CHAPTER 9 ESTABLISHMENT OF THE SEWERAGE DEVELOPMENT MASTER PLAN

9.1 Basic Condition for Master Plan

9.1.1 Target Year

One of Japan's most highly authoritative design guideline entitled, "Design Guidelines for Sewerage System" prescribes that the target year for a sewerage development plan shall be set approximately 20 years later than the current year. This is due to the following reasons:

- The useful life of both the facilities and the construction period should extend over a long period of time;
- Of special significance to sewer pipe construction is the phasing of the capacity strengthening. This should be based on the sewage volume increase although this may be quite difficult to track;
- Therefore, the sewerage facility plan shall be based on long-term prospect, such as the long-term urbanization plan.

In as much as this study started in November 2006, the year 2006 can be regarded as the "present" year. Though 20 years after 2006 is 2026, this was correspondingly adjusted as 2025. Hence, the year 2025 was adopted as target year for this Study.

9.1.2 Sanitation System / Facilities

The abovementioned guideline describes "service area" as the area to be served by the sewerage system, as follows:

- Since the service area provides the fundamental condition for the sewerage system development plan, investment-wise, the economic and O&M aspects shall be dully examined upon the delineation of the area.
- The optimum area, the area where the target pollution reduction can be achieved as stipulated in theover-all development plan, shall be selected carefully.
- Basically, the service area is the area of advantage that will be served by the centralized sewerage system based on the level of urbanization and the conditions obtaining in the surrounding communities in the target year.

The development of the sewerage system in Syria has just started and by and large, only the development of the sewer network has proceeded without the benefit of the over-all development plan. This resulted in the pollution of public water bodies that have been receiving the discharged raw sewage.

As mentioned earlier, the service area is the area of advantage to be served by the centralized sewerage system. Its condition corresponds to those conditions obtaining in urbanized areas where large populations reside in densely constructed housing settlements. Options are available to integrate the treatment of sewage generated by communities located near the urban area, and send these to the existing pipe network of the urban area through connecting sewer pipes. It will thus form part of the integrated sewage treatment by STP in the subject urban area. However, this option is only applicable if it is deemed advantageous by economical standards. The prerequisite is the existence of a huge number of communities that are unserved.

Sewage generated in these communities shall be properly treated as well. On-site system development is applicable in these cases. The on-site system can be divided into two methods, namely 1) Pit Latrine and 2) Septic Tank. The Pit Latrine is a bare ground pit dug into the ground. As most of them are not concrete-lined, there is risk of groundwater contamination is high if the ground has a high permeability. The typical on-site system prevalent in Syria is the Pit Latrine but as stated, but since it bears the potential risk of groundwater contamination, the method shall be converted into the Septic Tank method with less effluent pollution load.

Generally, the Septic Tank is comprised of two adjoining compartments made of concrete. Solids settle at the bottom of each compartment and are digested in anaerobic condition and the scum layer takes form on the surface. Solid sediments will decrease volumetrically but as part of the solids will be accumulated, the periodic removal of sludge should be undertaken at least once every five years, is necessary. Since the effluent collected cannot be discharged without any treatment, it shall be discharged into the soak pit or soak ditch. Absorption by plants will be effective as well.

9.1.3 Sewage Collection System

The guideline forwards that the “Sewage collection method shall be a separate system, in general. However, if the appropriate countermeasures are taken for the purpose of coping with conditions in the receiving water body, the combined system can be adopted.” The comparison between the Combined System and Separate System is shown in **Table 9.1.1**:

Table 9.1.1 Comparison of Combined System and Separate System

Items		Combined Sewerage System	Separate Sewerage System
Construction Work	Workability	As sewage and storm water is collected by means of one sewer, construction work is easy, posing no hindrance to other underground construction. The pipe diameter is larger that those of separate system.	As sewage and storm water is collected by two sewers respectively, construction work will be difficult in narrow streets. Since the diameter of the sewage pipe is small and its slope is large, pipe installation depth may become large in turn.
	Cost	Cheap, as sewage and storm water is collected by one sewer.	If the sewer for both sewage and storm water is constructed, the cost will be expensive. If only the sewer is constructed, the cost will be less.
O&M	In-pipe sediments	As the diameter is large and the in-pipe velocity is small, settlement is apt to occur. Sediments will be flushed by storm water.	As to the sewer pipe, its volume is comparatively small. As to the storm water drainage pipe, settlement is apt to occur as in the case of the Combined System. Sediments will be flushed by storm water.
Operation and Maintenance	Soil, sand intrusion	Intrusions mainly originate from road surfaces. This causes the defacement of the machinery and sand sedimentation.	Less in sewer pipe. In case of storm water drainage pipe, some soil and sand intrusion is observed.
	Inspection, Cleaning	As the diameter is large, inspection is made easier but in the case of super large diameters, cleaning may be difficult.	As to the sewer pipe, clogging may occur due to its small diameter but cleaning is easy. As to the storm water drainage pipe, the same conditions prevail as in the Combined System.
	Mis-connection of storm drainage facilities	None	Shall be duly guided. This might cause inundation during rains.
Water Quality Preservation	Combined Sewer Overflow	As pollutant overflows into the water bodies, there is a high risk of water pollution and environmental degradation. Proper countermeasure for combined sewer overflow is needed.	None
	Pollution load of Non-point Source	Collection and treatment of initial turbid storm water is possible. Incoming volume exceeding the capacity of the interceptor pipe will be discharged into water bodies without any treatment.	Storm water is discharged into water bodies without any treatment.
Land Use		Since the existing drainage gutter will be abolished, the resultant road widening and use will be beneficial	Storm water drainage gutter may remain.

The guideline indicates the adoption of a Separate Sewerage System in principle, considering the combined overflow of sewer into public water bodies and the load increase in the STP.

In Syria, the Combined Sewerage System has been adopted and has been implemented in many cities, towns and villages. The annual rainfall in Syria varies by Governorates and ranges widely from as high as 800 mm/year at the Mediterranean Coastal Area to as low as 200 mm/year at the Rural Damascus Governorate. Except for the Mediterranean Coastal Area, the annual rainfall is not heavy enough to require planning for a storm water overflow chamber to mitigate the wet weather sewage volume flowing into the STP, as this seems much less. Meanwhile, the storm water overflow chamber shall be planned because the projected storm water volume may not be negligible owing to the heavy annual rainfall. As mentioned above, the proper countermeasure for the combined sewer overflow should be definitely taken to reduce the discharge of the pollution load into the public water bodies. Furthermore, the replacement of deteriorated pipe network is preferably desirable.

9.1.4 Summary of Design Sewage Flow and Design Sewage Quality

(1) Design Service Population

Table 9.1.2 shows the design service population in seven designated districts in the seven prioritized Governorates for Master Plan preparation:

Table 9.1.2 Design Service Population in Seven Designated Districts in Prioritized Governorates for Master Plan Preparation

(Unit : person)

Governorate	District	Sub -district	City & Town	2004	2010	2015	2020	2025
Lattakia	Total			2,534	2,600	2,700	2,800	2,800
	Al-Haffeh	Slunfeh	Slunfeh	1,847	1,900	2,000	2,100	2,100
			Biereen	687	700	700	700	700
Tartous	Total			43,647	54,300	64,200	74,700	85,600
	Banias	Banias	Banias	41,632	52,100	61,700	71,900	82,500
			Tero	838	900	1,000	1,100	1,200
			Khabet Snasel	645	700	800	900	1,000
			Boston Al-Najor	532	600	700	800	900
Deir -Ez zor	Total			60,175	80,400	95,400	107,600	117,100
	Mayadin	Mayadin	Mayadin	44,028	60,200	72,400	82,400	90,300
			Taiba	6,061	7,600	8,700	9,500	10,100
			Makhan	10,086	12,600	14,300	15,700	16,700
Hassakeh	Malkieh	Malkieh	Malkieh	26,311	29,100	31,200	33,000	34,500
Raqqa	Thawra	Thawra	Thawra	69,425	80,300	90,700	102,400	115,600
Dar'aa	Total			30,536	35,600	39,600	43,100	46,200
	Dar'aa	Dar'aa	Atman	8,929	11,400	13,200	14,600	15,700
		Muzerib	Muzerib	12,640	14,200	15,500	16,700	17,900
			Yaduda	8,967	10,000	10,900	11,800	12,600
Rural Damascus	Total			47,737	54,000	58,700	62,700	66,100
	Zabadani	Zabadani	Zabadani	26,285	30,000	32,800	35,200	37,300
			Bloudan	3,101	3,300	3,400	3,500	3,600
			Rawdah	4,536	6,000	7,100	8,000	8,700
			Hosh Bajet	604	700	800	900	1,000
		Madaya	Madaya	9,371	9,800	10,100	10,400	10,600
			Bukein	1,866	1,900	2,000	2,000	2,000
		Serghaya	Ain Hour	1,974	2,300	2,500	2,700	2,900

(2) Design Sewage Flow

The design sewage flow was calculated by multiplying the design service population by the per capita sewage rate. **Table 9.1.3** shows the daily average sewage flow in seven designated districts. The daily maximum sewage flow and hourly maximum sewage flow is shown in the Master Plan of each district.

Table 9.1.3 Daily Average Sewage Flow in Seven Designated Districts

(Unit : m^3/day)

Governorates	District	Sub -district	City & Town	2004	2010	2015	2020	2025
Total								
Lattakia	Total			1,383	1,489	1,620	1,757	1,833
	Al-Haffa	Slunfeh	Slunfeh	1,008	1,088	1,200	1,318	1,375
			Biereen	375	401	420	439	458
Tartous	Total			8,273	10,834	13,429	16,346	19,556
	Banias	Banias	Banias	8,053	10,582	13,129	15,995	19,151
			Tero, Snasel,Najor	220	252	300	351	406
Deir-Ez-zor	Total			7,440	10,466	13,031	15,383	17,483
	Mayadeen	Mayadeen	Mayadeen	5,678	8,152	10,270	12,220	13,974
			Taiba	661	871	1,044	1,192	1,323
			Makhan	1,101	1,444	1,716	1,970	2,187
Hassakeh	Malkieh	Malkieh	Malkieh	2,871	3,334	3,745	4,141	4,518
Raqqa	Thawra	Thawra	Thawra	8,953	10,873	12,866	15,186	17,889
Dar'aa	Total			3,332	4,079	4,753	5,409	6,050
	Dar'aa	Dar'aa	Atman	974	1,306	1,584	1,832	2,056
		Muzerib	Muzerib	1,379	1,627	1,860	2,096	2,344
			Yaduda	978	1,146	1,308	1,481	1,650
Rural Damascus	Total			14,546	17,176	19,498	21,709	23,851
	Zabadani	Zabadani	Zabadani	10,169	12,187	13,959	15,661	17,317
			Bloudan	1,354	1,512	1,632	1,757	1,886
			Rawdah	495	687	852	1,004	1,139
			Hosh Bajet	66	80	96	113	131
		Madaya	Madaya	1,534	1,684	1,818	1,958	2,082
			Bukein	713	762	840	878	917
		Surghya	Ain Hour	215	264	300	339	380

(3) Design Sewage Quality

As described in the previous section, (7.4.2 Wastewater Quality), the design sewage quality of domestic sewage was established based on the pollution load and verified by the existing data and results of the sewage quality survey conducted in the course of the Study. Refer to **Table 9.1.4**.

Table 9.1.4 Design Sewage Quality

Water Quality Indices	Design Sewage Quality (mg/l)
BOD	310
SS	360
T-N	74
T-P	24

9.1.5 Sewage Treatment Method

9.1.5.1 External Conditions for Sewage Treatment Method

(1) Incoming Sewage Quality

Incoming Sewage Quality is one of the most important external conditions. As described in previous sections (7.4.2 2) Design Sewage Quality), a BOD concentration of 310 mg/l is approximately 1.5 times the standard Japanese sewage quality. Therefore, the tank capacity and oxygen requirement will become 1.5 times the Japanese examples.

(2) Sewerage Flow for STP Design

Japanese design standard has description that STP facilities shall be designed based on daily maximum sewage flow. In this study, daily maximum flow and hourly maximum flow was established based on daily average flow. However, as sewage flow estimated in this study has many indefinite factors and it is quite different from sewage flow estimated based on numerous existing data, it shall be examined whether STP facility design based on daily maximum flow is feasible in Syria. Accounting the following items into consideration, STP facility design by daily average flow was judged as appropriate to avoid excessive design and to realize effective and economical facility design:

- As tourism sewage flow was estimated without any actual flow measurement or any existing ground-data, STP facility design shall be carefully conducted to avoid excessive design.
- Water consumption rate is quite limited due to water source restriction. Generally precipitation is also small depends on areas and therefore, annual incoming sewage flow fluctuation is relatively small compared to Japan.
- By adoption of low-loaded system such as OD method, stable treatment against fluctuation in incoming sewage rate is ensured. In this study, 40 hours of retention time was secured owing to the high concentration of design sewage quality and to the restriction of BOD-SS loading.

STP facility design by other donor agencies also adopted daily average sewage flow

(3) Effluent Standards

Effluent standards for treated sewage shall be established depending on the status of the receiving water bodies and the usage of the treated effluents. The conditions of setting effluence standard vary in the different Governorates, for example;

- As the contamination of groundwater is in an advanced state in Rural Damascus, the effluent standard in Zabadani shall be set up to enable the re-use of treated sewage for irrigating vegetable farms. However, if treated sewage is to be discharged into the river, the standard of SS 30 mg/l shall be applied. This level is more stringent than the 50 mg/l applied for treated wastewater to be used for irrigating vegetable farms.
- In Muzerib, groundwater is abundant and commonly used for irrigation. Therefore, the treated sewage is discharged into the river and the corresponding stringent effluent standard should be considered.
- In Slunfeh, Thawra and Mayadin, treated sewage is discharged into the river as well.
- In Malkieh, the treated sewage is applied to the irrigation of cotton and industrial crops. The effluent standard for the irrigation of industrial crops is BOD 150 mg/l which is slacker than the 30mg/l for discharge to river. Therefore, the effluent standard for the discharge of effluents into the river shall be applied.

Refer to **Table 9.1.5**:

Table 9.1.5 Example of Effluent Standard (Unit : mg/l)

M/P Area	Discharge mode to water-body / Condition of re-use	Maximum Allowed Limited effluent standard from STP			
		BOD	SS	NH_3-N	NO_3-N
Zabadani	Irrigation (vegetable)/river	30	30	3	20
Muzerib	River	40	30	5	50
Slunfeh	River	40	30	5	50
Banias	Sea	60	60	10	50
Thawra	River	40	30	5	50
Mayadin	River	40	30	5	50
Malkieh	River /Irrigation (Industrial crops)	40	30	5	50

(4) Treatment Method related to Duty Time

Mainly, life in Syria centers on the family, and working time falls between 8:00 a.m. to 15:30 p.m. Most of the STP operators return home in the evening, which is also the peak time of incoming sewage flow. In the Adraa STP, some engineers continue working at the STP in the evening for the purpose of doing equipment repair as required. In evaluating the treatment performance, composite samples are collected every three hours by workers and handed over to the laboratory in the morning for analysis. Although the engineers evaluate the average treated sewage quality on a daily basis, they cannot evaluate the detailed treatment performance during peak hours under the current lifestyle practices.

The labor environment is thus traditionally oriented toward attaining the desirable family centered life. To maintain this labor environment and to achieve operational responsibility during peak flow time, the adoption of treatment processes requiring simple and lesser units of equipment and processes with long retention time is preferable. In Japan, the Oxidation Ditch Method with long retention time and a simplified treatment process is widely applied. Routine O&M is executed during daytime and the plant is operated without operators at night.

(5) Issues on Manpower Securing and Remarks on Sewage Treatment Method Selection

Currently, the number of plant operators is quite insufficient in Syria. Therefore, the human resources management should be strengthened in the following manner to ensure the presence of O&M engineers for new STP:

- Generate surplus engineers by re-structuring the O&M staffing at existing STPs
- Introduction of simplified sewage treatment methods

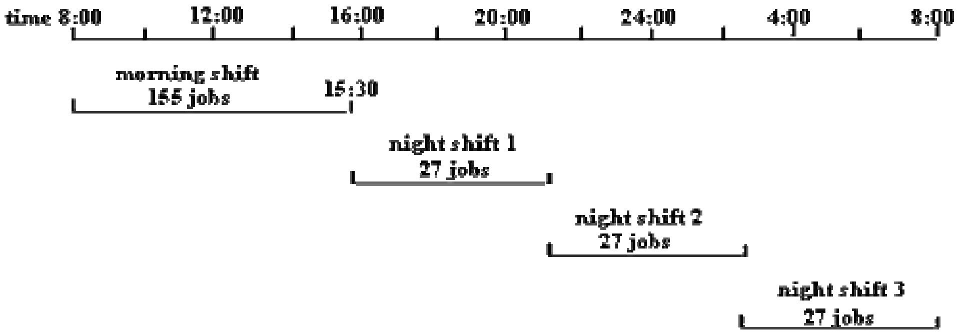
At the Adraa STP, more than 200 O&M staff members are working everyday and repair works are executed even during nighttime. Therefore, it seems possible to transfer some engineers to other STPs by improving the working efficiency of O&M activities. Refer to **Table 9.1.6**:

Since O&M cost, especially labor costs, contribute a large percentage to the total project cost, the use of simplified sewage treatment processes, when adopted, could reduce the total project cost. Simple treatment processes facilitate the smooth performance of O&M, thereby improving the labor and management environment. Therefore, simplified treatment processes with easy O&M activities shall be employed for the new STPs even if their construction costs are little more expensive.

Table 9.1.6 Manpower and O&M Shift in Adraa STP

Department	morning shift	night shift 1	night shift 2&3
Operation	22	12	23
Mechanical	21	1	3
Gas	10	2	4
Electricity	10	2	4
Electronic	4	1	2
Storage	9		
Agriculture	20		
Administration	14		
Laboratory	8		
Guard	8	8	15
Vehicle	19	1	3
Civil maintenance	10		
Total	155	27	54

Note) schedule



(6) Temperature

There are several sewage treatment methods with easy O&M activities, and these are the Stabilization Pond Method, the Trickling Filter Method, and the Gravel Contact Oxidation Method. However, as the treatment performance of each of these processes is largely affected by temperature, temperature stands as one of the most important design conditions.

The performance of the Trickling Filter and Gravel Contact Oxidation methods are affected by temperature over a certain number of days. On the contrary, the performance of the Stabilization Pond with long retention time is affected by the Monthly Average Temperature.

According to the temperature data provided by the Raqqa Governorate, the monthly average temperature in Tallabiad, located north of the Governorate was 5.4℃, while that of Raqqa City was 6.6℃. Refer to **Table 9.1.7**:

Table 9.1.7 Temperature in January -2006 on Al Rakka

Tallabiad					Al Rakka City				
Date	Wet (%)	Dry (%)	Min (℃)	Max (℃)	Date	Wet (%)	Dry (%)	Min (℃)	Max (℃)
1-Jan	66	5	-2.9	14.2	1-Jan	75	4.3	-2.5	10.4
2-Jan	77	7.3	3.3	10.9	2-Jan	68	7.5	1.9	13.6
3-Jan	77	6.7	1	15.9	3-Jan	79	4.5	-1.4	12.6
4-Jan	69	7.6	-0.6	17	4-Jan	75	4.5	-1.9	13.5
5-Jan	76	6.4	0.5	10.8	5-Jan	80	5.3	0.4	9.8
6-Jan	73	9.8	5	17	6-Jan	73	9	4.9	15.9
7-Jan	89	9.3	8.5	10	7-Jan	82	7.8	3.1	10.5
8-Jan	89	8.1	7.8	10	8-Jan	81	8.3	4.8	12
9-Jan	81	5.8	1	12.4	9-Jan	69	9	4.4	14.6
10-Jan	93	4.7	0	6.6	10-Jan	91	6.9	5.2	7.6
11-Jan	91	6.7	5.8	7.2	11-Jan	94	7	6.5	7.7
12-Jan	82	6.7	4.4	13.2	12-Jan	83	8.5	5.8	11.9
13-Jan	87	6	2.8	10.2	13-Jan	90	7.7	6.7	9
14-Jan	74	4.6	0.5	13.3	14-Jan	76	6.9	3	11.5
15-Jan	64	3.1	-2	11	15-Jan	65	4.9	1	10.4
16-Jan	68	1.5	-4.4	12	16-Jan	68	3.2	1.4	9.6
17-Jan	77	1.2	-6	10.3	17-Jan	66	4.6	1.4	12.7
18-Jan	88	2.5	-3.5	5.5	18-Jan	85	5.4	3	8
19-Jan	86	4.8	1.2	8	19-Jan	84	5.4	2.4	8.2
20-Jan	83	5.7	1.4	10	20-Jan	75	7.8	3.2	14.8
21-Jan	65	0.7	-3.6	6.2	21-Jan	59	3.3	-0.3	7.8
22-Jan	61	1.5	-3.5	5.9	22-Jan	60	3.8	-0.4	8.6
23-Jan	89	2.1	0.8	2.5	23-Jan	85	4.1	2.7	6.3
24-Jan	86	5.8	2.5	9.5	24-Jan	87	6.5	4.3	9.5
25-Jan	92	6.5	3.5	9.7	25-Jan	93	7	4.2	9.6
26-Jan	86	7.7	5	11.5	26-Jan	77	8.9	5.6	13.6
27-Jan	84	5.9	-0.4	11.2	27-Jan	73	9	5.9	13.5
28-Jan	77	3.9	-1.4	10.4	28-Jan	84	5.7	3.2	10.6
29-Jan	77	1.9	-4.4	10	29-Jan	68	4.1	-0.4	10.2
30-Jan	65	1.5	-4	9.5	30-Jan	72	3.4	0	9.9
31-Jan	65	2.3	-5.4	10.9	31-Jan	69	3	-2.2	9.9
Monthly Average Temperature			0.42	10.41				2.45	10.77
			5.4					6.6	

Note) Wet = Highest Humidity, Dry = Lowest Humidity, Min = Lowest Temperature, Max = Highest Temperature

Table 9.1.8 Monthly Average Temperature in Slunfeh

(unit: ℃)

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1994	Max. Ave	10.3	8.3	11.9	194	21.7	23.6	24.2	26.2	28.4	23.6	11.9	7.1
	Min. Ave	5.3	2.8	5.7	11.3	13.8	14.7	17	18.1	18.8	16.3	6.8	1.1
1996	Max. Ave	6.7	9.3	10.2	11.8	20.9	24.6		27	24	19.1	16.2	11.6
	Min. Ave	-0.7	3.6	1.4	5.3	12.1	16		18.4	16	10.1	9.4	6.5
1997	Max. Ave	10	8.3	9.3	13.6	23.7	24.3	26.3	23.3	24.4	22.5	15.6	10.6
	Min. Ave	3.1	1	2.3	6.3	14.5	15.7	17.3	15.8	15.5	15.1	9.7	5.4

Table 9.1.8 Monthly Average Temperature in Slunfeh

(unit: ℃)

YEAR		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1998	Max. Ave	7	9.3										
	Min. Ave	1.7	3.2										
Monthly Average Temperature		5.4	5.7	6.8	40.4	17.8	19.8	21.2	21.5	21.2	17.8	11.6	7.1

Note）At Climate Observation Station on Bab Al Jannah Tomn in Slunfeh district

In Slunfeh, a summer resort in a mountainous area, the monthly average temperature in January 1996 was 3℃. The average temperature over a four year period from 1994 to 1998 was 5.4℃ and corresponds with that in Tallabiad. As shown in **Table 9.1.8**, the temperature in Syria is very cold in the winter. Hence, the sewage treatment processes are sensitive to temperature levels and they should not be implemented in cases where the stable treated sewage quality is expected throughout the year and in cases where the treated swage is anticipated to be used for irrigation since its quality affects the aquatic environment, especially during the winter. This is due to fact that microorganism becomes inactive if temperature falls below 10℃. Refer to **Table 9.1.9**:

Table 9.1.9 Temperature Classification of Biological Processes

Type	Temperature Range(℃)	Optimum Range Range(℃)
Psychrophilic	10-30	12-18
Mesophilic	20-50	25-40
Termphilic	35-75	55-65

Source) Fourth Edition of Metcalf & Eddy

(7) pH

Added to the temperature, the pH value of sewage is also a key factor related to the growth of microorganism. The favorable pH range for bacterial growth lies between 4.0 and 9.5 and the optimum pH is 6.5 to 7.5. As shown in **Table 9.1.10**, the annual average pH of inflow was observed to be 8.0 at the Adraa STP in 2006. It was a little higher than the optimum range but lies within the tolerable range.

In the application of the Conventional Extended Aeration Method, since the pH has the tendency to fall due to the act of excessive aeration, great care should be taken. Therefore, this is categorized as a relatively difficult method to adopt in terms of air control in the reactor.

Table 9.1.10 pH of Incoming Sewer to Adraa STP

Date	pH
2006/1/15	8.1
2006/3/2	7.8
2006/4/3	7.8
2006/5/16	7.8
2006/6/1	8.0
2006/7/16	7.8
2006/8/21	7.9
2006/9/4	8.2
2006/10/2	8.0
2006/11/2	8.1
2006/12/5	8.0
Average	**8.0**

9.1.5.2 Applicable Sewage Treatment Methods in Syria

(1) List of General Treatment Method

Based on the existing aquatic environment in the M/P priority areas, the required level of sewage treatment shall be "Secondary Treatment". General Biological Treatment Methods classified as secondary treatment are shown in **Table 9.1.11**. They have been adopted worldwide and possess long operational histories.

Table 9.1.11 Biological Sewage Treatment Methods

Status of Sewage	Classification	Treatment Methods
Aerobic condition	Suspended-growth on sludge status	Activated sludge process -Conventional - Step aeration -Conventional extended aeration -Oxidation ditch (extended aeration) -Pure oxygen -Sequencing batch reactor Aerated lagoon
	Attached-growth on sludge status	Trickling filters Submerged Attached Growth Processes
		Activated Bio filter process
	Stabilization pond	Maturation pond
	Plant-based process	Wet Land
Aerobic to Anaerobic condition	Stabilization pond	Facultative pond
Anaerobic condition	Stabilization pond	Anaerobic pond
	Attached-growth on sludge status	Anaerobic filter process
Anoxic	Suspended-growth on sludge status	Suspended-growth de-nitrification
	Attached-growth on sludge status	Fixed-film de-nitrification

(2) Applicable Treatment Methods

Processes with high optimal values shall be identified from the general methods shown in **Table 9.1.11** based on recent studies and the required conditions in the course of design. The applicable methods are as follows:

1) Conventional Activated Sludge Method
2) Conventional extended aeration Method
3) Oxidation Ditch Method (one of Extended Aeration Method)
4) Constructed Wet Land Method
5) Submerged Attached Growth Method

The reasons of selection for various processes are as follows:

- 1) The Conventional Activated Sludge Method and 2) the Conventional Extended Aeration Method have been recently studied and recently adopted by the MHC and MLAE
- 3) The Oxidation Ditch Method requires an easy O&M and involves denitrification. It has been studied as a part of the F/S in Banias and will also be studied in near future as well by the GTZ. Since water resource pollution is one of the key issues in Syria, the OD method could provide the solution.
- Although performance analysis data is insufficient, 4) the Constructed Wet Land Method, has been operated in Rural Damascus and Thawra in Raqqa, and seems to have manifested good treatment efficiency. Therefore, this method was added to the other four advanced treatment methods.
- 5) The Submerged Attached Growth Method is easy in terms of O&M, because no return sludge is needed. Moreover, it is suitable for locations where the available STP site is small. In addition, denitrification is also possible in the application of this process that could serve as a substitute to the OD. This is also widely practiced as an on-site system in Japan. It is also quite applicable for small-scale target areas and could be operated without the continued presence of an operator. Thus, this method was added to the four abovementioned advanced treatment methods.

Special considerations in method selection and the reasons for the exclusion of other methods are presented below:

- The reasons for selecting the Constructed Wet Land Method and Submerged Attached Growth Method are attributed to the following background.
- In Syria, large-scale STPs have been constructed. On the other hand, several small-scale STPs employing Conventional Extended Aeration Method with capacities less than 1,000 m^3/d have been implemented to prevent water pollution. However, some STPs are not operated at all or operated without a feeding return-sludge. Obviously, the shortage of human resource is a major cause in such cases. Hence in the future, STPs with capacities less than 1,000 m^3/d should adopt the Wet Land Method and/or Submerged Attached Growth Method that are widely popular in Japan as on-site facilities, instead of the activated sludge methods that require return sludge management. Consequently, the economic burden for the relevant Ministries would be relieved.

- Though Trickling filters, Stabilization Pond and Aerated Lagoon are advantageous with respect to O&M, these methods are directly affected by low temperatures in winter and result in poor performance. Moreover, the Aerated Lagoon Method has exhibited low power efficiency and has failed in the Allepo Governorate.
- In the Study for Zabadani conducted by the EIB, the Biological Nitrogen Removal Method was proposed because only a small parcel of land was available for the construction of the STP. This process requires a complicated and sensitive operation to feed micro-organisms. Moreover, whenever the incoming BOD load is unstable, such as in the case of tourism spots, operation becomes even further difficult. As the OD and Submerged Attached Growth Method are also applicable for denitrification, this method was excluded from the comparative study.

In selecting the appropriate method for adoption, the nitrification or denitrification capabilities of the methods were carefully examined. Though the Conventional Activated Sludge Method has an inferior nitrification or denitrification capacity compared to the other four methods, this method requires a smaller land area and proves efficient if the treated sewage is discharged into the public water bodies that are not closed water bodies. Therefore, this was chosen as the target method for the comparative study.

(3) Profile of Treatment Methods

1) Conventional Activated Sludge Method

This is the most basic Activated Sludge Method. Settled sludge and return activated sludge (RAS) are mixed and aerated by diffused air or mechanical aeration equipment through several compartments. Organic matter would be absorbed and consumed by the activated sludge. Finally, the increased flocculated sludge solids are separated in the secondary settling tank.

This method is suitable for large-scale treatment plants that require the highly stable performance of the treated quality sewage and that have compact sites. On the other hand, the construction cost and O&M expenditure in this case are relatively higher than those of the other methods because of the number of experienced operators required, the daily inspection of equipment, the treatment of sludge generated in both primary and secondary clarifiers, and so on.

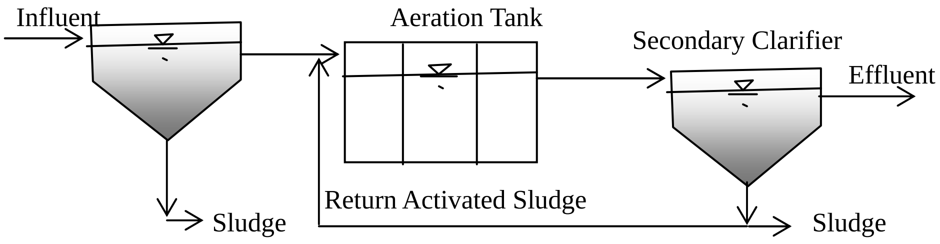


Figure 9.1.1 Schematic Drawing of Conventional Activated Sludge Method

2) Conventional Extended Aeration Method

This is one of the Activated Sludge Methods. As the primary settlement is omitted, the high concentration of organic matter is biologically treated and therefore, the aeration tank should be larger, approximately three times that of the conventional activated sludge method.

Characteristics are as follows:

- This method requires a huge power consumption, but generates a small amount of sludge. Therefore it is applicable for small-scale plants.
- O&M is relatively easy but presents difficulties in controlling the air volume and the RAS according to the concentration of the incoming sewage, steps that are necessary to avoid the disorganization of the activated sludge due to over-aeration.
- Less odor

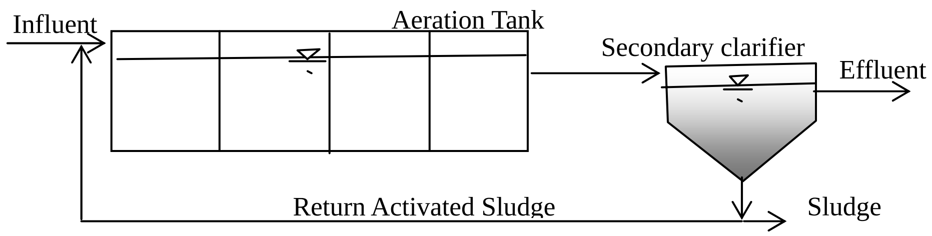


Figure 9.1.2 Schematic Drawing of Conventional Extended Aeration Method

3) Oxidation Ditch Method (a kind of extended aeration)

This is also another type of the Activated Sludge Method; one of the Extended Aeration Method. Reactor is an oval-shaped channel equipped with a mechanical aeration device. The sewage is passed through a screen and grit removal chamber and subsequently made to enter the reactors, until finally aerated and circulated.

Mechanical Aerators are divided into two groups to include the Mechanical Aerators with Vertical Axis and Mechanical Aerators with Horizontal Axis. These are further subdivided into surface and submerged aerators although, in the OD method, the Surface Mechanical Aerators is commonly applied.

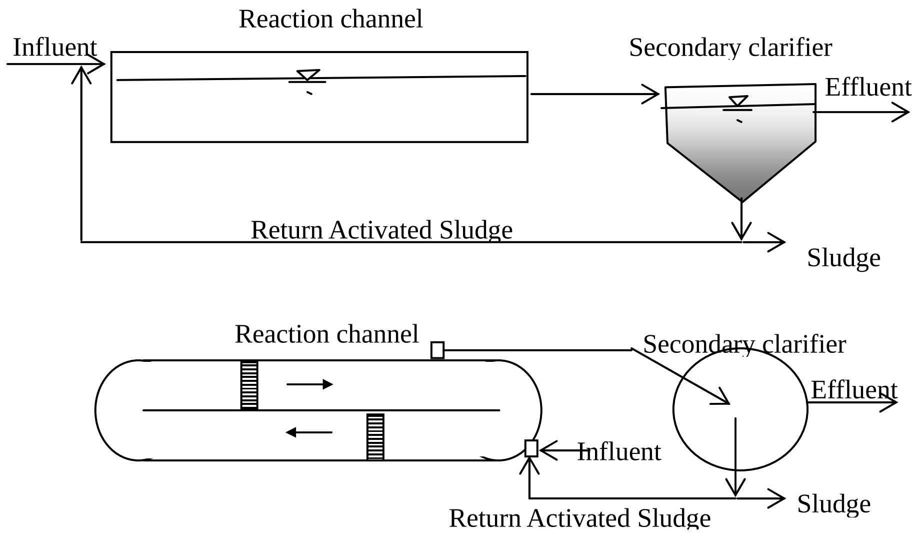


Figure 9.1.3 Schematic Drawing of Oxidation Ditch Method

Its salient features are as follows:

- Performance of treatment is stable because of the low-loaded operation and the even allocation of aerobic zone and anaerobic zone. The O&M can be easily implemented, even if difficulties are encountered in the availability or the mobilization of skilled operators in the local branches of the Ministry in charge. The OD could provide a better solution.
- Nitrification and denitrification could be carried out using this process.
- Less odor
- In the case of the combined sewer system, the sewage diluted by rain does not harm the biological process.
- Quantity of excess waste sludge is small and stable in the fermentation of organic matter.
- In Japan, the construction cost is almost same as the other processes in case of small STP.

4) Constructed Wet Land Method

The Constructed Wet Land Method is a simple and yet well-designed method that applies the self-purification capacity of reedy grass. The Constructed Wet Land Method consists of a reed bed and primary sedimentation tank which reduce the load on the reed bed for the fermentation of organic matter.

The main characteristics of this process are as follows:

As this system is simple, its O&M is very easy and correspondingly, the construction cost and O&M expenditure are very small. However, this process requires vast areas of land. So this method is suitable for rural towns where sizeable land areas are available and the population is small.

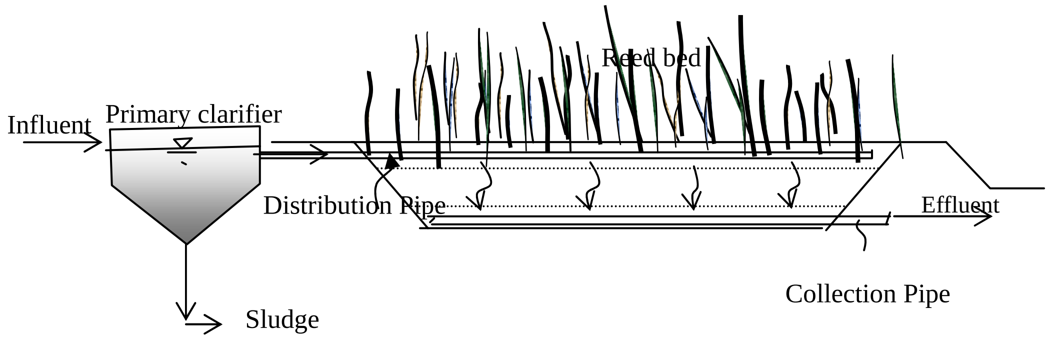


Figure 9.1.4 Schematic Drawing of Constructed Wet Land Method

5) Submerged Attached Growth Method

This is one of the attached growth methods that employs a package of bio-film (generally a plastic media). As the bio-film is submerged in the aeration tank, organic matters will be absorbed on the biological layer grown on the surface of the film through the action of metabolism.

Characteristics of this process are as follows:

- O&M is easy because no RAS is needed.
- By selecting materials with larger surface areas for the bio-film, the treatment would be flexible enough to accommodate the fluctuations of incoming sewage flow and organic load.
- Quantity of excess sludge is very small and stable in the fermentation of organic matter.
- The use of the bio-film might cause clogging because of the thickening of the biological layer in cases where the plant is operated under higher loading conditions.

Primary clarifier can be omitted in small-scale plant such as on-site facility.

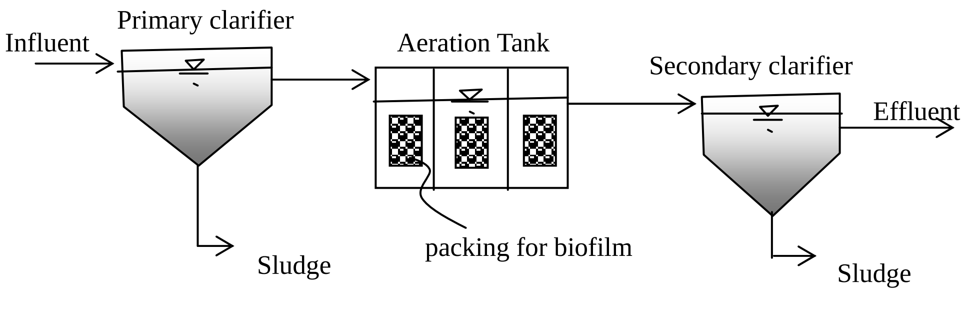


Figure 9.1.5 Schematic Drawing of Submerged Attached Growth Method

(4) Sludge Treatment Processes

Sludge Treatment Processes should be selected carefully for the safer treatment of the generated sludge and re-use of treated sludge. Sludge treatment processes may be proposed as the sewage treatment method described below:

Generated sludge that settle in the sedimentation tanks of the Conventional Activated Sludge Method, the Constructed Wet Land Method and the Submerged Attached Growth Method can be treated by means of the Gravity Thickening + Anaerobic Digestion + Drying Bed, if the treated sludge is to be re-used as compost. However, in the case of the Constructed Wet Land Method where the generated sludge volume is relatively small, this can be treated by Gravity Thickening + Drying Bed + Landfill. In the future, regional sludge treatment can be one option.

As the generated sludge of the Conventional Extended Aeration Method and the OD Method has low settling characteristics, it cannot be thickened efficiently by means of Gravity Thickening.

In the case of the Drying Bed that is applicable if there is enough land for the STP, the sludge can be thickened through the use of the Mechanical Thickening Equipment in subsequent dry bed processes. Since the thickened sludge is stable in nature, it can be treated by means of the Drying Bed for re-use as soil improvement additive, for reclamation, or as the base material for compost.

If land for the Drying Bed is not available, Mechanical Dewatering with gravity thickener for sludge reservation shall be applied.

Further, if there is a large STP existing nearby, the stored sludge can be transferred to this plant.

9.1.5.3 Applicable Sewage Treatment Method for Seven Governorates

(1) Strategy on Sewage Treatment Plant Planning

The optimum method for sewage treatment shall be selected considering the following factors that pertain to external conditions and general knowledge:

- Load Fluctuation: The fluctuation in the quantity and quality of incoming sewage should be prudently considered to facilitate stable operations and reliable performance. Peak flow occurs once a day between 5:30 pm and 9:30 pm. Though the peak factor is small and ranges from 1.5 to 1.6, the peak duration is long.
- System Composition and Aeration Time: A simpler system composition is preferred. As Syrian working hours begin at 8:00 a.m. and ends at 3:30 p.m., it could not cover the O&M activities that transpire during the peak flow time. Therefore, simple and stable treatment methods with longer retention time are more applicable for this kind of load fluctuation including peak flow.
- Treated sewage quality satisfies effluent regulations
- Small sludge volume
- Environmentally acceptable disinfection: The disinfection process should not be too complicated. Chlorination is not applicable if the treated sewage is to be re-used for irrigation.
- Reuse of treated sewage: As the purpose of treating the sewage is irrigation, the

treatment method that incorporates the denitrification process and has a longer retention time is preferable.

- Odor Problem: There are various sources of odor, among which are incoming wastewater, screenings, anaerobic stabilization pond, the anaerobic sludge digester, the sludge thickening tank and primary sedimentation tank, it follows that the layout of these facilities should be carefully examined to enable the installation of odor control mechanisms. As screenings emit strong odors and are frequently found near the screen facilities in STPs in other countries, the prompt and adequate disposal of screenings can be effective countermeasure in containing the odor problem.
- Operation: A technically complicated system is not applicable. Simpler systems should be adopted.
- Construction: Though complicated structures like sludge digesters and gas tanks were constructed by local contractors, simpler structure are preferable.
- Operation of equipment: Complicated equipment are not indicated either. Simpler equipment account for easier maintenance.
- Cost: For the purpose of curtailing construction costs, some authorities think highly of “the cheaper the better” but on the contrary, the total cost must be examined. The total cost is inclusive of construction as well as O&M costs. In general, the efficient life of sewage facilities is 35 years, and the O&M costs over this period should be included in calculating the total cost.
- Land for expansion: The land to be used for plant expansion shall be secured to enable the facility to cope with the impending increase of incoming sewage flow or plant upgrading.

