

**DEVELOPMENT OF SOUTH LEBANON
WASTEWATER MASTER PLAN**

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MASTER PLAN REPORT

(Revised Version)

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1. INTRODUCTION

1.1 Background

The purpose of the project is to develop a wastewater master plan based on previous studies in order to support the South Lebanon Water and Wastewater Establishment (SLWWE) and to provide a regional capital investment plan for wastewater collection, transport treatment system and disposal.

The general purpose of this initiative is to set priorities for capital investments in wastewater in the South of Lebanon. Such an investment plan aims to meet SLWWE stated strategic goals identified in the business plan and communicate its capital needs to the National Government and to potential lenders and donors.

The Master Plan will be studied for the horizon year of 2030 and based on a defined time schedule for the implementation of the development and modernization of the wastewater sector. It will cover in principle an implementation period of ten years (i.e. from the year 2006 till the year 2015), unless otherwise agreed with LWPP and SLWWE.

1.2 General Objectives

The general objectives of the South Lebanon Wastewater Master Plan can be summarized by the following:

- Strengthen the newly formed SLWWE;
- Improve the conditions of SLWWE towards the international funding community;
- Provide a tool for decision making, investment and planning in the wastewater sector;
- Introduce wastewater operations to the newly formed Establishment.

1.3 Specific Objectives

The specific objectives of the development of South Lebanon are to find sustainable, environmentally sound and cost-effective solutions to the following concerns:

- Containment (collection and treatment) of new wastewater flows that will come from a larger population;
- Ensure that new wastewater systems will meet future treatment needs and that water quality standards will be maintained;
- Finding economically feasible ways to reclaim and recycle as many resources as possible, including water and sludge; and
- Ensuring the most competitive and high quality service to customers

The Master Plan will be a more focused review of optimization concepts consistent with SLWWE strategic goals. There will be a strong focus on environmental quality and its implications and on the economic aspects that will ensure a cost-effective and acceptable service to subscribers.

The Master Plan will take into consideration the South Lebanon wastewater sector current and prospective situation (physical, organizational, etc) as well as the existing and possible plans for its development. Means to maximize the integration and utilization of all existing facilities will be considered. The impact of projected population growth and future infrastructure needs will be identified in order to produce a plan that would be acceptable to LWPP and SLWWE.

2. METHODOLOGY

2.1 Basic Master Planning Approaches and Alternatives

- Scheme approach

The scheme approach was considered for operation reasons and for project completeness requirements. The study area has been divided into 32 schemes (Appendix I) that will constitute operationally standalone and complete zones. Completeness of a scheme (i.e. a project) means that in one wastewater basin there will be a sewer network that coexists with one or more treatment plants and one or more pumping stations all located and distributed to have full containment of the wastewater generated. It is to be noted that the scheme size is dictated by the topography and extent of the wastewater basin.

- Integrated water resources management and environmental protection

Integrated water resources management consisted the framework for the development of the South Master Plan. The available water resources (rivers, springs, and wells), the existing and proposed infrastructure, the water supply demand and the resulting wastewater discharges were all incorporated in the Master Plan. Furthermore, the need to protect the surface and underground water in South Lebanon against wastewater pollution has defined the locations of the treatment plants as well as the levels of treatment required.

- Basic Alternatives

- On-site treatment (septic tank) was considered for remote areas, standalone small communities and agricultural farms, which are not connected to any public local or regional sewer network
- Local small treatment plants were considered for individual localities and a small group of close communities. On the other hand, regional centralized treatment plants (medium to large sized plants) with long collectors and pumping stations (if any) are proposed for large basins with a significant number of localities.
- Secondary treatment with chlorination is the minimum required level of wastewater treatment; tertiary treatment can be proposed when there is potential effluent reuse in agriculture.
- Gravity drawn sewer network in the valleys (wadis) generally along the watercourses is preferred over network configuration along the main road. The former alternative minimizes the need for lifting stations that require continuous electric power. It should also be noted that these lifting stations have potential risk of failure.

