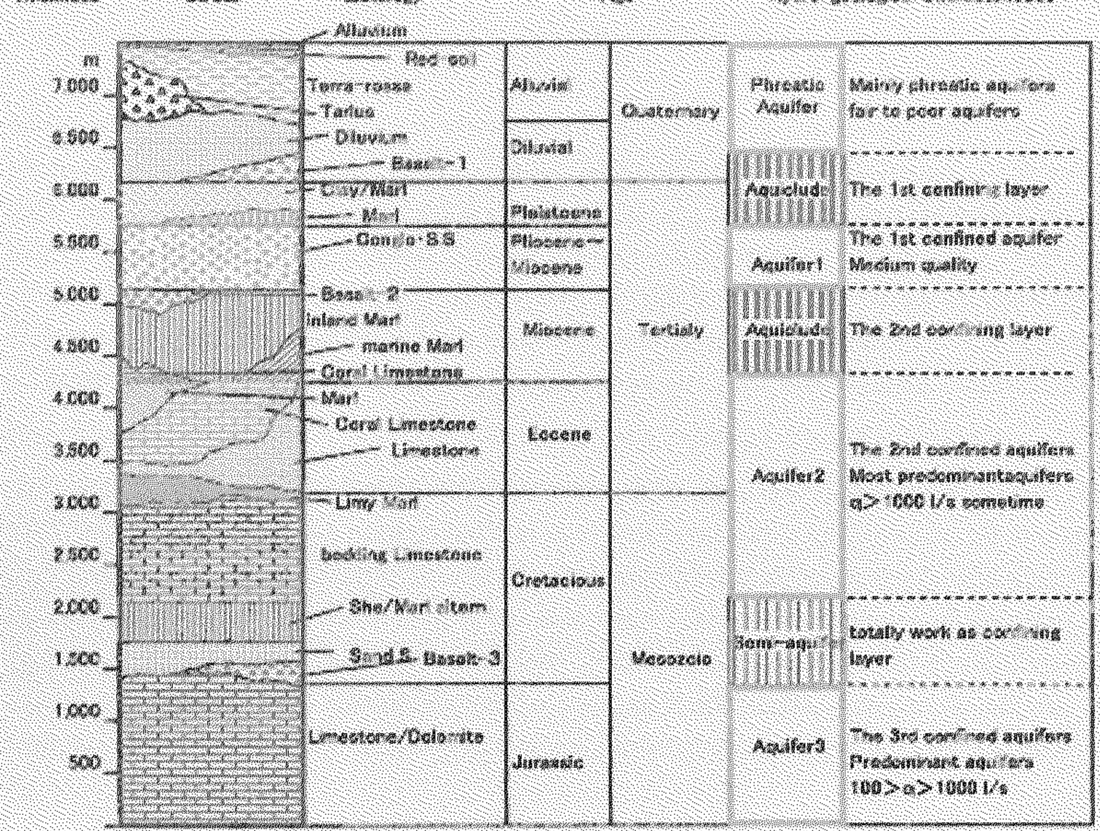
Figure 2.4-1 Stratigraphic Classification and Aquifers



(3) Groundwater, spring and river

When the groundwater table crosses to the ground surface, a spring flow happens. In the case of confined aquifer, the spring happens when the aquifer itself outcrops. In this meaning, the spring is an outcrop of groundwater, which must be classified into a category of groundwater. However, in Lebanon, the spring is clearly separated from the groundwater. "Spring" in this country is fresh water flows out to the ground surface (or sea bottom) and called as "Ain" or "Nabaa" meaning a source, while "Groundwater" is water contained in the ground which needs to construct a well to exploit it. This concept comes from, supposedly, historical and practical manner of water use. Groundwater use through a tube well is rather new manner for water resources.

The territory of Lebanon is covered by high and steep mountains except only the Bekaa Plain in between two mountain ranges. In particular, the western slopes of the Lebanon Mountain Rage are almost precipitous. Because of such topographic feature, a rainfall in winter season is quite quickly flows down and pours into sea immediately. And, there is no rainfall in summer. Thus, a river in the common sense, that is a perennial stream of water collecting rain water in the catchment area, can not be existing. Nevertheless, there are many perennial rivers in Lebanon. These are, exactly saying, drainage channels of spring water in most of the cases.

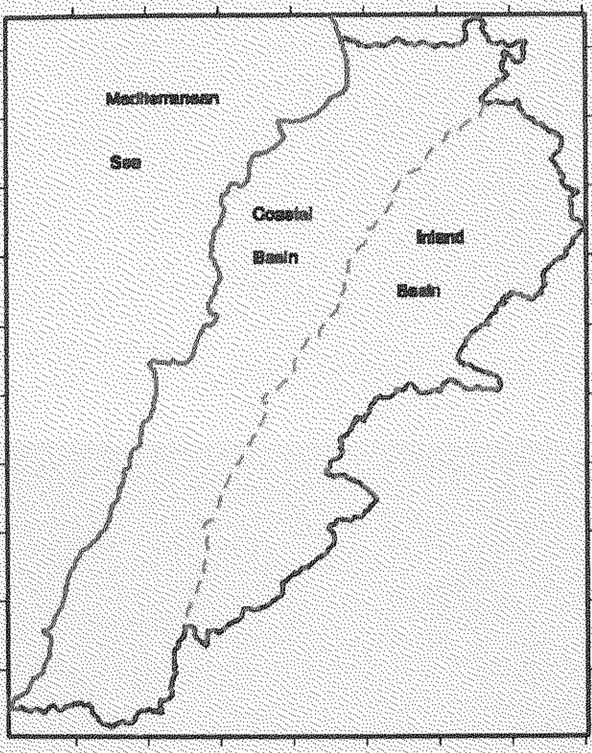
Under such background, in this report we follows the terms of spring, groundwater, and river, as common in this country.

2.4.2 Hydrogeological Unit

(1) Hydrogeological classification

Hydrogelogically, the territory is divided into two major regions: the Mediterranean Region and the Interior Region. Boundary of these two regions is, practically, the top of Lebanon Mountain Range. In the Report, however, the former is called as the "Coastal Region" or the "Coastal Basin" and the latter is called as the "Inland Region" or the "Inland Basin", only because of short wording.

Fig. 2.4-2 Hydrogeological Region



As the letter indicates, the rainfall in the Coastal Basin flows into the Mediterranean Sea and the rainfall in the inland Basin flows in the Bekaa Plain. The Bekaa Plain has two outlets: one to the north and another to the south. Through the northern outlet the Assi River flows out to Syria, and through the southern outlet the Hasbani River flows out to Palestine. And beside them, the Litani River, the overwhelmingly largest river in the country, collects the major part of water in the plain and courses out to the Coastal Basin at the south of the plain abruptly.

Sometime, the Inland Basin is subdivided into two: the Bekaa North and the Bekaa South. The situation is illustrated as Figure 2.4-2. Then, both of the Basins are sub-divided into several zones by the hydrogeology underlying and each zone is further subdivided into several hydrogeological units by individual aquifer. Finally, the land of Lebanon is divided into 30 hydrogeological units: 18 for the Coastal Basin and 12 for the Inland Basin, as shown in the Table 2.4.1 (by the Study of Groundwater, UNDP 1970).

(2) Aquifer type and hydrogeological unit

In the Coastal Basin, there are 3 major aquifer types, namely i) Calcareous Aquifer, ii) Porous Aquifer, and iii) Aquiclude, and the Calcareous Aquifer is further subdivided into 3 subtypes by their age: Jurassic, Cretaceous, and Eocene. While in the Inland Basin, there are 4 major aquifer types such as i) Calcareous Aquifer, ii) Porous aquifer, iii) Sandstone Aquifer, and iv) Aquiclude. The Calcareous aquifer is subdivided into 4 subtypes by their age: Jurassic, Cretaceous, Eocene, and Miocene. The distribution of those hydrogeological units is illustrated as Figure 2.4-3, and the situation is summarized as the Table 2.4-1.

Figure 2.4-3 Hydrogeological Unit

Source: Carte Hydrogeologique 1/200,000 (UN, 1970)

Table 2.4.1. Hydrogeological Units of Lebanon

A. Inland Basin

Calcareous Aquifer	Jurassic Calcareous	1. Barouk – Niha
		2. Jdaita
		3. Helmon
		4. Serghaya North-East
	Cretaceous Calcareous	5. Lebanon Mountain
		6. Anti Lebanon
		7. Bekaa South
	Eocene Calcareous	8. Bekaa South
		9. Bekaa North-East
		10. Bekaa West
Porous Aquifer	Neogene – Quaternary	11. Bekaa Plain
Aquiclude	Cretaceous – Neogene	12. Bekaa

B. Coastal Basin

Cretaceous Aquifer	Jurassic Calcareous	1. Sired Danie – Ain Yacoub
		2. Kesrouan
		3. Barouk – Niha
		4. Jisr el Oadi
	Cretaceous Calcareous	5. Lebanon North
		6. Betroun – Jounie
		7. Lebanon Plateau
		8. Hadath – Hazmiya
		9. Lebanon South
		10. Chouf – Jezzine
	Eocene Calcareous	11. Lebanon South
	Miocene Calcareous	12. Lebanon North
Sandstone Aquifer	Cretaceous Sandstone	13. Lower Cretaceous
		14. Inter Cretaceous
	Miocene Sandstone	15. Jabel Terbor
Porous Aquifer	Quaternary	16. Mountainous Area
		17. Coastal plain
Aquiclude	Cretaceous – quaternary	18. Non-aquifer

Source: Study of Groundwater (UNDP, 1970)

2.4.3 Springs

(1) Occurrence and distribution of the springs

Hydrogeologically, the spring is an outcrop of groundwater. A spring happens at the cross point of the groundwater table and the ground slope caused by the difference of their surface inclinations. Because of the high infiltration ratio of the countrywide calcareous foundation, the groundwater table is rather high (shallow), while the ground surface is generally steep, especially at the slopes of both mountain ranges. Thus, so many springs flow out to the ground everywhere in the country.