(2) Sewage Treatment Methods

The sewage treatment method should depend on the actual scale of communities prioritized for M/P preparation. And the preferred sewage treatment method should be based on local conditions are, typically, as follows:

a) In the Dar’aa and Damascus Rural Governorates, the treatment of sewage for irrigation purposes is essential. Therefore, the land to be occupied by the treatment plant should be located near the farm areas. Nitrification and denitrification are equally desirable.
   - Stabilization Pond is not suitable in these conditions because a big land area would be required, and it may be difficult as well to secure an area of this dimension near the farms,
   - Conventional Activated Sludge Method is not capable of performing denitrification,
   - Conventional Extended Aeration Method facilitates only nitrification. As for the stabilization of the K-N, a combination of the Oxidation Ditch and Constructed Wet Land methods would yield better performance.

- Consequently, the Conventional Extended Aeration Method, Oxidation Ditch Method and Constructed Wet Land Methods have been proposed.

b) In the Tartous and Lattakia Governorates that belong to a region with rich rainfall, treated sewage is usually discharged to the water bodies. An extensive land for the location of the treatment plant is frequently difficult to secure. In this case, the Conventional Activated Sludge Method is more applicable for a large-size STP and the Conventional Extended Aeration Method and Oxidation Ditch are best for a medium-scale STP. The Submerged Attached Growth Method would be the method of choice in the mountainous areas where land acquisition is difficult as well.

c) In Rakka, Deir-Er-zor and Hasakeh, treated sewage is usually discharged to the water bodies. Spacious lands for the location of the treatment plant are available. Here, all kinds of processes are proposed and these include the Conventional Activated Sludge Method, Conventional Extended Aeration Method, Oxidation Ditch Method and Constructed Wet Land Method. On the other hand, as the environmental assimilating capacity of the Euphrates River is huge, the application of primary treatment is possible in the initial stage of the STP construction during which time initial investments are usually restrained. In this case, the Conventional Activated Sludge Method and Constructed Wet Land Method with primary sedimentation tank are applicable.
If superior treated sewage quality is needed, the Oxidation Ditch Method can be adopted, considering the ease in O&M and available human resource.

Refer to **Table 9.1.12**:

Table 9.1.12 Applicable Treatment Method in Seven Governorates

Items	Scale of land acquisition	Aptitude for irrigation	-Dar'aa -Damascus Rural	-Tartous -Lattakia	-Raqqa -Deir-Er-zor -Hasakeh
1)Wet Land	big ↑	high ↑	+		+
2)Oxidation ditch			+	+	+
3) Conventional extended aeration			+	+	+
4)Submerged Attached Growth Methods				+	
5)Conventional Activated sludge	↓ small	↓ low		+	+

(3) Sludge Treatment Processes

Sludge Treatment Processes shall be selected considering a number of factors such as sewage treatment, urbanization status of surroundings, availability of land, etc. The Conventional Activated Sludge Method which generates a big amount of sludge, mainly adopted in large cities, most likely incorporates the sludge digestion process that reduces volume and stabilizes the nature of the generated sludge. Refer to **Table 9.1.13**:

Table 9.1.13 General Approach for Applicable Sludge Treatment Process

	Vast Land	Narrow Land/Close to the City
Conventional Activated sludge	Sludge Reservoir + digestion tank + Drying Bed	Mechanical/Gravity Thickener + Mechanical Dewatering
Conventional extended aeration	Gravity Thickener /Sludge Reservoir + Drying Bed	ditto
Oxidation ditch	ditto	ditto
Wet Land	ditto	ditto
Submerged Attached Growth Methods	ditto	ditto

(4) Final Disposal of Sludge

In STPs, the generated sludge will be dewatered to enable hauling. The final disposal of dewatered sludge could be in the form of landfill, soil improvement such as tree-planting in the desert, composting, agricultural land application, etc. Of these, agricultural land application is the most preferred disposal method because of the good agricultural prospects in Syria.

Upon choosing the agricultural land application, the fermentation process is indispensable and should be undertaken to prevent production failure. Further, once the quality of the composed sludge is secured and it gains popularity among the farmers, its demand will exceed the production capacity of each STP. Therefore, the establishment of regional compost factories is proposed as a future plan. These factories could gather sludge from several STPs. The fermentation process usually requires a time frame of three months.

For instance, sewage collected from five STPs may be treated using the OD method. Volumes with a capacity of 100,000 PE will have to be stored for three months to allow the fermentation process to take place. For this purpose, the dimension of the fermentation tank will be as shown in **Table 9.1.14**. The sludge will be mixed with chopped reed leaves and stored in the fermentation tank.

Table 9.1.14 Dimension of Fermentation Tank

	Dewatered Sludge （moisture content 80%）	Dried Sludge （moisture content 60%）
Population	500,000	500,000
Wastwater LDC	100 liter	100 liter
Sludge kgDS/yr	6,022,500	6,022,500
Sludge m^3/yr	30,113	15,056
Fermenter, h=1.0～2.0m	12-25m×25m	12-20m×20m
Required Land Area (ha)	100m×250m (2.5 ha)	90m×200m (1.8ha)

9.2 Design Criteria for Sewerage Facilities

9.2.1 Sewer Network

(1) Design Criteria

The sewer network shall be designed using the gravity system as the standard but the pumping station and force main shall also be examined in accordance with site conditions. The standardization of the gravity system is necessary in order to facilitate the pursuit of O&M activities after commissioning. However, if sewage collection by means of the gravity system is difficult to manage owing to the topographic conditions in the target area, the optimum solution shall be chosen by means of a comparative study on applicable alternatives, for instance:

1) Sewage transmission by pumping station and force main
2) Generated sewage treatment by On-site System

The sewer pipe diameter is determined based on the design's hourly maximum sewage flow given some allowance. As the incoming sewage flow exhibits an hourly fluctuation, the design of the sewer pipe shall be based on the hourly maximum sewage flow in order to cope with this hourly fluctuation.

In Syria, a combination type of sewer system has been mainly adopted. In this case, storm water and wastewater are collected by one pipe. Therefore, upon network planning, the two kinds of incoming flow must be taken into account.

Sewer pipe diameter and gradient shall be appropriately determined to enable enough in-pipe flow velocity, traction force and smooth flow that will prevent stagnancy and the accumulation of sediments that result in anaerobiosis. If the sediments accumulated in the sewer, flow section and flow capacity wll decrease and the sewage develop an anaerobic status that may generate highly toxic and corrosive hydrogen sulfide gases and result in the corrosion of the sewer itself, the pumping station and STP. Accordingly, the sewage shall be designed properly in order to circumvent the problems mentioned. Major design criteria and calculation formula are described below:

- Velocity Formula

  For flow velocity in gravity flow, Manning's Formula is adopted.

  $v = (R^{2/3} I^{1/2})/n$

  where:
  v：Velocity（m/s）
  R：Hydraulic radius（m）= flow section divided by wetted perimeter
  I：Gradient (decimal fraction)
  n：Roughness coefficient

  In case of pressured flow, Hazen-William's Formula is applicable:

$v = 0.84935 C R^{0.63} I^{0.54}$

where:
v：Velocity（m/s）
C：Velocity factor = 110
I：Hydraulic gradient (decimal fraction)
R：Hydraulic radius（m）

- Minimum and maximum velocity

  Velocity shall be within the range of 0.8 m/s to 3.0 m/s in case of Combined Sewer

- Allowance

  Upon determination of sewer diameter, allowance of 100% shall be counted to design hourly maximum sewage flow.

- Earth Cover

  More than 1.0m from Road Surface
  More than 1.5m from river bottom
  More than 0.5m from drainage bottom
  More than 2.0m from railroad facility

  If earth cover becomes smaller, pipe installation cost becomes cheaper. Earth cover of 0.6 m is applicable where the following conditions are satisfied:

  - Pipe safety is certificated.
  - House connection can be connected to the sewer pipe.
  - Permission of the road supervisor can be obtained.

- Minimum diameter

  The minimum diameter shall be 250mm accounting the intrusion of storm water since combined system is predominant in Syria.

(2) Pipe Materials

In the selection of sewer materials, consideration shall be given to the problem of pipe corrosion dealt by sulfide build up in sewers. Preference is given, therefore, to corrosion resistant and low roughness coefficient materials.

There are several factories manufacturing polyvinyl chloride pipes (PVC) and polyethylene pipes (PEP) in Syria. These pipes are exceedingly superior to concrete pipes in aspects of water-tightness and durability. As quality control in the manufacture of concrete pipes has not been dully exercised in Syria, they are fragile and inferior in material character compared with the two abovementioned pipe materials.

The role of sewer pipes is to transfer sewage to the STPs without any leakage. As concrete pipes are much inferior in water-tightness during pipe connection in comparison to PVC and PEP, they shall be adopted for sewer pipe in principle.

Since the percentage cost of pipe materials in the total project cost is less than 20%, the total project cost is not expected to drastically increase by specifyng the proposed pipe materials. As these pipes are much lighter than concrete, pipe installation cost will automatically decrease and the total project cost will not so increase as much. For reference, the unit price of PVCs and PEPs is less than one third of Japanese counterparts.

Though the pipe jacking method has not been applied in Syria so far, this method may be applied in the near future. In the pipe jacking method, the concrete pipe is commonly used but the material should be customized and exclusively manufactured for this purpose. Pipe materials are selected in general according to diameter, as shown in **Table 9.2.1**:

Table 9.2.1 Pipe Materials and Roughness Coefficients

Pipe Material	Diameter (mm)	Manning Formula's n and Hazen-William's Formula's C
PVC	250, 300, 400	n=0.010
HDPE	Larger than 250	n=0.010
Concrete	For Pipe Jacking	n=0.013
Cast Iron	For all pressure pipes	C=110

Note) HDPE = High Density Polyethylene

Rubber gasket bell and spigot joint specified to facilitate ease and speed in jointing. Experience shows that the compression type and rubber gasket joints are generally superior in preventing groundwater infiltration in sewers.

9.2.2 Pumping Station

Pumping stations will be either of the following types:

- Submersible pump station with guide rail pump removal system; and
- Package-type enclosed.

All stations will have a minimum of two pumps of equal capacity, capable of handling flows in excess of the expected peak flow. Where three or more pumps are required, they are to be of such capacity that when any of the units break down, the remaining units will still be capable of handling peak wastewater flows. In pumping stations designed for handling larger flows in the future, materials such as wet-well, piping, electrical equipment, etc. shall be sized to accommodate the volume of such anticipated flows.

Pumping station piping shall be sized to maintain flow velocities between 0.75 and 1.5m/s. Force main sizing shall be of such dimension as to provide a minimum velocity of 0.6 m/s and a maximum velocity of 1.2m/s. Sewer air release valves shall be provided at all high points where gas pockets may accumulate.

The difference between the sewage force main and the water pipe is sewage content that may include sand and other sediments. Further, the operation of the sewage pumping station is likely to be intermittent. Therefore, as sand or other sediments accumulate in the lower portion of the longitudinal pipeline profile, it should be removed periodically. In implementing this countermeasure, the installation of a mud removal valve should be planned in these sections to allow the removal of the sediments. Refer to **Figure 9.2.1**:

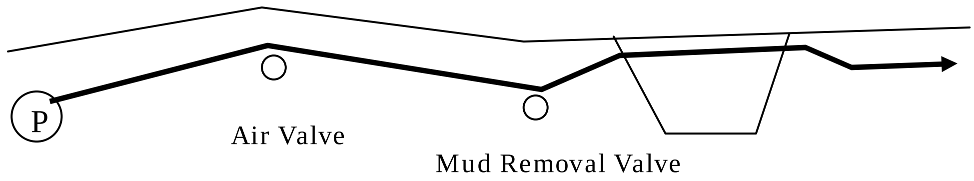


Figure 9.2.1 Schematic Drawing of Pump Station and Force Main

9.2.3 Sewage Treatment Plant

The design criteria utilizing the five treatment methods have been established based on Japanese design guidelines and internationally authorized guidelines as stipulated in "Wastewater Engineering Treatment and Reuse" issued by Metcalf & Eddy. In the case of the Constructed Wet Land Method, the design criteria actually adopted was based on the design of Harran Al Awameed STP, the existing STP in the Rural Damascus Governorate. Refer to **Table 9.2.2** to **9.2.4**. and **Appendix 9.2** for Wet land.

Table 9.2.2 Design Criteria for each Treatment Processes

Processes	Facilities	Typical Criteria
Conventional Activated sludge	Primary Settling tank	Surface load 35～70 m^3/m^2・d
	Reactor	BOD-SS load 0.2～0.4 kgBOD/kgSS・d
	Final Sedimentation tank	Surface load 20～30 m^3/m^2・d
Conventional extended aeration	Reactor	BOD-SS load 0.05～0.1 kgBOD/kgSS・d
	Sedimentation tank	Surface load 8～12 m^3/m^2・d
Oxidation ditch	Reactor	BOD-SS load 0.03～0.05 kgBOD/kgSS・d High-rate 0.04～0.1(Metcalf&Eddy)
	Sedimentation tank	Surface load 8～12 m^3/m^2・d
Wet Land	Primary Settling tank	Surface load 35～70 m^3/m^2・d
	Reed Bed	0.5 m^2/c・d
Submerged Attached Growth Methods	Reactor	BOD loading 0.3 kg/m^3・d
	Sedimentation tank	Surface load 20～30 m^3/m^2・d

Table 9.2.3 General Removal Rate

(Unit : %)

Treatment Method	BOD	SS	T-N	T-P
Conventional Activated Sludge Method	90～95	90～95	Not efficient	removable※
Conventional extended aeration Method	90～95	90～95	Not efficient	removable※
Oxidation Ditch Method	90～95	90～95	More than 70	80
Constructed Wet Land Method in Harran Al Awameed	90～95	90～95	Removable	Not efficient
Submerged Attached Growth Method	90～95	90～95	Removable	Not efficient

※it's removable under an operation of anaerobic-oxic activated sludge methods.

Table 9.2.4 Design Criteria of Sludge Treatment Processes

Facilities	Typical Criteria
Gravity Thickening	DS loading 60～90 kg/m^2・d
Mechanical Thickening	Proposed capacity by manufacturer
Anaerobic digestion Tank	Solid retention time 20 days
Mechanical Dewatering	Proposed capacity by manufacturer
Sludge Drying Bed	Sludge loading rate 60～100 $kgDS/m^2$・yr

9.2.4 Foreign Design Standard

Table 9.2.5 to **9.2.7** shows design standard adopted in major foreign countries.

Table 9.2.5 Comparison Table on the Design Criteria of Sewer Network (1/2)

Design Criteria	unit	Japanese Standards	Indian Standards (CPHEEO)	Malaysian Standards	Russian Standards (SNIP)	British Standards (BS)	Adopted Values
1 Design flow for calculation	-	Hourly maximum	Peak flow	Peak flow		4 ~ 6 times ✕ Dry weather Flow	
2 Velocity formula	-	(Gravity flow) Manning formula $V=(R^{2/3}I^{1/2})/n$ (Pressured flow) Hazen-Williams formula $V=0.84935CR^{0.63}I^{0.54}$	(Gravity flow) Manning formula $V=(R^{2/3}I^{1/2})/n$ (Pressured flow) Hazen-Williams formula $V=0.849CR^{0.63}I^{0.54}$	(Gravity flow) Manning formula $V=(R^{2/3}I^{1/2})/n$ (Pressured flow) Hazen-Williams formula $V=0.84935CR^{0.63}I^{0.54}$	(Gravity flow) $V=C(Ri)^{0.5}$ $C=R^{y}/n$ $y=2.5n^{0.5}-0.13-0.75R(n^{0.5}-0.1)$	Manning formula Colebrook-White formula etc.	
3 Maximum velocity (V)	m/sec	V = 3.0	V = 3.0	V = 4.0	V=4.0 (concrete and stone lining) V=1.6 (brick wall) V=2.0 (single layer pavement) V=3.0 to 3.5 (double layer pavement)	$V=2(D)^{0.5}$	
4 Minimum velocity (V)	m/sec	V = 0.8 (combined system)	V = 0.8	V = 0.8	V=0.7 (150<D<250mm) V=0.8 (300<D<400mm) V=0.9 (450<D<500mm) V=1.0 (600<D<800mm) V=1.15 (900<D<1,200mm) V=1.30 (D=1.500mm) V=1.50 (D>1,500mm)	V = 0.75	
5 Roughness coefficients	-	n=0.013 (Concrete) n=0.010 (PVC, PEP) C=110 (Cast iron)	n=0.015 (Concrete) n=0.011 (PVC, PEP) C=100 (Cast iron)	-	n=0.014 (gravity flow) n=0.013 (pressure flow)	-	
6 Flow allowance	%	100 (D<700mm dia.) 50~100 (700<D<1650mm dia.) 25~50 (D>1,650mm dia.)	0.8 of full at ultimate peak flow	-	0.6 (150<D<250mm) 0.7 (300<D<400mm) 0.75 (450<D<900mm) 0.8 (D>1,000)	-	
7 Minimum earth cover (H)	m	H=1.0	H=1.0 (branch sewer) H=1.5 (trunk sewer)	H=1.2	H=0.3 (D<500mm) H=0.5 (D>500mm) H=0.7 (prevent from freezing and traffic on load)	-	
8 Minimum pipe diameter (D)	mm	D=250 (combined system)	D=150	D=225	D=200	-	
9 Pipe materials	-	Reinforced concrete pipe Concrete pipe Manufactured rectangular conduits Polyvinyl chloride pipe Clay pipe Fiber reinforced plastic pipe Polyethylene pipe	Reinforced concrete pipe Precast concrete pipe Plastic pipe Cast iron pipe Steel pipe Clay pipe Asbestos cement pipe Glass fiber reinforced plastic pipe	Vitrified clay pipe Reinforced concrete pipe Ductile iron pipe Steel pipe Polyethylene pipe Glass reinforced plastic pipe	Reinforced concrete pipe Nonpressure concrete pipe Ceramic pipe Cast iron pipe Asbestos cement pipe Plastic pipe Steel pipe	Asbestos cement pipe Clay pipe Concrete pipe Box culvert Ductile iron pipe Glass reinforced plastic pipe High density polyethylene pipe Polyvinyl chloride pipe Steel pipe	

Table 9.2.5 Comparison Table on the Design Criteria of Sewer Network (2/2)

Design Criteria	unit	Japanese Standards	Indian Standards (CPHEEO)	Malaysian Standards	Russian Standards (SNIP)	British Standards (BS)	Adopted Values
10 Manhole diameter (P)	mm	P=900 (D<600) P=1,200 (700<D<900) P=1,500 (1,000<D<1,100) P=1,800 (1,200<D<1,350)	depth = H P=900 (0.90<H<1.65m) P=1,200 (1.65<H<2.30m) P=1,500 (2.30<H<9.00m) P=1,800 (9.00<H<14.00m) and less than internal diameter of the (sewer +150mm on both sides)	P=1,200mm (225<D<300) P=1,350mm (375<D<450) P=1,500mm (600<D<700)	P=1,000 (D<600mm) P=1,250 (D=700mm) P=1,500 (800<D<1,000mm) P=2,000 (D=1,200mm) P=1,500 (pipeline depth > 3.0m)	min. size of chamber = 1.05	
11 Manhole spacing	m	max. 75 (D<600mm dia.) max. 100 (D<1,000mm dia.) max. 150 (D<1,500mm dia.) max. 200 (D>1,650mm dia.)	max. 30 (D<900mm dia.) 90 ~ 150 (900<D<1,500mm dia.) 150 ~ 200 (1,500<D<2,000mm dia.)	max. 100 (D<1,000mm dia.) max. 150 (D>1,000mm dia.)	max. 35 (D=150mm) max. 50 (200<D<450mm) max. 75 (500<D<600mm) max. 100 (700<D<900mm) max. 150 (1,000<D<1,400mm) max. 200 (1,500<D<2,000mm)	max. 100 (D<1,000mm) 180 ~200 (1,000<D<1,800mm) max. 300 (D>1,800mm)	

Table 9.2.6 Comparison Table on the Design Criteria of Pumping Station

Design Criteria	unit	Japanese Standards	Indian Standards (CPHEEO)	Malaysian Standards	British Standard Code	Wastewater Engineering (Metcalf & Eddy)	Adopted Values
1 Grit chamber							
1.1 max. flow velocity (V)	m/s	V = 0.3	V = 0.15 ~ 0.30	V = 0.2	-	V = 0.3	
1.2 Water surface load (WS)	$m^3/m^2/day$	WS = 1,800	WS = 2,160	WS < 1,500	-	-	
1.3 Estimated grit quantity (Q1)	$m^3/10^3m^3$	Q1 = 0.0005 ~ 0.05	-	-	-	Q1 = 0.04 ~ 0.202 (aerated type)	
2 Screen system							
2.1 Primary screen							
Max. clear spacing (P1)	mm	P1 = 50 ~ 150	P1 = 75 ~ 150 (coarse screen)	P1 = 25	P1 = 30 ~ 75	P1 = 6 ~ 150	
Max. velocity at screen face (V1)	m/sec	V1 = 0.45	V1 = 0.6 ~ 1.2	V1 = 1.0	-	V1 = 0.3 ~ 0.6 (manual screen)	
2.2 Secondary screen							
Max. clear spacing (P2)	mm	P2 = 15 ~ 25	P2 < 20 (fine screen)	P2 = 12	-	P2 < 6	
2.3 Estimated screenings volume (Q2)	$m3/10^6m3$	Q2 = 0.5 ~ 50	Q2 = 1.5 ~ 15	Q2 = 30	-	Q2 = 4.0 ~ 40	
3 Pump equipment							
3.1 Design flow for calculation	-	Hourly maximum flow	Peak flow with 50% standby	Peak flow	Dry weather flow ×3	-	
3.2 Type of station	-	Q: design flow = m^3/min (1) Q<3.2 m^3/min (2 units) Manhole type (2) 3.2<Q<6~8 m^3/min (2~5 units) Small scale type without grit chamber and screen (3) Q>6~8 m^3/min (2~5 units) Conventional type	(1) Two wells type Wet well for storing sewage and dry well for setting pumps (2) One well type Use of wet-pit pump (submersible pump)	PE: Population Equivalent (1) Case of PE<5,000 Wet well with submersible pump (2 units) (2) Case of 5,000<PE<10,000 Wet well or dry well (2units) (3) Case of PE>10,000 Wet well and dry well 10,000<PE<20,000 2~4 units PE>20,000 6 units	-	-	
3.3 Proposed pump diameter (D)	mm	$D = 146(Q/V)^{0.5}$ where Q: discharging flow (m^3/min) V: Velocity at suction = 1.5 ~ 3.0 m/sec	-	-	-	-	
3.3 Retention time of wet well (T)	min	T = 4 (in case of manhole type)	T = 5	T = 30 minutes in average flow	T = 5 ~ 10	-	
4 Force main							
min. diameter (D)	mm	D = 80	D = 100	D=100	D = 100	-	

Table 9.2.7 Comparison Table on the Design Criteria of Sewerage Treatment Plant (1/3)

Design Criteria	unit	Japanese Standards	Indian Standards (CPHEEO)	Malaysian Standards	British Standard Code	Wastewater Engineering (Metcalf & Eddy)	Adopted Values
1 Applicable sewage treatment methods	-	(1) Conventional activated sludge (2) Oxygen activated sludge (3) Contact aeration (4) Oxidation ditch (5) Extended aeration (6) Biological aerated filter (7) Advanced treatment (8) Trickling filter etc.	(1) Conventional activated sludge (2) Completely mixed (3) Extended aeration (4) Oxidation ditch (5) Aerated lagoon (6) Trickling filter (7) Rotating biological contactor (8) Stabilization pond (9) Upflow anaerobic sludge blanket etc.	(1) Trickling filter (2) Rotating biological contactor (3) Submerged biological contactor (4) Stabilization pond (5) Aerated lagoon (6) Conventional activated sludge (7) Extended aeration (8) Oxidation ditch (9) Sequence batch reactor etc.	(for small sewage treatment works) (1) Extended aeration (2) Contact stabilization (3) Oxidation ditch (4) Rotary biological contactors	(1) Conventional activated sludge (2) Modified activated sludge (3) Extended aeration (4) Oxidation ditch (5) Sequence batch reactor (6) Trickling filter (7) Aerated lagoon (8) Stabilization pond (9) Rotating biological contactor (10) Wetland etc.	
2 Screen and grit chamber	-	refer to the sheet of pump station	refer to the sheet of pump station	refer to the sheet of pump station		refer to the sheet of pump station	
3 Primary sedimentation tank							
Detention time (T)	hour	T = 1.5	T = 2.0 ~ 2.5	T = 2 hours in peak flow		T = 2.0	
Water surface load (WS)	$m^3/m^2/day$	WS = 35 ~ 70	WS = 35 ~ 50	WS = 30 ~ 45 in peak flow		WS = 33 ~ 49	
Effluent weir load (EW)	$m^3/m/day$	EW = 250	EW = 125	EW = 100 ~ 200		EW = 124 ~ 496	
Water depth (H)	m	H = 2.5 ~ 4.0	H = 2.5 ~ 3.5	-		H = 3.05 ~ 4.6	
4 Typical secondary treatment process							
4.1 Conventional activated sludge (CAS)							
BOD-SS load (L)	kgBOD/kgSS	L = 0.2 ~ 0.4	L = 0.3 ~ 0.4	L = 0.25 ~ 0.50		L = 0.2 ~ 0.4	
Hydraulic retention time (HRT)	hour	HRT = 6 ~ 8	HRT = 4 ~ 6	HRT = 6 ~ 16		HRT = 4 ~ 8	
Oxygen requirement (O)	kgO2/kgBOD	O = 1.62	O = 0.8 ~ 1.0	O = 1.5		-	
Mixed liquor suspended solids (MLSS)	mg/l	MLSS = 1,500 ~ 2,000	MLSS = 1,500 ~ 3,000	MLSS = 1,500 ~ 3,000 (typical = 2,500)		MLSS = 1,200 ~ 3,000	
Sludge age (SA)	day	SA = 3 ~ 6	SA = 5 ~ 8	SA = 5 ~ 10		SA = 5 ~ 15	
Min. mixing power requirement (P)	w/m^3	-	-	P = 20		-	
Water depth (H)	m	H = 4 ~ 6	H = 3.0 ~ 4.5	H = 3.0 ~ 5.0 (diffused aerator type)		H = 4.57 (diffused aerator type)	
4.2 Extended aeration (EA)							
BOD-SS load (L)	kgBOD/kgSS	L = 0.05 ~ 0.10	L = 0.1 ~ 0.18	L = 0.05 ~ 0.10	L = 0.05 ~ 0.15	L = 0.05 ~ 0.15	
Hydraulic retention time (HRT)	hour	HRT = 16 ~ 24	HRT = 12 ~ 24	HRT = 18 ~ 24	HRT = 24 ~ 48	HRT = 18 ~ 36	
Oxygen requirement (O)	kgO2/kgBOD	O = 1.4 ~ 2.2	O = 1.0 ~ 1.2	O = 1.5 ~ 2.0	O = 2.0	-	
Mixed liquor suspended solids (MLSS)	mg/l	MLSS = 3,000 ~ 4,000	MLSS = 3,000 ~ 5,000	MLSS = 2,500 ~ 5,000	MLSS = 2,000 ~ 5,000	MLSS = 1,500 ~ 5,000	
Sludge age (SA)	day	SA = 13 ~ 50	SA = 10 ~ 25	SA = > 20	-	SA = 20 ~ 30	
Min. mixing power requirement (P)	w/m^3	-	-	P = 20	-	-	
Water depth (H)	m	H = 4 ~ 6	H = 3.0 ~ 4.5	H = 3~5 (diffused aerator type)	H = 2.0 ~ 3.5	H = 4.57 (diffused aerator type)	
4.3 Rotating biological contactor (RBC)							
Total BOD specific load (TL)	$g/m^2/day$	TL = 5 ~ 7	-	TL = 5 ~ 10	TL = 5.0 ~ 7.5	TL = 3.7 ~ 9.8	
Detention time (T)	hour	-	T = 1.0 ~ 1.5	T = 2 hours in average flow	-	T = 0.7 ~ 1.5	
Disc diameter (D)	m	D = 3.0 ~ 4.0	D = 1.0 ~ 4.0	D = 2.5 ~ 3.5	-	-	
Max. peripheral velocity (V)	m/sec	V = 0.3	less than 10 rpm	V = 0.3	V < 0.35	-	
Depth of disc submergence (H)	%	H = 35 ~ 45	H = 40 ~ 60	H = 40 ~ 90	-	H = 40	

Table 9.2.7 Comparison Table on the Design Criteria of Sewerage Treatment Plant (2/3)

Design Criteria	unit	Japanese Standards	Indian Standards (CPHEEO)	Malaysian Standards	British Standard Code	Wastewater Engineering (Metcalf & Eddy)	Adopted Values
4.4 Trickling filter (TF)							
Organic load (OL)	kg/day/m^3	-	OL = 0.08 ~ 0.32 (low rate)	OL = 0.08 ~ 0.15 (low rate)		OL = 0.08 ~ 0.40 (low rate)	
		OL < 1.2 (high rate)	OL = 0.32 ~ 1.0 (high rate)	OL = 0.50 ~ 2.00 (high rate)		OL = 0.48 ~ 0.96 (high rate)	
Hydraulic load (HL)	m^3/day/m^2	-	HL = 1.0 ~ 4.0 (low rate)	HL = 1.0 ~ 4.0 (low rate)		HL = 0.94 ~ 3.74 (low rate)	
		HL = 15.0 (high rate)	HL = 10.0 ~ 40.0 (high rate)	HL = 10.0 ~ 40 .0 (high rate)		HL = 9.35 ~ 37.4 (high rate)	
Sludge yields (SY)	kgSS/kgBOD			SY = 0.5 (low rate)			
				SY = 1.0 (high rate)			
Min. depth (H)	m	H = 1.5 ~ 2.0	H = 1.8 ~ 3.0 (low rate)	H = 1.5		H = 1.83 ~ 2.44 (low rate)	
			H = 0.9 ~ 2.5 (high rate)			H = 0.91 ~ 1.83 (high rate)	
4.5 Sequence batch reactor (SBR)							
BOD-SS load (L)	kgBOD/kgSS	L = 0.03 ~ 0.40		L = 0.05 ~ 0.30		L = 0.05 ~ 0.30	
Sludge age (SA)	day	-		SA = 10 ~ 30		-	
Sludge yields (SY)	kgSS/kgBOD	-		SY = 0.75 ~ 1.10		-	
Mixed liquor suspended solids (MLSS)	mg/l	MLSS = 1,500 ~ 4,000		MLSS = 3,000 ~ 6,000		-	
Cycle time (T)	hour	-		T = 4 ~ 8		MLSS = 1,500 ~ 5,000	
Decant time (DT)	hour	-		DT > 1.0		-	
Water depth (H)	m	H = 4 ~ 5		-		H = 4.57 (diffused aerator type)	
4.6 Oxidation ditch (OD)							
BOD-SS load (L)	kgBOD/kgSS	L = 0.03 ~ 0.05	L = 0.1 ~ 0.18		L = 0.05 ~ 0.15	L = 0.05 ~ 0.30	
Hydraulic retention time (HRT)	hour	HRT = 24 ~ 48	HRT = 12 ~ 24		HRT = 24 ~ 48	HRT = 8 ~ 36	
Oxygen requirement (O)	kgO2/kgBOD	O = 1.4 ~ 2.2	O = 1.0 ~ 1.2		O = 2.0	-	
Mixed liquor suspended solids (MLSS)	mg/l	MLSS = 3,000 ~ 4,000	MLSS = 3,000 ~ 5,000		MLSS = 2,000 ~ 5,000	MLSS = 1,500 ~ 5,000	
Sludge age (SA)	day	SA = 8 ~ 50	SA = 10 ~ 25		-	SA = 10 ~ 30	
Min. mixing power requirement (P)	w/m^3	-	-		-	-	
Water depth (H)	m	H = 1 ~ 3 (in case of surface mixer)	H = 3.0 ~ 4.5		H = 1.0 ~ 3.0	H = 4.57 (diffused aerator type)	
4.7 Facultative aerated lagoon (AL)							
Detention time (T)	day		T = 3 ~ 5			T = 3 ~ 6	
Water depth (H)	m		H = 2.5 ~ 5.0			H < 3.7 (surface aerator)	
Land requirement (A)	m^2/person		A = 0.15 ~ 0.30			-	
Power requirement (P)	kwh/pers./y		P = 12 ~ 15			-	
5 Secondary sedimentation tank							
5.1 In case of CAS							
Min. side water depth (H)	m	H = 2.5 ~ 4.0	H = 3.5 ~ 4.5	H = 3.0		H = 3.7 ~ 6.1	
Hydraulic retention time (T)	hour	-	T = 1.5 ~ 2.0	T = 2.0		-	
Water surface load (WS)	m^3/m^2/day	WS = 20 ~ 30	WS = 15 ~ 35	WS = < 30 in peak flow		WS = 16.3 ~ 32.6	
Effluent weir load (EW)	m^3/m/day	EW = 150	EW = 185	EW = 150 ~ 180		EW = 250	
5.2 In case of OD, EA							
Min. side water depth (H)	m	H = 3.0 ~ 4.0	H = 3.5 ~ 4.5		-	H = 3.7 ~ 6.1	
Hydraulic retention time (T)	hour	T = 6 ~ 12	T = 1.5 ~ 2.0		T = 2.0	-	
Water surface load (WS)	m^3/m^2/day	WS = 8 ~ 12	WS = 8 ~ 15		WS < 22.0 (peak flow)	WS = 8.2 ~ 16.3	
Effluent weir load (EW)	m^3/m/day	EW = 50	EW = 185		EW = 150	EW = 120	

Table 9.2.7 Comparison Table on the Design Criteria of Sewerage Treatment Plant (3/3)

Design Criteria	unit	Japanese Standards	Indian Standards (CPHEEO)	Malaysian Standards	British Standard Code	Wastewater Engineering (Metcalf & Eddy)	Adopted Values
5.3 In case of TF							
Min. side water depth (H)	m		H = 2.5 ~ 3.5			H = 3.0 ~ 4.5	
Hydraulic retention time (T)	hour		T = 1.5 ~ 2.0			-	
Water surface load (WS)	$m^3/m^2/day$		WS = 15 ~ 25			WS = 16.3 ~ 24.4	
Effluent weir load (EW)	$m^3/m/day$		EW = 185			EW = 120	
6 Disinfection							
Chlorine dosage (CD)	mg/l	CD = 2 ~ 4		CD = 2.0 ~ 8.0		CD = 2.0 ~ 8.0	
Contact time (T)	min	T = 15		T = 30 in average flow		T = 15 ~ 45	
7 Gravity sludge thickening							
Solid load (SL)	$kg/m^2/day$	SL = 60 ~ 90	SL = 30 ~ 50 (primary + activated) SL = 50 ~ 60 (primary + trickling filter)			SL = 39 ~ 78 (primary + activated) SL = 59 ~ 98 (primary + trickling filter)	
Tank depth (H)	m	H = 4.0	H = 3.0			H = 0.6 ~ 2.4	
Sludge retention time (T)	hour	T = 12	T = 24 (maximum)			-	
8 Sludge digestion							
Digestion day (T)	day	T = 20 ~ 30	T = 10 ~ 20 (high rate)	T = 30		T = 10 ~ 20	
Organic volatile solids rate (OS)	%	OS = 70	OS = 60 ~ 85	-		-	
Digestion rate (DR)	%	DR = 50	DR = 50	-		-	
9 Sludge dewatering							
Proposed type of dewatering	-	Belt press	Vacuum filter	Belt press	Drying bed	Belt press	
		Centrifuge	filter press	Centrifuge		Centrifuge	
		Filter press	Centrifuge	Filter press		Filter press	
		Screw press etc.		Drying bed		Drying bed	
Sludge depth in drying bed (H)	mm	H < 200	H = 300	H < 300	H < 225	H = 200 ~ 300	
Retention time in drying bed (T)	day	-	T = few day ~ 2 weeks	-	T = 6 ~ 10 weeks	T = 10 ~ 15	

9.3 Selection of the Priority Area for Master Plan

9.3.1 Lattakia Governorate

Lattakia Governorate is comprised of four major districts namely Lattakia, Jable, Al Hafeh and Al Qerdaha in order of population. As aforementioned in the previous chapter, Lattakia and Jable is contained in the EU supported "Protecting Mediterranean from land-based Pollution Program" and Feasibility Report of Pre-investment Study was completed on June 2005. Therefore, these two districts can be excluded from Master Plan priority area. According to the Census, the population of 2004 in Al Hafeh and Al Qerdaha was as shown in **Table 9.3.1**.

Table 9.3.1 Population in 2004

Name of District	Population in 2004	Service Ratio	Served Population	M/P Priority
Al Hafeh	81,213	83%	67,407	○
Al Qerdaha	75,279	77%	57,965	△

As both districts have no treatment facilities, the raw sewage has been discharged into channels, rivers or valleys nearby and the magnitude of the discharged pollution load is correlative to the served population. As borne by the table, Al Hafeh with the greater number of served population has the higher priority.

Al Hafeh is also comprised of several sub-districts as shown in **Table 9.3.2**.

Table 9.3.2 Comparison of Master Plan Priority in Lattakia Governorate

Name of Sub-district	Population in 2004	Number of Tourists	Total Population	Service Ratio	Served Population	M/P Priority
Al Hafeh Center	23,347	unknown, but negligible	24,905	80%	19,924	△
Slunfeh	19,518	*77,778	97,296	90%	87,566	○
Kansaba	17,615	unknown	17,615	60%	10,569	△
Mzeraa	13,908	unknown	13,908	90%	12,517	△
Ayen Teneh	6,825	unknown	6,825	90%	6,143	△

*) 1,000,000/90/7 = 77,778 : Assuming that tourists stay for a week per season

Among these sub-districts, Slunfeh is the summer resort area. During the summer season from July to September, the number of tourists that flock to the resort is estimated to be 1 to 1.5 million. Even if this influx is temporary, tourists should be counted in as part of the served population. As shown in the table, Slunfeh with greatest number of served population was selected as an MP priority area.

9.3.2 Tartous Governorate

The Tartous Governorate consists of four major districts, namely Tartous, Banias, Safita, Drekeish and Al Shreikh Bader in the order of population. The construction of the STPs in Tartous City and Banias that covers the rehabilitation of the wastewater treatment plant in the oil refining facilities is contained in the scope of EU supported "Protecting Mediterranean from Land-based Pollution Program". Therefore, Tartous can be excluded from the M/P priority area but as to Banias, the EU study only covers the Banias Center, the existing populated area along the Mediterranean Sea and the oil refining factory.

Table 9.3.3 Comparison of Master Plan Priority in Tartous Governorate

Name of District	Population in 2004	Service Ratio	Served Population	M/P Priority	Remarks
Tartous	283,571	85%	241,035	△	Studied by EU
Banias	174,233	95%	165,521	○	Whole area shall be Studies
Safita	129,632	90%	116,669	△	
Drekeish	60,978	80%	48,782	△	
Al Shreikh Bader	52,981	78%	41,325	△	

Actually, Banias is composed of several sub-districts, as shown in **Table 9.3.4**.

Table 9.3.4 Breakdown of Sub-districts Contained in Banias Center

Name of Sub-district	Population
Banias Center	94,832
Rawda	11,688
Anazeh	18,446
Kadmous	22,370
Talin	8,351
Al Tawahin	10,024
Haman Wasil	8,522

Even if the population here is smaller than that in Banias Center, raw sewage discharged from the six sub-districts located in the mountainous area has been found to infiltrate the groundwater and the Mediterranean Sea. The sewerage development plan for Banias Center cannot be completed without the appropriate treatment of the raw sewage generated in the upstream areas. Therefore, an appropriate and comprehensive sewerage system development master plan shall be prepared for the whole Banias area.

9.3.3 Deir-Ez-zor Governorate

The Deir-Ez-zor Governorate is composed of three major districts located along the Euphrates River, namely, Deir-Ez-zor, Mayasin and Abu Kamal, from upstream to downstream.

As to Deir-Ez-zor, the STP design including the incoming trunk sewer was completed by GCEC, and can be excluded from the scope of M/P prioritization.

Table 9.3.5 Comparison of Master Plan Priority in Deir-Ez-zor Governorate

Name of District	Population in 2004	Service Ratio	Served Population	M/P Priority	Remarks
Deir-Ez-zor	492,434	61%	300,384	△	STP design was completed
Abu Kamal	265,142	56%	148,480	△	Located in the most downstream
Mayadin	247,171	62%	153,246	○	Located next to Deir-ez-zor

As shown in **Table 9.3.5**, Mayadin has the second largest served population. The distance from Deir-Ez-zor to Mayadin is about 45 km, while that of Abu Kamal is 120 km. To maximize the benefits of the project, the sewerage system shall be developed in sequence and therefore, Mayadin located next to Deir-Ez-zor must be given priority in the M/P preparation.

9.3.4 Hassakeh Governorate

The Hassakeh Governorate consists of four major districts. The served population in each district is shown in **Table 9.3.6**.

Table 9.3.6 Comparison of Master Plan Priority in Hassakeh Governorate

Name of District	Population in 2004	Service Ratio	Served Population	M/P Priority	Remarks
Hassakeh	480,394	42%	201,765	△	STP design is now being prepared by GCEC.
Qameshili	425,580	37%	157,465	△	There are no communities along with Jag Jag river where sewage is currently discharged. Natural river purification function can be utilized to sewage treatment.
Malkieh	191,994	46%	88,317	○	As raw sewage is finally inflows to Tigris river, this area has responsibility to river water quality preservation.
Ras Al Ayen	177,150	44%	77,946	△	There is one existing STP.

Since the GCEC is preparing the detailed design for the Hassakeh STP, Hassakeh can be excluded from the scope of M/P prioritization.

As to Qameshili, all sewage is discharged into the Jag Jag river and the river flows down to the south, toward the confluent point with the Khabour river in Hassakeh. As there are no major inhabited communities along the Jag Jag river, no complaint is expected about the odor emitted by the discharged sewage. Furthermore, sewage treatment utilizing the natural river purification function may be applicable in this case, because the distance from Qameshili to the said confluent point with Khabour River is 80 km.

There is one existing STP in Ras Al Ayen adopting Aerated Lagoon Method.

In Malkieh, as most of the residents here are engaged in agricultural activities, there is a demonstrated need for sewage treatment for subsequent reuse. Morbidity due to the incidence of water-borne diseases such as diarrhea and leishmania is also high and this condition has gone on for a long time because of groundwater contamination that is caused by raw sewage discharged into the valley. Further, since Malikieh is located near the national border between Syria and Iraq, discharged sewage flows into the Tigris River. Thus, this place is the designated area of responsibility of Iraq as well in the preservation of the river water quality. Considering these current circumstances, the MP preparation should give priority to Malkieh.

9.3.5 Raqqa Governorate

The Raqqa Governorate is composed of three major districts and Thawla belongs to the second biggest area called Al Tabka. Thawla has the biggest population among the sub-districts included in Al Tabka as shown in **Table 9.3.7**.

