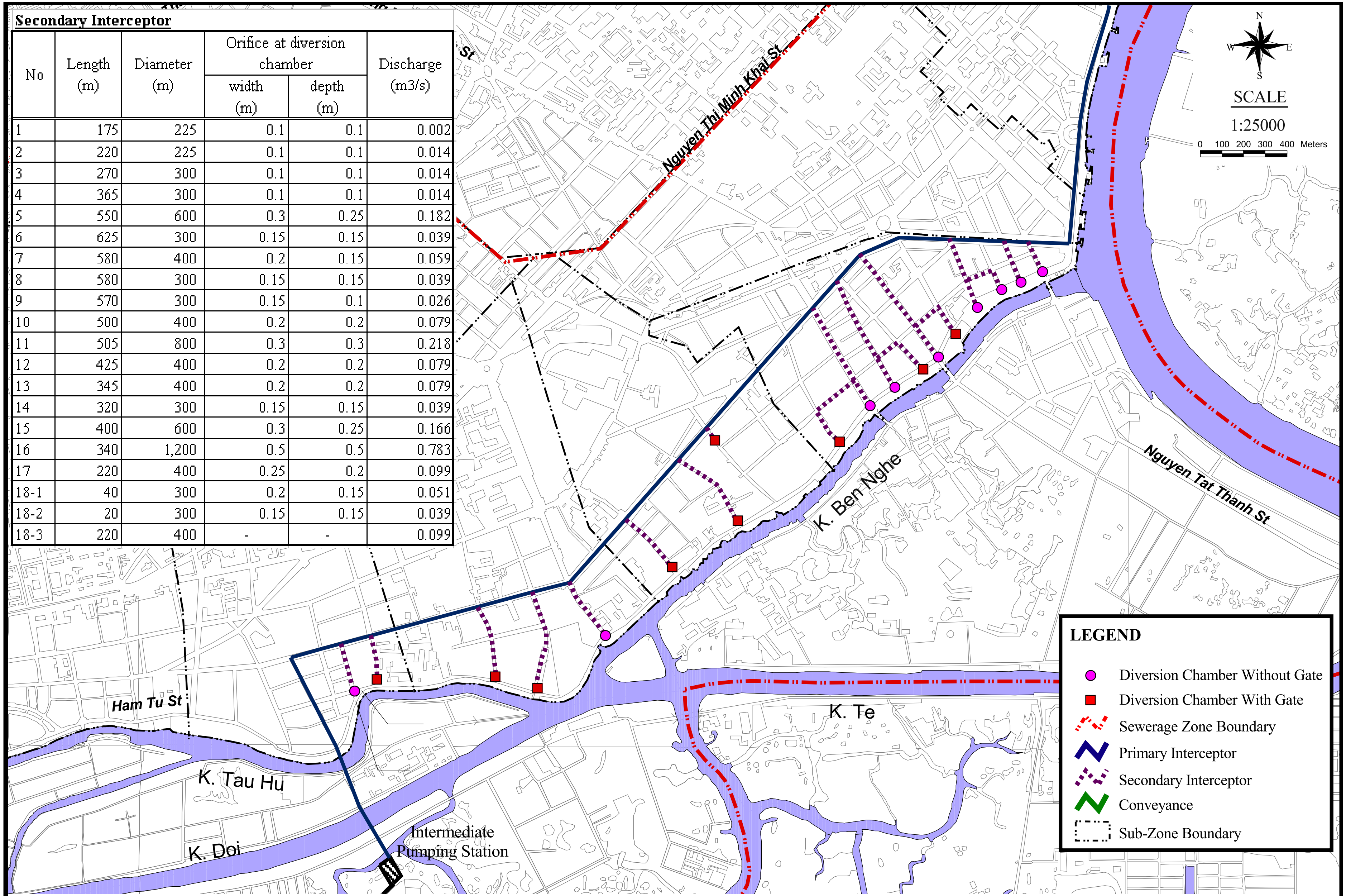


FIG. 7.2 INTERCEPTOR IN EAST AREA OF LEFT BANK OF TAU HU, BEN NGHE CANAL

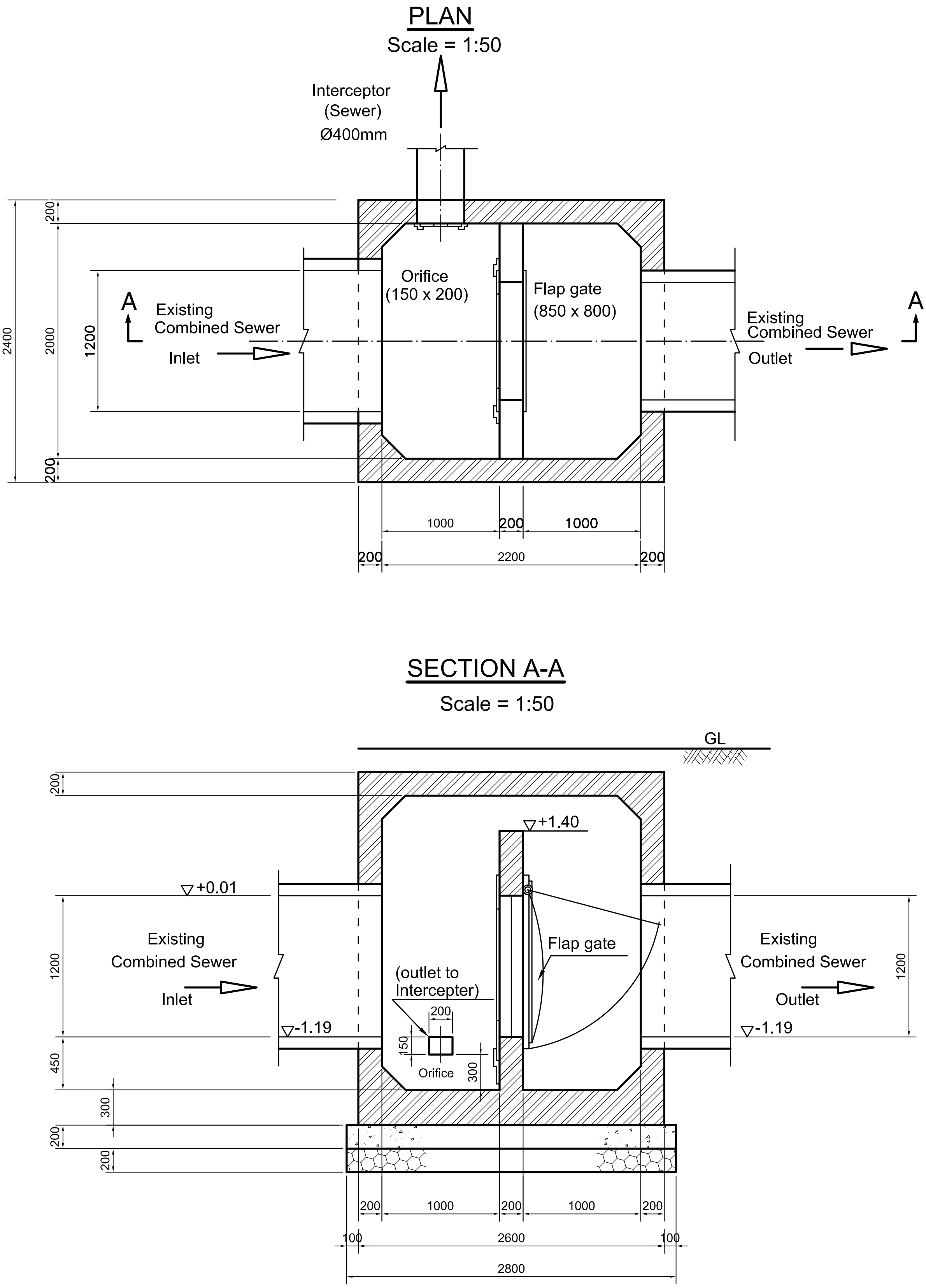
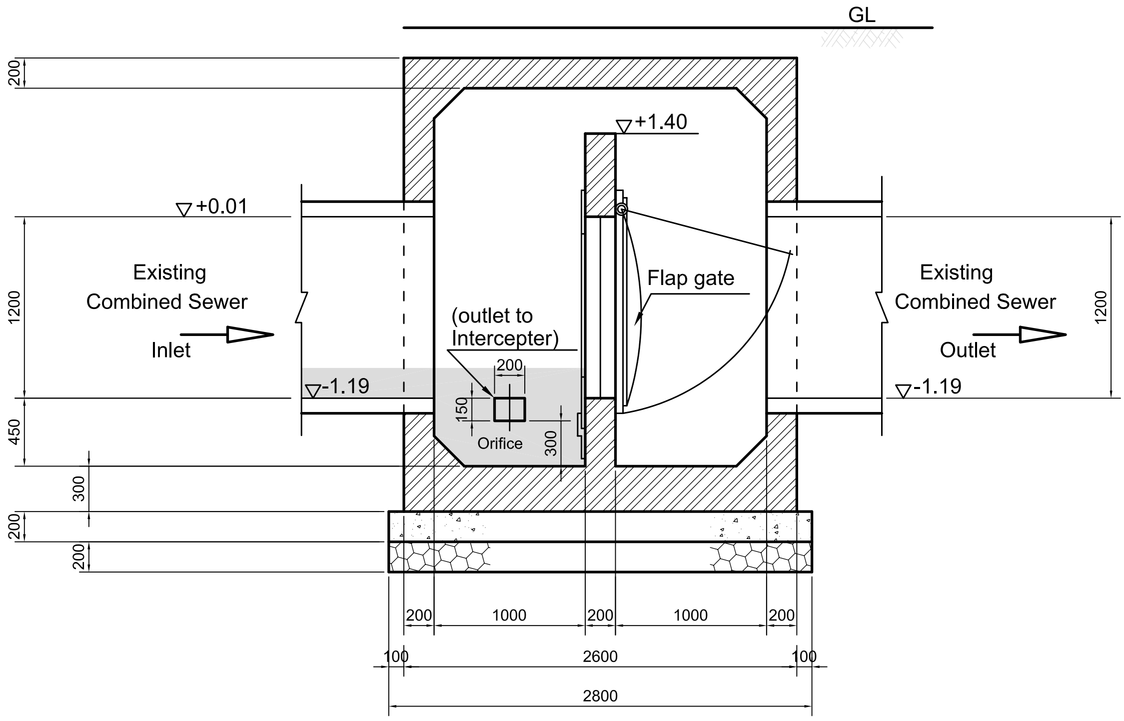
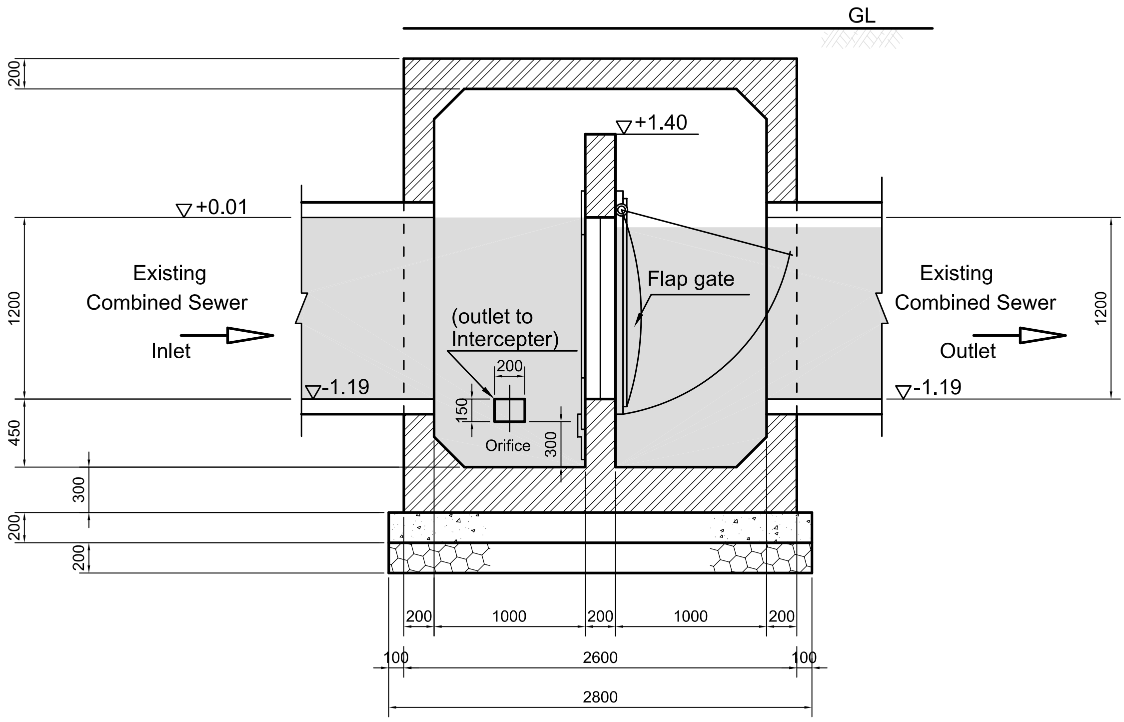


FIG. 7.3 PROPOSED TYPICAL SECTION DIVERSION CHAMBER
(Sample as Secondary Interceptor No.7)