2.2 Population

2.2.1 Background

Various sources and references for demographic characteristics and population growth rates were considered for the development of the South Lebanon Master Plan. These consist of the following:

1. Population census of 1932 updated in 1965 by the decree No. 7008 issued in 1967
2. Camp Dresser & Mackee Inc. – Master Plan for Wastewater Management, 1982
3. Lebanon's staged wastewater program prepared by Khatib & Alami in 1994 (update of Camp Dresser & Mackee Inc. report)
4. Wastewater Master Plan and Sewage Network Design for the Liberated Border Strip, the Adjacent Area, and Jezzine in South Lebanon and Nabatiyeh – Draft Final Master Plan, prepared by Kredon 2005 – local municipalities asked to fill out questionnaires to provide information regarding number of residents in the city or village etc.,
5. Central Administration for Statistics (CAS) – population by mohafazats 1997
6. Demographic characteristics prepared by the MoSA 1996-97
7. Central Administration for Statistics (CAS) – population by mohafazats 2004-2006 (not yet published for all Lebanon)

Proxy Indicators

In addition to the above sources, proxy indicators were also used as references for population estimation. The most commonly used proxy indicators in similar situations are:

1. Household water connections
2. Household electrical connections
3. Households number and occupancy rate

The Consultant, gathered population figures from the above-mentioned studies; a comparative analysis was accordingly conducted on the reported figures. The South Lebanon Wastewater Master Plan is developed to meet the requirements of the year 2030; accordingly the population of the different localities of the project area was projected. It is worth noting that the projected population figures have defined the network characteristics and the treatment plants' capacities.

Among the aforementioned sources for population estimates and other population-related figures, three sources were mainly considered in the preparation of the South Lebanon Master Plan. They are:

- The survey of the Ministry of Social Affairs (MoSA) published in 1996-1997
- The surveys of the Central Administration for Statistics (CAS) determined for the years 1996-1997 and for the years 2004-2006
- The Wastewater Master Plan of the Liberated Border Strip which is under preparation by the Consultant Kredon (2005)

The last comprehensive population census dates back to 1932 and this was updated and issued in 1967 by the decree No. 7008. The war in Lebanon (1975-1991) resulted in mass displacement and thus significant demographical changes. Therefore, the statistical information base in Lebanon was seriously disrupted.

In 1982, Camp Dresser & Mackee (CDM) prepared a master plan for wastewater management in Lebanon, where population projections were determined for the purpose of the master plan under consideration. These population projections were updated by Khatib & Alami in 1994. However, as these reports were conducted at a time when South Lebanon was still under occupation, they lacked reliable basic information to be used for population projections.

Central Administration for Statistics (CAS)

In 1978, the Central Administration for Statistics (CAS) was established (Law-Decree 1793) with a mission to collect and publish statistical information on economic and social conditions. However, due to the persisting conditions of the war, the CAS did not start functioning until 1993. Between 1996 and 1997, CAS conducted a census on buildings and establishments in all the Mohafazas of Lebanon. The CAS estimate of resident population included all nationals and non-nationals (i.e., Palestinians, etc.). CAS has also recently published a study of population by mohafazas for 2004 to 2006. It is to be noted that CAS's household figures were determined for each Mohafaza as a whole and not for each village in the Mohafaza.

Ministry of Social Affairs (MoSA)

The Ministry of Social Affairs (MoSA), carried out a population and housing survey, which was published in 1996 (MoSA/UNDP, 1996). For this survey, the number of households was used as a base unit to estimate the population size and average household occupancy rate by Caza. It should be noted that the MoSA survey was based statistically on the number of households and the household occupancy rate per caza. In addition, non-nationals (i.e., Palestinians) were not included in the estimation.

Kredo's study

Kredo s.a.l. conducted a thorough survey between the months of November 2004 and March 2005 in its quest to obtain population estimates for the individual villages in the Mohafazas of South Lebanon and Nabatiyeh. Their approach involved sending out detailed questionnaires to all municipalities in these two mohafazas, totaling 243, whereby all but 6 responded. In this questionnaire, the municipalities were asked to report the numbers of registered people, as well as the number of residents in the city or village, the number of houses, hospitals, schools, business shops, etc.. It should be noted that this report estimated the population size for the year 2025 whereas RELK's population projection will have the year 2030 as the project horizon year.

In order to estimate the number of residents in localities for which the survey could not provide a population figure, the Consultant Kredo assumed that an annual growth rate of 2.5% occurred between 1982 and 2005. In addition, due to the absence of reliable information and in order to realistically predict population estimates up until 2025, Kredo took into account displacement of populations, emigration as well as natural population growth and determine a range of annual growth rates for different population sizes as indicated in Table 1 below.

Table 1: Annual Population Growth Rate

Population	Annual Growth Rate
< 1000	2.0%
1,000 to 5,000	2.15%
5,000 to 10,000	2.25%
>10,000	2.35%

The Consultant Kredon assumed the population equivalent factor to be equal to 1.25. This figure takes into account the commercial, educational, health and light industrial activities and is believed to be very conservative as all localities are situated in rural or semi-rural settings where these above-mentioned activities are limited.