In this country, beside them, the flowing out of groundwater is often shown at a mouth of karst cave. The water run down through underground water channel, with extremely high flow rate sometimes. This is one of the types of spring but typical feature in the karst region.

Due to the occurrence, and the hydrogeological situation of the country, the springs are distributing almost everywhere. The number of the springs is said around 2,000 in Lebanon. They are utilized since very long times ago, so that the spring has almost same meaning as a water source (Aîn), supposedly. Figure 2.4.4 shows the location of major springs in the country, flowing out more than 10 mcm/an of water. As shown in the figure, the major springs distribute almost equally in the country, however, they are severely controlled by the hydrogeological structure such as fault lines, aquifers and aquicludes.

(2) Spring yield

Relatively high precipitation and very high infiltration ratio make all springs quite vigorous. Some springs flow out more than 140 million m^3/year (mcm/an), such as Afka and Jeita, or as high as more than 363 mcm/an as Ras el Assi. These levels of flow are exceeding the yearly runoff of the River Beirut (101 mcm/an), the fifth largest river in the Coastal Region, or the River Awali (284 mcm/an), the forth largest river in the country (Study of Groundwater, UNPP, 1970).

Lebanon has clearly contrasted two seasons: the dry summer and the rainy winter. During the cold half year, from November to April, around 93% of yearly rainfalls down. It means another half year has almost no rain. Depending upon the situation, spring flows also have heavy seasonal fluctuations. Even though the major springs, some of them have no water flow in the early winter, and most of the small springs stop to flow at September or early October. Figure 2.4.5 show the monthly spring flows of major spring. The highest flow occurs at May both in the Inland and Coastal Regions but the most of springs have their peak of flow in three months during February to April. And the springs in both regions, regardless the scale, have lowest flow in the three months from August to October. They have a close relation to the precipitation but have a considerable time lag (it shall be discussed later).

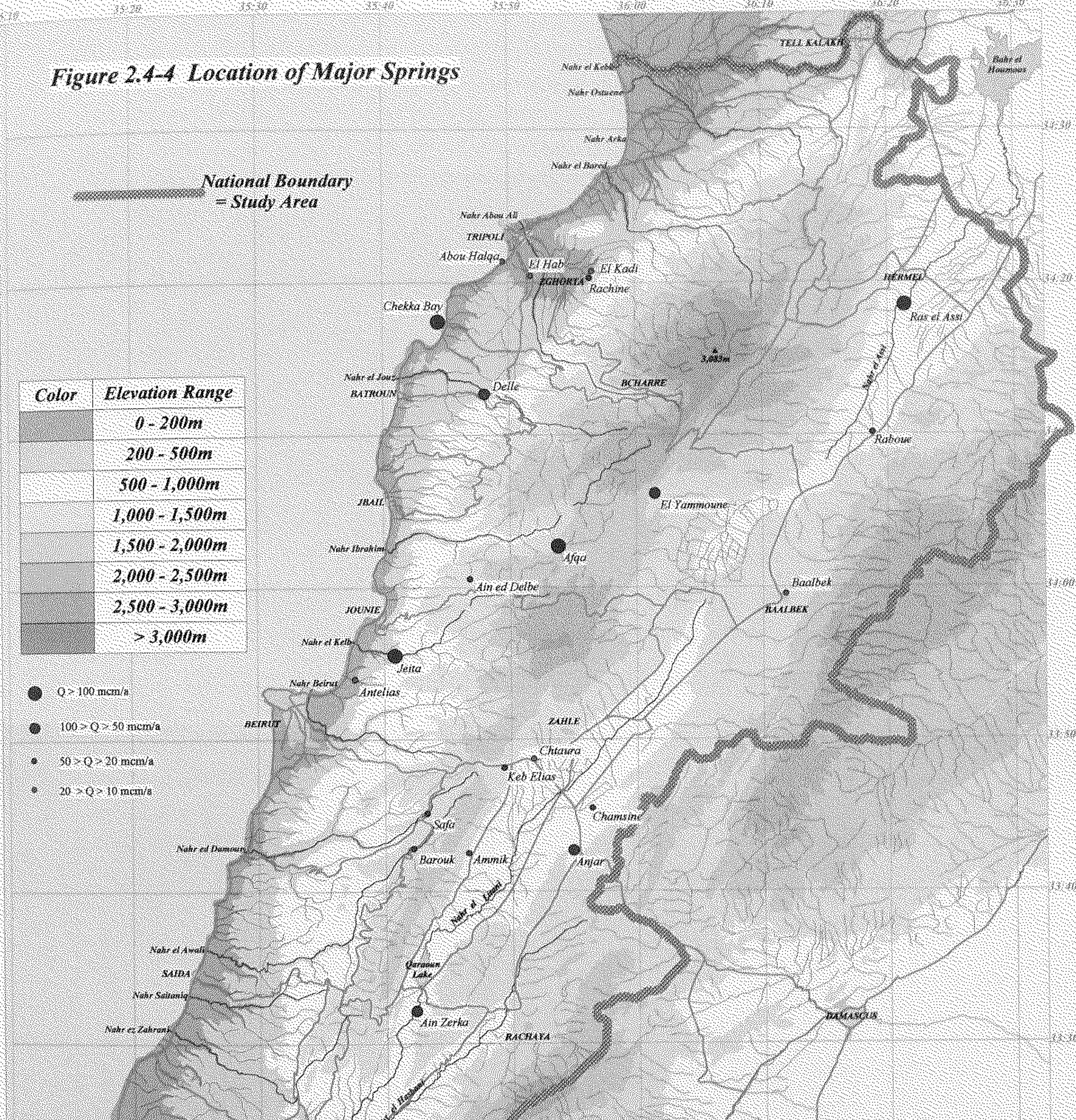
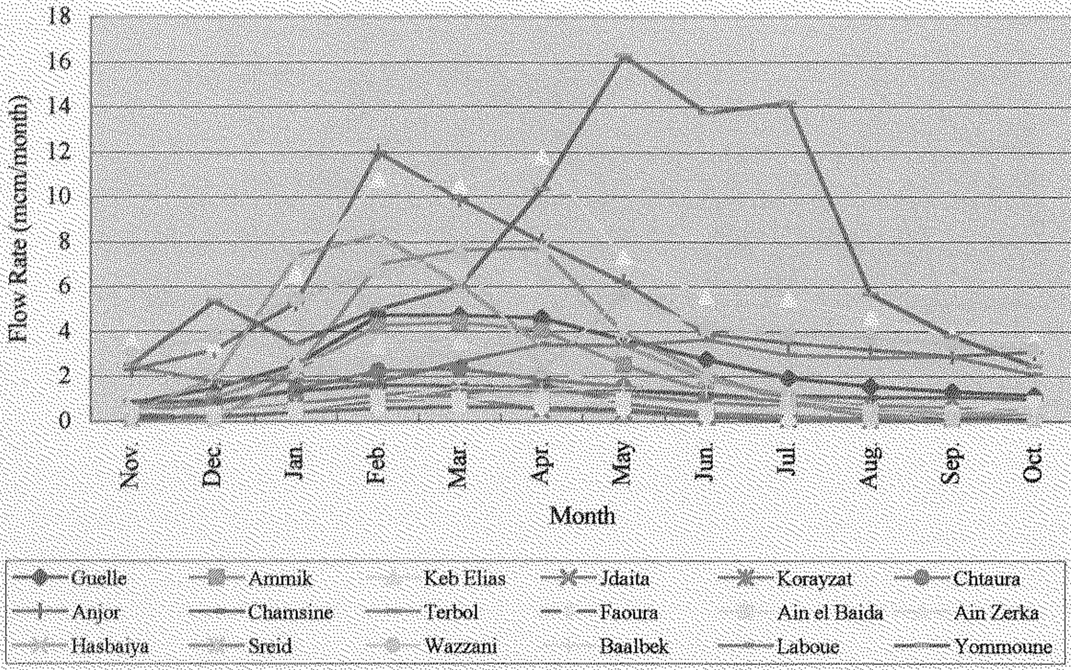
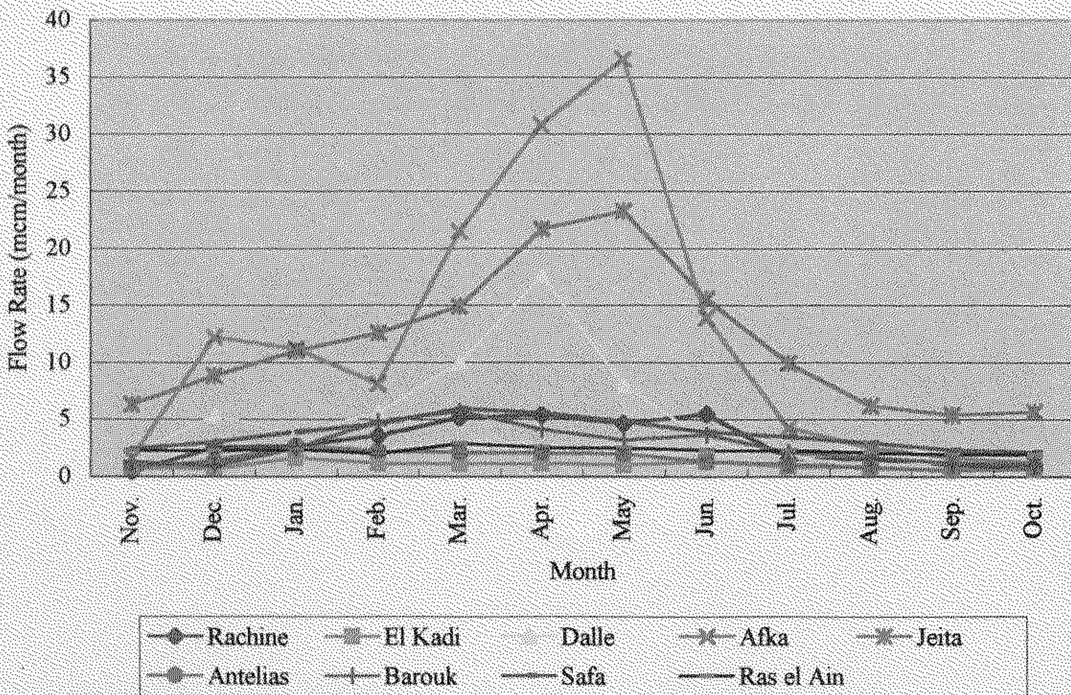