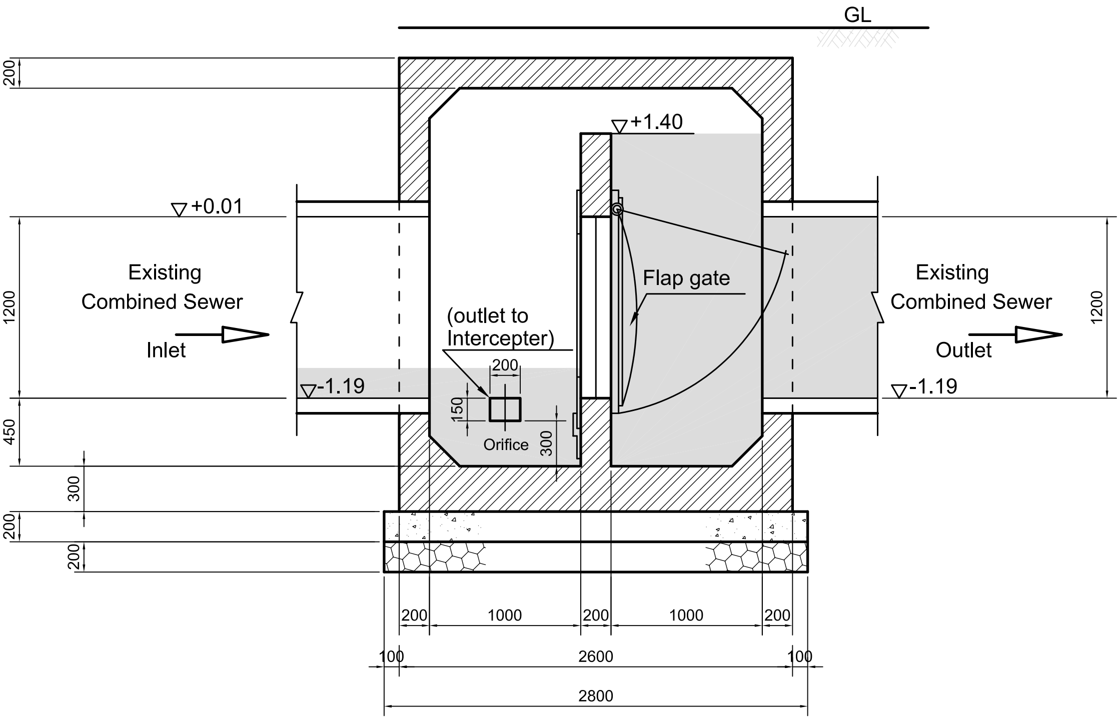


Case A (Dry Weather Flow & Low Tide)

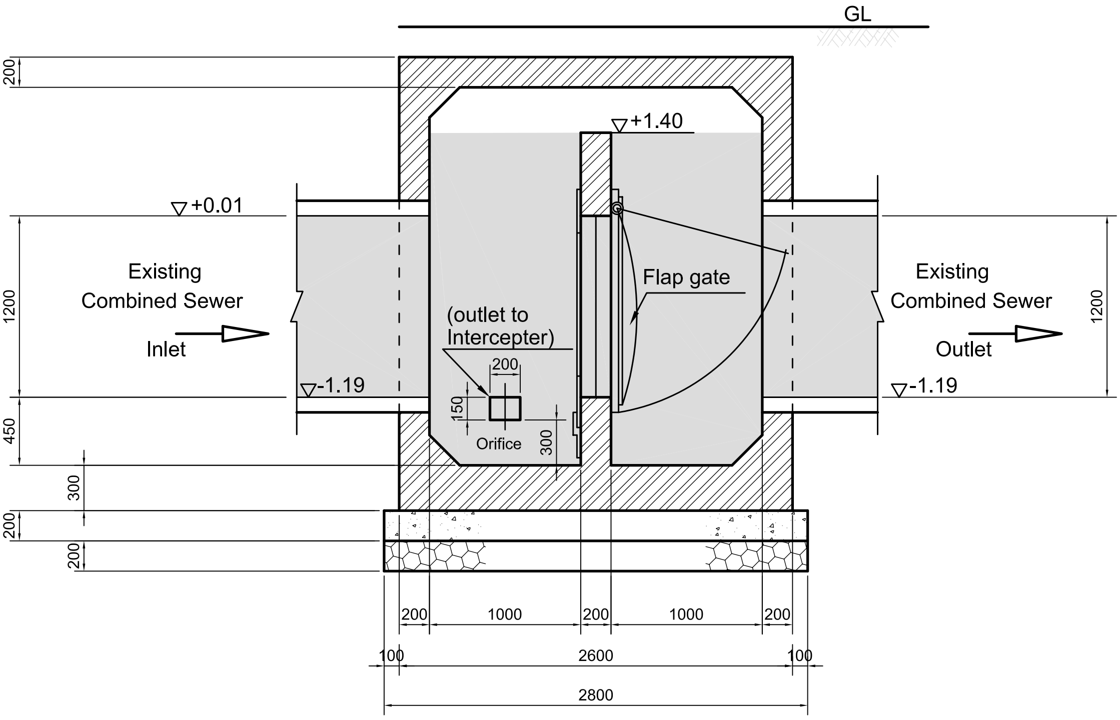


Case B (Wet Weather Flow & Low Tide)

FIG. 7.4 HYDRAULIC CONDITION OF DIVERSION CHAMBER - CASE A & B
(Sample as Secondary Interceptor No.7)



Case C (Dry Weather Flow & High Tide)



Case D (Wet Weather Flow & High Tide)

FIG. 7.5 HYDRAULIC CONDITION OF DIVERSION CHAMBER - CASE C & D
(Sample as Secondary Interceptor No.7)

Chapter 8
INTERMEDIATE WASTEWATER PUMPING STATION (IWPS)

CHAPTER 8 INTERMEDIATE WASTEWATER PUMPING STATION (IWPS)

8.1 Necessity of Intermediate Wastewater Pumping Station and Its Proposed Site

A total length of the interceptor and conveyance sewers amount to approximately 8.6 km. If no intermediate wastewater pumping station (hereinafter referred to as "IWPS") will be constructed, depth of the conveyance sewer at the wastewater treatment plant would be estimated at deeper than GL.-19.0 m. Hence, an ISPS is proposed to construct at the appropriate depth of interceptor or conveyance sewers, taking into consideration of the following technical and economical points of view:

(a) to optimize the project cost consisting of construction and O/M costs,
(b) to apply the conventional construction method for conveyance sewer, and
(c) to assure easier maintenance work of the conveyance sewer.

An appropriate location of IWPS would be selected nearby connection point with interceptor and conveyance sewers, which is almost center of total length of both sewers. However, IWPS is proposed to construct at swampy area having some illegal houses in Ward 4 in District 8 as shown in Fig. 8.1, which is about 200 m to the south from the Doi canal, considering the following view points:

(a) IWPS site would be selected to keep away from the concentrated urbanized area, because of high countermeasure cost for environmental deterioration, such as noise, bad smell, vibration, etc.
(b) Sufficient land with about 0.66 ha (60 m x 110 m) for construction of IWPS could not acquire along the proposed north conveyance sewer from Doi canal.
(c) Shield tunnel method was selected as most suitable one for construction of conveyance sewer crossing of Tau Hu and Doi canals.
(d) The proposed swampy area is the nearest open space from the junction with interceptor, which has a possibility of land acquisition and compensation for almost all illegal houses, resulting in the shortest of the conveyance sewer line by the shield tunnel method.

8.2 Planning Concept and Design Criteria

Planning concept and design criteria has been established, aiming to propose more practical, economical and sustainable project. These are as follows:

(1) Stepwise Construction

IWPS is proposed to construct step by step to meet the design wastewater flow in two phases, of which target year is 2005 and 2010. However, for preparation of the definitive plan, main features and dimension of each facility and equipment shall be determined basically based on the design criteria of Master Plan and checked its availability on Phase 1 and 2.

(2) Design Wastewater Flow

Design wastewater flow (DWF) for IWPS is to be basically set to meet the wet weather hourly maximum wastewater flow including ground infiltration assumed to be at 10 % of daily discharge. DWF in Phase 1 and 2 are estimated as shown in table below.

Phase	Wastewater Flow (m^3/day)			
	Dry Weather			Wet Weather
	Daily Discharge	Infiltration	Max. Daily Flow	Max. Hourly Flow
Phase 1	127,700	12,800	141,000	192,000 (133.3 m^3/min)
Phase 2	426,500	42,700	469,000	640,000 (444.4 m^3/min)
Master Plan	465,500	46,500	512,000	699,000 (485.4 m^3/min)

Note: 1. Wet weather max. hourly wastewater flow is assumed to be at 1.4 times of dry weather daily discharge plus ground infiltration assumed to be at 10 % of daily discharge.
2. Target year of Phase 1, 2 and Master Plan is 2005, 2010 and 2020 respectively

(3) Design Water Level (DWL)

Design water levels at the inlet and outlet chambers of IWPS connecting up and down conveyance sewers is planned as the table below:

Place	Design High Water Level (DHWL) (m)			Design Mean Water Level (DMWL) (m)		
	Phase 1	Phase 2	M/P	Phase 1	Phase 2	M/P
Inlet Chamber	-11.59	-10.91	-10.72	-11.74	-11.25	-11.18
Outlet Chamber	+0.10	+0.10	+0.10	-0.11	-0.11	-0.11

Note: 1. DHWL represents water level at wet weather hourly maximum flow of 133.3 m^3/s in Phase 1, 444.3 m^3/s in Phase 2 and 485.4 m^3/s in Master Plan (M/P).
2. DMWL represents water level at wet weather average daily flow of 97.9 m^3/min. in Phase 1, 325.7 m^3/min. in Phase 2.and 355.6 m^3/min. in M/P.

(4) Geological Condition

Soil investigation at the proposed intermediate pumping site were conducted in the Feasibility Study. According to the on-site soil survey results, the sub-soil consist of the following layers:

Layer	Depth (m)	Thickness (m)	Materials	N-Value	Notation
1	1.35 – 4.5	3.15	Very soft, high plasticity blackish gray organic clay	0	OH
2	4.5 – 8.5	4.0	Medium dense, yellowish gray clayey sand	12 – 15	SC
3	8.5 – 11.0	2.5	Medium dense yellow silty sand	14 – 15	SM
4	11.0 – 32.0	21.0	All medium dense soils. brownish yellow, reddish brown, pinkish brown and yellowish brown silty clayey sand	13 – 18	SM,SC
5	32.0 – 39.0	7.0	Medium dense, brownish yellow silty sand	13 – 18	SM
6	39.0 – 41.0	2.0	Medium dense, reddish brown, well graded sand	14 – 18	SW,SM
7	41.0 – 42.5	1.5	Medium dense, brownish yellow silty sand	20 – 32	SM
8	42.5 – 50.0	7.5	Hard, high plasticity brownish gray clay	36 – 46	CH

According to the soil test, characteristics of the sub-soil are summarized as follows:

* Natural Moisture Contents(Wn) : 14.0 – 111.9 %
* Specific Gravity(Gs) : 2.576 – 2.691
* Liquid Limit(Lw) : 17.1 – 115.2 %
* Plastic Limit(Pw) : 12.9 – 57.2 %
* Wet Density(rt) : 1.367 – 2.116 g/cm^3
* Dry Density(rd) : 0.645 – 1.804 g/cm^3
* Cohesion(C) : 0.057 – 0.538 kg/cm^2

8.3 Alternative Study

Grit chamber is generally installed before pump equipment to remove grit, solid and other inorganic substance that might clog and wear away the pump equipment (Forward Grid Chamber Method). However, the invert elevation of the conveyance sewer connecting to the IWPS reaches about EL.-13 m. Consequently, the grit chamber have to be constructed at very deep depth of EL.-15 m, resulting in its high construction cost, long construction period and hard operation and maintenance work after construction.

To cope with these problems, Backward Grit Chamber Method that the grit chamber is installed after pump equipment has recently been developed, taking into account of some mechanical countermeasures.

So, the following two options of alignment of the grit chamber have been examined to determine an optimum one in the previous Feasibility Study.

(a) Option A: Backward Grid Chamber Method (refer to Fig. 8.2)
(b) Option B: Forward Grid Chamber Method (refer to Fig. 8.3)

According to the comparative study on these options as shown in the table below, Option A has been recommended, because of its technically and economically feasible.

COMPARISON FOR TWO OPTIONS OF GRIT CHAMBER

Option A	Option B
Backward Grid Chamber	**Forward Grid Chamber**
Advantage	
(Structure Design) 1. Depth of Grit Chamber is about 10 m shallower. 2. Length of Grit Chamber is about 8 m shorter. 3. Height of Bar Screen is Smaller. 4. Size of devices for scraper and chain-driven rake to clean the channel and screen reduced and gate. 5. Volume of building under ground is reduced. (approximately 30 % smaller) 6. Area of building is reduced. **(Construction Cost)** 7. Construction cost of is estimated lower. Especially the cost of civil work is reduced to 70 % of **Option B**. **(Operation & Maintenance)** 8. O/M cost of mechanical and electrical equipment is estimated lower because the device sizes are smaller.	Subjects are contrary to Disadvantage of **Option A**.
Disadvantage	
(Structure & Equipment Design) 1. Pump should be a solid permissible type to prevent jamming from larger solids. **(Construction Cost)** 2. Cost of pump equipment may be slightly higher owing to a special impeller of pump. **(Operation & Maintenance)** 3. More frequent maintenance is required.	Subjects are contrary to Advantage of **Option A**.

8.4 Proposed Definitive Plan

In general, IWPS consists of two (2) facilities, pumping station and grit chamber. In the pumping station, emergency gate, fine screen, main pump and electrical equipment are to be installed. Inlet and outlet gate and grit removal equipment are to be installed in the grit chamber.

8.4.1 Pumping Station

(1) Major Mechanical and Electrical Equipment

Design Water Level and Pump Head

Based on the design water level at the inlet and outlet of the conveyance sewer mentioned before, the water levels for design of pump equipment by Phase were estimated as follows:

Phase	Inlet Chamber	Pump Before Screen	Pit After Screen	Discharge Sump	Grit Chamber	Outlet Chamber
Phase 1	-12.247	-12.400	-12.500	+0.55	+0.50	+0.45
Phase 2	-11.353	-11.500	-11.600	+0.55	+0.50	+0.45

Static pump head (Hs) and total pump head (Ht) are estimated as follows:
Hs = DWL in discharge sump – DWL in pump pit (before screen)
Ht = Hs + Hl
Where, Hl = Hydraulic losses of screen, pipe and other losses

Hl is estimated to be about 1.0m for fine screen and other facilities. Design static head and total pump head are estimated as follows:

Phase	Hs(m)	Hl(m)	Ht(m)
Phase 1	12.95	1.0	14.0
Phase 2	12.05	1.0	13.1

Pump Type Alternatives

The conventional pump applied for sewage system is generally classified into four types, such as (i) Axial Flow Pump, (ii) Mixed Flow Pump, (iii) Mixed Flow Pump with Volute Casing, (iv) Centrifugal Pump. The application ranges in total pump head and bore size are summarized below:

Pump Type	Total Pump Head (m)	Available Pump Diameter (mm)
Axial Flow Pump	Less than 5	More than 400
Mixed Flow Pump	3 to 12	More than 400
Mixed Flow Pump with Volute Casing	5 to 20	More than 400
Centrifugal Pump	More than 5	More than 80

In consideration of the above applicable ranges, the following three (3) alternative pump types are studied.

