WATER: THE MIDDLE EAST IMPERTATIVE

THE LITANI RIVER: HYDROLOGY AND MANAGEMENT (1987)

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Chapter 1

INTRODUCTION

In order to understand the nature of the Litani and its role both in Lebanon and in neighboring countries, it is necessary to suspend one's knowledge of the political chaos which now grips that country and treat the subject, initially, as though the more stable years of the 1950s and 1960s still existed. During that period there was an intense and rational effort to work out a comprehensive management scheme not only for the Litani but also for the other rivers of Lebanon vis-a-vis the several demands increasingly placed upon them. The result of this was the beginnings of a unified system of resource management in South Lebanon the intricacy of which might be compared to the workings of a complicated watch rather than to the simple turning on and off of flow through the sluices of one or two dams.

This effort was formalized by the government of Lebanon through its Decree Number 14.522 of 16 May 1970 which defined the disposible water resources, fixed priorities regarding them, and determined the rules for their being shared(3122) in an area essentially south of the Beirut-Damascus Road. In 1972 a cooperative effort was made by the Food and Agriculture Organization of the United Nations and the National Office of the Litani (ONL/FAO) to thoroughly investigate and analyze the many aspects that such development entailed.

These reports, which will be referred to in the pages that follow, establish a base line from which further historic events concerning the river can be evaluated. Once such a line has been drawn it becomes possible to consider the Litani in 1987 and what may become of it in the years ahead. Because of the very poor information currently available -- due to the civil war and Israeli invasion -- such a strategy is not easy to follow. Therefore, unlike many studies, speculation and uncertainty must of necessity increase when considering the present situation. Nevertheless, it is believed that the description and analysis that follow will provide a useful and essentially accurate picture of the Litani and its uses.

Chapter 2

THE IMPORTANCE OF THE LITANI IN THE DEVELOPMENT OF LEBANON

As with many rivers, the Litani's waters serve four distinct purposes: domestic, industrial, hydroelectric production and irrigation. Within Lebanon domestic consumption, though increasing, uses relatively small amounts of water drawn from sources near the point of consumption. While this will change in the future, for the time being Beirut and other population centers along the Mediterranean shore face special problems which do not engage the use of Litani waters in the interior. The general situation regarding the waters of the Litani vis-a-vis water use for domestic and industrial purposes in Lebanon can be briefly summarized.

It has been estimated(3092) that the total annual volume of surface and underground water consumed in Lebanon just before the civil war (1975) reached approximately 854 Mcm, that is 23% of the available reserves in the country. The sources of this water were 62.8 percent from surface water and 37.2 percent from underground water (Table DL-1).

2.1 Domestic Use of Water

The sub-regions of Lebanon directly concerned with the management of the Litani include not only the basin of the Litani itself (particularly the Bekaa Valley), but also the coastal zone from Beirut to the southern frontier, the metropolitan area of Beirut, and the area between the lower Litani (referred to locally as the Qasmieh; that is, the east-west flowing section upstream from the river's mouth) and the southern border with Israel. Coastal and mountain areas north of Beirut and the northern Bekaa Valley are and will be served by independent sources of water (in the latter case the Orontes/Asi). The former areas represent the greatest concentration of population within the country, and Beirut in 1970 contained 23 per cent of the country's total population, (Beaumont, Blake and Wagstaff, *The Middle East*(1440), p. 205), about 700,000 people. Also in 1970, the three southern regions centered on Sidon, Sur, and Marjayoun included 558 villages and had another 731,000 inhabitants(3122) (This figure increased to 851,000 (+16%) during the summer months.) The population of the Bekaa was and is considerably less (unavailable for this analysis). In any event, such domestic water needs as exist there are served by local sources.

In 1972 domestic water use in the three southern areas totaled 26.5 Mcm. (26.7 calculated by author for this report). This was about 100 liters per day per inhabitant but losses in the system amounted to at least 35 per cent. This left about 65 liters per person per day on the average. Rural areas, however, suffered considerable shortages, particularly in the summertime. South of the Litani per capita shares of 25 to 40 l/d were common, with less in the summer; in the Barouk mountain zone to the north this figure was about 60 l/d.

The city of Beirut in 1970 used about 190,000 cu m/d (68 Mcm/yr; 69.4 Mcm calculated by author). With losses of about 35 per cent, each inhabitant on the average received 140 l/d. By summer's end shortages developed and poor neighborhoods suffered accordingly. The bulk of this water came from the Jeita Spring (105,000 cu m/d). (All data in these sections comes from ONL/FAO(3122) unless otherwise noted).