Figure 2.4-4 Location of Major Springs

Figure 2.4-5 Monthly Flow of Major Springs (Inland Region)



(Coastal Region)

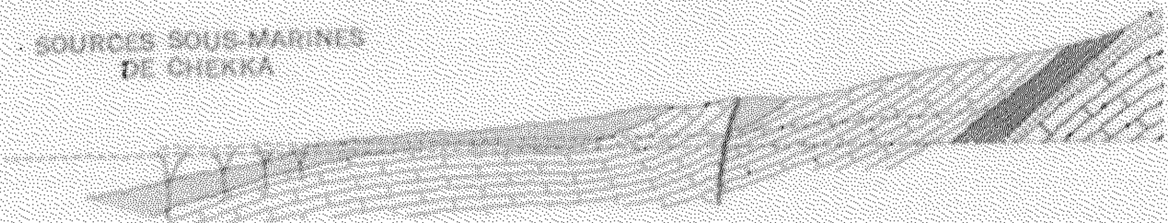


Source: Study of Groundwater, UNDP, 1970
data are in ave. 1961-68 (mostly)

(3) Submarine springs

Aquifers are, of course, extending to the bottom of sea. When the piezometric head of confined aquifer under the sea is higher than the sea water head, and if it has an outlet, the submarine spring occurs (refer to the Figure 2.4.6). Under such unique hydrogeological situation of Lebanon as most

Figure 2.4.6 Concept of Submarine Spring



Source: Carte Hydrogeologique (1/200,000)

of the country is underlain by calcareous formations, there are many spring not only on the land but along the shore line and offshore, called as submarine spring.

Submarine springs are known by the people living in sea site since rather long times ago, but they have been left untouched because of the difficulty to exploit efficiently. Just recently, they are surveyed scientifically (NCRS, AUB), and tried to utilize actually. However, the real utilization facility of submarine spring is still one place, Abou Halqa Spring which is one of the water sources for Tripoli water supply system. By the Study for Tripoli Water Supply (Redesign of Tripoli Water Supply and Wastewater System, 1999), the flow rate of this submarine spring is around 450 lit/sec. The flow rate of the spring is not so much fluctuated, ranging between 316 and 623 lit/sec, and the total flow in a year is estimated as around 13 mcm.

2.4.4 Groundwater Well

(1) Groundwater use

Since there were many springs everywhere in the country, as quite easy water sources for domestic, potable, and agricultural use, they did not use groundwater through a well for long time. Recently, along with the decreasing natural water sources (spring and river flows) and shortage of the artificial water supply, the people began to dig a well or drill the borehole unwillingly.

Major developers of groundwater are agricultural and water supply sectors. All together 21 of Water Authorities (now they are combining into 4 Regional Authorities) and several Water Supply Committees have own production wells to supplement the water sources of springs. And they are still paying a big effort to construct production wells, therefore, to catch the exact number of the production wells working currently is rather difficult but it can be estimated around 560 in total. Another big consumer of groundwater is an agricultural sector. LRA is the biggest organization in this sector. The major portion of water resources for irrigation is, however, the surface water stored in the Qaraoun Dam. The groundwater through production wells is the second water sources but it is depending upon the private wells in most of the cases.

Beside the production wells constructed and operated by official agencies or public sector, there are numerous wells constructed by a private sector. Generally, the wells constructed by private sector are small scale, mostly less than 100m of depth and 80 m^3/day of yield. The well construction by private sector is, they said, abruptly increased since 1975, the same with the beginning of civil war supposedly to protect their own living condition. By the MEW, there are nearly 10,000 private wells in whole Lebanon which are formally approved by the Ministry, but they said, more than 50,000 illegal (not approved) wells must be existing.

(2) Distribution of wells

Excepting a few geological formations such as massive marls, any volcanic rocks or recent clayey layers, almost all strata can contain water in them, therefore, water wells are distributing every where in Lebanon where people live. However, the major production wells operated by public sector are concentrated near around the major cities. Figure 2.4.7 shows the location of major wells operated by W.A., together with springs utilized as the water source on water supply.

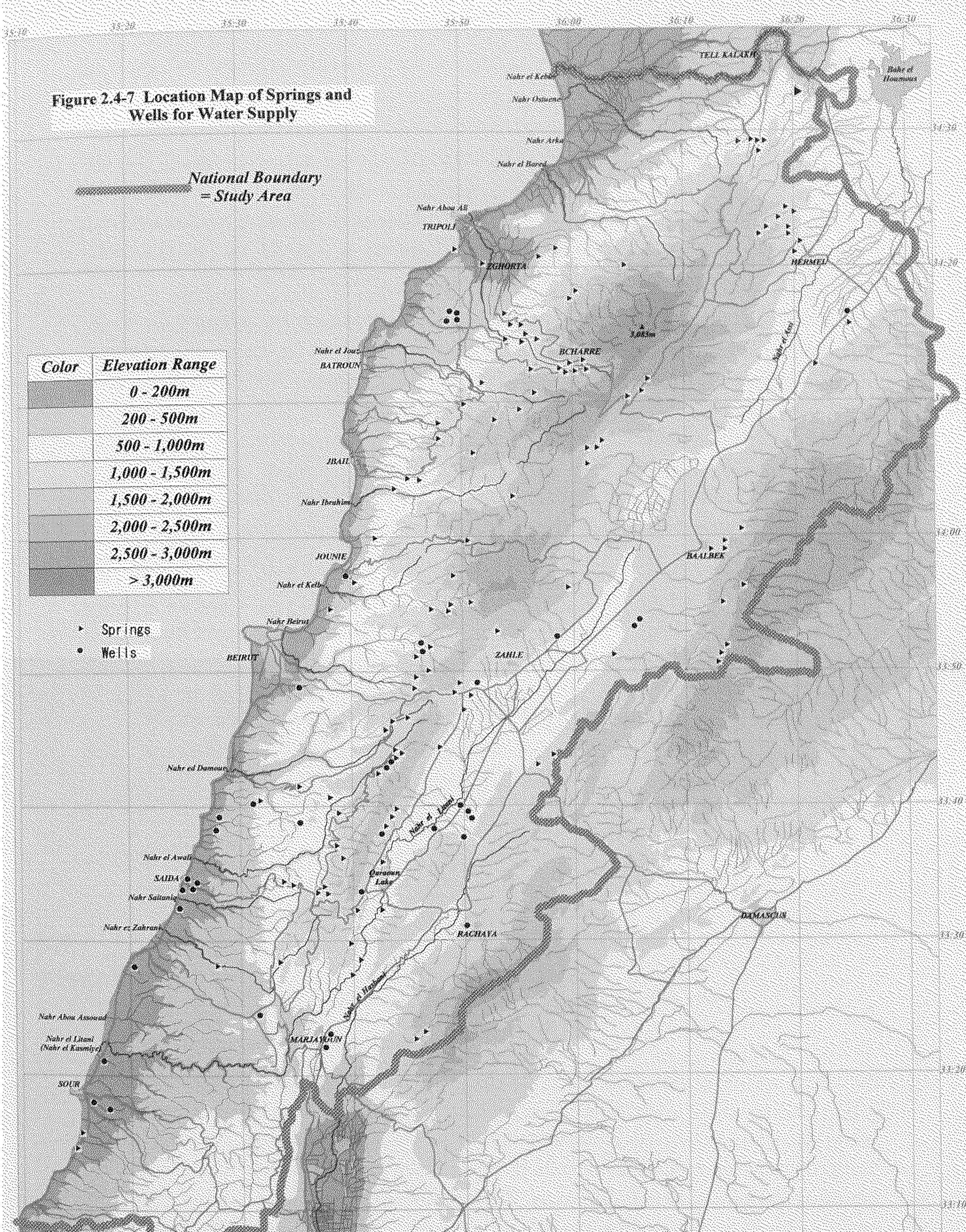


Figure 2.4-7 Location Map of Springs and Wells for Water Supply

(3) Well yield, groundwater yield

The spring is an outcrop of groundwater. A water well is a facility functioning to crop out the groundwater forcibly by man. When the aquifer is enough confined (having high piezometric head than the ground elevation), the groundwater flows out to the ground surface through the well, as same as the spring. Difference between the spring and artesian well is only whether it is natural or artificial. In this meaning, the yield potential of well is the same with the spring, difference is only a scale and efficiency such as well diameter, well efficiency, screen type, etc. The potential yields of spring and well are substantially same when they tapped to the same aquifer.