2.2.2 Comparative analysis

A comparative analysis on the different population related figures reported in the above-mentioned three main sources adopted, was undertaken in the process of preparation of the South Lebanon Master Plan. Accordingly, two population estimates were worked out and compared as explained below.

- The numbers of households determined by the Consultant Kredon and summed up for each caza are multiplied by the caza average household occupancy rates published in 1996 by MoSA. As a result, population estimates for the different cazas in the South Lebanon were determined on the basis of Kredon-determined household numbers.
- Similarly, the numbers of households (as number of residential and residential / commercial properties) published on the caza basis by CAS's for the year 2005 survey are multiplied by the caza average household occupancy rates published in 1996 by MoSA. As a result, other population estimates for the different cazas in South Lebanon were determined.

Correction Factor

A correction factor was determined by dividing CAS-published household numbers by Kredon-determined household numbers.

Revised Population

Since the Consultant Kredon had already obtained the population figures of all the concerned localities while CAS had only published household numbers per Caza, Kredon's population figures were utilized. However, the Consultant Kredon's population estimates were then corrected by multiplying their reported figures by RELK's Correction Factor in order to obtain final and revised figures that are closer in range to those of CAS. The latter is considered a reliable source of information being a well established and recognized government department. Thus, average population figures were calculated for each village in the South of Lebanon, which were required for the development of the wastewater master plan for the South of Lebanon. It should be noted that proxy indicators such as electrical connections were utilized in order to calculate the number of households where the above-mentioned references did not report any household numbers for certain localities.

Scenarios

As mentioned above, there are two main recognized sources that determine the population figures in Lebanon: the Central Administration for Statistics (CAS) and the Ministry of Social Affairs (MoSA). It should be noted that these population figures determined by CAS and MoSA will be reflected in the process of development of the capital expenditures (CAPEX) and operational expenditures (OPEX) for the Investment Plan. The latter will be established upon finalization of the Master Plan Report. Thus, for comparative purposes, two separate scenarios will be considered for the Investment Plan; one that is based on the total number of households per Muhafaza (CAS) and one that is based on the actual number of registered residents per Caza (MoSA).

2.3 Hydraulic Design Criteria

a- Previously studied – covered areas

Regarding previous studies undertaken by various consultants, the same design criteria, selected alternatives as well as technical solutions suggested by these consultants were adopted. The engineering added value of the extensive work that had been already exerted in the different previous studies was taken into consideration. In cases where unsatisfactory technical solutions are proposed in these studies, alternative solutions were worked out by the Consultant and was recommended instead as it was the case in the Naqoura scheme.

The design criteria adopted in the previous studies by the different consultants were thoroughly reviewed in order to ensure synergy, compatibility and continuity among them and with the suggested design criteria of the South Lebanon Master Plan. Table below

Table 2: Preliminary comparison of design criteria – Hydraulic design parameters

Designation / Title of study	Saida Coastal Area	Sarafand	Sour Coastal Area	Wadi Fakreddine	WW Master Plan SL
	RELK&P	GETI	RELK&P	Khalil. BARAKAT	Kredo
Horizon year	2030	2030	2030	2035	2025
Completion date	2004	2005	1996	2005	Aug. 2005 ⁽¹⁾
Sanitary flow / water supply	0.8	0.7	0.8	0.75	0.85
Infiltration l/c/d	20-23%	15%	20-23%	50%	10%
Velocity m/s - Min / Max	0.75 / 3	0.75 / 3	0.75 / 3	0.30 / 4	NA
Sizing h /D	0.5	0.65	0.5	0.75	0.75
Max Capacity of Sewer/full sect.	0.5	0.75	0.5	0.9	0.9
Sizing flow /peak factor	200 – 300	191.5	200 – 300	222	166 – 207
Configuration	hydrographic	on-road	hydrographic	on-road	on-road
Min. Diameter	20	20	20	20	NA
Manholes spacing distance	SPD 8 ⁽²⁾	SPD 8 ⁽²⁾	SPD 8 ⁽²⁾	Max 75m	NA
Min. cover m	0.90 / 1.20	0.90 / 1.20	0.90 / 1.20	0.6	NA
Total sanitary flow l/c/d	100-150	143.6	100-150	200	150-187

(1) as per project contract, however the Kredo WW master plan has not yet been completed

(2) SPD: Standard Practice Document prepared by SIU-Water (Sector Implementation Unit) for the CDR

(3) l/c/d: liter/capita/day

(4) h: height of wet section; D: diameter of the pipe

b- Non-studied / non-covered areas:

For the areas and zones which have not been considered in any of the previous studies, specific design criteria for both sewer network and wastewater treatment are set for the development of the Master Plan under consideration.