(a) Alternative 1: Vertical Shaft Mixed Flow Pump with Volute Casing (dry pit type)
(b) Alternative 2: Submersible Motor Mixed Flow Pump with Volute Casing
(c) Alternative 3: Vertical Shaft Mixed Flow Pump (wet pit type)

Note: Since required suction lift for the IWPS is high, vertical shaft type pumps and submersible motor type pump are proposed.

As the results of comparative study shown in Tables 8.1(1/3), (2/3) and (3/3), Alternative 2 " Submersible Motor Mixed Flow Pump with Volute Casing " is recommended as the most applicable and economical pump type taking into consideration of the following technical and economical points.

(a) Against clogging, Alternative 1&2 are superior than Alternative 3.
(b) Construction cost of mechanical and electrical works for Alternative 2 is lowest.
(c) Since siphon type is adopted for Alternative 2, yearly energy consumption is lowest among three (3) Alternatives.
(d) Area and height of the pumping station for Alternative 2 is smallest.
(e) Auxiliary system such as sealing water system or lubricating water system is not required.

Note: Replacing of mechanical seals and maintenance work of submersible motor pump can be made in Vietnam. Re-winding of submersible motor needs to be done by the original manufacturer at this moment, however re-winding may be possible in few years time in Vietnam.

<u>Unit Capacity and Number of Pump</u>

Based on required pump capacities for phase 1&2 and in year 2020, the following three (3) alternative plans are examined in order to select optimum unit pump capacity and number of pump.

Note) Design pump capacities for phase 2 and Master Plan in 2020 are 640,000 m^3/day and 699,000 m^3/day respectively. A difference between these capacities is only 59,000 m^3/day. In order to meet this capacity increment and make the minimized construction cost of the pumping station, concept of replacement of impeller in 2020 is applied in the study. In phase 2, smaller size of impeller will be supplied to meet a capacity of 640,000 m^3/day. In the year 2020, the impeller will be replaced to larger size to meet a capacity of 699,000 m^3/day.

Alternative	Phase 1	Phase 2	In Year 2020
1	44.5 m^3/min x 3 + 1 stand-by	○ ○ ○ ○ 44.5 m^3/min (additional pump) 133.2 m^3/min x 2 + 1 stand-by (small impeller)	○ ○ ○ ○ 44.5 m^3/min ○ ○ ● 153.7 m^3/min (large impeller)
2	66.7 m^3/min x 2 + 1 stand-by	○ ○ ○ 66.7 m^3/min (additional pump) 122.1 m^3/min x 2 + 1 stand-by (small impeller)	○ ○ ○ 66.7 m^3/min ○ ○ ● 142.7 m^3/min (large impeller)
3	133.3 m^3/min x 1 + 1 stand-by	○ ○ ○ 117.4 m^3/min (additional pump) 103.7 m^3/min x 3 (small impeller)	○ ○ ○ 117.4 m^3/min (large impeller) ○ ● 133.3 m^3/min

The comparison of three (3) alternative plans including construction cost is shown in Table 8.2. This comparison study is made under the following conditions.

(a) Unit capacity and number of pump should be determined to suit a hourly wastewater fluctuation as shown in Table 8.3.
(b) Unit capacity and number of pump should be determined considering design capacity increment of the pumping station from 192,000 m^3/day for phase 1 to 699,000 m^3/day in year 2020.
(c) At least one (1) stand-by unit should be prepared. Usually, stand-by unit has a biggest capacity in the pumping station.

As shown in Table 8.2, the construction cost for Alternative 3 (133.3 m^3/min x 2, 103.7 m^3/min x 3) is the cheapest if the civil and building works for Phase 1&2 will be constructed at Phase 1 stage. However, most frequent pump operation (start and stop) is anticipated for Alternative 3. Usually the pump unit capacity will be designed according to phases of the project. For this study, capacity of Phase 2 is much larger than that of Phase 1. In this point of view, pump unit capacity of Phase 2 would be larger than pump unit capacity of Phase 1. Pump unit capacity of phase 1 (133.3 m^3/min) seems large comparing with pump unit capacity of phase 2 (103.7 m^3/min).

Alternative 1 (44.5 m^3/min. x 4, 133.2 m^3/min x 3) have an advantage in terms of non-frequent pump operation, however pump unit capacity seems too small comparing with required total P/S capacity in the year 2020. Unit capacity of small pump for Alternative 1 is 44.5 m^3/min which capacity is less than one tenth of total P/S capacity of 485.4 m^3/min. The construction cost for Alternative 1 is the highest.

Alternative 2 (66.7 m^3/min x 3, 122.1 m^3/min x3) is recommended due to the following reasons:

(a) Frequent pump operation (start and stop) is not anticipated.
(b) The difference of construction cost between Alternative 2 and 3 is less than two (2) percent.
(c) Pump unit capacity for Phase 1 and 2 are adequate.
Small pump: about 1/8 of total P/S capacity
Large pump: about 1/4 of total P/S capacity

Siphon System

Siphon system is proposed for design of the pump discharge system taking into consideration of the following technical and economical points.
(a) Area of the pumping station is reduced.
(b) Loss of non-return and butterfly valve is eliminated. As a result, total head of pump is reduced and energy consumption of the motor is also reduced.
(c) Mechanical equipment cost can be minimized.

Instead of non-return valve and butterfly valve, siphon breaker valve is proposed to install at top of pipe to prevent reverse flow from grit chamber when the pump stops. DC motor is proposed as driving unit of the siphon breaker valve in order to open the valve even in case of power failure.

Emergency Gate

The emergency gate is proposed at the inlet of the IWPS in order to prevent the flooding of pumping station due to excessive storm water flowing into the pump. The emergency gate will be closed if the suction water level reaches to HHWL and be closed within two (2) minutes by its own weight. The emergency gate can be opened/closed by an electric motor during normal operation.

The storm water, which will be stored in the interceptor will be discharged by the main sewage pumps after the rain stops.

The sizes of emergency gate are proposed to be 2000mm square and 1600mm square for Phase 1 and 2 respectively to maintain the flow velocity through the gate not more than 1.0m/s at maximum daily wastewater flow.

Garbage Disposal Method

Garbage, rubbish and other materials in the sewer water are collected by the fine screen, which is installed in the IWPS. These garbage and other materials are transported by horizontal conveyor and inclined conveyor to the concrete made garbage-collecting box located outside of the station. In Phase 1, the stored garbage in the garbage-collecting box are cleared by man(s) and transported by the dump truck to the dumping area. Frequency of these works depends on the volume flowing into the station. In Phase 2, garbage, rubbish and other materials will be ground, washed and dehydrated by the grinding equipment, etc. and stored in the hopper.

Power Source of Pump Operation

The proposed pump is driven by an electric motor. The power source is supplied from the "Saigon South 4" sub-station through the WWTP and "Chanh Hung" sub-station, of which voltage is 22kV. The station will receive two (2) lines of 22kV as loop line at a new electric pole installed inside the IWPS area. 22kV incoming panels are installed at high voltage receiving area outside of the pumping station. Since the pump type is submersible motor type with voltage of AC380V, a 22kV/0.38kV step down transformer is installed in the electrical room. The 0.38kV also supplies electricity to each feeder in motor control center (MCC). MCC supply 380V to all the auxiliary equipment such as emergency gate, fine screen, conveyor, grit removal equipment, etc. The electrical room is located at B1 floor to reduce the building height minimize. 22kV/0.38kV transformer panel, main pump starter panel, MCC, battery and charger panel, relay panel, etc. are installed in the electrical room. The control room is located at ground floor. Supervisory panel, which monitors pump operating conditions such as start/stop, major and minor faults, etc. and suction/discharge water level conditions is installed in the control room.

The stand-by generating unit with capacities of 750kVA and 1500kVA is proposed for Phase 1 and 2 respectively. With these capacities, more than 80% of phase capacity can be discharged to the treatment plant as shown in the following table.

Phase	Stand-by generator capacity	Equipment covered by the generator
Phase 1	750kVA	66.7m3/min x 2, air inlet fan, lighting, battery
Phase 2	1500kVA	122.1m3/min x 2, air inlet fan, lighting, battery

Other Major Equipment

The other major mechanical and electrical equipment to be required for installation, operation and maintenance works of IWPS are listed in Tables 8.5(1/2) and (2/2).

(2) Civil Works

The proposed pumping station consist of inlet pit, pump well, pump and electrical room, and related structures. The civil works of these structures are composed temporary works, earth works, foundation work, reinforced concrete work, and others. The general layout of pumping station is shown in Fig. 8.4. Structural drawings of pumping station are shown in Figs 8.5(1/3) to (3/3), and design concept of for each component of the facilities is described below:

Inlet Pit

Wastewater collected from the project area of 3,065 ha flow into the inlet pit through the new interceptor sewer of 2,000 mm dia. constructed in Phase 1 and new interceptor of 1,800 mm dia. constructed in Phase 2. Inlet pit is planed at the front of pumping station. The inlet pit will be constructed with reinforced concrete and designed to provide four sluice gates of 1,500 mm W x 1,500 mm H, which is used at emergency shut down.

Main features of the pit are as follows:

Inlet Pipe Diameter (mm)	Bed Elevation (EL. m)	Inlet Pit Width (m)	Depth (m)	Length (m)	Number of Emergency Gate (nos.)
2,000 and 1,800	-12.50	3.00	14.50	15.80	4

Pump Well

The pump well is a reinforced concrete substructure for installation of fine trash screen and pump equipment. Pump well consists of two zones, mechanical screening zone and pump well zone.

Mechanical screening zone is divided into four channels, of which dimension are 3.5 m in width, 2.1 m in depth and 11.0 m in length to keep steady flow under lower velocity of 0.5 m/s, and solids and other inorganic materials in collected wastewater will be screened automatically by fine screen equipment installed at underground mechanical room, of which floor elevation of EL.-6.0 m.

Pump well zone is planned to have sufficient width, depth and length to storage enough wastewater for continuous pump operation as much as possible. Pump well forms one room having no partition wall. Bottom elevation of the pump well is designed to be deeper more than 3.7 times of the maximum pump bore from the pump stop level (L.L.W.L) of EL.-13.30 m.

Main features of pump well are as follows:

Width (m)	Water Depth from DWL (m)	Length (m)	Flow Elevation (EL. m)		
			Top	Middle	Bottom
28.90	5.10	3.00	+2.00	-6.00	-17.00

Pump Room

Pump room is also reinforced concrete sub-structure adjacent to the pump well and is designed to have sufficient space for installation, operation and maintenance of pump equipment (vertical shaft mixed flow pump: 3 units of ø700, 3 units of ø1000). Main features of the pump room are as follows:

Width (m)	Length (m)	Height (m)	Number of Story (nos.)	Floor Elevation (EL. m)		
				Top	Middle	Bottom
28.90	13.00	11.00	2	+2.30	-6.00	-17.00

Operation and Maintenance Building

O/M building is planned to provide pump motor room, generator room, electrical room, storage room and administration room including accommodation for operators. O/M building is designed to be two stories reinforced concrete super-structure having enough space of about 1,300 m^2 required for sufficient operation and maintenance. Main features of each room is as follows:

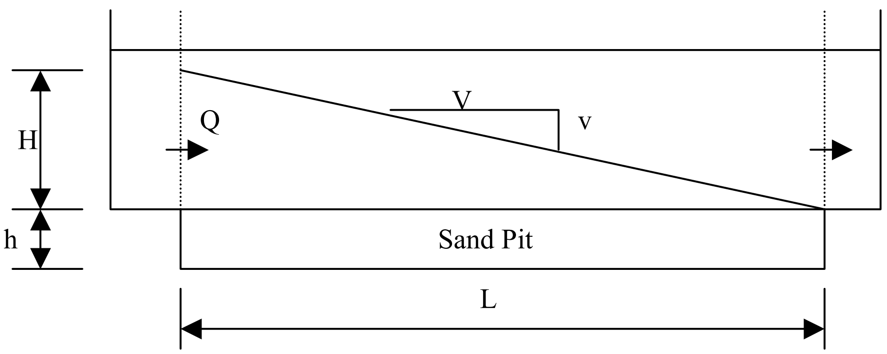
Room	Location (Floor)	Area (m^2)	Width (m)	Length (m)	Height (m)	Equipment
Pump Motor	1st floor	375	13.0	28.9	11.0	Pump: 6 sets, others
Generator	1st floor	113	7.8	14.5	5.5	Generator: 2 sets
Electric	1st floor	127	8.8	14.5	5.5	Electric panels
Storage	1st floor	141	8.5	16.6	5.5	Spare parts, others
Administration	2nd floor	480	16.6	28.9	5.5	Office, accommodation
Others	2nd floor	100	6.0	16.6	5.5	Entrance, lobby, others

8.4.2 Grit Chamber

(1) Main Features of Grit Chamber

Main features of grit chamber are calculated as follows.

