2.2.3 Items Analysed by the Laboratory for Well Waters

(1) Suspended Solids (SS) (mg/l)

(2) Alkalinity as $CaCO_3$ (mg/l)

(3) Chloride (mg/l)

(4) Ammonia Nitrogen (NH_4-N) (mg/l)

(5) Total Nitrogen (mg/l)

(6) Total Coliforms (MPN/100 ml)

(7) Faecal Coliforms (MPN/100 ml)

2.3 Results of Spot Analysis

On the spot sample analysis was conducted immediately after taking samples from the water. Results of the analysis are shown in Tables IV-2 through IV-15, together with sampling dates and sketches of the sampling points.

Table IV-2 Results of Spot Analysis (1)

No. 1 Effluent of Existing Sewage Treatement Plant, Zagazig City

(1)	Date	:	29th August, 1987
(2)	Time	:	1:30 p.m.
(3)	Weather	:	fine
(4)	Temperature	:	32°C
(5)	Sampling point	:	effluent pit of the sedimentation tank
(6)	Temperature of sample	:	26°C
(7)	Appearance		
	-1 suspended materials	:	a little
	-2 scum	:	none
	-3 oil	:	none
	-4 odor	:	faintly
	-5 color	:	light yellow
(8)	Sketch of the sampling point		

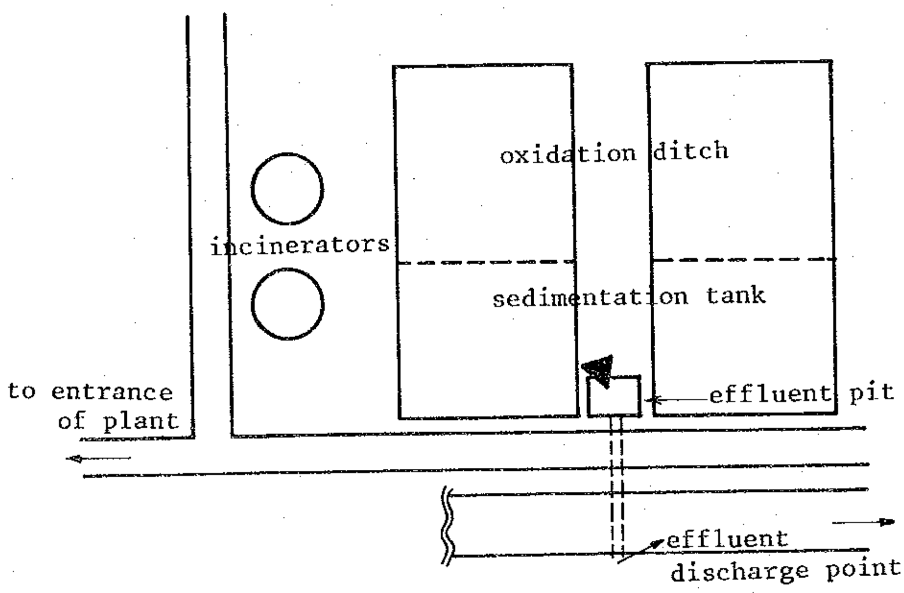


Table IV-3 Results of Spot Analysis (2)

No. 2 Raw Sewage, Existing Sewage Treatment Plant, Zagazig City

(1) Date : 29th August, 1987

(2) Time : 1:05 p.m.

(3) Weather : fine

(4) Temperature : 32°C

(5) Sampling point : outlet of the force main

(6) Temperature of sample : 26°C

(7) Appearance

-1 suspended materials: many

-2 scum : none

-3 oil : a little

-4 odor : odor of sewage

-5 color : dark gray

(8) Sketch of the sampling point

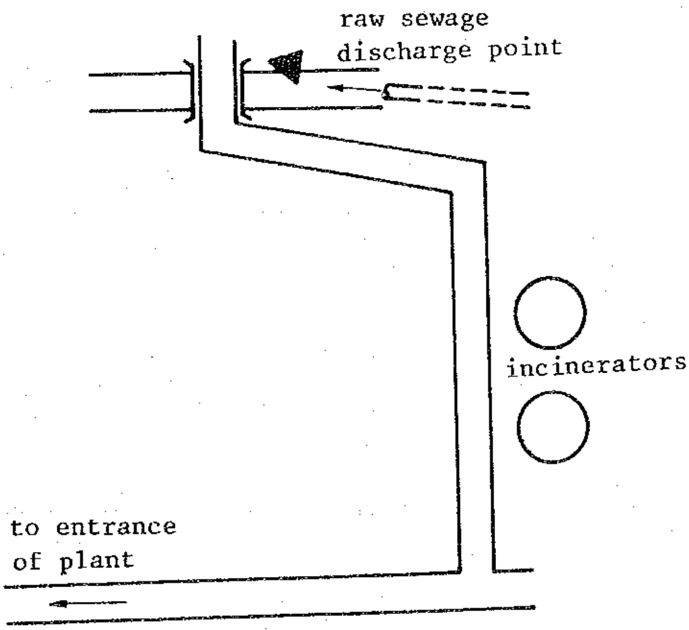


Table IV-4 Results of Spot Analysis (3)

No. 3 Well Water, Manshat El Hosein Beside El Chest Hospital Traffic Point, Zagazig City

(1)	Date	:	3rd September, 1987
(2)	Time	:	1:45 p.m.
(3)	Weather	:	fine
(4)	Temperature	:	32°C
(5)	Sampling point	:	shallow well (depth 15 m)
(6)	Temperature of sample	:	23°C
(7)	Appearance		
	-1 suspended materials	:	none
	-2 scum	:	none
	-3 oil	:	none
	-4 odor	:	none
	-5 color	:	none, clear
(8)	Transparency	:	over 50 cm
(9)	pH	:	7.5
(10)	Conductivity	:	1500 μs/cm
(11)	Sketch of the sampling point		

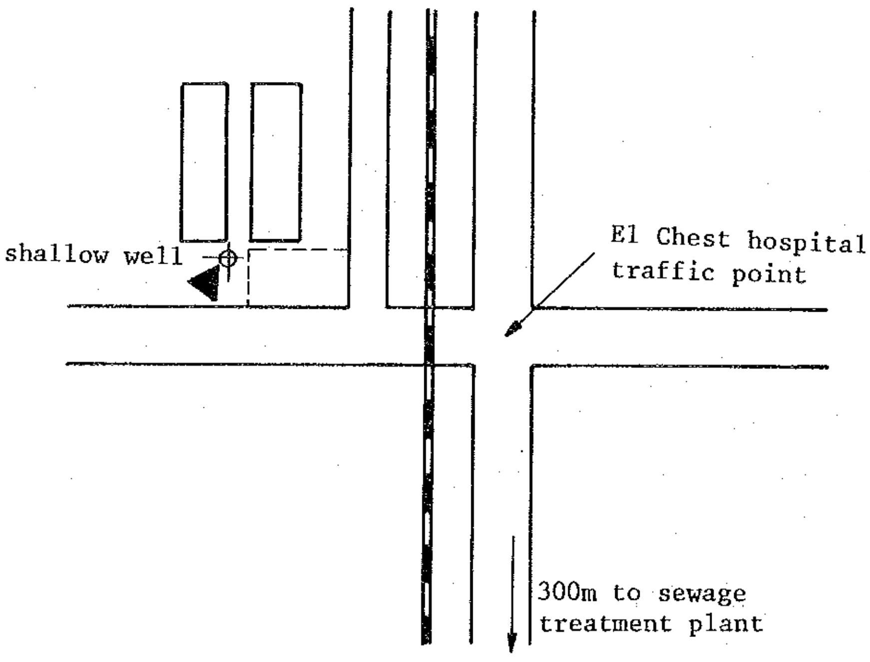


Table IV-5 Results of Spot Analysis (4)

No. 4 Drain Water, Bilbeis City

(1)	Date	:	27th August, 1987
(2)	Time	:	11:20 a.m.
(3)	Weather	:	fine
(4)	Temperature	:	34°C
(5)	Sampling point	:	center of the drain, about 50 cm deep from surface
(6)	Temperature of sample	:	25°C
(7)	Appearance		
	-1 suspended materials	:	many, black color
	-2 scum	:	a little
	-3 oil	:	a little
	-4 odor	:	faint, odor of sewage
	-5 color	:	light gray
(8)	Sketch of the sampling point		

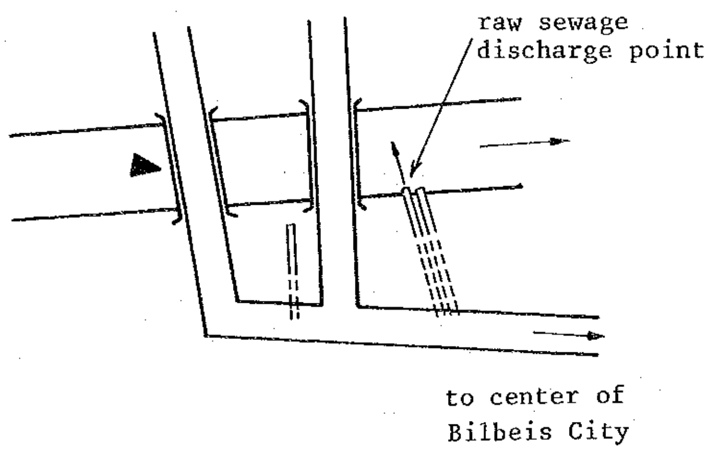


Table IV-6 Results of Spot Analysis (5)

No. 5 Raw Sewage, Bilbeis City

(1)	Date	: 27th August, 1987
(2)	Time	: 11:10 a.m.
(3)	Weather	: fine
(4)	Temperature	: 34°C
(5)	Sampling point	: outlet of the force main
(6)	Temperature of sample	: 25°C
(7)	Appearance	
	-1 suspended materials	: many, colloidal
	-2 scum	: a little
	-3 oil	: a little
	-4 odor	: odor of sewage
	-5 color	: dark gray

(8) Sketch of the sampling point

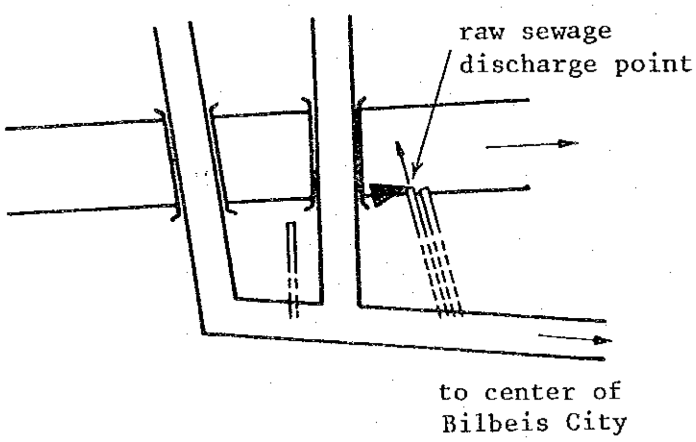


Table IV-7 Results of Spot Analysis (6)

No. 6 Drain Water, Minyet El Qamh City

(1) Date : 27th August, 1987

(2) Time : noon

(3) Weather : fine

(4) Temperature : 35°C

(5) Sampling point : Because of no flow in the drain, it is impossible to take sample.

(6) Sketch of the sampling point

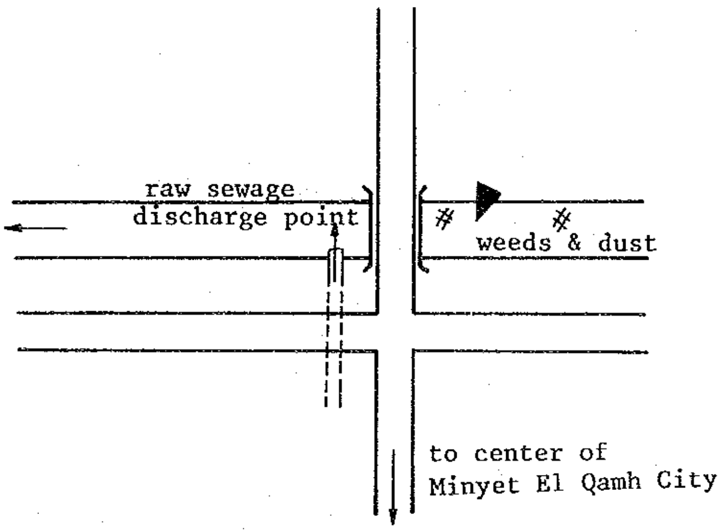


Table IV-8 Results of Spot Analysis (7)

No. 7 Raw Sewage, Minyet El Qamh City

(1)	Date	:	27th August, 1987
(2)	Time	:	11:50 a.m.
(3)	Weather	:	fine
(4)	Temperature	:	35°C
(5)	Sampling point	:	outlet of the force main
(6)	Temperature of sample	:	26°C
(7)	Appearance		
	-1 suspended materials	:	many, colloidal
	-2 scum	:	a little
	-3 oil	:	a little
	-4 odor	:	odor of sewage
	-5 color	:	dark gray
(8)	Sketch of the sampling point		

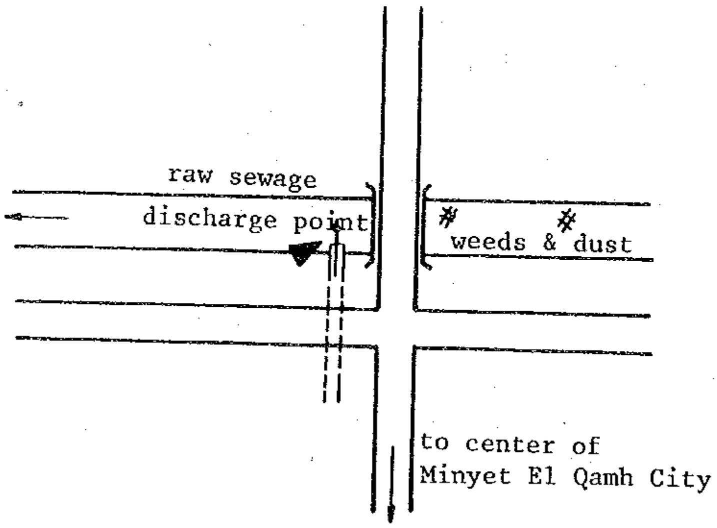


Table IV-9 Results of Spot Analysis (8)

No. 8 Drain Water, Abu Kebir City

(1)	Date	: 29th August, 1987
(2)	Time	: 0:30 p.m.
(3)	Weather	: fine
(4)	Temperature	: 32°C
(5)	Sampling point	: Because of no flow in the drain, it is impossible to take sample.

(6) Sketch of the sampling point

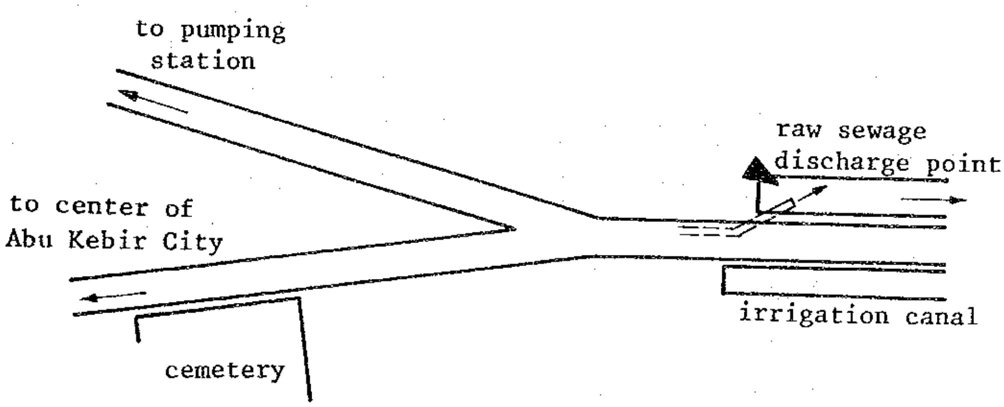


Table IV-10 Results of Spot Analysis (9)

No. 9 Raw Sewage, Abu Kebir City

(1)	Date	:	29th August, 1987
(2)	Time	:	noon
(3)	Weather	:	fine
(4)	Temperature	:	32°C
(5)	Sampling point	:	inlet chamber of the pumping station
(6)	Temperature of sample	:	26°C
(7)	Appearance		
	-1 suspended materials	:	many
	-2 scum	:	many
	-3 oil	:	gasoline on surface
	-4 odor	:	odor of gasoline, sewage
	-5 color	:	dark gray
(8)	Sketch of the sampling point		

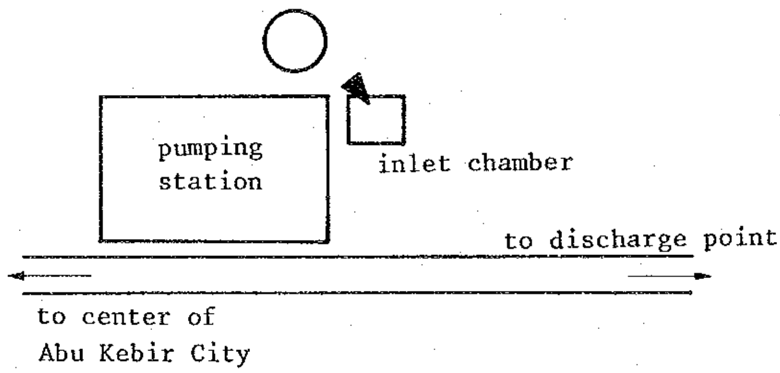


Table IV-11 Results of Spot Analysis (10)

No. 10 Drain Water (1), Faqus City

(1)	Date	:	29th August, 1987
(2)	Time	:	11:20 a.m.
(3)	Weather	:	fine
(4)	Temperature	:	32°C
(5)	Sampling point	:	center of the drain, surface, depth of the water in the drain is about 20 cm.
(6)	Temperature of sample	:	27°C
(7)	Appearance		
	-1 suspended materials	:	colloidal
	-2 scum	:	a little
	-3 oil	:	none
	-4 odor	:	odor of grass
	-5 color	:	light gray, green
(8)	Sketch of the sampling point		

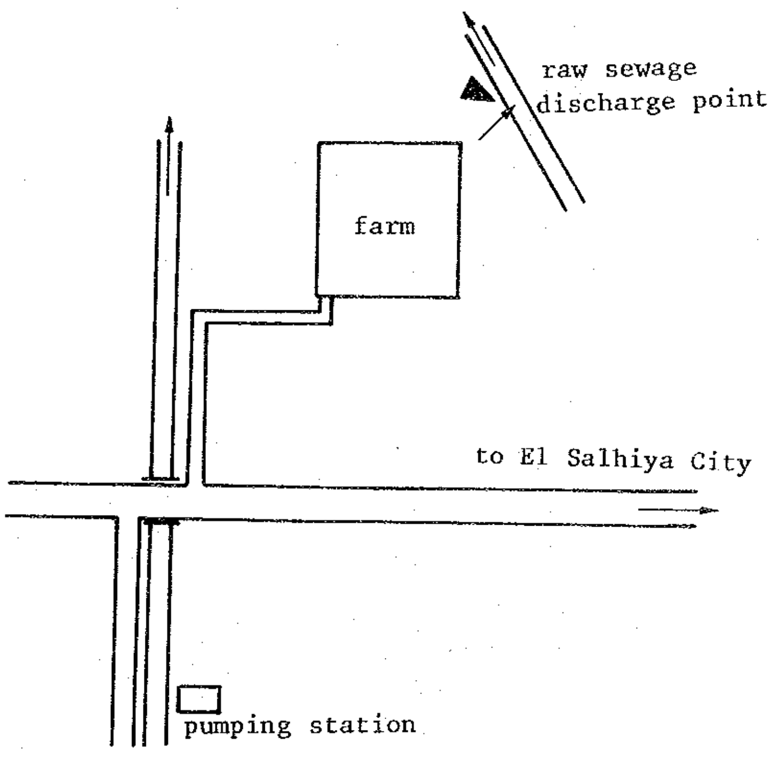


Table IV-12 Results of Spot Analysis (11)

No. 11 Drain Water (2), Faqus City, Bahr El Bakar Drain

(1)	Date	:	29th August, 1987
(2)	Time	:	10:10 a.m.
(3)	Weather	:	fine
(4)	Temperature	:	29°C
(5)	Sampling point	:	center of the drain, about 1 m deep from surface
(6)	Temperature of sample	:	26°C
(7)	Appearance		
	-1 suspended materials	:	many, small particle, black color
	-2 scum	:	a little
	-3 oil	:	a little
	-4 odor	:	faintly
	-5 color	:	none, clear but the drain looks dark gray or black

(8) Sketch of the sampling point

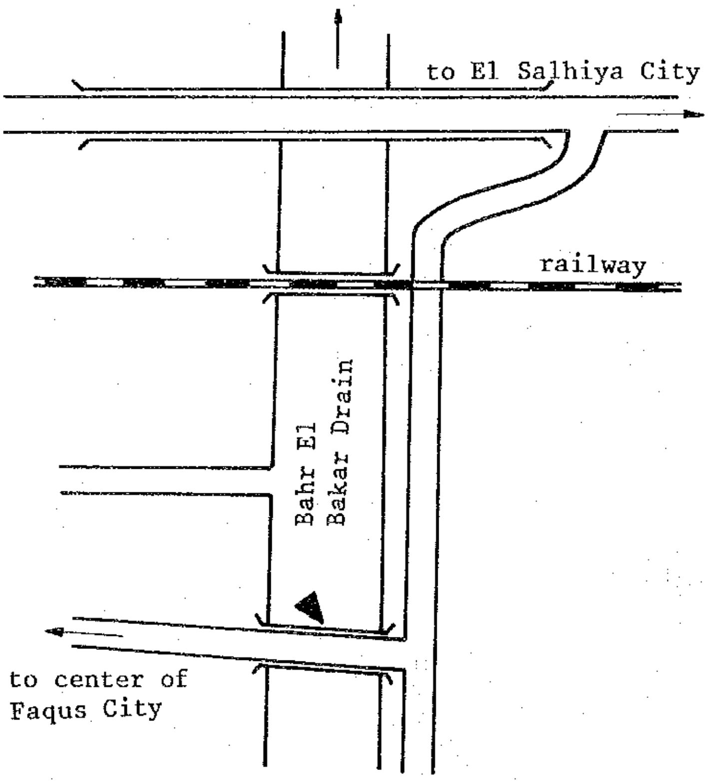


Table IV-13 Results of Spot Analysis (12)

No. 12 Raw Sewage, Faqus City

(1)	Date	:	29th August, 1987
(2)	Time	:	10:30 a.m.
(3)	Weather	:	fine
(4)	Temperature	:	29°C
(5)	Sampling point	:	inlet chamber of the pumping station
(6)	Temperature of sample	:	26°C
(7)	Appearance		
	-1 suspended materials	:	many, colloidal
	-2 scum	:	many
	-3 oil	:	gasoline on surface
	-4 odor	:	odor of gasoline, sewage
	-5 color	:	dark gray
(8)	Sketch of the sampling point		

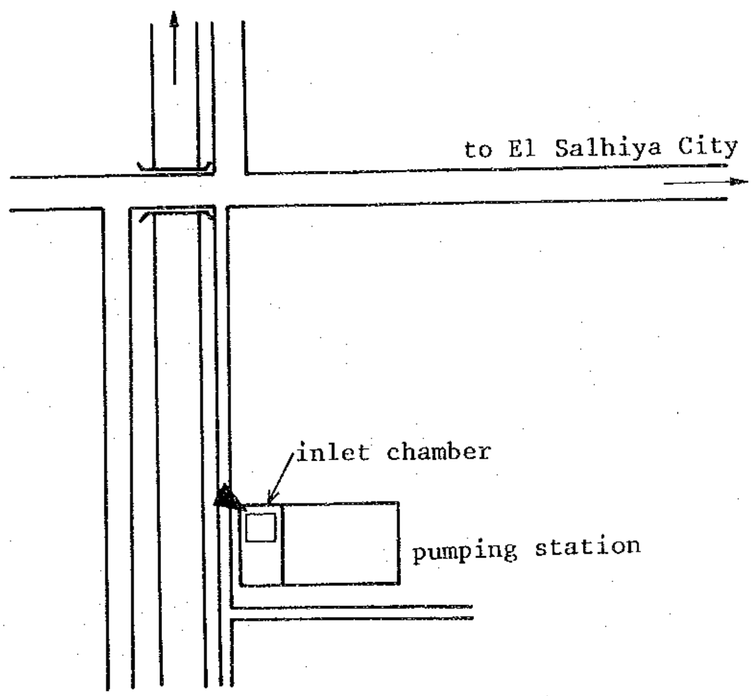


Table IV-14 Results of Spot Analysis (13)

No. 13 Well Water, Tahlet Bordien Village, Zagazig Markaz

(1)	Date	:	3rd September, 1987
(2)	Time	:	11:35 a.m.
(3)	Weather	:	fine
(4)	Temperature	:	34°C
(5)	Sampling point	:	shallow well (depth 9 m)
(6)	Temperature of sample	:	22°C
(7)	Appearance		
	-1 suspended materials	:	some dust
	-2 scum	:	none
	-3 oil	:	none
	-4 odor	:	none
	-5 color	:	none, clear
(8)	Transparency	:	over 50 cm
(9)	pH	:	7.1
(10)	Conductivity	:	2900 μs/cm

(11) Sketch of the sampling point (scale 1:200)

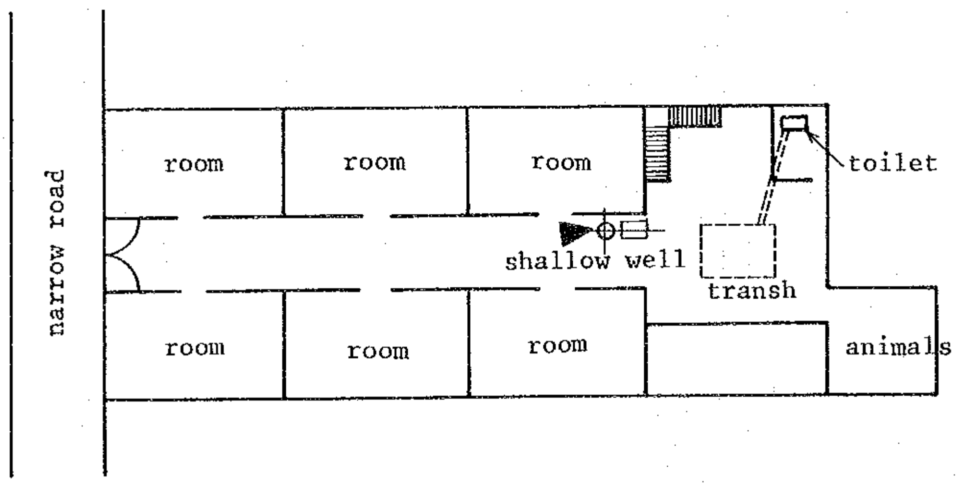
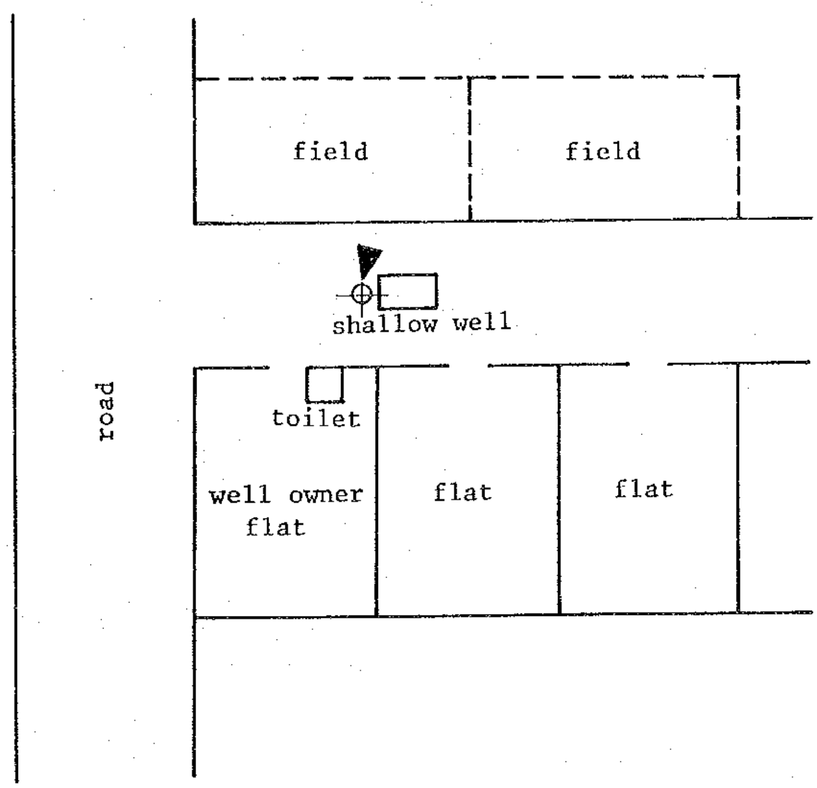


Table IV-15 Results of Spot Analysis (14)

No. 14 Well Water, Bany Korish Village, Minyet El Qamh Markaz

(1)	Date	:	3rd September, 1987
(2)	Time	:	1:05 a.m.
(3)	Weather	:	fine
(4)	Temp.	:	34°C
(5)	Sampling point	:	shallow well (depth 33 m)
(6)	Temperature of sample	:	22°C
(7)	Appearance		
	-1 suspended materials	:	none
	-2 scum	:	none
	-3 oil	:	none
	-4 odor	:	none
	-5 color	:	none, clear
(8)	Transparency	:	over 50 cm
(9)	pH	:	7.4
(10)	Conductivity	:	700 μs/cm

(11) Sketch of the sampling point (scale 1:400)



2.4 Results of Laboratory Analysis

Results of the laboratory analysis on the raw sewage, drain water and effluent of the treatment plant are shown in Table IV-16. Those of the well water are shown in Table IV-17. General characteristics of the waters obtained from the results of the analysis are described below.