According to the 1972 studies, population in the southern areas will reach 1,700,000 by the year 2000. Similarly, Beirut was expected to double in size by the same date (1,800,000). An increased net per capita water consumption in the south to 120 l/d would increase total use to 80.7 Mcm/yr.[1] In Beirut water use would increase to 245 l/d with an additional estimated loss of 18 per cent resulting in an overall need of 195 Mcm/yr (196.3 Mcm/yr calculated by author). All these estimates, however, must be viewed from the perspective of the violence which has taken place since they were made. Since that time there has been a negative growth rate for the country as a whole (-0.5/1975-80 and -0.2/1980-85)(1467). What impact this will have on long term water demands depends very much on whether peace returns to the area and how soon.

In order to meet the projected domestic water needs of both Beirut and the southern populations 80 Mcm was scheduled for the south and 63 Mcm (out of a total 195 Mcm) for Beirut, as shown on Table DL-2.

From the estimates given on Table DL-2, it can be seen that the Litani's direct share in meeting increased domestic needs would be from 27 Mcm to 38 Mcm/yr. In addition to this amount would be whatever increased population and upgraded consumption standards would demand in the Bekaa itself.

2.2. Industrial Water Use

Only one reference to industrial water use was available for this analysis(3092) and it is cursory. However, considering the nature of the Lebanese economy both before its disruption and at present, industrial water use was and is of little consequence. The reference cited above indicates that water used for industrial purposes amounts to about 35 Mcm/yr; that 20 to 30 percent of the plants have closed and that there has been very limited development in the remaining industries.

2.3. Hydroelectric Production

There are twelve power stations established on six rivers in Lebanon. Their total power is estimated to be 275.3 MW (Table DL-4). A complete record of electric power production in Lebanon is not available for this analysis. Some idea of the role of hydropower and particularly of the Litani within the overall system can be gained from the data at hand. Table DL-3 shows the source of electric energy in Lebanon for the years 1982-85.

The summary report of the 1972 joint ONL/FAO effort states that whereas hydroelectric power constituted 50% of Lebanon's total production in 1972, thermal production would continue to increase while water power, having taken advantage of most of the available sites in the country would remain unchanged in an absolute sense(3122). Overall power production was estimated to increase at 10 per cent per year. Thus, water power's share of the total would regress to 31% in 1980 and to 11% in 1990. Comparison of this estimate with the data shown in Table DL-3 indicates that it was essentially correct (e.g. est. 1985 -- by extrapolation -- 21%; actual share of water power, 1985 -- 17.2%). (It should be noted that the source of power sold to Syria is unspecified in the available reference, but that regardless of its origins the above comments would remain consistent).

Slightly more than two-thirds of all the hydropower produced in Lebanon came from the Litani-Awali system (Table DL-4) which will be described in Section 6.3. This in turn would represent about 11.7 per cent of the country's total power production in 1985 (see Table DL-3). It was estimated in 1974 that these three power plants produced 1.7 kWh for each cubic meter of water passed through the system. This is the equivalent of 475 g of fuel necessary for thermal generation, and would represent a saving on imported fuel oil.

But the most important aspect of the Litani power plants is their ability to come on and off line (i.e. production) with little or no lag time, unlike thermal generators which need several hours to fire up. Thus, despite the decreasing share of power provided by hydroelectric sources, their role -- and particularly that of the Litani-Awali system -- will remain useful if not critical for meeting peak load demands.

2.4. The Role of Irrigation Water

While irrigation within the Litani basin and its neighboring areas will be treated in greater detail below, at this point the importance of the Litani to the overall irrigated agriculture of Lebanon becomes apparent with reference to Table DL-5. In this table, the Bekaa Valley -- which in this instance represents the area essentially south of the Beirut-Damascus Road -- accounted for 43 per cent of the total irrigated cropland in Lebanon in 1985. To this can be added another 24 per cent in southern Lebanon which is closely tied to water availability in the Bekaa (see below).

"During the ten years of civil war irrigation using surface water has increased on the average at the rate of 1.2% per year, and irrigation using underground water has increased at an annual rate of 1.7% per year. In this period 930 ha/yr were newly irrigated. The areas currently irrigated represent 7.6% of the total land in the country and almost 25% of the agricultural areas. The most important expansion of the irrigation system was in the Bekaa and along the coastal area of southern Lebanon. The expansion of irrigation developed without any governmental assistance."(3092)

The preeminence of the Litani within the overall developmental scheme anticipated for Lebanon[2] is abundantly clear from the above discussion. In order to further understand the position of the river and its basin within the country it is now necessary to examine the general physical geography of the nation.