Groundwater yield must be discussed for each aquifer through their aquifer constants. The Study on Groundwater, done by UNDP (1970), drilled 73 holes, 1,2951m of boreholes and conducted pumping tests in them. They figured out the aquifer constants as shown in Table 2.4.2 below.

Table 2.4.2 Aquifer Constants

A. Inland Basin

Calcareous Aquifer	Jurassic Calcareous	Barouk – Niha	T= 6.5 x 10^{-2} m^2/s	S= 3.0 - 4.2 x 10^{-2}
		Jdaita	T= 5.2 x 10^{-2} m^2/s	S= 2.5 x 10^{-2}
	Cretaceous Calcareous	Lebanon Mountain	T= 1.4 - 5.5 x 10^{-1} m^2/s	-
		Anti Lebanon	T= 2.3 x 10^{-1} m^2/s	S= 2.5 x 10^{-2}
		Bekaa South	T= 0.23 - 7.4 x 10^{-2} m^2/s	S= 6.0 x 10^{-3}
	Eocene Calcareous	Bekaa South	T= 0.81 - 2.1 x 10^{-2} m^2/s	S= 3.0 x 10^{-3}
		Bekaa North-East	T= 1.4 - 6.1 x 10^{-2} m^2/s	S= 1.5 x 10^{-2}
		Bekaa West	T= 1.0 x 10^{-3} m^2/s	-
Porous Aquifer	Neogene – Quaternary	Bekaa Plain	T= 1.0 x 10^{-2} m^2/s	-

B. Coastal Basin

Cretaceous Aquifer	Jurassic Calcareous	Sired Danie – Ain Yacoub	T= 0.20 - 2.0 x 10^{-2} m^2/s	S= 5.0 x 10^{-3}
		Barouk – Niha	T= 4.5 x 10^{-1} m^2/s	-
	Cretaceous Calcareous	Lebanon North	T= 0.10 - 2.1 x 10^{-2} m^2/s	S= 0.6- 2.8 x 10^{-4}
		Hadath – Hazmiya	T= 2.4 x 10^{0} m^2/s	S= 3.1 x 10^{-2}
		Lebanon South	T= 1.0 - 8.1 x 10^{-2} m^2/s	-
	Eocene Calcareous	Lebanon South	T= 2.4 x 10^{-1} m^2/s	-
	Miocene Calcareous	Lebanon North	T= 1.0 x 10^{-1} m^2/s	-
Sandstone Aquifer	Miocene Sandstone	Jabel Terbor	T= 3.1 x 10^{-4} m^2/s	S= 0.75 - 5.1 x 10^{-3}
Porous Aquifer	Quaternary	Mountainous Area	T= 1.5 - 3.1 x 10^{-2} m^2/s	-
		Coastal plain	T= 5.1x10^{-3} – 4.5x10^{-1} m^2/s	S= 2.5 x 10^{-3}

Source: Study of Groundwater (UNDP, 1970)

The figures are rather old as more than 30 years ago, however, such kind of comprehensive hydrogeological survey in nation wide has not been conducted after that. Recently, there were several hydrogeological surveys conducted locally by each WA, but those results cannot replace the results of UNDP, still now. As shown in the above table, almost all of the aquifers have rather high Transmissivity (called as T) of the order of 10^{-2} m^2/sec. Remarkably, the T of Hadath – Hazmiya aquifer (Cretaceous calcareous aquifer) indicated 2.4 m^2/sec. It means the groundwater can move quite smoothly. Depending upon the thickness of the aquifer but the permeability of certain aquifer may be 2 to 10 cm/sec. The Storativity (called as S) is also quite high, as a general. Mostly, they show 10^{-2} order, and it can be converted that the effective porosity of the aquifer ranges between 1.0 to 3.0 %. The figures suggest that these aquifers can store big volume of water and pass water through them at quite high speed, having quite high yields.

2.4.5 Spring and Groundwater Quality

Water quality has two aspects: one is a hydrogeological aspect analyzed mainly for chemical properties, and another is an environmental aspect analyzed mainly for contamination. In the Study, both of water qualities are analyzed through sub-contracted works: Water Quality Analysis (1) for an environmental aspect and (2) for a hydrogeological aspect. General situation of groundwater and springs water qualities from a view point of hydrogeology was explained in the chapter of 2.10.4. Herewith, the water quality from environmental point of view is discussed. The groundwater is the important water source for potable water in Lebanon. The groundwater is also the water source flowing into most rivers in Lebanon. The groundwater, however, has been recently deteorized/contaminated by various causes such as industrial/domestic wastewater, domestic sewage, routine or accidental spills/leakage from underground tanks and saline intrusion in the coastal areas.

The AUB Water resource Center conducted a groundwater survey in 1999 to assess the water quality of the groundwater. 31 samples of from 13 regions were analyzed. Table 2.4-3 shows the results of the survey. The results show the high nitrate concentrations in the locations near in the agricultural lands such as Sadneyal (49.1 mg/l) and Choueifat (51.9 mg/l) which exceed WHO guidelines (50 mg/l) and Lebanese standard (45 mg/l). The high concentrations are suspected to be caused by the use of agro-chemicals such as fertilizers and pesticides.

Table 2.4-3 Nitrate Concentrations in 31 Wells in 13 Regions

Name of Well	Concentration of Nitrate (mg/l)	Compliance with WHO Guideline*	Compliance with Lebanese Standard*
Brital (3)	14.1	o	o
Haouch el	9.5	o	o
Qsarnaba (1)	11.1	o	o
Sadneyal (2)	49.1	x	x
Niha (1)	0.3	o	o
Cheka (3)	24.6	o	o
Selaatah (1)	7.3	o	o
Batroun (2)	11	o	o
Houboub (1)	11.1	o	o
Berbara (1)	15.6	o	o
Remeyleh (3)	9.1	o	o
Jiyeh (3)	15.6	o	o
Choueifat (9)	51.9	x	x

Remarks:
*: The nitrate standard in WHO guidelines is 50 mg/l and 45 mg/l in Lebanese standard (Decree 1039/1999), respectively.
Source: Lebanese Standard of the Environment Report

The AUB Water resource Center also conducted a groundwater survey in 1999 to assess the saline intrusion impact on the water quality of the groundwater from 31 water wells.

Table 2.4-4 shows the results of the survey. The concentrations of chloride and sodium were over the WHO guidelines (250 mg/l for chloride, 200 mg/l for sodium) and Lebanese standards (200 mg/l for chloride, 150 mg/l for sodium) in the wells near the coastal areas such as Cheka, Berbara, Remeyleh and Jiyeh. The high concentrations of these parameters are suspected to be caused by the over draw-up for the increasing demand of irrigation water.

Table 2.4-4 Chloride and Sodium Concentrations in 31 Wells in 13 Regions

Name of Well	Concentration of Chloride (mg/l) Compliance with WHO Guideline			Concentration of Sodium (mg/l) Compliance with Lebanese Standard		
	Surveyed Values	WHO Guideline	Lebanese Standard*1	Surveyed Values	WHO Guideline	Lebanese Standard*1
Brital (3)	33	o	o	550	x	x
Haouch el	35	o	o	235	x	x
Qsarnaba (1)	36	o	o	250	x	x
Sadneyal (2)	78	o	o	383	x	x
Niha (1)	62	o	o	240	x	x
Cheka (3)	1437	x	x	415	x	x
Selaatah (1)	15	o	o	140	o	o
Batroun (2)	273	x	x	153	o	x
Houboub (1)	720	x	x	345	x	x
Berbara (1)	2700	x	x	950	x	x
Remeyleh (3)	3100	x	x	637	x	x
Jiyeh (3)	503	x	x	458	x	x
Choueifat (9)	460	x	x	204	x	x

Remarks: *1: Lebanese standard regulated by Decree 1039/1999.
Source: Lebanese Standard of the Environment Report

The microbiological data such as faecal coliforms were not available. However, the epidemiological data caused by the water-borne diseases such as dysentery, hepatitis A and typhoid are reported by Ministry of Public Health. As for the details of such data, refer to 3) Public Health, 2.9.2 Current Situation on Environment.

According to the report, the microbiological contamination is assumed to be caused by the deterioration during the water supply distribution such as cross contamination of wastewater networks and seepage of domestic sewage. The report also showed the regional feature that the number of reported cases of such disease has declined in the South and Nabatiyeh, while sharply increased in Bekaa and North Mohafazas.

2.4.6 Data Collection on Hydrogeological Aspect

(1) Data collection general

Since the beginning of the study, all of the Team members worked assiduously to collect basic data to grasp the current condition. In the hydrogeological aspect, the basic data were collected from the Ministry of Energy and Water, Litani River Authority, Water Authorities, ESCWA, NRRS, and Universities. However, the progress of data collection was very slow and the outcomes were quite poor in spite of our efforts. Major reason was missing of data and information including references and study reports because of the long civil war. Second reason was inefficient data managing and control of each organization. Third reason was lacking in the monitoring system originally. Under the cooperation of many officers and engineers concerned, the data required were partly obtained, and the effort to collect data and information was continued. However, many of data are not existing from the first, so that such kind of data must be created in the future, then, the system to collect and/or monitor certain phenomena shall be established.