Design Surface Load of Grit Chamber: Ls = 1,800 $m^3/m^2 \cdot day$



$v / V = H / h$ $V = Q / (W \times L)$
$T = (W \times L \times H) / Q$

Where, v : Sedimentation Velocity of Particles (m / s)
minimum remove particle diameter = 0.2 mm (assumed)
specific gravity of sand = 2.65 (assumed)
then v = 0.021 m / s
V : Average Velocity in Grit Chamber (0.325 m / s)
H : Effective Depth of Grit Chamber (m)
T : Retention time (30 ~ 60 sec.) → use 60 sec.
h : Depth of Sand Pit (more than 0.30 m) → use 0.50 m
Q : Maximum inflow of wastewater (485.4 m^3/min./60 sec = 8.09 m^3/s)

$L = V \times T = 0.325$ m/sec. $\times$ 60 sec. = 19.5 m
$W = Q / (V \times T \times v) = 8.090$ m^3/s / ($0.325 \times 60 \times 0.021$) = 20.0 m
$H = T \times v = 60 \times 0.021 = 1.26$ m

Therefore, main features of grit chamber are as follows:

5.0 m (W) × 19.5 m (L) × 2.0 m (H + h) × 4 chambers
(effective depth 1.50 m + sand pit 0.50 m)

(2) Major Mechanical and Electrical Equipment

Grit Removal Equipment

The conventional grit removal equipment using in grit chamber is generally classified into three types, such as (i) Bucket conveyor type, (ii) Screw conveyor type and (iii) Grab bucket type. Alternative study for identification of the most appropriate grit removal equipment has been made as follows:

(a) Alternative 1: Fixed type bucket conveyor
(b) Alternative 2: Traveling type grab bucket
(c) Alternative 3: Screw conveyor with sand pump

As the results of comparative study for these alternatives as shown in Tables 8.4 (1/2) and (2/2), Alternative 2 “Traveling type grab bucket” is recommended by the following reasons:

(a) Equipment cost of Alternative 2 is much cheaper than those of Alternative 1 and 3.
(b) Construction of grab bucket is simple.
(c) Maintenance work is easiest since all mechanical parts are equipped above water.
(d) Even if large amount of grit are flowing into chamber, any damages will not be expected to the equipment.

Gate

Sluice gate of 1,500 mm W x 1,500 mm H is designed to install at each inlet and outlet of grit chamber. These gates are used to dry up and to maintain the grit chamber.

(3) Civil Works

The proposed grid chamber consists of discharge sump, grit chamber, outlet pit and related structures. The civil works of these structures are composed of temporary works, earth works, foundation work, reinforced concrete work and others. The general layout of pumping station is shown in Fig. 8.4. Structural drawings of grit chamber are shown in Figs. 8.5 (1/3) to (3/3). Design concept for each component of the grit chamber is described bellow:

Discharge Sump

Discharge sump is planned at the front of grit chamber. The discharge sump will be constructed with reinforced concrete and designed to have sufficient space to convey smoothly pumped up wastewater to 4 grit chambers through the sluice gates of 1,500 mm (W) × 1,500 mm (H).

Main features of the discharge sump are as follows:

Width (m)	Water Depth (m)	Length (m)	Elevation (EL. m)	
			Bottom	Top
28.00 to 21.50	2.05	7.00	-1.85	+2.30

Grit Chamber

Grit chamber is reinforced concrete substructure and has a function to remove the grit from a wastewater to the outside of pumping station. Grit chamber is designed to divide into four channels with sufficient width, length and depth to settle the grit in wastewater.

Main features of grit chamber are as follows.

Width (m)	Water Depth (m)	Length (m)	Number of Channel (nos.)	Elevation (EL. m)	
				Bottom	Top
5.00	2.00	19.50	4	-1.85	+2.30

Outlet Pit

Outlet pit is adjacent reinforced concrete sub-structure having a function to convey wastewater from grid chamber to conveyance sewers connected with wastewater treatment plant. Two conveyance sewers are box culverts of 1,300 mm (W) x 1,200 mm (H) to be constructed in Phase 1 and 2,000 mm (W) x 1,700 mm (H) to be installed in Phase 2.

Main features of outlet pit are as follows:

Width (m)	Water Depth (m)	Length (m)	Elevation (EL. m)	
			Bottom	Top
23.50	1.88	4.00	-1.85	+2.30

8.4.3 Landscape Design

The IWPS site is located suburban area of the District 8 and surroundings of the site generally in use of agriculture land use at present time, however recent land use characteristics shows a residential encroaching feature and the whole area will become a residential area in future urban land use planning scheme. The landscaping of the IWPS site shall meet with these tendency, so that aesthetic landscape design solution shall be essential in harmony with future vicinity residential environment. Fig. 8.6 shows proposed landscape layout plan for the IWPS site.

(1) Proposed Landscape

Main access for motor vehicle shall be minimum 4.0 m in width and concrete paving finish, and colored concrete block paving with 2.0 m in width shall be installed at office entrance surroundings and pedestrian path for aesthetic consideration.

All facility sites shall be enclosed by fence with 2.4 m in height and major gate door shall be minimum 6.0 m in width of enough space for motor vehicle goes in.

Plantings shall be introduced for establishing aesthetic and safety environmental condition of the facility site. Medium trees as major objectives shall be introduced for provision of rich greenery with seasonal flowering for the vicinity site of residential area. Some small flowering shrubs shall be also provided for an accent of the planting layout scheme. Along the enclosure fence especially it faces to the access road, species of flowering shrub, vine and creeper shall be introduced as a hedge planting.

Facility spaces in which without any paving provision shall be furnished with turf grass or some proper ground cover plants in strategic points, so that all the facility space will be covered with clean and greenfly with amicable environment accordingly.

(2) Related considerations

Existing access road shall be widen to 7.0 m in width in order to consider smooth and safety traffics of motor lorry vehicles for the operation and maintenance purpose. The area surroundings of waste water pumping station site is going to be a new housing development area, so that the pumping station site should be considered vicinity environmental condition with aesthetic solution with landscaping.

8.5 Bill of Quantities

Bill of quantities of civil work is shown in Table 8.6.

Table 8.1(1/3) Comparison of Sewerage Pump Type

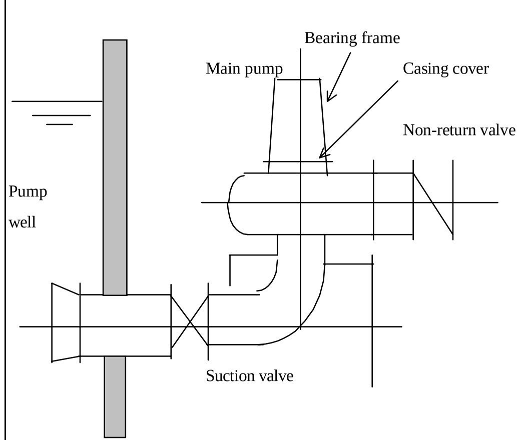
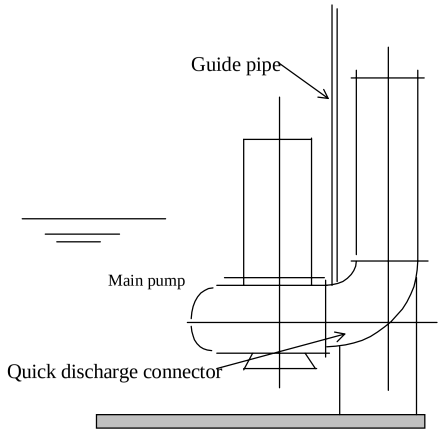
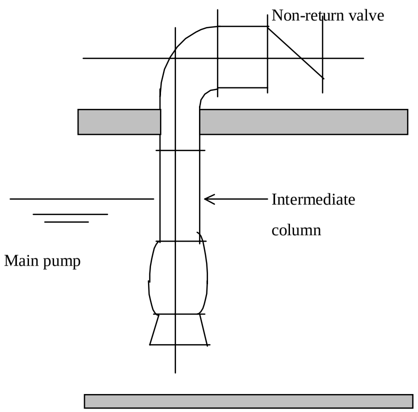
Item	Alternative 1 **Vertical shaft mixed flow pump with volute casing**	Alternative 2 **Submersible motor mixed flow pump with volute casing (siphon type)**	Alternative 3 **Vertical shaft mixed flow pump**
1. Pump Specification			
1-1. Main pump for phase 1			
1) Bore x Capacity x Head	700mm dia. x 66.7m3/min x 14.9m	700mm dia. x 66.7m3/min x **14m**	700mm dia. x 66.7m3/min x 14.9m
2) Quantity	2 + 1 (stand-by)	2 + 1 (stand-by)	2 + 1 (stand-by)
3) Speed	735min-1	735min-1	735min-1
4) Efficiency	80%	**79%**	79%
5) Motor	240kw	**220kw**	240kw
1-2. Main pump for phase 2			
1) Bore x Capacity x Head	1000mm dia. x 122.1m3/min x 14.4m	1000mm dia. x 122.1m3/min x **13.5m**	1000mm dia. x 122.1m3/min x 14.4m
2) Quantity	2 + 1 (stand-by)	2 + 1 (stand-by)	2 + 1 (stand-by)
3) Speed	593min-1	593min-1	593min-1
4) Efficiency	83%	**82%**	82%
5) Motor	400kw	**380kw**	400kw
2. Installation Layout	 Pump is installed in a dry pit (pump room). Pump impeller can be inspected after removing bearing frame and casing cover. For inspection, suction valve should be closed.	 Pump and motor are always submerged in a water. Pump impeller can be inspected only after the pump is lifted up from water.	 Pump is always submerged in a water. Pump impeller can be inspected only after the pump is lifted up from water.

Table 8.1(2/3) Comparison of Sewerage Pump Type

Item	Alternative 1 Vertical shaft mixed flow pump with volute casing	Alternative 2 Submersible motor mixed flow pump with volute casing (siphon type)	Alternative 3 Vertical shaft mixed flow pump
3. Related Equipment			
1) Suction valve	700mm dia. manual butterfly valve x 3 1000mm dia. manual butterfly valve x 3	**N.A.**	N.A.
2) Discharge valve	700mm dia. motor operated butterfly valve x 3 1000mm dia. motor operated butterfly valve x 3	**N.A.** **N.A.**	700mm dia. motor operated butterfly valve x 3 1000mm dia. motor operated butterfly valve x 3
3) Non-return valve	700mm dia. check valve x 3 1000mm dia. check valve x 3	**N.A.** **N.A.**	700mm dia. check valve x 3 1000mm dia. check valve x 3
4) Siphon breaker valve	N.A. N.A.	**150mm dia. siphon breaker valve x 3** **200mm dia. siphon breaker valve x 3**	N.A. N.A.
3) Pipe	700mm to 1000mm dia. cast iron	700mm to 1000mm dia. cast iron	700mm to 1000mm dia. cast iron
4) Electrical equipment	H.V. panels, L.V. panels, etc.	H.V. panels, L.V. panels, etc.	H.V. panels, L.V. panels, etc.
5) Generator	300kVA / 600kVA	**750kVA / 1500kVA**	300kVA / 600kVA
6) Overhead crane	10ton	10ton	20ton
7) Aux. equipment	Sealing water system	**N.A.**	Lubricating water system
4. Comparison			
1) Area and depth required for civil works (pump room only)	Area: 32m W x 13m L = 416m2 Depth: 19m	Area: 32m W x 9m L = 288m2 Depth: 19m	Area: 32m W x 12m L = 384m2 Depth: 18m
2) Height required for sub-structure (pump room only)	11m	**8m**	11m
3) Installation	Easy. Alignment for intermediate shafts are required.	Easy.	Installation work is the most difficult.

Table 8.1(3/3) Comparison of Sewerage Pump Type

Item	Alternative 1 Vertical shaft mixed flow pump with volute casing	Alternative 2 Submersible motor mixed flow pump with volute casing (siphon type)	Alternative 3 Vertical shaft mixed flow pump
4) Operation	Pump can start any time, since impeller is always submerged in the water.	Pump can start any time, since impeller is always submerged in the water.	Pump can start any time, since impeller is always submerged in the water.
5) Maintenance	Pump inside can be inspected from the inspection hole of suction casing.	Pump is required to lift up and disassemble when inspection of pump impeller is necessary.	Pump is required to lift up and disassemble when inspection of pump impeller is necessary.
6) Life of equipment	20years	**<u>15years due to submersible motor</u>**	20years
7) Clogging	Since there is no obstacle in a water passage except impeller, not so frequent clogging will be anticipated.	Since there is no obstacle in a water passage except impeller, not so frequent clogging will be anticipated.	Since intemediate bearing supports are required, more frequent clogging will be anticipated than Alternative 1&2.
8) Corrosion	Depends on material used.	Depends on material used.	Depends on material used.
9) Reliability	If periodical maintenace is carried out, long life operation and high reliability is expected.	Periodical maintenance for submersible motor is especially required.	If periodical maintenace is carried out, long life operation and high reliability is expected.
10) Accomplishment	Many. Over 3000mm dia.	(Volute type submersible motor pump) **<u>Up to 800mm dia.</u>** (Dry type submersible motor) **<u>Up to 420kw for 400V class</u>**	Many. Over 3000mm dia.