ENDNOTES

1. The derivation of this figure is uncertain. Computations for this report indicate approximately 93.0 Mcm before losses of 20 % or 74.4 Mcm after their deduction. The figure 80.7 occurs several times in the ONL/FAO text.

2. The range and complexity of state planning which involves the Litani can be appreciated by reference to the American plan first presented in 1954 (*Development Plan for the Litani River Basin*, Vol. I, U.S. Department of the Interior, Bureau of Reclamation, Foreign Operations Administration(2740)); by further reference to: the summary of the 1972 ONL/FAO study(3122), and to the World Bank's *Lebanon Reconstruction Assessment Report*, March 25, 1983(0910).

Table DL-1

DISTRIBUTION OF WATER CONSUMED IN LEBANON -- 1975

Utilization	Surface Water Volume in Mcm	%	Groundwater Volume in Mcm	%	Total Consumed Volume in Mcm	%
Irrigation water	422	79	247	78.3	669	78.4
Domestic water	105	20	40	12.3	145	16.9
Industrial water	10	1	30	9.4	40	4.7
TOTAL	537	100	317	100.0	854	100.0

Source: Engineering Report(3092), p. 6.

Table DL-2

PROPOSED SOURCES OF DOMESTIC WATER IN LEBANON -- 1972

Source		Volume
From southern wells		37 Mcm
From the Bizri River and the Jezzine grotto		55 Mcm
Qirawn Reservoir	(for the south)	17 Mcm
	(for Beirut)	5 Mcm*
Khardale Reservoir (proposed)		5 Mcm
Beit ed-Dine Reservoir		24 Mcm
TOTAL		143 Mcm

Source: ONL/FAO(3122), p. 43.

* To be increased to 16 Mcm in dry years.

Table DL-3

POWER PRODUCTION IN LEBANON

Year	Thermal kWh	Thermal %	Hydroelectric kWh	Hydroelectric %	Bought by Syria (source unspecified) kWh	Bought by Syria (source unspecified) %	Total kWh
1982	1792	71.9	576	23.1	125	5.0	2493
1983	1812	64.1	919	32.5	94	3.4	2825
1984	1686	62.1	984	36.2	46	1.7	2716
1985	2599	81.6	547	17.2	39	1.2	3185

Source: *Journal en Nahar*, 6/7/86, p. 7. (cited in Engineering Report[3092], p. 9.)

Table DL-4

HYDROELECTRIC POWER PLANTS IN LEBANON

Sub-region*	River	Power Plant	Starting Date	Power (MW)	% Total	Volume of Turbine Water Mcm
North Lebanon	Jaouz	Kaftoun	1954	5.00	1.8	46
	Abu Ali	Kadisha	1929	1.60	0.6	11
	Kadisha	Mar-Lisha	1958	3.10	1.1	20
	Abu Ali	Blaouza	1961	8.40	3.1	48
	Abu Ali	Kousba	1972	7.40	2.7	44
	el-Bared	Bared I	1954	13.50	4.9	148
	el-bared	Bared II	1961	3.70	1.3	52
		sub-total			15.5%	
Mount Lebanon	Ibrahim	na	na	32.48	11.8	na
	es-Safa	na	na	13.12	4.8	na
		sub-total			16.6%	
Litani Basin and Transfer	Litani	Markabeh	1962	34.0	12.4	317
	Awali	Awali	1965	105.0	38.1	282
	Awali	Joun	1968	48.0	17.4	377
		sub-total			67.9%	
Total for Lebanon				275.3	100.0%	

Source: *Journal en Nahar*, 6/7/86, p. 7. (cited in Engineering Report(3092), p. 9).

* No current map of the electrical grid in Lebanon was available for this analysis. However, some idea of the regions involved and of their interrelations can be gained from Appendix B, which contains materials from the original U.S. Department of the Interior report(2740). Of special interest is Map A and accompanying Table J. Also included in this appendix are Maps B and C showing projected energy needs and proposed power grid as designed by the American group.