Table 9.3.7 Comparison of Master Plan Priority in Raqqa Governorate

Name of District	Name of Sub-district	Population in 2004	Service Ratio	Served Population	M/P Priority	Remarks
Raqqa		506,960	78%	393,089	△	Now preparing for tender of STP construction contract
Al Thawla		159,840				
	Thawla	69,425	75%	52,069	○	Located close to Asad Dam
	Mansorah	58,727	90%	52,854		
	Jameah	31,688	5%	1,589		
Tal Abyad		129,714	62%	80,423	△	

In the case of Raqqa, preparations are being made for the tender of the STP construction contract assisted by the Spanish Government. Hence, the area can be excluded from the scope of M/P prioritization.

Located just upstream of Asad Dam, Thawla appears to have the highest and most urgent demand for sewerage system development and should therefore be given high priority in the sewerage Master Plan.

9.3.6 Dar'aa Governorate

The Dar'aa Governorate includes three major districts and Muzerib belongs to Dar'aa Center District having the biggest population and Muzerib has the second biggest population among the sub-districts composing Dar'aa Center District. Refer to **Table 9.3.8.**

Table 9.3.8 Comparison of Master Plan Priority in Dar'aa Governorate

Name of District	Population in 2004	Service Ratio	Served Population	M/P Priority	Remarks
Dar'aa Center	428,681	77%	329,321	○	One of the sub-district called Muzerib is well-known tourism spot
Ezraa	246,915	63%	155,822	△	
Al Sanameen	167,882	60%	99,922	△	

As Muzerib is well-knows as tourism spot, high priority shall be given to this area to facilitate environmental conservation of this beautiful area.

9.3.7 Rural Damascus Governorate

Rural Damascus Governorate is comprised of nine district including Zabadani District. Refer to **Table 9.3.9**.

Table 9.3.9 Comparison of Master Plan Priority in Rural Damascus Governorate

Name of District	Population in 2004	Service Ratio	Served Population	M/P Priority	Remarks
Rural Damascus Center	902,216	77%	691,270	△	
Doma	433,719	87%	377,154	△	
Daria	260,961	83%	215,548	△	
Qatana	207,245	73%	151,517	△	
Qotifeh	119,283	67%	53,109	△	
Al Tal	115,937	89%	103,061	△	
Zabadani	105,342	71%	75,201	○	Located near to Ain Fijeh Spring, Zabadani is quite important water and tourism resource
Nabek	80,001	55%	44,389	△	
Yabroud	48,370	70%	34,086	△	

Zabadani is situated just upstream of the Ain Fejeh Spring, the largest and most important water source of Damascus. Ain Fejeh is also facing the Barada River. As Zabadani is also well-known as a tourist spot, raw sewage being directly discharged into the Barada River has been particularly damaging to Zabadani's tourist resources. Further, since the Barada River flows through Damascus City, the prompt improvement of the river water quality can result in better water amenities. From the viewpoint of water quality improvement in the historical Barada River, high priority shall be given to Zabadani in the sewerage system development M/P preparation.

9.4 Sewerage Macro Plan for Seven Governorates

Upon establishment of sewerage development master plan, the work was executed through two stages, namely "Macro Plan" and "Master Plan". Refer to **Table 9.4.1** for their outline:

Table 9.4.1 Outline of Macro Plan and Master Plan

Plans	Outline of the Plan
Macro Plan	Prepare long-term goal of sewerage development plan such as , sewerage service area, served population, number of proposed STP, basic policy on re-use of treated sewage and sludge treatment and O&M plan. In Macro Plan, regional sewerage plan including not only target core-cities for M/P but also their surrounding cities, towns and villages is carried out to grasp the possibility in integrated or decentralized sewage collection and treatment. Results are utilized to establish more feasible Master Plan.
Master Plan	Further detailed sewerage service area delineation in target core city is conducted to allocate the optimum sewerage system options, namely Centralized Sewerage System, Decentralized Sewerage System and On-site System.

9.4.1 Preparation Works

As cited above, the seven target Governorates are 1) Lattakia, 2)Tartous, 3) Deir-Ez-zor, 4) Hassakeh, 5) Raqqa, 6) Dar'aa and 7) Rural Damascus Governorate. Upon formulation of Macro Plan, fundamental design criteria comprises long-term goal of sewerage development plan such as design service population, number of STPs, sewage and sludge treatment methods, O&M methods and project priority shall be examined.

Prior to the preparation of the Macro Plan, the Study Team organized a "Sewerage Database" to serve as a fundamental basis in the development of the sewerage plan. The Tartous Governorate was the first to submit its input to the data base. The Ministry of Housing and Construction disseminated this format to persons in charge in the remaining Governorates by fax. The Study Team subsequently processed the data submitted by each of the Governorates. The ensuing database is thus comprised of the following data on cities, villages and communities. The Study Team arranged these data according to Sub-district and District:

- Sewer service ratio by served population
- Served population
- Current raw sewage discharging points
- Existence of STP

Based on this database, cities, villages and communities can be divided into three categories as follows:

- Sewer network existing but wthout STP
- Sewer network and STP existing
- None = Served by Pit Latrine

If these three categories are described on a GIS map made by GIS engineers in each Governorate, it will prove useful in the proritization of areas to be served by the appropriate sewerage system options. As to the detailed Sewerage Database, refer to **Volume III, Supporting Report, Part I Master Plan, Appendix 9.1**.

9.4.2 Sewerage System Development Macro Plan

Based on the abovementioned three categories, the sewerage system will be developed according to the order of priority, but the optimum sewerage system option shall be selected based on the geographic features of the locality in each of the target areas such as topography, housing density, target service population and so on. Applicable options are as follows:

- On-site Sewerage System = Pit Latrine and Septic Tank
- Decentralized Sewerage System, serves one city and town
- Centralized Sewerage System, serves plural cities and towns

Presently, the predominant On-site Sewerage System in Syria is Pit Latrine but inasmuch as the pit is dug into the ground and most of these are not concrete-lined, there is a great risk of groundwater contamination if the ground has high permeability. Therefore, the system should be gradually converted into Septic Tanks with less effluent pollution load.

Figure 9.4.1 shows the proposed flow chart of the On-site Sewerage System selection. Major items in the selection process are: “Does the area form part of a Village?”; “Household Density”; “Ground Permeability” and “Groundwater Usage”. Areas where sewage collection by means of sewer network is not advantageous shall be served by the On-site Sewerage System.

Figure 9.4.2 presents the comparison between the Centralized Sewerage System and the Decentralized Sewerage System. The illustration shows Community A to be near large-scaled City A. Whether the sewage generated in Community A shall be connected to City A for integrated treatment (Centralized) or whether sewage generated by both of them shall be treated respectively (Decentralized) the final system must be determined by cost efficiency comparison. In topographies where the collection of sewage by gravity is difficult, a pumping station might be planned. Comparison should take into account the total project cost inclusive of construction and O&M costs.

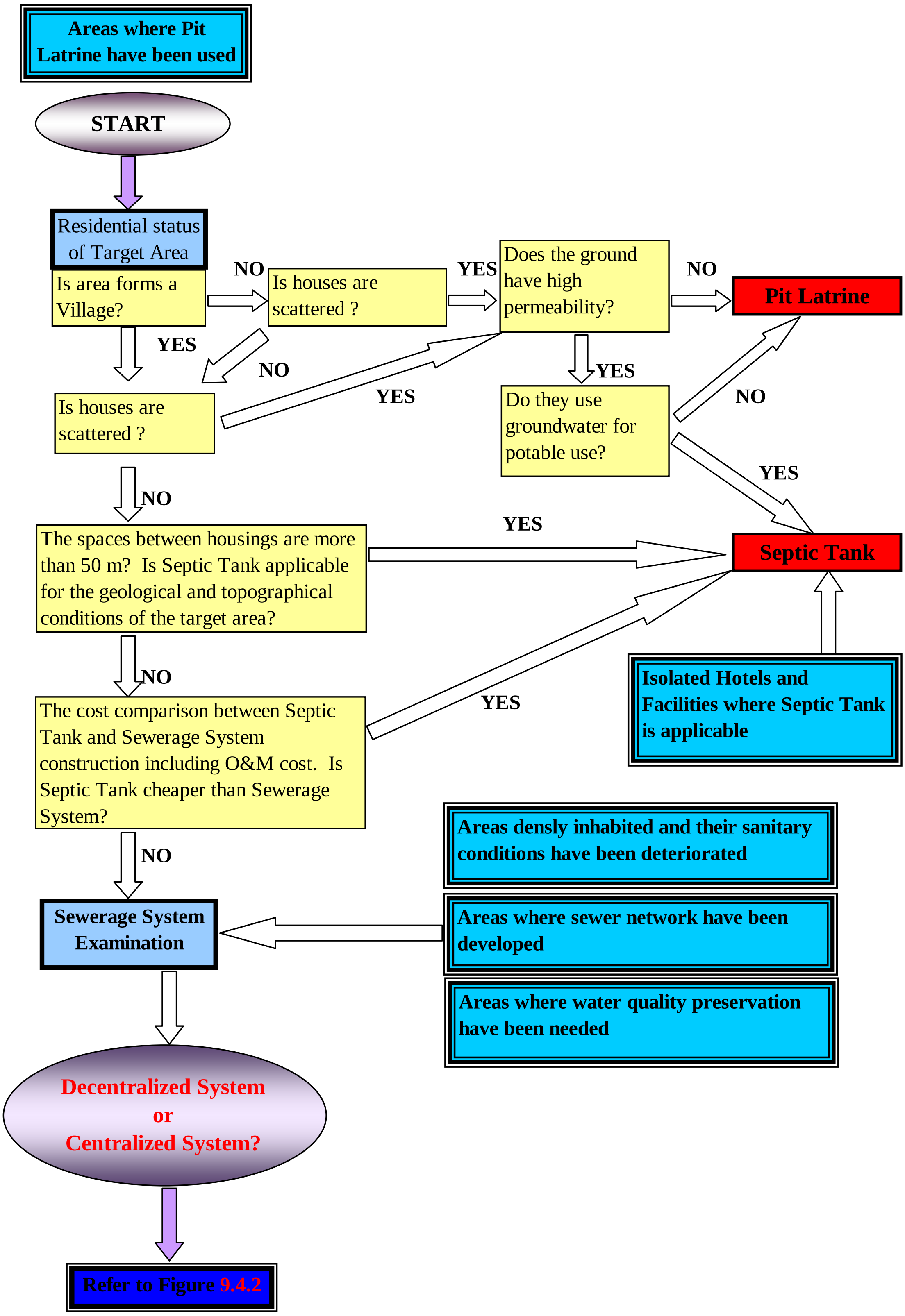
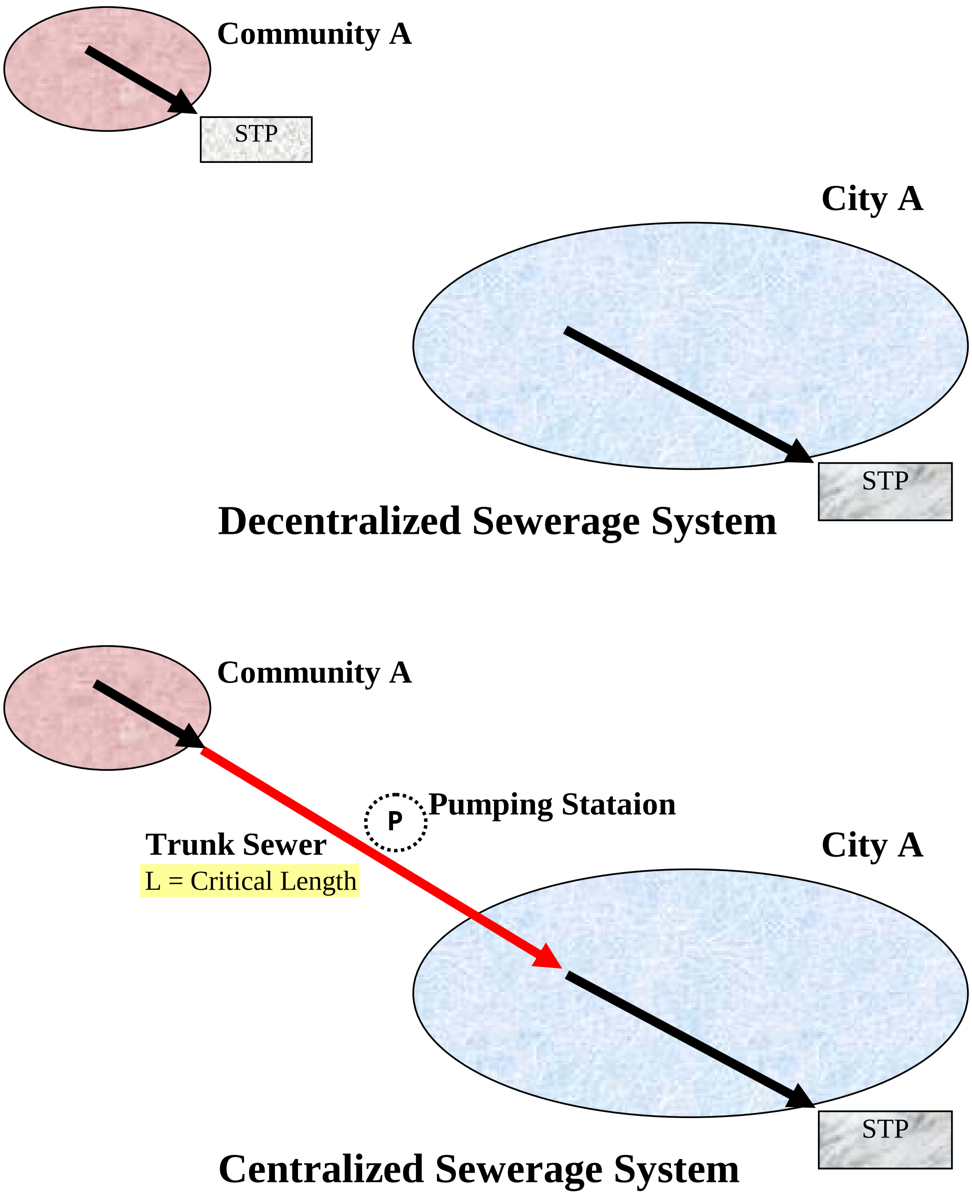


Figure 9.4.1 Flow Chart of Sewerage System Option Selection

Note) As to cost threshold sewer length (critical space between housings), refer to **Volume III, Supporting Report, Part I Master Plan, Appendix 9.4**.



Example of Cost Comparison Case in Japan

Population of Community A	Critical Length (m)
100	1,200
500	1,800
1,000	3,500

Note) Population of City A = 35,000

Figure 9.4.2 Comparison on Decentralized Sewerage System and Centralized Sewerage System

Based on the socio-environmental features of the target areas and the economical profiles of the projects, the order of priority of the evaluated items can be proposed as shown in **Table 9.4.2**.

Table 9.4.2 Proposed Priority Order Evaluation Items

Evaluation Items	Contents and Manner of Evaluation
1) Projected Service Population	Comparison by projected service population with consideration in scale-merit
2) Population Density	The higher the population density, the greater the health hazard from poor sanitation and the lower the unit cost of sewerage.
3) Failure on On-site System	The cause of failure shall be confirmed. Most of cases can be solved by removal of accumulated sludge and replacement of facilities. Conversion from on-site system to sewerage system is only applicable where on-site system is proved to have failed irreparably or is likely to fail within the design life.
4) Industrial Pollution	Industrial wastewater is much more concentrated and lager than domestic sewage. Effluents to sewer size and STP capacity shall be examined upon connection of industrial wastewater to public sewerage system.
5) Construction Cost and O&M Cost	Comparison by per capita construction cost and O&M cost
6) Tourist Impact	Number of tourists, length of contaminated river and beach
7) Environmental Impact	Odor and visual impact
8) Affordability	Presumed by “Affordability to Pay” through Social Survey to residents
9) Economy Scale	If plural communities are located near to the existing sewerage system, priority shall be determined by their economy scale.
10) Institutional Capacity	Higher priority shall be given to the communities where O&M institution has already formed or support by external institution is available
11) Health Benafits	Comparison by number of beneficiaries

Source) “Low Cost Sewerage”/Duncan Mara

(1) General

1) General Conditions

When priority areas for the Master Plan preparation are chosen, the following examination parameters should serve as guide in assessing general conditions:

1) Core City to be selected should fall within the designated area
2) The location and topographic conditions of the said core city and its surrounding communities shall be investigated to determine whether their merger is advantageous in terms of sewerage system development.
3) A field survey shall be conducted for core city and its surrounding communities to determine housing density. The communites should then be classified into two categories:
   a) Community where service by sewerage system is advantageous
   b) Community where service by sewerage system is not advantageous and thus shall be served by On-site system

4） In communities where service by sewerage system was determined to be more advantageous, a merger should be studied offering several alternatives. Alternatives shall be compared in terms of their economic effectovemess and the issues to be encountered in project implementation in order to arrive at the optimally beneficial alternative.

In this Study, the abovementioned examination was conducted in seven designated areas within the seven Governorates. Based on the results of the examination, the Ministry of Housing and Construction, as the Study Team's counterpart, is expected to extend the examination nationwide.

The detailed examination of conditions prevailing in communities that were identified for inclusion in the On-site system was terminated, due to the following factors:

- There is no sewer network and residents are served by Pit Latrine or Septic tank
- Since housing is scattered, opportunities for natural purification per housing unit are open. Therefore, the environmental impact brought about by their raw sewage discharge is quite small.
- As the distance between housing units is large, sewer installation cost per housing unit becomes higher. The critical distance between the housing units was determined based on the economic comparison between the existing system and the sewer pipe and Septic Tank installation. The critical distance was set at 50 m. As to the basis of this critical distance, refer to **Volume III, Supporting Report, Part I Master Plan, Appendix 9.4**.

As a result, the sewerage system development efficiency and urgency are low in these communities. Therefore the design system cannot take the form of a public utility. Accordingly, the installation cost of the Septic Tank for the improvement of the living environment will prove burdensome to the owner. If such communities are located near a potable water source or a dam, Septic Tank installation can be done through a public utility. In this case, the legislation of a policy authorizing the Governorate to extend needed subsidies for the installation of Septic Tanks in the subject communities should be seriously considered.

2) Detailed Conditions

a) Re-use of treated Sewage

In general, the objective plan with a firm base can only be prepared if data is available, but the Study Team faced several obstacles in this regard that made planning difficult. For instance,

- No updated topographic and urban development data are available
- No map with a suitable scale for planning is available
- Most of the information obtained were acquired through interviews/discussions with the relevant counterpart or through a field survey

However, subjective interpretation must be eliminated at most. Therefore, the design policy data must be clearly arranged in order to avoid serious discrepancies in the crafting of the sewerage system development plan.

Aside from assessing topographic conditions, another important condition relevant to the Macro Plan preparation is the re-use of treated sewage. Interviews with the engineers of Hassakeh Governorate, revealed that there was a need to re-use treated sewage in the summer months. The following points were confirmed in the course of those interviews:

- Treated sewage can be used to water wheat, crops for livestock and cotton
- Treated sewage can also serve the irrigation needs of wheat and crops during winter but relative precipitation can be expected during this season
- Therefore, the re-use of treated sewage for cotton cultivation can only be done in summer. As a huge volume of water is needed to cultivate cotton, this becomes the subject of agricultural water conservation.

Originally, effective plantation presupposes the selection of the most suitable breed given the local climate and soil condition since the random application of treated sewage may cause additional problems. If there is a need to treat sewage, then the Decentralized System can be introduced as the preferred treatment system because it requires a lesser number of transmission facilities when compared with the Centralized System.

Furthermore, market research in targeted farmhouses is also indispensable to accelerate the project benefit. The demand for treated sewage can be calculated by this means. Failure of treated sewage re-use in the Adraa STP is assumed to be due to the lack of research.

b) Project Urgency Considerations

If sewerage system development is critical to the target area, service by Decentralized System per each city, municipality and town is applicable and efficient. This is apparent when observing the circumstances surrounding Muzerib. In this case, the STP construction site was altered several times due to the opposition of residents, resulting in the huge loss of time and budget. The original Muzerib plan was an integrated plan for three core cities. Hence, the STP construction site had to be relocated twice due to popular pressure. The site is now site located in the intermediate point of these three core cities and adjustment work is on-going prior to project implementation. Residents in one city do not usually want to accept sewage generated by other cities into their STP. This is expected. Accordingly, if the sewerage system development is an urgent matter, the Decentralized System is applicable and the identification of the STP site can be the joint responsibility of the target city, municipality and town, respectively.

c) Condition on Economical Comparison for Alternatives

Upon the economical comparison of alternatives, the location of the Main Trunk (ML), Pumping Station (PS) and Sewage Treatment Plant (STP) was temporally planned and each project cost was estimated as shown in **Table 9.4.3** based on the following provisions:

- Per capita sewage flow was set at 100 l/day and STP capacity was calculated based on this
- Peak hourly flow is 2.0 times of the daily maximum flow in consideration of the Combined System
- O&M costs including labor, power, chemical and fuel consumption shall be estimated for a perod of 35 years which represents the average useful life of Civil Structures. Though the sewage treatment method was selected in the course of the Master Plan preparation, the OD was adopted on the basis of economical comparison.

Costs computed in the Pre-investment Study in Banias were accessed as reference.

Table 9.4.3 Condition on Economical Comparison for Alternatives

Population	5,000	10,000	50,000	100,000	200,000
Average flow (m^3/d)	500	1,000	5,000	10,000	20,000
Peak flow(m^3/d)	1,000	2,000	10,000	20,000	40,000
Diameter of Trunk Sewer (gravity) V = 1.5 m/s	250	250	500	600	800
Unit Cost of Trunk Sewer ($/m)	120	120	140	160	220
Diameter of Trunk Sewer (pressure) V=2.0m/s	100	150	300	400	500
Unit Cost of Trunk Sewer ($/m)	80	100	120	130	140
Capacity of PS (m^3/min)	0.69	1.39	6.94	13.89	27.78
Total Cost of PS ($)	428,471	623,277	1,638,910	2,509,858	3,797,786
Capacity of STP (m^3/d)	500	1,000	5,000	10,000	20,000
Construction cost of STP	1,440,000	1,670,000	3,530,000	5,800,000	10,500,000
O&M cost of STP (for 35 years)	2,277,136	2,658,525	5,959,939	9,881,432	17,193,118
Total Cost of STP ($)	3,718,136	4,328,525	9,489,939	15,681,432	27,693,118

(2) Study for each Area

1) Slunfeh, Lattakia Governorate

The core city located closest to Slunfeh is Ain Al Teyna and distance between them is 11km. As the existing road connecting these two cities has an intensive undulation, the installation of sewer pipes to convey sewage to Slunfeh is unrealistic. Though the community of Ain Alwadgi is located near Slunfeh, since this is situated at the bottom of the valley, a high head pump was considered indispensable to the conveyance of sewage to Slunfeh. There is no apparent merit in sending sewage generated in Ain Alwadgi to Slunfeh. Based on this examination, Slunfeh shall be served by the Decentralized System. **Figure 9.4.3** shows the location map of Slunfeh and other core cities.

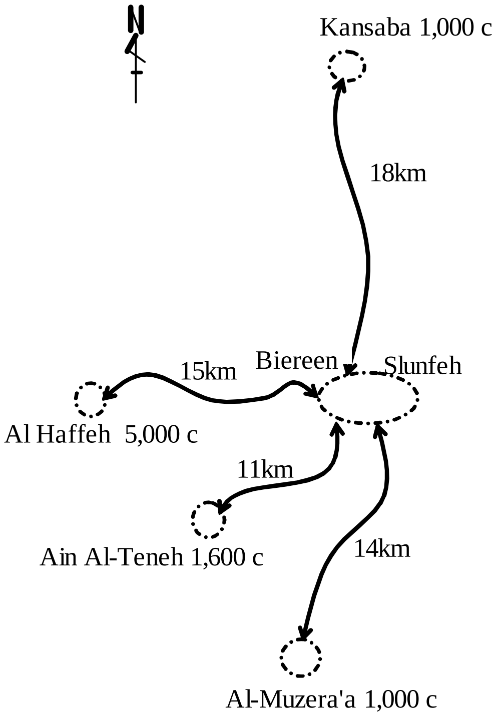


Figure 9.4.3 Schematic Location Map of Slunfeh and Adjoining Core Cities

2) Banias, Tartous Governorate

The distance between Banias and its closest core city, Anaze, is 11 km. As the existing road connecting these two cities is characterized by intensive undulation, sewer pipe installation to convey sewage to Banias is, likewise, unrealistic. In the other surrounding core cities, it is apparent that there is no merit in integrating their common sewage with that of Banias owing to size of their population as well as distance to Banias. These surrounding cities shall be served by the Decentralized System or the On-site system.

Because Banias is densly inhabited, service by means of the Centralized System is assessed to be more advantageous. **Figure 9.4.4** shows the location map of Slunfeh and other core cities.

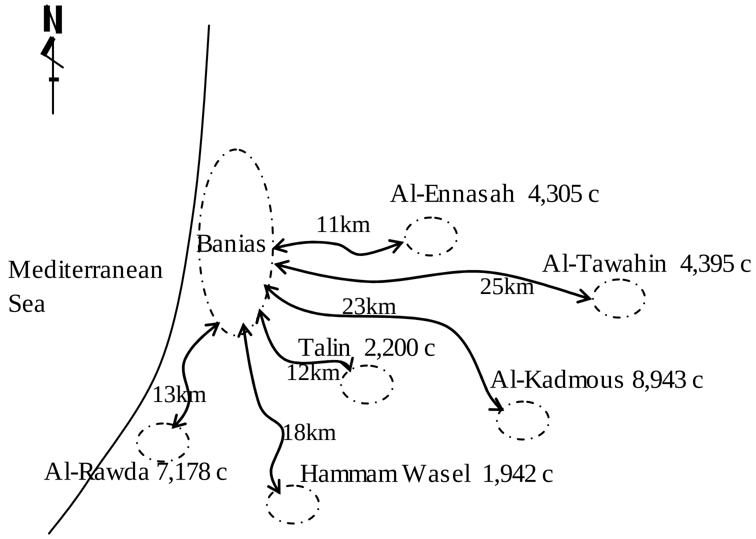


Figure 9.4.4 Schematic Location Map of Banias and Adjoining Core Cities

3) Mayadin, Deir-Ez-zor Governorate

Mayadin is a core city facing the Euphrates River. There is another core city called Al Eshara located 15 km downstream alongside the river. As these cities are large in scale, they can be the target of an integration study.

Meanwhile, there is another core city on the opposite riverbank, called Theeban. To send sewage generated here to Mayadin, a sewer trunk must traverse the Euphrates River but this has many drawbacks as described below and therefore, has obviously no merit:

- As the pipe traverses below the river, sufficient earth cover must be secured from the lowest bottom level of the river.
- The special pipe installation method must be employed, such as the Shield Method.
- Therefore, the pipe installation cost and O&M cost must both be expensive.

Accordingly, the integration of Theeban was excluded from the target of examination. **Figure 9.4.5** shows the location map of Mayadin and its surrounding core cities:

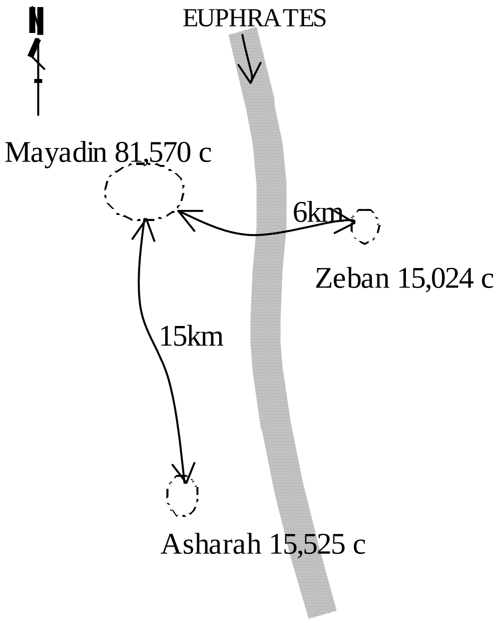


Figure 9.4.5 Schematic Location Map of Mayadin and Adjoining Core Cities

Based on the abovementioned, possible integration alternatives are as follows:

Alternative 1 Plan STP for Mayadin and Al Eshara, respectively
Alternative 2 Plan STP at Mayadin. Integrate Mayadin and Al Eshara.
Alternative 3 Plan STP at Al Eshara. Integrate Mayadin and Al Eshara.

Component of each alternative is shown in **Figure 9.4.6**:

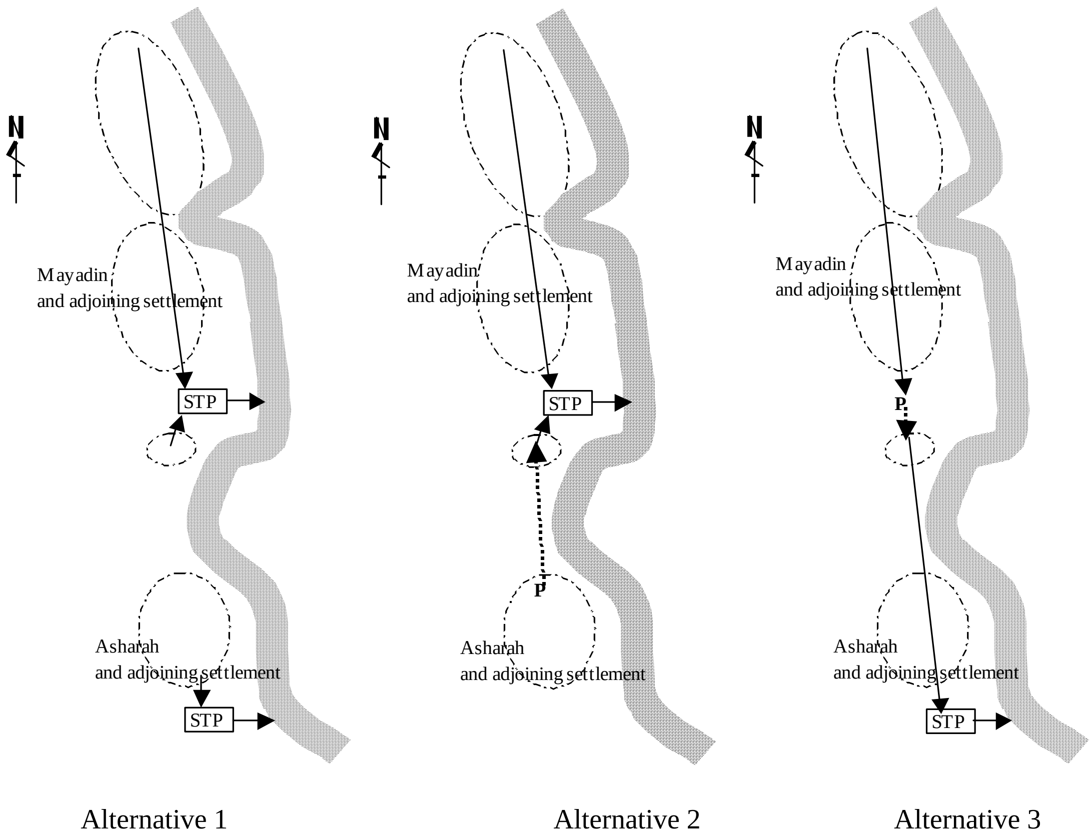


Figure 9.4.6 Component of each Alternative

As a result of the economical comparison of alternatives, Alternative 2, the planned STP in Mayadin demonstrates a larger sewage flow. Refer to **Table 9.4.4**. Further, compared with Alternative 3, Alternative 2 has more merit in terms of the antecedent project investment restriction, since there is no need for a long truck sewer to transmit sewage to Al-Eshara in the early stage of the project. Accordingly, sewerage development in Al-Eshara and its surrounding communities is not urgently called for, and can be scheduled to cope with the progress of urbanization and river water pollution.

Table 9.4.4 Economical Comparison on Alternatives

Alternatives	Main Components	Cost($)	Ratio
Alternative 1	STP at Mayadin	30,213,754	1.06
	STP at Al-Eshara		
	Trunk Sewer		
	Sewerage network on adjoining settlements of core city		
Alternative 2	STP at Mayadin	28,526,515	1.0
	PS & Trunk Sewer		
	Sewerage network on adjoining settlements of core city		
Alternative 3	STP at Mayadin	31,903,490	1.12
	STP at Al-Eshara		
	PS & Trunk Sewer		
	Sewerage network on adjoining settlements of core city		

Note) As to detailed cost estimation, refer to **Volume III, Supporting Report, Part I Master Plan, Appendix 9.6**.

4) Malkieh, Hassakeh Governorate

The distance between Malkieh and its closest core city called Yaroubieh is 45 km. There is no apparent need to conduct an economical comparison, since the integration of systems serving these two cities is unrealistic. Therefore, Malkieh shall be served by the Decentralized System. **Figure 9.4.7** shows location map including Malkieh and its surrounding core cities:

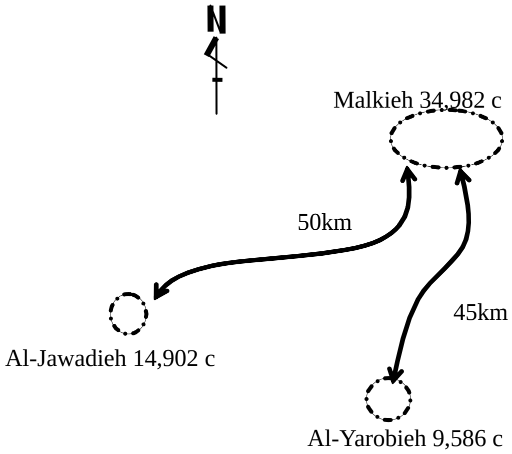


Figure 9.4.7 Schematic Location Map of Malkieh and Adjoining Core Cities

5) Al Thawra, Raqqa Governorate

Surrounding Thawra, there are core cities called Al-Jarneah located in the north and Mansorah situated in the east. However, as shown in **Figure 9.4.8**, Thawra and Al-Jarneah are divided by the Euphrates River and thus, the integration of both cities is unrealistic.

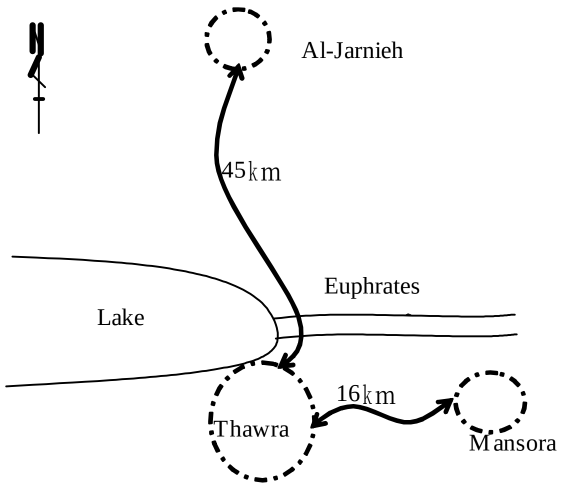


Figure 9.4.8 Schematic Location Map of Thawra and Adjoining Core Cities

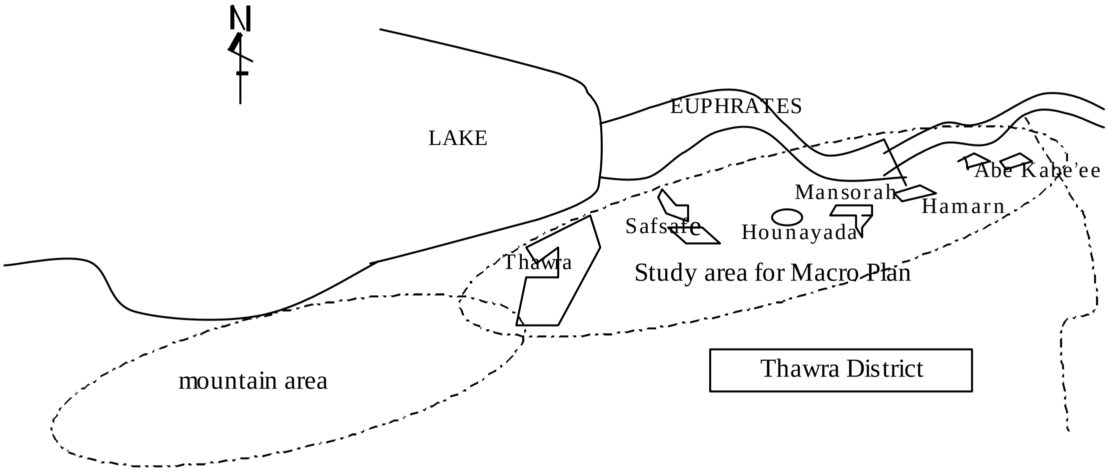


Figure 9.4.9 Schematic Location Map of Communities in Thawra Sub-district

Refer to **Figure 9.4.9** above. Status of Thawra City and communities located nearby is as follows:

1) Thawra city is situated on a hilly area facing Asad Lake. According to the Census conducted in 2004, the population here is about 70,000, making Thawra city the second biggest city in the Raqqa Governorate. To cope with rapid population growth, a city plan was designed to expand the urban area boundary.
2) Al Safsafeh is comprised of Safsafeh-Tahtany located on the terrace of the Euphrates River and Safsafeh-Foqany situated in the hilly area. Human excreta generated here are treated by Pit Latrine constructed by the respective households. No sewer network has been installed. Throughout the community, housing density is rather weak.
3) Al Hounayada is situated on the terrace of the Euphrates River. Human excreta generated here are treated by Pit Latrine constructed by the respective households. No sewer network has been installed as well. Housing density is likewise weak.
4) Located along the Euphrates River, Mansorah has an existing sewer network and STP.
5) Hamarn is located also on the terrace of the Euphrates River. Human excreta generated here are treated by Pit Latrine constructed by the respective households. No sewer network has been installed. Housing density is also rather weak.
6) Abe Kabe'ee Gharbe shares the same situation as Hamarn.

Figure 9.4.10 shows the existing sewerage system in this area.

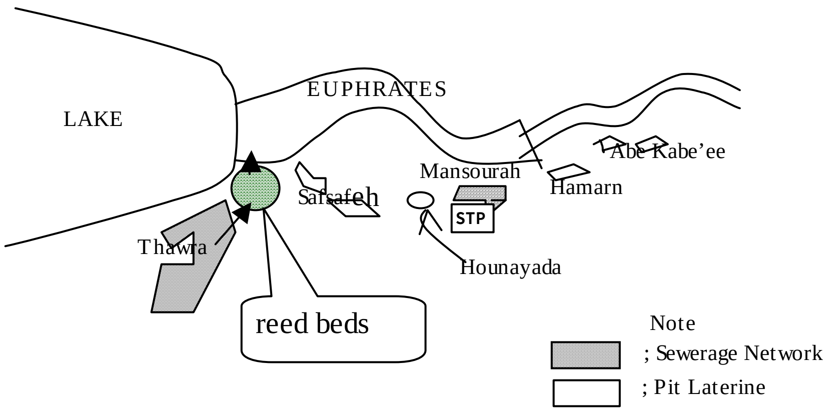


Figure 9.4.10 Existing Sewerage System in Thawra

Among the six communities described above, Thawra and Monsorah are considered large-scale cities with populations exceeding 50,000. Thus, scale-merit by integration can be expected. Remaining communities were excluded from the scope of the integration examination as they are served by Pit Latrine.

Although there are five existing small-scale STPs in Mansorah, STP operations have been suspended in three of these facilities due to the lack of proper O&M activities.

Integration examination is carried out in the design of two alternatives:

Alternative 1 STP is planned for Mansorah and Thawra, respectively

Alternative 2 Mansorah and Thawra will have integrated systems. STP is planned for Mansorah

As to the composition of each alternative, refer to **Figure 9.4.11** to **9.4.12**.

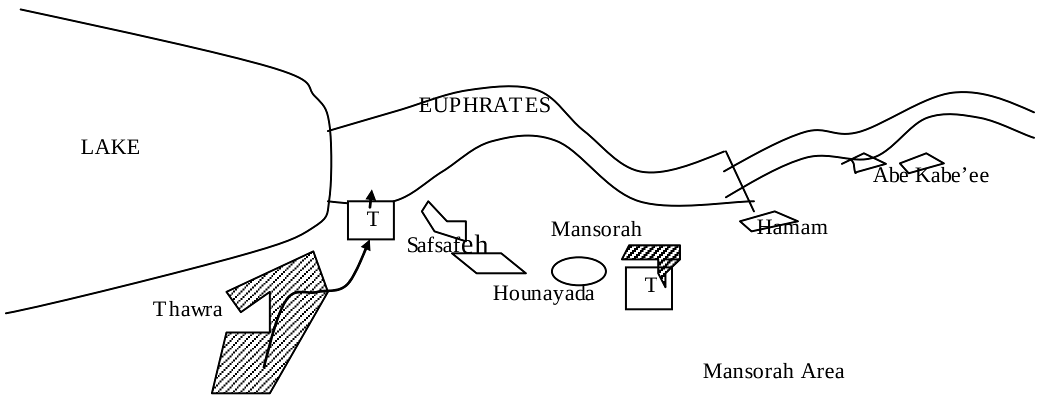


Figure 9.4.11 Composition of Alternative 1

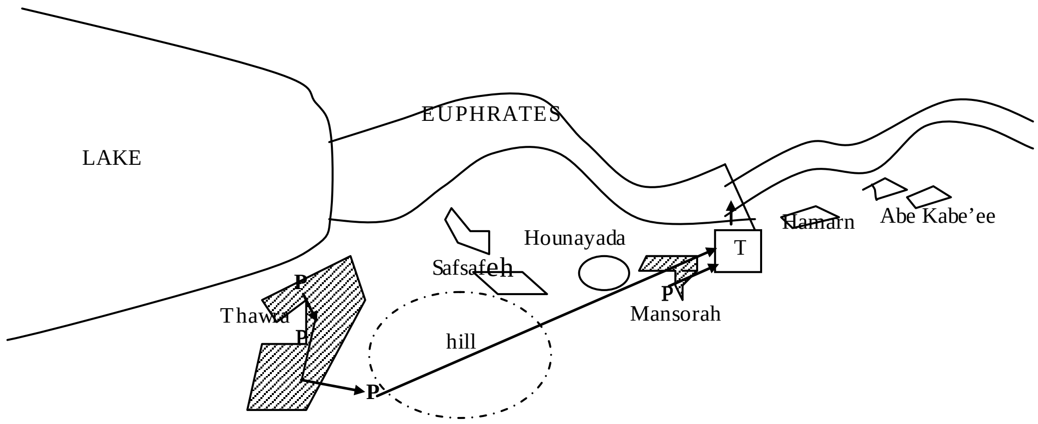


Figure 9.4.12 Composition of Alternative 2

Results of the economical comparison are described hereinafter:

The natural reed bed has been functioning quite efficiently and the quality of the treated sewage is excellent. Therefore, the sewerage system development plan shall be formulated premised upon its utilization in the future.