(2) Data required for SSM

In the Study, the total water balance study shall be conducted through a model simulation applying SSM (Synthetic Storage Model, developed by Sanyu Consultant). To build up the model, to verify it, and to operate it, following data are required:

DATA REQUIRED FOR SSM

1. Input data: Basic input data to the Model.
   - 1.1 **Rainfall (daily basis),**
   - 1.2 Snowfall or depth of snow (daily basis),
   - 1.3 **Evapo-transpiration data (monthly basis),**
   - 1.4 Temperature (max. min. and mean, daily basis)
   - 1.5 Tidal data (daily basis).
   - 1.6 Water utilization data (Pumping and/or intake volumes).
2. Verification data: Required to verify the Model.
   - 2.1 **Surface runoff of each river basin (daily basis),**
   - 2.2 **Groundwater hydrograph of each aquifer (daily basis),**
3. Parameters of the model: To be calibrated through trial operation.
   - 3.1 For Surface System
     - 3.1.1 Sub-basin division (area and distance of each sub-basin),
     - 3.1.2 Surface tank structure: stories of tanks
     - 3.1.3 Characteristics of Dummy Basins,
     - 3.1.4 Side-flow rates and percolation rates,
     - 3.1.5 Soil retention rates.
   - 3.2 For Groundwater System
     - 3.2.1 Sub-basin division: same with the surface system,
     - 3.2.2 Groundwater characteristics of Dummy Basins,
     - 3.2.3 Aquifer structure of each sub-basin (depth, thickness, volume, H-V curves)
     - 3.2.4 Aquicludes structure of each sub-basin (depth, thickness, leakance)
     - 3.2.5 Groundwater connections and their permeability,
     - 3.2.6 Practical porosities of unconfined aquifers,
     - 3.2.7 Specific yields of confined aquifers

Note) Items by Bold letter are indispensable

Concerning to the data set on the SSM simulation, its detail is to be discussed later, in the Chapter 3.2 "Hydrogeologocal Circulation Model".

(3) Meteo-hydrological data

Meteo-hydrological data required for SSM, such as rainfall, temperature, surface runoff, and evapo-transpiration, were almost collected by the efforts of our Hydrologist. However, there is no data on snow fall, which is not observed by Meteorological Service of Lebanon. The information of snow fall is one of quite important data for groundwater study because the snow is a natural huge storage of water. Beside the meteorological observation, the study to analyze the snow fall through remote sensing technique is already started by NCRS, University of St. Joseph and some others.

For the Meteorological and Hydrological data, for their general, please refer to the previous section, Chapter 2.3 "Meteorology and Hydrology".

(4) Data on springs

Among 2000 springs existing in the country, around 1600 spring were identified their location, not so much exact though. However, their yields and/or intake volumes, in time series such as weekly or monthly basis, have not yet grasped. Only some of major springs which are actually utilized as water sources are measured their yield periodically (still not systematic though).

(5) Data on groundwater

Production wells constructed by public sector such as W.A. or LRA were mostly identified their location (not all), and data of averaged pumping rate (utilized water volume) per year, on major wells, were roughly collected. Exact pumping rate in daily or monthly bases, on every wells, were not exist.

Further, the most important information on groundwater, the time series groundwater hydrograph, had not been obtained, and it seems to be almost hopeless to collect them in near future. Such kind of data are observed systematic by no one in Lebanon. Only short period observations by weekly or monthly bases, and on certain wells, have been carried out by LRA. To construct an exact simulation model, the groundwater hydrograph at each groundwater sub-basin are required as a verification data. In this study, therefore, the model shall be verified by the scattered data on groundwater hydrograph, by weekly or monthly bases, and on only where the data exist. And to establish the groundwater monitoring system urgently is to be recommended strongly. Through the study, the optimum groundwater monitoring system shall be figured out.

2.5 Water Supply and Wastewater Disposal

2.5.1 Water Supply

(1) Public and Private Water Supply Administrations

Twenty-one Water Authorities, which fell under the Ministry of Energy and Water (MEW), were previously responsible for supplying potable water to the public. In 2002, these authorities were integrated into four regional Water Authorities; i.e. North Lebanon, Beirut and Mount Lebanon, South Lebanon and Bekaa as follows and as shown in Figure 2.5-1. Within the areas of these authorities numerous committees on a small scale are also operated.

Water Authorities (21):

North Lebanon (8): Kubayat, Akkar, Tripoli, Dinnie - Minie, Zgharta, Koura, Batroun, Bcharri

Beirut and Mount Lebanon (5): Beirut, Ain El Delbeh, Jbeil, Kesrwan, Metn, Barouk

South (4): Saida, Nabaa Al Tasse, Sour, Jabal Amel

Bekaa (3): Baalbek - Hermel, Zahle, Chamsine

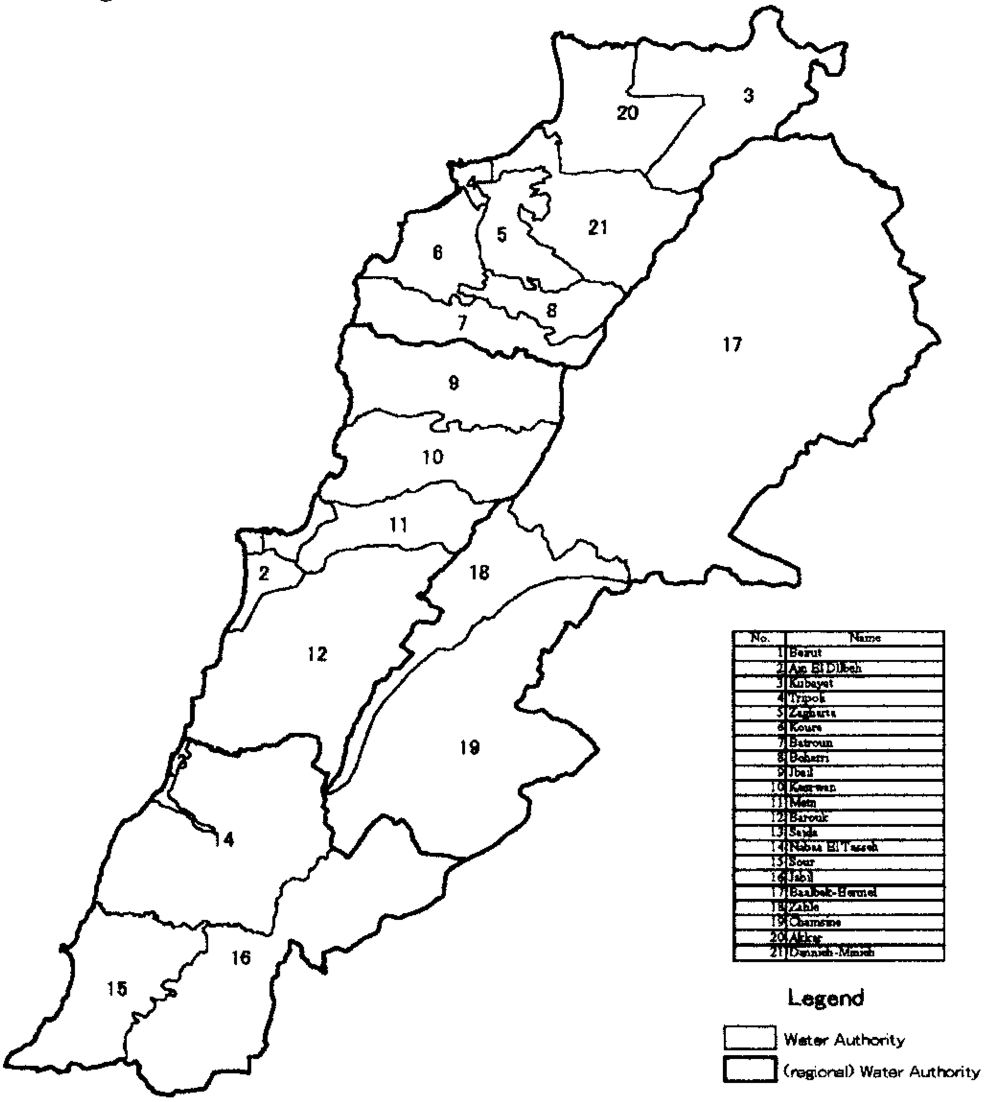
In addition to the Water Authorities, thousands of privately drilled, owned and operated wells are scattered around the country. In Beirut alone, because of war, lack of control and inadequate public water supply, some 10,000 privately owned wells is said to supplement the water supply systems operated by the Water Authorities. Private wells are mainly operated by large and medium consumers such as factories commercial buildings. There is no reliable inventory that provides the number of these wells, location and characteristics although the MEW only keeps records of part of the wells permitted, drilled and invested.

(2) Water Supply Zoning System

In Lebanon, the size of water supply systems varies from large to small. The largest water supply system is Greater Beirut followed by Tripoli. There are many small systems, which supply water to small communities. These small systems are mainly located in the Bekaa.

In the study of damage assessment reports in 1992 and National Emergency Rehabilitation Program (NERP) 2 & 3 Years in 1995 (see Annex for explanation), the boundary of each water supply system including its water sources and distribution areas was delineated and thus a water supply zoning system was developed. Detailed description is attached in the Annex. Based on this water supply zoning system, many studies and works for rehabilitation and extension of the water supply systems have been implemented.