Table DL-5

DISTRIBUTION OF IRRIGATED LAND IN LEBANON -- 1975 AND 1985

		Area Irrigated by Surface Water		Area Irrigated by Underground Water		Total Irrigated Area	
Region	Year	ha	%	ha	%	ha	%
North	1985	12,600	26.7	4100	14.1	16,700	21.9
Lebanon	1975	11,500	27.3	3400	13.8	14,900	22.3
Mount	1985	8100	17.2	240	0.8	8340	10.9
Lebanon	1975	7400	17.5	200	0.8	7600	11.4
Southern	1985	8900	18.9	9300	32.1	18,200	23.9
Lebanon	1975	8100	19.2	7800	31.6	15,900	23.8
Bekaa: Total	1985	17,600	37.2	15,360	53.0	32,960	43.3
Bekaa: Total	1975	15,200	36.0	13,300	53.8	28,500	42.6
Central	1975	10,600		7500		18,100	27.1
Southern	1975	4600		5800		10,400	15.5
Total	1985	47,200	100.0	29,000	100.0	76,200	100.0
Lebanon	1975	42,200	100.0	24,700	100.0	66,900	100.0
Increase 1975-1985		5000	11.8	4300	17.4	9300	13.9

Source: Engineering Report.(3092)

Chapter 3

PHYSICAL GEOGRAPHY OF LEBANON

3.1 Climate and Precipitation

Lebanon lies at the extreme eastern end of the Mediterranean Sea, between 33°5' and 34°40' N latitude (See Map 1). It is in a transitional zone which receives rain bearing westerly winds in the winter, but with the northward shift of the jet stream in the summer, Saharan conditions of cloudless skies and zero precipitation prevail in June, July, and August, while scant rainfall occurs in May, September, and October. Snow is common in the winter months at higher elevations, but the coastlands and the interior valley of the Bekaa seldom have temperatures below freezing. Generally speaking, a Mediterranean climate (Koppen Csa, humid mesothermal, dry summer) prevails with increasing continentality as one moves eastward across the Bekaa and Anti-Lebanon mountains toward Syria with its mid-latitude, sub-tropical steppe and desert conditions.

Atmospheric moisture driven eastward across the Mediterranean during the winter months rises against the west-facing slopes of the Lebanese mountains, providing heavy precipitation (up to 1800 mm) on the highest elevations (Maps 1 and 2). The Bekaa Valley lies in the rain shadow of the Lebanon Mountains and receives markedly less precipitation; the divide between the Litani and Orontes Drainage (in the Bekaa -- Map 3) receives barely 600 mm in an average year, while the lower portions of the Orontes Valley to the north receive far less. The west facing slope of the Anti-Lebanon Mountains has slightly more precipitation than the Bekaa itself. Beyond the Anti-Lebanon, only a few miles farther east, the Syrian steppe and desert prevail, while southward even before the northern border of Israel is reached precipitation is less than 600 mm annually. Table PG-1 shows the distribution of yearly precipitation averages, while Graph RS-2 displays the annual march of precipitation and aridity throughout the country. More detailed precipitation data can be found in Appendix A.

The precipitation through this region has a marked seasonality. Graph RS-2 shows how everywhere in Lebanon relatively heavy winter rains are followed by up to four months, from June through September, when no rain at all falls. This effect is especially marked in the Bekaa Valley and presents special problems vis-a-vis irrigation and the provision of water for drinking as well as power generation.

3.2. Geology and Hydrology

The principal physiographic regions of Lebanon consist of a coastal plain, underlain by a prism of seaward-dipping Cenozoic sediments on which is superimposed a discontinuous cover of Quaternary littoral sediments, and an orogenic highland of deformed Mesozoic carbonate rocks that rises to 2500 m above sea level in the parallel ranges of the Lebanon and the Anti-Lebanon Mountains. Between these mountain ranges lies the Bekaa Valley bounded along its major north-south axis by faults which are extension of the Dead Sea rift zone. The Bekaa is floored by Tertiary and Quaternary sediments. The coastal plain and the west facing slopes of the Lebanon Mountains drain directly to the Mediterranean. Precipitation that falls within the Bekaa and on the valley-facing slopes of the flanking ranges makes its way to the Litani in the southern part of the Bekaa and to the Orontes (Asi) in the northern part. The Litani flows southwest down the axis of the valley before turning west to skirt the southern end of the Lebanon Mountains to reach the Mediterranean. The Orontes drains the northern half of the valley and debouches to the Mediterranean having first flowed through both Syria and Hatay Province in Turkey.