5. Construction cost Unit: Million VND 1Yen=134.15VND	Alternative 1 Phase 1	Alternative 1 Phase 2	Alternative 2 Phase 1	Alternative 2 Phase 2	Alternative 3 Phase 1	Alternative 3 Phase 2
5-1) Mechanical and electrical works (initial cost)	105,737 101%	98,882 115%	104,814 100%	86,040 100%	112,750 108%	111,906 130%
5-2) Mechanical and electrical works (running cost)	240kw x 2sets x 8760hrs x 141,000m3/day / 192,000m3/day x 781VND/kw = 2412 109%	(240kwx3 + 400kwx2) x 8760hrs x 469,000m3/day / 640,000m3/day x 781VND/kw = 7621 107%	220kw x 2sets x 8760hrs x 141,000m3/day / 192,000m3/day x 781VND/kw = 2211 100%	(220kwx3 + 380kwx2) x 8760hrs x 469,000m3/day / 640,000m3/day x 781VND/kw = 7119 100%	240kw x 2sets x 8760hrs x 141,000m3/day / 192,000m3/day x 781VND/kw = 2412 109%	(240kwx3 + 400kwx2) x 8760hrs x 469,000m3/day / 640,000m3/day x 781VND/kw = 7621 107%

TABLE 8.2 COMPARISON OF UNIT CAPACITY AND NOS. OF PUMP

Items	Alt.1		Alt.2		Alt.3	
	Phase 1	**Year2020**	**Phase 1**	**Year 2020**	**Phase 1**	**Year 2020**
	44.5 m^3/min	**153.7 m^3/min**	**66.7 m^3/min**	**142.7 m^3/min**	**133.3 m^3/min**	**117.4 m^3/min**
1. Unit capacity and nos. of pump	44.5 m^3/min x 3 + 1 stand-by	153.7(*1) m^3/min x 2 + 1 stand-by *1 (485.4-44.5x4)/2 = 153.7	66.7 m^3/min x 2 + 1 stand-by	142.7(*2) m^3/min x 2 + 1 stand-by *2 (485.4-66.7x3)/2 = 142.7	133.3 m^3/min x 1 + 1 stand-by	117.4(*3) m^3/min x 3 *3 (485.4-133.3)/3 = 117.4
Pump dia.	600 mm x (3 + 1)	1100 mm x (2 + 1)	700 mm x (2 + 1)	1000 mm x (2 + 1)	1000 mm x (1 + 1)	900 mm x (3)
Total capacity as P/S	178 m^3/min	639.1 m^3/min including Phase 1	200.1 m^3/min	628.2 m^3/min including Phase 1	266.6 m^3/min	618.8 m^3/min including Phase 1
2. Motor output Total motor output	160 kW x (3 + 1) 640 kW	490 kW x (2 + 1) 2110 kW including Phase 1	230 kW x (2 + 1) 690 kW	460 kW x (2 + 1) 2070 kW including Phase 1	440 kW x (1 + 1) 880 kW	380 kW x (3) 2020 kW including Phase 1
3. Pump room -Width (m) -Length (m) -Area (M^2)	 15 13 195	 31 13 403	 13 13 169	 29 13 377	 13 13 169	 27 13 351
4. Ratio of total P/S capacity vs daily average wastewater	44.5x4x60x24/141,000= 1.82	(44.5x4+153.7x3)x60 x24/512,000= 1.8	66.7x3x60x24/141,000= 2.04	(66.7x3+142.7x3)x60 x24/512,000= 1.77	133.3x2x60x24/141,000= 2.72	(133.3x2+117.4x3)x 60x24/512,000= 1.74
5. Frequency of pump opearation for Phase 1pump operating condition condition	1 st pump start: -12.30 2 nd pump start: -12.10 3 rd pump start: -11.80 Stop: -13.20		1 st pump start: -12.15 2 nd pump start: -11.80 Stop: -13.20		1 st pump start: -11.80 Stop: -13.20	
Maximum suction water level during operation (m)	-11.69		-11.41		-11.06	
Frequency of pump operation	1 st pump: 68 / day 2 nd pump: 51 / day 3 rd pump: 19 / day Ave. 34.5 / day / unit, Max. 5 times/hr		1 st pump: 92 / day 2 nd pump: 46 / day Ave. 46 / day / unit, Max. 6 times/hr		1 st pump: 113 / day Ave. 56.5 / day / unit, Max. 7 times/hr	
6. Construction cost (Unit: Million VND)	(Phase 1)	(Phase 2)	(Phase 1)	(Phase 2)	(Phase 1)	(Phase 2)
1) Civil & building works	59,368	-	55,226	-	51,281	-
2) Mecha. & Elect. Works	70,150	91,432	69,540	81,493	71,432	69,051
Total cost	129,518	91,432	124,766	81,493	122,713	69,051

TABLE 8.3 HOURLY WASTEWATER FLUCTUATION

Hourly maximum discharge of wastewater:		
Phase 1	Phase 2	Master Plan
133.3 m^3/min	444.4 m^3/min	485.4 m^3/min

Time	%	Wastewater Fluctuation					
		Phase 1		Phase 2		Phase 3	
		m^3/hr	m^3/min	m^3/hr	m^3/min	m^3/hr	m^3/min
0	0.033	4,700	78.3	15,633	260.6	17,067	284.4
1	0.029	4,113	68.5	13,679	228.0	14,933	248.9
2	0.029	4,113	68.5	13,679	228.0	14,933	248.9
3	0.028	3,931	65.5	13,076	217.9	14,275	237.9
4	0.026	3,638	60.6	12,099	201.7	13,209	220.1
5	0.031	4,406	73.4	14,656	244.3	16,000	266.7
6	0.042	5,875	97.9	19,542	325.7	21,333	355.6
7	0.053	7,411	123.5	24,652	410.9	26,912	448.5
8	0.057	7,999	133.3	26,606	444.4	29,045	485.4
9	0.052	7,344	122.4	24,427	407.1	26,667	444.4
10	0.050	7,050	117.5	23,450	390.8	25,600	426.7
11	0.048	6,756	112.6	22,473	374.5	24,533	408.9
12	0.046	6,463	107.7	21,496	358.3	23,467	391.1
13	0.046	6,463	107.7	21,496	358.3	23,467	391.1
14	0.044	6,169	102.8	20,519	342.0	22,400	373.3
15	0.042	5,875	97.9	19,542	325.7	21,333	355.6
16	0.042	5,875	97.9	19,542	325.7	21,333	355.6
17	0.042	5,875	97.9	19,542	325.7	21,333	355.6
18	0.045	6,373	106.2	21,197	353.3	23,140	385.7
19	0.049	6,870	114.5	22,851	380.9	24,946	415.8
20	0.047	6,666	111.1	22,174	369.6	24,207	403.4
21	0.044	6,169	102.8	20,519	342.0	22,400	373.3
22	0.040	5,581	93.0	18,565	309.4	20,267	337.8
23	0.038	5,288	88.1	17,588	293.1	19,200	320.0
Total	1.000	141,000		469,000		512,000	

Note) Wastewater fluctuation (%) in Table is refered from
" Japanese design manual of wastewater treatment (JDM) "

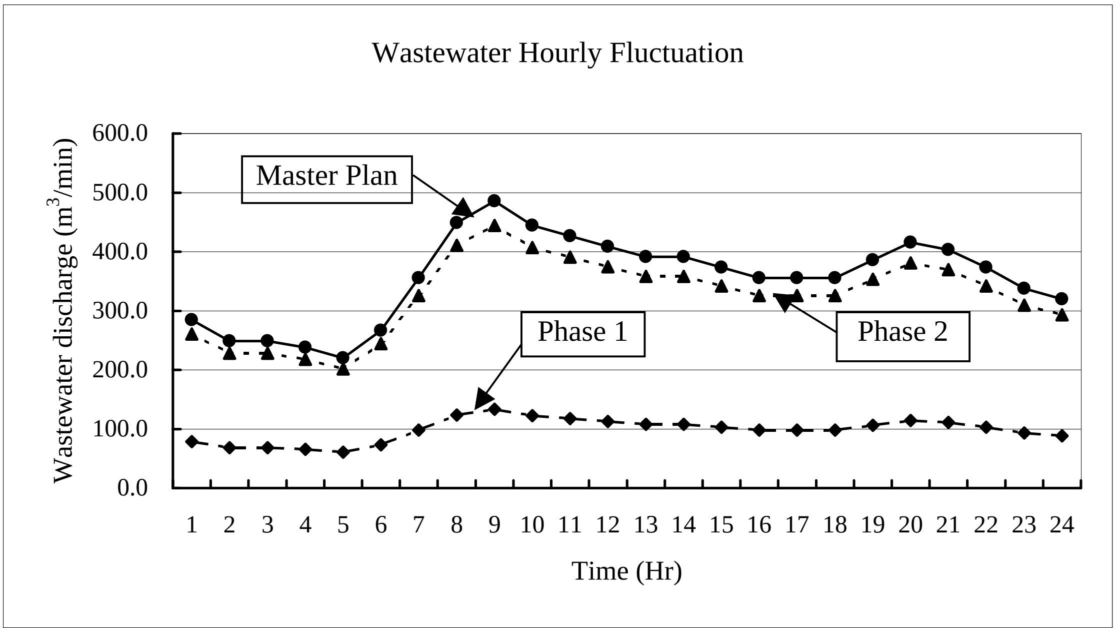


TABLE 8.4 (1/2) COMPARISON OF GRIT REMOVAL TYPE

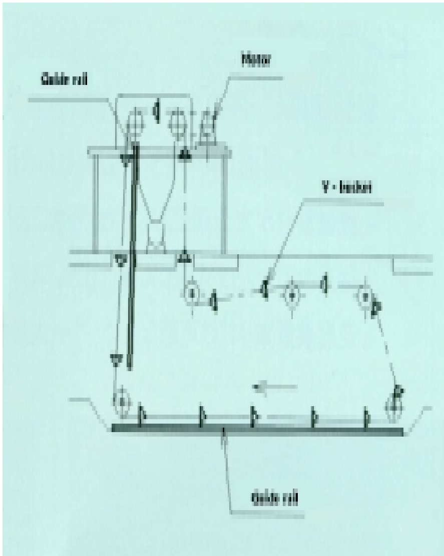
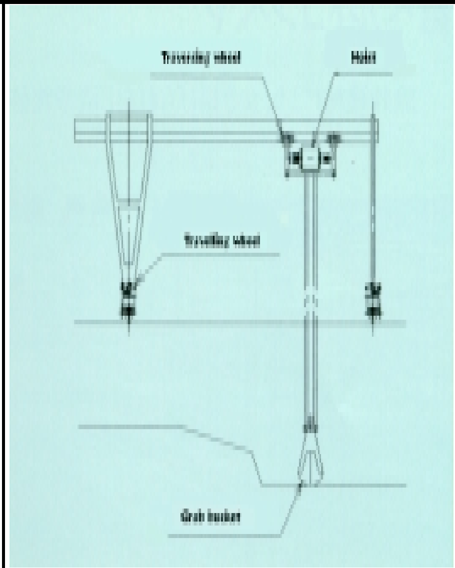
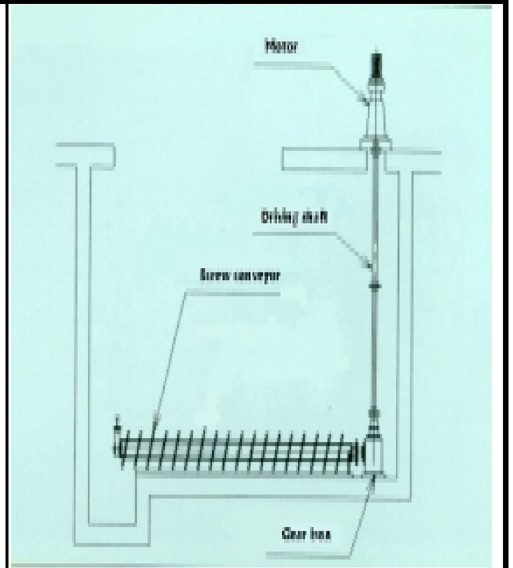
Items	Rotary Bucket Conveyor Type	Grab Bucket Type	Screw Conveyor Type with Sand Pump
1. Installation Layout			
2. Design	V-buckets are rotated with double chains installed at each side of chamber Since width of V-bucket csover almost whole length of chamber and the buckets moves continuously, removing capacity of grit is high. Grits removed by V-buckets are transported by conveyors to hopper	A bucket, which is installed on a travelling crane, grabs grit in a chamber and carrys them to the designated point. One grab backet will move to whole area of grit chamber. Grits are transported by conveyors conveyors to hopper.	A screw conveyor is installed at a bottom of chamber and by a movement of screw, grits are collected to the end of of chamber. Collected are transported to the designated point by sand pump.
3. Comparison 3.1) Operation	Automatic operation can be applied.	All the movement such as lowering/lifting, traversing and travelling should be operated by a operator.	Automatic operation can be applied.

TABLE 8.4 (2/2) COMPARISON OF GRIT REMOVAL TYPE

Items	Rotary Bucket Conveyor Type	Grab Bucket Type	Screw Conveyor Type with Sand Pump
3.2) Maintenance	When chains are damaged, a chamber should be dewatered. Maintenance can be done on a floor.	Since all mechanical parts are equipped above water, maintenance can be done on a floor. maintenance can be done on a	When screw conveyor, gearbox, etc. are damaged, a chamber should be dewatered.
3.3) Consumables	Shoe, chain, etc. need to be replaced periodically.	Only bearings of motors need tro be replaced after their design life.	Seal, submerged bearing, etc. needed to be replaced periodically.
3.4) Grit removing capacity	High	Low	High
3.5) Safetyness when large amount of grit flowing into chamber	Scraper and chains are embedded in a sand.	Safety since all mechanical parts are equipped above water.	Screw and gearbox are embedded in a sand.
3.6) Height of building	6m	11m	2 to 3m
3.7) Depth of chamber	4.4m	4.4m	7m
3.8) Length of chamber	19.5m	19.5m	Since length of screw is limited up to 7 to 9m, in case screw conveyor is applied for 19.5m, two (2) screws for each chamber are required to install.
3.9) Equipment Cost (Miilion VND)			
Total cost of Phase 1&2 including conveor system and hopper	23,120 172%	13,477 100%	26,422 196%