2.4.1 Drain Water

Water samples collected from the drains contain, in general, many suspended materials, but these are not colloidal in form. These suspended materials are mostly organic and black in color. Appearance of suspended materials indicates digestion in a prolonged anaerobic condition. BOD and SS average concentrations are 372 mg/l and 167 mg/l respectively, which are almost the same as sewage itself indicating heavy organic contamination by domestic and other wastewaters. Nutrient level indicated by ammonia nitrogen and total phosphorus concentration is also high suggesting the same tendency.

2.4.2 Raw Sewage

Raw sewage samples contain many suspended and colloidal materials. SS concentrations are very high. However, average SS concentration of 902 mg/l is calculated by including one extraordinary high value of 2,622 mg/l obtained from No. 9 sample. If this value is disregarded, an average of the other four samples is 472 mg/l. In addition to suspended materials, large quantities of scum and garbage were observed at the sampling points, especially in the inlet chambers of pumping stations in Abu Kebir and Faqus Cities. Also in these two cities, odor of gasoline emanated from the raw sewage. BOD concentrations range from 440 mg/l to 900 mg/l, and 626 mg/l on average. These values, together with results of the other items, indicate that the sewage are mostly of domestic origin. The level of total phosphorus is relatively high compared with BOD and ammonia nitrogen.

2.4.3 Effluent of Sewage Treatment Plant

One sample was taken from the existing sewage treatment plant in Zagazig. Compared with the raw sewage, reduction is noticeable in such items as SS, BOD, COD, ammonia nitrogen. This indicates effectiveness of treatment though entire treatment process is not deemed to function properly. Overall effluent characteristics does not satisfy the standards which are usually expected for secondary treatment. For example, BOD concentration of 350 mg/l is still high and does not meet the requirements set by Law No. 48/1982.

2.4.4 Shallow Well Water

All of the three samples from the shallow wells are odorless, colorless and very clear by observation. However, high conductivity indicates that the water contains high levels of dissolved solids. Chloride ion, which is sometimes an indicator of the contamination by domestic sewage, is also high. The most important thing from the results of the analysis is the existence of the faecal coliforms. Standards for the drinking water set by the government require non-existence of faecal coliforms. Existence of faecal coliforms is an indicator of contamination by human and/or animal excreta. These shallow wells are considered to be contaminated by the nearby transhes or other sewage disposal systems.

Table IV-16 Results of Laboratory Analysis (Raw Sewage, Drain Water, Effluent of Treatment Plant)

Sampling Points	No.1	No.2	No.4	No.5	No.7	No.9	No.10	No.11	No.12	Ave. Drain	Ave. Raw Sewage
Temperature (°C)	26	26	25	25	26	26	27	26	26	26	26
pH	7.4	6.9	7.1	6.9	7.4	6.9	7.1	7.3	7.1	7.2	7.0
Suspended Solids (mg/l)	122	342	182	364	166	2622	206	112	1014	167	902
BOD_5 (mg/l)	350	500	355	610	440	900	420	340	680	372	626
COD-Mn (mg/l)	82	170	80	220	110	420	112	74	210	89	226
Alkalinity as $CaCO_3$ (mg/l)	576	580	388	704	564	760	692	388	728	489	667
Chloride (mg/l)	240	264	160	168	164	460	388	128	336	225	278
Ammonia Nitrogen (mg/l)	15	25	25	30	20	40	25	15	30	22	29
Total Phosphorus (mg/l)	10	12	4	18	9	22	10	2	10	5	14

Note; Raw sewage ...... 2. Zagazig city
5. Bilbeis city
7. Minyet El Qamh city
9. Abu Kebir city
12. Faqus city

Drain Water ...... 4. Bilbeis city (discharge point)
10. Faqus city (discharge point)
11. Faqus city (Bahr El Bakar Drain)

Effluent .... 1. Sewage treatment plant in Zagazig city

Table IV-17 Results of Laboratory Analysis (Well Water)

Sampling Points	No.3	No.13	No.14	Max.	Ave.	Min.
Temperature (°C)	23	22	22			
pH	7.5	7.1	7.4	7.9	7.5	7.2
Conductivity (S/cm)	1500	2900	700	15000	2245	900
Transparency (cm)	50	50	50			
Total Hardness (mg/l)	322	734	380	336	203	32
Suspended solid (mg/l)	ND	ND	ND			
Alkalinity as $CaCO_3$ (mg/l)	382	468	320	2204	308	73
Chloride (mg/l)	386	880	116	459	223	100
Ammonia Nitrogen (mg/l)	ND	ND	ND	1.6		ND
Total Nitrogen (mg/l)	ND	ND	ND			
Faecal Coliforms (MPN/100 ml)	62	114	42			

Note; 3. Zagazig city
13. Tahlet Bordien Village, Zagazig Markaz
14. Bany Korish Village, Minyet El Qamh Markaz

3. Second Analysis

The second water quality analysis has been conducted from 23rd to 31st January, 1988, at selected locations, representative for current conditions in the study area.

3.1 Sampling Points

(1) Drains

For the drain water survey, ten samples were collected from Bilbeis Drain and Bahr El Bakar Drain at four points, two in Bilbeis, one near Abu Hammad, and one in Faqus. A schematic diagram which indicates the relation of four sampling points is shown in Figure IV-8, and sketches of points are shown in Figures IV-9 through IV-12. These four points were selected to investigate two things, i) magnitude of pollution caused by wastewaters from contributing cities in the study area, and ii) assimilative capacity of the drain. Before the sampling, preparatory measurement of the flow velocity was carried out at sampling points in Bilbeis and time schedule of the sampling was decided.

(2) Raw Sewage

The raw sewage sampling were conducted at Nadi pumping station in Bilbeis and at Faqus pumping station to investigate the change in quality and quantity during a 24 hour period in an attempt to estimate per capita waste loadings. Consultations with the Governorate and Marakaz engineers were held for the selection of the sampling points and present conditions of the served area. In case of sampling at Nadi pumping station, ten samples were collected on 27th January, from 3:00 a.m. through 11:00 p.m. according to the pump operation. In case of Faqus puming station, another ten samples were collected on 31st January, from 6:00 a.m. through 6:00 p.m. according to the pump operation.

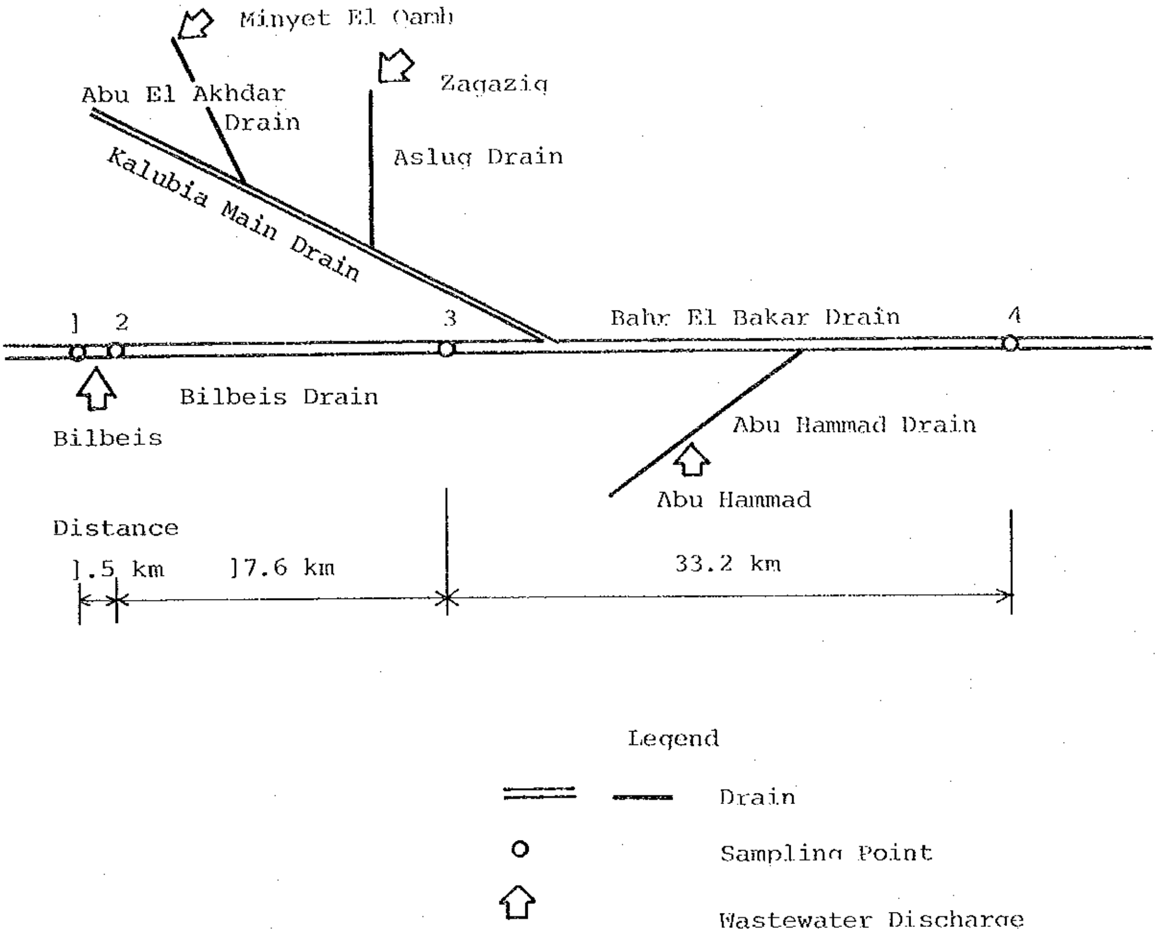


Figure IV-8 Schematic of Drain Sampling Points

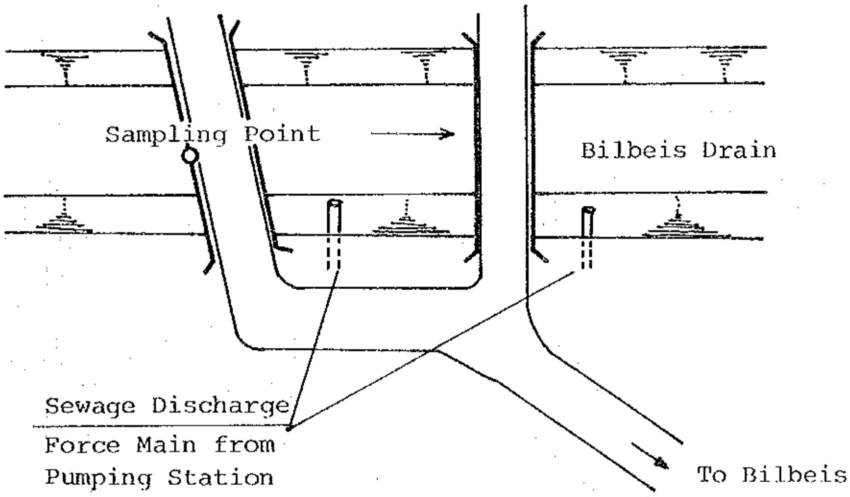


Figure IV-9 Sketch of No. 1 Sampling Point

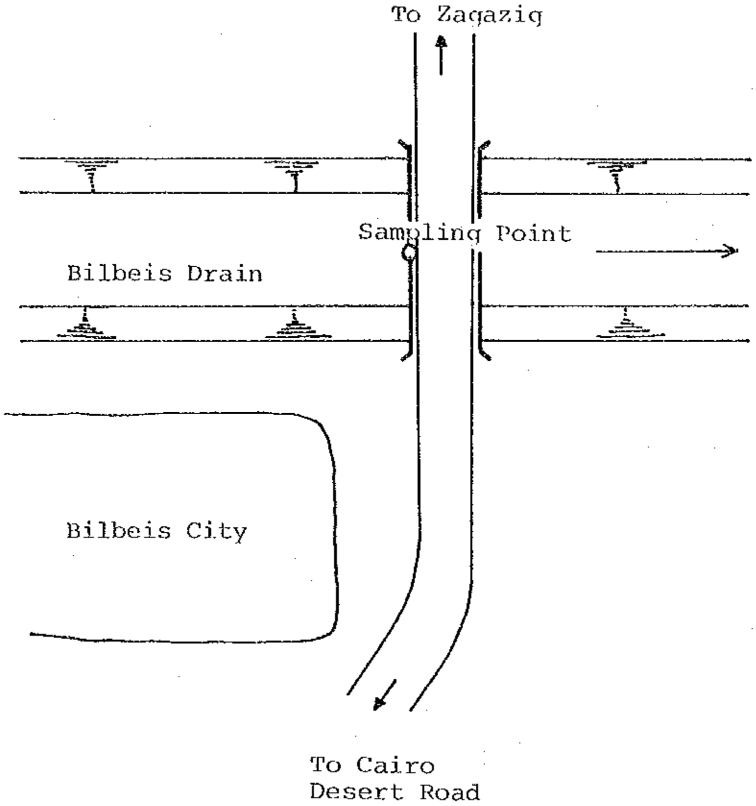


Figure IV-10 Sketch of No. 2 Sampling Point

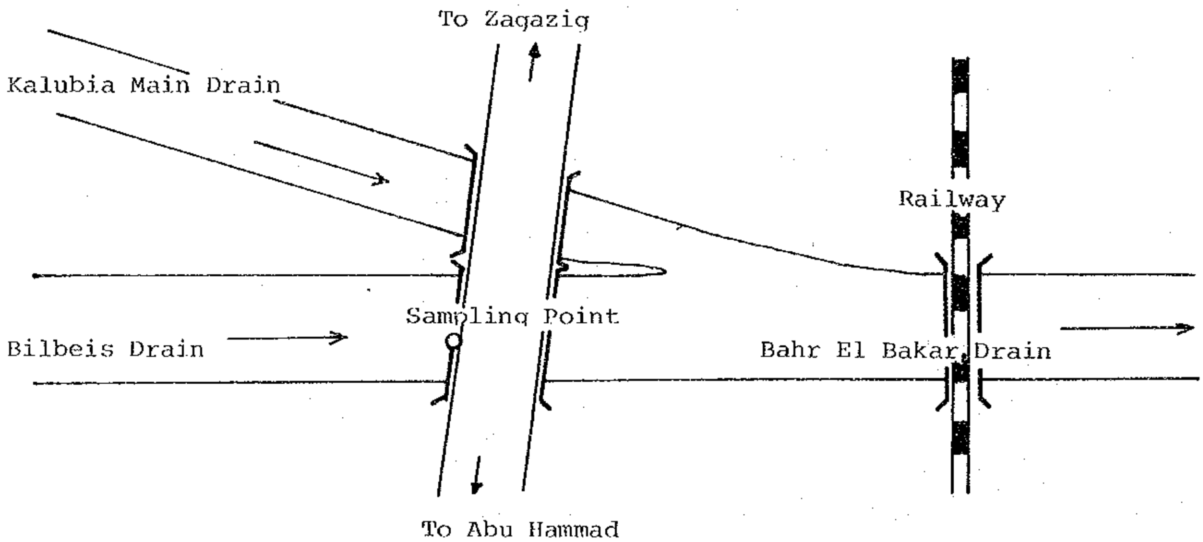
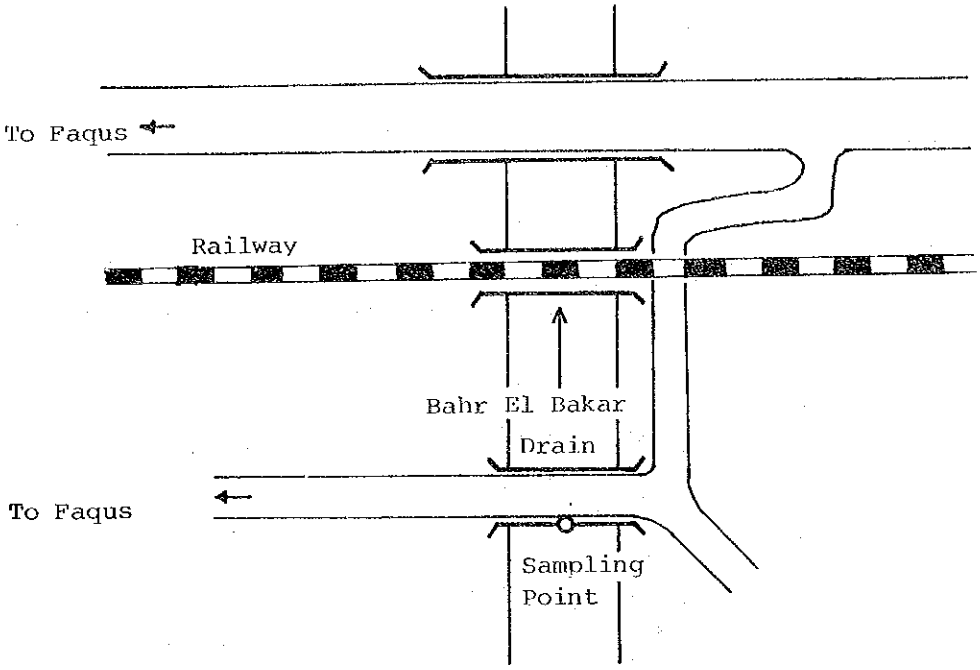


Figure IV-11 Sketch of No. 3 Sampling Point



Note: This point is same as No. 11 point of the first analysis.

Figure IV-12 Sketch of No. 4 Sampling Point

3.2 Water Quality Items Analysed

From a consideration of the results of the first water quality analysis, some items were omitted and some were added for the second analysis. Major items added are BOD and COD (permanganate) for the filtrated raw sewage. These two items were analysed in order to evaluate the concentrations caused by suspended solids for the purpose of establishment of the treatment design criteria.

Items analysed for drain water and raw sewage are described below. Among the quality items, temperature, pH, conductivity were analysed at the sampling points. Other items were analysed at the Central Laboratory of the Ministry of Health. The results of the analysis were obtained on 8th March.

3.2.1 Items for Drain Water

(1) Water Temperature (°C)
(2) pH
(3) Conductivity (S/cm)
(4) Chemical Oxygen Demand (COD-Mn) (mg/l)
(5) Biochemical Oxygen Demand (BOD) (mg/l)
(6) Suspended Solids (mg/l)

3.2.2 Items for Raw Sewage

(1) Water Temperature (°C)
(2) pH
(3) Conductivity (S/cm)
(4) Chemical Oxygen Demand (COD-Mn) (mg/l)
(5) COD-Mn (filtrated) (mg/l)
(6) Biochemical Oxygen Demand (BOD)(mg/l)
(7) BOD (filtrated) (mg/l)
(8) Suspended Solids (mg/l)
(9) Ammonia Nitrogen (NH_4-N) (mg/l)
(10) Nitrate Nitrogen (NO_3-N) (mg/l)
(11) Nitrite Nitrogen (NO_2-N) (mg/l)

3.3 Results of Analysis

Results of the analysis obtained from the Central Laboratory are presented in Table IV-18. General characteristics of the drain water and raw sewage deduced from the results are described below.

3.3.1 Drain Water

BOD concentrations of the drain water range from 100 mg/l to 400 mg/l, with an average value for eight samples of 193 mg/l. These figures indicate heavy organic pollution caused by wastewaters both from outside the upstream district and from the Governorate. Compared with raw sewage samples, BOD concentrations of the drain water are lower than those of raw sewage, however, these are almost of the same order of magnitude of those of the filtrated raw sewage. This means that most of the sewage waters is discharged into the drain without any effective treatment.

3.3.2 Raw Sewage

Hourly changes of BOD, COD and SS concentrations at two pumping stations are illustrated in Figures IV-13 and IV-14. As shown in the Figures, concentration of these items recorded their highest levels around 12:00 time, and generally, values are high during the day time when sewage flows are considered large. Average, lowest and highest concentrations of BOD, COD and SS in two cities are as follows.

		Average	Lowest	Highest
Bilbeis	BOD	500	370	660
	COD	183	140	275
	SS	509	374	1194
Faqus	BOD	376	340	440
	COD	88	62	132
	SS	297	112	594

Raw sewage strength determined from the above-mentioned quality items is higher in Bilbeis than in Faqus. However, the low figures recorded in Faqus, for example, average BOD of 376 mg/l and SS 297 mg/l, are still high compared to those of the other countries. This strong characteristics of raw sewage might be attributable to low water consumption and different life styles.

BOD and COD concentrations in filtrated samples are significantly lower in comparison of those in raw sewage. This indicates that a large quantity of BOD is attributed to solid materials and oil and grease. This will also results in a high removal ratio of organic materials by primary sedimentation. However, it should be noted that BOD and COD concentrations after filtration are still high which indicates the necessity for complete biological secondary treatment before discharge to drains.

Ammonia nitrogen concentrations range from 20 to 40, and 30 mg/l on an average in Bilbeis, and from 12 to 48, and 32 mg/l on an average in Faqus. Nitrate and nitrite nitrogen are not detected.

Table IV-18 Results of the Second Water Quality Analysis

A. Drain Water

No.	Point	Time	Date	Temp.	pH	Cond.	SS	COD	BOD
1	No.1	8:35	Jan. 23	15.0	7.4	720	280	104	400
2	No.2	8:20	Jan. 23	15.0	7.3	780	200	98	200
3*	No.7	10:40	Jan. 23				40	5	9.6
4*	No.8	11:10	Jan. 23				40	5	8
5	No.1	20:30	Jan. 23	14.0	7.6	750	120	78	120
6	No.2	22:00	Jan. 23	14.5	7.6	780	200	94	120
7	No.3	20:00	Jan. 23	13.0	7.6	820	80	62	200
8	No.3	10:00	Jan. 24	14.5	7.5	900	40	62	220
9	No.4	16:00	Jan. 24	14.5	7.5	840	40	52	100
10	No.4	8:00	Jan. 25	13.5	7.6	850	80	52	180

Note: * indicates canal water

B. Raw Sewage

B.1 Bilbeis, Sampling date: Jan. 27

No.	Time	Temp.	pH	Cond.	SS	NH_4-N	NO_2-N	NO_3-N	COD	COD(f)	BOD	BOD(f)
1	3:30	16.5	7.0	900	422	20	none	none	175	42	380	115
2	6:00	16.5	7.0	860	394	25	none	none	145	44	370	120
3	8:00	17.0	7.0	1200	406	40	none	none	190	62	560	185
4	10:00	17.5	7.1	1220	502	35	none	none	190	62	580	195
5	12:00	18.0	7.0	1220	1194	40	none	none	275	66	660	230
6	14:00	18.0	6.9	1180	512	35	none	none	220	62	600	195
7	16:00	17.5	7.0	1200	392	35	none	none	160	42	520	120
8	18:00	17.5	7.0	1200	508	30	none	none	190	52	560	190
9	20:00	18.0	7.0	1180	386	20	none	none	145	42	380	115
10	23:00	17.5	7.1	1100	374	25	none	none	140	44	390	115

B.2 Faqus, Sampling date: Jan. 31

No.	Time	Temp.	pH	Cond.	SS	NH_4-N	NO_2-N	NO_3-N	COD	COD(f)	BOD	BOD(f)
1	5:40	18.0	7.4	1400	120	12	none	none	62	16	340	110
2	7:15	18.0	7.6	1300	270	24	none	none	72	21	340	160
3	8:00	17.5	7.4	1400	260	40	none	none	96	26	380	200
4	9:00	17.0	7.6	1420	485	28	none	none	92	25	360	140
5	10:00	17.5	7.6	1420	440	48	none	none	132	39	360	170
6	12:00	18.0	7.4	1420	112	40	none	none	98	23	440	160
7	14:00	18.0	7.4	1460	594	24	none	none	106	17	440	120
8	16:00	18.0	7.4	1420	302	28	none	none	80	18	400	200
9	17:00	18.0	7.4	1360	118	40	none	none	82	16	340	150
10	18:00	17.5	7.5	1380	271	40	none	none	62	21	360	150

Note: Temperature is measured in °C, conductibity is in μS/cm, and other items are in mg/l.
(f) indicates filtered samples.

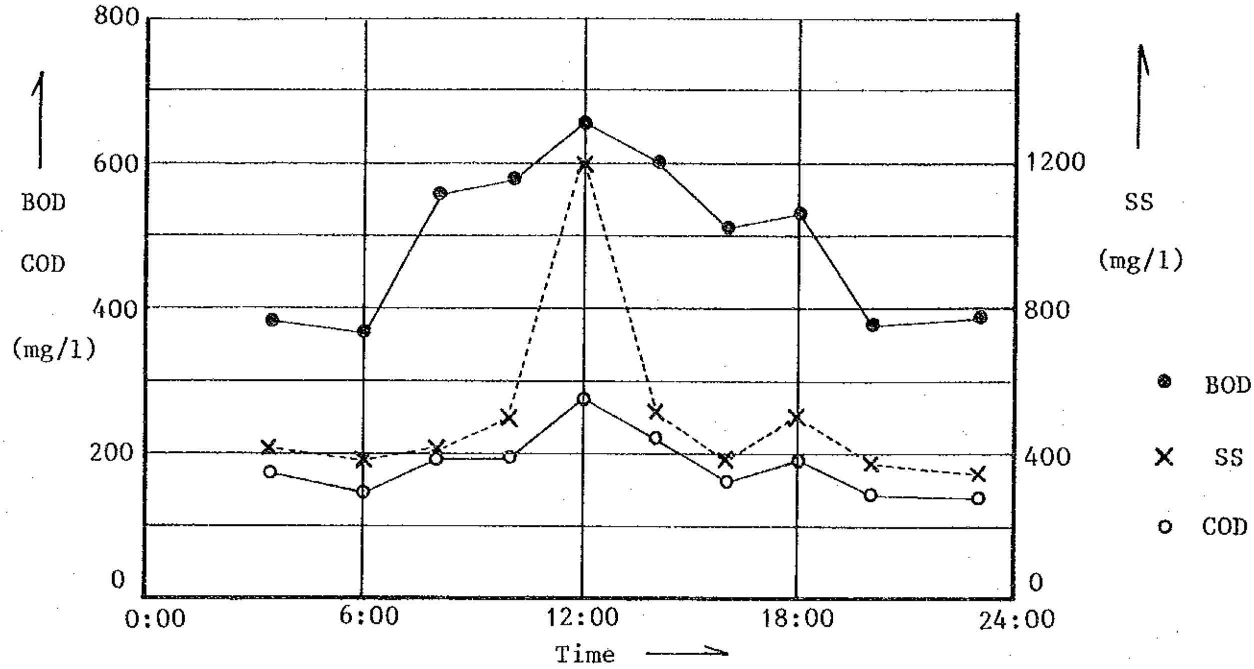


Figure IV-13 Hourly Changes of BOD, COD and SS in Raw Sewage, Bilbeis

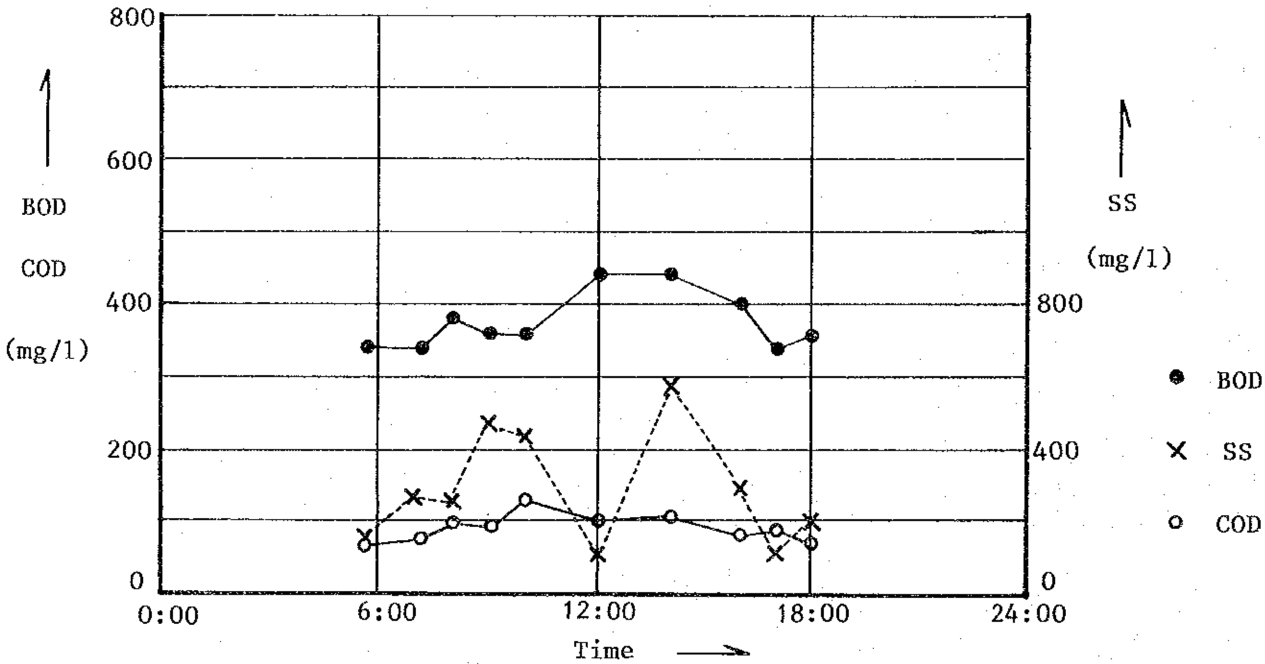


Figure IV-14 Hourly Changes of BOD, COD and SS in Raw Sewage, Faqus

4. Pollution in Drains

The results of the water quality analysis for drain indicate heavy pollution caused by organic loadings throughout the Governorate. However, taking into account the fact that the major drains in the Governorate originate in Greater Cairo and receive its wastewaters, most of the pollutants enter upstream, outside the Governorate. Although contribution by the wastewaters in the Governorate to the overall pollution of the drain can not be specified, it is apparent that the existing sanitation conditions is adding to already deteriorated condition of the drains.