Figure 2.5-1 Territories of Water Authorities



No.	Name
1	Beirut
2	Ain El Dilbeh
3	Kubayet
4	Tripoli
5	Zagharta
6	Koura
7	Batroun
8	Bcharri
9	Jbail
10	Kesrwan
11	Metn
12	Barouk
13	Sayda
14	Nabaa El Tasseh
15	Sour
16	Jabal
17	Baalbek-Hermel
18	Zahle
19	Chamsine
20	Akkar
21	Dannieh-Minieh

(3) Water Resource of Water Authority

(a) Review of Previous Study

The Water Authorities derive their water from springs and wells and distribute the water through their networks. In Lebanon, an accurate evaluation of yield or extraction of water resources is very difficult because a water flow meter is not installed in most of sources and not monitored periodically. Extracted volume from boreholes may be estimated from pump capacity and operation hours but it is impossible to estimate extracted volume of spring water that is generally let the water flow into the network without flow meter.

Several studies, however, estimated yield of water resources in each Water Authority, as summarized in Annex. Betchel (1991) estimated at 777,000 m^3/day for dry (summer) and 1,056,000 m^3/day for wet (winter) season. Howard Humphrey (1995) estimated at 823,236 and 1,139,000 m^3/day. Haggar (1997) estimated a total resource of 976,401 m^3/day, of which 42 % was derived from groundwater. These figures indicate that the dry season yields decrease by about 30 percent from the wet season yields.

In comparison of figures of each Water Authority, the studies of Betchel and Howard Humphrey give very close figures. The figures of Howard Humphrey could give more reliable figures because a comprehensive study for water supply was conducted in the study.

(b) Evaluation of Current Water Resource of Water Authority

In order to estimate the yield of current water resources of Water Authorities, the figures were directly collected from 15 Water Authorities in this study. In addition, the latest reports of study for water supply projects are reviewed. These yield data are tabulated in Annex. Considering these data, a best estimate is made to estimate the current water resources by basically applying the data from Water Authority. Unless the data is available, either the figures of the latest study or the Howard Humphrey study (1995) are utilized. The result is shown in Table 2.5-1.

The total yield of the water resource of Water Authority is 832,000 m3/day for the dry season and 1162,000 m3/day for the wet season. In the dry season, one third of the total yield of the country are available for Greater Beirut Area (Beirut and Ain El Delbeh Water Authorities), followed by 11 percent in Baalbek-Hermel and 8 percent for Tripoli. Large part of the water resource of Baalbeck - Hermel may include water for irrigation.

Major water resources of Water Authority is presented in Figure 2.5.2 and in Annex, being classified into local or regional borehole, and local or regional borehole

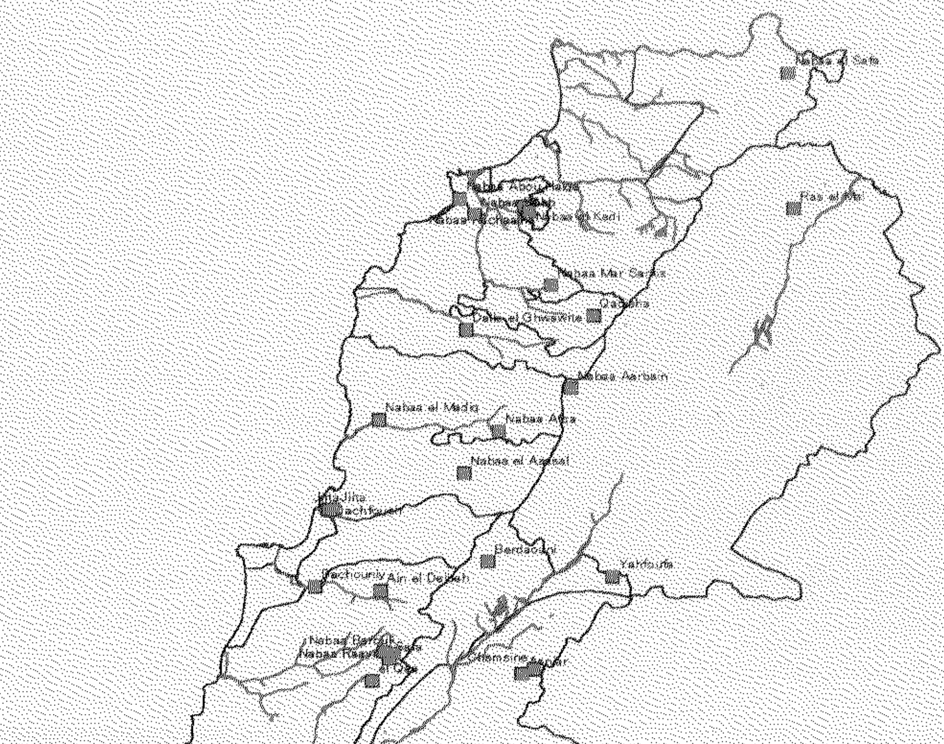
Table 2.5-1 Estimated Water Resource of Water Authority in 2020

(Unit = m^3/day)

Region	Water Authority	Water resource of Water Authority in 2001 Collected from WA, 2001 by JICA			Water resource Complied based on the latest studies*1				Estimated water resource in 2001	
		Summer (Dry)	Winter (Wet)	Average	Summer (Dry)	Winter (Wet)	Sustainable yield	Incl. expected exploitable yield	Summer (Dry)	Winter (Wet)
North	Kubayat				30,640	46,040			30,640	46,040
	Akkar			5,654				73,400	5,654	5,654
	Dinnie-Minie								-	-
	Tripoli	68,000	90,000		76,680	117,380			68,000	90,000
	Zgharta	16,000	40,000						16,000	40,000
	Koura	21,000	24,360		35,800			42,510	21,000	24,360
	Batroun				12,950	16,400			12,950	16,400
Mount,	Bcharri								11,606	12,825
Beirut	Beirut	220,000	290,000						220,000	290,000
	Ain El Delbeh	50,000	110,000						50,000	110,000
	Jbeil	13,305	18,680						13,305	18,680
	Kesrwan	47,100	50,600		108,417	362,906		162,027	47,100	50,600
	Metn	20,000	24,000		28,300	72,600			20,000	24,000
	Barouk	26,300	46,500				64,000	168,500	26,300	46,500
South	Saida	40,000	40,000				36,308		40,000	40,000
	Sour	28,328	21,500				79,432		28,328	21,500
	Nabaa Al Tasse	60,000	70,000				110,149		60,000	70,000
	Jabal Amel	20,276	27,035						20,276	27,035
Bekaa	Baalbek - Hermel						93,605		93,605	93,605
	Zahle		80,000-100,000						35,035	85,485
	Chamsine						12,399		12,399	49,360
Total									832,198	1,162,044

Source: *1 compiled from several water supply master plans

Figure 2.5-2 Major Regional Springs and Boreholes and Supply Area



(4) Water Supply Service Level

(a) Coverage of Public Water Supply Service

The most reliable and detailed figures for the coverage rates of public water supply service are provided by the household study performed by Central Administration of Statistics (CAS) during the period of 1996 and 1998. In Annex, the water supply coverage together with private wells and sewer coverage are presented. The Ministry of Social Affairs (MSA) study in 1997 also gives country level's global figures of the water supply coverage and main water source as presented in Annex.

According to the CAS study, a country's average water supply coverage is 79 %. In the region level, the coverage of Beirut is the highest (93 %) and North Lebanon the lowest (65 %). The private wells coverage is also the highest (16 %) in Beirut and the lowest (1 %) in Nabatiye. In Beirut, the total percentage of water supply service and private wells is more than one hundred (109 %). This indicates that private wells are used for supplementing water supply network service in the same building. According to the MSA study, 6.1 % of household use both public network and well.

In the Caza level, the water supply coverage of Hasbaiya is the highest (95 %) and Hermel the lowest (41 %) followed by Akkar (43 %). In Baabda, the percentage of private wells is the highest and 20 % of the buildings own a well. In Jezzine, Hasbaiya, Marjayoun and Bent Jbeil, the percentage of private wells is negligible and the people mainly rely on public water network.

(b) Service Population and Per Capita Water Resource

Using the estimated population for the year of 2002 and the water supply coverage rates, the current service population is estimated as in Table 2.5-2. Total service population is estimated to be 3,701,000 in 2002.

Estimating actual consumption per capita is very difficult as water consumption data are not available due to lack of individual water meter system in most of Water Authorities.

Using yield or extracted volumes evaluated above, water resources per capita for the dry season are estimated as shown in Table 2.5-2. These figures may be close to actual consumption per capita including leakage since water resources in dry season are very scarce and most of water resources are consumed.

Note: Data are compiled from GIS database of JICA

Assuming 50 % of leakage, the estimated water available per customer in the following Cazas or Water Authorities is less than 80 l/c/d, which is considered below the minimum requirement. In particular, that of the Beirut south area (Ain El Delbeh Water Authority) is estimated to be as low as 50 l/c/d, which is considered far less than the minimum requirement. In these areas of water shortage, the people could heavily rely on other sources. (Note: In NERP 2nd and 3rd Year Program, the minimum requirement was stipulated at 80 l/c/d.)