The lithology of this region accounts in large part for the unusual flow characteristics of Lebanon's rivers. Soluble, heavily fractured limestones of the Turoenien-Cenomanien (Middle Cretaceous) formation are underlain by aquicludes which prevent the deep percolation and escape of the rains which fall on the Lebanon and Anti-Lebanon Mountains (Diagram PG-1). Similar formations overlay the Cenomanien, which while less capable of storing water, provide significant amounts to the springs bordering the valley.[1]

3.3. Groundwater

Groundwater resources in the Litani basin are attributed to the following aquifer systems which are shown on Diagram PG-2 and in part on Maps 4 and 5.

1. The Neogene-Quaternary aquifer in the upper Bekaa Valley and its connections to the Jurassic aquifer at Amiq (B-8).

2. The Jurassic aquifer at Barouk-Niha (C-1).

3. The Cretaceous aquifer at Jezzine (C-4).

4. The Eocene aquifer of Nabatiya-Ghandouriye (D-5a).

5. The Middle Cretaceous aquifer of the western cliff (D-3).

6. The Eocene aquifer of the coastal plain (D-5b).

7. The Quaternary aquifer of the coastal plain (not shown).

According to Abd El-Al (0382) the two massifs on either side of the Bekaa constitute upthrust horsts with an intervening graben (the Bekaa). The raised limestone blocks are heavily fractured and contain extensive karstic features such as caverns and channels. All in all, they create vast reservoirs for the heavy winter rains. He suggests that the major springs of the area of the Vaucluse type; that is, they emerge at the lowest points of the massif as overflow mechanisms because the entire structure is full, rather than because the flow of underground waters has met some barrier.

Abd El-Al has computed the reserves of several of the springs feeding the Litani River. Of those on the west slope of the Anti-Lebanon Mountains the Anjar Spring is most important. It receives its water from the Cenomanien plateau lying above it and surfaces where the formation dips beneath the recent alluvium of the Bekaa Valley floor (Diagram PG-3a). It is estimated that about 48 Mcm reserves compensate for flow from the spring. The *curve of exhaustion* indicates the rate which the spring would be exhausted if no rain were to restore its reserves.

The Khraizat and Barouk Springs are typical of those of the Lebanon massif. The former spring rises along the throw of the fault which delimits the western edge of the Bekaa. The source of water for this spring is not established but is probably water circulating along the fracture itself. The Barouk Spring owes its flow to the Jurassic formation upon which it is found. The reserves of the Barouk are estimated at slightly more than 27 Mcm, and those of the Khraizat at only 6.4 Mcm (Diagram PG-3b). The Safa Spring (Diagram PG-3c) is similar to the Barouk and apparently feeds from the same flow of underground waters. It surfaces where the formation dips beneath overlying, younger strata and has a reserve of about 30.4 Mcm. To the east at the west edge of the Bekaa are the Amiq Spring and Kob Elias wells. These surface at the western edge of the alluvial fill. (No estimated reserve is available for these latter sources.)

ENDNOTES

1. A transitioinal formation apparently exists between the Senonien of the Upper Cretaceous and overlying Miocene formations. The Eocene is present in parts of the Bekaa but not everywhere. This transitional formation is referred to by Vaumas as the Nummulithique and is shown as such in Diagram PG-1. A complete stratigraphic sequence of this region is found in Appendix C.