Among the drains in the Governorate, Bahr El Bakar drain is the most heavily polluted. Water quality in the other drains are fairly in good condition, but pollution by the wastewaters from the urban areas and rural villages is apparently increasing.

5. Per-capita Waste Loadings

The characteristics of the raw sewage in the Governorate indicate that the sewages are predominantly of domestic origin. No major effect by industrial wastes or any other wastes is recognized, except for traces of waste oils and garbage disposal into the sewerage systems. The results are considered to give reasonable bases for planning. Raw sewage is readily treatable by conventional biological treatment processes. For comparison purpose, wastewater characteristics of the other Egyptian cities are shown in Table IV-19. There is no significant differences in water quality items, and it can be said that sewage in Sharqiya Governorate is similar in nature to those of other cities in Egypt.

In order to work out design parameters for sewage treatment facilities, per-capita waste loadings, such as BOD and SS are estimated by using the results of the analysis. Population served by the two pumping stations in Bilbeis and Faqus, and pumping capacities are obtained from Markaz offices and shown below.

(1) Bilbeis

Served population : 21,000

Pumping capacity : 30 l/sec

Pump operating hours: 21 hrs. on 27 Jan.

(2) Faqus

Served population : 12,100

Pumping capacity : 30 l/sec

Pump operating hours: 12.5 hrs. on 31 Jan.

Based on the above data and average concentrations, per-capita waste loadings are calculated as follows.

(1) Bilbeis

Per-capita sewage flow = (30x60x60x21)/21,000
= 108 lcd

Per-capita BOD loading = $108 \times 500 \times 10^{-3}$
= 54.0 gcd

Per-capita COD loading = $108 \times 183 \times 10^{-3}$
= 26.7 gcd

Per-capita SS loading = $108 \times 509 \times 10^{-3}$
= 55.0 gcd

(2) Faqus

Per-capita sewage flow = (30x60x60x12.5)/12,100
= 111 lcd

Per-capita BOD loading = $111 \times 376 \times 10^{-3}$
= 41.7 gcd

Per-capita COD loading = $111 \times 88 \times 10^{-3}$
= 9.8 gcd

Per-capita SS loading = $111 \times 297 \times 10^{-3}$
= 33.0 gcd

Per-capita sewage flows, 108 lcd in Bilbeis and 111 lcd in Faqus, are in good conformity with estimated per-capita sewage flow of 125 lcd, taking into account that sampling dates were in the winter season and water consumption was considered to be low. However, it should be noted that sewage leakage from manholes for canal crossing was observed on the sampling day in Faqus. Taking into consideration this above mentioned leakage together with the fact that groundwater levels are generally high in Faqus, per-capita loadings calculated by data obtained in Bilbeis are considered more reliable and representative for the Study.

Table IV-19 Raw Sewage Characteristics Obtained in Other Studies

Sampling Number	1	2	3	4	5
Temperature (°C)	30.0	26.5			
pH	7.6	8.0	7.9	7.5	7.7
Suspended solids (mg/l)	121	165	800	350	600
BOD_5 (mg/l)	375	225	550	200	325
COD-Cr (mg/l)	517	524			950
Alkalinity as $CaCO_3$ (mg/l)	281	198	400	225	300
Chloride (mg/l)	499	400			340
Kjeldahl Nitrogen (mg/l)	39.7	60.5	50	20	35
Ammonia Nitrogen (mg/l)	26	29	30	15	20
Nitrite Nitrogen (mg/l)	ND	ND			
Nitrate Nitrogen (mg/l)	12	22			
Total Phosphorus (mg/l)	8.6	11.0			14

Note; 1. raw sewage of a hotel at El Arish on 20th August, 1984,

2. raw sewage of a hotel at El Arish on 21st August, 1984, feasibity study on El Arish sewerage and drainage system

3. 4. 5. maximum, minimum, average value of raw wastewater characteristics for design of Abu Rawash Wastewater Treatment Plant, preliminary and final design report of Abu Rawash Wastewater Treatment Plant Project.

APPENDIX - V

WASTEWATER QUANTITIES AND CHARACTERISTICS

APPENDIX - V

WASTEWATER QUANTITIES AND CHARACTERISTICS

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1. Wastewater Production

1.1 General

Since wastewater flow records for the existing sewerage systems are not available to estimate the present and future wastewater production levels in the area, it is not possible to make a direct determination of the quantity of the sewage now being produced.

Estimates have been made, therefore, using the available data with regard to the water supply conditions in the urban and rural areas and the results of the field surveys conducted at selected locations. These were further reviewed and analysed taking into account the information obtained from various sources in the study area and information from other similar cities throughout Egypt.

The existing water supply systems in the Governorate are supplying a total of about 227,000 m^3/day water to roughly 76 percent of the Governorate's population in 1983. Based on the field surveys conducted under the water supply feasibility study project, the water consumption patterns have been identified in the following three categories and consumption in each category was estimated:

- Urban domestic
- Rural domestic
- Non-domestic
  - Commercial
  - Industrial
  - Institutional

1.2 Domestic Water Use

The present and future per capita water consumption rates estimated by the water supply feasibility study are tabulated in Tables V-1 and V-2.

As shown in the table, estimates are made based on the three different classes according to their income levels, as summarized in the following:

- Urban areas,
  - Class A : High income group
  - Class B : Medium income group
  - Class C1: Low income group
- Rural areas
  - Class C1: Same as urban consumer Class C1
  - Class C2: Lowest class with house connection users
  - Class D : Standpipe users, majority of rural served population.

1.3 Industrial Water Use

The main economic activities in the Sharqiya Governorate are related to agricultural production and some other small scale industries, such as spinning, carpet manufacturing, wood-works, textile, etc., using small quantities of water. Major industries existing in Sharqiya are shown in Table V-3.

As shown in the table, neither large scale water-consuming industries nor commercial development exist in the study area, and the major portion of the water consumption is by domestic uses, and a small portion by commercial, industrial and institutional consumption.

The water consumption survey made under the water supply feasibility study indicates that the industrial water consumption accounts for 10 percent of the domestic and commercial water consumption in Zagazig and Bilbeis cities, while in other cities such as Abu Kebir, Faqus and Minyet El Qamh, the industrial water consumption were estimated to reach the level of 10 percent of the domestic and commercial use from the year 1985 when their population exceeds 75,000. In cities where their population is less than 75,000 and rural areas, industrial consumption was negligible and was not accounted for.

Table V-1 Urban Domestic Consumer Populations by Classification and Per Capita Demands

Year	Class	Per Capita Consumption (lcd)	Population Percentage: Zagazig (%)	Population Percentage: Faqus, Bilbeis, Abu Kebir & Minyet El Qamh (%)	Population Percentage: Other Cities (%)
1985	A	185	16	8.0	-
	B	120	28	26.5	16.5
	Cl	90	56	65.5	83.5
	Average		(114 lcd)	(106 lcd)	(95 lcd)
1990	A	190	17	8.5	-
	B	125	30.5	27.5	17.5
	Cl	90	52.5	64.0	82.5
	Average		(118 lcd)	(108 lcd)	(96 lcd)
1995	A	195	19	9.5	-
	B	130	33	28.5	19
	Cl	90	48	62.0	81
	Average		(123 lcd)	(111 lcd)	(98 lcd)
2000	A	200	20	10	-
	B	140	35	30	20
	Cl	90	45	60	80
	Average		(130 lcd)	(116 lcd)	(100 lcd)
2005	A	205	20	10	-
	B	150	35	30	20
	Cl	90	45	60	80
	Average		(134 lcd)	(120 lcd)	(102 lcd)

[Source: Ref. No. 4]

Table V-2 Rural Domestic Consumer Populations by Classification and Per Capita Demands

Year	Class	Per Capita Consumption (lcd)	Population Percentage (%)
1985	C1	90	2
	C2	65	11
	D	48	87
	Average	51.2	
1990	C1	90	2
	C2	65	13
	D	55	85
	Average	57.6	
1995	C1	90	2
	C2	65	18
	D	55	80
	Average	58.5	
2000	C1	90	2
	C2	65	21
	D	55	77
	Average	59.0	
2005	C1	90	2
	C2	65	23
	D	55	75
	Average	59.4	

[Source: Ref. No. 4]

Table V-3 Numbers and Types of Industries in Sharqiya

Markaz	No. of Factories	Main Products
Zagazig	8	Textile, soap, rice milling, cooking oil, cattle feeds, soft drinks
Kafr Sagr	1	Carpet
Faqus	7	Spinning, ice
Abu Kebir	5	Fruits, canned juice
Abu Hammad	4	Fruit juice
Ibrahimiya	2	Food processing
Hihya	12	N.A.
Diarb Nigm	170*	Tile, iron, carpet, milk
Bilbeis	90*	Spinning, cattle feeds
Minyet El Qamh	9	N.A.
Mashtul El Soak	12	Jute
Qenayat	3	Wood works, carpet

Source: Ref. No. 4

Note: (*) The numbers include small scale commercial shops.
N.A. Data not available.

1.4 Commercial Water Use

The unit water consumption of such establishments as shops, hotels and restaurants was estimated to be 10 lcd for the population in the urban areas based on the water consumption surveys.

1.5 Institutional Water Use

Such establishments as governorate offices, educational institutions, railway stations, mosques, churches and hospitals fall under this category, but military facilities are excluded. The institutional water consumptions are estimated to account for 15 percent of the domestic and commercial consumptions for Zagazig City, and 10 percent for other cities (Ref. No. 4). No institutional water consumption was accounted in rural areas.

1.6 Total Water Use

Based on the above discussions, the per capita water consumptions for the five different areas, namely, i) Zagazig City, ii) Bilbeis City, iii) Abu Kebir, Faqus and Minyet El Qamh cities, iv) Other cities and v) rural areas have been estimated for the years 1990, 1995, 2000 and 2005. The results are tabulated in Tables V-4 through V-8.

1.7 Losses of Water

Wastewater flow quantities usually are little less than per capita water consumption quantities because water is lost through leakage, sprinkling, cooking, etc. Although definitive data to indicate the present conditions of water losses in the region are lacking, it can be reasonably assumed, based on data gained from other similar cities in Egypt, or other countries.

The water losses considered in the sewerage system planning in Egypt range from 0 to 15 percent (Ref. No.5, 10, 15, 16). In high population density built-up urban districts in the Governorate, houses are built of five or more stories with small open plots for utilities. As such, the water loss due to sprinkling is considered to be low.

In view of the above considerations, 10 percent losses are taken for sewerage planning purposes, except for particular cases which require some special considerations.

1.8 Overall Average Per Capita and Total Wastewater Flow Rates

Based on the studies and analysis mentioned above, the overall average per capita sewage flow rates for different stages have been calculated, by summing up the domestic, commercial, industrial and institutional water consumption, and deducting 10 percent from the consumption as losses. The average per capita sewage flow rates for five groups at different stages are shown in Tables V-4 through V-8. Daily sewerage wastewater flows calculated on the basis of the average per capita flow rates in urban and rural areas in each Markaz are shown in Table V-9. Total daily average wastewater flow in 1986 is estimated to be approximately 207,214 m^3/day for entire Governorate, which is estimated to increase to 375,304 m^3/day in 2005.

Table V-4 Average Per Capita Sewage Flow Rates in Zagazig City

(lcd)

Year	Domestic	Comm.	Indust.	Inst.	Total	Sewage Flow
1990	118	10	12.8	19.2	160.0	144.0
1995	123	10	13.3	20.0	166.3	150.0
2000	130	10	14.0	21.0	175.0	157.5
2005	134	10	14.4	21.6	180.0	162.0

Table V-5 Average Per Capita Sewage Flow Rates in Bilbeis, Faqus and Abu Kebir Cities

(lcd)

Year	Domestic	Comm.	Indust.	Inst.	Total	Sewage Flow
1990	108	10	11.8	11.8	141.6	127.4
1995	111	10	12.1	12.1	145.2	130.7
2000	116	10	12.6	12.6	151.2	136.1
2005	120	10	13.0	13.0	156.0	140.4

Table V-6 Average Per Capita Sewage Flow Rates in Minyet El Qamh City

(lcd)

Year	Domestic	Comm.	Indust.	Inst.	Total	Sewage Flow
1990	108	10	11.8	11.8	141.6	116.8
1995	111	10	12.1	12.1	145.2	119.8
2000	116	10	12.6	12.6	151.2	124.7
2005	120	10	13.0	13.0	156.0	140.4

Table V-7 Average Per Capita Sewage Flow Rates in Other Cities

(lcd)

Year	Domestic	Comm.	Indust.	Inst.	Total	Sewage Flow
1990	96	10	-	10.6	116.6	104.9
1995	98	10	-	10.8	118.8	106.9
2000	100	10	-	11.0	121.0	108.9
2005	102	10	-	11.2	123.2	110.9

Table V-8 Average Per Capita Sewage Flow Rates in Rural Areas

(lcd)

Year	Domestic	Comm.	Indust.	Inst.	Total	Sewage Flow
1990	57.6	-	-	-	57.6	51.8
1995	58.5	-	-	-	58.5	52.7
2000	59.0	-	-	-	59.0	53.1
2005	59.4	-	-	-	59.4	53.5

Table V-9 Daily Average Wastewater Flow Rates

(m3/day)

Markaz	Year	1986	1990	1995	2000	2005
Zagazig	U	34,370	38,592	44,550	51,824	58,644
	R	19,288	24,605	28,657	30,533	35,364
Huseiniya	U	2,011	2,100	2,461	2,834	3,219
	R	11,682	14,867	19,048	20,284	23,487
Kafr Saqr	U	2,181	2,310	2,782	3,270	3,885
	R	6,067	7,252	8,580	8,496	9,149
Faqus	U	6,026	6,318	7,320	8,625	10,920
	R	15,337	19,529	24,996	26,996	30,816
Abu Kebir	U	8,618	9,906	11,659	13,736	15,960
	R	6,767	8,288	10,182	10,461	11,663
Abu Hammad	U	2,746	2,940	3,531	4,142	4,884
	R	8,787	10,464	12,412	12,266	13,161
Ibrahimiya	U	2,769	2,940	3,531	4,142	4,884
	R	3,075	3,781	4,633	4,726	5,243
Hihya	U	3,311	3,465	4,066	4,687	5,439
	R	5,136	6,320	7,722	7,912	8,771
Diarb Nigm	U	3,639	3,885	4,708	5,668	6,771
	R	9,616	11,810	14,472	14,815	16,478
Bilbeis	U	12,063	14,224	17,423	21,216	25,620
	R	12,604	16,058	20,535	21,877	25,306
Minyet El Qamh	U	5,692	6,084	7,320	8,875	11,480
	R	15,725	19,270	23,624	24,214	26,911
Mashtul El Soak	U	3,243	3,360	3,852	4,469	5,106
	R	3,139	3,989	5,091	5,416	6,260
Qenayat	U	3,322	3,570	4,280	5,014	5,883
	R	-	-	-	-	-
Total	U	89,991	99,694	117,483	138,502	162,695
	R	117,223	146,233	179,952	187,656	212,609
Grand Total		207,214	245,927	297,435	326,158	375,304

1.9 Infiltration

Although the proposed sewer joints are water-tight types which will reduce the quantity of unwanted groundwater infiltration into the sewers, the sewer design flow rates must include an allowance for non-waste components which inevitably become a part of the total flow. The groundwater elevations of the region are in general high, which are, at many locations, as high as 60 cm below the ground surface.

Since no data are available in the existing sewerage system for the infiltration rates, an effort was made to obtain data regarding infiltrations from existing sewerage systems in Egypt that may represent conditions similar to those in the study area. Table V-10 shows cities in Egypt. As can be seen from the table, the allowances in the cities range widely from 0 to 20 m^3/ha/day. However, it may be reasonable to assume that the sewerage systems in Sharqiya represent the typical condition in the Delta, and for the planning purpose, an average infiltration of 10 m^3/ha/day is determined.

1.10 Design Flow Rates

From the foregoing reviews and discussions, design wastewater flow rates for the sewerage system in the region have been determined. For sewer hydraulic computations, the infiltration allowances should be included, according to the sewerage districts to be served.

In general, there are two flow rates to the design of any sewerage facilities, the peak flow and the maximum daily flow (or other suitable flow). The peak flow is the absolute maximum flow rate anticipated for the facilities regardless of its duration. The maximum daily flow is a measure of the highest average rate of flow for that specified time period the sewage treatment plant must treat.

The water supply feasibility study estimated the daily maximum demands as 1.25 times the daily average demand which includes water consumption and system losses. System losses were considered 30 to 40 percent of the total water demand at present and projected to decrease to 18 to 25 percent by 2005. If system losses are assumed constant regardless of the water consumption, maximum daily consumption is calculated to be 1.26 to 1.33 times the daily average consumption.

NOPWASD used monthly maximum sewage flow in the design of the new Zagazig sewage treatment plant, which was considered to occur during summer months and 1.4 times the daily average sewage flow, not including infiltration. Infiltration was assumed to be constant. NOPWASD also estimated monthly minimum sewage flow, which occur in winter months as 0.7 times the daily average flow.

Taking into account the above, daily maximum sewage flow to be used for the design of the treatment plants is determined to be 1.4 times the daily average wastewater flow. Peak flow for the design of pipes, conduits, and pumps is determined to be 2.0 times the daily average flow. Design flow rates, which are daily maximum and peak flow plus infiltration, in 2005 by cities are shown in Table V-11.

Table V-10 Design Groundwater Infiltration in Sewerage Systems in Egypt

City		Infiltration Allowances	
1.	El Arish	Sewers mostly above groundwater elevations	2 percent of total daily average sewage.
		Sewers in low-lying areas	- 8 m^3/ha/day
2.	Port Said	Existing developed areas	- 12 m^3/ha/day
3.	Ismailia	New areas	- 8 m^3/ha/day
4.	Suez	General areas	- 10 m^3/ha/day
		Low-lying areas adjacent to canal water	- 12 m^3/ha/day
5.	Alexandria		- 0.1 l/ha/sec (8.64m^3/ha/day)
6.	Helwan	$Q = a.d.h^{2/3}$, where Q = flow per 1,000 m a = constant (5 to 10) d = exterior dia. of pipe in inch h = average depth of pipe below groundwater surface.	
7.	Cairo	Residential and commercial areas	
		For all sewers with invert levles above elevation 25 m A.O.D.	- Nil -
		For sewers with invert levels of elevation 25 m, A.O.D. or less existing prior to 1980 or to be constructed without flexible joints.	- 20 m^3/ha/day
		For sewers with invert levels of elevation 25 m, A.O.D. or less to be constructed with flexible joints.	- 10 m^3/ha/day

Source: 1) Ref. No. 5 2) Ref. No. 17 3) Ref. No. 16 4) Ref. No. 15
5) Ref. No. 19 6) Ref. No. 18 7) Ref. No.

Table V-11 Design Flow Rates in 2005

(m3/day)

City	(1) Daily average	(2) Daily maximum 1.4x(1)	(3) Peak flow 2.0 x (1)	(4) Infiltration	(5) Design flow for treatment (2) + (4)	(6) Design flow for pipes (3) + (4)
Zagazig	58,644	82,102	117,288	27,260	109,362	144,548
Huseiniya	3,216	4,502	6,432	2,530	7,032	8,962
Kafr Saqr	3,882	5,435	7,764	2,480	7,915	10,244
Faqus	10,951	15,331	21,902	5,150	20,481	27,052
Abu Kebir	16,006	22,408	32,012	4,440	26,848	36,452
Abu Hammad	4,880	6,832	9,760	3,100	9,932	12,860
Ibrahimiya	4,880	6,832	9,760	1,700	8,532	11,460
Hihya	5,434	7,608	10,868	2,650	10,258	13,518
Diarb Nigm	6,765	9,471	13,530	2,590	12,061	16,120
Bilbeis	27,097	37,936	54,194	6,670	44,606	60,864
Minyet El Qamh	11,513	16,118	23,026	3,000	19,118	26,026
Mashtul El Soak	5,101	7,141	10,202	2,540	9,681	12,742
Qenayat	5,878	8,229	11,756	2,280	10,509	14,036
Total	162,843	227,979	325,686	66,390	294,369	392,076

2. Wastewater Characteristics

2.1 Water Quality Survey Results

Water quality surveys were conducted during the course of the first and the second on-site survey periods for the long term and the first phase programs (refer to Appendix IV, Water Quality Survey). Results of the water quality analysis of raw sewage and treated effluent characteristics are shown in Table V-12. Five raw sewage grab samples from five major cities, namely Zagazig, Bilbeis, Minyet El Qamh, Abu Kebir and Faqus, were analysed during the first on-site survey. Ten samples, each covering 24 hours, were taken at two pumping stations, one in Bilbeis and another in Faqus, during the second on-site survey.

Biochemical oxygen demand (BOD) concentrations range from 350 to 900 mg/l, and 501 mg/l on an average. These are considered normal figures of raw sewage which is predominantly of domestic origin. Suspended solids (SS) concentrations range from 166 to 2,622 mg/l, and 426 mg/l on average. These figures are very high, although SS concentrations in the raw sewage in Egypt is, in general, higher than those in the other countries. SS concentration of 2,622 mg/l recorded in Abu Kebir City is extraordinary high taking into consideration the results of the other quality items. Therefore, this high figure is disregarded in calculating the average. For the development of the design basis, it is considered appropriate to use the results of the analyses, putting emphasis on the second survey.

Ammonia nitrogen (NH_4-N) and total phosphorus concentrations range from 20 to 40 mg/l, and from 9 to 22 mg/l, respectively. Ammonia nitrogen concentrations are considered typical figures of domestic sewage, while total phosphorus concentrations are relatively high as domestic sewage, but still in the normal range.

In general, results of the analysis indicate that raw sewage is predominantly of domestic origin and suitable for the conventional biological treatment.

The results of the analysis obtained from one effluent sample indicate the effects of the treatment. Comparing the figures for raw sewage and effluent, reduction is noticeable in such items as BOD, SS, NH_4-N, and COD. These reductions are considered as effects of sedimentation and biological treatment. However, as can be seen in the effluent BOD concentration, biological treatment does not function properly as designed. Usually after secondary treatment by oxidation ditch and trickling filter, BOD concentration is reduced to about 30 mg/l or less. Also, SS concentration of 122 mg/l is considered high as secondary treated effluent. From any viewpoint, the existing treatment can not be said to be operating effectively. Malfunctioning of the plant is mainly due to the overloading and aging mechanical equipment.

2.2 BOD Loading

Per-capita waste loadings are evaluated based on the results from the second analysis (see Appendix IV). Per-capita BOD loading of 54.0 gcd obtained from Bilbeis is considered the most representative figure for the study area, for the reasons mentioned in Appendix IV.

If annual increment of per capita BOD loading due to upgrading of living standards and so on up to the year 2005 is assumed to be 1 gcd, per capita BOD loading will increase to 72.0 gcd in 2005. With a total population of 183,000 and a total daily average wastewater flow of 32,363 m^3/day including infiltration in Bilbeis in 2005, average BOD concentration of the influent is estimated as follows:

BOD concentration = 183,000 x 72.0 / 32,363 = 407 mg/l

Making some allowances for extra loadings due to non-domestic wastewaters, design BOD concentration is determined to be 450 mg/l.

Table V-12 Wastewater Quality

Item	First Analysis							Second Analysis**		
	Zagazig		Bilbeis	Minyet El Qamh	Abu Kebir	Faqus	Average Raw Sewege	Bilbeis	Faqus	Average 1st and 2nd Analyses
	effl.*	raw								
pH	7.4	6.9	6.9	7.4	6.9	7.1	7.0	7.0	7.5	7.2
Temperature (°C)	26	26	25	26	26	26	26	17.4	17.8	
Dissolved Solids	1,140	1,189	1,016	694	1,788	1,428	1,223	n.a.	n.a.	
Suspended Solids	122	342	364	166	2,622	1,014	902 (472)	509	297	426
NH_4-N	15	25	30	20	40	30	29	30	32	30
NO_2-N	-	-	-	-	-	-	-	-	-	-
NO_3-N	-	-	-	-	-	-	-	-	-	-
BOD	350	500	610	440	900	680	626	500	376	501
COD-Mn	82	170	220	110	420	210	226	183	88	166
Cl^-	240	264	168	164	460	336	278	n.a.	n.a.	
Total Alkalinity	576	580	704	564	760	728	667	n.a.	n.a.	
Total-P	10	12	18	9	22	10	14	n.a.	n.a.	

Note: Units are mg/l unless otherwise indicated.

( ) in Suspended Solids indicates average of 5 samples except for 2,622 mg/l.

* is effluent from sewage treatement plant.

** Figures are average of ten samples taken during 24 hours.

n.a. means not analysed.

2.3 Design Parameters

Other necessary design parameters are estimated based on the proportions to BOD concentration obtained from water quality analysis. These are shown in Table V-13.

Table V-13 Design Parameters

BOD	450 mg/l
SS	460 mg/l
COD	170 mg/l
NH_4-N	30 mg/l
Total-P	13 mg/l

APPENDIX - VI

ZAGAZIG SEWAGE TREATMENT PLANT (BY NOPWASD)

APPENDIX - VI

ZAGAZIG SEWAGE TREATMENT PLANTS

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1. Existing Treatment Plant

The original sewage treatment plant in Zagazig was constructed in the 1930's, consisting of the following component facilities:

1) Primary sedimentation tanks

   Three units of rectangular sedimentation tanks with the Meader type sludge collectors. 37.0m (l) x 10.0m (w) x 4.5m (d).

2) Oxidation ditches

   Two units of oxidation ditch, with paddle aerators and final sedimentation tanks. 48.0m (l) x 18.0m (w)

3) Trickling filters

   Four units of trickling filter. Dimensions not available.

4) Sludge drying beds

   Three units of sludge drying beds. No details are available.

Figure VI-1 shows the location of the sewage treatment plant. Figures VI-2 through VI-6 show some details of the component facilities of the original sewage treatment plant.

2. New Treatment Plant

Since the original sewage treatment plant facilities have become obsolete and overloaded, a new sewage treatment plant was planned and designed by NOPWASD, and the facilities are now under construction at the site close to the original sewage treatment plant.
Design basis for the new treatment plant is as follows:

1) Design flow rates

For 2010 (Second stage)	121,275 m^3/day
For 2030 (Third stage)	195,750 m^3/day

2) Design populations

For 2010	385,000
For 2030	522,000

3) Loadings

BOD	Influent (raw sewage)	460 mg/l
	Effluent	40 mg/l
SS	Influent (raw sewage)	450 mg/l
	Effluent	50 mg/l

4) Efficiencies

BOD in primary sedimentation tanks	25 to 35%
SS in primary sedimentation tanks	50 to 70%
BOD in final sedimentation tanks	75 to 95%
SS in final sedimentation tanks	80 to 95%

5) Detention time in primary sedimentation tank — 2 hours

6) Aeration time — 5.8 hours

7) Detention time in final sedimentation tanks — 2 hours

8) Overflow Rates

Primary sedimentation tanks	36.38 m^3/m^2/day
Final sedimentation tanks	34.11 m^3/m^2/day

9) Weir loadings

Primary sedimentation tanks	318.31 m^3/m/day
Final sedimentation tanks	298.40 m^3/m/day

10)	BOD in aeration tanks	345 mg/l
11)	Sludge quantity produced (P.S.T, + F.S.T.)	700 m^3/day
12)	Moisture contents of sludge from P.S.T. and F.S.T.	99 %
13)	Sludge drying time on beds	5 days
14)	Moisture contents of sludge	
	Wet sludge	95 %
	Dried sludge	60 %

Layout plan and hydraulic profile of the new sewage treatment are shown in Figures VI-7 and VI-8.