TABLE 8.5(1/2) MAJOR MECHANICAL EQUIPMENT LIST

Item	No.	Name	Model	Specification	1st	2nd	Total	Remarks
1. Pump Well	1	Inlet gate	Cast iron made sluice gate	1500mm W x 1500mm H	2	2	4	
	2	Fine screen	Rotary front raking type	3500mm W x 6400mm H	1	3	4	
		Bar screen	Hand raking type	3500mm W x 6400mm H	1	0	1	Temporary use until phase 2
	3	Horizontal conveyor	Belt type	750mm W x 8000mm L	1	*1	1	*1 Extension of belt
	4	Garbage grinder	Vertical rotary type	$1.0m^3/hr$	1	-	1	
	5	Garbage washing equipment	Mixing type	$1.0m^3/hr$	1	-	1	
	6	Dehydrorating equipment	Screw type	$1.0m^3/hr$	1	-	1	
	7	Inclined conveyor	Belt with fin	1050mm W x 14850mm H	1	-	1	
	8	Hopper	Cut gate type	$7m^3$	1	-	1	
	9	Stop log guide frame	Steel made	3500mm W x 8000mm H	2	2	4	With one (1) stop log
2. Pump Room	1	Main sewage pump	Vertical shaft mixed flow pump	700mm dia. x $66.7m^3/m$ x 14.5m	3	-	3	
			with volute casing	1000mm dia. x $122.1m^3/m$ x 14m	-	3	3	
	2	Motor for Item 1	Wound rotor induction	AC3.3kV x 50Hz x 230kw	3	-	3	
				AC3.3kV x 50Hz x 460kw	-	3	3	
	3	Suction valve	Cast iron made butterfly valve	700mm dia. x PN6	3	-	3	
				1000mm dia. x PN6	-	3	3	
	4	Non-return valve	Cast iron made swing type	700mm dia. x PN10	3	-	3	
				1000mm dia. x PN10	-	3	3	
	5	Discharge valve	Cast iron made butterfly valve	700mm dia. x PN10	3	-	3	
				1000mm dia. x PN10	-	3	3	
	6	Pipework	Ductile cast iron	700mm dia. x PN7.5	3	-	3	
				1000mm dia. x PN7.5	-	3	3	
	7	Overhead crane	Crab type	10ton	1	-	1	
	8	Drain pump	Submersible pump	50mm dia.	2	-	2	
3. Grit Chamber	1	Inlet gate for grit chamber	Cast iron made sluice gate	1500mm W x 1500mm H	2	2	4	
	2	Grit removal equipment	Grab bucket type	5000mm W x 19500mm L	1	-	1	
	3	Horizontal/inclined conveyor	Trough type	600mm W x 17500mm L	1	-	1	
	4	Hopper	Cut gate type	$3.5m^3$	1	-	1	
	5	Outlet gate for grit chamber	Cast iron made sluice gate	1500mm W x 1500mm H	2	2	4	

TABLE 8.5(2/2) MAJOR ELECTRICAL EQUIPMENT LIST

Item	No.	Name	Model	Spec	1st	2nd	Total	Remarks
1. Electrical Equipment	1	H.V. Incoming	Outdoor	AC22kV x 50Hz	1	-	1	
	2	Transformer	Outdoor	AC22kV/AC3kV x 2000kVA	1	-	1	
	3	Battery charger panel		DC	1	-	1	
	4	3.3kV Incoming panel		AC3.3kV x 50Hz	1	-	1	
	5	Sewage pump panel		AC3.3V x 50Hz x 230kw	3	-	3	
				AC3.3V x 50Hz x 460kw	-	3	3	
	6	Aux. transformer panel		AC3.3kV/380V x 500kVA	1	0	1	
	7	L.V. switchboard		AC380V x 50Hz	1	0	1	
	8	Motor control center		AC380V x 50Hz	12	4	16	
	9	Aux. relay panel (pump)		AC380V x 50Hz	2	2	4	
	10	Aux. relay panel (grit chamber)		AC380V x 50Hz	2	0	2	
	11	Aux. relay panel (pump well)		AC380V x 50Hz	2	2	4	
	12	Instrument panel			2	0	2	
	13	Local panel		AC380V x 50Hz	1	1	2	
	14	Stand-by generating unit		AC3.3kV x 50Hz x 300kVA	1	0	1	
				AC3.3kV x 50Hz x 1100kVA	0	1	1	
	15	Supervisory panel			1	0	1	
	16	Cable			1	1	2	

TABLE 8.6 BILL OF QUANTITIES FOR INTERMEDIATE WASTEWATER PUMPING STATION

Item	Unit	Quantities	Remark
1. Earth Work			
(1) Sheathing	m^2	3,520	Steel Sheet Pile
(2) Excavation	m^3	27,464	
(3) Backfill	m^3	8,592	
(4) Surplus Soil	m^3	18,872	
(5) Filling	m^3	14,268	Sand
2. Foundation Work			
(1) RC Pile (400x400x20)	nos.	321	
(2) Sand Mat (t=20 cm)	m^3	340	
3. Concrete Work			
(1) Leveling Concrete (180 kg/cm^2)	m^3	170	t=10cm
(2) Reinforced Concrete (210 kg/cm2)	m^3	4,800	Concrete Volume
4. O/M Office			
(1) Building (Rainforced Concrete)	m^2	2,551	
(2) Gard Fence (Steel Net, H=2.4 m)	m	357	Road side 120m, Other side 237m
5. O/M Road			
(1) Road Construction (Grade V)	m^2	1,680	
(2) Landscaping(Planting)	m^2	1,990	

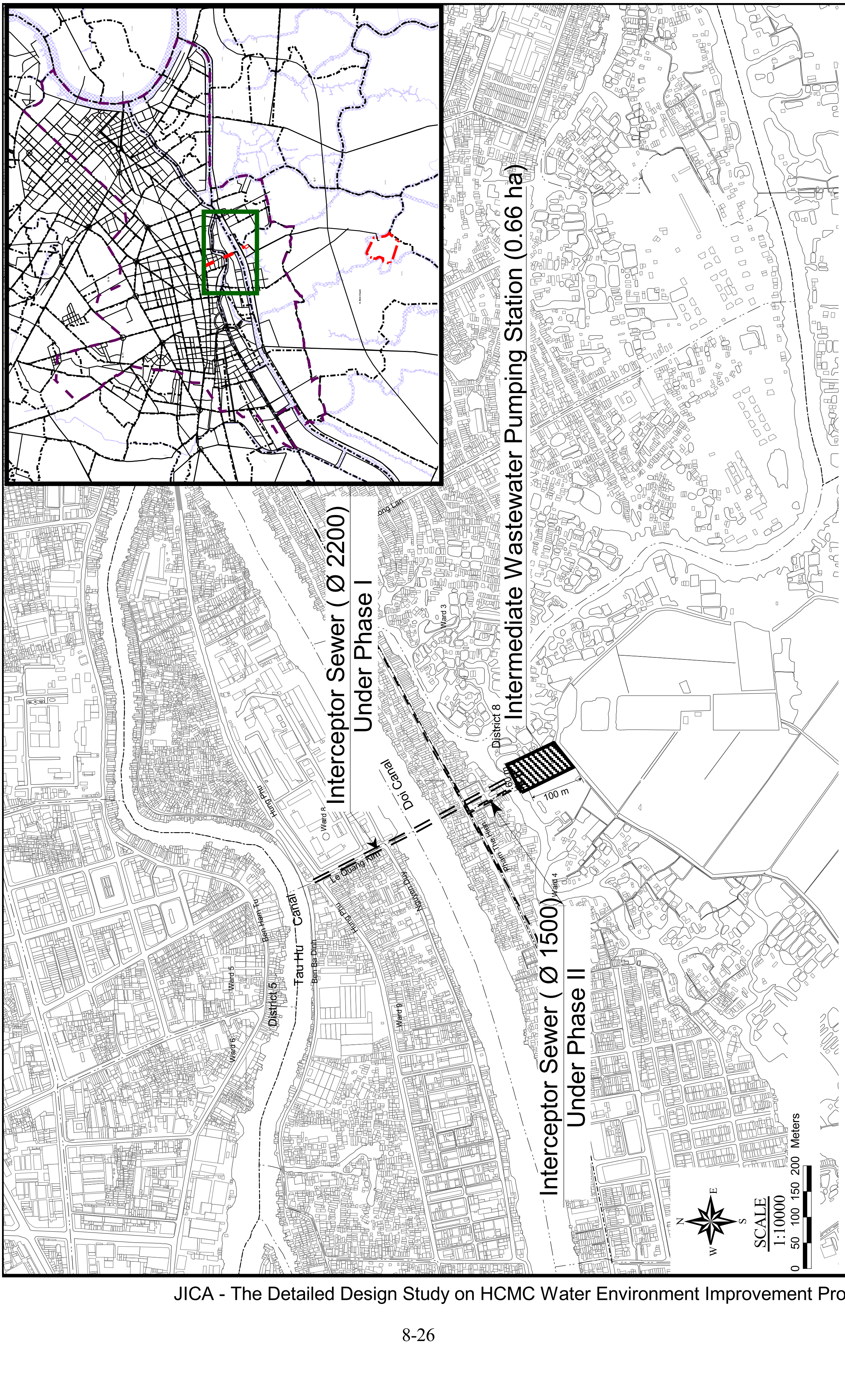
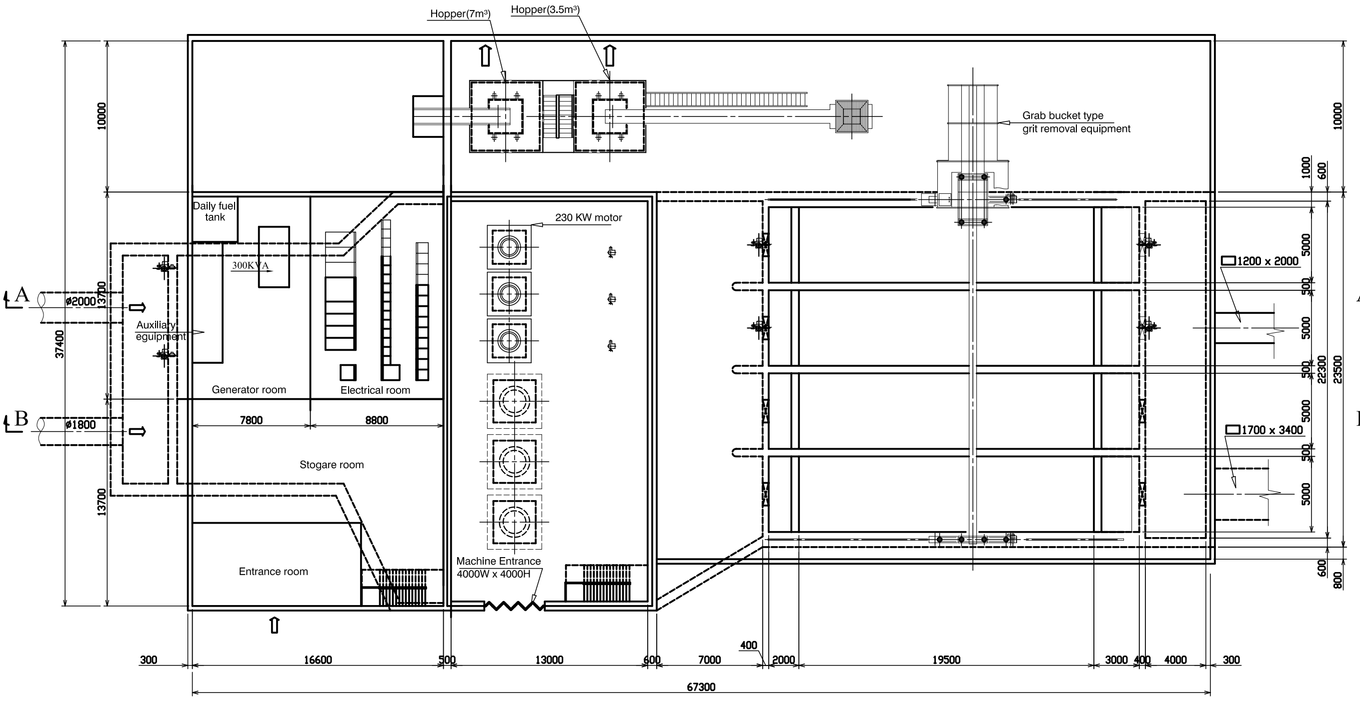
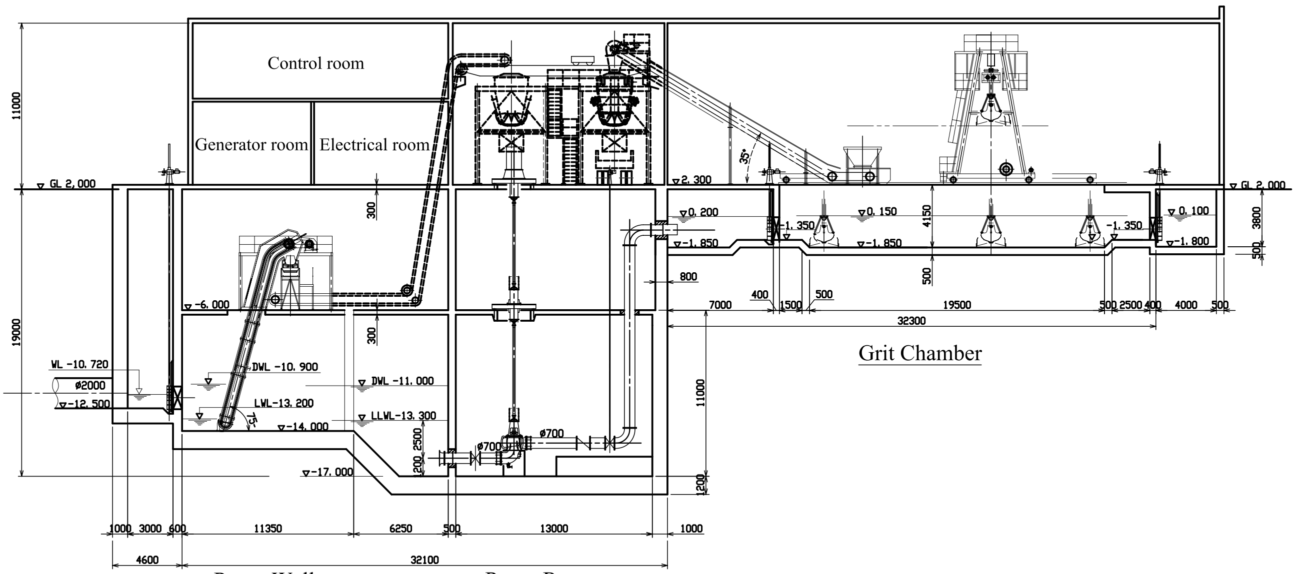