Table 2.5-2 Population Connected to Network and Per Capita Dry Season Resources in 2001

Region	Caza/major urban	Water authority corresponding to Caza	Public water supply coverage (%)	Population in 2002		Water resource in the dry season (m^3/day)	Per capita dry season	
				Total (person)	WA service population (person)		For total pop (l/c/d)	For service pop (l/c/d)
North	Akkar	Kubayat & Akkar	49	147,772	72,408	36,294	246	501
	Tripoli	Tripoli city	86	336,445	289,343	68,000	202	235
	Tripoli	Dinnie-Minie	63	45,740	28,816			
	Zgharta	Zgharta	85	106,409	90,447	16,000	150	177
	Koura	Koura	77	85,995	66,216	21,000	244	317
	Batroun	Batroun	73	94,328	68,859	12,950	137	188
	Bcharri	Bcharri	81	63,919	51,774	11,606	182	224
	Sub-total		65	880,608	667,863	165,850	188	248
Mount, Beirut	Beirut City	Beirut	93	440,015	409,214	220,000	267	287
	Beirut North	Beirut	93	385,416	358,437			
	Beirut South	Ain El Delbeh	93	596,200	554,466	50,000	84	90
	Jbeil	Jbeil	89	54,697	48,680	13,305	243	273
	Kesrwan	Kesrwan	94	126,563	118,969	47,100	372	396
	Metn	Metn	91	134,315	122,227	20,000	149	164
	Baabda	Barouk	81	96,909	78,496			
	Aaley	Barouk	80	90,573	72,459	26,300	76	90
	Chouf	Barouk	89	159,979	142,380			
	Sub-total		87	2,084,667	1,905,328	376,705	181	198
South	Saida Center	Saida	85	145,597	123,757	40,000	275	323
	Sour	Sour	80	199,029	159,223	28,328	142	178
	Saida Rural	Nabaa Al Tasse	85	84,743	72,032			
	Jezzine	Nabaa Al Tasse	90	85,669	77,101	60,000	352	402
	Sub-total		83	515,037	432,113			
Nabatiye	Nabatiye	Nabaa Al Tasse	93	115,162	107,100			
	Hasbaiya	Jabal Amel	95	42,228	40,117			
	Marjayoun	Jabal Amel	88	69,139	60,842	20,276	109	123
	Bent Jbeil	Jabal Amel	86	73,885	63,541			
	Sub-total		90	300,413	271,600			
Bekaa	Hermel	Baalbek - Hermel	41	29,607	12,139	93,605	424	786
	Baalbeck	Baalbek - Hermel	56	190,942	106,928			
	Zahle	Zahle	80	240,902	192,722			
	West Bekaa	Zahle and	93	86,108	80,081	47,434	129	155
	Rachaiya	Chamsine	81	40,944	33,165			
	Sub-total		68	588,504	425,035	141,039	240	332
Total			79	4,369,229	3,701,939	832,198	190	225

Note: ☐ : indicates that the per capita resource is less than 160 l/c/d.

(c) Supply Pressure and Water Rationing

Average water supply hours per day collected from Water Authorities are compiled in Table 2.5-3. In most areas of Lebanon, supply pressure is currently intermittent due to insufficient water sources, limited system capacity and intermittent electricity supply. So constant 24-hour supply is very rare except in Tripoli in the summer, Saida and the coastal areas of Kesrwan. In the summer months, particularly, the supply hours decrease and reach only 5 hours per day on average in the supply areas of Beirut and Jbeil Water Authorities. Because of this situation, the current water consumption may be suppressed and the people consume less water than they expect.

Table 2.5-3 Number of Subscribers and Water Supply Conditions in 2001

Water Authority	Total number of subscribers	Number of non-residential	Average water supply hours per day	
			Summer	Winter
Kubayat	2,487	-	Intermittent	Intermittent
Akkar	7,829	-	-	-
Tripoli	49,213	-	12 (in the high area)	24
Dinnie Minie	-	-	-	-
Zgharta	3,000	-	8 - 16	19
Bcharri	4,173	-	-	-
Koura	11,800	3,243	at least 12	18
Batroun	7,457	1,797	2 days/week	
Beirut	210,067	No data	5	10
Ain El Delbeh	80,000	24239	8	20
Jbeil	16,697	3,505	5 (max)	8 (max)
Kesrwan	60,000	7,795	24 (coast by gravity)	24 (coast by gravity)
Metn	38,000	-	8 - 18	12 - 17
Barouk	64,636	9,956	6	9
Saida	19,000	-	24	24
Nabaa Al Tasse	53,258	-	4 days/week	0-4
Sour	17,954	-	16	20
Jabal Amel	23,677	-	-	-
Baalbek - Hermel	9,120	-	-	-
Zahle	26,000	-	12	16 - 18
Chamsine	15,723	-	-	-
Total	720,091	-	-	-

Source: water Authorities

To overcome this discontinuous supply, many buildings have individual or communal storage tanks. In Beirut, it is also common practice to use booster pumps within buildings to feed roof tanks. Some properties have private boreholes to supplement the intermittent supply. Also, in the summer months, supply by tanker is common for properties without a boreholes. In some areas it is common practice for new buildings to have large communal storage tanks at both basement and roof levels feeding smaller individual tanks on each floor (CDR/GIBB, 1997).

(5) Water Supply Facility

(a) Water Treatment Plant

The capacity of major water treatment plants in Lebanon is presented in Annex. There are 12 working conventional treatment plants and a total of 388,000 m^3/day of water can be treated, which account for 47 percent of total water resources in the dry season. The rest of raw water is not treated but it is possible to become drinkable only by applying chlorination since water sources, both boreholes or springs, have very low turbidity. Therefore, most treatment facilities are equipped with chlorination only.

Even in some treatment plants, the water with low turbidity in the dry season is treated by filters and chlorination only. During the rainy season when the water has relatively high turbidity, coagulation and settlement processes are operated.

(b) Distribution Facility

Description of water distribution facilities in Lebanon is presented in Annex. The total length of the distribution pipe is 11,898,646 km and major pipe materials are asbestos cement, steel pipe and galvanized iron. The average ages of distribution pipe vary up to 70 years and generally, the water distribution network is 30 to 50 years old.

(c) Unaccounted for Water (UFW)

1) Leakage

Little is known of the actual quantity of leaks in distribution networks since the amount of water distributed from sources and actually consumed by customers is not measured by a water meter. The following studies provide useful information to estimate current leakage level.

Haggar (1997) collected the information of distribution networks conditions of Water Authorities and evaluated leakage ratios. In JICA study, the leakage ratios estimated by Water Authorities are collected. The results of both studies are summarized in Table 2.5-4. The figures estimated by Haggar vary from as much as 84 % to 28 %. Those estimated by Water Authorities vary between 20 - 70 % and mostly fall in between 30 and 50 %.

Table 2.5-4 Estimated Leakage Ratio

Water Authority	Leakage ratio estimated by WA. 2002	Leakage ratio estimated by Haggar. 1997
Kubavat		54 %
Akkar	-	84 %
Tripoli	50%- 55 %	75 %
Dennie	-	75 %
Zgarta	50%	
Koura	46%	
Batroun		28 %
Bcharri		39 %
Beirut	30% - 50%	59 %
Ain El Delbeh	40%	70 %
Jbeil	60%	66 %
Kesrwan	30%- 50%	
Metn	50%- 70%	38 %
Barouk	30%- 50%	42 %
Saida	20%	72 %
Sour	40%	
Nabba El Tasse	40%	
Jabel Amel	40%	
Baalbek	-	76 %
Zahle	35%	73 %
Chamsine	-	70 %
Average	-	59 %

The Study of Unaccounted - for Water (CDR/GIBB, 1997), in which two district metering areas were established in Achrafieh and Zalka in Beirut Water Authority area, is summarized in Annex. The result of the study indicated that UFW due to physical losses are 57 % and 55 % for Achrafieh and Zalka, respectively.

In the NERP 2 & 3 Years Feasibility Study, unauthorized connections to the system are frequently found in almost all Water Authorities. In Ain El Delbeh, a large community is known to have connections with water networks without paying. Part of UFW is attributed to illegal connections.

(d) Orifice and Metering System

Domestic connection normally has a calibrated orifice which limits flow to predetermined quantities, most frequently 1 m^3, and this capacity also determine the minimum fixed charge for water supplied. Apartments have a 1 to 3-m^3 orifice depending on floor size. It is generally agreed that a typical orifice will on average allow one cubic meter of water to be consumed per day. However, when pressures are high and supply continuous the orifice may deliver considerably more water than pre determined.

The charging structure is based upon orifice size not volume consumed and therefore the orifice offers no incentive to save water or repair internal plumbing even if most leakage is found in internal plumbing. The charging structure is arbitrary in areas of intermittent supply and the volume supplied is a function of pressure and not charged made.

The number of water meters installed by Water Authorities is presented in Annex. Generally, meters are installed only to large water consumers such as manufactures and commercial buildings. The percentage of meter-installed subscribers is negligible except for Saida, Tripoli and Koura. In Saida, water meters are installed for 91 % of subscribers and the Water Authority plans to complete installation of a meter for all subscribers within a few years.

(6) Industrial Water Supply

Industries receive water through the public water supply system as well as domestic users if they are located in the service area. In addition, most industries are equipped with private wells and tap underground water at liberty with minor costs for pump operation. Currently, there is no regulatory monitoring on controlling the source or quantity of water which may be used at the industrial premises. Therefore, little is known of industrial water consumption. Also many of the establishments do not keep records or could not even estimate accurately their water consumption (MOE/Dar Al-Handasah, 1996).

In Lebanon much of the water used by industry is understood to be from private groundwater abstractions, for which no charge is made and there is no incentive for industry to conserve water or even to measure consumption.