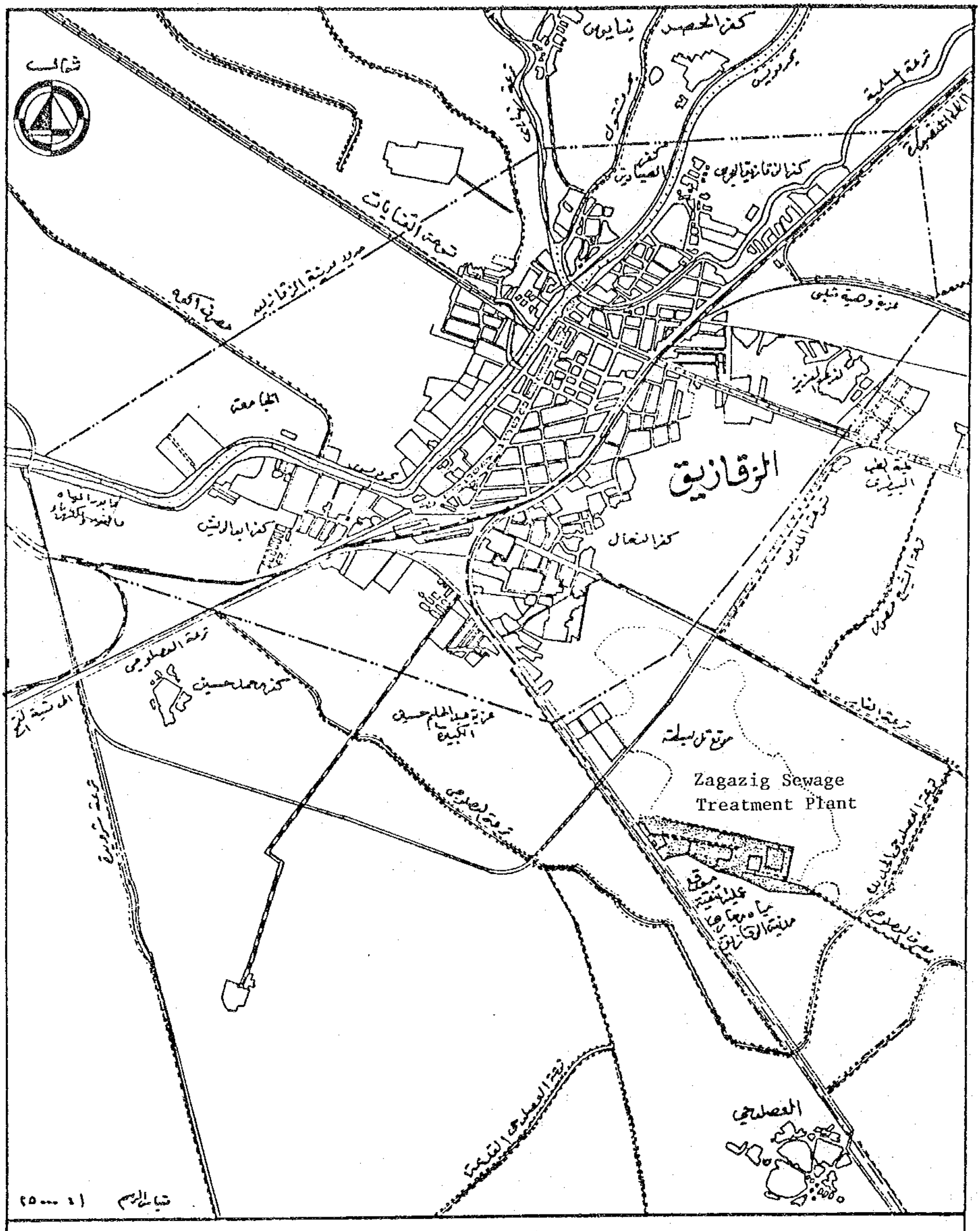

Figure VI-1 Location of Zagazig Sewage Treatment Plant

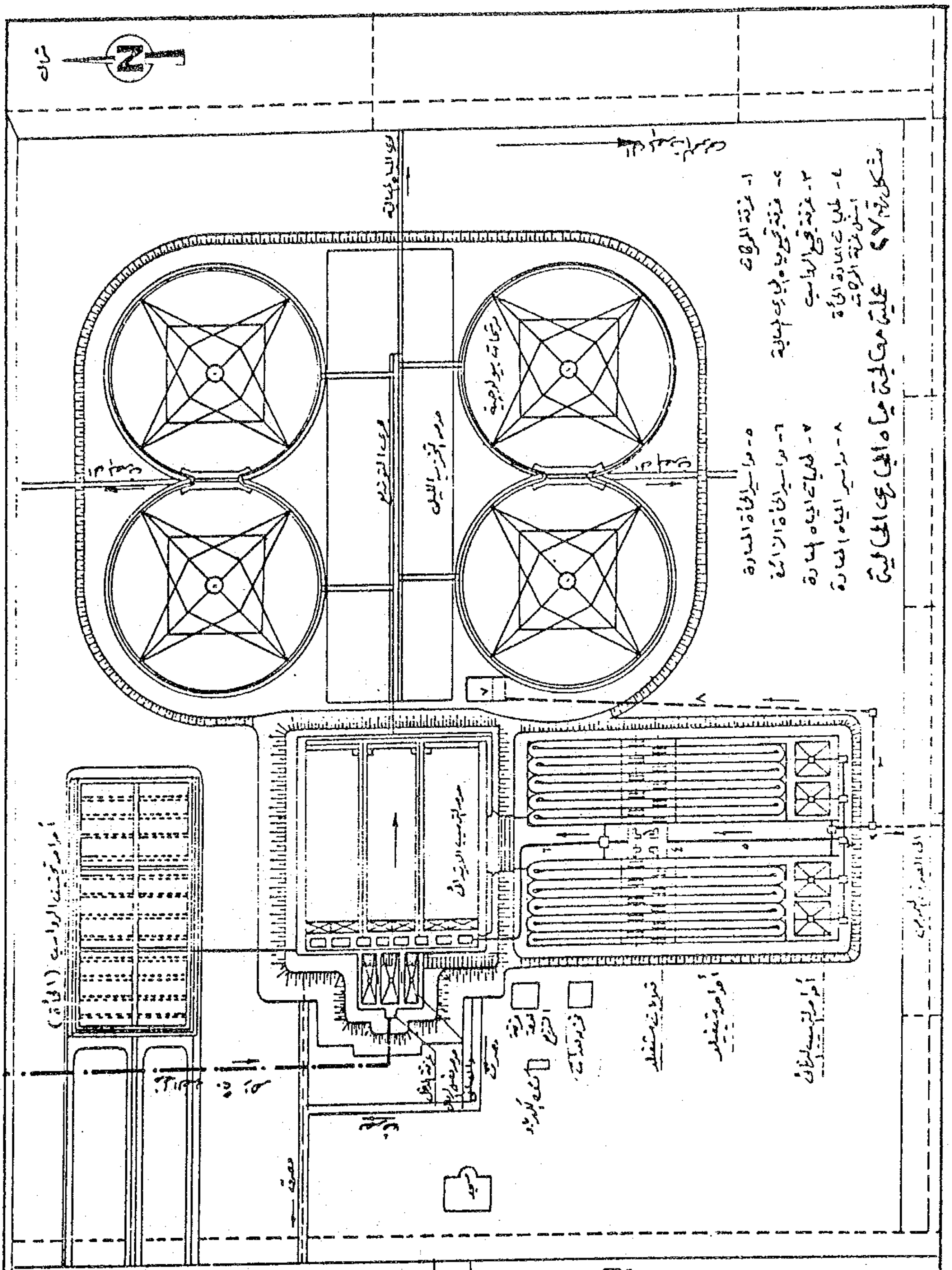

Figure VI-2 Layout of Old Sewage Treatment Plant Facilities

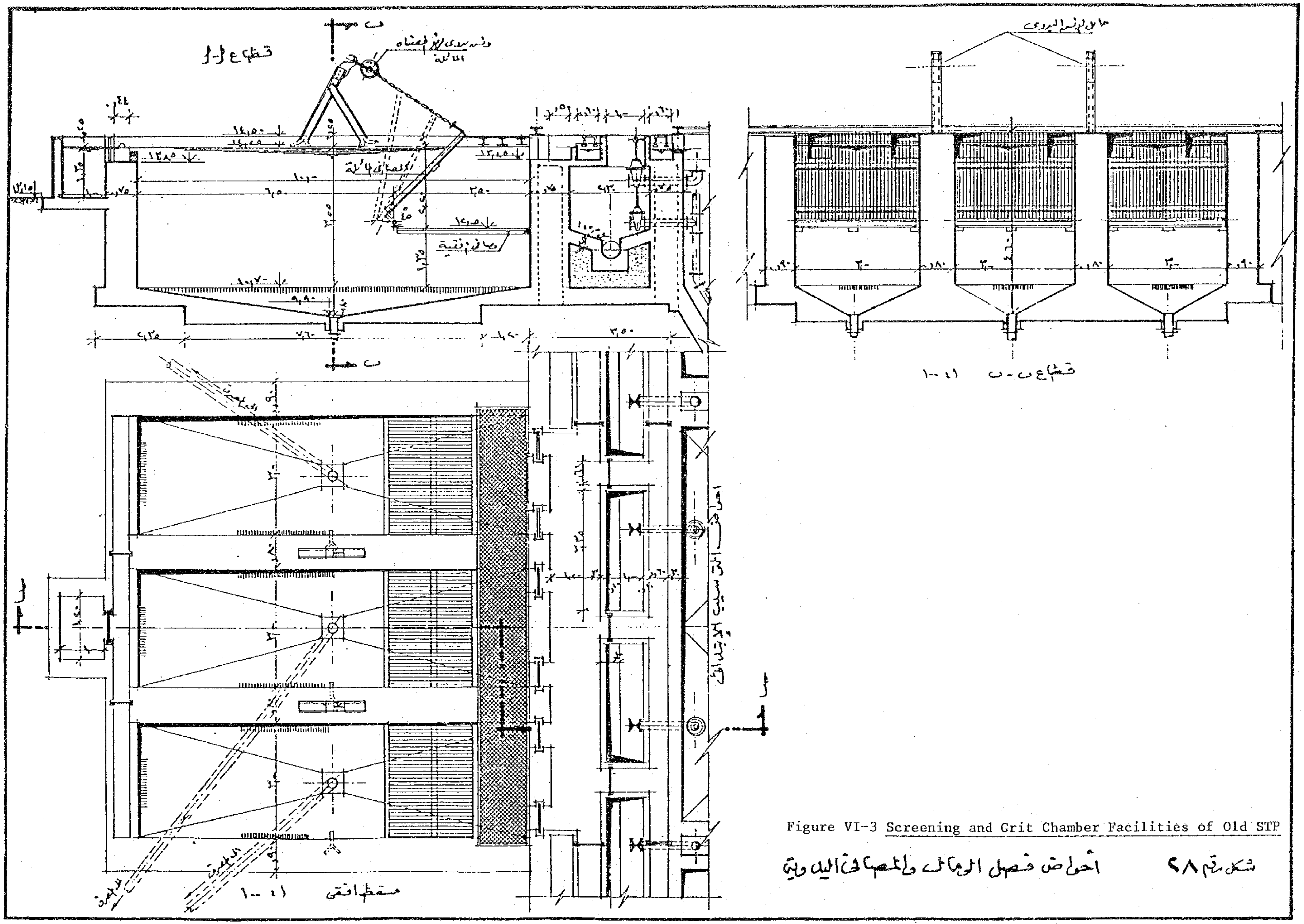

Figure VI-3 Screening and Grit Chamber Facilities of Old STP

شكل رقم ٢٨ أحواض فصل الرمال والمصافي الميكانيكية

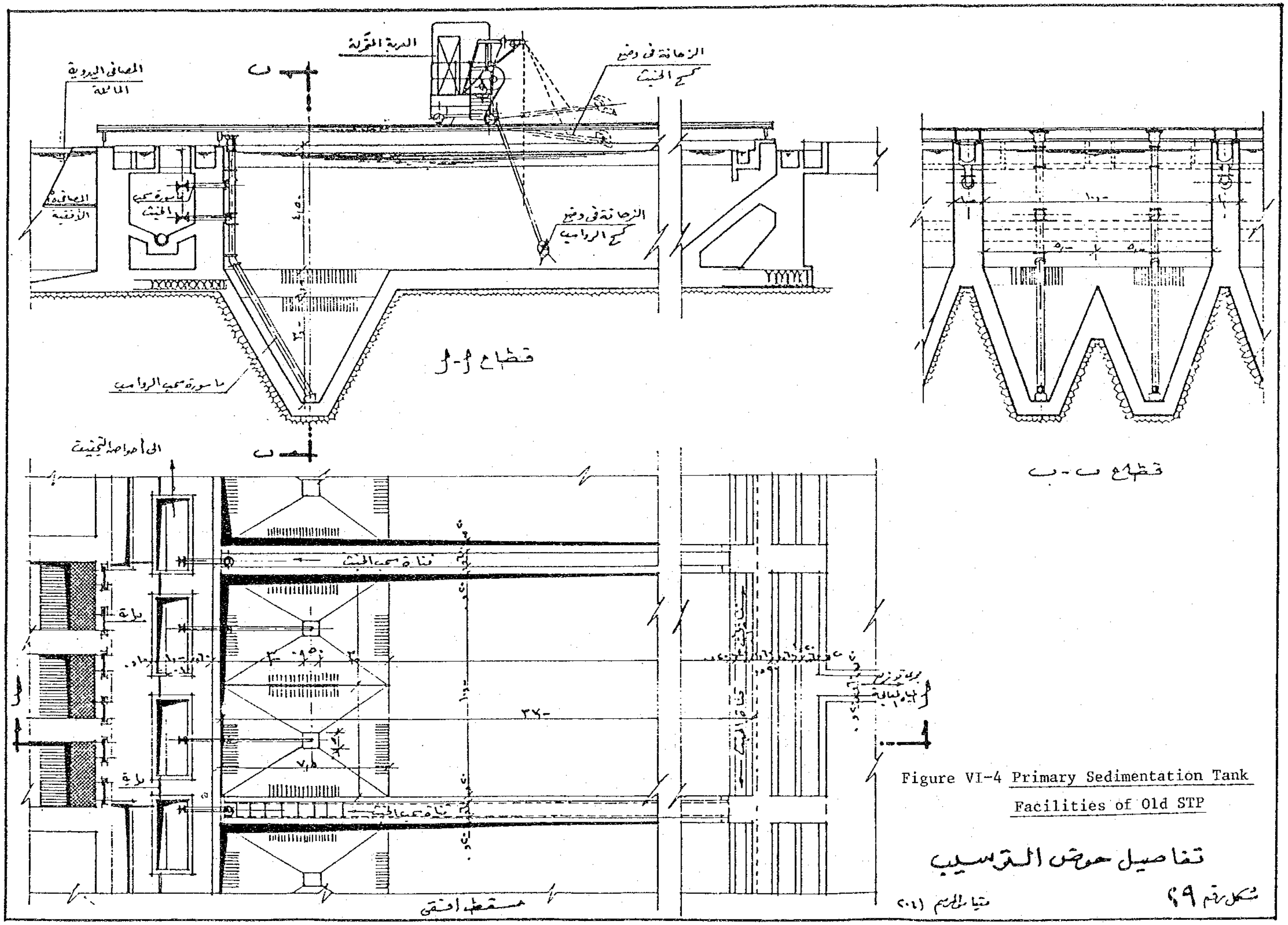

Figure VI-4 Primary Sedimentation Tank Facilities of Old STP

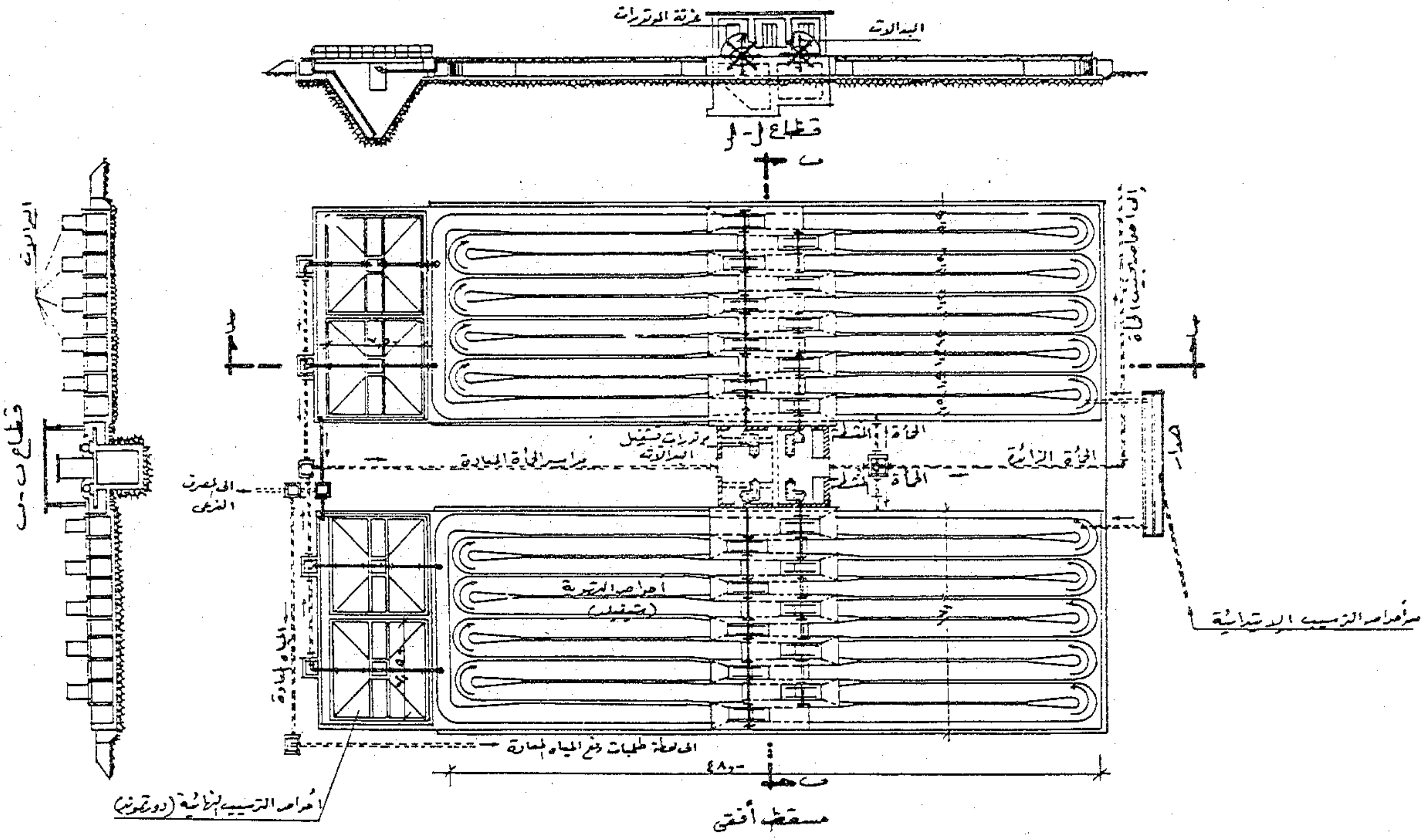

Figure VI-5 Aeration Tank Facilities of Old STP

شكل رقم ٣٠ أحواض التهوية (طريقة شيفيلد) وأحواض الترسيب النهائية "دورتموند"

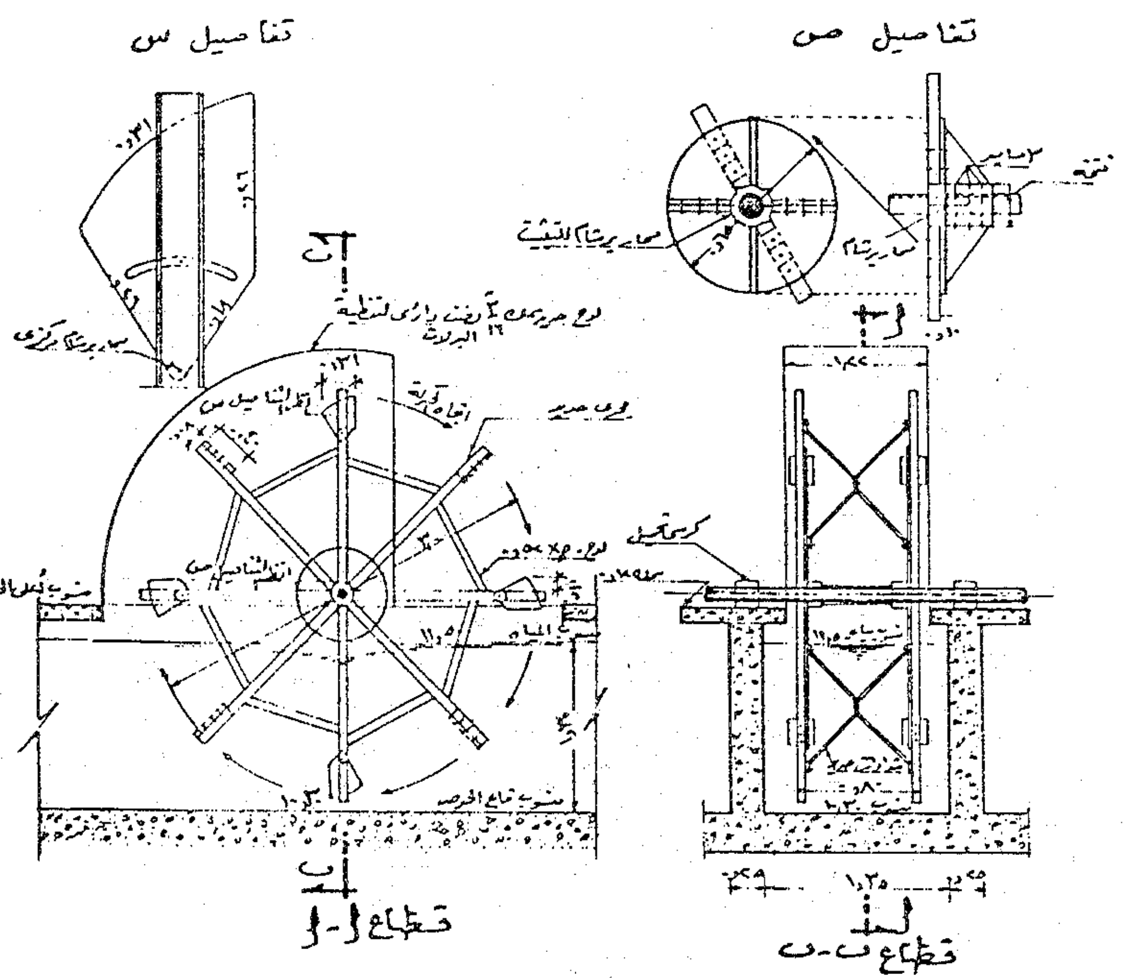

Figure VI-6 Details of Paddle Aerator, Old STP

تفاصيل البدالات "مشيفيل"   شكل رقم ٣١

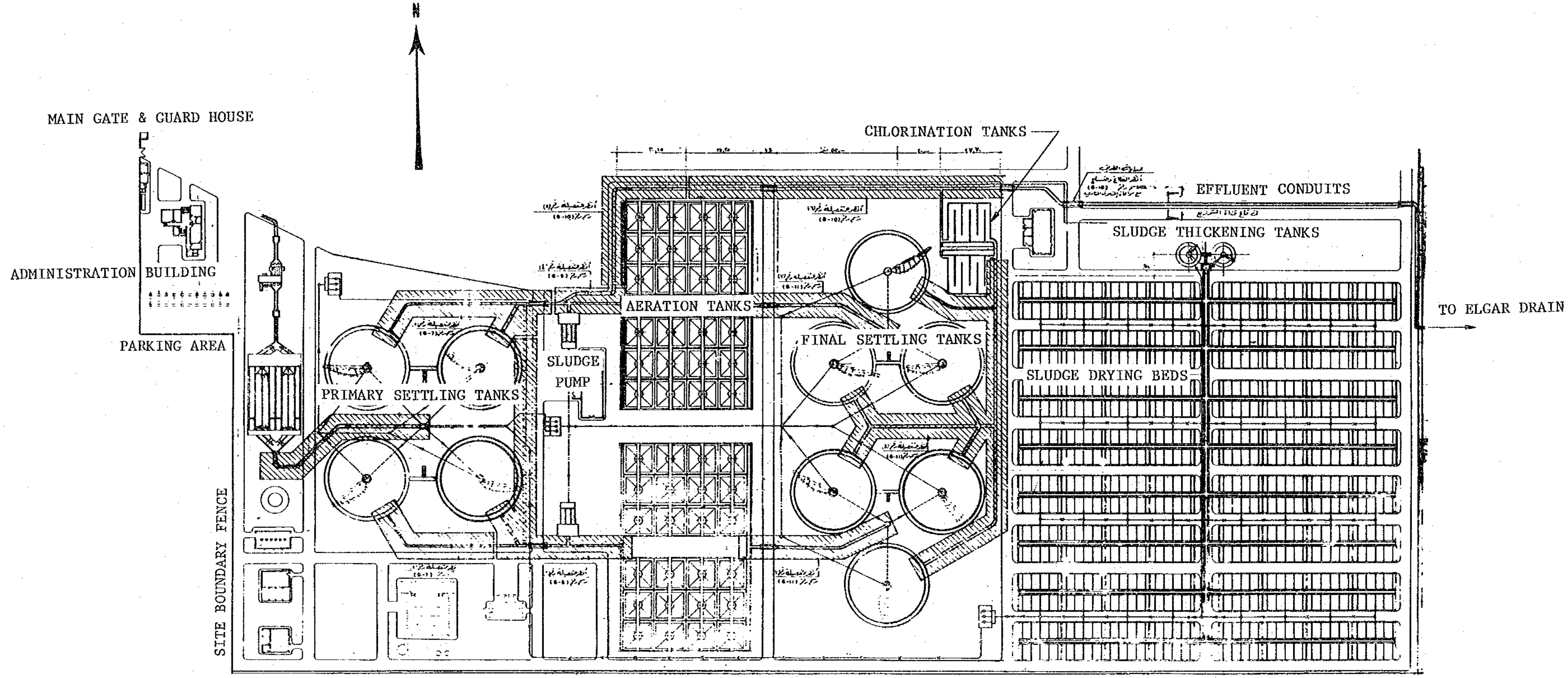

Figure VI-7 Layout of New Treatment Plant Facilities

FEASIBILITY STUDY ON SHARQIYA SEWERAGE SYSTEM	DATE SEP. 1986	JICA
ZAGAZIG NEW STP GENERAL LAYOUT PLAN	SCALE 1 1,000	DRAWING NO.

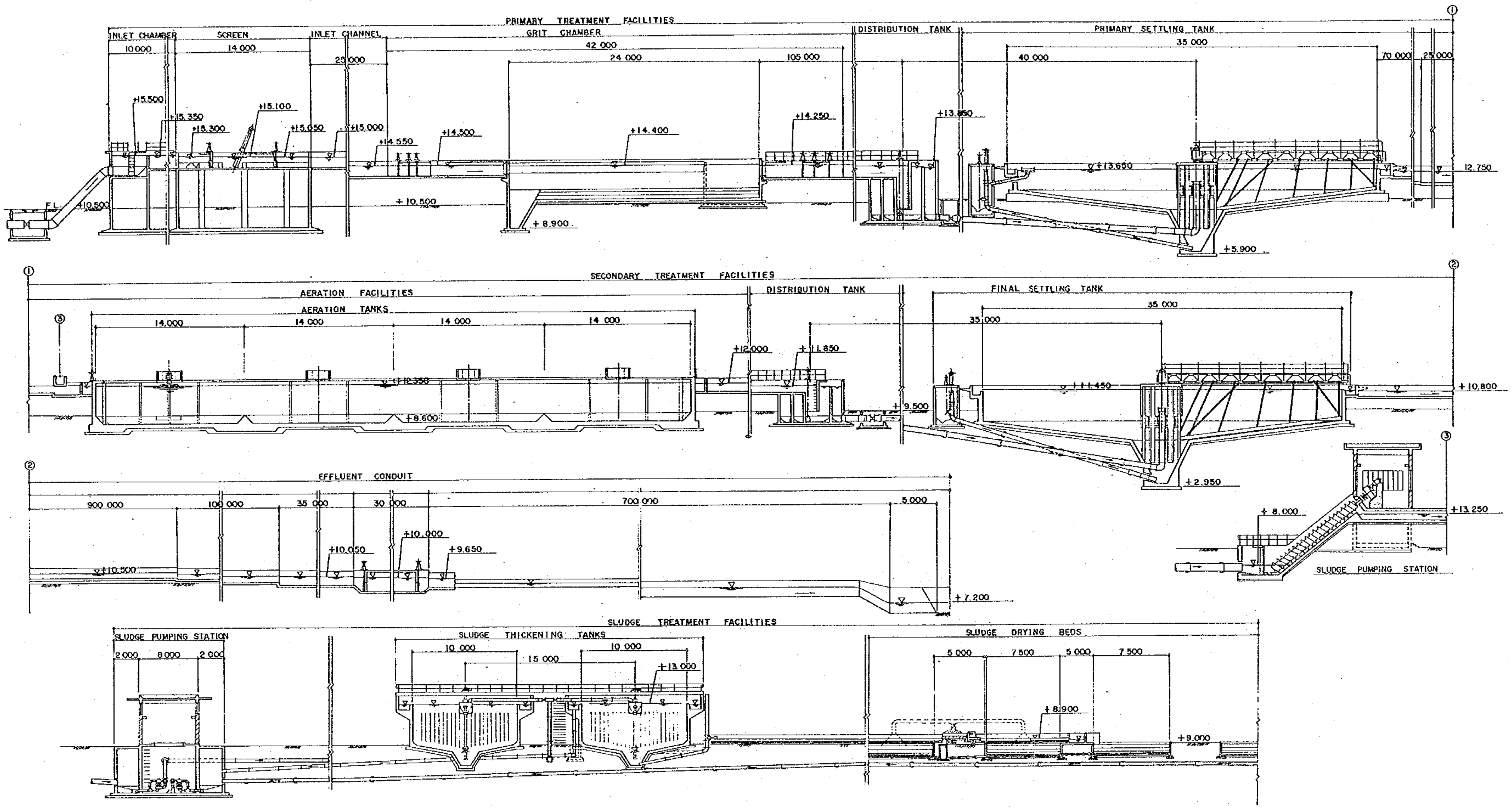

Figure VI-8 Hydraulic Profile of New Treatment Plant

FEASIBILITY STUDY ON SHARQIYA SEWERAGE SYSTEM	DATE: SEP. 1988	JICA
ZAGAZIG NEW STP HYDRAULIC PROFILE	SCALE: 1 : 200	DRAWING NO. II - 21

APPENDIX - VII

COST ESTIMATES

APPENDIX - VII

COST ESTIMATES

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1. Basic Labor and Material Costs

Specifications and costs of the materials used for the sewerage system are shown in this appendix. Most of the construction materials for the system facilities are locally available except for some parts of the sewage treatment plant and the pumping station. Major materials to be used for the sewerage facilities are listed with the necessary costs.