As Alternative 1 utilizes the existing reed bed and will consist only of a supplemental primary sedimentation tank and a sludge treatment facility to cope with the future pollution load growth, it is adjudged to be more economical than Alternative 2 that employs a conventional STP.

Since Alternative 2 will require a PS to transmit sewage that will traverse a hilly area, its construction cost will necessarily be more expensive.

Consequently, Alternative 1 was selected as the optimum plan. Refer to **Table 9.4.5**:

Table 9.4.5 Economical Comparison on Alternatives

Alternatives	Main Components	Cost ($	Ratio
Alternative 1	STP at Thawra	22,781,236	1.0
	PS & Trunk Sewer at Mansorah		
Alternative 2	PS & Trunk Sewer at Thawra	37,212,346	1.6
	PS & Trunk Sewer at Mansorah		
	STP at Mansorah		

Note) As to detailed cost estimation, refer to **Volume III, Supporting Report, Part I Master Plan, Appendix 9.6**.

6) Muzerib, Dar'aa Governorate

In Muzerib, the sewerage development plan was established by the GCEC and according to this plan, Muzerib, Yaduda and Atman were planned to benefit from a common and integrated Centralized System. Therefore, these three cities were included in the scope of examination. The current status of three cities is shown in **Table 9.4.6**:

Table 9.4.6 Current Status of Cities in Scope of Examination

Name of City	Current Status
Muzerib	Has the largest population. Sewer network has been developed already and raw sewage is discharged into channel nearby called Wadi Al Dhahab.
Yaduda	Located 6 km upstream of Muzerib, it has second largest population. Sewer network has been developed already and raw sewage is discharged into Wadi Al Dhahab as well.
Atman	Located 4 km upstream of Muzerib, it has the smallest population. Sewer network has not been developed yet.

As these three cities are densely inhabited, service by a Centralized System seems advantageous. However, Atman was judged to be more efficiently served by a Decentralized System due to the following circumstances:

- Since the sewer network has not yet been installed,, the development is estimated to take a longer perod of time.
- No contamination of public water bodes has been reported yet.
- As the topography between Atman and Yaduda is flat, PS is necessary to send sewage generated in Atman to Yaduda.
- Raw sewage generated in Atman is discharged through a channel nearby that differs from that n Muzerib and Yaduda.
- Severe opposition might arise from residents near to the STP construction site who are against the treatment of sewage coming from other communities.

Considering the abovementioned conditions, alternative study presenting two alternatives has been conducted and they are as follows:

Alternative 1 Plan separate STPs for Muzerib, Yaduda and Atman, respectively
Alternative 2 Plan an integrated system for Muzerib and Yaduda and another Decentralized system for Atman.

The major components of each case are as follows:

Alternative 1

- Plan an STP with a capacity of 1,700 m^3/d located near the discharge point of Muzerib with a population of 17,180.
- Plan an STP with a capacity of 1,700 m^3/d located near the discharge point of Yaduda with a population of 17,200.
- Plan an STP with a capacity of 1,500 m^3/d located near the discharge point of Atman with a population of 15,200.

Alternative 2

- Plan a PS with a capacity of 2.386 m^3/sec located near the discharge point of Muzerib with a population of 17,200 to pump sewage to STP 4.5 km away. Diameter of the force main is 200 mm.
- Send sewage generated in Yaduda with total population of 17,200 including refugees numbering 5,000 to the STP by gravity. Pipe length is 2.0 km and diameter is 300 mm.
- Plan an STP with a capacity of 3,400 m^3/d located at the intermediate point between Muzerib and Yaduda.
- Plan an STP with a capacity of 1,500 m^3/d in Atman.

The results of the economical comparison are shown in **Table 9.4.7**.

Table 9.4.7 Economical Comparison on Alternatives

Alternatives	Main Components	Cost ($)	Ratio
Alternative 1	STP at Muzerib	15,512,087	1.00
	STP at Yaduda		
	STP at Atman		
Alternative 2	PS at Muzerib	14,036,999	0.90
	Trunk Sewer from Muzerib to STP		
	Trunk Sewer from Yaduda to STP		
	STP at Muzerib&Yaduda		
	STP at Atman		

Note) As to detailed cost estimation, refer to **Volume III, Supporting Report, Part I Master Plan, Appendix 9.6**.

As shown on this Table, the total project cost of Case 2 that represents the integration case of Muzerib and Yaduda is 10 % cheaper than the cost of Case 1. As the cost difference is small, Case 1 with the advantage of phased implementation is feasible but Case 2 was the one that was finally selected owing to the following considerations:

- Adjustments in anticipation of project implementation are on-going between Muzerib, Yaduda and Dar'aa Governorates.
- Sewerage system development in Muzerib and Yaduda is urgent.
- STP O&M engineers cannot be easily hired.

Figure 9.4.13 shows the schematic map of the sewerage system.

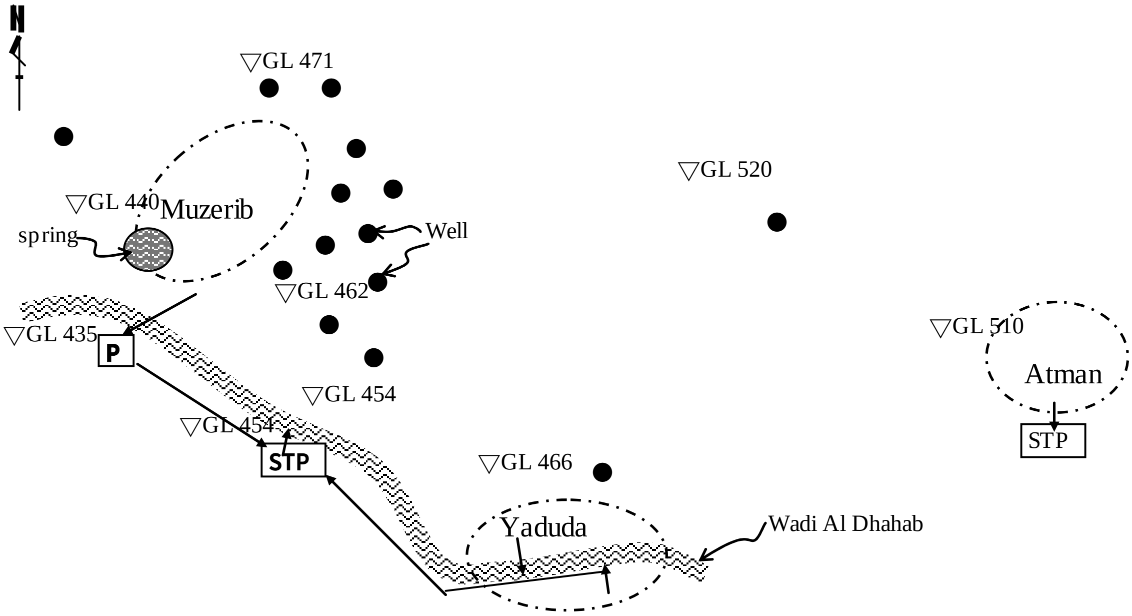


Fig 9.4.13 Schematic Map of Sewerage System of Muzerib

7) Zabadani, Rural Damascus Governorate

As to Zabadani, the Pre-Feasibility Study was prepared by the EIB. According to this study, the seven communities of Zabadani, Bludan, Buqqin, Madaya, Ain Hour, Rawdah and Hosh Bujd were planned to be served by one Centralized System. Based on the field survey, the Study Team classified these communities into two categories, namely communities to be served by the Centralized System and those to be served by the Decentralized System.

a) Zabadani, Bludan, Buqqin, Madaya

These four communities are located at the central area of Zabadani. As housing here is dense, service by Centralized System appears advantageous. Further, since these communities are located close to each other, they shall be inevitably served by an integrated system.

b) Ain Hour

This community is located 5 km away from Zabadani in the north. In consideration of the following circumstances, the Decentralized System was employed for this community:

- The residential area is served by two existing sewer network systems divided by a small creek that flows down the middle of the community. Collected raw wastewater has been discharged into the said creek and has been contributing to water contamination.

It should be noted further that the existing sewer network has deteriorated badly due to aging. Pipe breakage was also reported. As concrete pipes are supposed to be installed, these will be replaced by more reliable pipe materials like PVC and PE as indicated in

Chapter 5, p5-48, Table 5.2.33.

c) Rawdah

Rawdaw is a community located in a western hilly area with a population of 4,536. As the average housing interval is 50 m approximately, the Decentralized System is applicable. However, since Rawdah is located far from Zabadani, Bludan, Buqqin and Madaya, integration with these communities is not advantageous.

d) Hosh Bujd

Although Hosh Bujd is a small-scaled community located at the end of western hilly area, it has been served by an existing sewer network and collected wastewater has been discharged into small creeks through two discharge points. Since efforts are ongoing to conserve the Zabadani area as a tourist resource, a thorough pollution control measure should be undertaken. Therefore, the Study Team proposed the installation of a Decentralized System for the purpose of this community.

As abovementioned, the classification is as follows:

- Zabadani, Bludan, Buqqin and Madaya = Integrated service by Centralized System
- Rawdah, Ain Hour and Hosh Bujd = Decentralized System

Figure 9.4.14 shows schematic map of sewerage system.

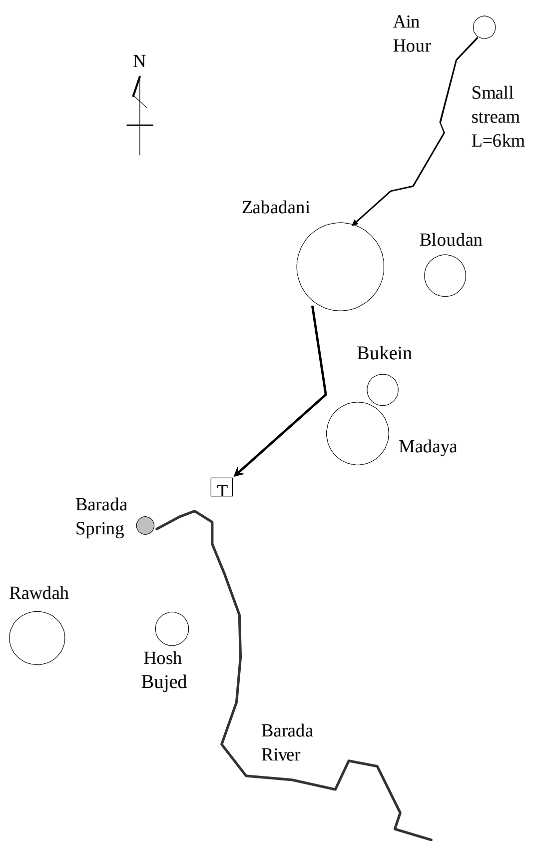


Fig 9.4.14 Schematic Map of Sewerage System of Zabadani

The examination results of the Macro Plan are shown in **Figure 9.4.15** to **Figure 9.4.21**.

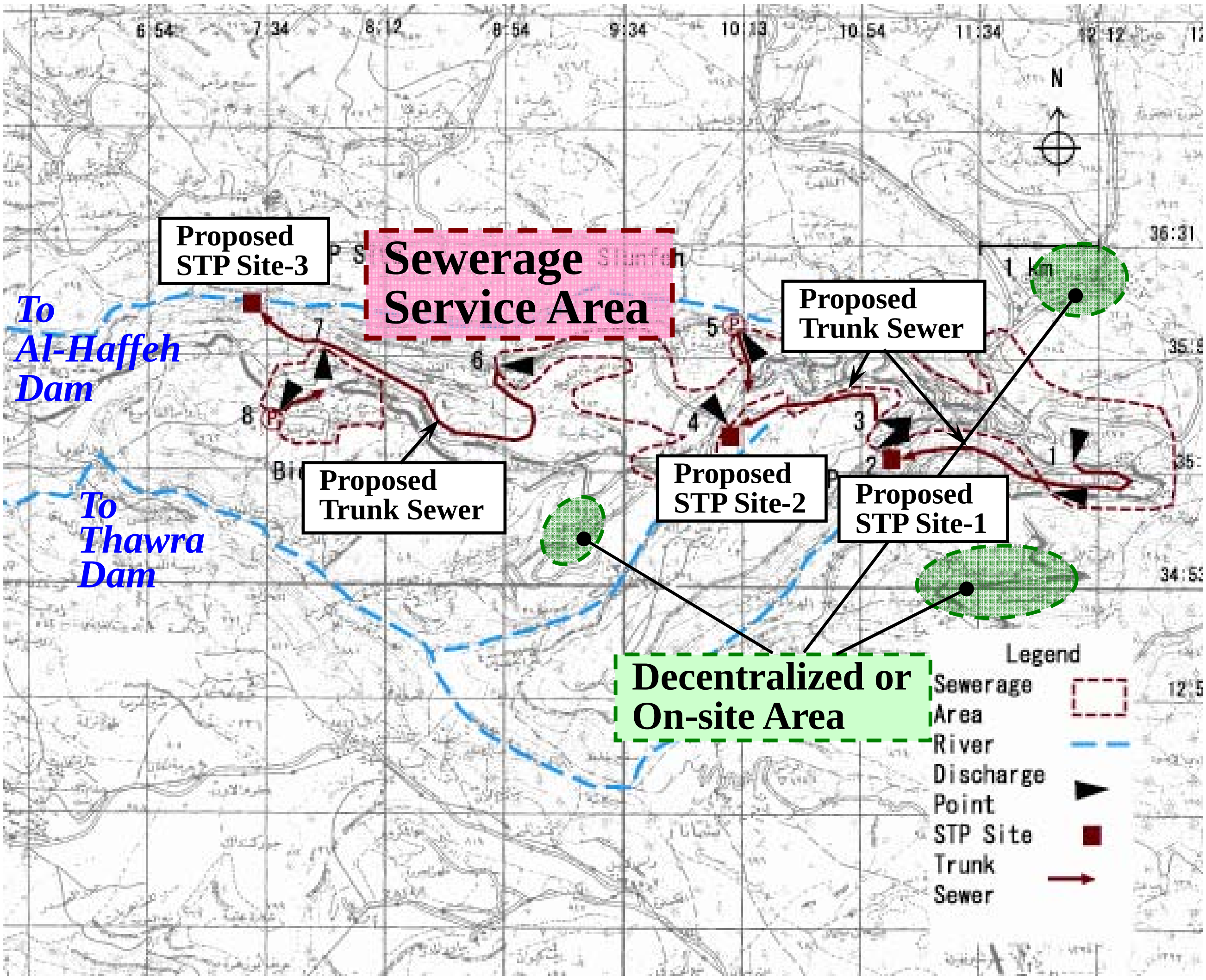


Figure 9.4.15 Macro Plan of Slunfeh (Lattakia Gov.)

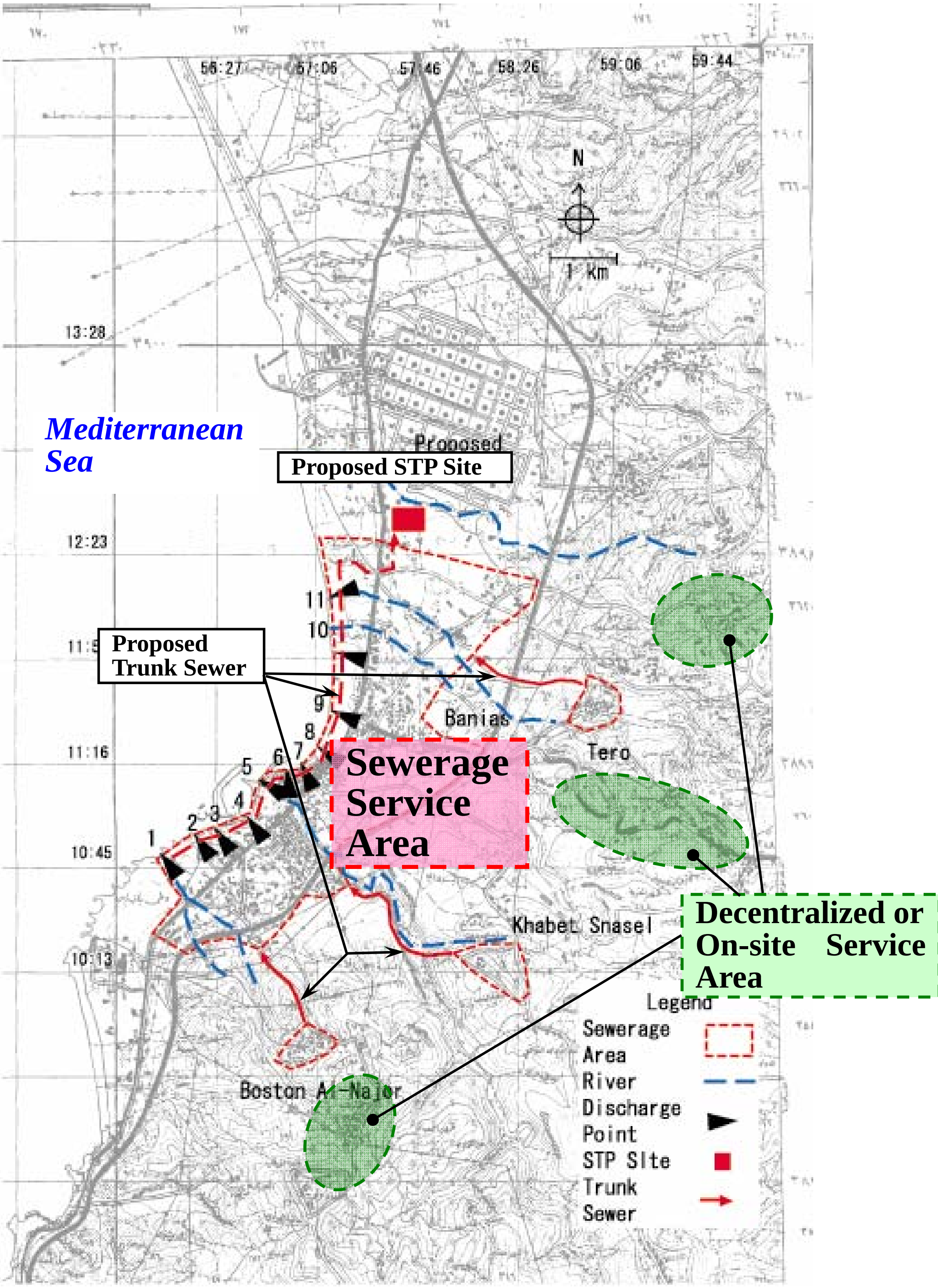


Figure 9.4.16 Macro Plan of Banias (Tartous Gov.)

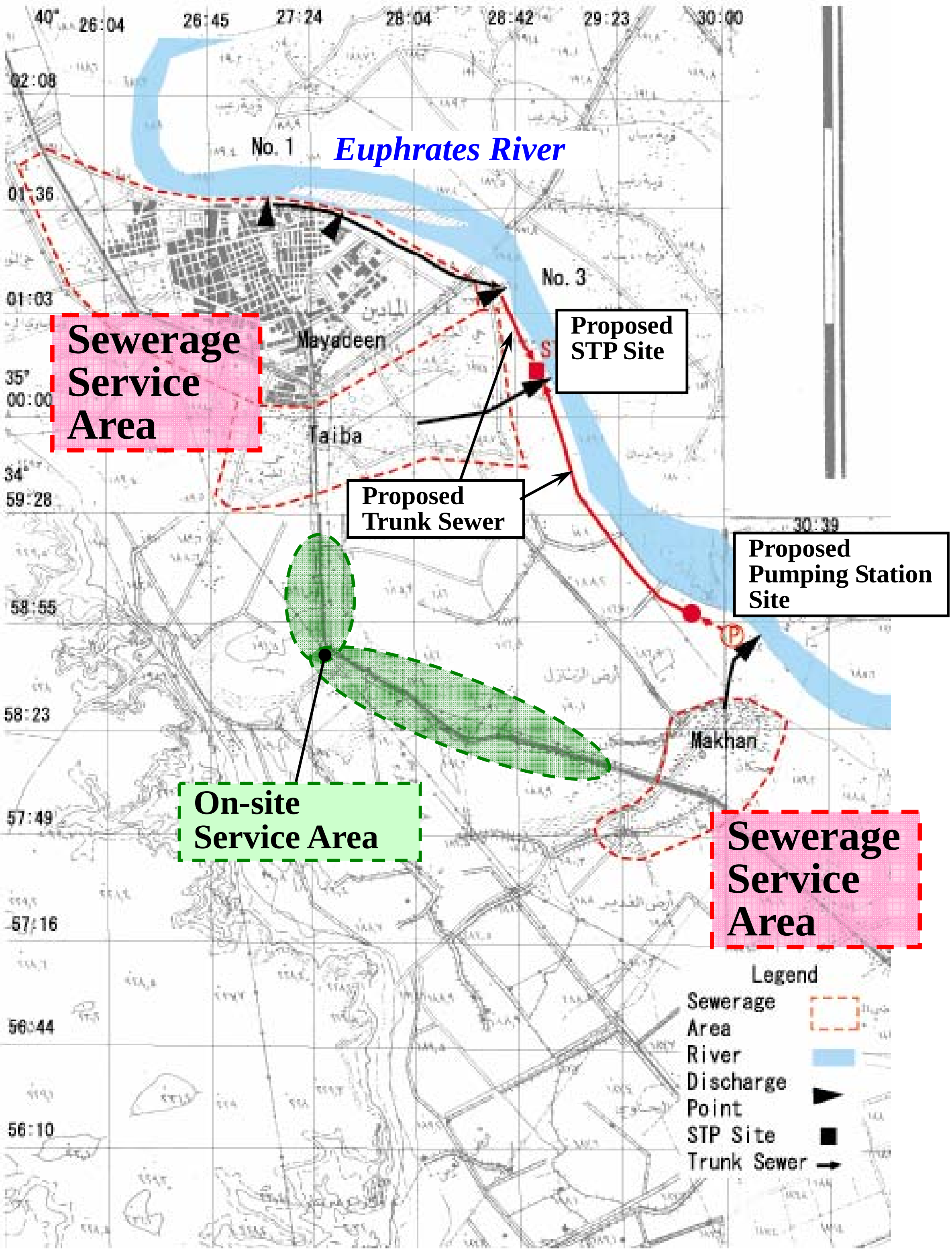


Figure 9.4.17 Macro Plan of Mayadin(Deir-Ez-Zor Gov.)

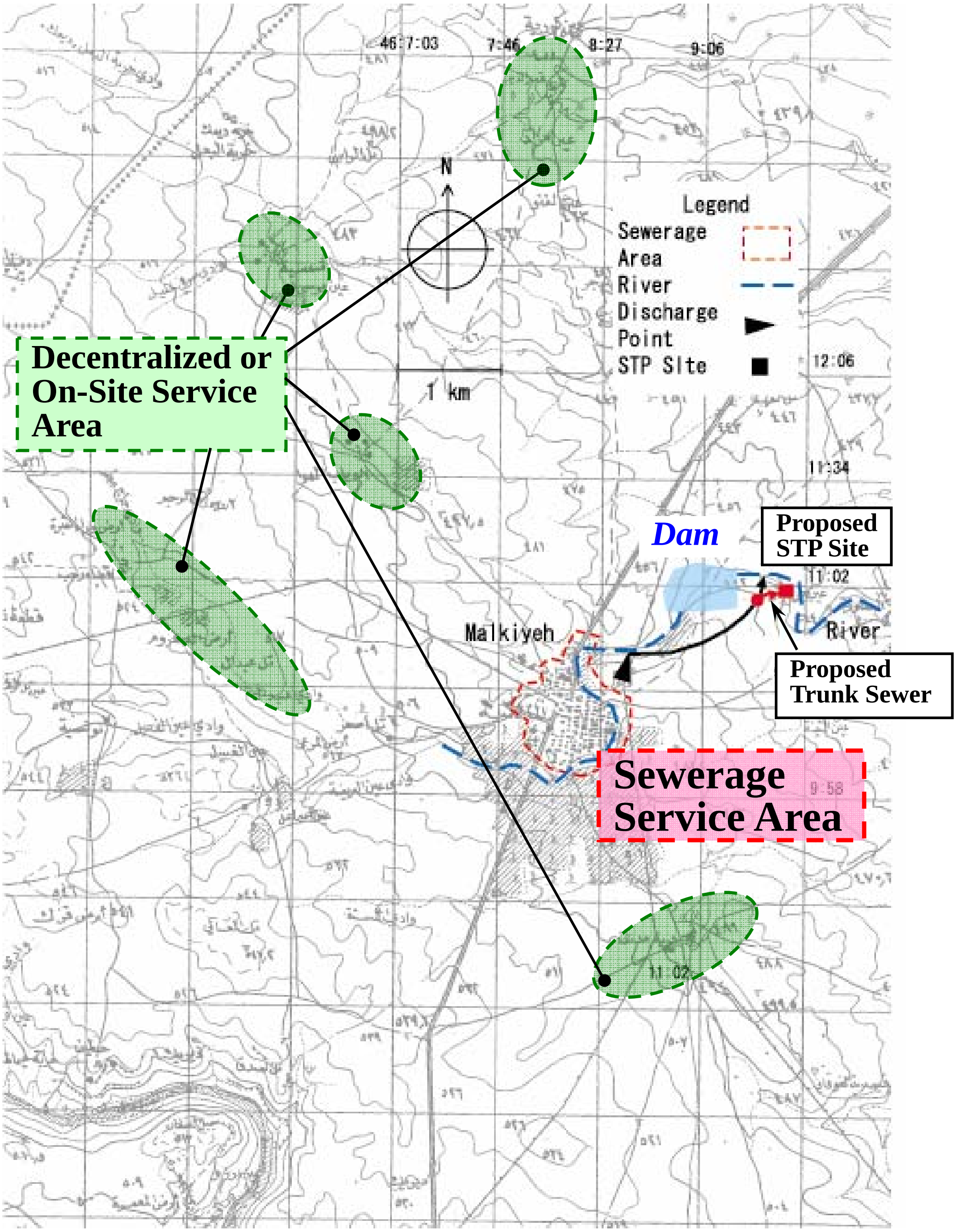


Figure 9.4.18 Macro Plan of Malkieh (Hassakeh Gov.)

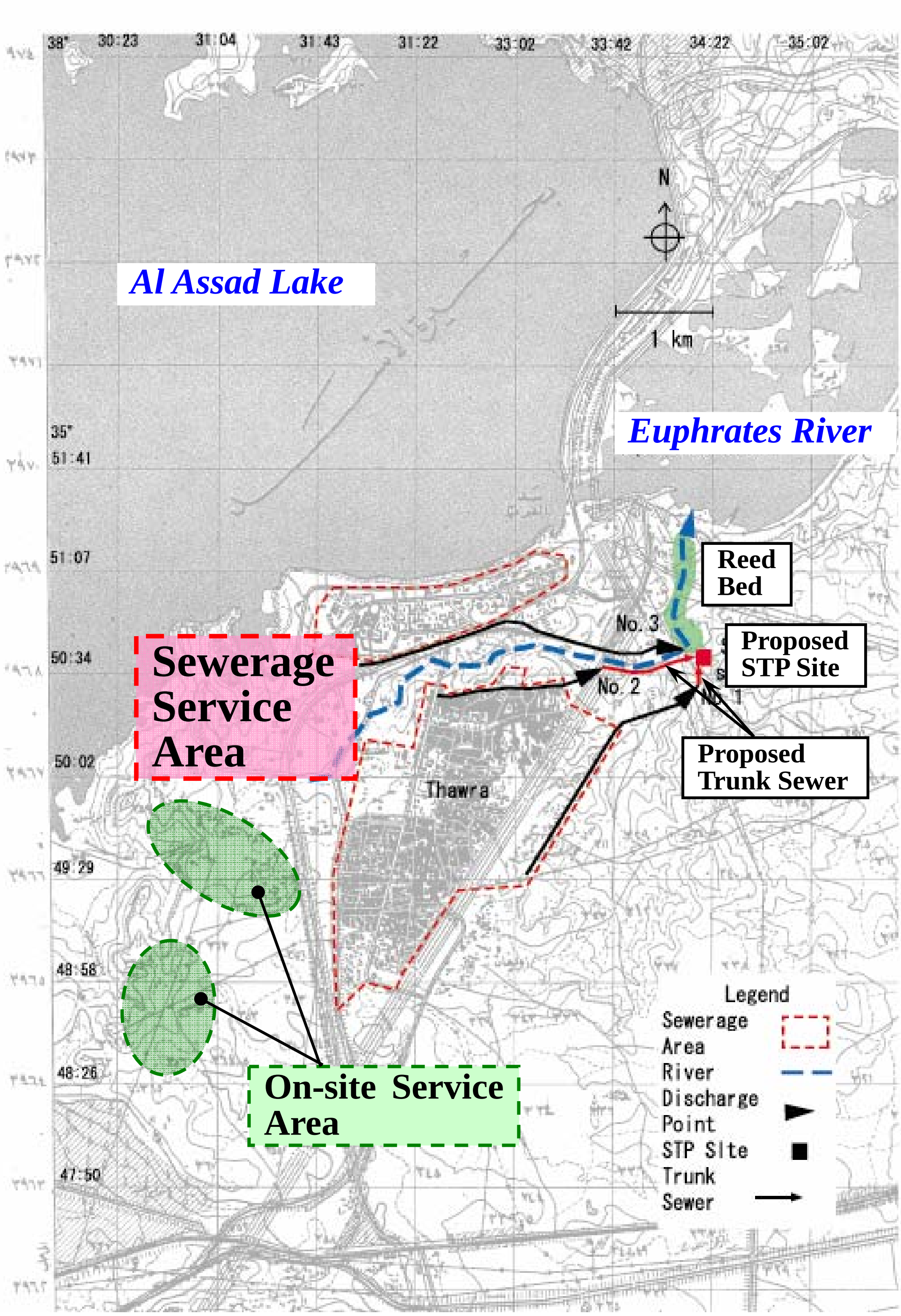


Figure 9.4.19 Macro Plan of Thawra (Raqqa Gov.)

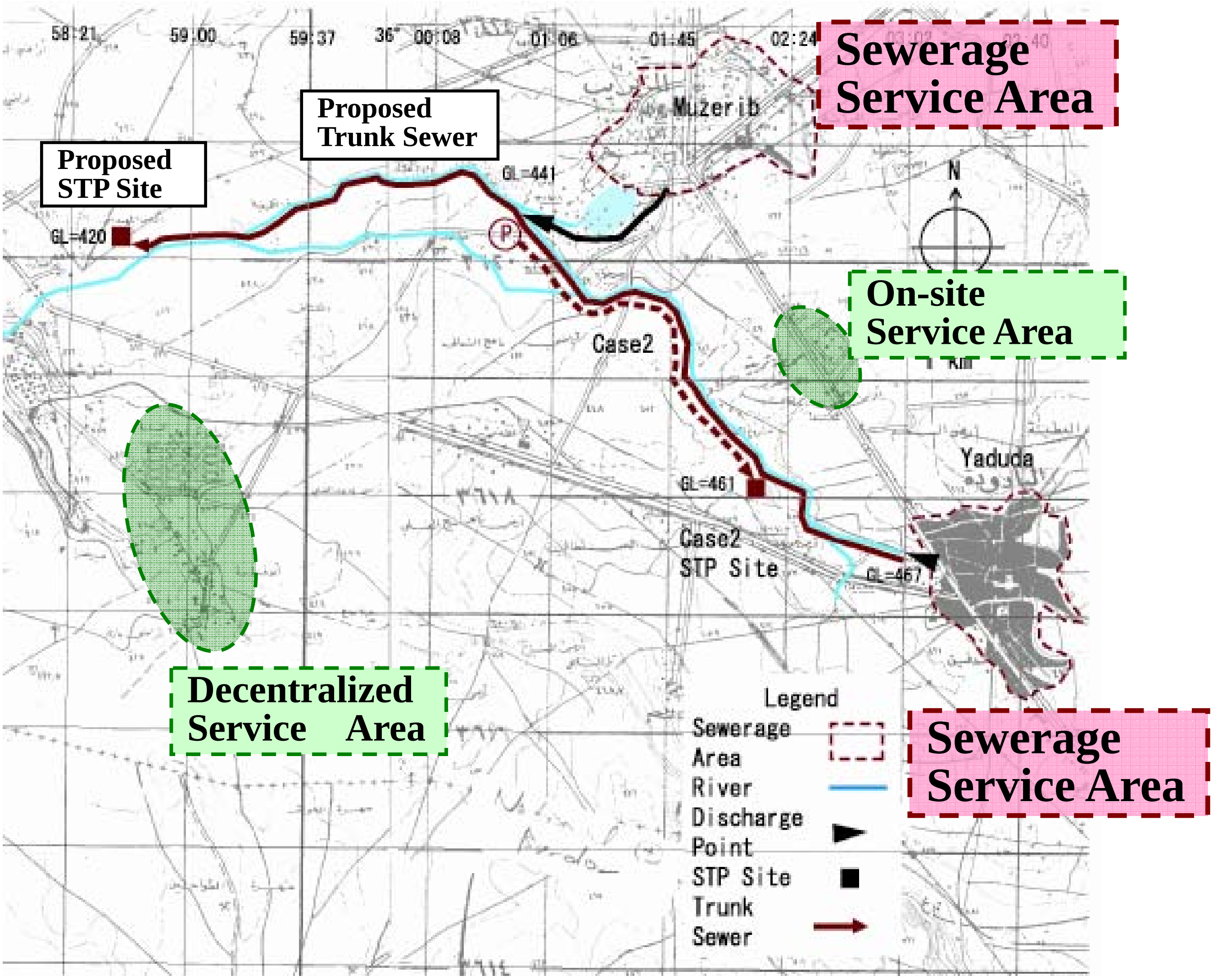


Figure 9.4.20 Macro Plan of Muzerib (Dar'aa Gov.)

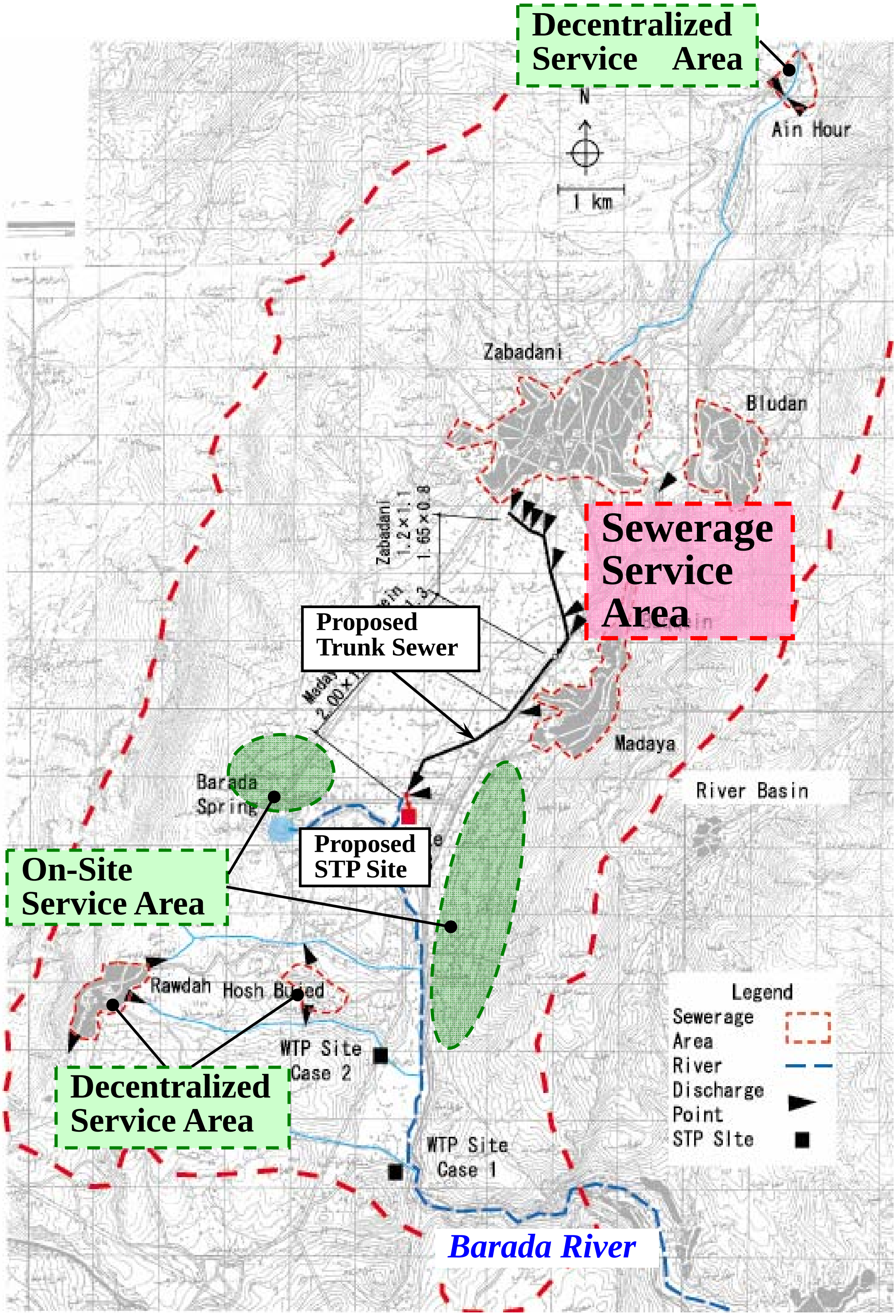


Figure 9.4.21 Macro Plan Of Zabadani (Rural Damascus Gov.)

9.5 Sewerage Master Plan for Seven Governorates

Master plan area of 7 Governorate is shown in **Figure 9.5.1**:

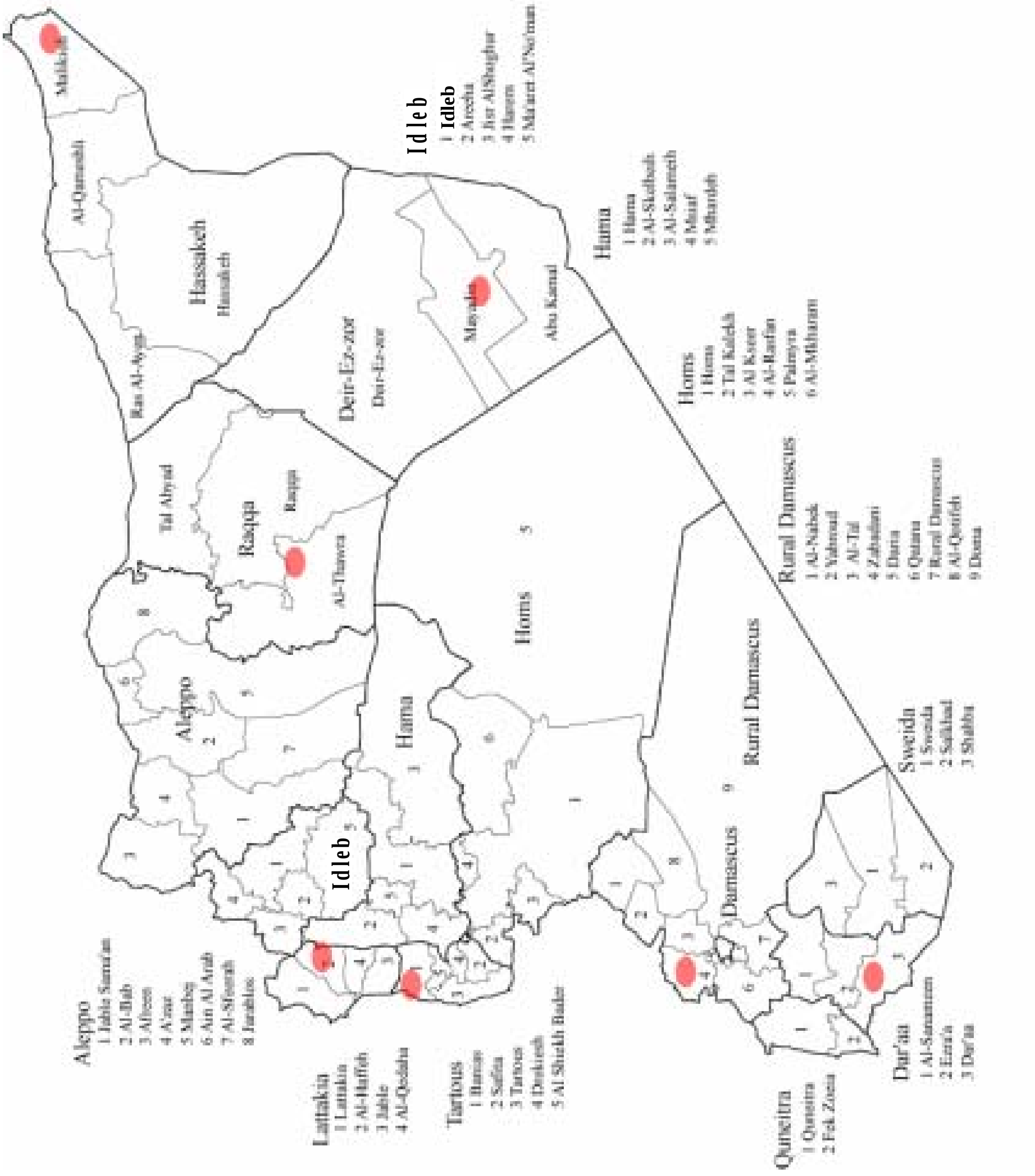


Figure 9.5.1 Master Plan Area of 7 Governorate

9.5.1 Slunfeh, Lattakia Governorate

(1) Study Area

Lattakia Governorate is located along Mediterranean Sea and is a center of industry and tourism. In the eastern side of the governorate, the area is steep mountainous and there are several villages near the top of mountains. Total population of the governorate is about 900 thousands. There are 4 districts in Lattakia Governorate, namely, Lattakia, Jable, Al-Haffeh, and Al-Qedaha.

Figure 9.5.2
Master Plan Area in Al-Haffeh District

Slunfeh, which is the target city of the Master Plan, is located in Al-Haffeh District and the District has 5 sub-districts such as Al-Haffeh, Slunfeh, Ain Al-Tineh, Kansaba, and Al-Mzer'aa. Population of Slunfeh Sub-district is about 20,000 and population of Slunfeh occupies about 10 % of the sub-district population, about 1,900. There are 25 communities in the Slunfeh Sub-District like Slunfeh and the largest community is Salma of which population is about 2,100 and the Slunfeh is the second largest community in the sub-district.