A major finding of the survey of industrial wastes (MOE/Dar Al-Handasah, 1996) was that a significant proportion of the establishments visited operate dry processes. This is largely a consequence of the general nature of the manufacturing industry in Lebanon, which is based principally on assembly or processing of (frequent imported) components to form finished products rather than on primary manufacture. The majority of industries in Lebanon, which rely on consuming relatively large quantities of water are those associated with food products and beverages, textiles, leathers and leather products, pulp and paper products, and basic metals.

Currently, there are no regulatory restrictions to control the source or quantity of water used in industry Consequently, industry is currently not in a position to reduce water consumption or recycle used water (MOE/Dar Al-Handersah, 1996). The study by Dar Al-Handersah (1996) found that only one establishment out of 173 surveyed was equipped with recycling facilities.

2.5.2 Domestic and Industrial Wastewater

(1) Wastewater Collection Service Level

In the Damage Assessment Report in 1992, the population connected to sewer was estimated to be 1,945,000 and about 50 % was covered. According to the survey conducted by Bureau of Central Statistics (BCS), 58 % was covered in 1997. In the CAS surveys (1996-98), 37 % was covered. The detailed tables are presented in Annex.

In the Survey on the Quality of Potable Water (NWRU/AUB 1998), a sample survey on potable water quality was conducted and wastewater disposal systems were surveyed (Table 2.5-5). Sewer coverage rate in 1996 was estimated to be 36 %. Compared to the situation in 1992, the sewerage network coverage decreased by 8 %.

The remaining population (62 %) either use cesspools and septic tanks or simply release raw sewerage directly into the environment, including rivers and streams, dry river beds, and underground (though dry wells). Since 1997, extensive wastewater works have been achieved, which has presumably improved the wastewater collection capacity. The current extent of buildings connected to sewer networks is not known, but presumably higher than 1996-97 levels (MOE/LEDO, 2001).

Table 2.5-5 Type of Wastewater Disposal Systems

Type of disposal system	Percentage (%) in 1992	Percentage (%) in 1996
Sewerage network	44.0	36.2
Open bottom "Cesspools or septic tank	56.0	63.8

Source: Survey on the Quality of Potable Water (NWRU/AUB 1998)

Table 2.5-6 presents comparison of sewer coverage between in 1982 and 1996-8. In Mount Lebanon and North Lebanon, the coverage was decreased. This is mainly due to the fact that the population has increased but the sewer faculties remain same.

Table 2.5-6 Sewer Coverage

Source	National Wastewater Master Plan 1982		1996-98 CAS studies
Region	Number of communities	Population covered	
North	29 (5.8 % of total)	46 % (90 % in Tripoli)	36 %
Greater Beirut			
Mount	64 (20 % of total)	54 %	45 %
South	6 (1.4 % of total)	21 %	26 %
Nabatiye	6 (4.7 % of total)	14 %	19 %
Bekka	15 (5.8 % of total)	28 %	30 %
Total	121	50 %	37 %

(2) Wastewater Management

There is currently no operational municipal wastewater treatment plant in Lebanon, with exception of Ghadir facility, which performs preliminary or physical treatment only, and sewers discharge directly to either surface water or the sea. Outside the urban areas where there is no established sewer system, discharge is generally to watercourses or, for coastal areas, direct to the sea.

Most networks are old, requiring urgent replacement. The accelerated rate of urbanism was not matched by adequate construction of wastewater collection networks. This resulted in overburdening and clogging by debris of the network. The general trend for wastewater management in urban areas along the seashores, where the greater majority of the population resides has been limited to a deteriorated wastewater collection system that typically discharges into the sea. In other urban, as well as rural areas, untreated wastewater is directly dumped into rivers, irrigation channels, valleys, and ravines, as well as septic systems and then land disposal (CDR/LACECO, 2000). A summary of disposal routes of the existing sewer system is attached in Annex.

(3) Industrial Wastewater Discharge

As there are no adequate wastewater networks, most industrial establishments, except those located in Tripoli and Beirut, tend to discharge their waste illegally and informally into adjacent rivers and water bodies hence posing a serious threat to the water quality. Industrial by-products are also discharged through wastewater discharge. Discharged products are of all kinds. Their toxicity is variable and their origins are diverse such as electrolysis water, acids special to certain industries, cyanides, organic solvents, ketons, phenolic products, alcohols, etc. The most polluting industries in Lebanon are chemical fertilizer industries, tanneries, dairy industries, paper industries and cement industries. These discharges are considered as dangerous water pollution sources. The high cost of such treatment incites the industries to get rid of their waste in an illegal and careless manner (MOE/LEDO, 2001).

The existing practices of dealing with the industrial wastewater discharges have in general been found to fall into one of the following categories (MOE/Dar Al-handasah, 1996):

1) Discharging directly into a nearby river, as in the case at Kfarchima/Chouifat in Mount Lebanon, where the existing leather tanning industries dump their wastes into Nahr El-Ghadir. Similarly, at Jdaide also in Mount Lebanon where the existing quarries dump their wastes into Nahr El-Mout. This practice is widely used by almost all existing industries regardless of their location, type of production, or extent of activities. Besides, no pre-treatment facilities are incorporated.

2) Discharging into an underground cesspool or soakaway system, from which liquid wastes seep through the underground soil formation. This practice has been found to have a very limited application and is used in industries which are relatively old or lack a proper access to a nearby watercourse.

3) Discharging into nearby low lying areas which form naturally built lagoons from which the liquid wastes would either evaporate into the surrounding atmosphere or seep into the underlying soil formation. This practice has been found to have a very limited application and is used only in Mount Lebanon where the liquid wastes from a company is discharged into a small creek which leads to a natural ponding area. This ponding area also receives storm water from the surrounding areas.

4) Discharging directly to the seashore generally via short coastal outfalls. This practice is being used by almost all industries that are situated in the coastal areas.

5) Discharging into an existing sewage collection system. Industry in urban areas such as Greater Beirut and Tripoli generally discharges to the municipal sewer system. It should be borne in mind that where industrial discharges to sewer ultimately enter watercourses, the industrial effluent would generally be an admixture with large quantities of untreated domestic wastewater, which would itself have an adverse effect on local water quality.

Treatment of potentially polluting wastewater prior to discharge is very limited. Visible evidence of contamination by, for example, oily material, suspended solids and foams may be observed in discharges from certain industrial premises. It is understood that organic liquids, such as used solvents and waste oils, are on occasions dumped into sewers, watercourses or spread on land. There is currently no enforcement of the legislation that relates to industrial waste management (MOE/Dar Al-handasah, 1996). Major locations where adverse water and environmental quality impacts caused by industrial waste have developed and its descriptions are presented in Annex.

(4) Wastewater Treatment Facility

Currently, in Lebanon there is only one operated wastewater treatment plant (Ghadier) in South Beirut. The treatment process is preliminary treatment only, screening. However, plans for rehabilitation and construction of wastewater treatment plants have been finalized and are in the process of implementation. Table 2.5-7 summarizes expected operation year and capacity of treatment plants and more details are presented in Annex. These plants are expected to be operational around 2004 to 2007 with a total capacity of 585,000 m^3/day. Treated wastewater or reclaimed water in these plants could be a potential water resource. Potential uses in Lebanon include Crop irrigation, Industrial, greenbelt, park irrigation, recreational impoundments, forest irrigation, groundwater recharge, control of sea water intrusion into coastal groundwater basins, stream flow augmentation. Also collection and proper treatment of wastewater will reduce degradation of water quality of pristine water resource.

Table 2.5-7 Expected Operation Year and Capacity of Wastewater Treatment Plant

No	Cazas	Plant	Capacity (m^3/day)	Inhabitants (person)	Horizon	Expected Starting Year
1	Akkar	Michmich	7,400	49,500	2015	2007
2	Tripoli	Tripoli	134,500	821,000	2010	2006
3	Batroun	Chekka	2,700	18,000	2015	2005
4	Batroun	Batroun	2,900	19,100	2015	2005
5	Greater Beirut	Dora	181,000	1,200,000	2015	2007
6		Ghadir	146,600	977,000	2015	2007
7	Jbail	Jbail	5,300	35,500	2015	2005
8	Chouf	Ras Habi Younis	6,240	44,000	2015	2005
9		Mazraat Chouf	30	200	2020	2006
10	Saida *	Saida	36,700	282,308	2030	2005
11	Nabatieh	Nabatieh	8,228	74,800	2015	2005
12	Zahleh	Zahleh	37,000	206,600	2015	2005
13	Baalbek	Baalbek	12,412	88,660	2020	2004
14	Karaoun	Karaoun	3,600	24,000	2015	2005
15	Total		584,610	3,840,668		

Note: *. Pretreatment only

Source: MEW, General Directorate of Hydraulic & Electric Resources, May 2001 and SIU figures

(5) Wastewater Reuse

Final disposal sites of wastewater are presented in Table 2.5-8. About 10 % of the wastewater is disposed on land and used directly for irrigation without any filtration and treatment (NWRU/AUB, 1998). However, in most of the agricultural areas such as Akkar plains and the Bekaa, wastewater discharged into irrigation canal or watercourse is finally used for irrigation.

Table 2.5-8 Final Disposal Sites of Wastewater of Sewerage System

Sites	Percentage in 1992 (%)	Percentage in 1996 (%)
Land	59	43.6
Water bodies	41	51.3
Unspecified	-	5.1

Source: (NWRU/AUB, 1998).