Construction and operation cost of the sewerage system are estimated on the current labor and material costs prevailing in the region. All costs are indicated at the mid-1987 price level. Construction costs of the project may be defined as the sum of all expenditures required to complete the project. These expenditures are divided into direct and indirect items. The direct items include excavation of trenches, laying and construction of sewers, and all the related construction works. Indirect items include office and administrative overhead, engineering and supervision.

In estimating the construction costs of the facilities, first the unit costs for laborers, materials, electricity, equipment and transportation were established, and then the construction costs for component works such as concrete works, excavations, masonry works, etc., were estimated. Unit costs were mostly obtained from the housing Department of Sharqiya Governorate.

Laborers required for the sewerage construction such as common workers, skilled operators for heavy equipment etc., are summarized in Table VII-1. Material costs, unit construction costs for component works, price list of clay pipes, specifications and price list of PVC pipes are shown in Table VII-2 through VII-6.

Table VII-1 Labor Costs in Sharqiya Governorate

Type of Labor	Unit	Cost (LE)
Common worker	day	6
Concrete mixer operator	day	10
Steel worker	day	12
Carpenter	day	12
Brick builder	day	20
Plumber	day	20
Operator (power shovel, bulldozer, etc.)	day	15
Electric worker	day	15
Welder	day	15
Plasterer	day	10
Site engineer	day	15
Site manager	day	25
Office boy	day	6
Driver	day	10
Typist	day	8
Foreman	day	10

Table VII-2 Costs of Basic Materials

Item	Unit	Price (LE)
Sand	m^3	3
Sand for concrete	m^3	5
Gravel	m^3	10
Gravel for concrete	m^3	13
Crushed stone	m^3	8
Cement type I	m^3	38
Cement type IV	m^3	75
Timber	m^3	300
Wood plank	m^3	500
Plywood (t = 12 mm)	m^3	500
Round steel bar	t	520
Deformed steel bar	t	550
Reinforced concrete pipe 900 mm dia.	m	37
Ductile iron pipe 100 mm dia.	m	18
Ductile iron pipe 500 mm dia.	m	159

Table VII-3 Unit Construction Costs for Component Works

Item	Unit	Price (LE)
Excavation soil	m^3	4
Backfilling	m^3	2
Banking	m^3	8
Soil disposal	m^3	5
Sheeting by timber up to 3 m deep	m^2	8
Sheeting by timber deeper than 3 m	m^2	12
Lean concrete	m^3	50
Plain structural concrete	m^3	70
Reinforced concrete	m^3	150
Form work substructure	m^2	15
Form work super structure	m^2	15
Masonry	m^3	70
Cement mortar plastering	m^2	6
Asphalt pavement t = 5 cm	m^2	7
Asphalt pavement t = 11 cm	m^2	15

Source: Sharqiya Governorate

Table VII-4 Price List of Clay Pipes for Sewer

Int. dia. (mm)	Length (mm)	Weight (kg/pipe)	Price (LE/m)
100	1,000	13	2.50
125	1,000	20	3.35
150	1,000	25	5.00
175	1,000	50	6.25
200	1,000	54	6.80
225	1,000	63	8.40
250	1,000	74	9.40
300	1,500	105	14.00
375	1,500	175	21.75
450	1,500	255	39.25
500	1,500	290	47.00
600	1,500	360	58.25
750	1,500	420	106.70
900	1,500	540	150.40
1,000	1,100	850	215.30
1,250	1,100	1,110	306.30

Table VII-5 Standard Specifiations for PVC Pipe

Ext. Dia.	4 atm.		6 atm.		10 atm.		16 atm.	
(mm)	T (mm)	W (kg/m)	T (mm)	W (kg/m)	T (mm)	W (kg/m)	T (mm)	W (kg/m)
16							1.2	0.09
20							1.5	0.137
25					1.5	0.174	1.9	0.212
32					1.8	0.264	2.4	0.342
40			1.8	0.334	2.0	0.366	3.0	0.525
50			1.8	0.422	2.4	0.552	3.7	0.809
63			1.9	0.562	3.0	0.854	4.7	1.29
75	1.8	0.642	2.2	0.782	3.6	1.22	5.6	1.82
90	1.8	0.774	2.7	1.13	4.3	1.75	6.7	2.61
110	2.2	1.16	3.2	1.64	5.3	2.61	8.2	2.90
125	2.5	1.48	3.7	2.13	6.0	3.34	9.3	5.01
140	2.8	1.84	4.1	2.65	6.7	4.18	10.4	6.27
160	3.2	2.41	4.7	3.44	7.7	5.47	11.9	8.17
180	3.6	3.02	5.3	4.37	8.6	6.86		
200	4.0	3.70	5.9	5.37	9.6	8.51		
225	4.5	4.70	6.6	6.76	10.8	10.80		
250	4.9	5.65	7.3	8.31	11.9	13.20		
280	5.5	7.11	8.2	10.41	13.4	16.60		
315	6.2	9.02	9.2	13.20	15.0	20.90		
355	7.0	11.4	10.4	16.7	16.9	26.50		
400	7.9	14.5	11.7	21.1	19.1	33.7		

*Note T: Thickness
W: Unit weight

Table VII-6 Price List of PVC Pipes for Sewer

Ext. dia. (mm)	Unit weight (kg/m)	Price (LE/m)
110	2.0	2.59
125	2.0	4.16
160	2.6	6.40
200	4.5	10.22
250	6.1	15.40
315	7.7	24.42
400	9.8	39.16

2. Sewer Construction Costs

Sewer construction costs are estimated for the three categories, i.e. trunk sewers, branch and lateral sewers, and house connections. In order to estimate sewer construction costs, unit construction costs of pipes with diameters 150 mm to 1,200 mm are estimated. A study was then conducted to estimate average length of branch and lateral sewers per unit area for the two selected urban built-up areas. Branch and lateral sewer construction costs in each city is estimated by using an areawise unit cost. House connection costs are estimated based on the unit construction cost and average number of connections per served population.

2.1 Unit Sewer Construction Costs

Unit construction costs of sewer pipes are estimated taking into account the estimated basic costs of excavation, sheeting, bracing, dewatering, bedding, pipe supplying and laying, concrete placing, forming, reinforcing, restoration of pavement, and the contractor's overhead and profit. The cost estimates are developed for normal conditions, excluding such additional costs as required for rock excavation or dewatering for which special techniques are required, and any works to be carried out under special conditions.

Fourteen pipes for the diameters ranging from 150 mm to 1,200 mm were selected and the costs were estimated. For the estimation purpose, pipe materials are selected with diameters from 150 to 375 mm - PVC, diameters of 450 to 750 mm - clay, and those of 900 to 1,200 mm - steel core concrete. Also small pipes with diameter up to 200 mm are considered to be used for house connections and the minimum diameter of branch and lateral sewer is considered at 200 mm. Small sewer pipe consruction costs are included in the house connection costs. Construction costs of the sewer pipes with diameter 200 mm or above are estimated in four cases based on the invert depths of 2.0, 4.0, 6.0, and 8.0 m respectively.

Design conditions for pipe construction costs are shown in Table VII-7. Unit construction costs specified by pipe diameters and depths to invert are shown in Table VII-8.

Table VII-7 Design Conditions for Pipe Construction Costs

Case	Nominal Diameter (mm)	Depth to Invert (m)	Bedding	Material	Use
1	150	1.5	Cement Mortar	PVC	House connection
2	200	1.5	Cement Mortar	PVC	House connection
3	200	1 - 2	Gravel/Sand	PVC	Sewer
4	225	1 - 2	Gravel/Sand	PVC	Sewer
5	250	1 - 3	Gravel/Sand	PVC	Sewer
6	300	2 - 5	Gravel/Sand	PVC	Sewer
7	375	2 - 5	Gravel/Sand	PVC	Sewer
8	450	3 - 6	Gravel/Sand	Clay	Sewer
9	500	3 - 6	Gravel/Sand	Clay	Sewer
10	600	3 - 6	Gravel/Sand	Clay	Sewer
11	750	4 - 7	Gravel/Sand	Clay	Sewer
12	900	4 - 7	Gravel/Sand	Steel core concrete pipe	Sewer
13	1,000	5 - 8	Gravel/Sand	Steel core concrete pipe	Sewer
14	1,200	5 - 8	Gravel/Sand	Steel core concrete pipe	Sewer

Table VII-8 Construction Costs of Sewer

(LE/m)

1) PVC Pipes

Depth to Invert (m)	Diameter (mm) 200	250	300	350	400
2.0	50	60	80	100	120
4.0	60	80	100	120	140
6.0	100	140	180	220	260
8.0	140	180	220	260	300

2) Clay Pipes

Depth to Invert (m)	Diameter (mm) 450	500	600	750
2.0	200	250	300	400
4.0	250	300	350	450
6.0	500	600	700	900
8.0	600	700	800	1,000

3) Concrete Pipes

Depth to Invert (m)	Diameter (mm) 900	1,000	1,200
2.0	530	600	750
4.0	600	690	900
6.0	1,200	1,370	1,700
8.0	1,300	1,500	1,900

2.2 Branch and Lateral Sewer Pipe Length

Two representative existing served areas are selected for the calculation of the sewer pipe length per unit area. These are categorized as middle class housing areas in Zagazig and Faqus Cities. Maps indicating sewer pipe network arrangement were obtained from each Markaz office, which are shown in Figures VII-1 and VII-2. Sewer pipe and road lengths and areas measured from the maps are indicated as follows:

	Road Length (m)	Sewer Pipe Length (m)	Area (ha)	Sewer Pipe Length Per Area (m/ha)
Zagazig	3,825	2,680	7.87	340
Faqus	3,175	2,925	6.63	440

Taking into consideration the future population densities, land use and the fact that those of the middle class housing areas are representative for whole served area, the average length of 400 m/ha is adopted uniformly over the served area for cost estimation purposes.

2.3 Construction Costs of House Connections

A typical house connection is comprised of a house inlet and connection pipes to a manhole. A house inlet is constructed with bricks plastered by mortar on the surface. Connection pipes made of PVC in average length of 6 m are considered. Construction cost of a house connection is estimated at LE 200. Average served population per house connection is estimated at 30 persons, taking into account the features of present housing buildings and average family numbers. Construction cost of house connections in each city are tabulated in Table VII-10 in the following Section 2.6.

2.4 Construction Costs of Branch and Lateral Sewers

Construction costs of branch and lateral sewers are estimated based on the future service area in 2005. The present service areas where sewer pipes have already been installed are excluded from cost estimation, since the existing sewer pipes can be utilized until the year 2005. Costs for some rehabilitations and improvements of the branch and lateral sewers in the present service areas are separately estimated in Section 6 of this Appendix. As described in the previous Section 2.3, average length of branch and lateral sewers per service area is assumed to be 400 m/ha. Based on the assumption that most of the branch and lateral sewers are of diameters 200 mm to 250 mm and depth of invert are within the range up to 4.0 m, an average unit construction cost of 75 LE/m is worked out. Then unit construction cost per area is calculated to be 30,000 LE/ha. Construction cost for the new service area where branch and lateral sewers are to be installed are shown in Table VII-10 in the following Section 2.6.

2.5 Construction Costs of Trunk Sewers

Hydraulic calculations were conducted to design the outline of the trunk sewers in each of 13 cities. Lengths of the trunk sewers obtained from the design, which are classified by diameters and depths to invert are shown in Table VII-9. These trunk sewers do not include the existing facilities.

Figure VII-1 Existing Branch and Lateral Sewers in Zagazig City
(Middle Class Housing Area)

Figure VII-2 Branch & Lateral Sewers in Faqus City (Middle Class Housing Area)

Table VII-9 Length of Trunk Sewers

1) Zagazig

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
250	PVC	2.0	800
300	CI	-	980
350	PVC	4.0	2,330
400	PVC	2.0	440
400	PVC	4.0	790
400	CI	-	200
450	Clay	2.0	1,560
450	Clay	4.0	530
450	CI	-	3,430
500	Clay	2.0	460
500	Clay	4.0	1,520
500	Clay	6.0	1,110
500	CI	-	2,240
600	Clay	4.0	1,660
600	Clay	6.0	2,270
600	Clay	8.0	430
600	CI	-	660
700	CI	-	1,650
750	Clay	4.0	1,470
750	Clay	6.0	240
900	Concrete	4.0	1,410
900	Concrete	6.0	1,100
900	CI	-	710
	Total Length		27,990

2) Huseiniya

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
150	CI	-	420
200	PVC	2.0	1,790
250	PVC	2.0	1,200
300	PVC	2.0	370
300	PVC	4.0	670
400	PVC	2.0	1,180
450	Clay	4.0	770
600	Clay	6.0	150
	Total Length		6,550

Table VII-9 Length of Trunk Sewers (Cont'd)

3) Kafr Saqr

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
150	CI	-	620
200	PVC	2.0	340
250	PVC	2.0	690
300	PVC	2.0	950
300	PVC	4.0	620
350	PVC	4.0	690
400	PVC	2.0	610
400	PVC	4.0	1,020
600	Clay	4.0	550
900	Concrete	4.0	290
	Total Length		6,380

4) Faqus

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
200	PVC	2.0	720
200	PVC	4.0	290
250	PVC	2.0	1,070
250	PVC	4.0	510
300	PVC	2.0	410
300	PVC	4.0	1,000
300	PVC	6.0	320
350	PVC	4.0	1,580
350	PVC	6.0	1,370
350	PVC	8.0	400
350	CI	-	700
400	PVC	2.0	320
400	PVC	8.0	300
450	CI	-	2,400
500	Clay	2.0	240
500	Clay	8.0	250
600	Clay	4.0	640
600	Clay	8.0	200
750	Clay	8.0	1,020
900	Concrete	6.0	600
1000	Concrete	6.0	50
	Total Length		14,620

Table VII-9 Length of Trunk Sewers (Cont'd)

5) Abu Kebir

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
150	CI	-	570
200	PVC	2.0	280
250	PVC	2.0	2,990
250	CI	-	590
300	PVC	2.0	300
300	PVC	4.0	270
300	CI	-	500
350	CI	-	3,900
350	PVC	4.0	2,030
400	CI	-	3,900
450	CI	-	200
500	Clay	4.0	130
500	Clay	6.0	550
600	CI	-	370
600	Clay	6.0	450
750	CI	-	370
	Total Length		14,910

6) Abu Hammad

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
200	PVC	2.0	2,190
250	PVC	2.0	620
300	CI	-	630
300	PVC	2.0	760
300	PVC	4.0	810
350	CI	-	630
350	PVC	2.0	2,610
450	Clay	4.0	520
600	Clay	4.0	660
750	Clay	6.0	100
900	Concrete	6.0	730
	Total Length		7,440

Table VII-9 Length of Trunk Sewers (Cont'd)

7) Ibrahimiya

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
150	CI	-	140
200	PVC	2.0	830
250	PVC	2.0	350
300	PVC	2.0	830
300	PVC	4.0	760
350	PVC	2.0	690
450	Clay	4.0	460
500	Clay	4.0	250
600	Clay	4.0	230
900	Concrete	4.0	330
	Total Length		4,040

8) Hihya

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
200	PVC	2.0	440
200	CI	-	110
250	PVC	2.0	800
250	PVC	4.0	1,080
300	PVC	2.0	1,180
300	PVC	4.0	660
400	PVC	2.0	580
500	Clay	4.0	420
750	Clay	4.0	310
750	Clay	6.0	340
900	Concrete	6.0	410
	Total Length		6,330

Table VII-9 Length of Trunk Sewers (Cont'd)

9) Diarb Nigm

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
400	PVC	2.0	500
450	Clay	2.0	300
500	Clay	2.0	490
500	Clay	4.0	750
600	Clay	4.0	550
750	Clay	4.0	200
1,000	Concrete	4.0	690
1,200	Concrete	6.0	660
	Total Length		4,140

10) Bilbeis

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
200	PVC	2.0	180
200	CI	-	1,000
250	PVC	4.0	500
250	CI	-	1,600
300	PVC	2.0	630
350	PVC	2.0	380
350	PVC	4.0	300
400	CI	-	500
450	Clay	2.0	700
450	Clay	4.0	240
450	CI	-	440
500	CI	-	750
600	Clay	2.0	890
600	CI	-	1,390
750	Clay	4.0	1,330
900	Concrete	6.0	350
	Total Length		11,070

Table VII-9 Length of Trunk Sewers (Cont'd)

11) Minyet El Qamh

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
200	CI	-	230
250	PVC	2.0	240
250	PVC	4.0	280
250	CI	-	280
300	PVC	2.0	280
300	PVC	4.0	330
300	CI	-	1,150
350	PVC	4.0	240
350	PVC	6.0	360
350	CI	-	190
400	PVC	2.0	680
400	PVC	4.0	300
400	CI	-	860
450	Clay	2.0	350
450	Clay	4.0	350
500	Clay	4.0	80
500	Clay	6.0	360
600	Clay	2.0	540
600	Clay	6.0	320
750	Clay	4.0	80
750	Clay	6.0	50
	Total Length		8,170

12) Mashtul El Soak

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
200	PVC	4.0	540
250	CI	-	50
300	PVC	2.0	1,190
300	PVC	4.0	960
350	PVC	4.0	2,270
400	PVC	2.0	320
600	Clay	2.0	470
750	Clay	4.0	210
900	Concrete	4.0	850
	Total Length		6,860

Table VII-9 Lengths of Trunk Sewers (Cont'd)

13) Qenayat

Diameter (mm)	Material	Depth to Invert (m)	Length (m)
250	PVC	2.0	330
300	PVC	2.0	1,480
300	PVC	4.0	790
350	PVC	4.0	1,780
400	PVC	4.0	500
400	CI	-	1,000
600	Clay	4.0	370
750	Clay	6.0	190
900	Concrete	6.0	240
	Total Length		6,680

Note: CI indicates cast iron pipe used for force main.

2.6 Total Sewer Construction Cost

Total sewer construction costs for house connections, branch and rateral sewers, and trunk sewers are tabulated in Table VII-10. A total of approximately LE 186 million will be required by 2005 for the construction of sewer pipes. Of the total, the greater part or about LE 148 million or 80 percent of the total cost will be spent for branch and lateral sewer construction, followed by that of the trunk sewer of about LE 32 million or 17 percent. The smallest portion will be house connection construction cost which is about LE 5.8 million or 3 percent of the total cost.

Table VII-10 Total Sewer Construction Costs

City	New Service Area (ha)	Construction Costs (LE 1,000) House Connection	Branch and Lateral Sewer	Trunk Sewer	Total
Zagazig	1,932	1,714	57,960	10,549	70,223
Huseiniya	253	194	7,590	724	8,508
Kafr Saqr	150	140	4,500	899	5,539
Faqus	515	520	15,450	4,153	20,123
Abu Kebir	341	586	10,230	3,093	13,909
Abu Hammad	166	160	4,980	1,405	6,545
Ibrahimiya	154	266	4,620	709	5,595
Hihya	235	286	7,050	1,458	8,794
Diarb Nigm	194	306	5,820	2,349	8,475
Bilbeis	394	720	11,820	2,716	15,256
Minyet El Qamh	150	274	4,500	1,614	6,388
Mashtul El Soak	228	274	6,840	1,284	8,398
Qenayat	223	346	6,690	1,270	8,306
Total	4,935	5,786	148,050	32,223	186,059

3. Pumping Station Construction Costs

Design of the sewerage facilities in 2005 include hydraulic calculations of the sewage collection system, a part of which is a design of pumping station. Small pumps with diameter up to 250 mm are designed as a submersible type in circular pump pit. Medium-size pumps of diameters between 300 mm to 400 mm are designed as a centrifugal type in a dry well which is separated from the wet well in a circular basin. Typical structure of these two types of the pumping stations are shown in Figures VIII-7 and VIII-8 in Appendix VIII. Design outline of the pumping stations are shown in Table VII-11. It is considered that the existing pumping stations shall be used with necessary improvements and replacements to be done at a proper time up to 2005. Rehabilitation costs for the existing pumping stations are shown in Table VII-15.

Table VII-11 Design Outline of Pumping Stations

City	P/S No.	Design Peak Flow (m3/sec)	Inlet Depth (m)	Diameter (mm)	Q'ty	Remarks
Zagazig	No.1	0.083	9.3	150	3	
	No.2	0.271	6.2	250	4	
	No.3	0.305	4.3	250	4	
	No.4	0.239	3.8	200	4	
	No.5	0.206	5.9	200	4	
	Main	0.488	4.0	300	4	Existing
Huseiniya	No.1	0.025	5.6	100	2	
	No.2	0.020	4.0	100	2	
Kafr Saqr	No.1	0.011	3.9	100	2	
	No.2	0.015	3.6	100	2	
Faqus	No.1	0.145	6.6	200	3	
	No.2	0.060	3.0	150	3	
	No.3	0.313	4.4	300	3	
Abu Kebir	No.1	0.272	5.4	250	3	
	No.2	0.067	4.0	150	3	
Abu Hammad	No.1	0.102	5.2	200	3	
Ibrahimiya	No.1	0.017	4.3	100	2	
Hihya	No.1	0.033	4.0	150	2	
Diarb Nigm		- None -				
Bilbeis	No.1	0.212	5.3	250	3	
	No.2	0.041	3.0	150	2	
	No.3	0.080	3.0	150	3	Existing
	No.4	0.098	3.0	200	3	Existing
	No.5	0.042	3.0	150	2	
	No.6	0.029	3.0	150	2	Existing
	No.7	0.056	3.0	200	2	Existing
	No.8	0.049	3.0	200	2	
	No.9	0.066	3.0	200	2	
Minyet El Qamh	No.1	0.090	4.3	150	3	Existing
	No.2	0.030	3.0	150	2	Existing
	No.3	0.068	3.1	150	3	Existing
Mashtul El Soak	No.1	0.064	4.4	150	3	
	No.2	0.028	4.4	150	2	
	No.3	0.023	4.6	100	2	
Qenayat	No.1	0.163	5.9	250	3	

Note: Number of pumps includes one standby unit

Construction costs are estimated under three work items, namely, civil, architectural, and mechanical and electrical works. Costs are also divided into two portions, i.e. local currency and foreign currency portions. Minor civil works such as sheet piling for deep excavation are considered to be included in the foreign portion. Mechanical and electrical costs, which are mostly for supply and installation of the equipment are included in the foreign portion. Construction costs of the pumping stations are shown in Table VII-12.

Table VII-12 Pumping Station Construction Costs

(LE 1,000)

City	P/S No.	Construction Costs Civil	Arch.	M/E	Total	L/C	F/C
Zagazig	No.1	160	170	250	580	364	216
	No.2	216	238	400	854	512	342
	No.3	184	238	400	822	484	338
	No.4	176	238	350	764	466	298
	No.5	211	238	350	799	498	301
	Main	-	-	500	500	100	400
	Sub-total				4,319	2,425	1,894
Huseiniya	No.1	42	36	122	200	98	102
	No.2	34	36	122	192	91	101
	Sub-total				392	189	203
Kafr Saqr	No.1	34	36	122	192	91	101
	No.2	32	36	122	190	89	101
	Sub-total				382	180	202
Faqus	No.1	173	206	300	679	422	257
	No.2	88	170	250	508	299	209
	No.3	143	206	400	749	415	334
	Sub-total				1,936	1,136	800
Abu Kebir	No.1	131	173	290	594	349	245
	No.2	84	116	235	435	239	196
	Sub-total				1,029	588	441
Abu Hammad	No.1	112	143	235	490	291	199
Ibrahimiya	No.1	36	36	122	194	93	101
Hihya	No.1	45	51	200	296	131	165
Diarb Nigm			- None -				

(to be cont'd)

Table VII-12 Pumping Station Construction Costs (Cont'd)

(LE 1,000)

City	P/S No.	Construction Costs Civil	Arch.	M/E	Total	L/C	F/C
Bilbeis	No.1	155	206	350	711	416	295
	No.2	46	170	200	416	251	165
	No.3	-	-	250	250	50	200
	No.4	-	-	300	300	60	240
	No.5	46	170	200	416	251	165
	No.6	-	-	200	200	40	160
	No.7	-	-	250	250	50	200
	No.8	59	170	250	479	273	206
	No.9	59	170	250	479	273	206
	Sub-total				3,501	1,665	1,836
Minyet El Qamh	No.1	-	-	250	250	50	200
	No.2	-	-	200	200	40	160
	No.3	-	-	250	250	50	200
	Sub-total				700	140	560
Mashtul El Soak	No.1	87	116	235	438	241	197
	No.2	47	51	200	298	133	165
	No.3	37	36	122	195	94	101
	Sub-total				931	468	463
Qenayat	No.1	137	173	290	600	354	246
	Total				14,770	7,660	7,110

Note: P/S: Pumping Station
M/E: Mechanical and Electrical
L/C: Local Currency Portion
F/C: Foreign Currency Portion

4. Sewage Treatment Plant Construction Costs

Construction costs of the sewage treatment plant (STP) are estimated, based on the design outline for each plant. As discussed in Appendix X, Sewage Treatment Process Selection, four plants with larger capacities are designed to use the conventional activated sludge process and seven smaller plants are designed to use the oxidation ditch process. Both of these processes are designed to obtain an effluent concentration of BOD and SS of 30 mg/l each. Design parameters and dimensions of the main facilities are shown in Tables VIII-1 and VIII-2 in Appendix VIII Design Outline and Typical Structures of Sewerage Facilities. General plans of the plant are also shown in Appendix VIII.

Costs are divided into four work items, namely civil, architectural, mechanical and electrical. These costs are further divided into local and foreign currency portions. A small portion of the civil work, such as steel sheet piling, cast iron pipes for yard piping, is included in the foreign currency portion. Supply and a part of erection of the mechanical and electrical equipment to be imported is also included in the foreign currency portion. The rest of the construction cost is included in the local currency portion, taking into consideration the present local availability of the materials and equipment. The study team was advised by NOPWASD of its present policy to limit the foreign currency portion as much as possible. In this regard, division of cost was reexamined and NOPWASD's policy was duly reflected. Materials and equipment which are not locally available are assumed to be imported from Japan. Construction costs of the sewage treatment plants are shown in Table VII-13.