Table PG-1

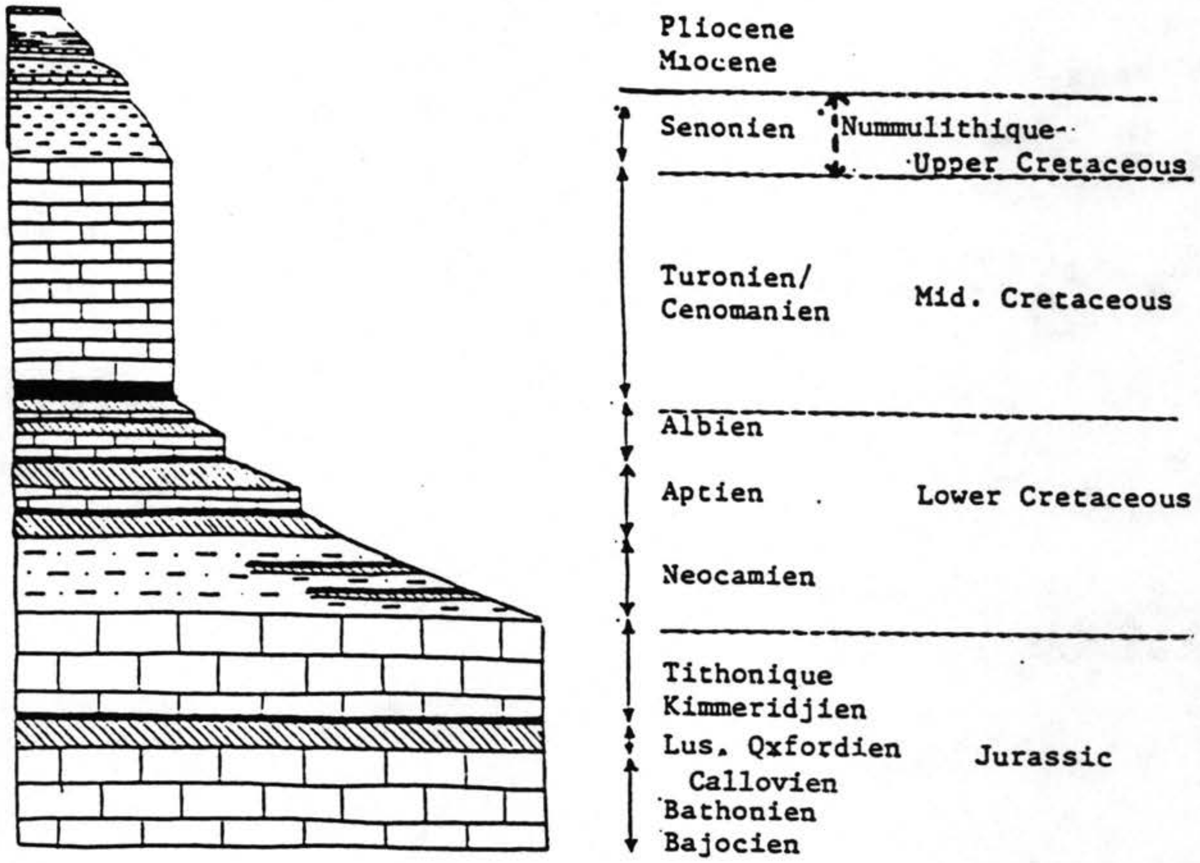
YEARLY RAINFALL IN LEBANON (AVERAGES)

Station Name	Altitude (m)	Years of Observation	Yearly Average (mm)	Average for 1939-40 to 1970-71 (mm)
1. North Batroun	20	30	1024	1035
2. Ghazir	390	22	1085	1108
3. Suq Mikayel	70	28	901	901
4. Arbaniya	510	12	1299	1256
5. A.U.B.	34	95	899	926
6. St. Joseph University	45	20	885	887
7. Beirut Airport	15	18	740	757
8. Suq el-Gharb	790	23	1184	1192
9. Jisr el-Qadi	260	22	1108	1132
10. Keter-Maya	380	6	796	788
11. Sidon	5	6	690	678
12. Sfaray pilot section	570	10	1016	940
13. Deir Zahrani	450	6	1089	994
14. Arab Salim	580	6	1020	1010
15. Qasmieh (Litani mouth)	30	24	676	660
16. Ain Ebel	766	12	802	775
17. Aitaroun	680	32	787	787
18. Insariya	160	7	730	656
19. Duwier	380	10	931	860
20. Nabatiya	410	7	928	834
21. Tyre	5	6	704	627
22. Jouaya	300	6	726	719
23. Qana	300	4	631	618
24. Jarmaq	400	6	978	969
25. Qlaya	1050	28	1210	1211
26. Bikfaya	900	22	1308	1336
27. Dahr el-Baydar	1510	19	1361	1381
28. Beit ed-Dine	880	31	1138	1138
29. Jezzine	945	30	1380	1352
30. Rihan	1090	4	1194	938
31. Hermel Bekaa	700	32	239	239
32. Jamouneh	1370	31	982	995
33. Baalbek	1150	31	406	407
34. Qaa el-Rim	1320	32	1294	1294
35. Tel Amara (agr. research)	905	18	618	632
36. Ksara	920	50	634	650
37. Chtaura	920	19	833	845
38. Taanayel	880	5	879	?
39. Anjar	925	31	531	527
40. Mansura South Bekaa	860	33	632	637
41. Joub Jannin	920	25	720	720
42. Qirawn village	950	16	675	680
43. Mashghara	1070	28	1462	1396
44. Terbol	890	3	804	604
45. Qirawn Dam	950	9	1151	1066
46. Markabeh	670	5	1256	1040
47. Hasbaya	750	27	1030	1037
48. Marjayoun	760	25	894	885
49. Deir el-Ashayer	1280	5	754	649
50. Rashaya	1235	25	847	847