Although Biereen which locates in west of Slunfeh is not considered in the Macro Plan, the Biereen is treated as part of the study area since the Biereen is under administrative jurisdiction of Slunfeh. Slunfeh is located in east of and at 38 km away from Lattakia. Because of comfortable temperature in summer season, many tourists visit Slunfeh. During the high season of tourism, volume of wastewater reaches 5 times of one in winter season.

Slunfeh is located at the most upstream of the river basin. Wastewater of Slunfeh is collected by sewer pipelines and discharged to V-shaped valley. According to the results of investigation at winter season, there was no wastewater flow at the discharge point. It seems all wastewater penetrates into ground because less quantity of wastewater during the winter season.

Untreated wastewater will penetrate into ground during flow down in the valley and it may contaminate groundwater which is used as source of water supply. In seaside area in downstream, people depends on spring or well for their drinking water. Therefore, contamination of groundwater is considered as urgent issue and people are eager to have adequate wastewater treatment system in upstream area.

Wastewater flow from Slunfeh is divided into two directions. In downstream of Slunfeh, about 20 km, there are Haffeh Dam and Thawra Dam. These dams were constructed for irrigation purpose and no water is used for water supply. Water quality of dam lake water is good in winter season. On the other hand, tendency of eutrophication is observed during summer season since wastewater inflow becomes dominant over the rain water flow. Therefore, it is anticipated that development of sanitation system will contribute for improvement of water quality of these dam lakes.

Master plan area in Al-Haffeh district is shown in **Figure 9.5.2**:

(2) Planned Population and Volume of Wastewater

Population and volume of wastewater of Slunfeh is as shown in **Table 9.5.1**. The rate of population increase is very moderate. Volume of wastewater in summertime will reach to five times of one of in winter season because of tourism industry.

Table 9.5.1 Planning Parameters of Slunfeh

Items			Unit	2004	2010	2015	2020	2025
Slunfeh		Population	per.	1,847	1,900	2,000	2,100	2,100
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourist		%	400	400	400	400	400
	Generated Wastewater	Daily Average	m^3/day	1,008	1,088	1,200	1,318	1,375
		Daily max		1,170	1,264	1,394	1,530	1,597
		Peak Hourly		1,950	2,107	2,323	2,550	2,661
Biereen		Population	per.	687	700	700	700	700
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourist		%	400	400	400	400	400
	Generated Wastewater	Daily Average	m^3/day	375	401	420	439	458
		Daily max		435	466	488	510	532
		Peak Hourly		725	776	813	850	887
Total		Population	per.	2,534	2,600	2,700	2,800	2,800
	Generated Wastewater	Daily Average	m^3/day	1,383	1,489	1,620	1,757	1,833
		Daily max		1,606	1,730	1,882	2,040	2,129
		Peak Hourly		2,676	2,883	3,136	3,400	3,548

Note) LCD : liter/capita/day

(3) Investigation on Raw Sewage Discharging Points

A survey was conducted to collect information on the existing eight outlets of sewers. These outlets are located near valley thus the collected sewage is finally discharged to the valley. The information was provided by the engineers of Slunfesh. The city of Slunfeh is developed at the top of mountain area, the sewage is discharged through the existing outlets of sewers and reached at two different destinations: Haffeh dam or Thawa dam. **Table 9.5.2** summarizes the information of outlets including estimated flow rate ratios between those in winter and summer. The average ratio is about 20%, in other words, the sewage would be generated five times higher than those in winter.

Table 9.5.2 Discharge Points in Slunfeh

No	Location of Outlet	Sewer Diameter (mm)	Final Discharge Point	Flow Rate Ratio (%)
1	Ain Al Bayda	400	Al Thawra Dam	30
2	Jeb Sulaiman	300	Al Thawra Dam	20
3	Al Bareed	400	Al Thawra Dam	25
4	Al Joubeh	400	Al Thawra Dam	20
5	Haret Al Derjeh	300	Al Haffeh Dam	15
6	Hannah Village	400	Al Haffeh Dam	10
7	Biereen (school)	300	Al Haffeh Dam	10
8	Biereen (Al Harah Al Kadimeh)	400	Al Thawra Dam	20

Note) Flow Rate Ratio = Winter/Summer

(4) Selection of STP Site

The planning area is divided into two sub-basins. In addition, there are eight raw sewage discharge points being dotted about over 7 km length. Under these circumstances, construction of only one sewage treatment plant to collect all sewage in a centralized manner would not be feasible. It was selected three candidate sites for STPs after due consideration of geographical conditions and site investigations with the officials of the Ministry of Housing and Construction of Slunfeh District. Following issues are considered in the course of selection of the candidates of proposed STP sites:

- Sewage effluent from a dischage point can be efficiently collected.
- Access road to the proposed site is available.
- Enough area is available for STP construction.
- There are not many houses around the proposed STP site.

Table 9.5.3 gives a summary of the proposed STP sites.

Table 9.5.3 Location of the Proposed STP Sites (Slunfeh)

No	Latitude N	Longitude E	Level	Discharge Point ID No.	Available Area	Land Cost	Land Owner	Distance from residential area
1	35 ° 35 ′ 31.4 ″	36 ° 11 ′ 03.1 ″	1,000	1, 2	More than 1ha	1,000 SP/m^2	Private	200m
2	35 ° 35 ′ 41.8 ″	36 ° 09 ′ 59.7 ″	994	3, 4, 5	More than 1ha	-	Public	50m
3	35 ° 36 ′ 11.4 ″	36 ° 07 ′ 24.4 ″	737	6, 7, 8	0.5ha	-	Public	100m

(5) Sewage Collection Plan

1) Trunk Sewer Plan

It is proposed that the sewage collected by the existing sewers will be conveyed by new gravity trunk sewers from each discharge point to the proposed STP in principal. However the sewage at the discharge point No. 5 and No.8, both are located near the proposed STP, will be conveyed by pumping stations considering following reasons:

- Installation of a force main is more economical than a gravity sewer, because the distance from No.5 discharge point to No.6 discharge point is as much as 2.5km.
- No.8 discharge point locates at different basin from No.3 STP. However, a provision of pump station is more economical than construction of another STP.

A sewage flow at each discharge point is approximately 450m^3/day, as the total design maximum hourly flow of 3,548m^3/day is divided by eight discharge points. The sewer slope can be applicable more than 10 ‰ because the STP sites locate lower than those discharging points. It is possible for 250mm of minimum diameter sewer to cater for the flow form two discharge points as shown in **Table 9.5.4**.

Table 9.5.4 Design of Trunk Sewer

Flow rate		Capacity	Diameter	Gradient	v	Q
m^3/day	m^3/s	m^3/s	mm	‰	m/s	m^3/s
900	0.010	0.020	250	10	1.58	0.077

2）Pumping Station Plan

Design maximum hourly sewage flow =3,548/8=444 m^3/day=0.3 m^3/min

Pump capacity is recommended to be 0.5m^3/min including some allowance.

Size of force main is 100mm as calculated bellow.

$$D = \sqrt{\frac{0.00833 \times 4}{3.14 \times 1.0}} = 0.103 \rightarrow 0.100\text{m}$$

(6) Planning of STP

1) Influent quality and Effluent standard

Treated wastewater will be discharged to valley. It finally flows to the two dams through valley distance of 20 to 28 km away from Slunfeh. Reserved water in dams is used for irrigation of fruit trees.

Therefore, Effluent Standard would be applied for the discharge to River.

Table 9.5.5 Incoming Sewage Quality and Effluent Standard

Items	Discharge mode to water-body / Condition of re-use	Maximum Allowed Limited effluent standard from STP (mg/l)					
		BOD	SS	NH_3-N	NO_3-N	T-N	T-P
Influent		310	360			74	24
Effluent Standard	Proposed effluent standard (River)	40	30	5	50		

2) Summary of conditions and proposed facilities

The conditions considered for Planning and specifications of proposed facilities are listed in **Table 9.5.6**

Table 9.5.6 Summary of Conditions and Proposed Facilities

Items	Contents
Average wastewater (m^3/d)	1,833
Hourly max wastewater (m^3/d)	3,548
Sludge (kgDS/d)	224
Sludge (m^3/d)	2.7
Moisture content (%)	92
No. of STP	3
Treatment method	Submerged attached growth
For each STP of capacity 500 m^3/d)	
Grit chamber (No.-w×L)	1-1m×1m
Main P (No.-D×power)	-
Reactor (No.-W×L×H)	2-5.5m×12m×5m
Final sedimentation tank	2-5.5m×3m
Disinfection channel	1-φ0.9m(manhole)
Required land area （ha）	Each 0.1

3) Sewage treatment method

There are three narrow lands available for STP, each with an area of 0.1 ha. Therefore, 3 small STPs are proposed to be constructed with capacity of 610 m^3/d each, collecting sewage from several discharges to three STPs.

As the proposed STP is very small, Submerged Attached Growth Method, known as unmanned on-site facility in Japan, is suitable for small stretch of available land.

Submerged Attached Method has some favorable features, for example, no need of return activated sludge, sludge, digested slime peeled from bio-film is assumed 30 percent of removed SS because removed VSS would be almost digested and gasified. So disposal of sludge could be carried out using low-budget.

This method requires bio-film, generally plastic media, so relatively costly in terms of construction. However, O&M in this process is easy and it does not need the resident engineers, therefore in long run the total cost for this method is cheaper. Moreover, the environmental risk through an unmanned operation is small because of small amount of wastewater. In consequence, Submerged Attached Growth Method has been proposed for this case.

4) Sludge treatment method

This sewage treatment method generate small amount of sludge, so in Japan mainly maintenance is carried out once a year. Also, annual rainfall in Slunfeh is 1,000 mm to 1,400 mm, and therefore drying bed is not applicable. Considering these factors, sludge treatment would be neglected for this case, and generated sludge is proposed to be conveyed to Lattakia STP by tanker.

5) Special Consideration on facility Planning

- All facilities are set up on the condition of unmanned operation, but by patrol duty, so there is no sludge treatment facility or administration building.
- To achieve effective O&M, following periodic maintenance activities would be required necessarily:

a) Adjustment of aeration device, Two times a year, once before and once at end of summer

b) Water analysis of discharged sewage once a month

c) Checking and removal of the coarse material remaining at screen basket, and supply of solid chlorine, once a week.

d) Sludge, settled bio-slim peeled from bio-film, would be collected at the bottom of settling tank and collected by the tanker with vacuum device and conveyed to Lattakia STP.

Master plan of Slunfeh is shown in **Figure 9.5.3**:

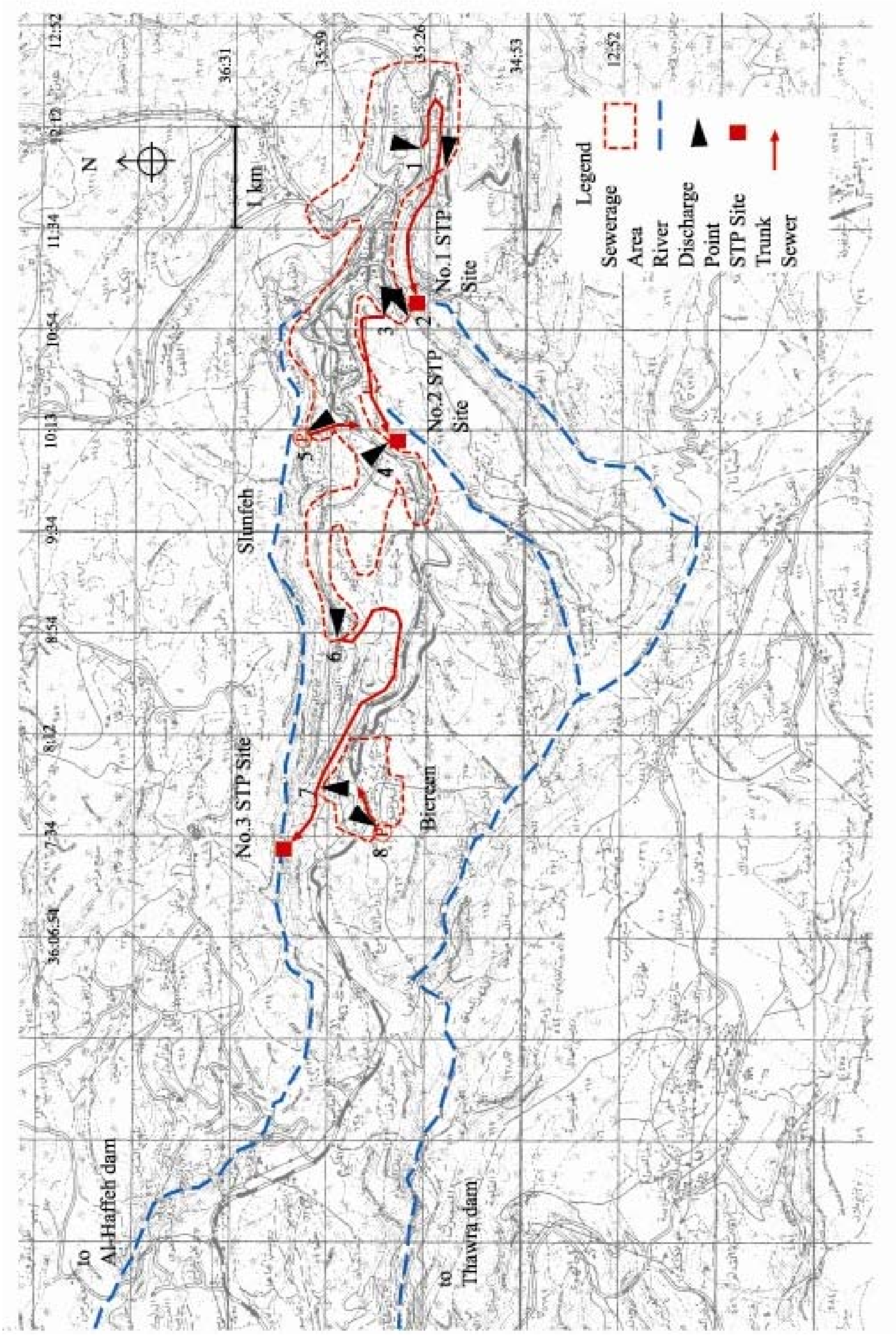


Figure 9.5.3 Master Plan of Slunfeh

9.5.2 Banias, Tartous Governorate

(1) Study Area

Tartous Governorate is located along the Mediterranean Sea. In the governorate, wastewater is discharged into the sea without any treatment through 60 discharge points. These discharges cause sea water pollution.

Figure 9.5.4
Master Plan Area in Banias District

Total population in the governorate is about 700 thousand. Tartous Governorate consists of five districts such as Tartous, Banias, Safita, Drekiesh, and Al-Shiekh Bader. Banias district has 7 sub-districts and they are Banias, Al-Rawda, Hemmam Wasel, Al-Eennasah, Al-Kadomous, Talin, and Al-Tawahin. Total population of the Banias District is about 95,000 and about half of the total population, 42,000 people lives in Banias. There are 36 communities in the Banias Sub-District like Banias. Population of the second largest city is about 5,000 and the other communities have lesser population and these small scale communities are scattered in mountainous area in eastern side.

Although these three areas, Tero, Khrbet Snasel, and Boston Al-Najo, were not included in the Macro Plan, these areas will be treated as part of the study area from aspects listed below.

- Elevation of these three areas are higher and wastewater can be transmitted to Banias easily
- Roads are available to accommodate sewer pipelines
- Engineers in Banias had already agreed to accept wastewater from these three areas

Master plan area in Banias district is shown in **Figure 9.5.4**:

Banias is the oceanfront city and wastewater from Banias is discharged into the sea without treatment. This area is tourist spot and many tourists visit Banias in summer vacation season. Water quality of the sea is deteriorated because of discharged domestic wastewater. Water quality will be drastically improved if adequate wastewater treatment system was introduced in this area. Improvement of sea water quality will contribute to not only for tourism industry but also for domestic living conditions.

Sewage Development Plan of Banias was once prepared by Egyptian Consultant as Pre-Investment Study in March 2005. Based on "MED POL (Mediterranean Marine Pollution Monitoring and Research Program)", the sewage development plan will be implemented using

EU financial aid. Estimated project costs for Banias was 11.85 Million US$ and the project included sewer pipeline, pumping stations, and treatment plant. Although the project was planned to be completed by 2010, no progress of the project is observed.

(2) Planned Population and Volume of Wastewater

Population and volume of wastewater of Banias is as shown in **Table 9.5.7**. The rate of population increase is very high and population size will become double in year 2025 from 2004 level.

Table 9.5.7 Planning Parameters of Banias

Items			Unit	2004	2010	2015	2020	2025
Banias		Population	per.	41,632	52,100	61,700	71,900	82,500
	per capita Wastewater	Daily Average	LCD	129	135	142	148	155
		Daily max		150	157	165	172	180
		Peak Hourly		250	262	275	287	300
	Tourist		%	50	50	50	50	50
	Generated Wastewater	Daily Average	m^3/day	8,053	10,582	13,129	15,995	19,151
		Daily max		9,352	12,289	15,246	18,574	22,239
		Peak Hourly		15,587	20,482	25,411	30,957	37,066
Tero Khabet -Snasel Boston -Al-Najor		Population	per.	2,015	2,200	2,500	2,800	3,100
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourist		%	0	0	0	0	0
	Generated Wastewater	Daily Average	m^3/day	220	252	300	351	406
		Daily max		255	293	348	408	471
		Peak Hourly		426	488	581	680	786
Total		Population	per.	43,647	54,300	64,200	74,700	85,600
	Generated Wastewater	Daily Average	m^3/day	8,273	10,834	13,429	16,346	19,556
		Daily max		9,608	12,582	15,595	18,982	22,711
		Peak Hourly		16,013	20,969	25,991	31,637	37,851

Note) LCD : liter/capita/day

(3) Investigation on Raw Sewage Discharging Points

The major existing raw sewage discharging points were surveyed in the Pre-investment Study. **Table 9.5.8** shows the information collected for this study.

Table 9.5.8 Discharge Points in Banias

No	Location	Year of Construction	Diameter (cm)	Physical Condition	Ground Level	Pipe Level
1	Saqyat sook Elhal	2000	60	Good	3.25	0.3
2	Alqobbiat	before 1990	40	Accepted	1.4	-0.6
3	Gamaa Altawhwed	before 1990	80	Good	1.6	-1.1

Table 9.5.8 Discharge Points in Banias

No	Location	Year of Construction	Diameter (cm)	Physical Condition	Ground Level	Pipe Level
4	Almawani	before 1990	50	Accepted	2.43	-1.38
		2001	100	Good	2.43	-1.38
5	Ras Elnabaa	before 1990	40	Accepted	2.62	0.62
		2001	100	Good	2.62	0.62
6	Gamaa Elbahr	before 1985	40	Accepted	2.94	-0.73
7	Naqliat Alqadamos	before 1985	100	Accepted	2.98	-0.92
8	Nahr Elgaam	before 1985	50	Accepted	3.11	-1.28
9	Alzoryqat	before 1980	60	Broken	4.44	-2.58
10	Almashfa Elwatany	before 1980	60	Broken	2.56	?
11	Shalehat Almasfah	before 1980	40	Broken	3.97	-2.83

(4) Selection of STP Site

The candidate site for the STP located on the south of the oil refinery factory, which is in the northern part of the city, has already been proposed by the Pre-investment Study. The engineers of the city have already given a green light to pick up this location as a candidate site of STP. It is also identified that there are no appropriate alternatives in Banias. Therefore, the site shall be proposed for the construction of STP. Addingly there is no house in the STP site. Then no resettlement will be required.

The location of proposed STP site is shown in **Table 9.5.9**.

Table 9.5.9 Location of Proposed STP Site (Banias)

No	Latitude N	Longitude E	Level	Available Area	Land Cost	Land Owner	Distance from residential area
1	35 ° 12 ' 49.1 "	35 ° 57 ' 32.1 "	17 m	More than 2ha	2,500 SP/m^2	Private	50m

(5) Sewage Collection Plan

An appropriate sewage conveyance system is studied to convey the sewage from the existing sewer outlets to the proposed STP. The Pre-investment Study planned a system of intermediate pumping stations located in series and each pumping station connected with gravity sewers to convey the sewage to the STP as shown in the **Figure 9.5.5**.

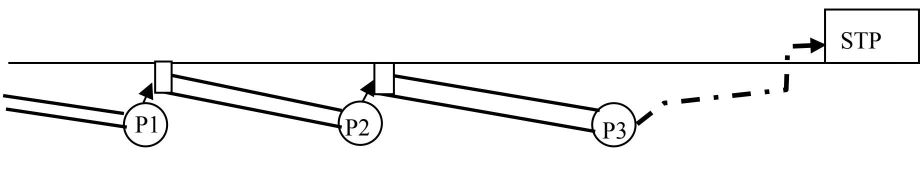


Figure 9.5.5 Sewer System in Pre –Investment Study

However, this system has following disadvantages:

- Because pump at lower location requires larger capacity, a simplified pump station such as manhole type would not be applicable and some land area for pumping station would be required.
- Once a pumping station stopped its operation, the sewage collected at upper locations of the pump could not be conveyed to the STP.
- At the lower areas where the gravity sewers installed below the mean sea level, a possibility of inflow of sea water into the conveyance system would become high.
- Construction cost of gravity sewers would be high because the capacity of gravity sewers is required to cover the full capacity at the target year.

To solve the disadvantages, the following a multi-pressure sewage conveyance system is proposed in which a common pressured trunk sewer would be installed between the initial pumping station to the STP and many pumping stations would be connected to the common pressured trunk sewer at various locations as illustrated in **Figure 9.5.6**.

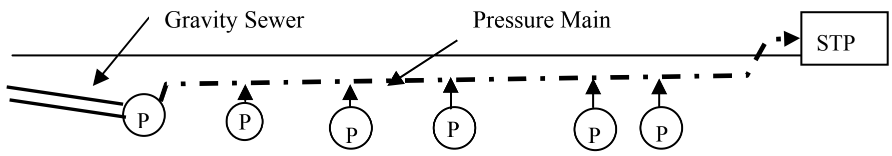


Figure 9.5.6 Proposed Sewer System

Each pumping station would be installed at each existing sewer outlet (sewage discharging point), the pump capacity required is limited to cover the sewage volume collected by each existing sewer. But this system requires special attention to select pumps covering wider working heads because the head loss would be varied depending on the operational conditions of each pump installed along the common pressured trunk sewer.

Table 9.5.10 shows a design sheet of the proposed multi-pressure sewage conveyance system, showing the magnitude of pumps and pressured trunk sewer. As pressured trunk was planned by dual-system, design flow was set by the half of full design flow at the target year. Temporally the wastewater quantity was calculated according to the pipe area. In F/S stage, investment of the pipe installation situation will be needed. Then wastewater quantity should be estimated.

Table 9.5.10 Design of Trunk Sewer

No	Location	A (m^2)	Q (m^3/s)	Q (m^3/min)	1/2Q (m^3/min)	Pump (m^3/min)	Pipe (m^3/min)	Calc.Dia (mm)	Dia (mm)	L (m)	Total Head (m)	Kw
1	Saqyat sook Elhal	0.28	0.027	1.6	0.8					326		
2	Alqobbiat	0.13	0.012	0.7	0.4					255		
3	Gamaa Altawhwed	0.50	0.048	2.9	1.4	3.0	3.0	0.25	250	139	30.7	28.7
4	Almawani	0.20	0.019	1.1	0.6							
		0.79	0.075	4.5	2.2	3.0	6.0	0.36	300	548	26.1	24.5
5	Ras Elnabaa	0.13	0.012	0.7	0.4							
		0.79	0.075	4.5	2.2	3.0	9.0	0.44	400	675	19.2	18.0
6	Gamaa Elbahr	0.13	0.012	0.7	0.4	1.0	10.0	0.46	400	95	17.4	5.4
7	Naqliat Alqadamos	0.79	0.075	4.5	2.2	3.0	13.0	0.53	500	362	17.1	16.0
8	Nahr Elgaam	0.20	0.019	1.1	0.6	1.0	14.0	0.55	500	871	16.4	5.1
9	Alzoryqat	0.28	0.027	1.6	0.8	1.0	15.0	0.56	500	580	14.6	4.6
10	Almashfa Elwatany	0.28	0.027	1.6	0.8	1.0	16.0	0.58	600	639	11.7	3.6
11	Shalehat Almasfah	0.13	0.012	0.7	0.4	1.0	17.0	0.60	600	1672	11.4	3.6
	Total	4.60	0.438			17.0						

As to detailed economical comparison, refer to **Volume III, Appendix 9.5**.

(6) Planning of STP

1) Influent quality and Effluent standard

Treated wastewater in this case will be discharged to sea through storm channel.

Table 9.5.11 Incoming Sewage Quality and Effluent Standard in Banias

Items	Discharge mode to water-body / Condition of re-use	Maximum Allowed Limited effluent standard from STP (mg/l)				
		BOD	SS	NH_3-N	NO_3-N	Coliform
Influent		310	360			
Effluent Standard	Proposed effluent standard (Sea)	60	60	10	50	5000 MPN/100ml

2) Summary of conditions and proposed facilities

Planning conditions and dimensions of proposed facilities based on the design results are listed in **Table 9.5.12**.

Table 9.5.12 Summary of Conditions and Proposed Facilities

Items	Contents
Average wastewater (m^3/d)	19,556
Hourly max wastewater (m^3/d)	37,851
Sludge (kgDS/d)	4,401
Sludge (m^3/d)	22.0
Moisture content (%)	80
Treatment method	OD +Gravity Thickener + Mechanical dewatering
Grit chamber (No.-w×L)	2-1.5m×7m
Main P (No.-D×power)	-
Reactor (No.-W×L×H)	12-4.5m×140m×3.0m（high rate）
Final sedimentation tank	8-φ18m
Disinfection channel	2-2m×24×2.1m
Gravity Sludge Thickener	2-5.0m×5.0m
Mechanical Sludge Dehydrator	2-2,201 kg DS/d
Required land area （ha）	5.1

3）Sewage treatment method

Conventional Activated Sludge method is applicable due to the effluent standard though, primary settling tank of Conventional Activated Sludge method generates offensive odor. As STP land will be in the future urban district, Conventional Extended Aeration or OD that does not require primary settling tank, is better than conventional activated sludge method.

Based on the result of comparison, OD is better than Conventional Extended Aeration considering the total cost including O&M cost and others. Hence, OD which requires easy operation among them, has been proposed.

Table9.5.13 Comparison of Treatment Process in Banias

Items	OD	Conventional extended aeration	Conventional Activated Sludge
Possibility of layout	+	+	+
Nitrification	+	++	
De-nitrification	++		
Correspondence to load fluctuation	++	++	+
Sludge Reduction	+	+	
Offensive odor Problem	+	+	
Simple equipment	++	+	
Easiness of operation	++	+	
Construction cost		+	
Maintenance cost	++	+	
Evaluation	14 points	11 points	2 points

4）Sludge treatment method

As mentioned earlier, the STP site is to be located in the future urban district, the sludge should be treated promptly, keeping fresh, hence Mechanical Dewatering unit has been proposed, and so not to annoy neighborhood by offensive odor. And since generated sludge could not be well thickened by gravity, Gravity Sludge Thickener shall be placed mainly for the purpose of reservoir of sludge.

5) Special Consideration on facility Planning

- For designing of facilities and layout planning, offensive odor problem must be considered.
- Wastewater will be conveyed directly from the pumping station in the city. Since the conveyed wastewater is 2.2 times of daily average flow, reservoir or distribution tank must be affected and tank water level might fluctuate significantly. Therefore, these tanks are required to have sufficient freeboard or capacity.

Master plan of Banias is shown in **Figure 9.5.7**:

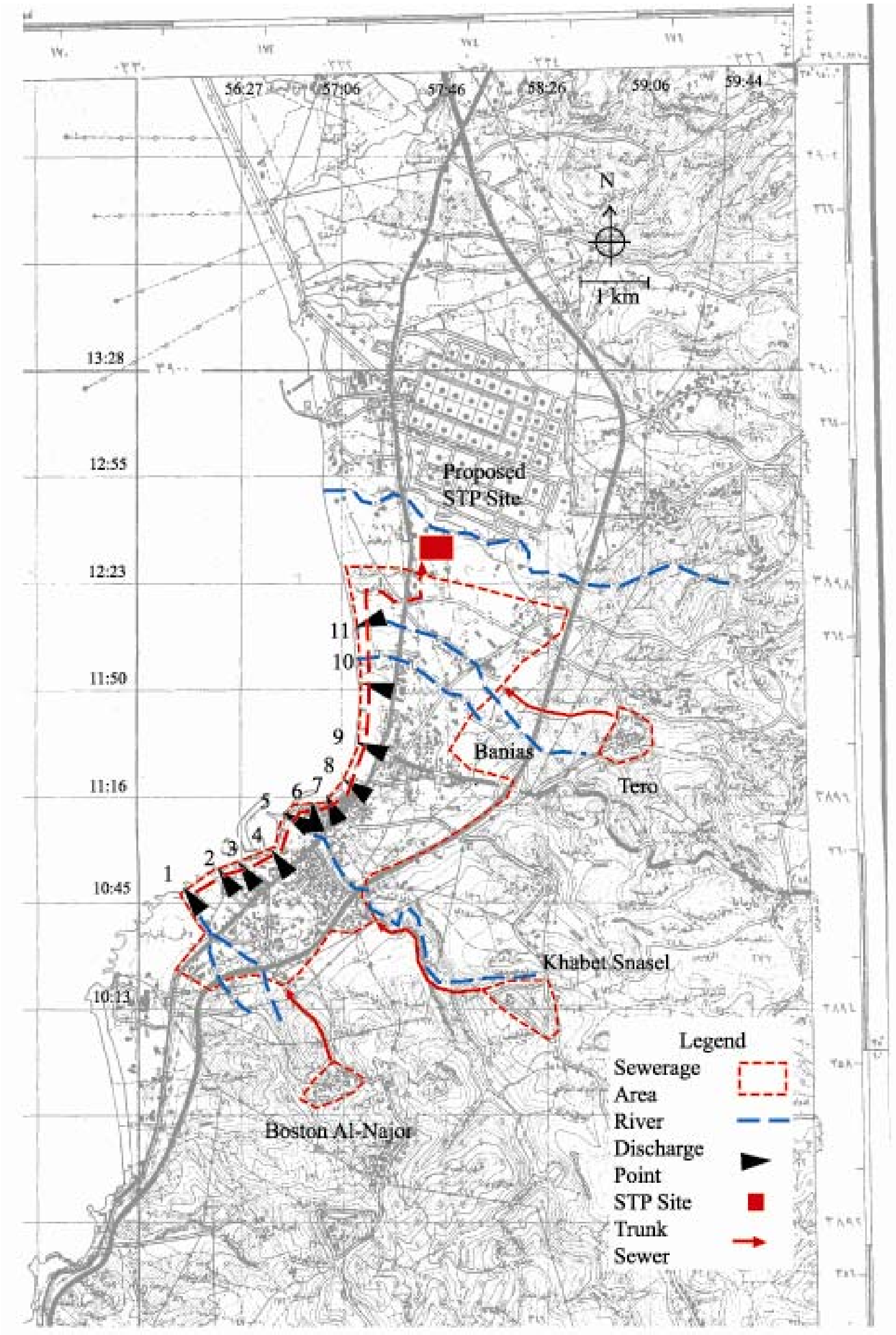


Figure 9.5.7 Master Plan of Banias

9.5.3 Mayadin, Deir-Ez-zor Governorate

(1) Study Area

Deir-Ez-zor Governorate is located in downstream of the Euphraties River and its population is about one million. There are three districts, Deir-Ez-zor, Abu-Kamal, and Mayadin, in Deir-Ez-zor Governorate.

Figure 9.5.8 Master Plan Area in Mayadin District

Mayadin consists of three sub-districts, Mayadin, Zeban, and Asharah. Population of Mayadin Sub-Districts is about 86,000 and about half, 44,000, population live in Mayadin. Mayadin Sub-District has 8 communities such as Mayadin.

Although Taiba and Makhan were not included in the Macro Plan, these areas will be treated as part of the study area from the aspects listed below.

- Taiba is neighboring city with Mayadin in its downstream side. Since discharge point from Taiba is very near from Mayadin discharge point, these two areas should be treated as combined system.
- Discharge point from Makhan is located 3.5 km downstream of Taiba's discharge point. However, difference of ground level of these two discharge points is very small. Wastewater from Makhan can be easily pumped up to Taiba.
- Engineers of Mayadin had already agreed to establish combined system among Taiba, Makhan, and Mayadin.

Master plan area in Mayadin district is shown in **Figure 9.5.8**:

(2) Planned Population and Volume of Wastewater

Population and volume of wastewater of Mayadin is as shown in **Table 9.5.14**. Wastewater volume in 2025 for Mayadin, Taiba, and Makhan will be 13,974, 1,323, 2,187 m^3/day, respectively.

Table 9.5.14 Planning Parameters of Mayadin

Items			Unit	2004	2010	2015	2020	2025
Mayadin		Population	per.	44,028	60,200	72,400	82,400	90,300
	per capita Wastewater	Daily Average	LCD	129	135	142	148	155
		Daily max		150	157	165	172	180
		Peak Hourly		250	262	275	287	300
	Tourist		%	0	0	0	0	0
	Generated Wastewater	Daily Average	m^3/day	5,678	8,152	10,270	12,220	13,974
		Daily max		6,594	9,466	11,927	14,191	16,228
		Peak Hourly		10,989	15,777	19,878	23,652	27,047
Taiba		Population	per.	6,061	7,600	8,700	9,500	10,100

Table 9.5.14 Planning Parameters of Mayadin

Items			Unit	2004	2010	2015	2020	2025
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourist		%	0	0	0	0	0
	Generated Wastewater	Daily Average	m^3/day	661	871	1,044	1,192	1,323
		Daily max		768	1,011	1,213	1,384	1,536
		Peak Hourly		1,280	1,685	2,021	2,307	2,560
Makhan		Population	per.	10,086	12,600	14,300	15,700	16,700
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourist		%	0	0	0	0	0
	Generated Wastewater	Daily Average	m^3/day	1,101	1,444	1,716	1,970	2,187
		Daily max		1,278	1,677	1,993	2,288	2,539
		Peak Hourly		2,130	2,794	3,322	3,813	4,232
Total		Population	per.	60,175	80,400	95,400	107,600	117,100
	Generated Wastewater	Daily Average	m^3/day	7,440	10,466	13,031	15,383	17,483
		Daily max		8,640	12,154	15,133	17,864	20,303
		Peak Hourly		14,400	20,257	25,222	29,773	33,839

Note) LCD : liter/capita/day

(3) Investigation on Raw Sewage Discharging Points

Physical features of the existing raw sewage discharging points are summarized in the **Table 9.5.15**. The discharging No.2 is planned to abandoned and shifted to the No.3. The necessary sewer between No.2 and No.3, having diameter of 1,500 mm, is now being installed. At No.4 the sewage collected from Taiba area will be discharged. Because the lateral sewer networks are still being under construction, the sewage has not been discharged yet when our survey was conducted. At No.5 the sewage collected from Makhan area is discharged, maybe including some irrigation water.

Table 9.5.15 Discharge Points in Mayadin

Location	Latitude N	Longitude E	Level	Remarks
1	35°01′37.3″	40°27′01.8″	188	Mayadin
2	35°01′30.5″	40°27′47.1″	191	Mayadin
3	35°01′15.4″	40°28′40.1″	189	Mayadin D 1.0m
4	35°00′21.8″	40°29′10.3″	186	Taiba D 1.0m
5	34°59′06.7″	40°30′32.8″	185	Makhan 1.5×1.0 water depth=8cm

(4) Selection of STP Site

The engineers of Mayadin recommended that the location near the discharge point No.4 is promising for the site of STP. The reasons are as follows:

- Because the proposed site locates between the discharge points of Mayadin and Taiba, the sewage generated in both area can be collected and conveyed efficiently.
- The proposed site is public owned and would be easily acquired without any cost.

- Because there are no houses around the proposed site, environmental measures would not be required.

The location of the proposed STP sites is shown in **Table 9.5.16**.

Table 9.5.16 Location of the Proposed STP Site (Mayadin)

Latitude N	Longitude E	Level	Available Area	Land Cost	Land Owner	Distance from residential area
35°00′22.1″	40°29′09.1″	186	More than 6ha	-	Public	100m

There would be an alternative site near Makhan for the STP, downstream of the discharge point No.4, enable to collect sewage generated from three cities of Mayadin, Taiba and Makhan. However, in practice, the site near the discharging point No.4 would have advantages for following reasons:

- Sewage volume of Mayadin and Taiba is overwhelmingly greater than that of Makhan. It would be advantagous to construct the STP near Mayadin and Taiba. Because of the trunk sewers generally would require smaller dimenstion (diameter and length) when a STP site were located at the area where sewage generation were higher. In other words, if the STP were constructed in the Makhan side, installation of trunk sewer having larger diameter and longer would be required.
- Sewer invert elevation at the discharge point No.4 is about same height with the river water level. If the sewer were extended to the downstream, the extended sewer would be installed at lower level compared to the river water level. This would bring a risk of inflow of river water into the sewer and require preventive measures during construction stage.

Relationship between extended trunk sewer and river water level is shown in **Figure 9.5.9**:

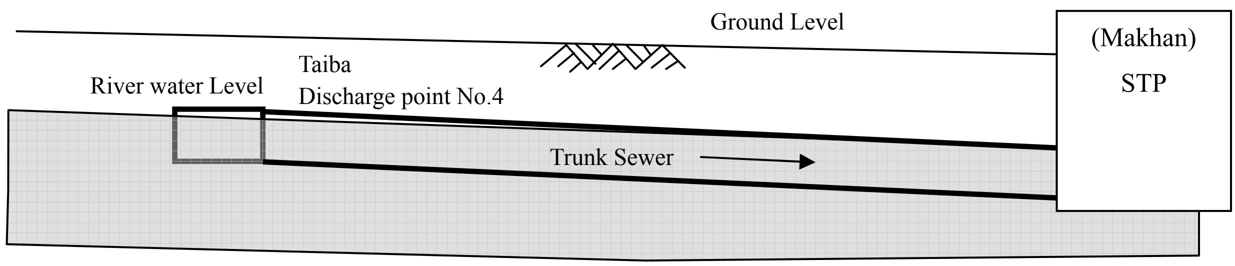


Figure 9.5.9 Relationship between Extended Trunk Sewer and River Water Level

(5) Sewage Collection Plan

1) Trunk Sewer Plan

The design of conveyance sewers from the existing sewer outlet No.3 and No.5 to the STP is as illustrated in **Figure 9.5.10** and **Table 9.5.17**.

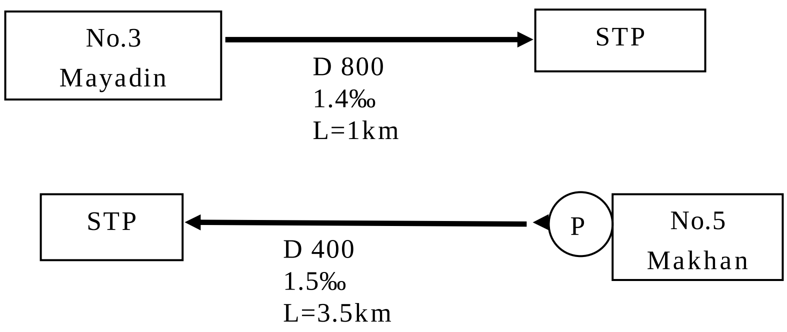


Figure 9.5.10 Schematic Drawing of Trunk Sewers

Table 9.5.17 Design of Trunk Sewer

Items	Flow rate		Capacity	Dia.	I	v	Q
	m^3/day	m^3/s	m^3/s	mm	‰	m/s	m^3/s
Mayadin (No.3 — STP)	27,047	0.313	0.626	800	1.4	1.28	0.643
Makhan (No.5 — STP)	4,232	0.049	0.098	400	1.5	0.83	0.105

The sewage collected at the discharge point No.3 is planned to convey by a gravity sewer to the proposed STP. The sewage collected at the discharge point No.5 is planned to lift up by a new pumps installed and conveyed by a gravity sewer to the STP. The reasons why the sewage would be not conveyed by pressured sewer are as follows:

- The length of the pressured sewer will be long as about 3.5 km, a hydrogen sulfide would be generated at the outlet and would damage the concrete structures. Some countermeasures to protect the damages would be required.
- There are no obstacles such as channels crossing over the conveyance sewer between the discharge point No. 4 and No.5. A gravity type conveyance sewer can be installed at shallower depth along the bank of the Euphraties.

2) Pumping Station Plan

The planned sewage flow is 4,232 m^3/day or 2.9 m^3/min. The design capacity of pumping station is proposed at 3.0 m^3/min.

(6) Planning of STP

1) Influent quality and Effluent standard

Treated sewage in this case is to be discharged to Euphraties river. Data on influent quality and effluent standard has been presented in Table 9.5.18

Table 9.5.18 Incoming Sewage Quality and Effluent Standard in Mayadin

Items	Discharge mode to water-body / Condition of re-use	Maximum Allowed Limited effluent standard from STP (mg/l)					
		BOD	SS	NH_3-N	NO_3-N	T-N	T-P
Influent		310	360			74	24
Effluent Standard	Proposed effluent standard (River)	40	30	5	50		

2) Summary of conditions and proposed facilities

The conditions considered for planning and specifications of proposed facilities are listed in **Table 9.5.19**. It shall be noted that Makhan was excluded from the scope of this M/P. Makhan will be integrated to the proposed STP in future and at that moment, STP shall be expanded.

Table 9.5.19 Summary of Conditions and Proposed Facilities

Items	Contents
Average wastewater (m^3/d)	15,300
Hourly max wastwater (m^3/d)	29,610
Sludge (kgDS/d)	3,787
Sludge (m^3/d)	9.5
Moisture content (%)	60
Treatment method	OD + Mechanical Thickening + Drying Bed
Grit chamber (No.-w×L)	2-1.4m×6m
Main P (No.-D×power)	5-φ200mm×11kw
Reactor (No.-W×L×H)	8-4.5m×140m×3.0m(high rate)
Final sedimentation tank	8-φ15m
Disinfection channel	2-2m×21×1.9m
Mechanical Sludge Thickener	2-1,893kg/d
Drying Bed	24-15m×43m
Required land area (ha)	5.9

3) Sewage treatment method

The agricultural land along the river bank is available for STP establishment.

It is vast public land and good farm, so consideration should be given to acquire the minimum land for STP construction.