Table VII-13 Sewage Treatment Plant Construction Costs

(LE 1,000)

City		Civil	Arch.	Mech.	Elec.	Total
Zagazig	T	-	-	-	-	-
	L/C	-	-	-	-	-
	F/C	-	-	-	-	-
Huseiniya	T	1,274	408	1,886	1,529	5,097
	L/C	1,147	408	566	459	2,580
	F/C	127	-	1,320	1,070	2,517
Kafr Saqr	T	1,399	448	2,070	1,677	5,594
	L/C	1,259	448	621	503	2,831
	F/C	140	-	1,449	1,174	2,763
Faqus	T	4,089	1,837	3,453	2,672	12,051
	L/C	3,680	1,837	1,727	1,336	8,580
	F/C	409	-	1,726	1,336	3,471
Abu Kebir	T	4,221	1,125	4,926	3,798	14,070
	L/C	3,799	1,125	2,463	1,899	9,286
	F/C	422	-	2,463	1,899	4,784
Abu Hammd	T	1,673	535	2,475	2,007	6,690
	L/C	1,506	535	743	602	3,386
	F/C	167	-	1,732	1,405	3,304
Ibrahimiya	T	1,484	475	2,196	1,780	5,935
	L/C	1,335	475	659	534	3,003
	F/C	148	-	1,537	1,246	2,932
Hihya	T	1,716	549	2,539	2,059	6,863
	L/C	1,544	549	762	618	3,473
	F/C	172	-	1,778	1,441	3,390
Diarb Nigm	T	1,949	624	2,885	2,339	7,797
	L/C	1,754	624	865	702	3,945
	F/C	195	-	2,019	1,637	3,852
Bilbeis	T	7,953	2,455	6,603	5,282	22,293
	L/C	7,158	2,455	3,302	2,641	15,556
	F/C	795	-	3,301	2,641	6,737
Minyet El Qamh	T	4,735	1,837	3,453	2,672	12,697
	L/C	4,262	1,837	1,727	1,336	9,162
	F/C	473	-	1,726	1,336	3,535
Mashtul El Soak	T	1,639	525	2,426	1,967	6,557
	L/C	1,475	525	728	590	3,318
	F/C	164	-	1,698	1,377	3,239
Qenayat	T	-	-	-	-	-
	L/C	-	-	-	-	-
	F/C	-	-	-	-	-
Total	T	32,132	10,818	34,912	27,782	105,644
	L/C	28,919	10,818	14,163	11,220	65,120
	F/C	3,212	-	20,749	16,562	40,524

Note: Abbreviations are as follows:

T : Total
L/C: Local currency portion
F/C: Foreign currency portion

5. Land Purchasing Costs

Land areas necessary for the sewerage facilities such as pumping stations and sewage treatment plants are determined based on the design outline of each facility. Sewer pipes are considered to be constructed under public road and therefore, no land purchasing costs are estimated. Unit cost of land obtained from each city is used for cost estimation. Land purchasing costs are shown in Table VII-14.

Table VII-14 Land Purchasing Costs

(LE 1,000)

City	Pumping Station Area(m2)	Pumping Station Cost	Treatment Plant Area(m2)	Treatment Plant Cost	Total
Zagazig	2,300	375	-	-	375
Huseiniya	400	40	20,000	2,000	2,040
Kafr Saqr	400	40	22,000	2,200	2,240
Faqus	1,100	165	45,000	4,500	4,665
Abu Kebir	600	60	55,000	5,500	5,560
Abu Hammad	300	30	27,000	2,700	2,730
Ibrahimiya	200	20	23,000	2,300	2,320
Hihya	200	20	27,000	2,700	2,720
Diarb Nigm	-	-	32,000	3,200	3,200
Bilbeis	1,700	285	80,000	8,000	8,285
Minyet El Qamh	-	-	45,000	4,500	4,500
Mashtul El Soak	700	70	26,000	2,600	2,670
Qenayat	300	30	-	-	30
Total	8,200	1,135	402,000	40,200	41,335

6. Costs for Rehabilitation

Information of the present conditions of the existing sewerage facilities is inadequate to determine the extent and degree of rehabilitation required. Therefore, costs for rehabilitation are estimated based on the assumption that 15 percent of the construction costs of the sewer pipes will be needed for the existing service areas and all the pumps will be replaced once by the year 2005. Division of the costs into local and foreign currency portions are calculated on the same assumption as mentioned in the previous sections. Costs for rehabilitation works are shown in Table VII-15.

Table VII-15 Costs for Rehabilitation

(LE 1,000)

City	Pumping Station	Sewer Pipes	Total	L/C	F/C
Zagazig	9 P/S Dia. 250 mm x 5 Dia. 200 mm x 19	777 ha	5,841	2,561	3,280
Huseiniya	-	-	-	-	-
Kafr Saqr	2 P/S Dia. 200 mm x 4	15,000 m	596	252	344
Faqus	1 P/S Dia. 200 mm x 2	168 ha	592	420	172
Abu Kebir	3 P/S Dia. 150 mm x 3	103 ha	552	294	258
Abu Hammd	2 P/S Dia. 200 mm x 2 Dia. 100 mm x 2	6,000 m	388	130	258
Ibrahimiya	1 P/S Dia. 150 mm x 3	2,000 m	343	86	257
Hihya	3 P/S Dia. 250 mm x 2 Dia. 200 mm x 2	3,000 m	424	110	314
Diarb Nigm	-	10,000 m	112	112	-
Bilbeis	3 P/S Dia. 150 mm x 6	267 ha	942	426	516
Minyet El Qamh	3 P/S Dia. 150 mm x 2 Dia. 200 mm x 5	66 ha	930	244	686
Mashtul El Soak	-	3,000 m	33	33	-
Qenayat	-	1,000 m	11	11	-
Total			10,764	4,679	6,085

7. Total Project Costs

Total project cost consisting of the construction costs of the new facilities, land purchasing costs, costs for rehabilitation and indirect costs, i.e. contingency and engineering costs are summarized in Table VII-16. Construction costs for house connections are excluded from the project cost, since these costs have been and will be borne by inhabitants and not by governments. Contingency costs including physical and price escalation are estimated as 20 percent of the construction and rehabilitation costs. Engineering costs are estimated as 10 percent of the same said amount.

Table VII-16 Total Project Costs

(LE 1,000)

City		B/L Sewer	Trunk Sewer	P/S	STP	Sub-total	Land Purchasing Cost	Rehabili. Cost	Contingency	Engineering Cost	TOTAL COST
Zagazig	T	57,960	10,549	4,319	-	72,828	375	5,841	15,734	7,868	102,646
	L/C	57,960	8,967	2,425	-	69,352	375	2,561	14,382	7,192	93,862
	F/C	-	1,582	1,894	-	3,476	-	3,280	1,352	676	8,784
Huseiniya	T	7,590	724	392	5,097	13,803	2,040	-	2,761	1,381	19,985
	L/C	7,590	615	203	2,580	10,988	2,040	-	2,198	1,099	16,325
	F/C	-	109	189	2,517	2,815	-	-	563	282	3,660
Kafr Saqr	T	4,500	899	382	5,594	11,375	2,240	596	2,394	1,197	17,802
	L/C	4,500	764	202	2,831	8,297	2,240	252	1,710	855	13,354
	F/C	-	135	180	2,763	3,078	-	344	684	342	4,448
Faqus	T	15,450	4,153	1,936	12,051	33,590	4,665	592	6,836	3,418	49,101
	L/C	15,450	3,530	1,136	8,580	28,696	4,665	420	5,823	2,912	42,516
	F/C	-	623	800	3,471	4,894	-	172	1,013	506	6,585
Abu Kebir	T	10,230	3,093	1,029	14,070	28,422	5,560	552	5,795	2,898	43,227
	L/C	10,230	2,629	441	9,286	22,586	5,560	294	4,576	2,288	35,304
	F/C	-	464	588	4,784	5,836	-	258	1,219	610	7,923
Abu Hammad	T	4,980	1,405	490	6,690	13,565	2,730	388	2,791	1,396	20,870
	L/C	4,980	1,194	199	3,386	9,759	2,730	130	1,978	989	15,586
	F/C	-	211	291	3,304	3,806	-	258	813	407	5,284
Ibrahimiya	T	4,620	709	194	5,935	11,458	2,320	343	2,360	1,180	17,661
	L/C	4,620	603	101	3,003	8,327	2,320	86	1,683	842	13,258
	F/C	-	106	93	2,932	3,131	-	257	677	338	4,403
Hihya	T	7,050	1,458	296	6,863	15,667	2,720	424	3,218	1,609	23,638
	L/C	7,050	1,239	165	3,473	11,927	2,720	110	2,407	1,204	18,368
	F/C	-	219	131	3,390	3,740	-	314	811	405	5,270
Diarb Nigm	T	5,820	2,349	-	7,797	15,966	3,200	112	3,216	1,608	24,102
	L/C	5,820	1,997	-	3,945	11,762	3,200	112	2,375	1,188	18,637
	F/C	-	352	-	3,852	4,204	-	-	841	420	5,465
Bilbeis	T	11,820	2,716	3,501	22,293	40,330	8,285	942	8,255	4,128	61,940
	L/C	11,820	2,309	1,665	15,556	31,350	8,285	426	6,355	3,178	49,594
	F/C	-	407	1,836	6,737	8,980	-	516	1,900	950	12,346
Minyet El Qamh	T	4,500	1,614	700	12,697	19,511	4,500	930	4,088	2,044	31,073
	L/C	4,500	1,372	140	9,162	15,174	4,500	244	3,083	1,542	24,543
	F/C	-	242	560	3,535	4,337	-	686	1,005	502	6,530
Mashtul El Soak	T	6,840	1,284	931	6,557	15,612	2,670	33	3,129	1,565	23,009
	L/C	6,840	1,091	463	3,318	11,712	2,670	33	2,349	1,175	17,939
	F/C	-	193	468	3,239	3,900	-	-	780	390	5,070
Qenayat	T	6,690	1,270	600	-	8,560	30	11	1,714	857	11,172
	L/C	6,690	1,080	246	-	8,016	30	11	1,605	803	10,465
	F/C	-	190	354	-	544	-	-	109	54	707
TOTAL	T	148,050	32,223	14,770	105,644	300,687	41,335	10,764	62,291	31,149	446,226
	L/C	148,050	27,390	7,386	65,120	247,946	41,335	4,679	50,524	25,267	369,751
	F/C	-	4,833	7,384	40,524	52,741	-	6,085	11,767	5,882	76,475

Note: B/L: Branch and lateral
P/S: Pumping station
STP: Sewage treatment plant
T : Total

L/C: Local currency portion
F/C: Foreign currency portion

8. Operation and Maintenance Costs

Operation and maintenance costs include labor, electricity, fuel and materials. The procedure adopted for the estimation of these costs are described below.

8.1 Sewers

The following assumptions are made for the estimation of operation and maintenance costs of the sewer pipes.

- Pipe cleaning will be carried out every five years.
- Daily cleaning length will be 100 m.
- Life expectancy of the cleaning equipment is 15 years.
- Cleaning gang consists of five laborers.
- Annual maintenance cost of the equipment is 5 percent of the purchasing costs.
- Annual repair cost of the sewer pipes is 0.5 percent of the construction costs.
- Working days in a year is 250 days.
- Labor wage per day is LE 6.0.
- Purchase costs of the cleaning equipment will be LE 140,000 per set.

Under the above conditions, the annual operation and maintenance costs are estimated as follows.

- Total length of the sewer pipes including trunk and branch and lateral sewers is 2,656,000 m in the Governorate.
- Total length of pipe cleaning per year
  2,656,000 / 5 (years) = 531,200 (m/year)
- Number of teams
  531,200 / (100 (m) x 250 (days/year)) = 21 (teams)
- Labor costs

  5 (persons) x 21 (teams) x 250 (days/year) x LE 6.0 = LE 157,500/year
- Depreciation costs
  LE 140,000 / 15 (years) x 21 (sets) = LE 196,000/year

- Maintenance costs
  LE 140,000 x 0.05 x 21 (team) = LE 147,000/year

- Repair costs
  LE 157,043,000 x 0.005 = LE 785,215/year

- Total per year = LE 1,285,000

Thus, total annual costs of operation and maintenance for sewer pipes are LE 1,285,000 per year. Breakdown of the costs by Marakaz is shown in Table VII-17.

8.2 Pumping Stations

The following assumptions were made for the estimation of the operation and maintenance costs of the pumping stations.

- Labor cost is not estimated, since most of the pumping stations are small in capacity and operation and maintenance is assumed to be carried out by the staff stationed at the treatment plant.

- Repair costs are assumed at 0.5 percent of the construction costs.

- Operation of the pumps is assumed at 12 hours per day, taking into consideration the ratios of daily average flow to peak flow.

- Unit electricity cost is at 10 PT/kWH.

Operation and maintenance costs for pumping stations are shown in Table VII-17.

8.3 Sewage Treatment Plants

Operation and maintenance costs for sewage treatment plant including labor, power, chemicals and repair costs are estimated by using cost functions developed in the El Arish sewerage feasibility study with price escalation adjustments. These cost functions are as follows.

- For activated sludge process: $Com1 = 7.580\ Q^{0.87}$

- For oxidation ditch process : $Com2 = 11.920\ Q^{0.88}$

Com1, Com2: Operation and maintenance cost (LE/year)
Q : Daily average wastewater flow (1,000 m^3/day)

Operation and maintenance costs for sewage treatment plants are shown in Table VII-17.

Table VII-17 Operation and Maintenance Costs

(LE 1,000/year)

City	Service Area	Sewer Length	Watwer Flow	Treatment Process	Operation and Maintenance Costs			
	ha	km	m3/day	Total	Sewer	P/S	STP	Total
Zagazig	2,726	1,090	94,062	AS	528	365	395	1,288
Huseiniya	253	101	5,746	OD	48	6	56	110
Kafr Saqr	248	99	6,362	OD	47	26	61	134
Faqus	515	206	16,101	AS	100	130	85	315
Abu Kebir	444	178	20,446	AS	86	95	105	286
Abu Hammad	310	124	7,980	OD	60	35	74	169
Ibrahimiya	170	68	6,580	OD	32	3	63	98
Hihya	265	106	8,084	OD	52	26	75	153
Diarb Nigm	259	104	9,355	OD	50	-	85	135
Bilbeis	667	267	33,767	AS	130	180	162	472
Minyet El Qamh	300	120	14,513	AS	58	45	78	181
Mashtul El Soak	254	102	7,641	OD	50	22	71	143
Qenayat	228	91	-	-	44	69	-	113
Total	6,639	2,656	230,637		1,285	1,002	1,310	3,597

Note: Wastewater flow of Qneyat is included that of Zagazig
Wastewater flow of Bilbeis includes flow from army camp
AS: Activated sludge process
OD: Oxidation ditch process

APPENDIX - VIII

DESIGN OUTLINE AND TYPICAL STRUCTURES OF SEWERAGE FACILITIES

APPENDIX - VIII

DESIGN OUTLINE AND TYPICAL STRUCTURES OF SEWERAGE FACILITIES

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1. Introduction

Design outline and typical structures of the sewerage facilties used for the various purposes in the study are described in this Appendix. The method of laying sewer pipes is proposed, essentially based on present practice in Egypt. Typical trench sections of the gravity sewer pipes and force mains are illustrated in Figures VIII-1 and VIII-2. As illustrated in the figures, crushed stone or gravel bedding is proposed for the gravity sewer pipes in normal conditions. Sand or other selected materials are used for the bedding of force mains. Figure VIII-3 illustrates bracings for the trench excavation of the various depths. Figure VIII-4 depicts the typical water tight flexible joints for various kinds of pipe materials. Typical structures of the manholes are shown in Figure VIII-5. Figure VIII-6 illustrates typical layout of the house connections.

Typical structures of the pumping stations with centrifugal type pumps for larger capacities and with submersible pumps for smaller capacities are shown in Figure VIII-7 and Figure VIII-8, respectively.

Design outlines of the major facilities of the eleven new sewage treatment plants proposed for the Governorate by the year 2005 are tabulated in Tables VIII-1 and VIII-2. Design parameters, layout plan and hydraulic profiles of the sewage treatment plant under construction in Zagazig are illustrated in Appendix VI. Four sewage treatment plants for four medium-size cities are proposed to be designed as activated sludge process, the same process adopted in Zagazig plant. The other seven treatment plants are proposed to be designed as oxidation ditch process. Layout plans of treatment plants are shown in Figures VIII-9 to VIII-13.

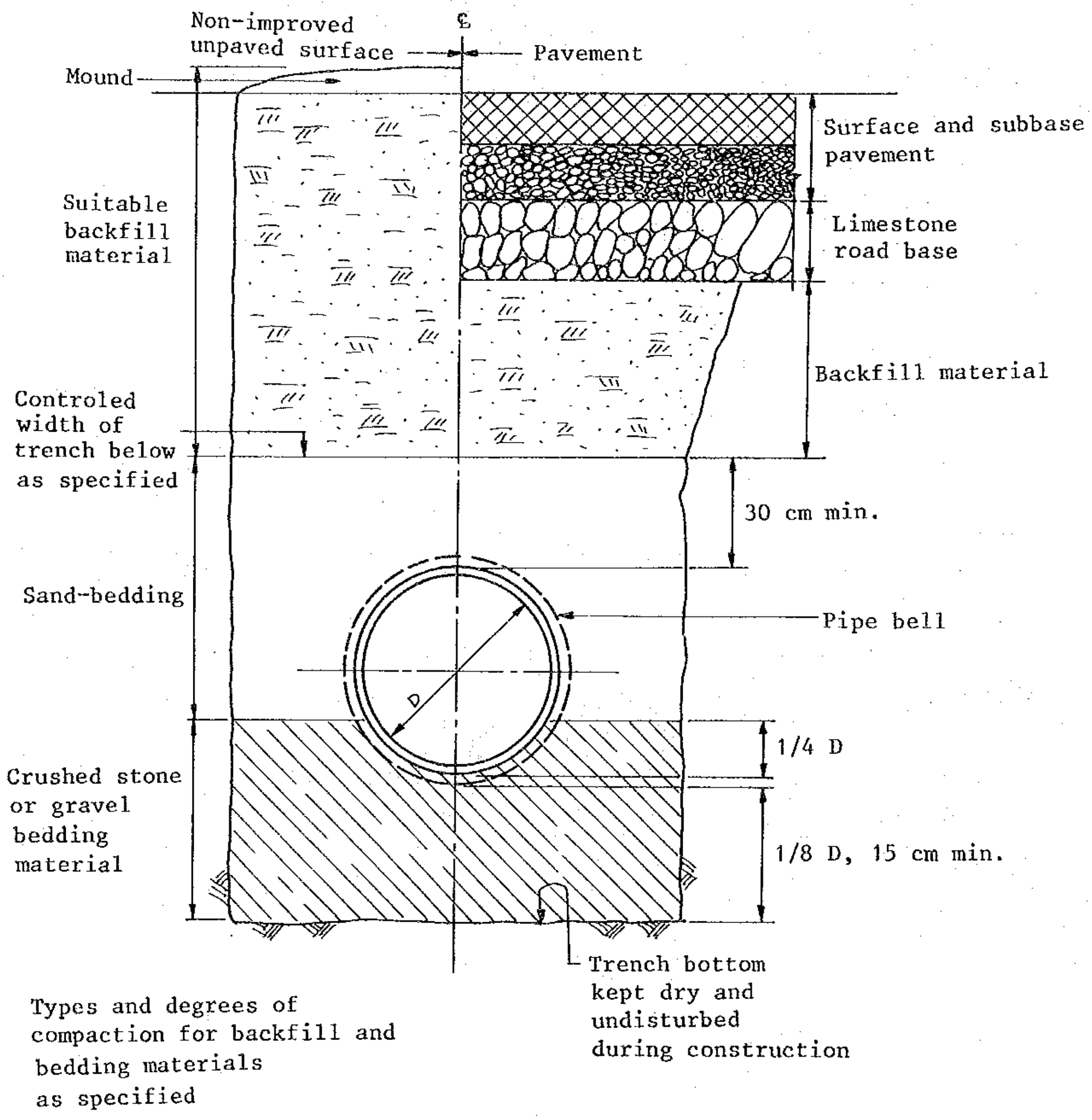


Figure VIII-1 Typical Trench Section for Gravity Sewer

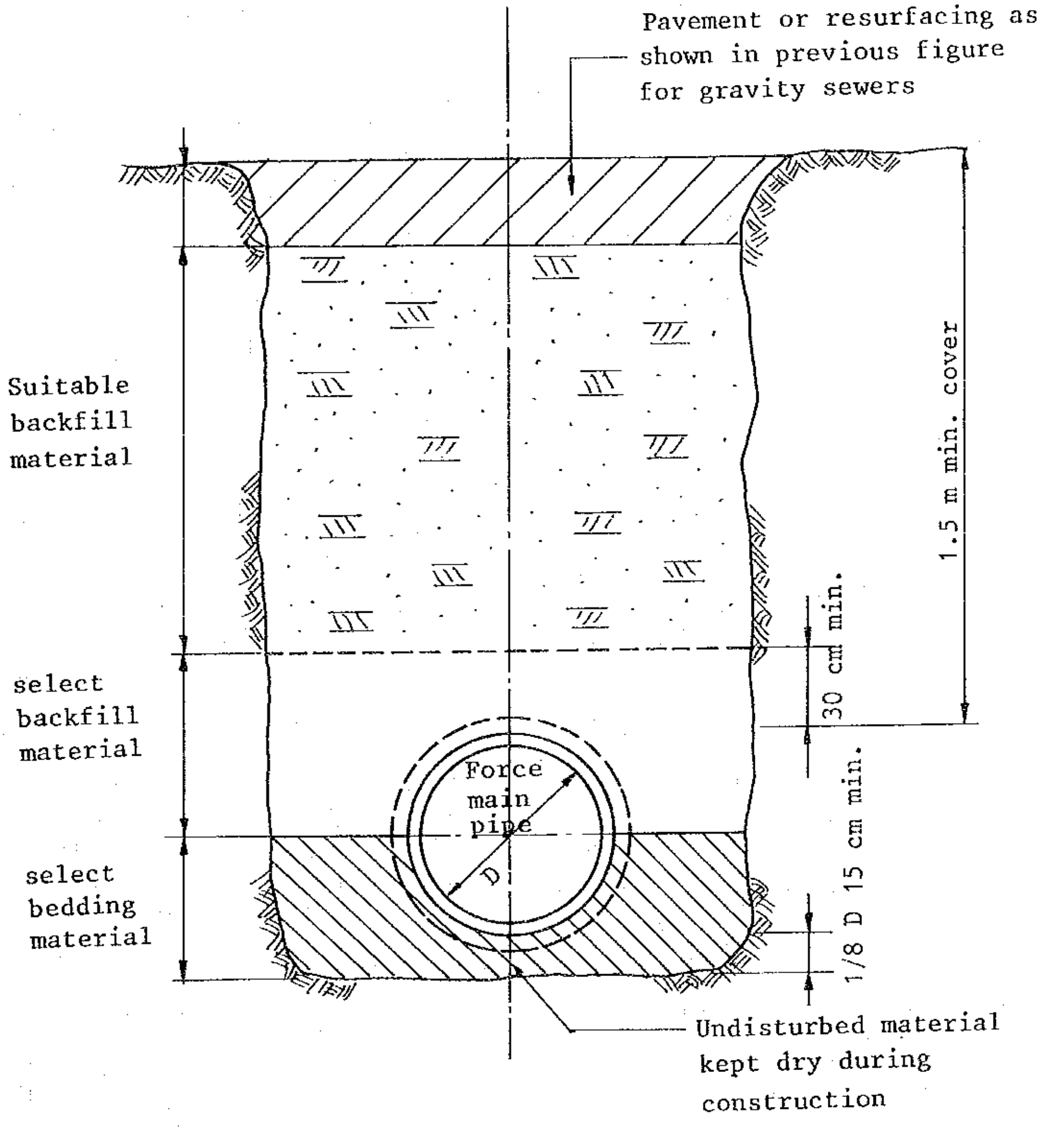


Figure VIII-2 Typical Trench Section for Force Main

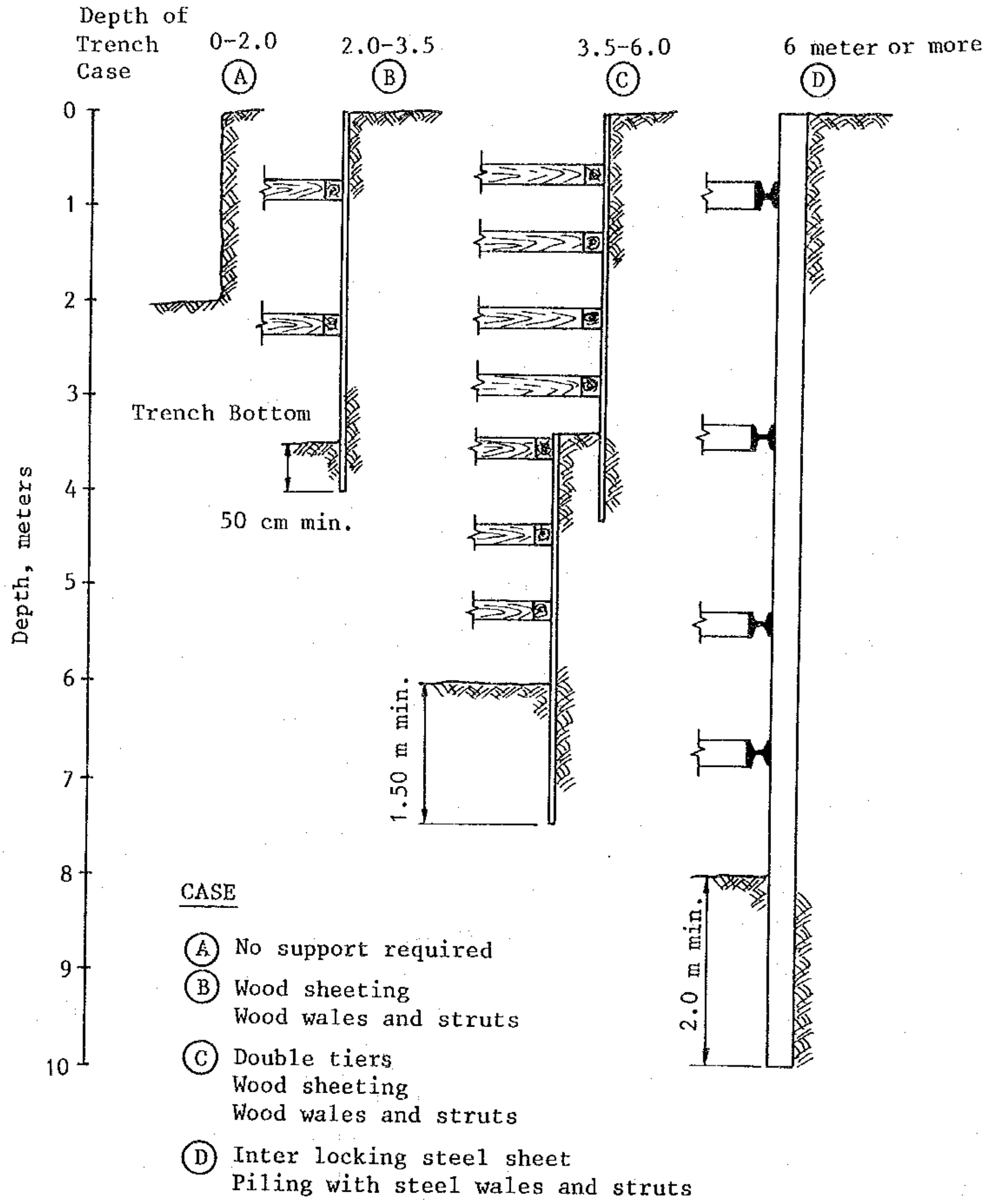
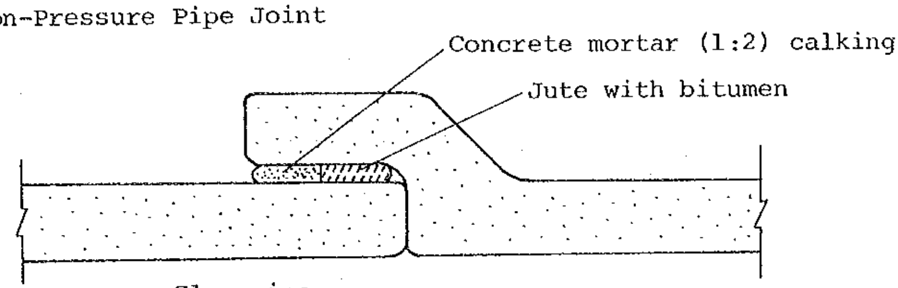
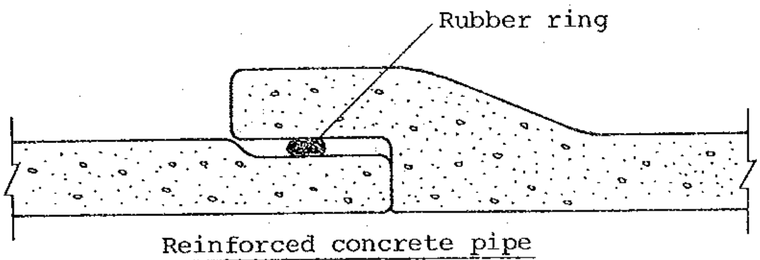