Source: UNDP, Annuaire des precipitations mensuelles at annuelles du Liban (Beirut, 1973).(2986)

Diagram PG-1

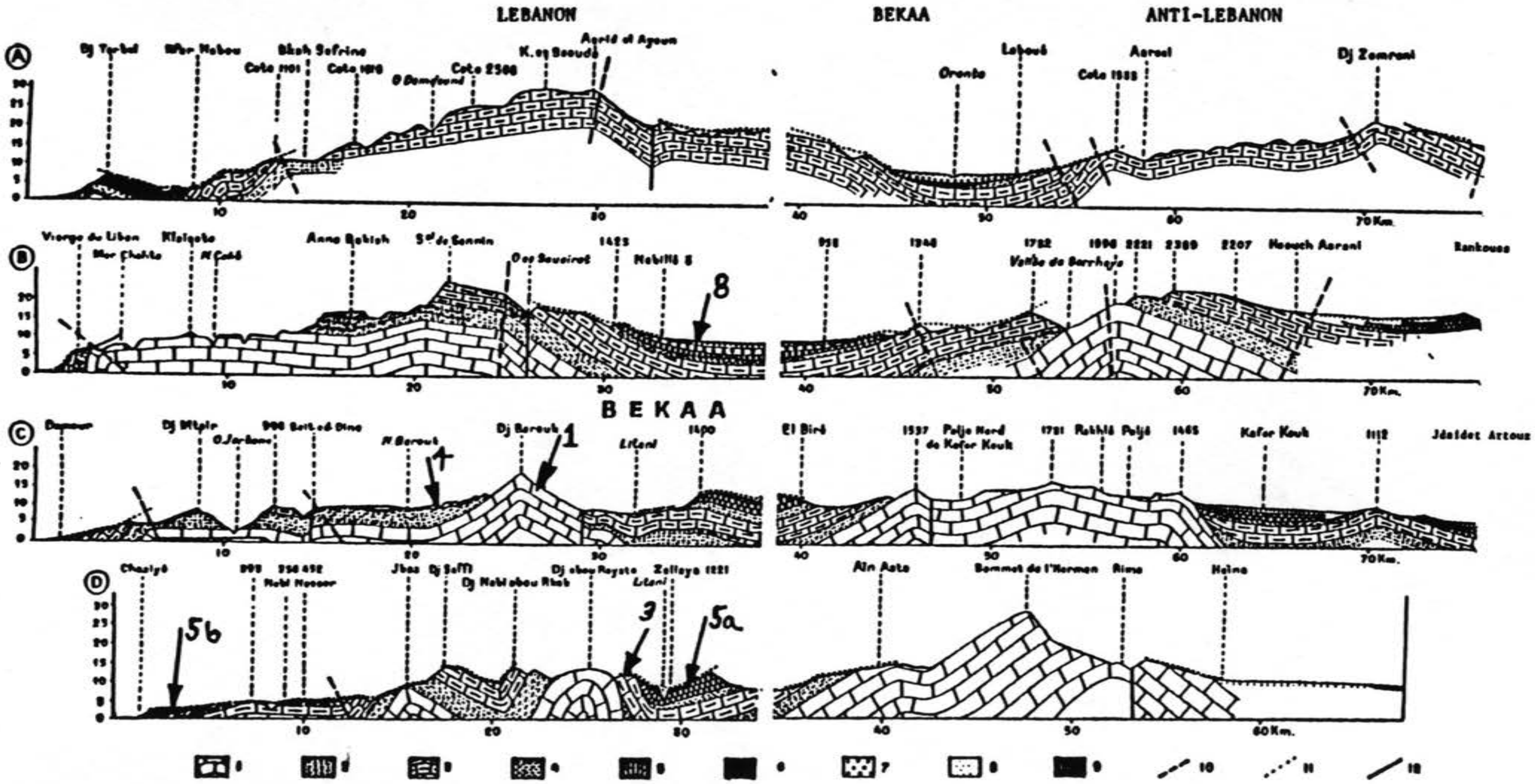
LITHOLOGY OF AQUIFERS AND SPRINGS IN THE LITANI BASIN



(Solid layers represent aquicludes)

Source: Vaumas(3290,3291), pp. 26-27 and 237-239, respectively.