- Design criteria for sewer network:

- Horizon Year: 2030
- Daily water supply consumption
 - Domestic Consumption: 145 l/c/d
 - Non domestic consumption: Rural 10% 15 l/c/d
Urban 33% 48 l/c/d
- Wastewater flow: 80% of daily consumption
- Infiltration: 10%
- Total Sanitary flow
 - Rural: 141 l/c/d
 - Urban: 170 l/c/d
- Daily peak flow due to diurnal variation
- $\frac{Q_{max}}{Q_{ave}} = \frac{5}{P^{0.167}}$ where P = Population in thousands
Giffit's formula (Source: SPD 8 – Standard Practice Document No 8; by SIU-Water)
- Daily peak flow due to seasonal variation
 - In summer Q max + 10%
 - In winter Q max – 10%
- Velocity: Min 0.75 m/s Max 3 m/s
- Max capacity of sewer/Full section 0.75
- h/D 0.65
- Type of Network: Conventional separate sewer system
- Configuration: Hydrographic
- Min Diam.: 200 mm.
- Manholes space: SPD 8 – Ref.
- Min cover: 0.9-1.20 m

2.4 Design criteria for Wastewater Treatment

The level of treatment of wastewater generally depends on the nature of the influent wastewater. For a proper selection of the treatment process, wastewater characterization is considered essential. Few previous studies undertook domestic wastewater characterization in several regions in the South Lebanon. Therefore, general and universal wastewater characterization was adopted in the Master Plan as indicated in Table 3 below. The latter characterizes wastewater as weak, medium or strong according to contaminant loads.

Table 3: Characterization of raw wastewater (Journey W.K.)

<i>Parameter</i>	<i>Weak</i>	<i>Medium</i>	<i>Strong</i>
BOD₅ (mg/l)	110	220	400
TSS (mg/l)	100	200	350
N_{total} (mg/l)	20	40	85
P (mg/l)	4	8	15

Several technical design considerations were considered when planning for wastewater treatment plants. They included among others the technical considerations below:

- the treatment process;
- proximity to nearby communities;
- prevailing climatic conditions;
- odor production and control possibility;
- land availability and accessibility;
- environmental limiting values of the effluent and receiving watercourses;
- effluent potential reuse and irrigation requirements; and
- sludge treatment and possible disposal methods, including use of treated sludge as fertilizer or soil conditioner.

The proposed Master Plan was developed to be in full compliance with Lebanon’s national and international obligations for environmental protection. These national and international environmental obligations constituted an environmental framework with design limitations and requirements for wastewater treatment plants.

- National effluent and sludge standards

In 2001 the MoE established national standards for environmental quality under Ministerial decision no. 8/1 (1/3/2001). The national standards set in 2001 are an updated version of the standards set in 1996 under the Ministerial decision no. 52/1. The standards set upper limit values for wastewater discharges from existing and new facilities in the sea and surface water bodies.

- Binding protocols and conventions

The presence of Lebanon on the Mediterranean Sea obligates the Government through several international conventions to protect the Mediterranean Sea from all types of pollution. The Master Plan carefully considered all the conventions that set ELV’s on the treated effluent.

- International standards and regulations: US-EPA and European Commission

The Master Plan revisited the United States Environmental Protection Agency (USEPA)-published guidelines for the reuse of wastewater in a number of applications, including use in agriculture (Manual Guidelines for Water Use). Sludge is an inevitable outcome from wastewater treatment plants that are of Extended Aeration Activated Sludge (EAAS). Countries across Europe have developed permissible levels for sludge application in agriculture as well as requirements for proper and less polluting incineration.

In addition, the Master Plan addressed other environmental concerns and accordingly formulated technical considerations to be taken into account, such as:

Table 4. International conventions and protocols related to wastewater

<i>Year</i>	<i>Relevant conventions and protocols signed or ratified by Lebanon</i>
1973	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter Signature: 15/5/1973
1976	Convention for the Protection of the Mediterranean Sea against Pollution Signature: 16/2/1976 Accession: 30/6/1977 by decree law # 126
1980	Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft Signature: 17/5/1980 Accession: 27/12/1994 by law # 292
1980	Protocol Concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Case of Emergency Signature: 17/5/1980 Accession: 27/12/1994 by law # 292
1980	Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources Signature: 17/5/1980 Accession: 27/12/1994 by law # 292
1980	Protocol Concerning Mediterranean Specially Protected Areas Signature: 17/5/1980 Accession: 27/12/1994 by law # 292
1999	Convention on Wetlands of International Importance especially as Waterfowl Habitat Accession: 1/3/1999 by law # 23
2001	Stockholm Convention on Persistent Organic Pollutants Signature: 22/5/2001 Accession: 3/1/2003

- Pollution risks and vulnerability zones

The Master Plan highlighted the pollution risks of inappropriately discharging wastewater inland and along the coastal area as well as the vulnerable water aquifers that risk becoming polluted. The general locations of the proposed treatment plants were assessed taking into account the geological specificities and tectonic characteristics of the area under consideration.