Figure VIII-3 Lateral Bracing for Various Trench Depths

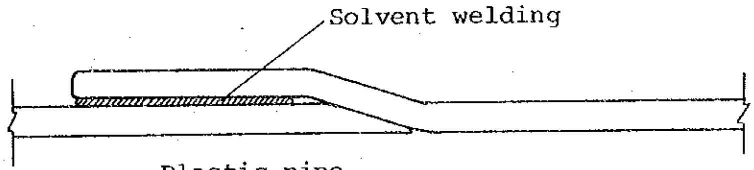
- Non-Pressure Pipe Joint



Clay pipe

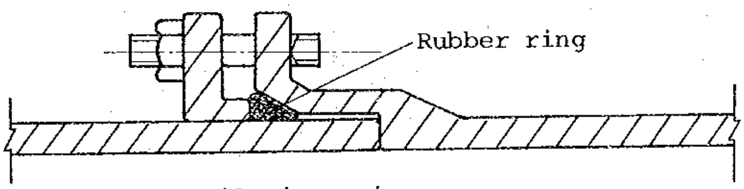


Reinforced concrete pipe



Plastic pipe

- Pressure Pipe Joint



Ductile iron pipe

Figure VIII-4 Typical Pipe Joints

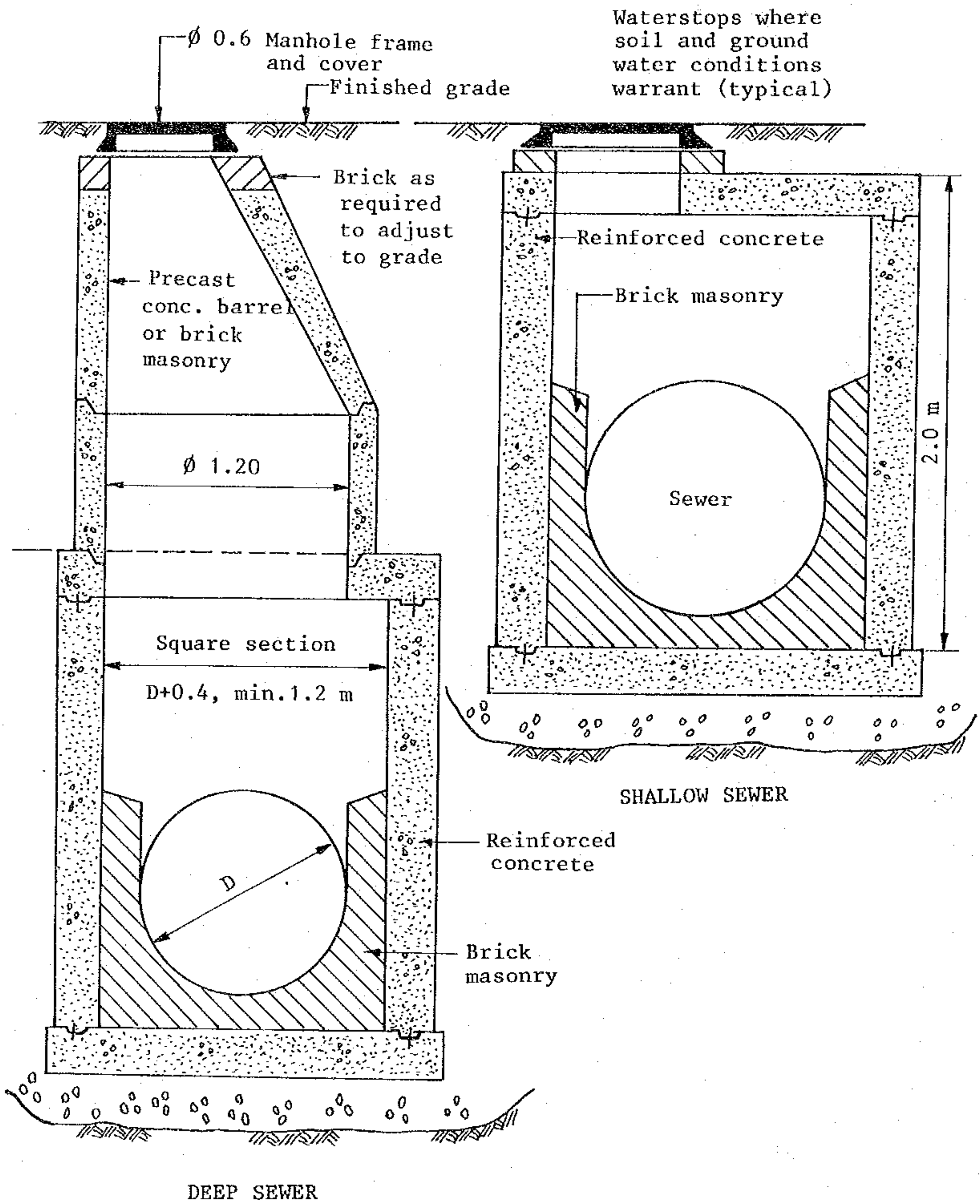


Figure VIII-5 Typical Manhole for Gravity Sewers

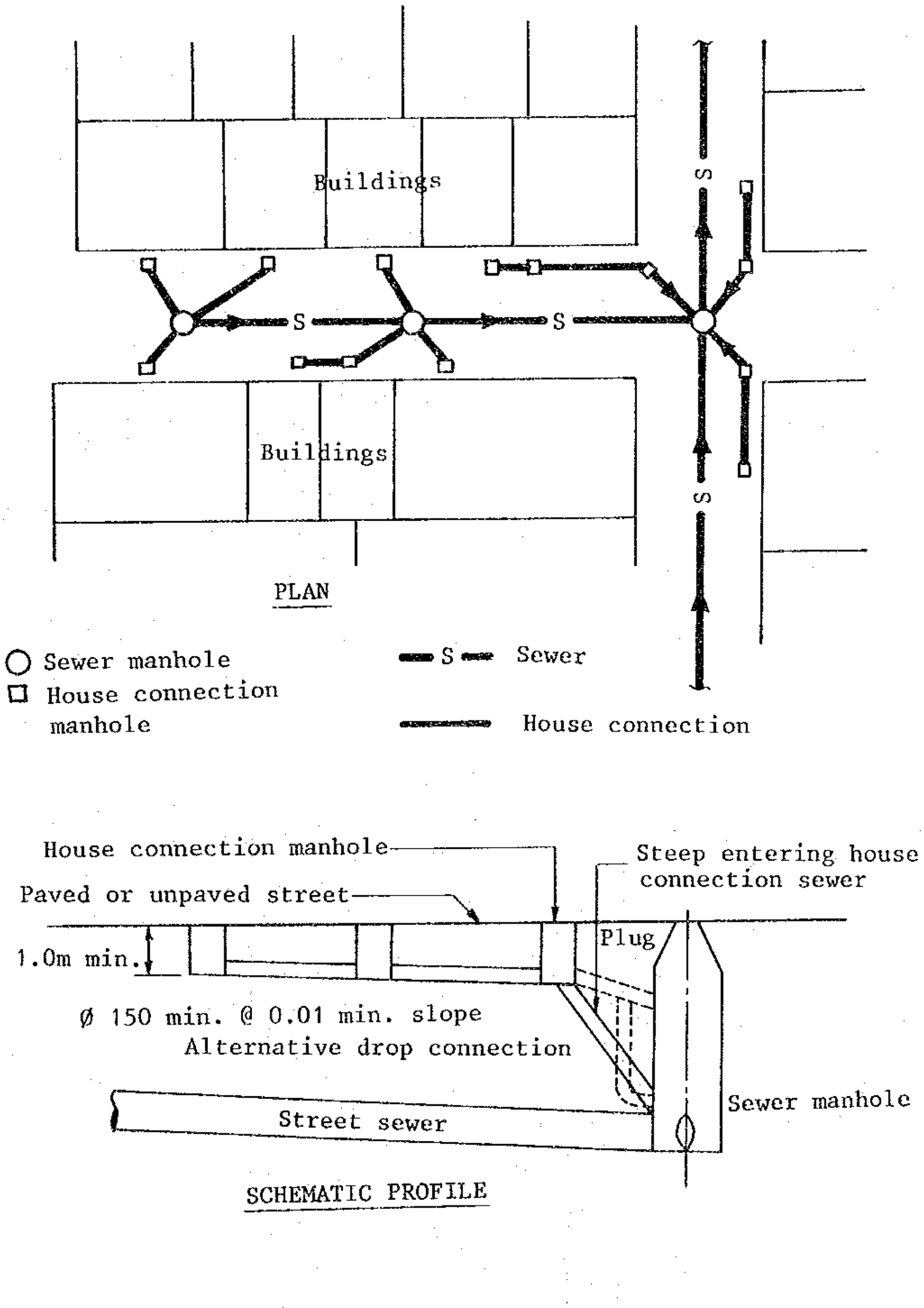


Figure VIII-6 Typical Layout of House Connections

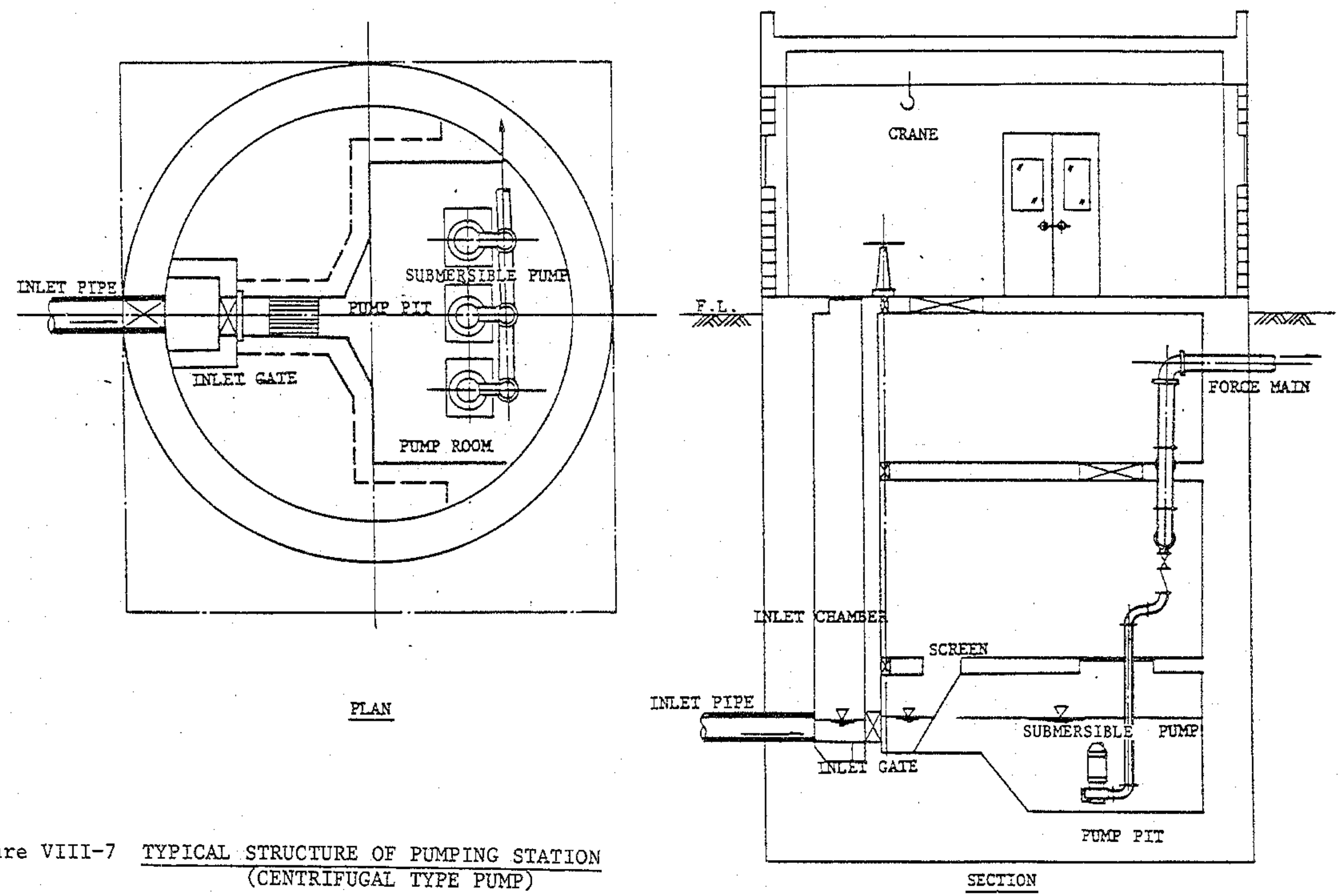


Figure VIII-7 TYPICAL STRUCTURE OF PUMPING STATION (CENTRIFUGAL TYPE PUMP)

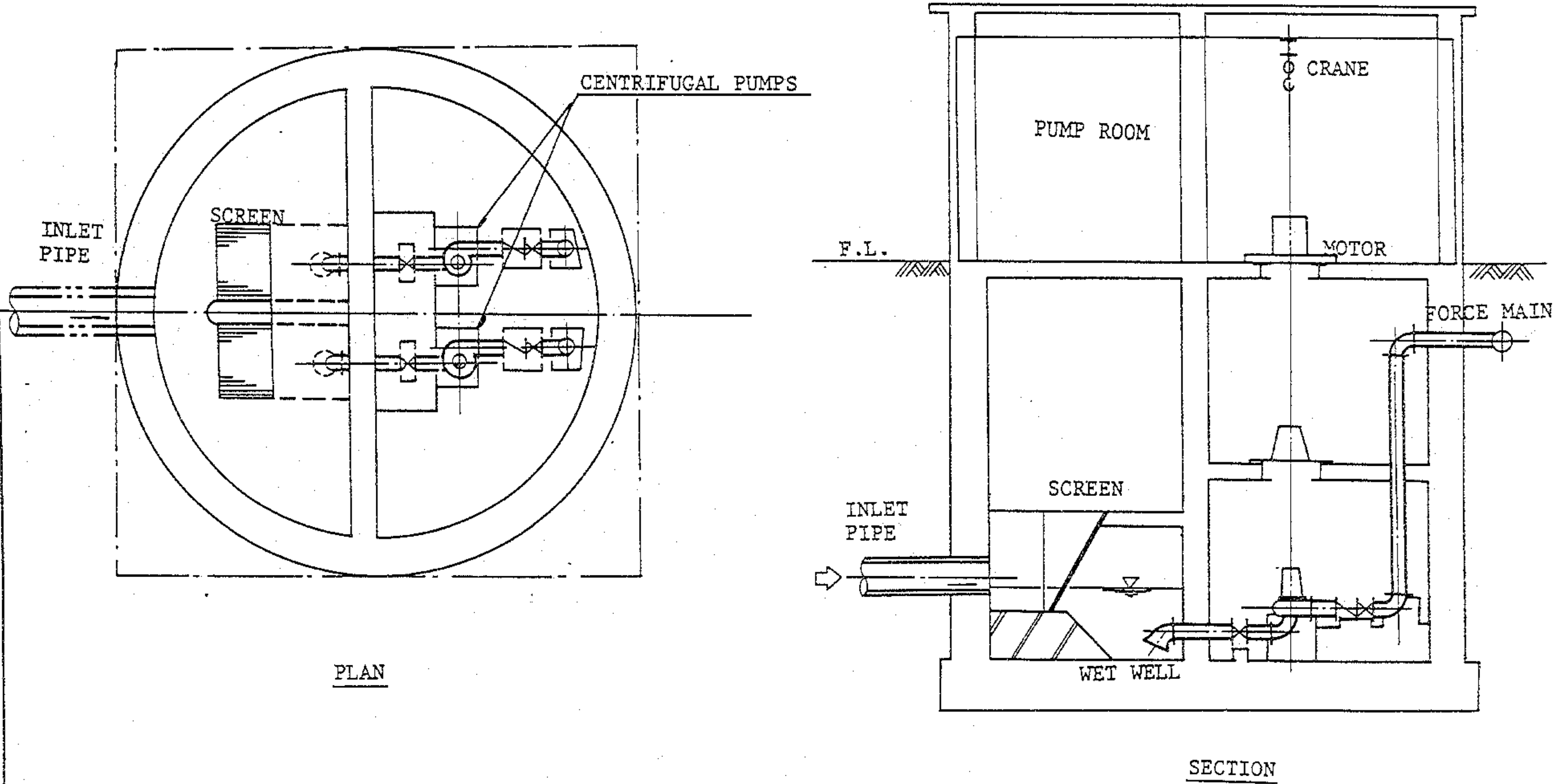


Figure VIII-8 TYPICAL STRUCTURE OF PUMPING STATION
(SUBMERSIBLE TYPE PUMP)

Table VIII-1 Design Outline of the Sewage Treatment Plants (Activated Sludge Process)

City	Design Flow (m^3/day) Daily Max./Peak	Screen and Grit Chamber	Lift Pump	Primary Sedi-mentation Tank	Aeration Tank	Final Sedimen-tation Tank	Chlorine Contact Tank	Sludge Thi-ckening Tank	Sludge Drying Beds
Faqus	20,481 27,052	W1.0xL7.5x D1.0xNos.2	-	Circular, Mechanical sludge scraper Dia.18.0xD3.5x Nos.2	Mechanical aerator W10.0xL50.0x D5.0xNos.4	Circular, Mechanical sludge scraper Dia.22.0xD3.5x Nos.2	W6.0xL20.0x D2.0xNos.1	Circular, Mechanical sludge scraper Dia.10.0xD4.0x Nos.2	Sand bed with drain W40.0xL50.0x Nos.1
Abu Kebir	26,848 36,452	W1.0xL7.5x D1.0xNos.2	Dia.350mm, 30kW, Nos.3 Well dia.12.0	Circular, Mechanical sludge scraper Dia.16.0xD3.5x Nos.4	Mechanical aerator W12.0xL72.0x D5.0xNos.4	Circular, Mechanical sludge scraper Dia.18.0xD3.0x Nos.4	W6.0xL30.0x D2.0xNos.1	Circular, Mechanical sludge scraper Dia.14.0xD4.0x Nos.2	Sand bed with drain W40.0xL60.0x Nos.1
Bilbeis	44,606 60,864	W1.2xL7.5x D1.0xNos.4	-	Circular, Mechanical sludge scraper Dia.19.0xD3.5x Nos.4	Mechanical aerator W12.0xL84.0x D5.0xNos.4	Circular, Mechanical sludge scraper Dia.22.0xD3.5x Nos.4	W6.0xL40.0x D2.0xNos.1	Circular, Mechanical sludge scraper Dia.10.0xD4.0x Nos.4	Sand bed with drain W40.0xL100.0x Nos.1
Minyet El Qamh	19,118 26,026	W1.0xL7.5x D1.0xNos.2	Dia.200mm, 11kW, Nos.3 Well dia. 10.0	Circular, Mechanical sludge scraper Dia.18.0xD3.5x Nos.2	Mechanical aerator W10.0xL50.0x D5.0xNos.4	Circular, Mechanical sludge scraper Dia.22.0xD3.5x Nos.2	W6.0xL20.0x D2.0xNos.1	Circular, Mechanical sludge scraper Dia.10.0xD4.0x Nos.2	Sand bed with drain W40.0xL50.0x Nos.1

Note: Dimensions of facilities are indicated in meters(m) and abbreviations are as follows:

Dia.: diameter W: width L: length D: depth Nos.: number

Table VIII-2 Design Outline of the Sewage Treatment Plants (Oxidation Ditch Process)

City	Design Flow (m^3/day) Daily Max./Peak	Screen Chamber	Lift Pump	Grit Chamber	Oxidation Ditch	Final Sedimentation Tank	Chlorine Contact Tank	Sludge Thickening Tank	Sludge Drying Beds
Huseiniya	7,032 8,962	-	Dia.200mm, 11kW, Nos.3 Well Dia.10.0	W0.8xL9.0xD0.8	Oval, Horizontal aerator W5.0xL130.0x D3.0x2channel xNos.4	Circular, Mechanical sludge scraper Dia.14.0xD3.0 xNos.2	W4.0xL10.0x D2.0x2channel	Circular, Mechanical sludge scraper Dia.6.0xD4.0x Nos.2	Sand bed with drain W25.0xL20.0x Nos.1
Kafr Saqr	7,915 10,244	W0.6xD0.6	Dia.200mm, 11kW, Nos.3 Well Dia.10.0	W0.8xL8.0xD1.0	Oval, Horizontal aerator W5.0xL150.0x D3.0x2channel xNos.4	Circular, Mechanical sludge scraper Dia.14.0xD3.0 xNos.2	W5.0xL9.0x D2.0x2channel	Circular, Mechanical sludge scraper Dia.6.0xD4.0x Nos.2	Sand bed with drain W25.0xL20.0x Nos.1
Abu Hammad	9,932 12,860	W0.6xD0.6	Dia.250mm, 15kW, Nos.3 Well Dia.10.0	W0.8xL10.0 xD1.0	Oval, Horizontal aerator W5.0xL130.0x D3.0x2channel xNos.6	Circular, Mechanical sludge scraper Dia.16.0xD3.0 xNos.2	W6.0xL9.0x D2.0x2channel	Circular, Mechanical sludge scraper Dia.7.0xD4.0x Nos.2	Sand bed with drain W25.0xL25.0x Nos.1
Ibrahimiya	8,532 11,460	W0.6xD0.6	Dia.250mm, 11kW, Nos.3 Well Dia.10.0	W0.8xL9.0 xD1.0	Oval, Horizontal aerator W5.0xL100.0x D3.0x2channel xNos.6	Circular, Mechanical sludge scraper Dia.15.0xD3.0 xNos.2	W5.0xL10.0x D2.0x2channel	Circular, Mechanical sludge scraper Dia.7.0xD3.5x Nos.2	Sand bed with drain W25.0xL25.0x Nos.1
Hihya	10,258 13,518	W0.6xD0.6	Dia.250mm, 15kW, Nos.3 Well Dia.10.0	W0.8xL10.0 xD1.0	Oval, Horizontal aerator W5.0xL130.0x D3.0x2channel xNos.6	Circular, Mechanical sludge scraper Dia.16.0xD3.0 xNos.2	W6.0xL10.0x D2.0x2channel	Circular, Mechanical sludge scraper Dia.7.0xD4.0x Nos.2	Sand bed with drain W25.0xL25.0x Nos.1
Diarb Nigm	12,061 16,120	W0.8xD0.8	Dia.250mm, 15kW, Nos.3 Well Dia.10.0	W1.0xL9.5 xD1.0	Oval, Horizontal aerator W5.0xL140.0x D3.0x2channel xNos.6	Circular, Mechanical sludge scraper Dia.18.0xD3.0 xNos.2	W6.0xL10.0x D2.5x2channel	Circular, Mechanical sludge scraper Dia.7.0xD4.5x Nos.2	Sand bed with drain W30.0xL25.0x Nos.1
Mashtul El Soak	9,681 12,742	W0.6xD0.6	Dia.250m, 11kW, Nos.3 Well Dia.10.0	W0.8xL10.0 xD1.0	Oval, Horizontal aerator W5.0xL120.0x D3.0x2channnel xNos.6	Circular, Mechanical sludge scraper Dia.16.0xD3.0 xNos.2	W6.0xL9.0x D2.0x2channel	Circular, Mechanical sludge scraper Dia.7.0xD4.0x Nos.2	Sand bed with drain W25.0xL25.0x Nos.1

Note: Dimensions of facilities are indicated in meters(m) and abbreviations are as follows:

Dia.: diameter W: width L: length D: depth Nos.: number

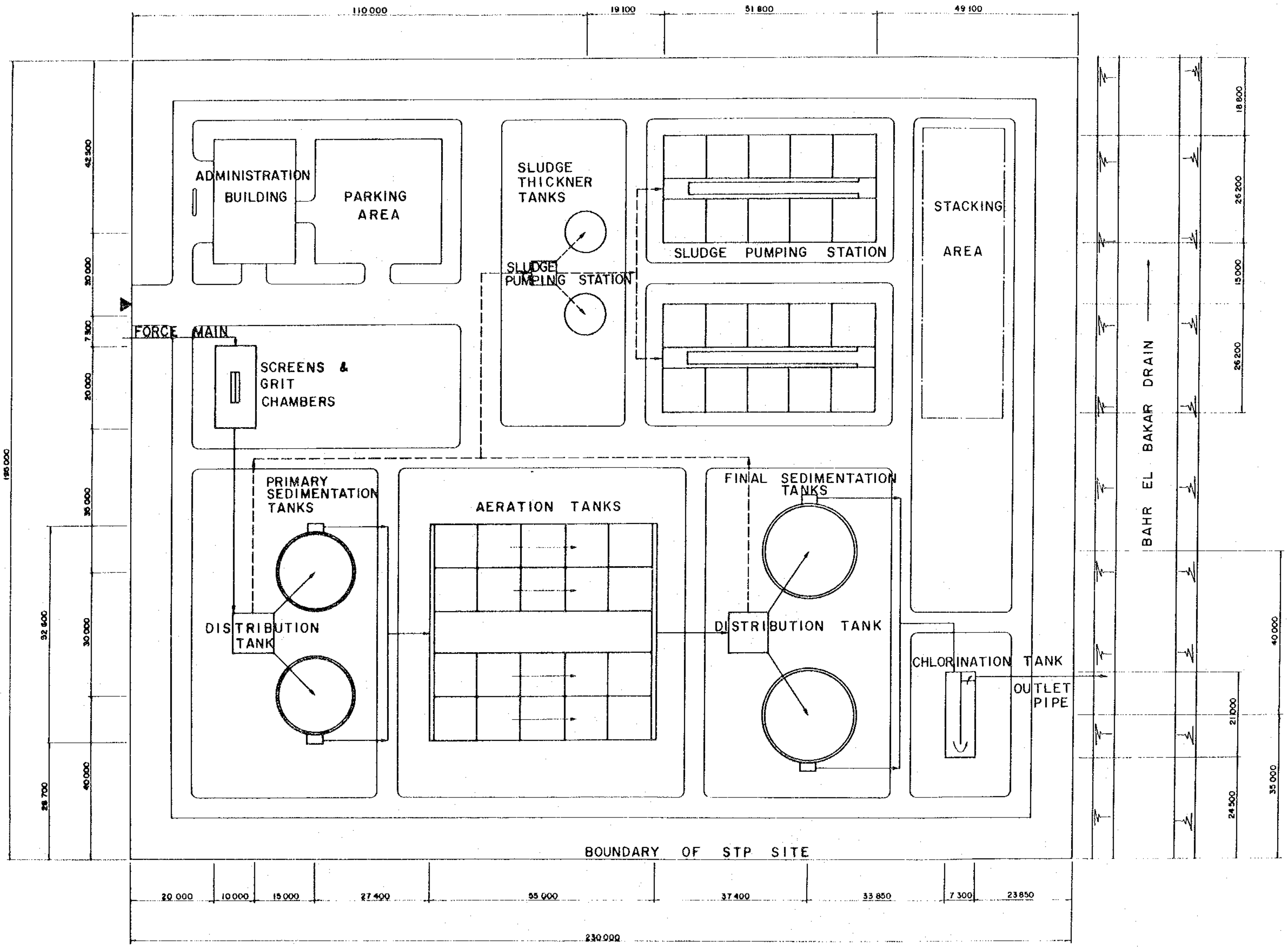


Figure VIII-9 Sewage Treatment Plant Layout Plan(Activated Sludge, for Faqus) S=1:1000

FEASIBILITY STUDY ON SHARQIYA SEWERAGE SYSTEM	DATE SEP. 1988	JICA
PROPOSED LAYOUT PLAN FOR FAQUS STP	SCALE 1:1000	DRAWIG NO. II - 22

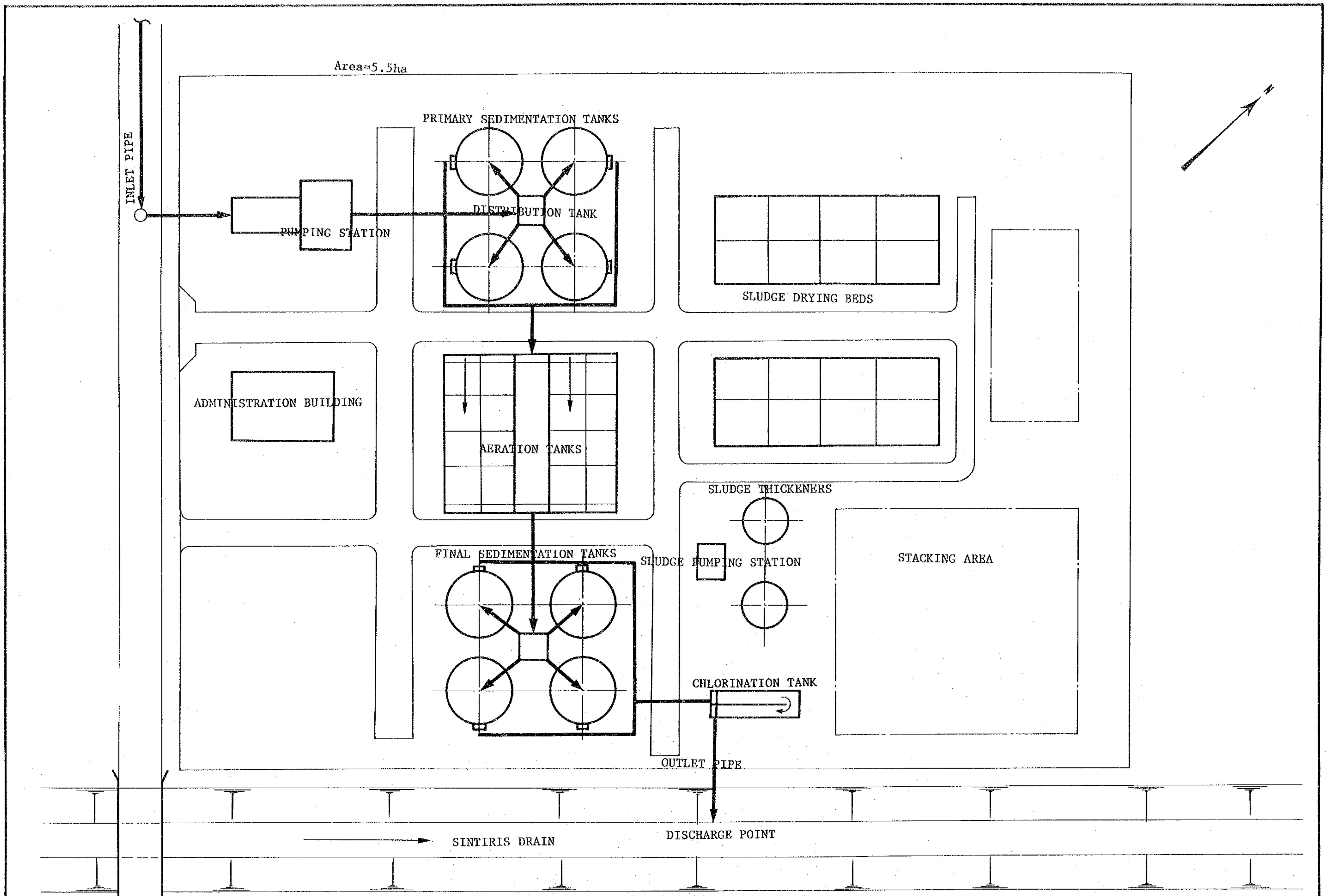


Figure VIII-10 Sewage Treatment Plant Layout Plan S=1:1000

(Activated Sludge, for Abu Kebir)