For selection of treatment method it is important to consider that water for irrigation is abundant, and environmental capacity of Euphraties is large., Therefore, it is possible to select a primary treatment method if not counting on effluent standard, like only primary sedimentation. However, the water from the river provides for the water supply in many cases downstream. Therefore, primary treatment would not be sufficient, and secondary treatment has been proposed.

Conventional Extended Aeration, OD, or Wet-land is applicable as the treatment method for this scale of wastewater flow. As the economic value of land is high, wet-land which demand larger land, would be excluded, and Conventional Activated Sludge for comparison with

Conventional Extended Aeration and OD is added.

Since de-nitrification is not included as treatment target, BOD-SS loading of OD is set as the same rate as of Conventional Extended Aeration.

Preservation of agricultural land has been considered important while comparison and evaluation of methods is carried out.

As a result, OD is proposed in terms of easiness of O&M and structural reason considering that the load of OD is relatively small and it is better to construct OD on such land near river for which bearing capacity of foundation must be small.

Comparison of treatment process in Mayadin is shown in Table 9.5.20.

Table 9.5.20 Comparison of Treatment Process in Mayadin

Items	OD	Conventional extended aeration	Conventional Activated Sludge
Possibility of layout	+	+	+
Preservation of farm land	+	+	++
Correspondence to load fluctuation	+	+	
Sludge Reduction	+	+	
Offensive odor Problem	+	+	
Simple equipment	++	+	
Easiness of operation	++	+	
Construction cost		+	
Maintenance cost	++	+	
Evaluation	11 points	9 points	3 points

4）Sludge treatment method

Sufficient land is available for any method. However, generated sludge cannot be thickened by gravity, and therefore Mechanical Thickening and Drying Bed are proposed.

5) Special Consideration on facility Planning

- STP site is located within flood plain, so embankment and bank protection must be constructed.
- The foundation must be soft ground because it is located in flood plain, so light weight structure like the digging ditch covered by rubber sheet would be preferred. Foundations for the aerators would be required though.
- Proposed area of Mayadin may be coupled with neighboring cities along the river, and STP would possibly require extension, because centralization of management of sewage facilities would have economical advantages in this region. However, at this moment it is uncertain, so land requirement for STP for future population of Mayadin and Taiba should be estimated and land acquisition should be carried out as enough land is available near STP for the future plan.

Maser plan of Mayadin is shown in **Figure 9.5.11**:

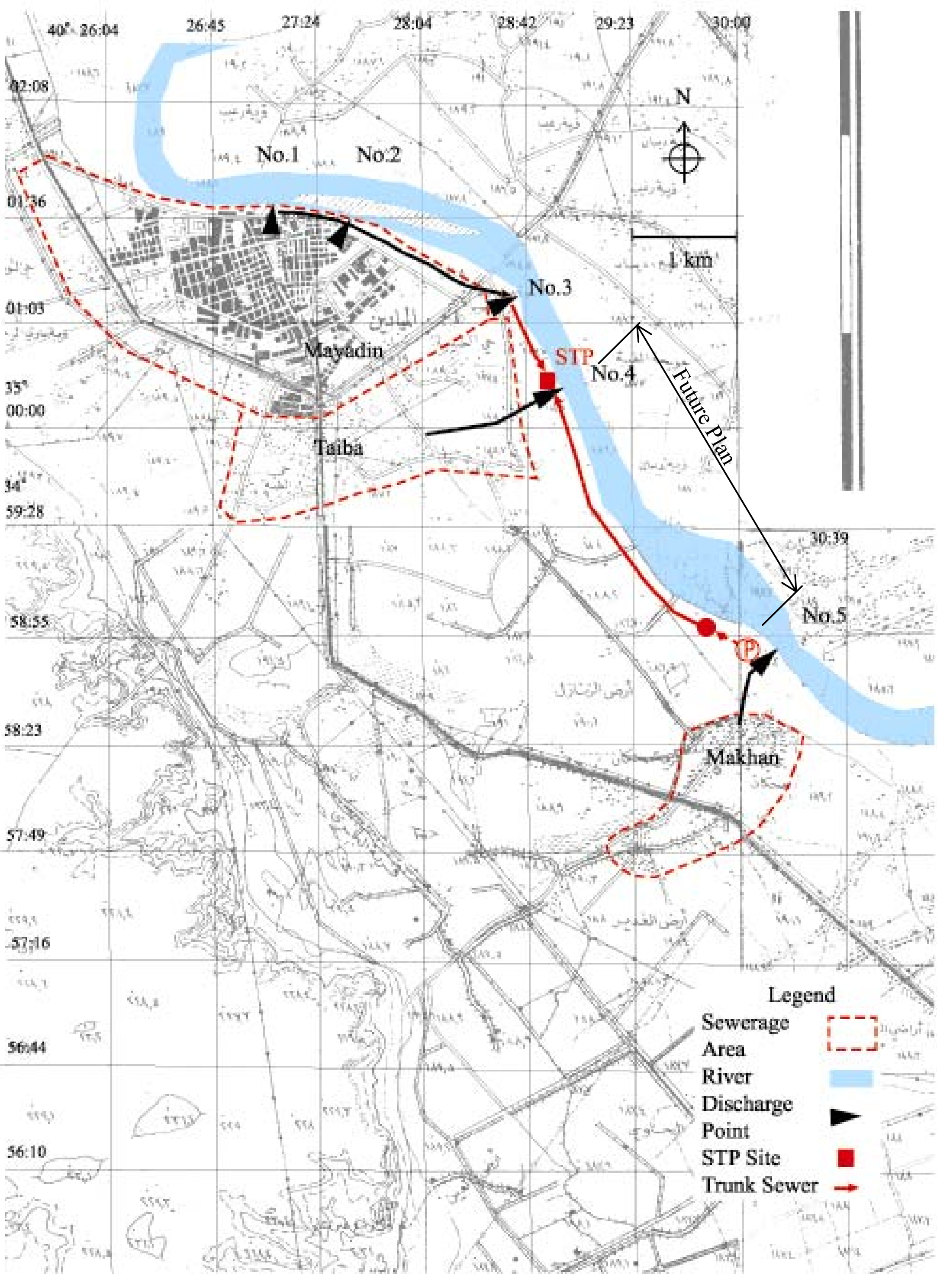


Figure 9.5.11 Master Plan of Mayadin

9.5.4 Malkieh, Hassakeh Governorate

(1) Study Area

Hassakeh Governorate is located in northern area of the Euphraties River. A major part of the governorate is located in the Al-Khabour River basin and eastern part of the governorate including Malkieh exists in the Tigris River basin. There are four districts, Hassakeh, Al-Qamishli, Malkieh, and Ras Arain in the governorate. Malkieh District consists of three sub-districts namely, Malkieh, Al-Jawadieh, and Al-Yarobieh. There are 108 communities in Malkieh Sub-district. Population in Malkieh is about 26,000 and about 16,000 for Al-Mabadeh. Other communities are rather small and their populations are less than 3,000.

Figure 9.5.12
Master Plan Area in Malkieh District

Development in Malkieh will occupy a hilly area with a good run-off for water since the river crosses the middle of the city. The river flows into a dam that was constructed for irrigation.

The sewer pipeline system in the city is already almost developed. To avoid the discharge of raw wastewater into the dam lake, the raw wastewater transmission pipeline should reach the downstream of the dam.

The wastewater that is discharged flows into the Tigris River. On the way to the Tigris River, there are many small scale communities, along the riverbanks that depend on wells as their water source. To reduce the risk of groundwater contamination, the development of a sewage system in Malkieh is urgently required.

The Master Plan area in Maikieh district is shown in **Figure 9.5.12**:

(2) Planned Population and Volume of Wastewater

The population and volume of wastewater in Malkieh is as shown in **Table 9.5.21**.

Table 9.5.21 Planning Parameters of Malkieh

Items		Unit	2004	2010	2015	2020	2025
	Population	per.	26,311	29,100	31,200	33,000	34,500
per capita Wastewater	Daily Average	LCD	109	115	120	125	131
	Daily max		127	133	139	146	152
	Peak Hourly		211	222	232	243	253
Tourist		%	0	0	0	0	0
Generated Wastewater	Daily Average	m^3/day	2,871	3,334	3,745	4,141	4,518
	Daily max		3,334	3,872	4,349	4,809	5,246
	Peak Hourly		5,557	6,453	7,248	8,015	8,744

Note) LCD : liter/capita/day

(3) Investigation on Raw Sewage Discharge Points

The sewage collected from the urban area is discharged at a point located downstream of the dam within the vicinity of the proposed STP. The outlet is about 40 m below the level of the urban area. The diameter of the sewer is 800 mm.

(4) Selection of STP Site

All sewage generated from the city is being diverted around the dam and discharged downstream of the dam. City officials plan to construct the STP near the discharge point. This location would be appropriate for the following reasons:

- No houses exist in the STP site and therefore, no resettlement will be required.
- Becasuse the site is remote from residential areas, environmental measures would not be required.
- Since the site is located lower than the residential area, it could efficiently collect the sewage generated.
- The proposed site is not flat but can be developed by filling and cutting work.
- An appropriate discharge channel is available near the proposed site.

Diagrammatic sketch of discharge point is shown in **Figure 9.5.13**.

Location of proposed STP site in Malkieh is shown in **Table 9.5.22**.

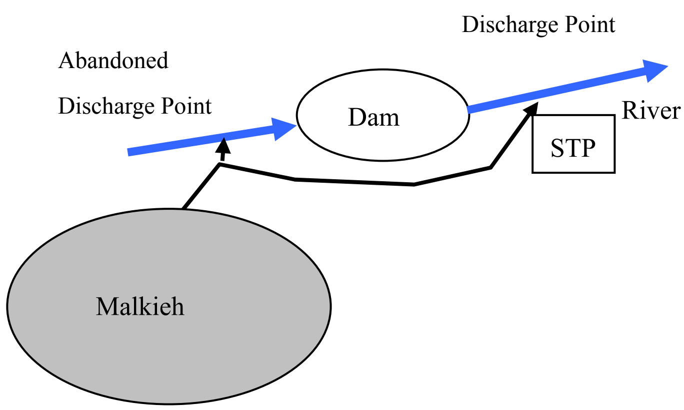


Figure 9.5.13 Diagrammatic Sketch of Discharge Point

Table 9.5.22 Location of Proposed STP Site (Malkieh)

No	Latitude N	Longitude E	Level	Available Area	Land Cost	Land Owner	Distance from residential area
1	37°11′02.0″	42°09′56.5″	444 m	More than 2ha	-	Public	1,500m

(5) Sewage Collection System

It is proposed that a structure be installed to divert the sewage from the existing trunk sewer and convey to the proposed STP. **Table 9.5.23** summarizes the design of the conveyance sewer.

Table 9.5.23 Design of Trunk Sewer

Flow rate		Capacity	Diameter	Inclination	v	Q
m^3/day	m^3/s	m^3/s	mm	‰	m/s	m^3/s
8,744	0.101	0.202	500	1.7	1.03	0.202

(6) Planning of STP

1) Influent quality and Effluent standard

Treated sewage will be discharged to river.

Incoming sewage quality and effluent standard in Markieh are shown in **Table 9.5.24**.

Table 9.5.24 Incoming Sewage Quality and Effluent Standard in Markieh

Items	Discharge mode to water-body / Condition of re-use	Maximum Allowed Limited effluent standard from STP (mg/l)					
		BOD	SS	NH_3-N	NO_3-N	T-N	T-P
Influent		310	360			74	24
Effluent Standard	Proposed effluent standard (River)	40	30	5	50		

The treated sewage is expected to be used for the irrigation of cotton, where cotton is assumed to be an industrial crop. The effluent standard for the irrigation of industrial crops is BOD 150 mg/l, which is more lenient than 30mg/l for discharge into the river. Therefore, the effluent standard for discharge into the river shall be applied.

2) Summary of conditions and proposed facilities

Planning conditions and results are listed in **Table 9.5.25**.

Table 9.5.25 Summary of Conditions and Proposed Facilities

Items	Contents
Average wastewater (m^3/d)	4,518
Hourly max wastwater (m^3/d)	8,744
Sludge (kgDS/d)	1,119
Sludge (m^3/d)	2.8
Moisture content (%)	60

Table 9.5.25 Summary of Conditions and Proposed Facilities

Items	Contents
Treatment method	OD + Mechanical Thickening + Drying Bed
Grit chamber (No.-w×L)	1-1.3m×4.0m
Main P (No.-D×power)	3-φ150mm×3.7kw
Reactor (No.-W×L×H)	4-4.5m ×140m×3.0m
Final sedimentation tank	4-φ11m
Disinfection channel	1—0.9×3.5×0.8m (UV)
Mechanical Sludge Thickener	1-1,119 kg/d
Drying Bed	8-15m×38m
Required land area (ha)	2.6

3）Sewage treatment method

Conventional Extended Aeration, OD or Wet-land treatment methods are applicable judging from the quantity of .wastewater flow. On the other hand, the capacity of the water body is small, and there is a need for irrigation and wells downstream. At this moment, the Conventional Extended Aeration and OD type of treatments in which the locals have managed to gain a lot of experience, can be assessed to be on the safe side.

Consequently, the OD method may be proposed in terms of ease of O&M and and groundwater pollution factors

The comparison of the treatment processes in Markieh is shown in **Table 9.5.26**.

Table 9.5.26 Comparison of Treatment Process in Markieh

Items	OD	Conventional extended aeration
Possibility of layout	+	+
nitrification	+	++
de-nitrification	++	
Correspondence to load fluctuation	++	++
Sludge Reduction	+	+
Offensive odor Problem	+	+
Simple equipment	++	+
Easiness of operation	++	+
Construction cost		+
Maintenance cost	++	+
Evaluation	14 points	11 points

It concerned about re-use of treated sewage for industrial crops, disinfection method by UV would be desirable.

4）Sludge treatment method

Though sufficient land is available for any method, generated sludge cannot be thickened by gravity. Therefore, Mechanical Thickening and Drying Bed is proposed.

5) Special Considerations in Facility Planning

As the STP site is located on a relatively low ground, an extended embankment will be constructed to avoid submergence. The foundation will be set on the embankment, so that a light structure like a digging ditch covered with a rubber sheet would be preferred. Foundations at the aerators are required though.

Master plan of Malkieh is shown in **Figure 9.5.14**:

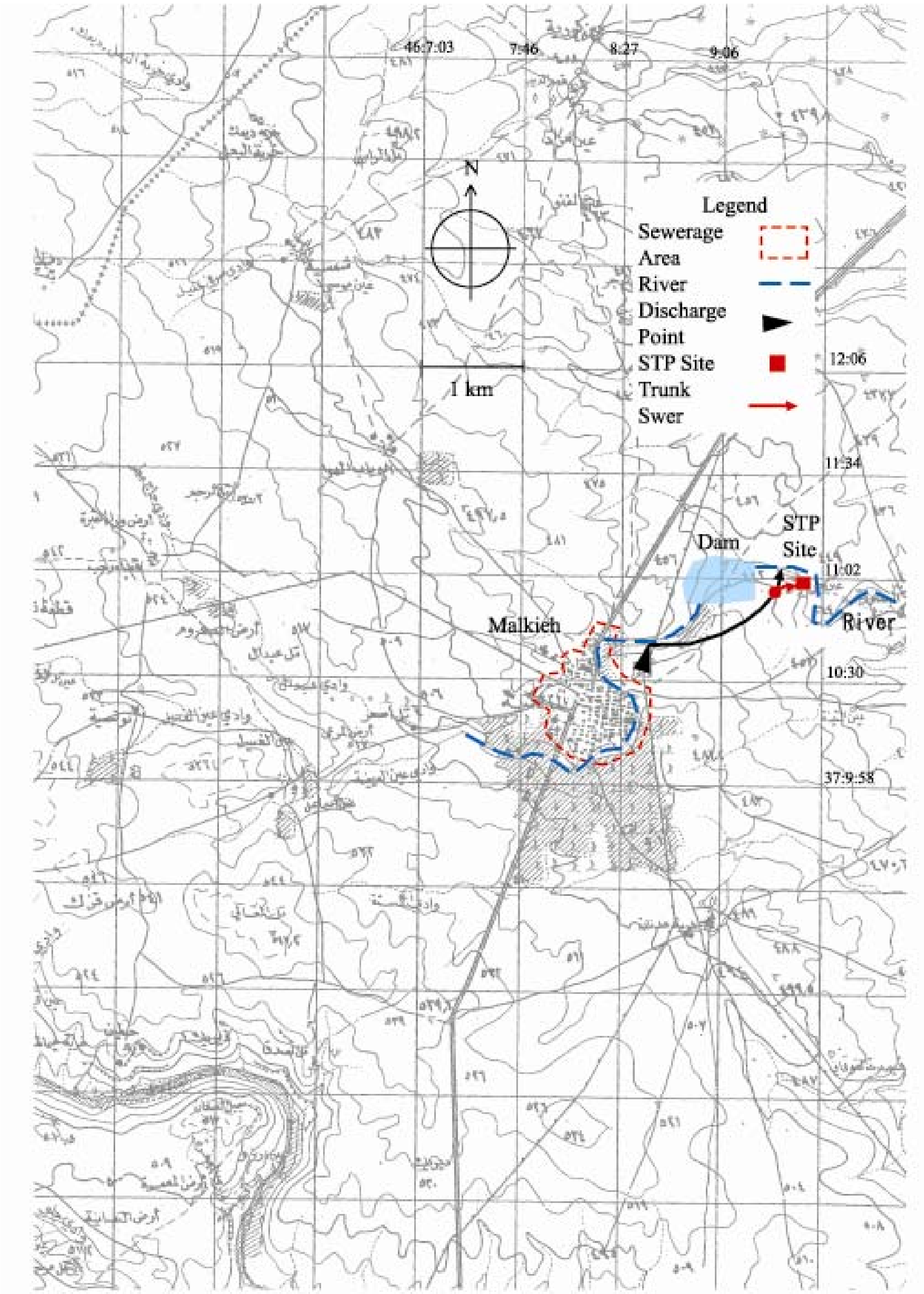


Figure 9.5.14 Master Plan of Malkieh

9.5.5 Thawra, Raqqa Governorate

(1) Target Area

The Raqqa Governorate is located north of the country and the Euphraties River flows down the middle of the Governorate. River water is utilized as potable water source and agricultural water. Total population is approximately 800,000. The Governorate has three districts, namely Raqqa, Tal Abyad and Thawra.

Fig 9.5.15
Master Plan Area in Thawra District

The Thawra district is comprised of the three sub-districts of Thawra, Al-Mansorah and Al-Jameah. The Thawra sub-district, in turn, is composed of Thawra City that has a population of 70,000, roughly. Thawra City is divided into two areas, namely the old-urban area in the south and the newly developed urban area in the north facing the Asad Lake. A new urban area was developed during the construction period of the Asad Dam.

The urban area of Thawra City is located on a hilly area. Raw domestic sewage is discharged into a valley running through the urban area. Sewer pipes are installed up to this valley and raw sewage flows through a natural open channel that emits a foul odor and this has led to the deterioration of the sanitary environment in the area.

The raw sewage flows down the said natural open channel and passes through a vast wet land with reeds. By the natural self-purification of this wet land, raw sewage turns into clear water without the characteristic bad odor at the discharge point to the Euphraties River. Based on the current situation, no sewage treatment facilities are deemed necessary, but an appropriate sewerage development plan shall be prepared to deal with the following items:

- As Thawra has a large population growth rate, there is a great risk for the generated sewage flow to exceed the existing self-purification capacity of the wet land.
- Raw sewage flowing in the open channel has adversely affected the sanitary environment.

The Master Plan area of the Thawra district is shown in **Figure 9.5.15**:

(2) Design Population and Sewage Flow

Design population and relevant data on sewage flow calculation are shown in **Table 9.5.27**:

Table 9.5.27 Planning Parameters of Thawra

Items		Unit	2004	2010	2015	2020	2025
	Population	per.	69,425	80,300	90,700	102,400	115,600
per capita Wastewater	Daily Average	LCD	129	135	142	148	155
	Daily max		150	157	165	172	180
	Peak Hourly		250	262	275	287	300
Tourists		%	0	0	0	0	0
Generated Wastewater	Daily Average	m^3/day	8,953	10,873	12,866	15,186	17,889
	Daily max		10,397	12,627	14,942	17,636	20,775
	Peak Hourly		17,328	21,045	24,903	29,393	34,625

Note) LCD : liter/capita/day

(3) Investigation on Raw Sewage Discharging Points

According to the results of field survey, there are three raw sewage discharging points. **Table 9.5.28** shows the coordinates and pipe sizes. However, discharge point No.3was unidentified. Discharge point No.1 was constructed recently and no sewage was discharged as sewer pipe was not connected yet. Since discharge point No.2 was submerged, sewage flow could not be confirmed but it was assumed that considerable sewage volume runs.

Table 9.5.28 Discharge Points of Thawra

Location	Latitude	Longitude	Level	Remarks
1	35 ° 50 ′ 34.2 ″	38 ° 34 ′ 13.3 ″	275	Dia. 1,000mm
2	35 ° 50 ′ 28.5 ″	38 ° 33 ′ 37.1 ″	292	Dia. 700mm
3	-	-	-	Unidentified

(4) Selection of STP Site

According to the Governorate engineer, the land near discharge point No.1 was proposed as the STP construction site. As this land has a lower ground elevation, it has not been utilized as agricultural land and thus land acquisition will be easy. Further, since there are no housing units in the surrounding areas, no strict environmental countermeasure will be needed. Therefore, the said land is appropriate for the STP construction site. **Table 9..5.29** indicates the relevant data on the site.

Table 9.5.29 Location of Proposed STP Site (Thawra)

Location	Latitude	Longitude	Level	Available Area	Land Cost	Land Owner	Distance from residential area
1	35 ° 50 ′ 38.7 ″	38 ° 34 ′ 19.8 ″	278	More than 1 ha	-	Public	1,300m

(5) Sewage Collection Plan

1) Trunk Sewer Plan

A trunk sewer shall be installed to send discharged sewage to the STP, provided that the sewage flow of discharge point No.1 and 2 is 40% of the total flow, while that of discharge point No.3 is 20%. Refer to **Figure 9.5.16** and **Table 9.5.30**.

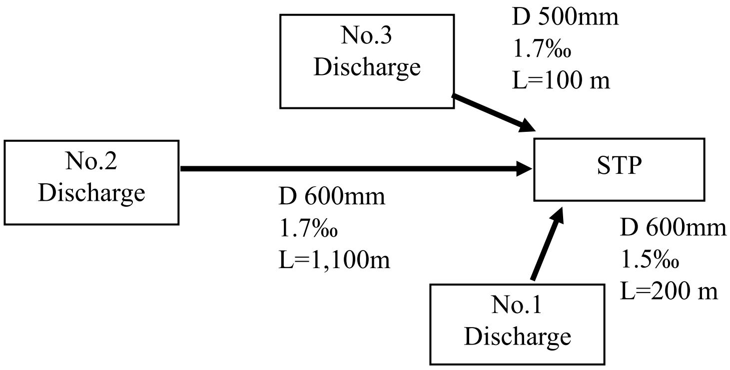


Figure 9.5.16 Schematic Drawing of Trunk Sewer

Table 9.5.30 Design of Trunk Sewer

Items	Flow		Capacity	Diameter	I	v	Q
	m^3/day	m^3/s	m^3/s	mm	‰	m/s	m^3/s
No.1, 2	13,850	0.160	0.320	600	1.7	1.13	0.329
No.3	6,925	0.080	0.160	500	1.5	0.97	0.190

(6) Sewage Treatment Plant Plan

1) Incoming Sewage Quality and Effluent Standard

Treated sewage will be discharged into river. Refer to **Table 9.5.31** for the proposed effluent standard:

Table 9.5.31 Incoming Sewage Quality and Effluent Standard

Items	Discharge mode to water-body / Condition of re-use	Maximum allowed effluent standard from STP (mg/l)					
	Indices	BOD	SS	NH_3-N	NO_3-N	T-N	T-P
Incoming Sewage		310	360			74	24
Effluent Standard	Proposed Effluent Standard （to River）	40	30	5	50		

2) Summary of Conditions and proposed Facilities

The summary of design conditions and data on proposed facilities are shown in **Table 9.5.31**:

Table 9.5.32 Summary of Conditions and Proposed Facilities

Items	Contents
Population	115,600
Daily Average Sewage Flow (m^3/d)	17,889
Hourly Maximum Sewage Flow (m^3/d)	34,625
Sludge (kgDS/d)	2,361
Sludge (m^3/d)	5.9
Moisture content (%)	60
Treatment processes	Existing Wet-land + Primary Settling Tank +Drying Bed
Grit chamber (No.-w×L)	2-1.3m×7.5m
Main P (No.-D×power)	5-φ250mm×11kw
Primary Settling Tank	4-φ10
Drying Bed	20-15m×32m
Required land area (ha)	2.4

3) Sewage Treatment Method

Considering that the Euphraties River (the receiving water body of treated sewage) has a large environmental capacity and that Reed Bed, the existing natural system has been functioning well, the existing Reed Bed will be utilized as a Wet Land and a Primary Settling Tank shall be constructed to cope with future population growth.

A possible alternative is the construction of an STP with 120,000 PE in the land located between Safsafe and Thawra but as this land has a higher elevation, a pumping station would be required. From the viewpoint of the optimization of existing facilities and power saving, this alternative lacks rationality.

4) Sludge Treatment Method

If a Primary Settling Tank will be constructed, raw sludge will be generated. As there is vast land available south of Thawra City that could be used as sludge reclamation land, sludge can be transferred to this location for treatment. Sludge treatment by Gravel Thickening and Drying Bed will be economical.

However, considering the environmental aspect, the establishment of a regional compost factory has been planned for future construction to gather sludge from several STPs.

5) Special Consideration on Facility Planning

The Study Team has proposed the establishment of Primary Settling Tanks and Sludge Drying Beds as supplemental facilities for the existing Reed Bed. However, there are several issues to be addressed towards project implementation as follows:

The establishment of the sewerage system in Thawra was intended basically to maintain the natural self-purification of existing reed beds for sewage treatment, and to effect budget savings simultaneously. The self-purification capacity is expected to be sufficient for purposes of the present service area in 2007, thus, the prompt construction of the STP would be not required. But in the future, when the capacity of the reed bed is expected to be exhausted due to the increase in population, several options should be considered. For example, the expansion of the reed bed or the construction of new supplemental facilities such as a primary sedimentation tank and sludge treatment facility shall be carried out. Therefore, the M/P shall be prepared considering these long-term factors.

On the other hand, in formulating the future option, the Raqqa Governorate should monitor the sewage quality (at inlet and outlet) in order to recognize the relationship between the growth of the population and self-purification capacity of reed beds. In this way, the Governorate would be able to determine the exact year when the reed beds would need expansion or when supplemental facilities would be introduced.

The collection of following fundamental information shall be carried out and compiled by the Governorate from hereon for subsequent use in future design:

a) Location of the Main Trunks
b) Area of reed beds and flood plains
c) Pollution loading on the reed beds
d) Monitoring of treated sewage quality discharged to the river

6) Proposal on Fundamental Data Collection by Governorate

Survey a) Location of Main Trunks

Location and elevation of the main trunks that reach the reed bed are not available. It is impossible to design the supplemental facilities without considering data on existing facilities. For this purpose, a topographic survey of main trunks located outside the city shall be conducted and the location of these main trunks shall be confirmed by the topographic map. A ;ongitudinal section shall also be prepared.

Survey b) Area of reed beds and flood plain

The area of the existing reed beds and its drawing is not defined on the map. So a topographic survey of the reed bed site shall also be carried out. At the same time, the areas of the reed beds and flood plain shall be defined on the map. Equally, a specific area within the reed bed that wll be identified for the location of the sewage treatment should be identified.

Survey c) Pollution Loading to the reed bed

Though the existing reed bed seems to have a sufficient treatment capacity to contain the present loading, the actual load is not well defined. To accomplish this, the population growth rate, flow and fundamental sewage indices of BOD, SS, COD, NH_3, NO_3, DO, Coliform, etc. should be periodically monitored for each main trunk.

Survey d) Monitoring of treated sewage quality discharged to the river

Treated effluent from the reed bed looks very clear at the discharge point near the river but the actual treated sewage quality is still unknown. Along with the population growth, the pollution load will simultaneously increase and this will apparently affect the capacity of the reed bed. Therefore, through the successive monitoring of the incoming pollution load on the reed bed and the treated sewage quality, the Government would be able to decide appropriately when the supplemental facilities shall be constructed.

Refer to **Figure 9.5.17**:

:

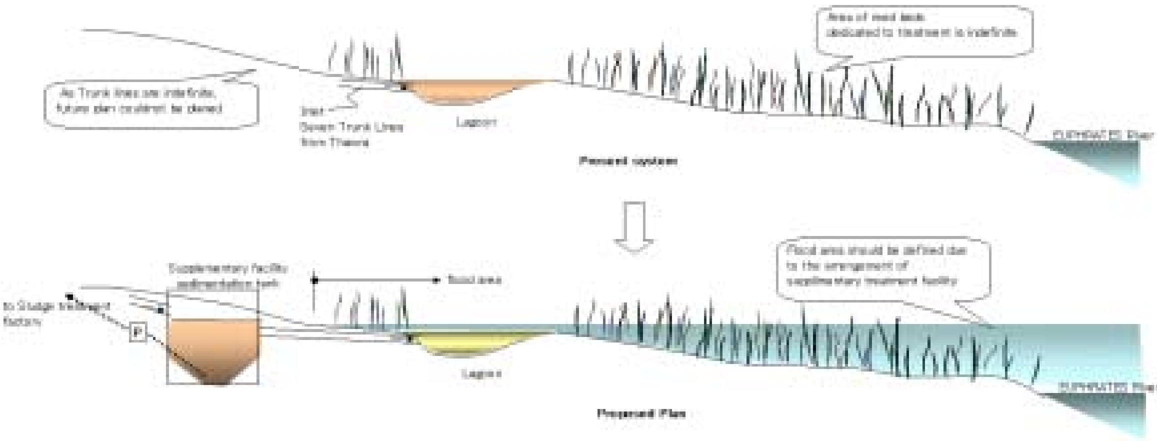


Figure 9.5.17 Schematic Drawing of Existing Reed Bed and Future Plan

Master plan of Thawra is shown in **Figure 9.5.18**:

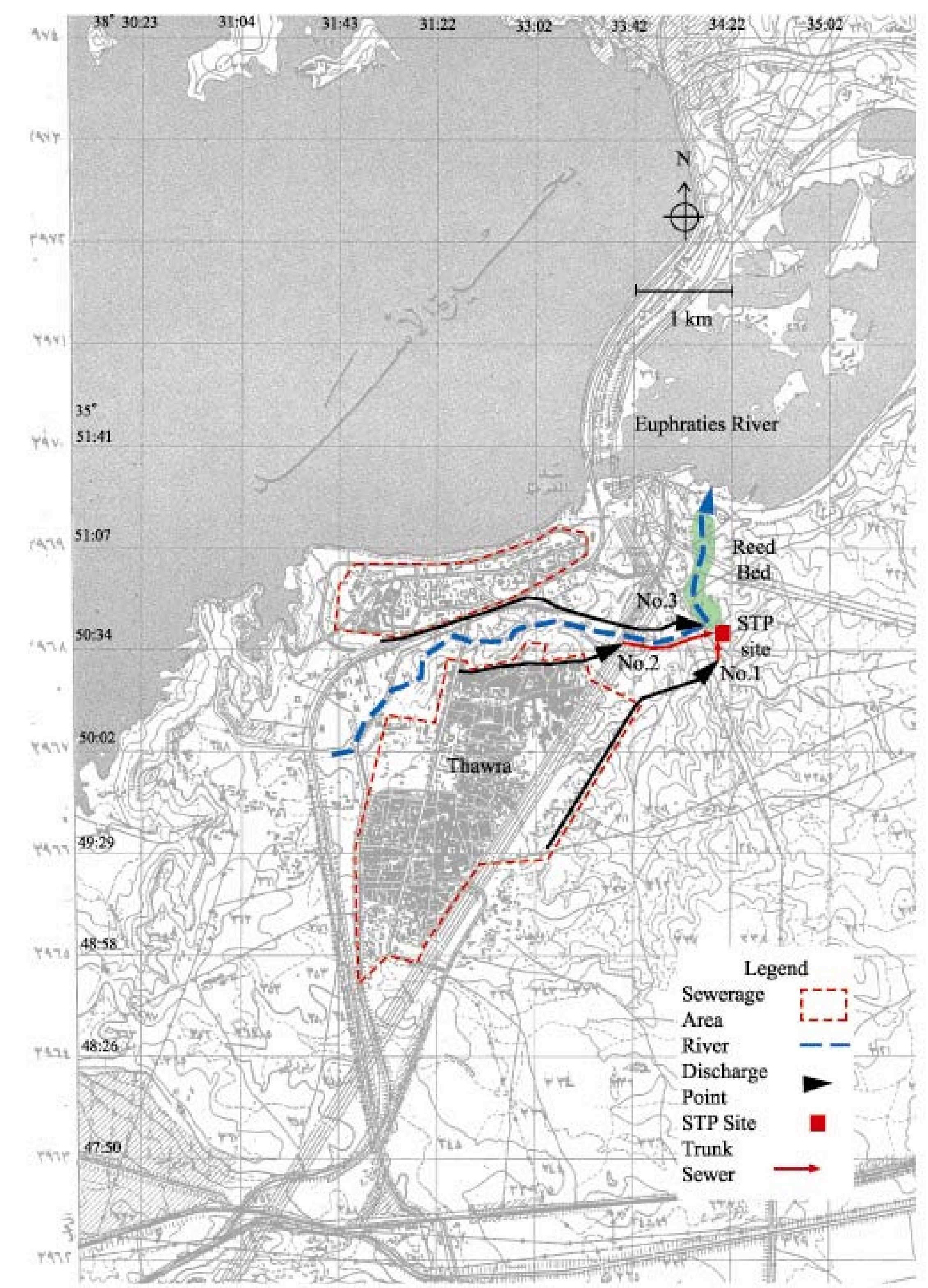


Figure 9.5.18 Master Plan of Thawra

9.5.6 Muzerib, Dar'aa Governorate

(1) Target Area

The GCEC has already prepared the study on the sewerage system development for this area. According to this study, the proposed centralized sewerage system will collect sewage generated in the three cities of Muzerib, Yaduda and Atman for treatment in one STP. Comparison was done on five alternatives for the proposed STP site and the optimum site was chosen. The proposed site is an agricultural land located between Muzerib and Yaduda.

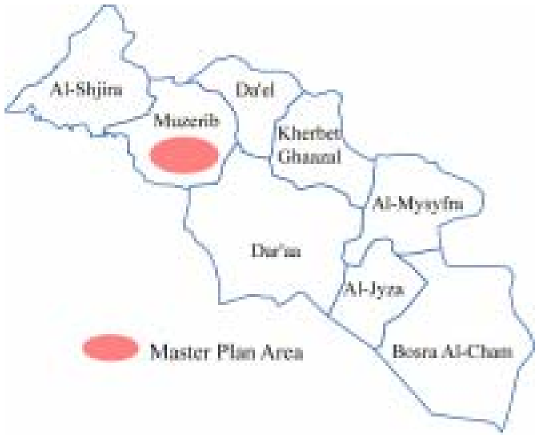


Figure 9.5.19 Master Plan Area in Muzerib District

These three cities are medium-scale cities populated by more than 8,000 persons and geographically adjoin each other. Their order of location from upstream to downstream is Atman, Yaduda and Muzerib. The largest city is Muzerib. The distance between Atman and Yaduda is about 6 km and that between Yaduda and Muzerib is 5 km, approximately.

As a result of the examination indicated in the Macro Plan, Atman will be served by a decentralized system, while Yaduda and Muzerib will be served by a centralized system. The major issue to be addressed by the Master Plan is the selection of the proposed STP construction sites.

The Master Plan area in Muzerib district is shown in **Figure 9.5.19**:

(2) Design Population and Sewage Flow

Design population and sewage flow in study area is shown in **Table 9.5.33**:

Table 9.5.33 Planning Parameters of Muzerib

Items			Unit	2004	2010	2015	2020	2025
Muzelib		Population	per.	12,640	14,200	15,500	16,700	17,900
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourists		%	0	0	0	0	0
	Generated Wastewater	Daily Average	m^3/day	1,379	1,627	1,860	2,096	2,344
		Daily max		1,602	1,889	2,161	2,434	2,722
		Peak Hourly		2,670	3,149	3,601	4,056	4,537
Yaduda		Population	per.	8,967	10,000	10,900	11,800	12,600
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourists		%	0	0	0	0	0

Table 9.5.33 Planning Parameters of Muzerib

Items			Unit	2004	2010	2015	2020	2025
	Generated Wastewater	Daily Average	m^3/day	978	1,146	1,308	1,481	1,650
		Daily max		1,136	1,331	1,519	1,720	1,916
		Peak Hourly		1,894	2,218	2,532	2,866	3,193
Atman		Population	per.	8,929	11,400	13,200	14,600	15,700
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
	Tourists		%	0	0	0	0	0
	Generated Wastewater	Daily Average	m^3/day	974	1,306	1,584	1,832	2,56
		Daily max		1,131	1,517	1,840	2,128	2,387
		Peak Hourly		1,886	2,528	3,067	3,546	3,979
Total		Population	per.	30,536	35,600	39,600	43,100	46,200
	Generated Wastewater	Daily Average	m^3/day	3,332	4,079	4,753	5,409	6,050
		Daily max		3,870	4,737	5,520	6,281	7,025
		Peak Hourly		6,449	7,895	9,200	10,468	11,709
Total Muzelib Yaduda		Population	per.	21,607	24,200	26,400	28,500	30,500
	Generated Wastewater	Daily Average	m^3/day	2,357	2,773	3,168	3,577	3,994
		Daily max		2,738	3,220	3,680	4,154	4,638
		Peak Hourly		4,564	5,367	6,133	6,922	7,730

Note) LCD : liter/capita/day

(3) Investigation of Raw Sewage Discharging Points

Coordinates of discharge points located by GPS survey were shown in **Table 9.5.34**:

Table 9.5.34 Discharge Points of Muzerib

Name of Discharge Points	N	E	Diameter
Yaduda Discharge Point	32°40′38.1″	36°02′59.6″	
Muzerib Discharge Point	32°42′22.5″	36°00′34.1″	Dia.= 1,000 mm

(4) Selection of STP Site

a) STP Site

Two STP construction sites were identified for further examination. From the viewpoint of economy, the site near the existing Muzerib discharge point is preferable but as both of the proposed sites are 4 km away from Muzerib, the discharge point, they are not suitable as STP construction sites. Hereinafter, a comparative analysis was conducted on these two alternatives. Refer to **Table 9.5.35** to **Table 9.5.39**:

In both site, there are no housing units and therefore, no resettlement will be required.

Table 9.5.35 Characteristics of Proposed STP Site

Case	Characteristic of the Sites
Case 1	Site proposed by engineer of Dara'a Governorate. 4 km away from Muzerib discharge point in downstream.
Case 2	The optimum site extracted comparison study executed on five alternatives by GCEC. 4 km away from Muzerib discharge point in upstream.

Explanation drawing of case 1 and case 2 are shown in **Figure 9.5.20** and **9.5.21**:

Table 9.5.36 Location of the Proposed STP Site (Muzerib)

Site	N	E	Level	Land-use	Land Cost (SP/m^2)	Land Owner	Distance from residential area
No.1 STP Site	32°42′03.3″	35°58′42.1″	420	Farm land	500	Private	150m
No.2 STP Site	32°41′00.0″	36°02′02.6″	461	Farm land	1,000	Private	300m

Figure 9.5.20 Explanation Drawing of Case 1

Table 9.5.37 Construction Cost of Case 1

Facility	Number	Unit cost	Cost
Dia. 500	4,000 m	6,000SP/m	24.0 Mil.SP
Dia. 400	5,800 m	4,500SP/m	26.1 Mil.SP
Total			50.1 Mil.SP

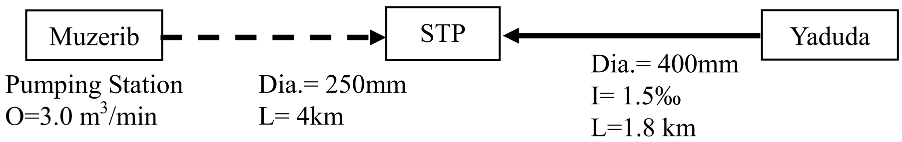


Figure 9.5.21 Explanation Drawing of Case 2

Table 9.5.38 Construction Cost of Case 2

Facility	Number	Unit cost	Cost
D 400	1,800 m	4,500 SP/m	8.1 Mil SP
D 250	4,000 m	3,000 SP/m	12.0 Mil SP
PS	3.0 m^3/min	15 Mil.SP	15.0 Mil SP
Maintenance	30 Years	0.5 Mil.SP	15.0 Mil SP
Total			50.1 Mil SP

b) Head of Pump

Actual Head＝461 - 441 = 20 m

Pipe Friction Loss＝0.006×4,000 = 24 m

Total Head＝20 + 24 = 44 m

Daily Average Sewage Flow in 2004 = 1,112 m^3/day

Power Consumption＝1,112×44×0.0045×365= 80,000 kWh/Year

Electricity＝80,000 kWh×2.5 SP/kWh=200,000 SP/Year

As planned, a pumping station for transporting the whole sewage generated is indicated in Muzerib. However, it cannot be designed as a simplified facility such as the manhole-type pumping station. A general pumping station shall be planned. The necessary equipment for the pumping station are the following:

- Generator as an emergency facility in case of power failure
- Air injector to restrain the generation of Hydrogen Sulfide that is likely to build up in longer forced sewage transmission
- Serge tank to prevent water hammer
- Pump with higher head
- Sedimentation tank and screening removal equipment
- Anti-odor measures shall be taken as housing units are located nearby

Electricity was calculated based on the computed result, wherein the electricity needed to pump sewage was estimated to be 1 m^3 to 1 m higher is 0.0045 kwh/m^3/m; the annual electricity was calculated as 200,000 SP. The O&M cost of the pumping station was estimated to be 500,000 SP/Year including labor cost.