FIG. 8.1 PROPOSED LOCATION OF INTERMEDIATE WASTEWATER PUMPING STATION

SCALE 1:500



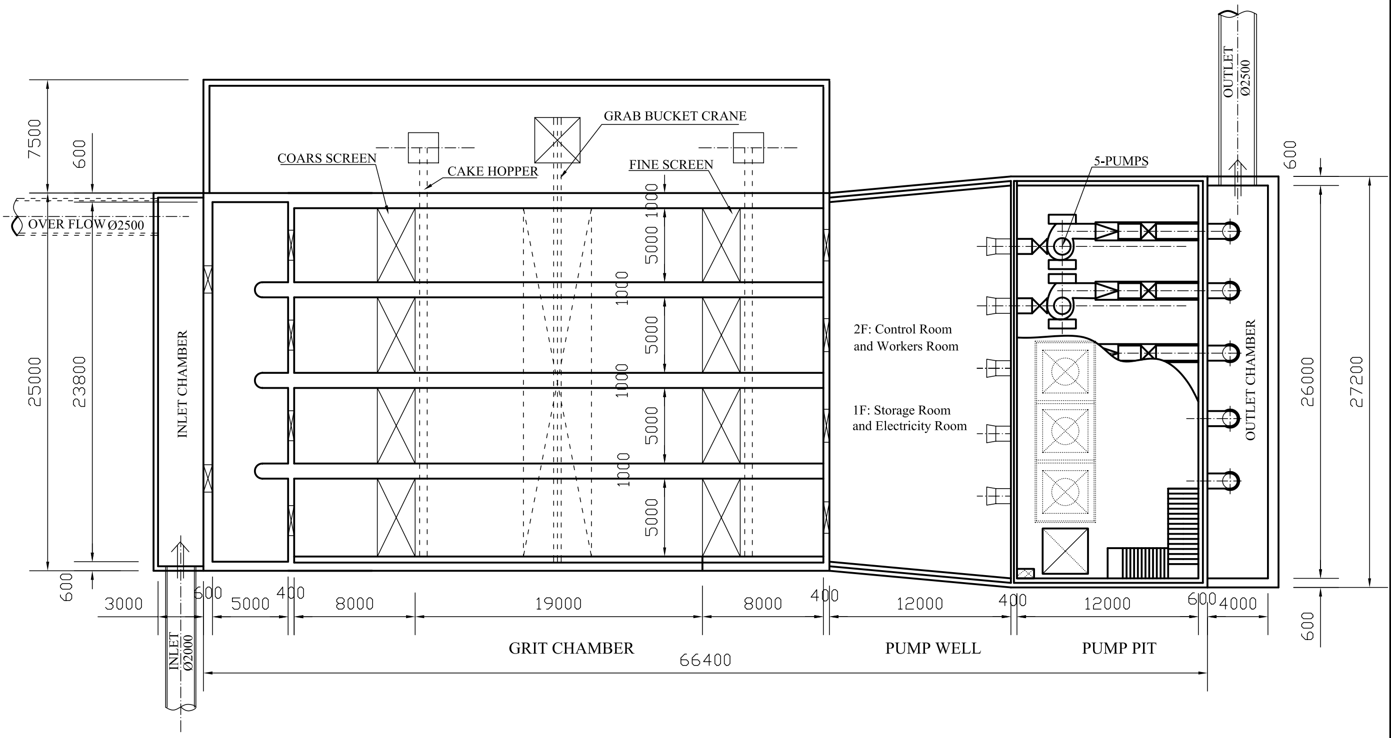
1 F PLAN VIEW



SECTION A-A

FIG. 8.2 COMPARISON STUDY ON INTERMEDIATE WASTEWATER PUMPING STATION (OPTION A - PROPOSED)

SCALE 1:500



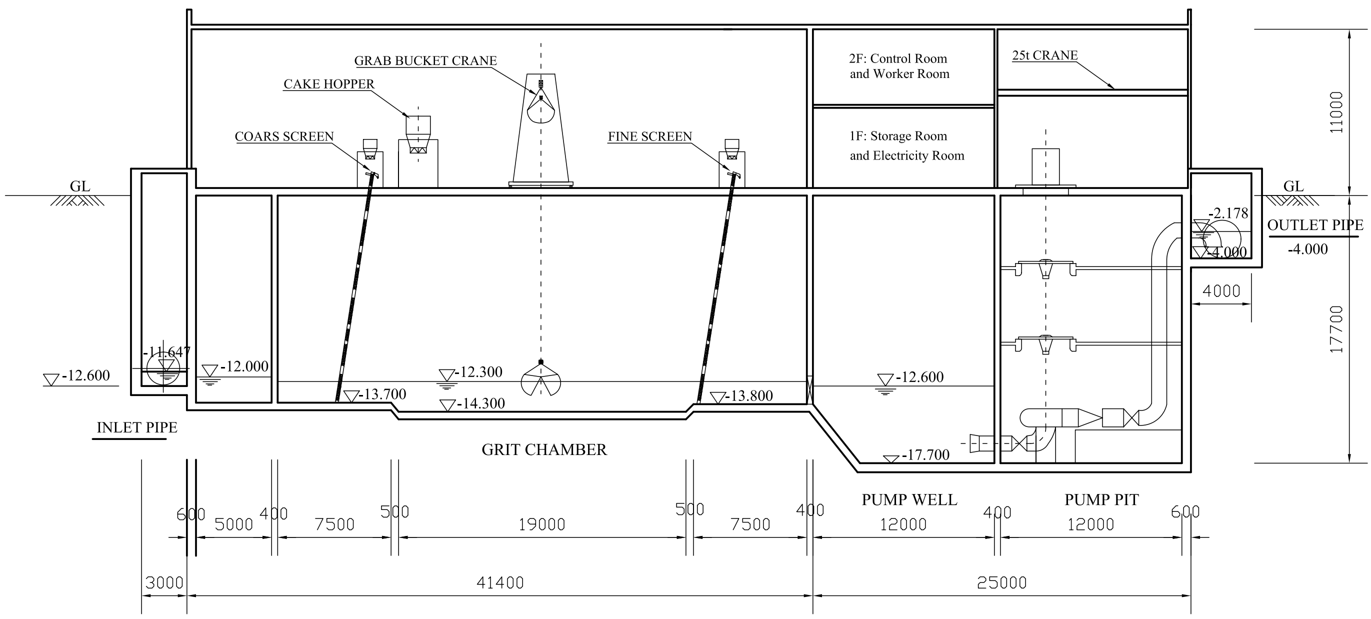


FIG. 8.3 COMPARISON STUDY ON INTERMEDIATE WASTEWATER PUMPING STATION (OPTION B)

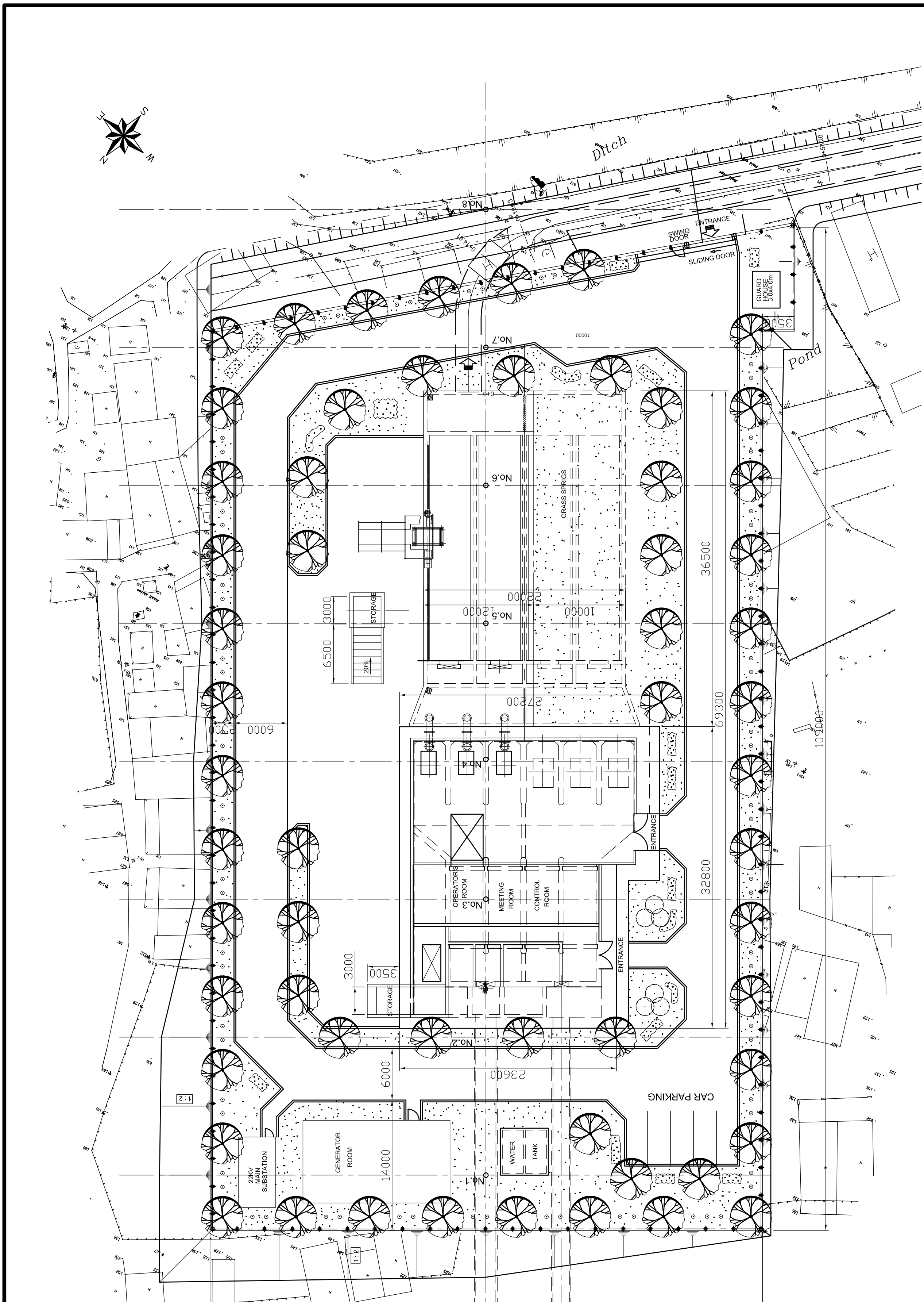
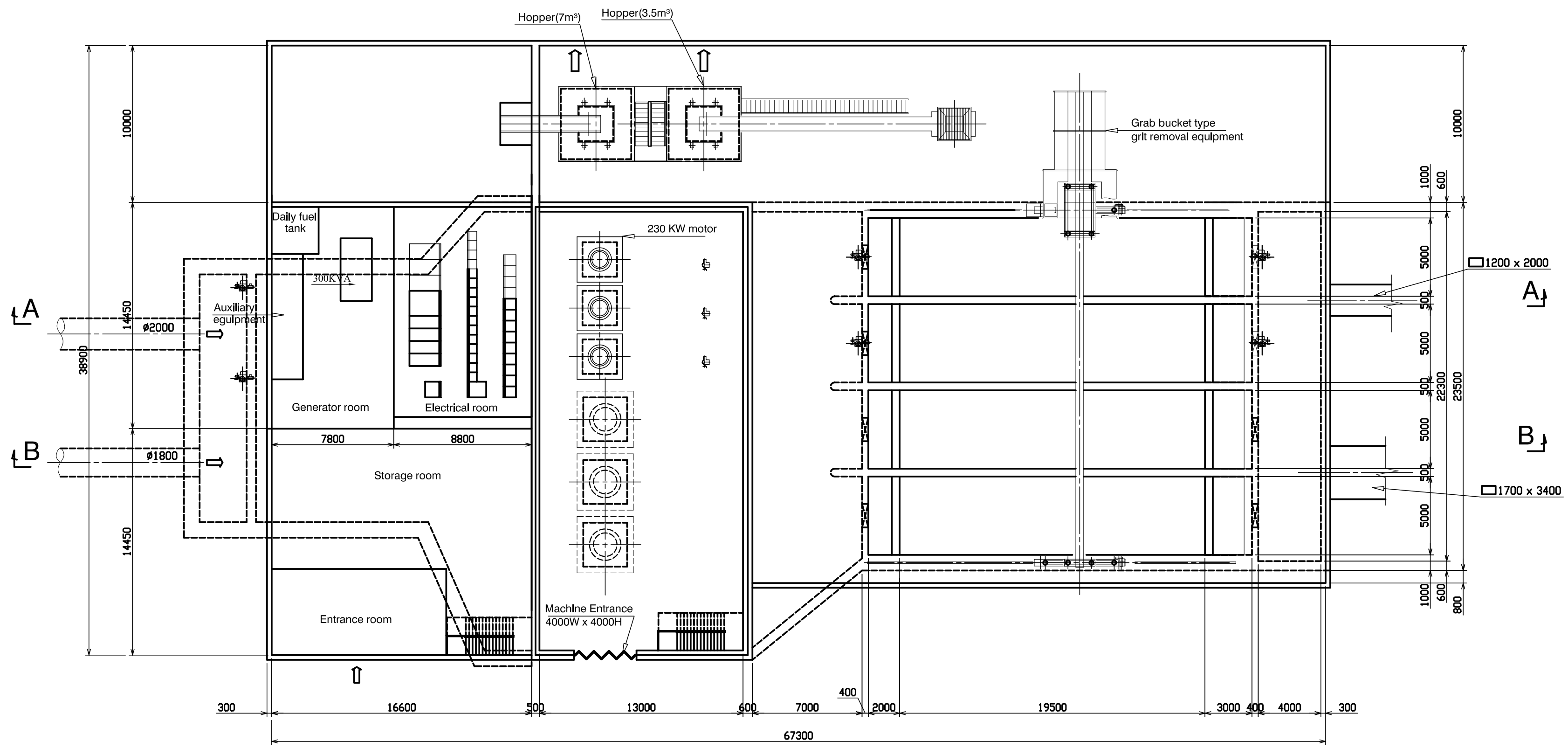