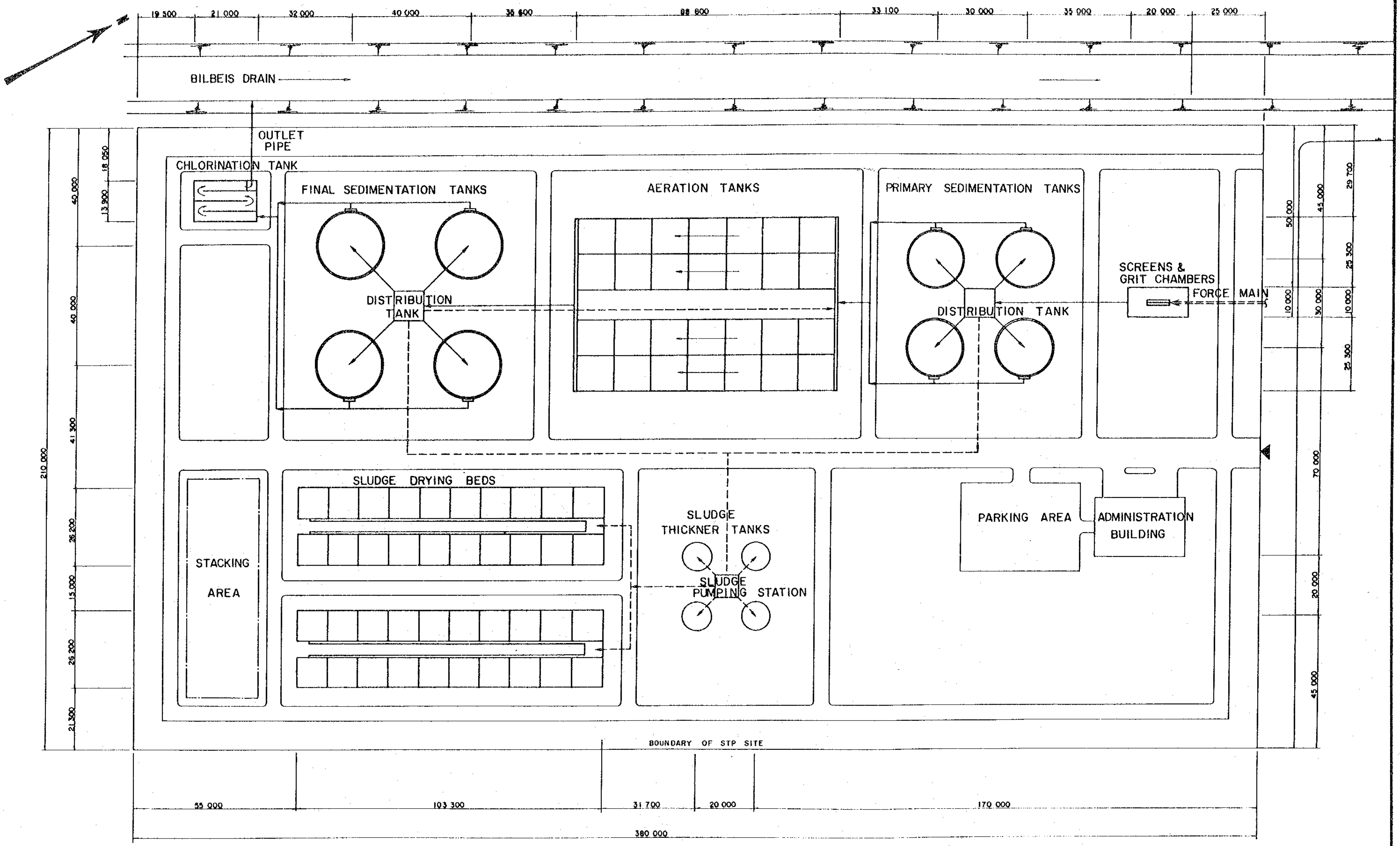


Figure VIII-11 Sewage Treatment Plant Layout Plan (Activated Sludge, for Bilbeis) S=1:1200

FEASIBILITY STUDY ON SHARQIYA SEWERAGE SYSTEM	DATE SEP. 1988	JICA
PROPOSED LAYOUT PLAN FOR BILBEIS STP	SCALE 1:1200	DRAWING NO. II - 25

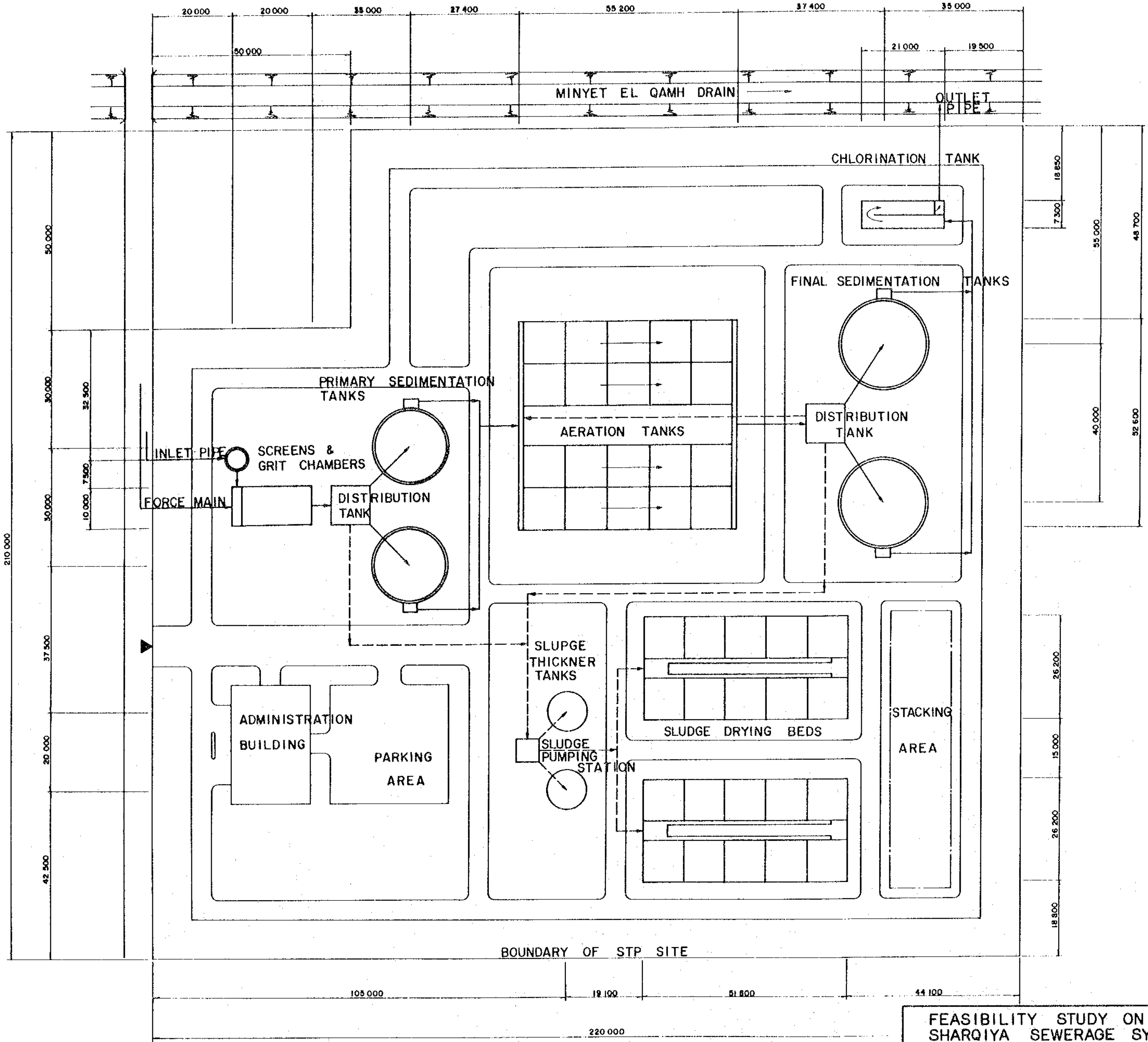


Figure VIII-12 Sewage Treatment Plant Layout Plan(Activated Sludge,for Minyet El Qamh) S=1:1000

FEASIBILITY STUDY ON SHARQIYA SEWERAGE SYSTEM	DATE SEP. 1988	JICA
PROPOSED LAYOUT PLAN FOR MINYET EL QAMH STP	SCALE 1:1000	DRAWING NO II - 28

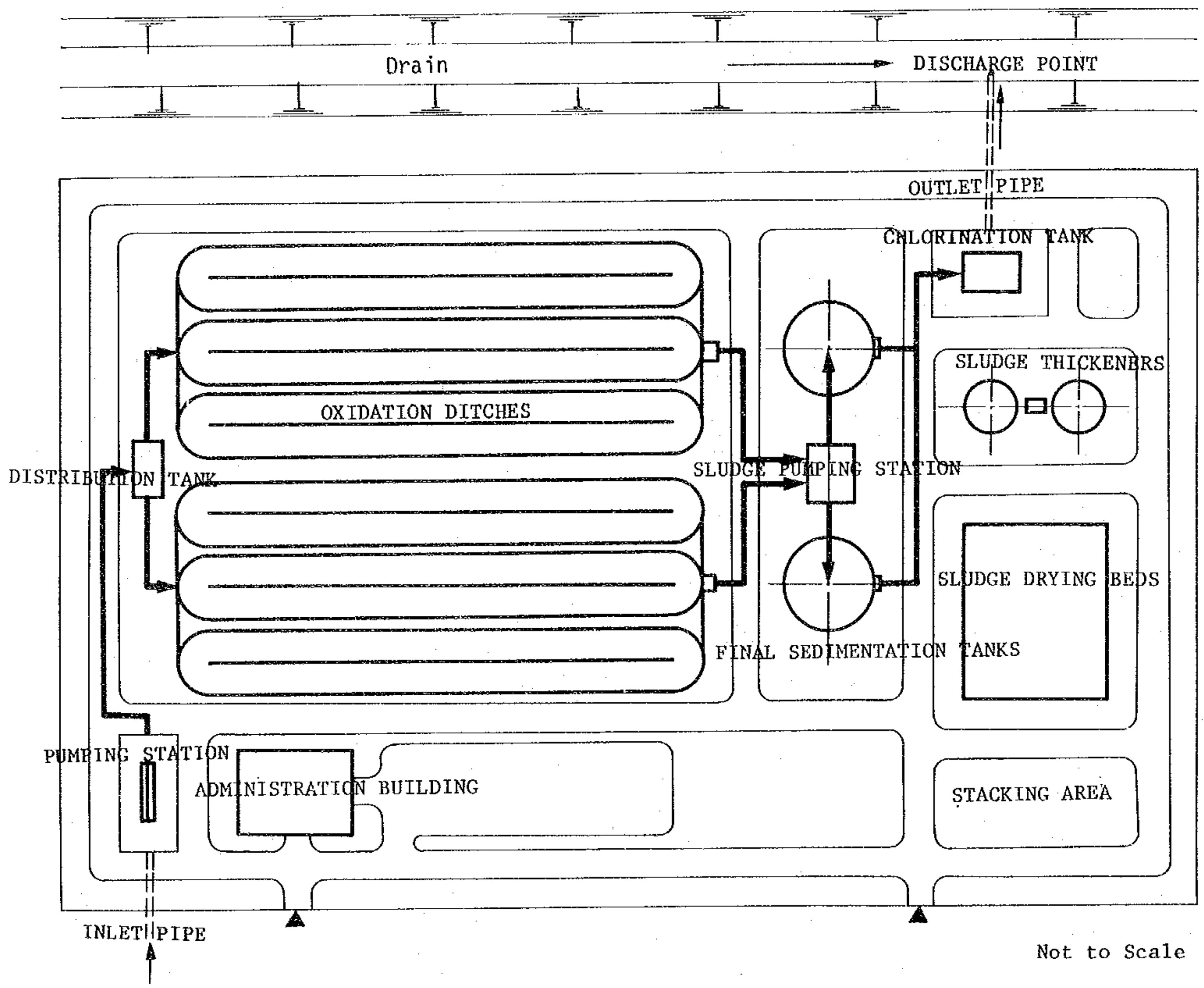
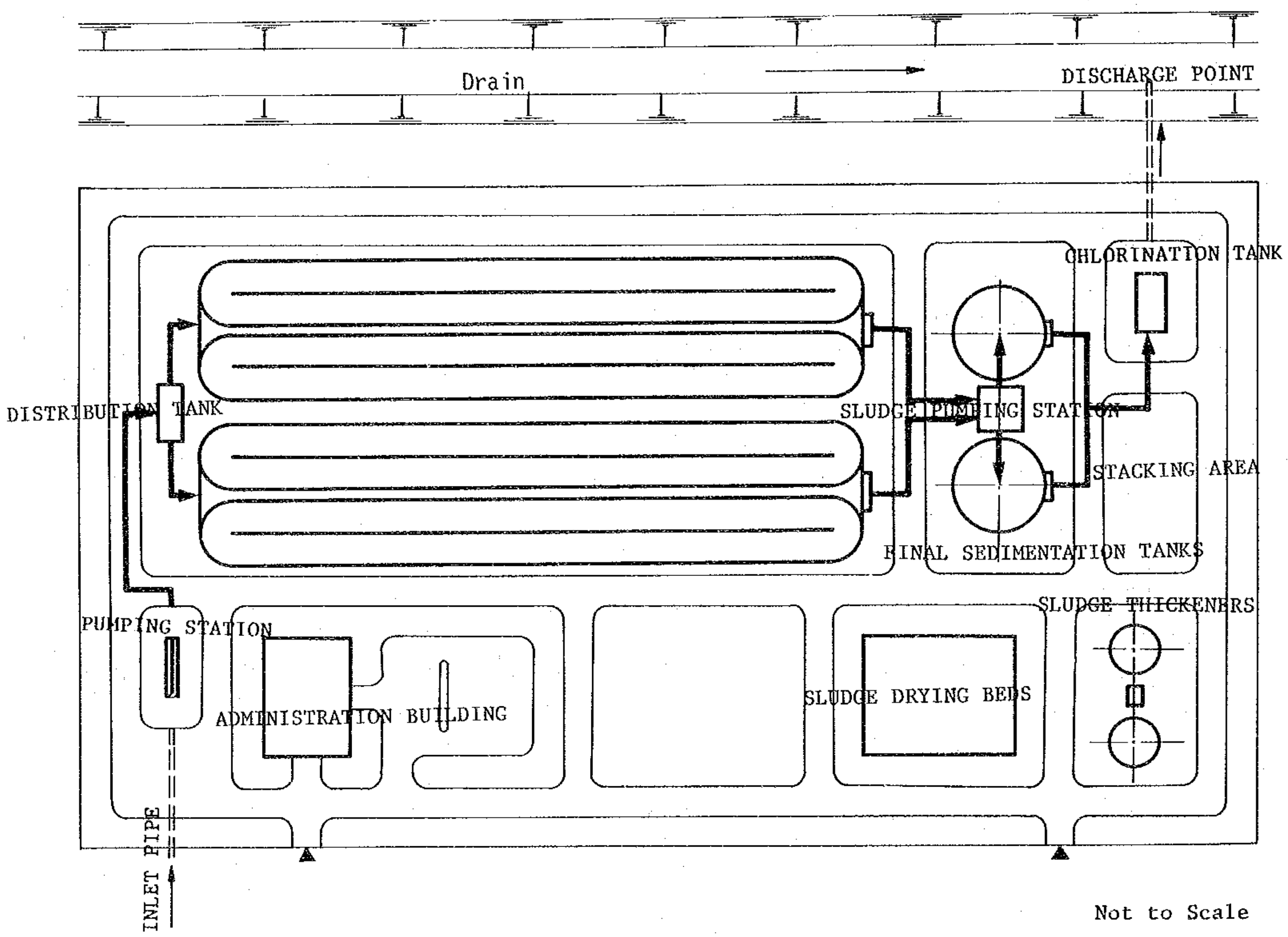


Figure VIII-13 Sewage Treatment Plant Layout Plan
(Oxidation Ditch, for Abu Hammed, Ibrahimiya, Hihya, Diarb Nigm and Mashtul El Soak)



Not to Scale

Figure VIII-14 Sewage Treatment Plant Layout Plan

(Oxidation Ditch, for Huseiniya and Kafr Saqr)

APPENDIX - IX

DESIGN CRITERIA FOR SEWERS

APPENDIX - IX

DESIGN CRITERIA FOR SEWERS

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1. Summary

In this Appendix, the design criteria necessary to design sanitary sewers in the Sharqiya Governorate are described, covering flow friction formulae, sizes of structures and facilities, hydraulics of sewers, construction materials for facilities, and measures needed for the control of sulfides. Criteria thus developed for use in the sewerage planning in Sharqiya are summarized below:

(a) The Manning formula should be used for design of pipes and channels.

(b) No public sanitary sewer shall be less than 200 mm in diameter, but for house connection pipes 150 mm in diameter may be allowed.

(c) Earth covering of public sewers should not be less than 1 meter unless special protection measures against the expected load are provided.

(d) Generally, sewer depths for branches and laterals should be less than 5 m. Those for trunk sewers should also be less than 5 m except when study demonstrates that a deeper sewer is economically more feasible.

(e) All sanitary sewers shall be so designed and constructed to give mean velocities, when flowing full or half-full, of not less than 60 cm/sec for CP or PVC, based on the Manning formula using 'n' values of 0.013 and 0.012 respectively. For RCP or any cement-bonded pipe material, for an 'n' value of 0.013, for sewers up to 300 mm size, the minimum flow velocity should be 75 cm/sec, and for larger sizes, the design velocity should be determined using appropriate procedure for hydrogen sulfide control.

(f) For sanitary sewers, full pipe capacity for the design peak flow should be provided.

(g) Minimum sewer slopes for different sewer pipe sizes are recommended, so that in no case the velocity of flow will be less than 75 cm/sec for AC and concrete pipes, and 60 cm/sec for CP and PVC.

(h) Sewers should generally be laid with straight alignment between manholes. Exceptions (curvilinear alignment) should be allowed only when there is assurance the available cleaning methods will be workable in the curved sections.

(i) When a smaller sewer joins a larger sewer, the crown of both sewers should be placed at the same elevation.

(j) Sanitary sewers of smaller size up to 400 mm in diameter should normally be of either clay or PVC pipes, assuming these materials are available at reasonable cost. For larger size sewers of 30 inch (762 mm) to 50 inch (1270 mm) in diameter, clay or concrete pipe should be used. For sewers larger than 50 inch in diameter, centrifugally-cast reinforced concrete pipes conforming to internationally accepted standards, should be used.

(k) Joints of concrete pipe may be rubbergaskets, when this type of joints become available.

(l) Manhole spacing should not be more than 200 m.

2. Design Factors

In determining the required capacities of sanitary sewers, the following factors should be considered:

(a) Peak flow rate of sewage.

(b) Groundwater infiltration where the groundwater table is high.

(c) Depth of excavation.

(d) Pumping requirements.

(e) Design velocities needed to assure self-cleaning and prevention of sulfide build-up.

3. Flow Friction Formulae

For determining sewer capacities, a wide variety of equations have been developed. Among the equations widely used are:

(a) The Chezy and Darcy-Weisbach equation

(b) The Manning equation

(c) The Kutter equation, and

(d) The Hazen-Williams equation.

The Kutter and the Manning equations are most widely used for pipes and conduits of all shapes, flowing either full or partly full. Although the use of the Kutter equation has been extensive and the graphs and tables for the equation are available, its popularity is declining because of its empirical and cumbersome nature. The Manning equation tends to be used very extensively, because of its simplicity and because the 'n' value is essentially the same as used in Kutter's equation.

A comparison was made between the velocities of circular pipes calculated by means of three different equations namely; Kutter, Manning, and Hazen-Williams. The velocities for full flow in sewer pipes from 200 mm to 2,000 mm in diameter were calculated using a friction coefficient 'n' value of 0.013 for the Kutter and Manning equations, and a 'C' value of 110 for Hazen-Williams which corresponds to 'n' value of 0.013.

As shown in Table IX-1, the results of the calculations indicate that the velocities given by the three equations are essentially the same, with some minor variations. In smaller sewers, the Kutter's equation gives the lowest values, but the values become practically the same as the sewer size increases, and the order is then reversed for the larger sewer pipes. It is not possible to judge the adaptability of the equations by such calculations; however, it is clear that Manning's equation gives intermediate values, hence appears to be the best choice for general application and has been adopted for use on this project.

Table IX-1 Comparison of Flow Velocities in Pipes Calculated by Different Formulae

(Unit: m/sec)

Pipe dia.	Pipe slope (1)	Kutter (n=0.013)	Manning (n=0.013)	Hazen-Williams (C=110)
200mm	0.0055	0.706	0.774	0.852
250mm	0.0045	0.760	0.813	0.880
300mm	0.0040	0.770	0.865	0.927
350mm	0.0035	0.865	0.897	0.950
400mm	0.0030	0.885	0.908	0.951
450mm	0.0026	0.898	0.914	0.948
500mm	0.0024	0.932	0.942	0.970
600mm	0.0019	0.945	0.947	0.959
700mm	0.0016	0.968	0.963	0.963
800mm	0.0014	0.994	0.984	0.975
900mm	0.0012	0.998	0.986	0.966
1,000mm	0.0011	1.028	1.012	0.985
1,200mm	0.0009	1.053	1.034	0.939
1,500mm	0.0007	1.078	1.058	0.996
1,800mm	0.0006	1.126	1.106	1.029
2,000mm	0.0006	1.208	1.187	1.099

Note: (1) Slopes for sanitary sewers are selected for the comparison to give a minimum flow velocity of more than 75 cm/sec and gradual increase as diameter increases.

In view of these facts the Manning equation is recommended for the design of sewers and channels. The equation is expressed as;

$$v = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

where: v=velocity, m/sec

n=coefficient of roughness

R=hydraulic radius, m

S=slope

Care shall be paid in selecting the friction coefficient. In general, 'n' values from 0.010 to 0.015 are used in sewer design, depending upon the type of joint and the pipe material. Table IX-2 is a summary of friction coefficients for different sewer materials for use with the Manning formula.

Table IX-2 Values of 'n' to be used with the Manning Equation

Conduit Materials	Manning n Value
1. Closed Conduits	
Asbestos-cement pipe	0.010 - 0.105
Brick	0.013 - 0.017
Cast iron pipe	
Cement-lined & seal coated	0.011 - 0.015
Concrete (monolithic)	
Smooth forms	0.012 - 0.014
Rough forms	0.015 - 0.017
Concrete pipe	0.011 - 0.015
Plastic pipe (smooth)	0.011 - 0.015
Vitrified clay pipe	0.011 - 0.015
2. Open Channels	
Lined channels	
Brick	0.012 - 0.018
Concrete	0.011 - 0.020
Vegetal	0.030 - 0.040
Excavated or dredged	
Earth, straight and uniform	0.020 - 0.030
Earth, winding, fairly uniform	0.025 - 0.040
Rock	0.030 - 0.045
Unmaintained	0.050 - 0.140
Natural channels (minor streams, top width at flood stage 100 ft)	
Fairly regular section	0.030 - 0.070
Irregular section with pools	0.040 - 0.100

Note: WPCF Design Manual of Practice No. 9 (1970)

4. Sewer Design and Construction

4.1 Minimum Size of Sewer

The adoption of a minimum size of sewer is necessary, because experience has shown that comparatively large objects, such as sand, stone, scrub brushes, and also tree roots, sometimes get into sewers and that stoppage resulting from them is much less likely if sewers are not smaller than 200 mm. Smaller pipes experience more frequent troubles in cleaning of settled debris, roots, etc., especially where slopes are minimal.

Another factor to be considered for determining the minimum size of sewer pipe is construction cost, which may be affected by the depth of branch and lateral sewers. If the branch and lateral sewers are to be laid at a steeper gradient, the cumulative effect in the level of trunk and outfall sewers will become deeper. For example, to keep the velocity of flow more than 0.75 m/sec, using the Manning formula with an 'n' value of 0.013, the slope of 200 mm pipe must be 0.0055 while for a 150 mm pipe the slope is 0.0076, and the difference of depth is 2.1 m per km of sewer length. This deeper level of sewers not only increases the cost of excavation as the trenches are wider and deeper for trunk and outfall sewers, but also to the power cost as it involves lifting of the sewage from a greater depth.

For the reasons mentioned above, the minimum size of sanitary sewers in Sharqiya, except house connections, should be 200 mm. For house connections, smaller sizes may be used; however, house connection pipes should be larger than the building sewers, so that articles which pass through the building sewers may readily pass through the building connection pipes. Experience shows that a diameter of more than 150 mm is usually satisfactory for house connection pipes, except for large buildings which have terminal pipes of more than 150 mm in diameter.

4.2 Minimum Depth of Sewer

Enough earth covering should be made between the top of the sewer and the bottom of paved surfaces to protect the sewers from traffic loads and to avoid undue interference with other underground facilities. The minimum allowable cover may depend on the size of pipe, soil conditions, pavement and traffic loads.

A computation was made to check the effect of earth covering on centrifugally-cast-reinforced-concrete pipes. The calculation indicates that for one meter of earth covering under a 20 ton truck load, pipes laid on continuous concrete cradle bedding will be capable of supporting the load. It was concluded that it is reasonable to use at least one meter of earth covering for sewer pipes.

Another factor, to be considered in deciding the required earth covering for public sewer pipes, is the length and slope of private sewers to be connected. Where the private sewers are deep, it may be more economical to pump from the buildings than to lower the public sewers to such depths. Deeper house sewers may be due either to low terrain or because the houses are located far from the street.

An estimate was made to check the depth of private sewer pipes. At a house, with a plot of 25 meters of frontage and depth, assuming an average slope of pipe at 2 percent and minimum earth covering at the starting point of the sewer as 30 cm, the minimum earth covering of the public sewer would be 1.3 meters to receive the sewage from the remotest point of the house by gravity.

In view of the above results, it is recommeded that the earth covering of public sewers be not less than one meter except of specific situations where studies show that shallower depths are feasible.

4.3 Velocity of Flow

(a) Minimum Velocity

Sewage should flow, at all times, with sufficient velocity to prevent the settlement of solid matter and consequent loss of sewer capacity. This is particularly important in Sharqiya because of its flat terrain. The most significant factors to be considered are discussed below:

i) The commonly accepted minimum velocity for self-cleansing of sanitary sewers is 60 cm per second. A velocity of 60 cm per second can prevent most deposits of solids in sewers. The velocity of 60 cm per second in 250 mm sewer pipe can transport sand of 0.012 cm diameter, a size greater than most particles in sanitary sewers.

ii) Ground surface slopes in the area are generally flat. Sewer slopes are generally steeper than the ground surface slopes and sewers will become deeper, and costs for construction will be significantly increased if higher minimum velocities are used. A minimum slope for 200 mm sewer pipe to give a flow velocity of 60 cm per second is 0.35 percent, based on an 'n' value of 0.013, but for 75 cm per second, 0.55 percent is necessary. In case ground surface slope is very flat, the difference of construction cost is significant.

iii) An important consideration in selecting the design flow velocities for sanitary sewers in regions of warm climate is the problem of deposition of solids and generation of sulfides because of the high temperatures. This is especially important where concrete or other cement-bonded pipe is used as the sewer material, because unless solid deposition is controlled the sulfides will attack and dissolve the cement which binds the pipe material together, so that sooner or later the pipe may be suffer structural failure. Experience with this problem in other countries has shown that the most effective method of sulfide control is to use a design velocity at average flow not less than 75 cm/sec, and preferably more. At velocities of 75 cm/sec or more, the reoxygenation capacity of the flow will neutralize sulfide generation and also virtually eliminate deposition.

For purposes of final design, more precise methods should be used for evaluating the sulfide hazard (which is a function of BOD and temperatures as well as flow velocity) on a case by case basis, but the general rule noted above should be sufficient for master plan purposes. Another solution to the sulfide problem, where concrete or other corrodable materials are used, is to protect the pipe with suitable linings or coating.

iv) For final design of all concrete sewer mains (or other cement-bonded pipe), each situation should be analyzed on a case by case basis to ensure that for each such case the design flow velocity will be sufficient to prevent sulfide generation and accumulation for the particular case.