Electricity needed to pump sewage equivalent to 1m^3/min to 1 m higher was computed using the following formula:

$$P = \frac{0.163 \times r \times Q \times H}{\eta} \times (1 + \alpha) = \frac{0.163 \times 1 \times 1 \times 1}{0.7} \times (1 + 0.15) = 0.27\text{kwh}$$

If the pump is operated for 1 hour, the pumped sewage volume will be 60 m^3. Thus, the needed electricity per 1 m^3 was computed by dividing the figure by 60. (0.27/60=0.0045)

Table 9.5.39 Comparison of Proposed STP Sites

Items	Case1	Case 2	Remarks
1. Construction Cost	△	○	Case 1 was calculated as 50.1 Mil.SP, while that of Case 2 was 35.1 Mil.SP.
2. O&M Cost	○	△	Case 2 requires annual O&M cost of 0.5Mil.SP
3. Length of Trunk Sewer	△	○	Case 1 has larger trunk sewer length. 4 km longer than Case 2. Further pipe diameter is larger.
4. Pumping Station	○	△	Case 2 needs pumping station. Pump shall have higher head.
5. Effect on Groundwater	○	△	As STP proposed in Case 2 located near to production wells in Muzerib, adverse effect is anticipated.
6. Re-use as Irrigation Water	△	○	Since Case 2 can discharge treated sewage into channel located upstream, it can be utilized as irrigation water efficiently.
7. Surrounding Conditions	△	○	There is no residential area near STP site of Case 2, while there are residential area 500 m away from STP site of Case 1.
8. Sewage generated in neighboring villages	○	△	Case 1 can collect and treat sewage generated in three communities located downstream of Muzerib.
9. Land Acquisition Cost	○	△	Land acquisition cost of Case 1 was 500 SP/m^2, while that of Case 2 was 1,000 SP/m^2.

According to the comparison shown in **Table 9.5.39**, number of ○ is 5 in Case 1 and that of Case 2 is 4. They are almost equivalent. However, the JICA Study Team selected Case 1 as the optimum plan owing to the following reasons:

- Total project cost inclusive of construction and O&M cost is almost equivalent.
- As this area has an abundant agricultural water source, there is no need for the re-use of treated sewage.
- Though there are some communities 500 m away from the proposed STP construction site in Case 1, the environmental impact caused by the STP can be minimized through the adoption of proper countermeasures.
- Long pressured sewage transmission tends to generate Hydrogen Sulfide that might cause corrosion of sewer pipe and treatment facilities.
- Pumping station needs equipment such as air injector, surge tank and anti-odor facility.

(5) Sewage Collection Plan

1) Trunk Sewer Plan

Table 9.5.40 shows the design criteria and relevant data on the trunk sewer. In-pipe velocity of the force main was set at 1.0 m/s.

Table 9.5.40 Design of Trunk Sewer

Items	Flow		Capacity	Diameter	I	v	Q
	m^3/day	m^3/s	m^3/s	mm	‰	m/s	m^3/s
Yaduda-Muzerib	3,193	0.037	0.074	400	1.5	0.83	0.105
Muzerib-STP	7,730	0.089	0.178	500	1.4	0.94	0.184
Muzerib-STP(Case2)	4,537	0.053	0.053	250	6.0	1.03	0.050

(6) Sewage Treatment Plant Plan

1) Incoming Sewage Quality and Effluent Standard

Treated sewage is discharged to Waji (river). As the ground water is abundant, there is no need to re-use treated sewage for irrigation. If the quality of the treated sewage is well within effluent standard for discharging into the river, this effluent could be used for the irrigation of fruit trees or grain. Refer to **Table 9.5.41**.

Table 9.5.41 Incoming Sewage Quality and Effluent Standard

Items	Discharge mode to water-body / Condition of re-use	Maximum allowed effluent standard from STP (mg/l)					
	Indices	BOD	SS	NH_3-N	NO_3-N	T-N	T-P
Incoming Sewage		310	360			74	24
Effluent Standard	Proposed Effluent Standard （to River）	40	30	5	50		
Reference：Irrigation (Grain)		100	150	5	25		

2) Summary of Conditions and Facilities

Planning condition and summarized data on proposed facilities are shown in **Table 9.5.42**:

Table 9.5.42 Summary of Conditions and Proposed Facilities

Items	Contents
Population	30,500
Daily Average Sewage Flow (m^3/d)	3,994
Hourly Maximum Sewage Flow (m^3/d)	7,730
Sludge (kgDS/d)	527
Sludge (m^3/d)	1.3
Moisture content (%)	60
Treatment processes	Wet-land + Drying Bad
Grit chamber (No.-w×L)	1-0.9m×5m
Main P (No.-D×power)	3-φ150mm×5.5kw
Primary settling tank	2-φ6.5m
Reed Bed	24-21m×37m
Drying Bed	8-12m×22m
Required land area (ha)	4.9

3) Sewage Treatment Method

As no groundwater contamination was observed, the environmental capacity has been sufficient to cope with the needs of the present population. However, since the residents depend on wells as potable water sources, the advanced sewage treatment method shall be employed to avoid groundwater contamination that might be caused by increased pollution load. The existing water quality of Waji will also be improved. OD, Conventional Extended Aeration and Constructed Wet Land treatment processes have been chosen for comparison based on the design sewage flow.

Comparison of treatment processes is shown in **Table 9.5.43**:

Table 9.5.43 Comparison of Treatment Processes

Items	OD	Conventional extended aeration	Constructed Wet Land
Land Availability	+	+	+
Nitrification	+	++	+
Denitrification	++		
Re-use for Irrigation	++	+	+
Correspondence to load fluctuation	+	+	+
Sludge Reduction	+	+	
Odour Problem	+	+	
Simple equipment	++	+	+++
Easiness of operation	++	+	+++
Construction cost		+	+++
Maintenance cost	++	+	+++
Evaluation	15 points	11 points	16 points

If land is readily available, then a Constructed Wet Land with the cheapest construction cost and ease in O&M is the most suitable method. Moreover, as the STP site is located near communities and is visible to them, the reeds could serve as a good landscape. However, available data on nitrogen removal through the use of this method is not sufficient and careful examination is needed prior to adoption. However, treated sewage looks clean in both existing facilities in Thawra and Harran Al Awameed and currently there is no need to re-use treated sewage for irrigation. Therefore, the Constructed Wet Land method is applicable in cases where the treated sewage is discharged into the Waji. Further, since design loading to the reed bed is small, it has the needed flexibility to cope with the fluctuation of incoming pollution load. Based on abovementioned comprehensive assessment of the Constructed Wet-land, the Study Team would like to propose this method as it is superior to others in terms of ease in the carrying out of O&M and financial cost effectiveness. From hereon, data collection on the existing facilities in Thawra and Harran Al Awameed is desirable.

4) Sludge Treatment Method

As generated sludge in the Constructed Wet Land is non-digestible, the applicable option is to send the sludge to Dara'a STP for integrated treatment. However, since the generated sludge concentration which is four % is rather high for conveyance by pipe and of small amount, it can be treated using the Drying Bed method. In the future, given that the Dar'aa governorate will have a lot of STPs in good agricultural locations, so the Study Team would like to propose the establishment of regional compost factories to gather sludge from several STPs to serve future purposes. Further, as primary sludge has a higher concentration in Syria, the thickening process has been excluded.

5）Special Consideration on Facility Planning

Layout plan is available in the Appendices. The land required for expansion was secured to cope with the growth in future pollution load.

Wet lands will be considered as a more reliable and better method for adoption in Syria, particularly when criteria is improved in the future, so that the contingency spaces for the expansion of reed beds on the layout plan can be conveniently secured (refer to Appendix 9.3).

Master plan of Muzerib is shown in **Figure 9.5.22**:

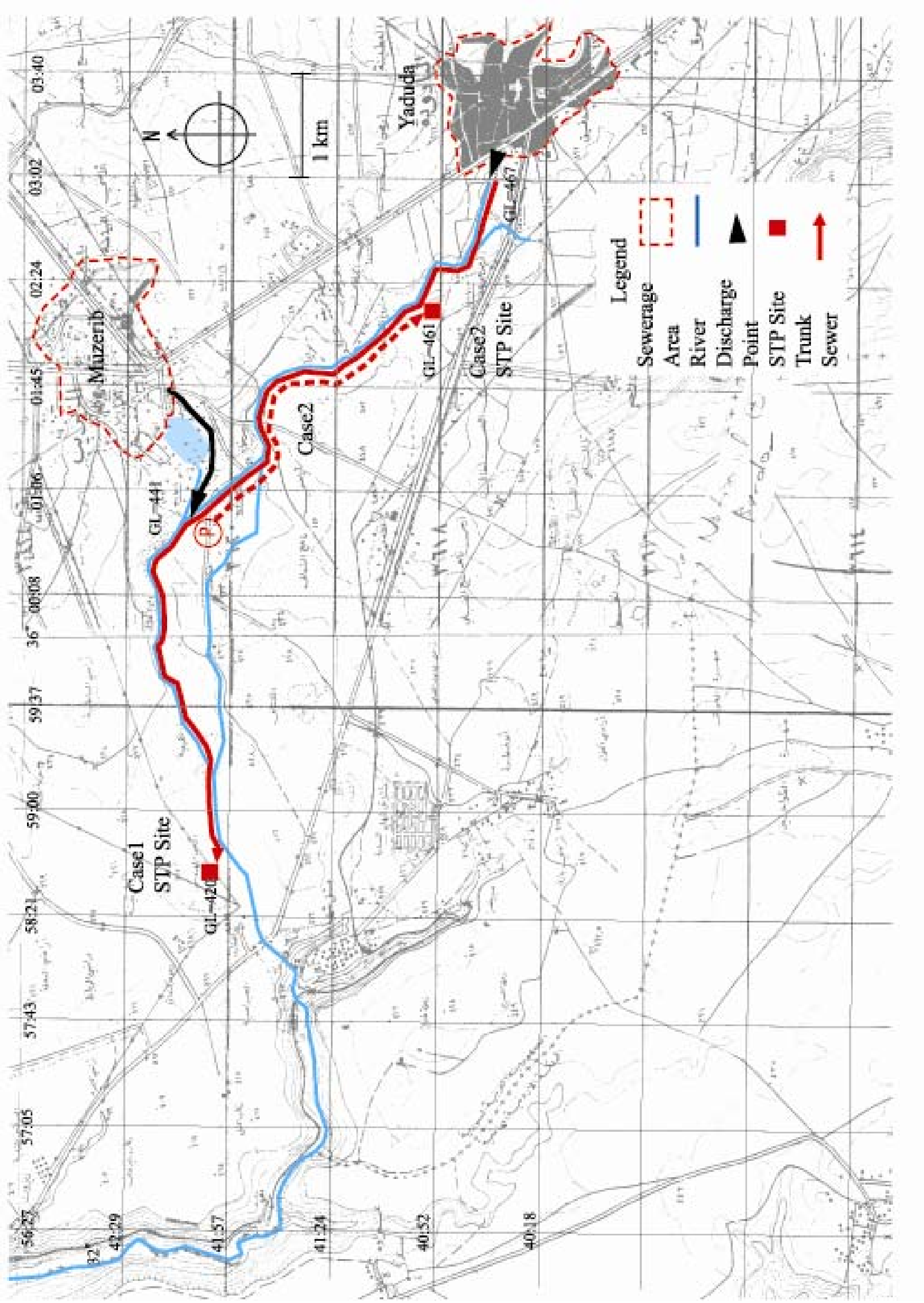


Figure 9.5.22 Master Plan of Muzerib

9.5.7 Zabadani, Rural Damascus Governorate

(1) Target Area

Zabadani is situated in north-west of Damascus City. This is an origin of Barada River. There are four core cities, namely Zabadani, Bludan, Bukein and Madaya. Topographically, the area forms V-shaped valley and Zabadani is located in east and other three cities are situated in east. As residential area is located hilly area, sewage can be collected by gravity. Ain Hour community is located about 5 km upstream of this residential area and Hosh Bujed and Rawdah are situated in 6 km downstream approximately.

Fig 9.5.23
Master Plan Area in Zabadani District

According to the Pre-F/S conducted by EIB for this area, these seven cities and communities are planned to be served by one STP, Centralized System. The JICA Study Team reviewed this study in our Macro Plan. As abovementioned small-scaled community namely, Ain Hour, Hosh Bujed and Raudah are isolated from large-scaled core cities were planned to be served by Decentralized System.

Barada River originated by Barada Spring has clear water in its origin but as there is raw sewage discharge point in 2 km downstream, river water has been heavily polluted. Raw sewage is mainly composed of domestic sewage generated in Zabadani City. Barada River is divided into five tributaries in downstream and river water is used for irrigation purpose. However, since river water has been contaminated by domestic sewage, this hinders the river water utilization.

Furthermore, as Barada River flows through Damascus City, if sewerage system development in upstream, namely in Zabadani is advanced, river water quality will be drastically improved and it will be resulted in great amelioration of urban environment of Damascus City. Thus, environmental improvement in this area by sewerage system development has huge influence. There are rich spring sources namely Fijeh, Barada Spring and Buqqein. Source of this groundwater is snow accumulated in mountainous area near the border of Lebanon. Melt snow infiltrates into ground spouts here. Groundwater quality is excellent for potable water contains minerals temperately. As these springs are located in elevated hilly areas, they have not been deteriorated by domestic sewage. Domestic sewage could not infiltrate into groundwater vein.

Zabadani has vast area in upstream and there is marsh in Ain Hour but it vanished in south side of Zabadani. Accordingly, there are no rivers in southern side of Zabadani. This means all marsh water in upstream is exploited as irrigation water and infiltrated into ground. Rain water is infiltrated into ground as well. Ground of Zabadani is diluvial deposit with high permeability.

Master plan area in Zabadani district is shown **Figure 9.5.23**:

(2) Design Population and Sewage Flow

Table 9.5.44 shows design service population and design sewage flow of Zabadani. As Zabadani has a lot of tourists especially during summer season, sewage flow generated by these tourists are also estimated.

Table 9.5.44 Planning Parameters of Zabadani

Items			Unit	2004	2010	2015	2020	2025
Zabadani		Population	per.	26,285	30,000	32,800	35,200	37,300
	These "per capita wastewater rates" are commonly used in theses seven communities							
	per capita Wastewater	Daily Average	LCD	129	135	142	148	155
		Daily max		150	157	165	172	180
		Peak Hourly		250	262	275	287	300
	Tourist		%	200	200	200	200	200
	Generated Wastewater	Daily Average	m^3/day	10,169	12,187	13,959	15,661	17,317
		Daily max		11,809	14,152	16,210	18,187	20,110
		Peak Hourly		19,682	23,587	27,017	30,311	33,516
	per capita Wastewater	Daily Average	LCD	109	115	120	125	131
		Daily max		127	133	139	146	152
		Peak Hourly		211	222	232	243	253
Bloudan		Population	per.	3,101	3,300	3,400	3,500	3,600
	Tourist		%	300	300	300	300	300
	Generated Wastewater	Daily Average	m^3/day	1,354	1,512	1,632	1,757	1,886
		Daily max		1,572	1,756	1,896	2,040	2,190
		Peak Hourly		2,620	2,927	3,160	3,400	3,650
Bukein		Population	per.	1,866	1,900	2,000	2,000	2,000
	Tourist		%	250	250	250	250	250
	Generated Wastewater	Daily Average	m^3/day	713	762	840	878	917
		Daily max		828	885	976	1,020	1,064
		Peak Hourly		1,379	1,475	1,626	1,700	1,774
Madaya		Population	per.	9,371	9,800	10,100	10,400	10,600
	Tourist		%	50	50	50	50	50
	Generated Wastewater	Daily Average	m^3/day	1,534	1,684	1,818	1,958	2,082
		Daily max		1,781	1,956	2,112	2,273	2,418
		Peak Hourly		2,969	3,260	3,520	3,789	4,030
Rawdah		Population	per.	4,536	6,000	7,100	8,000	8,700
	Tourist		%	0	0	0	0	0
	Generated Wastewater	Daily Average	m^3/day	495	687	852	1,004	1,139
		Daily max		575	798	990	1,166	1,323
		Peak Hourly		958	1,331	1,649	1,943	2,205
Hosh Bujet		Population	per.	604	700	800	900	1,000
	Tourist		%	0	0	0	0	0
	Generated	Daily Average		109	115	120	125	131

Table 9.5.44 Planning Parameters of Zabadani

Items			Unit	2004	2010	2015	2020	2025
	Wastewater	Daily max	m^3/day	127	133	139	146	152
		Peak Hourly		211	222	232	243	253
Ain Hour		Population	per.	1,974	2,300	2,500	2,700	2,900
	Tourist			%	0	0	0	0
	Generated Wastewater	Daily Average		215	264	300	339	380
		Daily max	m^3/day	250	306	348	393	441
		Peak Hourly		417	510	581	656	735
Total		Population	per.	47,737	54,000	58,700	62,700	66,100
	Generated Wastewater	Daily Average		14,545	17,177	19,498	21,709	23,851
		Daily max	m^3/day	16,891	19,947	22,643	25,211	27,698
		Peak Hourly		28,152	33,245	37,738	42,018	46,163
Total Zabadani Bloudan Bukein Madaya		Population	per.	40,623	45,000	48,300	51,100	53,500
	Generated Wastewater	Daily Average		13,769	16,145	18,250	20,254	22,201
		Daily max	m^3/day	15,990	18,749	21,193	23,520	25,782
		Peak Hourly		26,650	31,249	35,322	39,201	42,970

Note) LCD : liter/capita/day

(3) Investigation on Raw Sewage Discharge Points

Sewage generated in Zabadani, Bludan, Buqqein and Madaya is collected by one channel and discharged into Barada River. Coordinate of discharge point by GPS research is shown in **Table 9.5.45**:

Table 9.5.45 Discharge Point of Zabadani

Name	N	E	Diameter
Discharge Point	33°40′43.9″	36°04′33.8″	Dia. 800mm x 2

(4) Selection of STP Site

As described in **Table 9.5.46**, three candidates are proposed as STP construction sites. If STP is planned beside discharge point, project cost will be less as trunk sewer length will be shortened. In this regard, the JICA Study Team would like to propose Case 3 planned the nearest land to discharge point as STP construction site. This owes to the following reasons:

- There is no house in and around the STP site.
- Less trunk sewer length realize less project cost.
- Longer trunk sewer increases the risk of sewage leakage.
- Long forced sewage transmission might cause problems such as Hydrogen Sulfide generation and in-pipe settlement of sediments.
- Sewage shall be treated at the nearest place to its origin. The further, the longer transmission time is needed and it hinders sewage treatment as sewage turns to anaerobic.
- Since Barada spring is situated in upstream of proposed STP construction site, it won’t be affected by discharged treated sewage.

Table 9.5.46 Comparison of Proposed STP Sites

Items	Case 1	Case 2	Case 3
1. Proposed by	EIB	MHC	The JICA Study Team
2. Location	Located at downstream of Study Area. Orchard in right bank of Barada River.	Located at downstream of Study Area. Hilly area 800 m away from right bank of Barada River. Near to discharge point compared with Case 1.	Land 400 m away from discharge point.
3. Sewage transmission measure	Trunk sewer with length of 6 km and pumping station to cross the river is needed.	Trunk sewer length is shorter than Case 1 by 1.8 km. As STP site has high elevation, PS is needed to transmit sewage to STP.	As STP site is close to discharge point, trunk sewer length is the shortest. No PS is needed.
4. Surrounding Environment	As surrounding is orchard and there are no housings. As located near to Barada River, groundwater level is high and ground is soft.	There are no housings in surrounding. Ground is quite firm. Since ground is uneven, grading work is needed.	There is trunk road and housings near to STP site. Barada spring is located 2 km in the west.

Location of the proposed STP site (Zabadani) is shown in **Table 9.5.47**:

Table 9.5.47 Location of the Proposed STP Site (Zabadani)

Site	N	E	Level	Land-use	Land Cost (SP/m^2)	Land Owner	Distance from residential area
No.1 STP Site	33°38′39.9″	36°04′13.0″	1093	Farm land	2,000	Private	150m
No.2 STP Site	33°37′37.9″	36°04′17.0″	1149	Not used	500	Private	200m
No.3 STP Site	33°40′39.9″	36°04′37.5″	1110	Ministry of Irrigation	-	Public	100m

(5) Sewage Collection Plan

1) Trunk Sewer Plan

Currently, installation work of trunk sewer is on-going in Zabadani City. The jurisdiction of Zabadani City is within city boundary and outside of it shall be managed by Buqqein and Madaya located in downstream. Therefore, most of trunk sewer is about to be completed. Diversion chamber shall be installed in upstream of discharge point to send sewage to STP. Refer to **Table 9.5.48**.

Table 9.5.48 Design of Trunk Sewer

Flow rate		Capacity	Diameter	Gradient	v	Q
m^3/day	m^3/s	m^3/s	mm	‰	m/s	m^3/s
42,970	0.497	0.994	800	3.4	1.99	1.002

Transmission trunk sewer length is 100 m approximately stated from the diversion chamber to pumping station at STP.

(6) Sewage Treatment Plant Plan

1) Incoming Sewage Quality and Effluent Standard

Treated sewage will be discharged to Barada River trough a creek. As the contamination of groundwater has been increasing in Rural Damascus Governorate, effluence standard in Zabadani shall be set up so as to enable the re-use of treated sewage to irrigate vegetable farms. However, if treated sewage is to be discharged into river, standard of SS 30 mg/l shall be applied. It is stringent than 50 mg/l applied in case of irrigation use for vegetable. Refer to **Table 9.5.49**.

Table 9.5.49 Incoming Sewage Quality and Effluent Standard

Items	Discharge mode to water-body / Condition of re-use	Maximum allowed effluent standard from STP (mg/l)					
	Indices	BOD	SS	NH_3-N	NO_3-N	T-N	T-P
Incoming Sewage		310	360			74	24
Effluent Standard	Irrigation (vegetable)	30	50	3	20		
	River	40	30	5	50		
	Proposed effluent standard	30	30	3	20		

2) Summary of Conditions and Facilities

The conditions considered for Planning and information on proposed facilities are listed in **Table 9.5.50**.

Table 9.5.50 Summary of Conditions and Proposed Facilities

Items	Contents
Daily Average Sewage Flow (m^3/d)	22,201
Hourly Maximum Sewage Flow (m^3/d)	42,970
Sludge (kgDS/d)	5,495
Sludge (m^3/d)	27.5
Moisture content (%)	80
Treatment processes	OD Gravel Thickener + Mechanical dewatering
Grit chamber (No.-w×L)	2-1.6m×8m
Main P (No.-D×power)	5-φ250mm×15kw
Reactor (No.-W×L×H)	10-5.5m×150m×5m
Final sedimentation tank	8-φ18m
Disinfection channel	3-1.5m×3.5m×0.8m (UV)
Gravity Sludge Thickener	2-6.0m×6.0m
Mechanical Sludge Dehydrator	2-2,747kg/d
Required land area (ha)	5.5

3) Sewage Treatment Method

Applicable treatment methods in this case are Conventional Extended Aeration, Conventional Activated Sludge, and OD judging based on the amount of sewage flow. These methods enable facility layout within the proposed land for STP construction. Special consideration shall be paid to secure the possibility of re-use of treated sewage and the topographical feature of closed groundwater body in Rural Damascus Governorate where contamination of groundwater is apt to advance by accumulated nitrogen compound.

In case of Conventional Extended Aeration method, though nitrification will advance, removal rate of T-N is low, and thus nitrogen concentration in groundwater will increase. The effect is similar in case of Conventional Activated Sludge method. Therefore, the JICA Study Team would like to propose OD because de-nitrification is available and O&M is easy if this method is applied. **Table 9.5.51** shows the overall comparison of these methods. OD method has many advantages.

Table 9.5.51 Comparison of Treatment Processes

Items	OD	Conventional extended aeration	Conventional Activated Sludge
Land Availability	+	+	+
Nitrification	+	++	+
Denitrification	++		
Re-use for Irrigation	++	+	
Correspondence to load fluctuation	++	+	
Sludge Reduction	+	+	
Odour Problem	+	+	
Simple equipment	++	+	
Easiness of operation	++	+	
Construction cost		+	
Maintenance cost	++	+	
Evaluation	16 points	11 points	2 points

Concerned about re-use of treated sewage for agricultural irrigation, disinfection method by UV would be desirable.

4) Sludge Treatment Method

The proposed STP land has insufficient area to allocate sludge drying beds and drying bed is not preferable in the tourist spot because of offensive odor. Mechanical sludge dehydrator is applicable. Generated sludge can not be well thickened by gravity therefore thickening tank was planned mainly for the purpose of sludge reservoir. The sludge should be treated promptly, keeping fresh, hence mechanical sludge dehydrator was proposed to minimize odor emission.

* Sludge treatment is an early field of technical innovation. As an example, adoption of the "multiplex board type screw press dehydrator" which enabled continuous and efficient processing by withdrawing low concentration sludge directly from a reactor is generalized in small-scale STP, such as the Oxidation Ditch method in Japan. The adoption of this dehydrator can omit a thickening process and a storage tank, and has a merit, like control of maintenance becomes easy. In a design phase, it is important to discern the trend of sludge treatment technology well, to take into consideration economical efficiency, control of maintenance, marketability, etc., and to select a sludge treatment flow.

5) Special Consideration on Facility Planning

- There are some issues that need consideration while preparing plan:
  a) The population of tourist is uncertain.
  b) Actual condition on water consumption is not defined.
  c) Agricultural effluent or spring has possibly to be contained in sewage.

  As we could not figure out the entire actual conditions through our survey in short period, layout plan in Appendix is planned based on design conditions established by the JICA Study Team. To cope with future incoming pollution load fluctuation, land required for expansion is secured.
- As current effluent standard is too stringent in terms of NH_3-N concentration, stabilization pond is planned upstream of discharge point for keeping in mind safety. This would become landscape pond to raise fishes, and ecological pond for environmental education as well.

Master plan of Zabadani is shown in **Figure 9.5.24**:

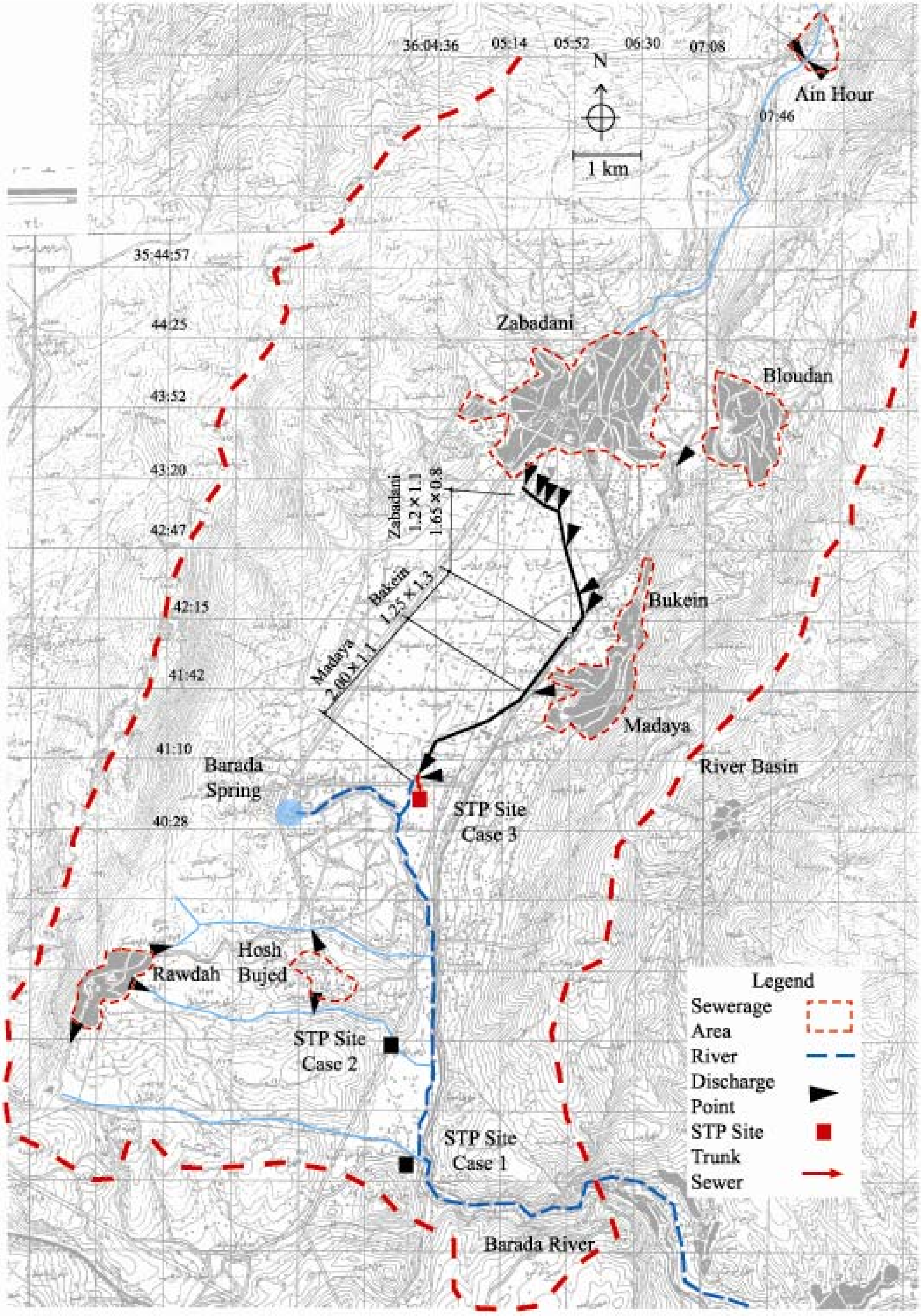


Figure 9..5.24 Master Plan of Zabadani

9.6 Summary of the Proposed Sewerage Facilities

9.6.1 Proposed Sewerage Facilities

The JICA Study Team proposed sewerage facilities for seven designated M/P areas based on careful investigation on the existing sewerage facilities, topographic condition, availability of STP construction land and locally available O&M skill. The outline of proposed sewerage facilities are shown in **Table 9.6.1**. Trunk sewer covers from existing discharge points to STP.

Table 9.6.1 Proposed Sewerage Facilities in Seven Designated Areas

M/P Areas	Items	Facilities	Quantity	Remarks
Slunfeh/ Lattkia	Pipe	D 250	2,700 m	No.1DP – No.1 STP
		D 250	1,600 m	No.3DP – No.2 STP
		D 250	3,600 m	No.6DP – No.3 STP
		Total	7,900 m	
		D 100	500 m	No.5 DP
		D 100	500 m	No.8 DP
		Total	1,000 m	
	Pumping Station	0.5 m^3/min	2	No.5,8 DP
	STP	Incoming Flow	610 m^3/day×3	3 STPS
		Treatment Method	Submerged attached method	
		Site Area	0.1 ha ×3	3 STPs
Banias/ Tartous	Pipe First phase	D 250	1,800 m	From Tero
		D 250	1,300 m	From Kharbet Snasel
		D 250	1,600 m	From Al-Najor
		D 300	580 m	Gravity
		D 250	140 m	Pressure
		D 300	550 m	Pressure
		D 400	770 m	Pressure
		D 500	1,820 m	Pressure
		D 600	2,310 m	Pressure
	Second phase	D 250	140 m	Pressure
		D 300	550 m	Pressure
		D 400	770 m	Pressure
		D 500	1,820 m	Pressure
		D 600	2,310 m	Pressure
	Manhole Pump	3.0 m^3/min	4×2	(First phase, Second phase)
		1.0 m^3/min	5×2	(First phase, Second phase)
	STP	Incoming Flow	19,556 m^3/day	
		Treatment Method	Oxidation Ditch	
		Site Area	5.1 ha	
Mayadin/ Deir-Ez-zor	Pipe	D 400	3,500m	
		D 800	1,000m	
	STP	Incoming Flow	15,300 m^3/day	
		Treatment Method	Oxidation Ditch	
		Site Area	5.9 ha	
Malkieh/ Hassakeh	Pipe	D 500	100 m	diversion device –STP
	STP	Incoming Flow	4,518 m^3/day	
		Treatment Method	Oxidation Ditch	
		Site Area	2.6 ha	
Thawra/ Raqqa	Pipe	D 500	100 m	No.3 – STP
		D 600	1,300 m	No.2,3 – STP
	STP	Incoming Flow	17,889 m^3/day	
		Treatment	Constructed	

Table 9.6.1 Proposed Sewerage Facilities in Seven Designated Areas

M/P Areas	Items	Facilities	Quantity	Remarks
		Method	Wet Land	
		Site Area	2.4 ha	
Muzerib/ Dar'aa	Pipe	D 400	5,800 m	
		D 500	4,000 m	
	STP	Incoming Flow	3,994 m^3/day	
		Treatment Method	Constructed Wet Land	
		Site Area	4.9 ha	
Zabadani/ Rural Damascus	Pipe	D 800	100 m	diversion device –STP
	STP	Incoming Flow	22,201 m^3/day	
		Treatment Method	Oxidation Ditch	
		Site Area	5.5 ha	

Note) D : Diameter (mm), DP : Discharge point

9.6.2 Treatment Methods and Major Effluent Regulations

Table 9.6.2 shows the proposed sewage and sludge treatment methods employed in each STP in seven target areas. Syrian effluent standards according to the types of receiving water bodies and to the usage of treated sewage are also described.

Table 9.6.2 Proposed Treatment Methods and Major Effluent Regulations

M/P Area	Situations of STP site and Sewage Treatment Method	Sludge Treatment Method	Maximum allowed effluent standard from STP (mg/l)			
			BOD	SS	NH_3-N	NO_3-N
Slunfeh/ Lattakia	Three STP lands are allocated in mountainous tourist spot. Each plant capacity is 500 m^3/d. As proposed plant capacity is small, Submerged Attached Growth Method generally adopted to on-site facility in Japan was proposed as this facility needs no daily O&M. Weekly O&M is sufficient to maintain treatment function. Treated wastewater discharged to valley reaches to two dams located 20 to 28 km away. Dam water has not been polluted.	Small amount of sludge peeled from bio-film shall be conveyed to Lattakia STP by tanker.	Discharge to River			
			40	30	5	50
Banias/ Tartous	As proposed STP construction site is supposed to be urban area in the future, OD requires easy O&M and no primary settling tank generates offensive odor, was proposed.	As stated, offensive odor must be minimized. Mechanical sludge dewatering unit was proposed.	Discharge to Sea			
			60	60	10	50
Mayadin/ Deir-Ez-zor	STP was planned in the midst of public owned farmland. Receiving water body has big environment capacity. OD needs easier O&M was proposed.	Proposed STP site has enough area but sludge can not be thickened by gravity. Mechanical Thickening and Drying Bed was proposed	Discharge to River			
			40	30	5	50
Malkieh/ Hassakeh	All methods are applicable as proposed STP construction site has vast area. OD was	Proposed STP site has enough area but sludge can	Discharge to River / Irrigation for cotton			

Table 9.6.2 Proposed Treatment Methods and Major Effluent Regulations

M/P Area	Situations of STP site and Sewage Treatment Method	Sludge Treatment Method	Maximum allowed effluent standard from STP (mg/l)			
			BOD	SS	NH_3-N	NO_3-N
	proposed to satisfy the effluent standard, to preserve water resources. Easiness in O&M was another reason of adoption.	not be thickened by gravity. Mechanical Thickening and Drying Bed was proposed	40	30	5	50
Thawra/ Raqqa	There is well performed reed beds spread about 2 km's long. Wet-land was proposed to optimize the existing facility. To cope with future population growth, pre-treatment facility - primary settling tank- supporting the existing reed beds shall be installed.	Though generated sludge is not digested, Sludge Drying Bed was proposed due to the economical efficiency.	Discharge to River			
			40	30	5	50
Muzerib/ Dar'aa	STP was planned in private farm land. As pollution in water resource (well), has not been reported, Wet-land was proposed in terms of improvement of water environment of water body and lowering of financial burden.	Ditto	Discharge to River			
			40	30	5	50
Zabadani/ Rural Damascus	STP was proposed in public land of 5.5ha in the midst of farm land. OD was proposed in terms of mitigation of nitrogen contained in water within Barada river basin, efficient and safe irrigation purpose use and easiness in O&M.	Considering the odor issue, proposed site area is not enough for drying bed. Mechanical Dewatering were proposed.	Irrigation/ Discharge to River			
			30	30	3	20

9.6.3 Design Criteria and Major Facilities

Table 9.6.3 indicates design criteria, structural dimension of major facilities and specifications of major equipment.

Table 9.6.3 Design Criteria and Major Facilities

	Slunfeh	Banias	Mayadin	Malkieh	Thawra	Muzerib	Zabadani
Average flow (m^3/d)	1,833	19,556	15,300	4,518	17,889	3,994	22,201
Hourly max (m^3/d)	3,548	37,851	29,610	8,744	34,625	7,730	42,970
Sludge (kgDS/d)	224	4,401	3,787	1,119	2,361	527	5,495
Sludge (m^3/d)	2.7	22.0	9.5	2.8	5.9	1.3	27.5
Moisture content (%)	92	80	60	60	60	60	80
No. of STP	3	1	1	1	1	1	1
Treatment method	Submerged attached growth	OD	OD	OD	Wet-land	Wet-land	OD
Grit chamber (No.-w×L)	Each 1-1×1m	2-1.5×7m	2-1.4×6m	1-1.3×4.0m	2-1.3×7.5m	1-0.9×5m	2-1.6×8m
Main pump (No.-D×power)	-	-	5-φ200mm ×11kw	3-φ150mm ×3.7kw	5-φ250mm ×11kw	3-φ150mm ×5.5kw	5-φ250mm ×15kw
Primary settling tank					4-φ10	2-φ6.5m	
Reed bed						24-21m×37m	
Reactor (No.-W×L×H)	Each 2-5.5×12 ×5m	12-4.5 ×140× 3.0m/ high rate	8-4.5 ×140×3.0m/high rate	4-4.5 ×140×3.0m			10-5.5 ×150 ×5m
Final sedimentation tank	Each	8-φ18m	8-φ15m	4-φ11m			8-φ18m

Table 9.6.3 Design Criteria and Major Facilities

	Slunfeh	Banias	Mayadin	Malkieh	Thawra	Muzerib	Zabadani
	2-5.5×3m						
Disinfection channel (No.-W×L×H)	Each 1-φ0.9m	2-2×24×2.1m	2-2×21×1.9m	1-0.9×3.5×0.8 m (UV)			3-1.5×3.5×0.8m (UV)
Gravity thickener (No-kg/d)		2-5.0×5.0					2-6.0×6.0
Mechanical thickener (No-kg/d)			2-1,893	1-1,119			
Mechanical dehydrator (No-kg/d)		2-2,201					2-2,747
Drying bed (No.-W×L)			24-15×43m	8-15×38m	20-15×32m	8-12×22m	
Required land area （ha）	Each 0.1	5.1	5.9	2.6	2.4	4.9	5.5
Land owner	Public/ Private	Private	Public	Public	Public	Private	Public

Source: Japanese Sewerage System Standard as to sludge moisture content

9.6.4 Maps for Sewerage Master Plan

Master plans for seven prioritized cities in seven Governorates were prepared in this study. The Study Team dully aware that master plan for other prioritized cities shall also be established by Syrian side utilizing design procedures shown in this study. Therefore, the Study Team prepared maps showing the locations of STPs in seven governorates. These maps were prepared as reference data to plan STPs for cities with considerable population in 2025 and where sewer network have already been developed.

Maps are shown in **Figure 9.6.1 to 9.6.7**. Population range by sub-district was indicated by different colors and STP locations, the following legend of STPs and STP list were described in the maps:

LEGEND	
Proposed STP	● (red)
Existing STP	● (black)
STP under Construction	● (blue)
STP under Study	● (green)

No.	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	A STP	20,000		Proposed
2	B STP		1,000	Existing
3	C STP		2,500	Under Construction
4	D STP		1,400	Under Study

JICA Study Team prepared the following Maps:

- Large Governorate-wise Map showing STP location and STP List Size = A2
- Detailed City-wise Map showing the boundary of service area Size = A4

The Study Team proposed the following criteria in STP planning prioritization:

Table 9.6.4 Proposed Criterion on STP Planning Prioritization

Criteria	Prioritization Order
(Existing STP)	Shall be excluded from priority order
STP under Construction	Shall be given the highest priority order and if there are plural STPs under Construction, their order shall be determined by design plant capacity. The greater, the higher.
STP under Study	Shall be given 2nd highest priority order and if there are plural STPs under Study, their order shall be determined by design plant capacity. The greater, the higher.
Proposed STP	Shall be given 3rd highest Priority Order and if there are plural proposed STPs, their order shall be determined by served population. The greater, the higher.

Of course the Study Team dully aware that there must be another factors to be considered:

Table 9.6.5 Another Factors to be considered upon STP Planning Prioritization

Factors	Prioritization Order
Sanitary Condition in target area including odor problem, drinking water quality and morbidity of water-borne disease.	The poorer, the greater order
Water quality in receiving public Water bodies	The worse, the greater order

As the detailed topographic map was not available, the Study Team prepared "Detailed City-wise Map" utilizing Google Map Information. However, STP location shown in the said map was proposed by the Study Team without detailed information on topographic condition, location of existing trunk sewer and wastewater discharging points, land availability of STP site, modification shall be made based on the abovementioned information.

Since these maps were prepared as reference data for future STP planning, the Study Team consolidated them as reference data apart from official report. As to maps prepared by the Study Team, refer to **Sewerage Master Plan Maps**.

The following is the list of detailed City-wise Map.

Table 9.6.6 List of detailed City-wise Map

Governorate	Area	Population	Remarks
Lattakia	No 1: Jableh	54,500	
	No 2: Al Qurdaha	10,100	
Tartous	No 1: Banias	85,600	
	No 2: Drekiesh	13,800	
	No 3: Al Shiekh Bader	9,800	
Deir-Ez-zor	No 1: Mo Hasan	12,400	No 1+No 2 (integrated service area)
	No 2: Al Bu-Lail	13,100	
	No 3: Abu Kamal	64,900	
	No 4: Hajeen	51,100	
	No 5: Gharaneej	15,500	

Table 9.6.6 List of detailed City-wise Map

Governorate	Area	Population	Remarks
	No 6: Sha'afah	14,600	
	No 7: Bogros Tahtani	12,100	
	No 8: Mhagan	15,800	No 8+No 12 (integrated service area)
	No 12: Mayadin	14,100	
	No 9: Asharah	21,900	No 9+No 11 (integrated service area)
	No 11: Qorieh	35,200	
	No 10: Sbekhan	25,600	
Hassakeh	No 1: Al-Shadadi	22,500	
	No 2: Qamishli	214,400	
	No 3: Amoda	24,700	
	No 4: Al-Kahtanieh	10,900	
	No 5: Al-Moua'abadeh	18,900	
	No 6: Al Derbasieh	11,600	
	No 8: Malkieh	34,500	
Raqqa	No 1: Thawra	115,600	
Dar'aa	No 1: Tafas	43,100	
	No 2: Al Ghariya Al Sharkiya	14,600	
	No 3: Al Harah	16,400	
	No 4: Enkhel	29,800	
	No 5: Kherbet Ghazal	33,000	
	No 6: Al Jyza	24,200	
	No 7: Harrak	36,100	
Rural Damascus	No 4: Saieda Zeinab	238,500	
	No 34: Daria	167,800	No 34+No 35+No 37+No 43 (integrated service area)
	No 35: Modamiet Al Cham	84,300	
	No 37: Ashrafiet Sahnaya	35,200	
	No 43: Artouz	40,000	
	No 46: Kanaker	19,200	No 46+No 47 (integrated service area)
	No 47: Sasa	12,200	
	No 49: Al Qotifeh	32,200	No 49+No 51+No 53 (integrated service area)
	No 51: Mo'damiet Al Kalamout	18,200	
	No 53: Al Rhaibe	47,000	

STP lists of seven Governorates are shown in **Table 9.6.7** to **Table 9.6.13**. It's noteworthy that "Priority Order" shown in the said tables was proposed by the Study Team based on "proposed criterion on STP planning prioritization" shown in **Table 9.6.4**.