FIG. 8.4 LAYOUT OF INTERMEDIATE WASTEWATER PUMPING STATION

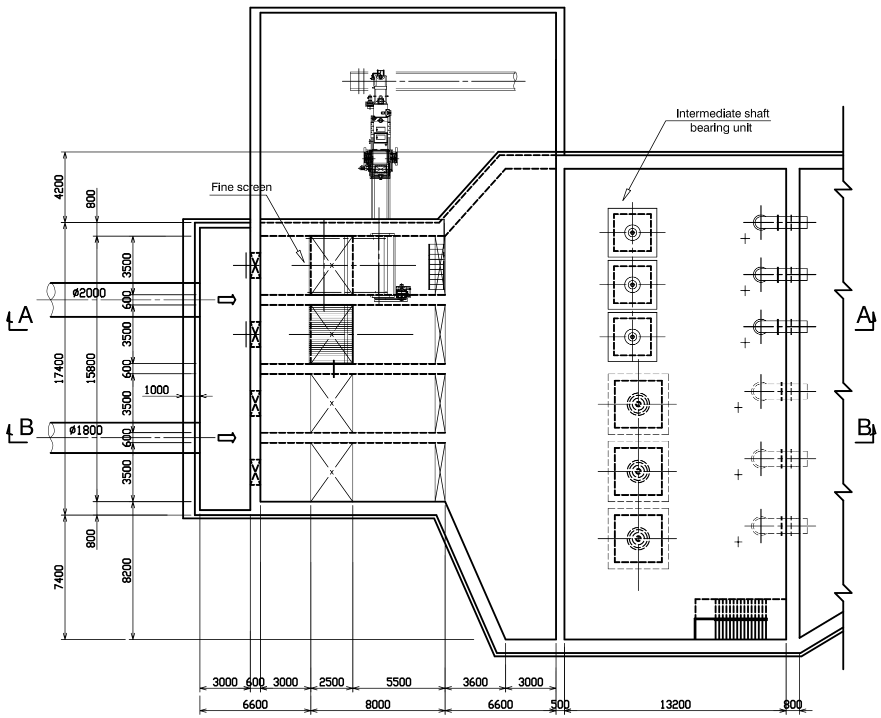
SCALE 1:450



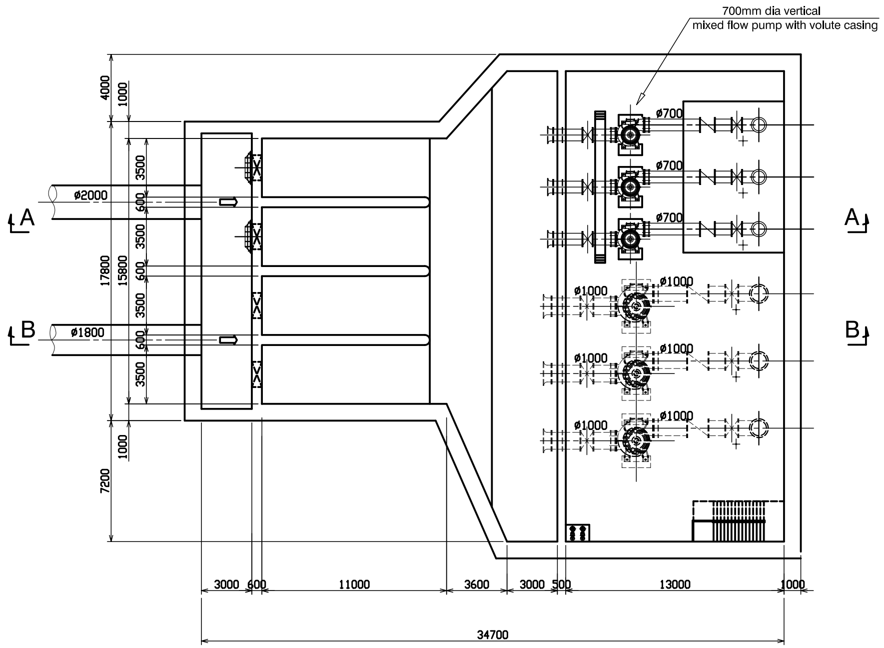
1 F PLAN VIEW

FIG. 8.5(1/3) PRELIMINARY DRAWING OF INTERMEDIATE WASTEWATER PUMPING STATION

SCALE 1:450



B 1 F PLAN VIEW



B 2 F PLAN VIEW

FIG. 8.5(2/3) PRELIMINARY DRAWING OF INTERMEDIATE WASTEWATER PUMPING STATION

SCALE 1:450

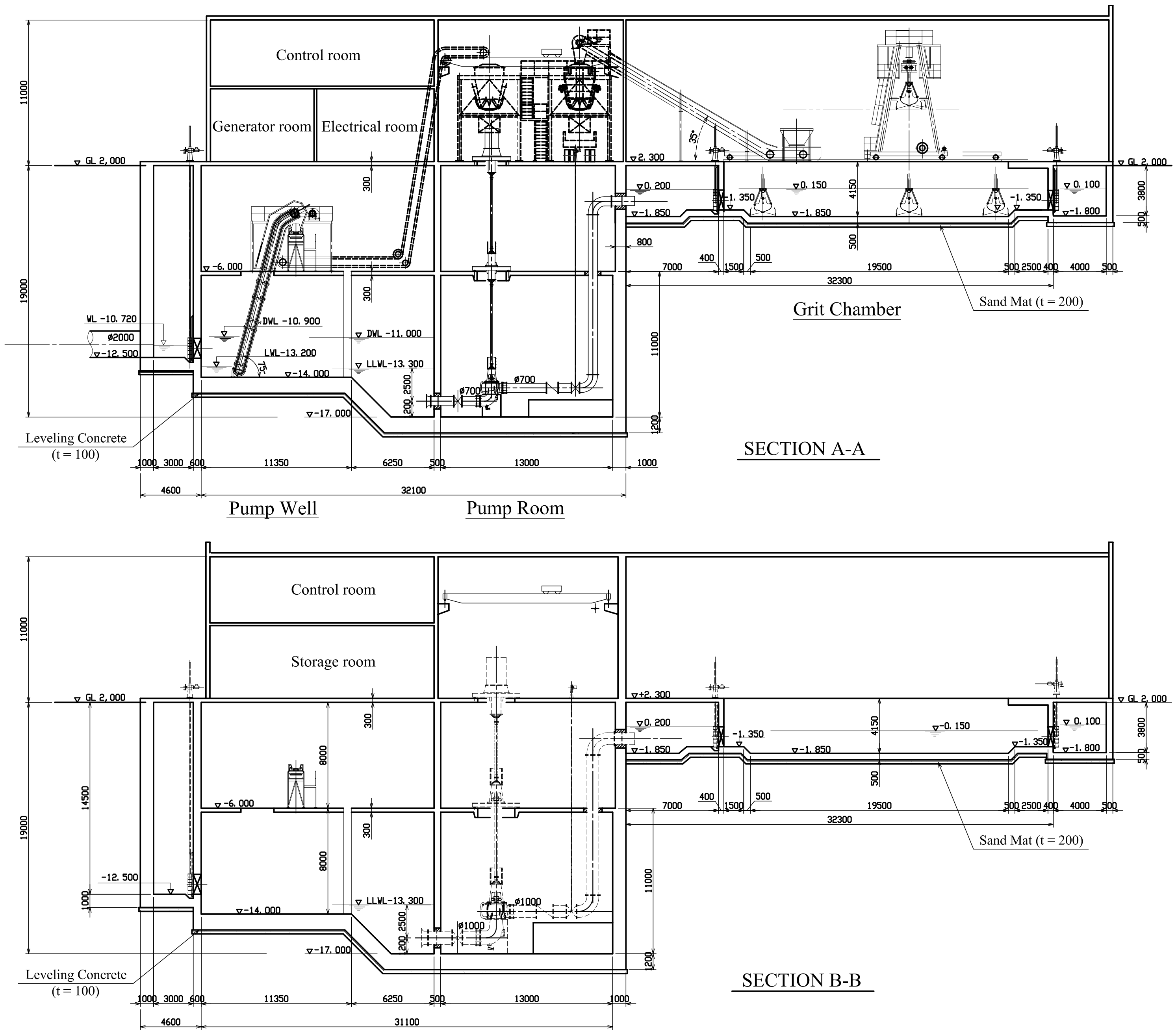
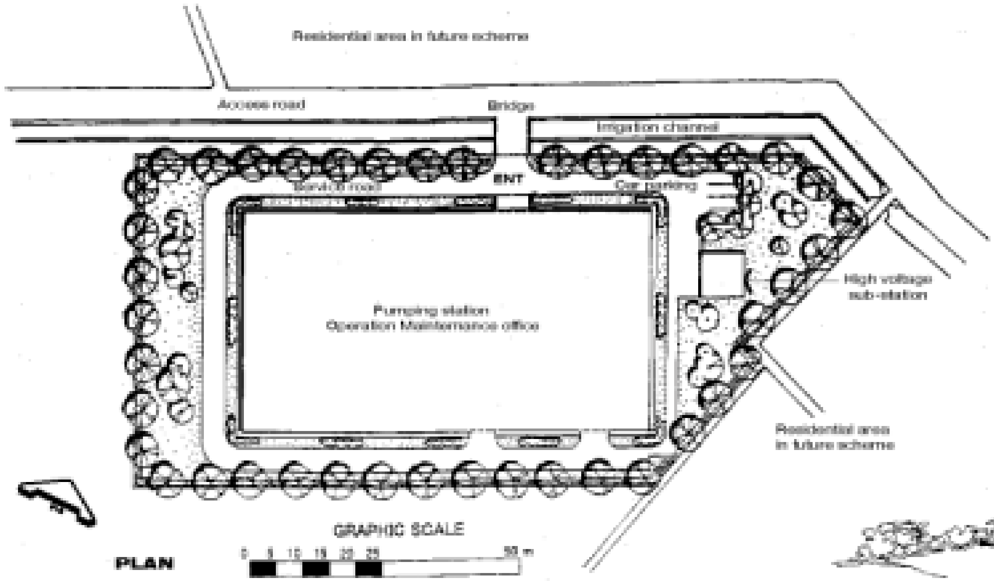
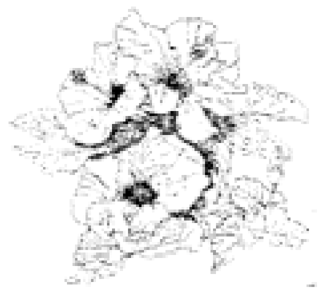


FIG. 8.5(3/3) PRELIMINARY DRAWING OF INTERMEDIATE WASTEWATER PUMPING STATION

PROPOSED LANDSCAPE SCHEMATIC PLAN FOR INTERMEDIATE WASTEWATER PUMPING STATION





Related considerations

Existing access road shall be widen in order to consider smooth and safety traffics of motor lorry vehicles for the operation and maintenance purpose, also adjacent irrigation channel and additional new bridge or box culvert shall be improved and installed in relation to the access road widening.

The area surroundings of waste water pumping station site is going to be a new housing development area, so that the pumping station site should be considered vicinity environmental condition with aesthetic solution with landscaping.

LANDSCAPE DESIGN CRITERIA

Main access for motor vehicle shall be minimum 4.0m in width and concrete paving finish, and colored concrete block paving with 2.0m in width shall be installed at office entrance surroundings and pedestrian path for aesthetic consideration.

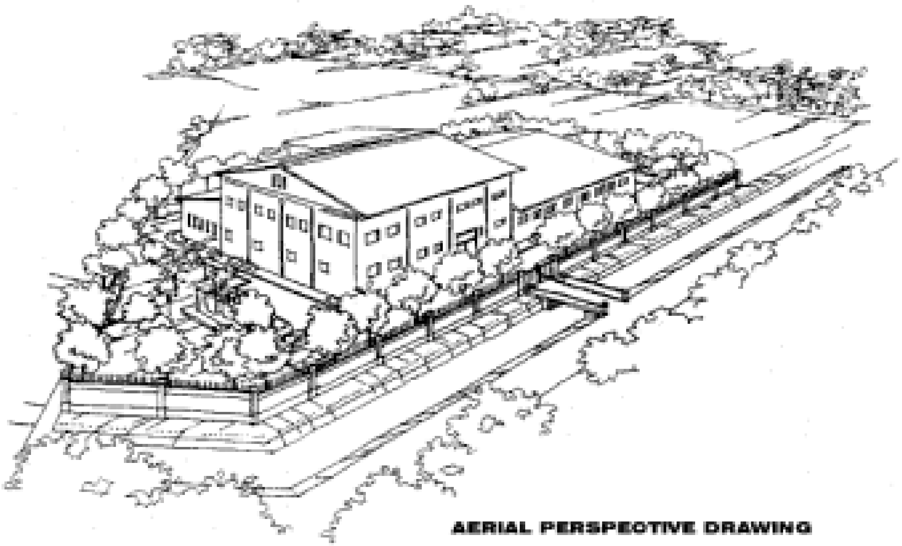
All facility sites shall be enclosed by fence with 2.4 m in height and major gate door shall be minimum 5.0m in width of enough space for motor vehicle goes in.

Plantings shall be introduced for establishing aesthetic and safety environmental condition of the facility site. Medium trees as major objectives shall be introduced for provision of rich greenery with seasonal flowering for the site of residential area.

Some small flowering shrubs shall be also provided for an accent of the planting layout scheme.

Along the enclosure fence especially it faces to the access road, species of flowering shrub, vine and creeper shall be introduced as a hedge planting.

Facility spaces in which without any paving provision shall be furnished with turf grass or some proper ground cover plants, so that all the facility space will be covered in condition of clean and amicable environment accordingly.



AERIAL PERSPECTIVE DRAWING

FIG. 8.6 LANDSCAPE PLAN FOR THE INTERMEDIATE WASTEWATER PUMPING STATION SITE