- Pretreatment requirements for industrial effluents (olive mills, industrial zones)

The common practice in Lebanon is the discharge of industrial effluents into the sewer systems. However, the Master Plan presupposes the pretreatment of any industrial effluents before being disposed of into the municipal sewer network. A mixed flow of domestic wastewater and industrial effluents cannot be treated using conventional treatment processes being of different biological and chemical compositions.

2.5 In-Locality Collection Network

In order to have a complete wastewater scheme, the collection network inside the concerned localities should be taken into account. It is to be noted that a complete and comprehensive investment plan should consider the collection network and their corresponding costs. The in-locality collection network will collect wastewater from the different households and buildings along the different streets and roads of the locality. At the externals of the localities start the main collectors that constitute the scheme wastewater network.

In the absence of any topographic survey along the different streets and roads of the concerned locality, the length of the in-locality collection network was estimated based on the followings:

- the degree of urbanization of the locality
- the household occupancy rate
- the population figure of the locality

An index-based method was developed in order to determine the lengths of the in-locality collection networks of the different localities based on the degree of urbanization and population figures. An occupancy rate of 5 has been assumed and adopted as an average occupancy rate for all localities in the South of Lebanon. The length-per-person index when multiplied by the population figure of the locality is then expected to give the length of the in-locality collection network.

In order to determine the length-per-person indexes for different types of localities (rural, semi-rural, and urban, etc), satellite imagery, GIS layers of the roads inside the localities and population figures of the concerned localities were used. Ten representative villages, on which additional detailed data about in-locality collection network exist, were selected. A cross-checking exercise was undertaken and a range of length-per-person indexes was determined as shown in the table below.

Table 5: Length-per-person indexes for in-locality collection network length

Population	Length-per-person Index
< 2000	5 m
2000 - 5000	4 m
5000 - 15000	3.5 m
15000 - 25000	3 m
> 25000	2 m

Using the above table, the lengths of the in-locality collection networks were then determined based on the population figures of the localities under consideration. It can be safely assumed that the collection networks in most of the villages and towns will be of 200 mm (minimum diameter prescribed) and 300 mm diameter pipes at a ratio of 80% to 20% respectively

3. RESULTS

The proposed Master Plan integrated the above master planning criteria and technical considerations. A Master Plan consists of long-range plans to determine how services to the community are going to be provided in the coming years. This type of broad-based plan addresses issues such as the physical facilities which will be needed during the coming years and specific technologies used in wastewater treatment.

The South Lebanon Wastewater Master Plan divided the area of South Lebanon into 32 wastewater schemes, where each scheme consists of the following:

- A number of localities (cities, towns, villages and small farms)

- A network of main collectors starting at the externals of the localities
- In-locality collection networks for the concerned localities
- One or more pumping stations (if any)
- One or more treatment plants
- Sea or river outfall – an effluent discharge point.

Appendix I presents the 32 schemes in the form of scheme datasheets containing all essential and necessary data such as:

- scheme extent with all included localities
- the presence of any previous relevant studies or design details
- details on network lengths and diameters
- treatment process proposed
- the presence of any wastewater characterization records
- the existence of any treatment plants or old network

It should be noted that for the Master Plan Report, all 32 schemes established are based on the populations determined by the Central Administration for Statistics (CAS), which are based on the total number of households in each Muhafaza. However, as mentioned in Item 2.2.3 above, the population figures established by both CAS and MoSA will be reflected in the process of development of the Investment Plan, whereby the two different sources will be considered as two separate scenarios.

For remote areas, standalone small communities and agricultural farms, which are not connected to any public local or regional sewer network, septic tanks are proposed in order to provide full containment and sound management of the wastewater discharged in these areas. Appendix II listed the small communities and farms that are recommended to use septic tanks as cost effective and environmentally safe on-site wastewater preliminary treatment method.

A GIS-based general layout for the South Lebanon Wastewater Master Plan (Layout 1) was developed where the 32 schemes are presented with all the associated networks, treatment plants, pumping stations and sea and river outfalls. In addition, small communities and agricultural farms proposed to have septic tanks are shown on the general layout.