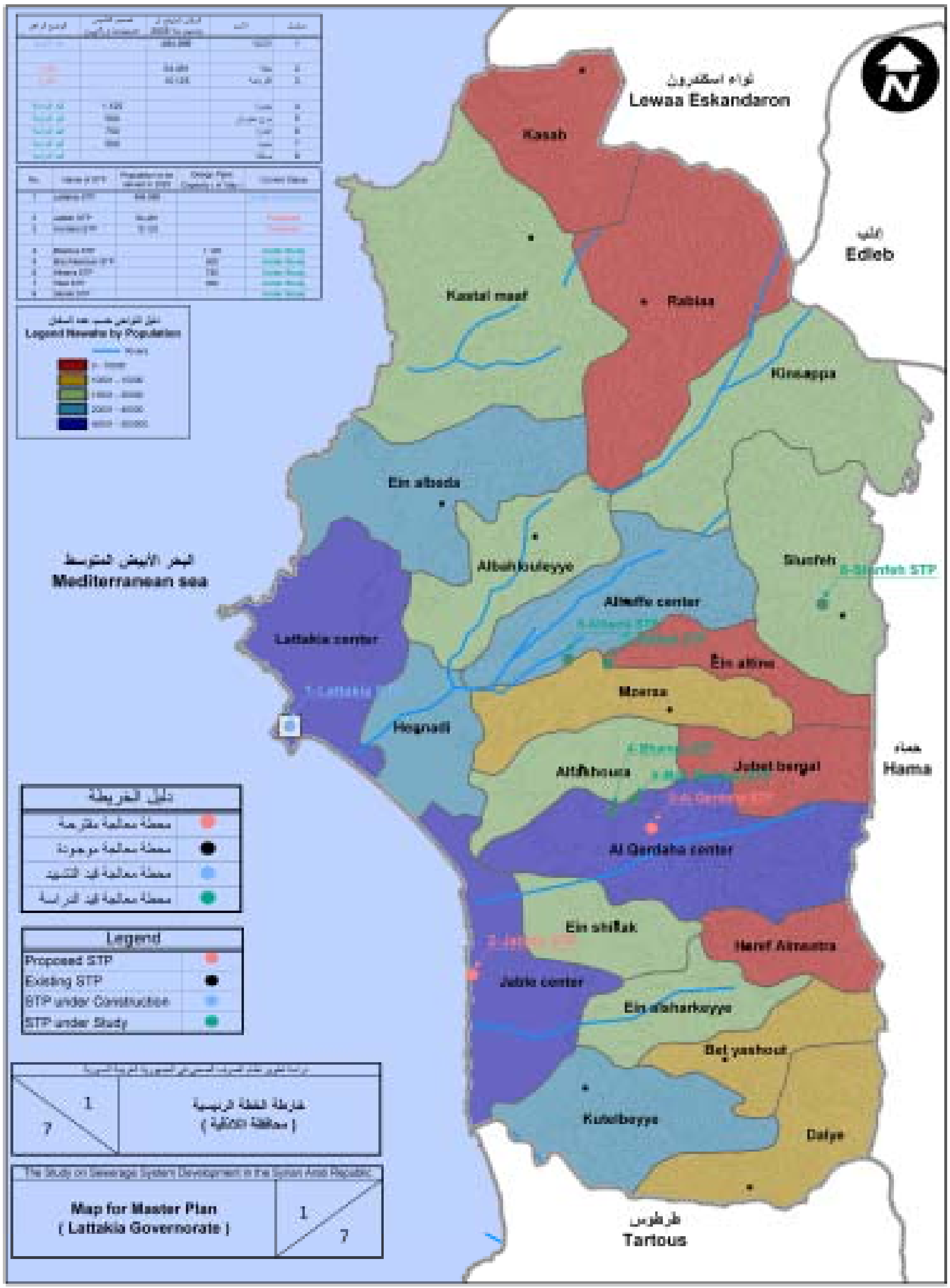


Figure 9.6.1 Map for Sewerage Master Plan in Lattakia

Table 9.6.7 STP List of Lattakia Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	1	Lattakia STP	484,999		Under Construction
2	7	Jableh STP	54,491		Proposed by Study Team
3	8	Querdaha STP	10,125		Proposed by Study Team
4	3	Bhamura STP		1,125	Under Study by Syrian side
5	5	Marj Me'erban STP		500	Under Study by Syrian side
6	4	Alharra STP		750	Under Study by Syrian side
7	6	Habeet STP		500	Under Study by Syrian side
8	2	Slunfeh STP		610×3	Studied by this Study

Note 1) "STP No." is STP number shown in the Map.

Note 2) "Priority Order" for STP planning was determined by the following criteria:

Existing STP	Shall be excluded from priority order
STP under Construction	Shall be given the highest priority order and if there are plural STPs under Construction, their order shall be determined by design capacity. The greater , the higher.
STP under Study	Shall be given 2nd highest priority order and if there are plural STPs under Study, their order shall be determined by design plant capacity. The greater, the higher.
Proposed STP	Shall be given 3rd highest priority order and if there are plural proposed STPs, their order shall be determined by serced population. The greater, the higher.

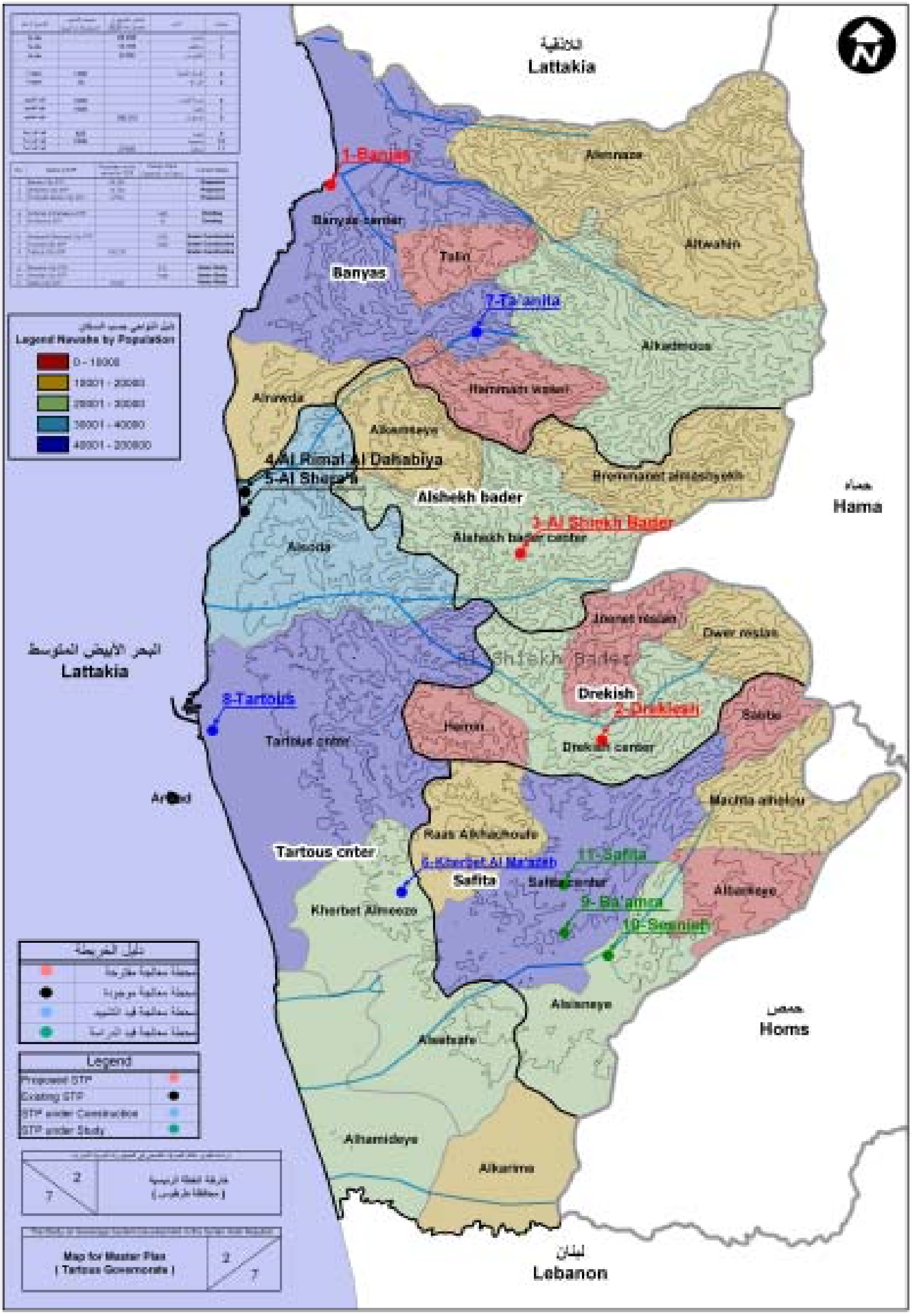


Figure 9.6.2 Map for Sewerage Master Plan in Tartous

Table 9.6.8 STP List of Tartous Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	4	Banias STP		19,556	Studied by this Study
2	8	Dreikiesh City STP	13,783		Proposed by Study Team
3	9	Al Shiekh Bader City STP	9,769		Proposed by Study Team
4	-	Al Rimal Al Dahabiya STP		1,400	Existing
5	-	Al Shera'a STP		70	Existing
6	2	Kherbet Al Ma'azeh City STP		1,000	Under Construction
7	3	Ta'anita STP		1,000	Under Construction
8	1	Tartous STP	180,210		Under Construction
9	7	Alharra STP		625	Under Study by Syrian side
10	6	Habeet STP		1,680	Under Study by Syrian side
11	5	Slunfeh STP		5,360	Under Study by Syrian side

Note 1) "STP No." is STP number shown in the Map.
Note 2) "Priority Order" for STP planning was determined by the following criteria:

Existing STP	Shall be excluded from priority order
STP under Construction	Shall be given the highest priority order and if there are plural STPs under Construction, their order shall be determined by design capacity. The greater , the higher.
STP under Study	Shall be given 2nd highest priority order and if there are plural STPs under Study, their order shall be determined by design plant capacity. The greater, the higher.
Proposed STP	Shall be given 3rd highest priority order and if there are plural proposed STPs, their order shall be determined by serced population. The greater, the higher.

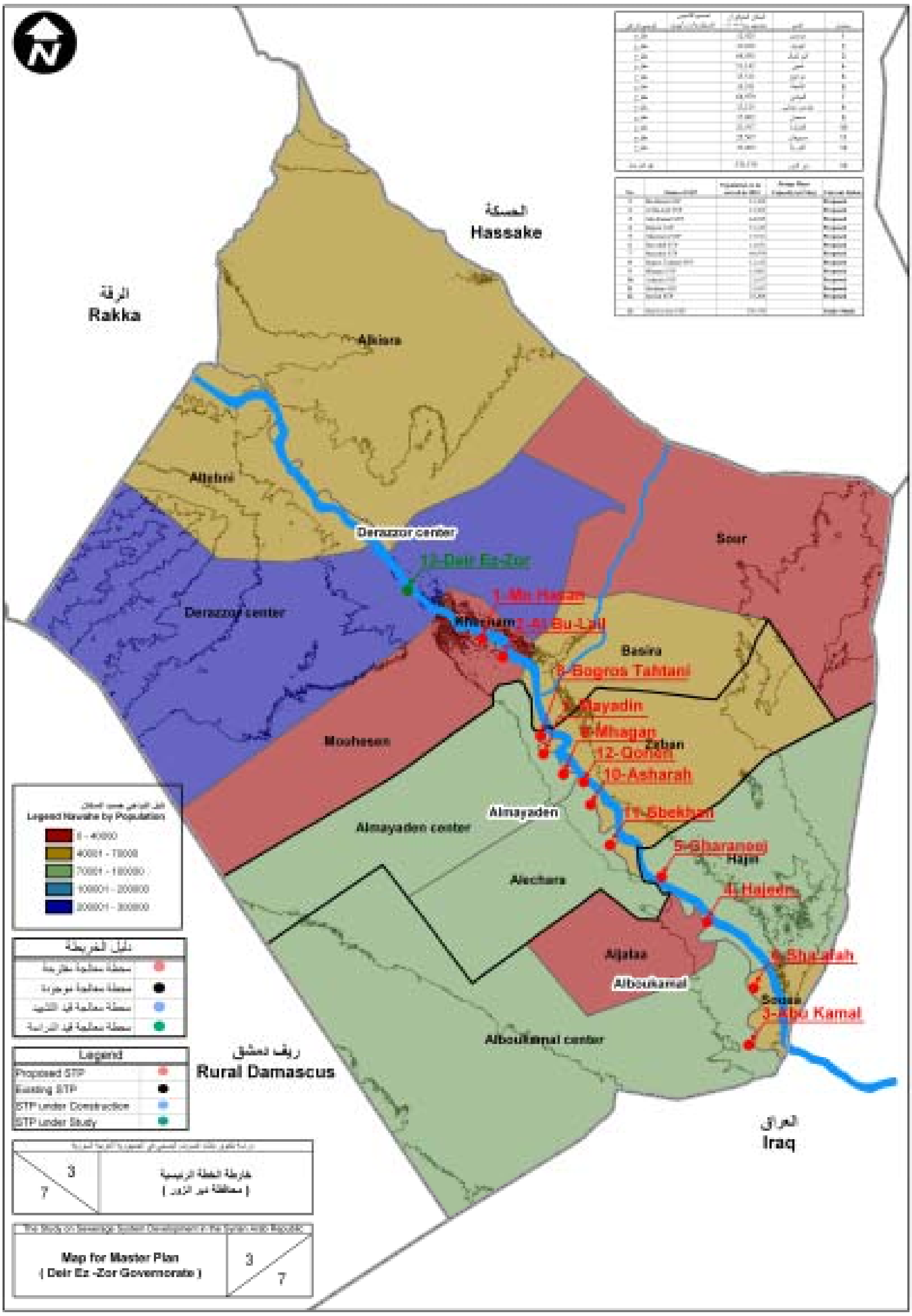


Figure 9.6.3 Map for Sewerage Master Plan in Deir-Ez-zor

Table 9.6.9 STP List of Deir-Ez-zor Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	12	Mo Hassan STP	12,425		Proposed by Study Team
2	11	Al Bu-Lail STP	13,102		Proposed by Study Team
3	3	Abu Kamal STP	64,935		Proposed by Study Team
4	4	Hajeen STP	51,145		Proposed by Study Team
5	9	Gharaneej STP	15,511		Proposed by Study Team
6	10	Sha'afah STP	14,551		Proposed by Study Team
7	13	Bogros Taftani STP	12,125		Proposed by Study Team
8	8	Mhagan STP	15,802		Proposed by Study Team
9	7	Asharah STP	21,917		Proposed by Study Team
10	6	Sbekhan STP	25,567		Proposed by Study Team
11	5	Qorieh STP	35,209		Proposed by Study Team
12	2	Mayadin STP		15,300	Studied by this Study
13	1	Deir-Ez-zor STP		67,850	Under Study by Syrian side

Note 1) "STP No." is STP number shown in the Map.
Note 2) "Priority Order" for STP planning was determined by the following criteria:

Existing STP	Shall be excluded from priority order
STP under Construction	Shall be given the highest priority order and if there are plural STPs under Construction, their order shall be determined by design capacity. The greater , the higher.
STP under Study	Shall be given 2nd highest priority order and if there are plural STPs under Study, their order shall be determined by design plant capacity. The greater, the higher.
Proposed STP	Shall be given 3rd highest priority order and if there are plural proposed STPs, their order shall be determined by serced population. The greater, the higher.

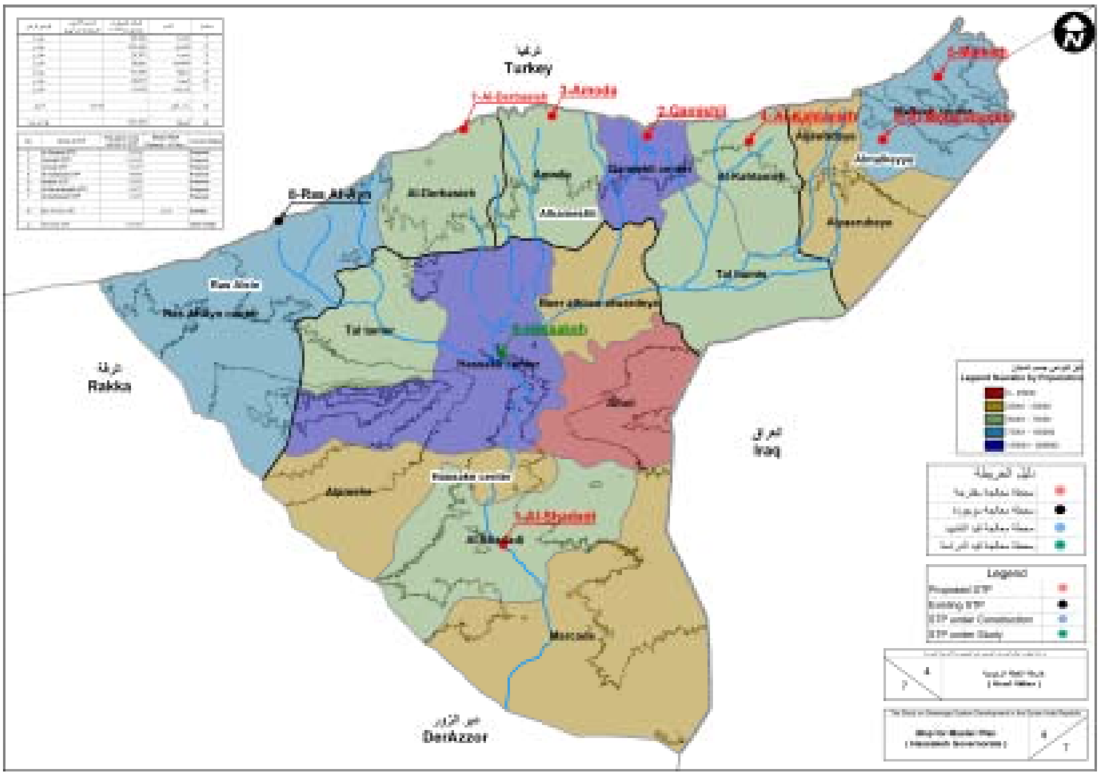


Figure 9.6.4 Map for Sewerage Master Plan in Hassakeh

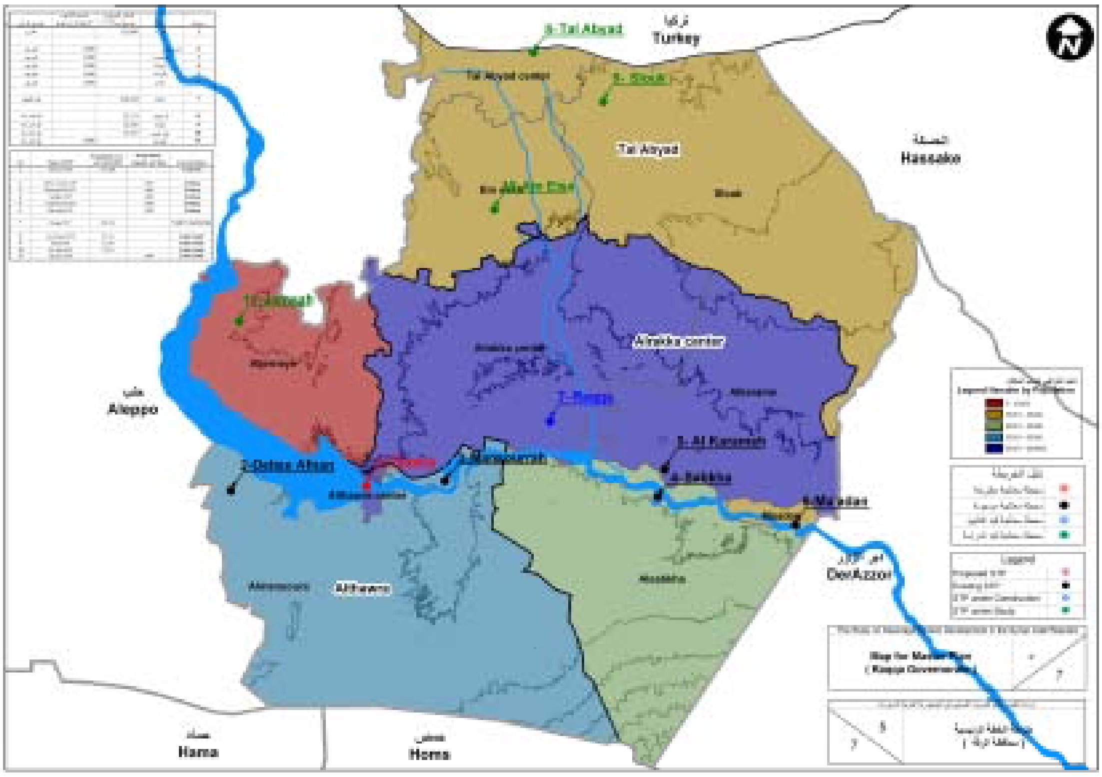


Figure 9.6.5 Map for Sewerage Master Plan in Raqqa

Table 9.6.10 STP List of Hassakeh Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	5	Al Shadadi STP	22,536		Proposed by Study Team
2	3	Qamishli STP	214,446		Proposed by Study Team
3	4	Amoda STP	24,707		Proposed by Study Team
4	8	Al Kahtanieh STP	10,866		Proposed by Study Team
5	6	Al Moua'abadeh STP	18,897		Proposed by Study Team
6	7	Al Derbasieh STP	11,639		Proposed by Study Team
7	-	Ras Al-Ayn STP		2,130	Existing
8	2	Malkieh STP		4,518	Studied by this Study
9	1	Al Hassakeh STP		37,315	Under Study by Syrian side

Note 1) "STP No." is STP number shown in the Map.
Note 2) "Priority Order" for STP planning was determined by the following criteria:

Table 9.6.11 STP List of Raqqa Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	-	Debse Afnan STP		1,000	Existing
2	-	Mansourrah STP		1,000	Existing
3	-	Sabkha STP		1,000	Existing
4	-	Al Karameh STP		1,000	Existing
5	-	Ma'adan STP		1,000	Existing
6	1	Raqqa STP		90,900	Under Construction
7	2	Thawra STP		17,889	Studied by this Study
8	6	Tal Abyad STP		2,500	Under Study by Syrian side
9	4	Slouk STP		4,100	Under Study by Syrian side
10	5	Ain Eisa STP		3,100	Under Study by Syrian side
11	3	Jarneah STP		4,600	Under Study by Syrian side

Note 1) "STP No." is STP number shown in the Map.
Note 2) "Priority Order" for STP planning was determined by the following criteria:

Existing STP	Shall be excluded from priority order
STP under Construction	Shall be given the highest priority order and if there are plural STPs under Construction, their order shall be determined by design capacity. The greater , the higher.
STP under Study	Shall be given 2nd highest priority order and if there are plural STPs under Study, their order shall be determined by design plant capacity. The greater, the higher.
Proposed STP	Shall be given 3rd highest priority order and if there are plural proposed STPs, their order shall be determined by serced population. The greater, the higher.

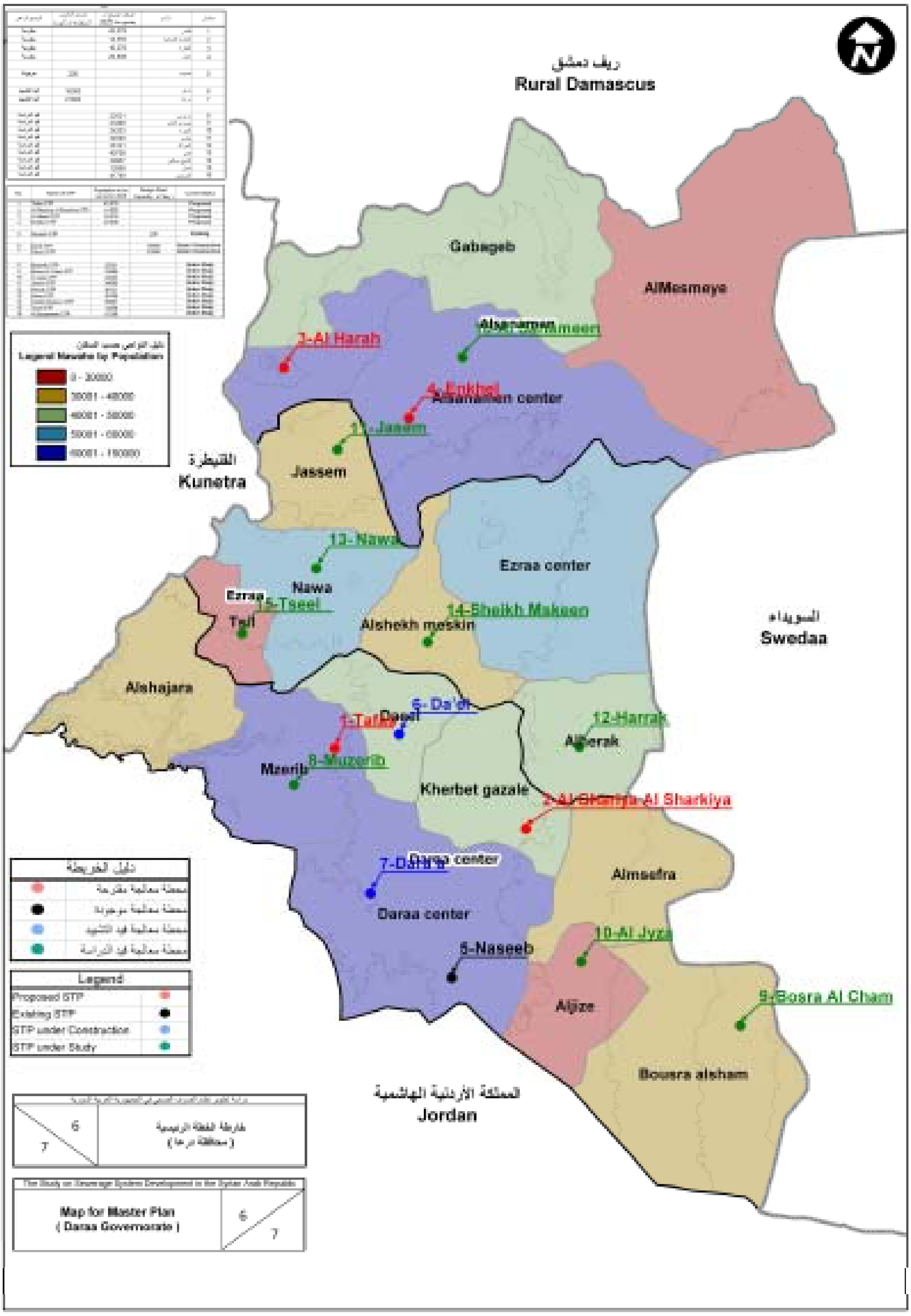


Figure 9.6.6 Map for Sewerage Master Plan in Dar’aa

Table 9.6.12 STP List of Dar'aa Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	10	Tafas STP	43,078		Proposed by Study Team
2	16	Al Ghariya Al Sharkiya STP	14,555		Proposed by Study Team
3	15	Al Harah STP	16,376		Proposed by Study Team
4	13	Enkhel STP	29,808		Proposed by Study Team
5	12	Kherbet Ghazal STP	32,982		Proposed by Study Team
6	14	Al Jyza STP	24,203		Proposed by Study Team
7	11	Harrak STP	36,121		Proposed by Study Team
8		Naseeb STP		200	Existing
9	2	Da'el STP		16,000	Under Construction
10	1	Dar'aa STP		21,800	Under Construction
11	8	Muzerib STP		3,994	Studied by this Study
12	4	Bosra Al Cham STP		7,800	Under Study by Syrian side
13	5	Jasem STP		6,500	Under Study by Syrian side
14	7	Nawa STP		5,500	Under Study by Syrian side
15	6	Shiek Mskeen STP		6,500	Under Study by Syrian side
16	9	Tseel STP		3,000	Under Study by Syrian side
17	3	Al Sanameen STP		8,500	Under Study by Syrian side

Note 1) "STP No." is STP number shown in the Map.

Note 2) "Priority Order" for STP planning was determined by the following criteria:

Existing STP	Shall be excluded from priority order
STP under Construction	Shall be given the highest priority order and if there are plural STPs under Construction, their order shall be determined by design capacity. The greater , the higher.
STP under Study	Shall be given 2nd highest priority order and if there are plural STPs under Study, their order shall be determined by design plant capacity. The greater, the higher.
Proposed STP	Shall be given 3rd highest priority order and if there are plural proposed STPs, their order shall be determined by serced population. The greater, the higher.

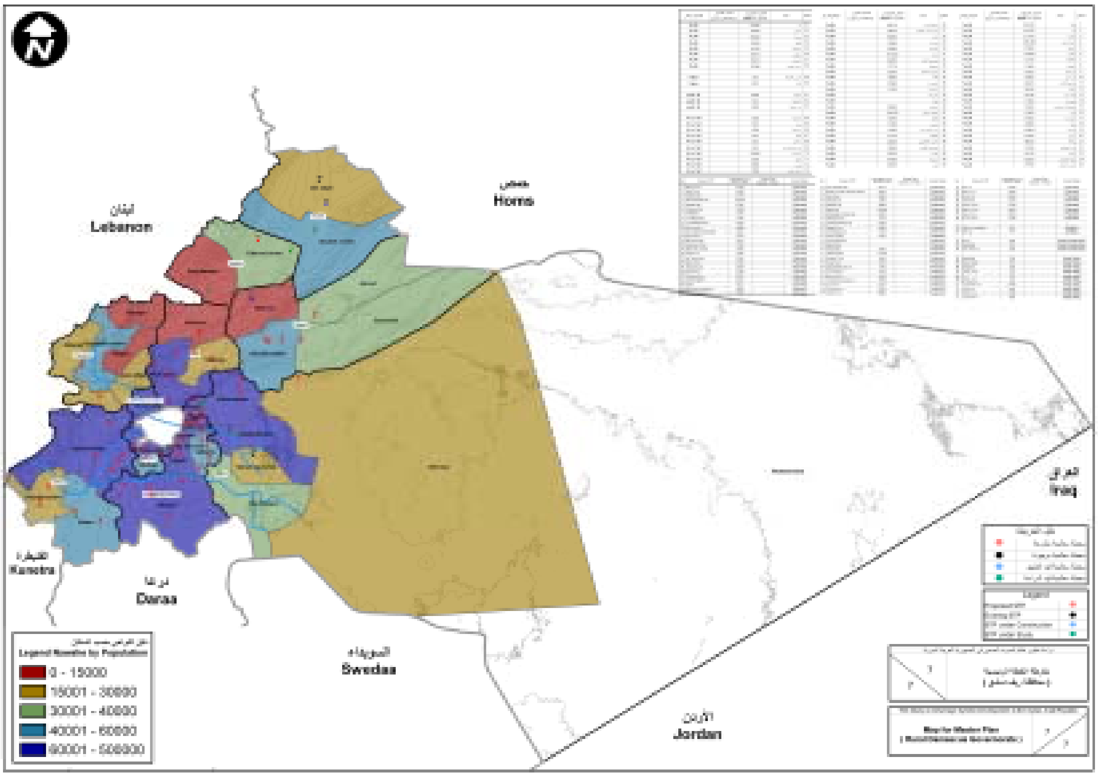


Figure 9.6.7 Map for Sewerage Master Plan in Rural Damascus

Table 9.6.13 (1/2) STP List of Rural Damascus Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
1	21	Babyla STP	89,420		Proposed by Study Team
2	32	Yalda STP	44,900		Proposed by Study Team
3	48	Hajeera STP	21,670		Proposed by Study Team
4	16	Saieda Zeinab STP	238,490		Proposed by Study Team
5	22	Sbene STP	87,890		Proposed by Study Team
6	20	Keswe STP	116,500		Proposed by Study Team
7	61	Mkilbieh STP	12,790		Proposed by Study Team
8	67	A'deliya STP	11,900		Proposed by Study Team
9	75	Darkhabien STP	10,500		Proposed by Study Team
10	68	Adlieh STP	11,900		Proposed by Study Team
11	56	Dyer Ali STP	16,660		Proposed by Study Team
12	45	8th of March STP	25,470		Proposed by Study Team
13	39	Zakieh STP	30,340		Proposed by Study Team
14	76	Bait Sawa STP	10,140		Proposed by Study Team
15	52	Hammoura STP	17,860		Proposed by Study Team
16	58	Sabrin STP	15,450		Proposed by Study Team
17	66	Hazzwh STP	12,060		Proposed by Study Team
18	26	Ain Tarma STP	57,950		Proposed by Study Team
19	34	Sabkba STP	41,680		Proposed by Study Team
20	18	Jaramana STP	134,910		Proposed by Study Team
21	27	Arbeen STP	57,360		Proposed by Study Team
22	30	Zamalka STP	48,010		Proposed by Study Team
23	77	Htietet Al-Turkman STP	6,820		Proposed by Study Team
24	63	Dier Al-Asafir STP	12,530		Proposed by Study Team
25	57	Zabdin STP	16,130		Proposed by Study Team
26	28	Htietet Al-Turkman STP	52,820		Proposed by Study Team
27	43	Housh Al-Soltan STP	27,750		Proposed by Study Team
28	25	Adra Suburb STP	68,710		Proposed by Study Team
29	41	Basel Al Asad laborers STP	28,870		Proposed by Study Team
30	29	Adra Town STP	50,950		Proposed by Study Team
31	62	Mesraba STP	12,560		Proposed by Study Team
32	72	Nashabieh and Jerba STP	11,140		Proposed by Study Team
33	42	Dhmeer STP	28,390		Proposed by Study Team
34	17	Daria STP	167,830		Proposed by Study Team
35	23	Mo'damiet Al Cham STP	84,280		Proposed by Study Team
36	53	Sehnaya STP	17,710		Proposed by Study Team
37	36	Ashrafiet Sehnaya STP	35,240		Proposed by Study Team
38	24	Qatana STP	78,980		Proposed by Study Team
39	59	Al Drousha STP	14,150		Proposed by Study Team
40	70	Meneh STP	11,380		Proposed by Study Team
41	38	Al Saboura STP	31,860		Proposed by Study Team
42	71	Al Rawda STP	11,330		Proposed by Study Team
43	35	Artouz STP	39,990		Proposed by Study Team
44	74	Arneh and Reemah STP	10,690		Proposed by Study Team
45	19	Jdaidet Artouz STP	124,150		Proposed by Study Team
46	49	Kanaker STP	19,240		Proposed by Study Team
47	65	Sa'sa STP	12,190		Proposed by Study Team
48	69	Mazra'et Beit Jien STP	11,640		Proposed by Study Team
49	37	Al Qotifeh STP	32,170		Proposed by Study Team
50	47	Military House STP	22,620		Proposed by Study Team
51	51	Mo'damiet Al Kalamoun STP	18,240		Proposed by Study Team
52	40	Jairoud STP	29,230		Proposed by Study Team
53	31	Al Rhaibe STP	47,000		Proposed by Study Team
54	33	Mnien STP	42,820		Proposed by Study Team
55	46	Bada STP	22,690		Proposed by Study Team
56	55	Halboun STP	16,850		Proposed by Study Team
57	44	Ma'raba STP	26,940		Proposed by Study Team
58	60	Talfita STP	12,830		Proposed by Study Team
59	73	Sydnaya STP	11,020		Proposed by Study Team
60	50	Rankous STP	18,670		Proposed by Study Team

Table 9.6.13 (2/2) STP List of Rural Damascus Governorate

STP No.	Priority Order	Name of STP	Population to be served in 2025	Design Plant Capacity (m^3/day)	Current Status
61	54	Dimas STP	16,910		Proposed by Study Team
62	64	Ras Al Ma'rra STP	12,390		Proposed by Study Team
63	-	Harran Al Awameed STP		300	Existing
64	-	Qara STP		600	Existing
65	3	Maydaani STP		500	Under Construction
66	2	Tawani and Jaba'den STP		2,000	Under Construction
67	1	Deir Atteih STP		2,400	Under Construction
68	5	Nashabieh and Jerba STP		7,500	Under Study by Syrian side
69	14	Maida'a STP		500	Under Study by Syrian side
70	15	Marj Al Sultan STP		500	Under Study by Syrian side
71	9	Hajianeah STP		1,500	Under Study by Syrian side
72	10	Arneh and Reemah STP		850	Under Study by Syrian side
73	11	Bait Saber STP		500	Under Study by Syrian side
74	12	Dyer Maker STP		500	Under Study by Syrian side
75	13	Bait Jin STP		500	Under Study by Syrian side
76	4	Zabadani STP		22,201	Studied by this Study
77	7	Nabek STP		3,250	Under Study by Syrian side
78	6	Tawani and Jba'den STP		3,900	Under Study by Syrian side
79	8	Assal El Ward STP		1,500	Under Study by Syrian side

Note 1) "STP No." is STP number shown in the Map.

Note 2) "Priority Order" for STP planning was determined by the following criteria:

Existing STP	Shall be excluded from priority order
STP under Construction	Shall be given the highest priority order and if there are plural STPs under Construction, their order shall be determined by design capacity. The greater , the higher.
STP under Study	Shall be given 2nd highest priority order and if there are plural STPs under Study, their order shall be determined by design plant capacity. The greater, the higher.
Proposed STP	Shall be given 3rd highest priority order and if there are plural proposed STPs, their order shall be determined by serced population. The greater, the higher.

9.7 Master plan for On-site and Decentralized Facilities

According to Regional Plan prepared by GCEC, whole Governorate area is covered by Centralized Sewerage System, with several sets of long trunk sewer and STP. However, as aforementioned, service by centralized system is only advantageous in densely populated and inhabited urban areas. As to communities located near to these urban areas, there are some possibilities to connect the generated sewage to the existing sewerage system in urban area by connection sewer for integrated treatment but there must be huge number of communities not corresponding to such conditions.

As such communities were evaluated as “service by centralized sewerage system is not advantageous”, treatment shall be executed by other sewerage options. Applicable sewerage options are as follows:

- Pit Latrine, On-site System
- Septic Tank, On-site System
- Decentralized Sewerage System

According to the comprehensive evaluation on locality of the target area, such as topographic features, population scale, soil conditions, anticipated incoming sewage flow and quality, the optimum sewerage option shall be selected.

(1) On-site System

a) Definition of On-site System

On-site system collects not only sewage and human excreta generated in household but also miscellaneous wastewater having higher pollution load than human excreta and treat them then effluent is infiltrated through soak pit or discharged into gutter. This system is water quality control facility has roles to compensate the service by centralized sewerage system.

b) Necessity of On-site System and its applicable Areas

Water pollution in public water body shall be mitigated by synthetic counter measures. Areas where water pollution has been advanced, STP shall be constructed but where sewage collection by sewer pipe is not advantageous, generated sewage shall be treated by On-site system to lessen the discharged pollution load.

In Syria, there are many cities served by sewer network and therefore as to these cities, sewerage system is completed by the construction of STP. While in case of communities with the following conditions, project efficiency by On-site system may become higher than that of by centralized system:

- Where housings, hotels and schools are totally scattered and sewer network installation cost is expensive.

- Communities with large ground level fluctuation
- Where groundwater and dam water contamination is anticipated but sewage cannot be collected by centralized network owing to topographic feature.

c) Concept of On-site System

As this system is maintained by residents basically, system was simplified and downsized to achieve "maintenance free". System can be operated without operator and periodical, say once in a year, removal of scum and accumulated sludge is contracted out to expert firms. Since the system is installed within the premise, it must be compact and emits less odor. In Japan, Submerged Attached Growth Method is predominant as treatment method in On-site system since facility size is compact, emits no odor and generates less sludge. **Figure 9.7.1** shows Japanese Johkasou system as a sample of on-site system facility.

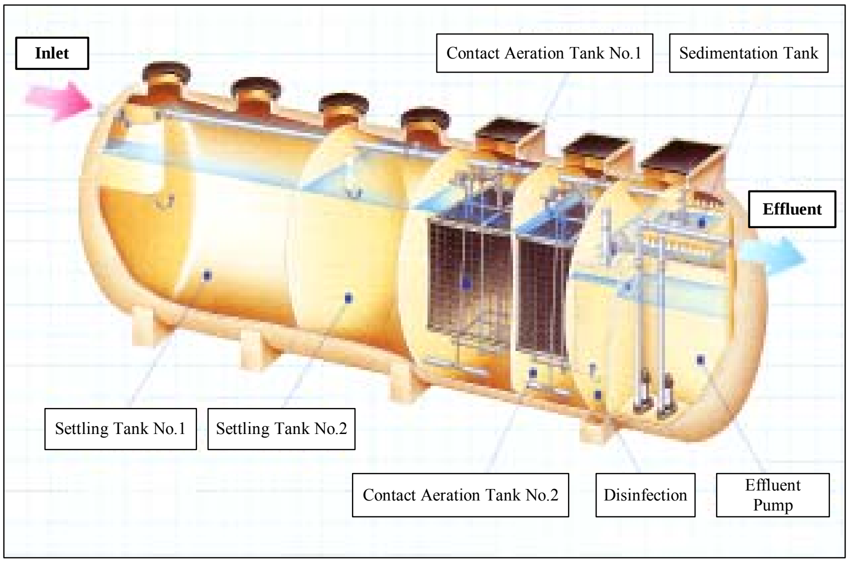


Figure 9.7.1 Typical Packaged Treatment System in Japan

d) Governmental Subsidy Institution upon introduction of On-site System

By designating areas having great urgencies in water pollution control and subsidizing the part of construction and O&M cost of On-site system, project efficiency will drastically increased. For instance, as groundwater in Rural Damascus Governorate forms closed water body, conventional infiltrate Pit Latrine accelerates groundwater contamination. Therefore, the whole Governorate area can be designated and Governmental subsidy institution can be introduced.