Diagram PG-2: STRUCTURE AND LITHOLOGY OF THE LEBANON, BEKAA, AND ANTI-LEBANON



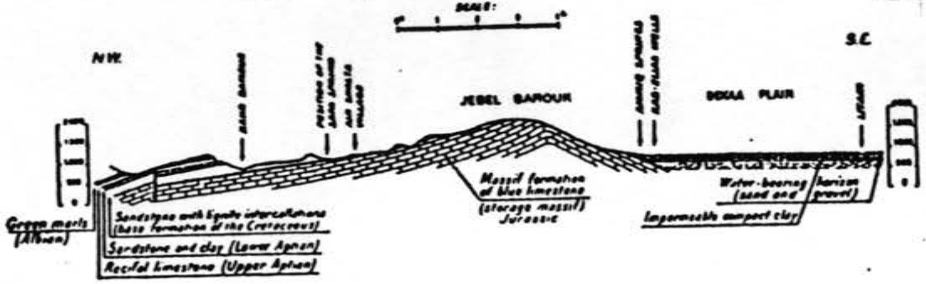
Cross-sections west north-west, east south-east across the Lebanon, the Bekaa, and the Anti-Lebanon from north (A) to south (D). 1. Jurassic; 2. Lower Cretaceous; 3. Cenomanian-Turonian; 4. Senonian; 5. Nummulitique; 6. Miocene; 7. Upper Neogene; 8. Alluvial; 9. Basalts; 10. Folding axes; 11. Cyclic pattern; 12. Fault.

Source: Birot and Dresch$^{(3282)}$Vol. 2, pp. 214-15.

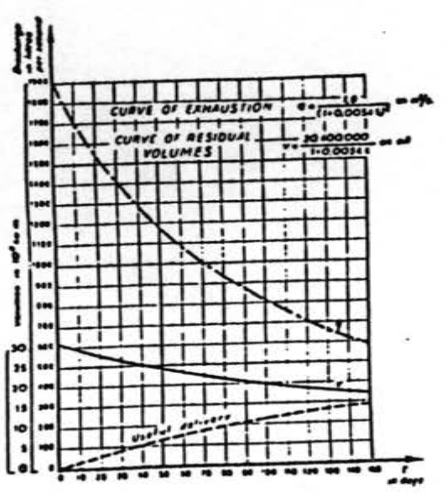
Diagram PG-3

MAJOR SPRINGS OF
THE LITANI

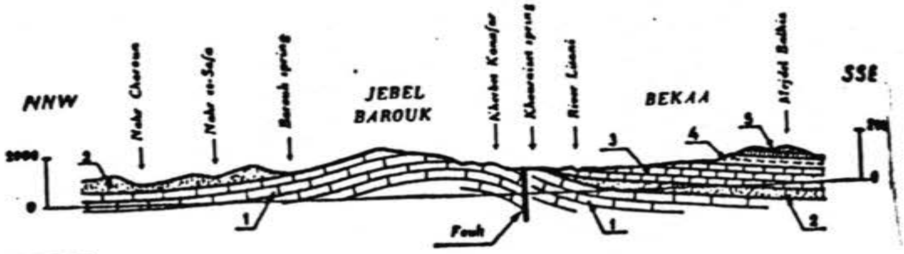
Section showing the mode of emergence of the Safa Spring



C



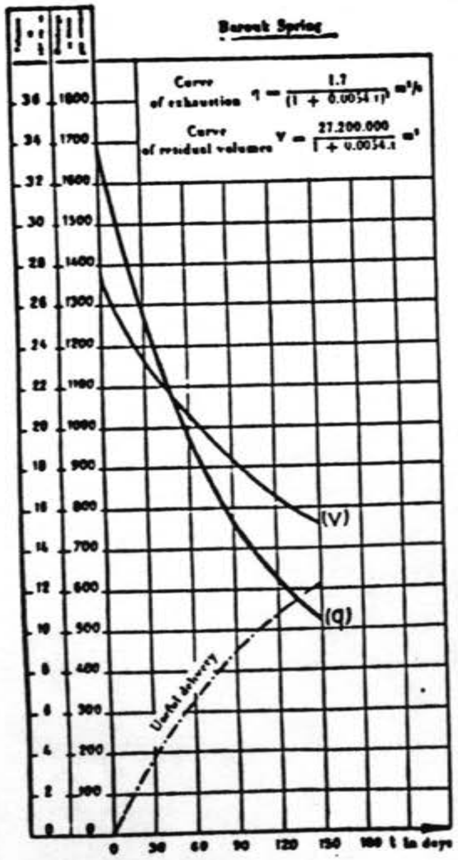
Barouk and Khoursizat Springs



Section showing the formation of both springs

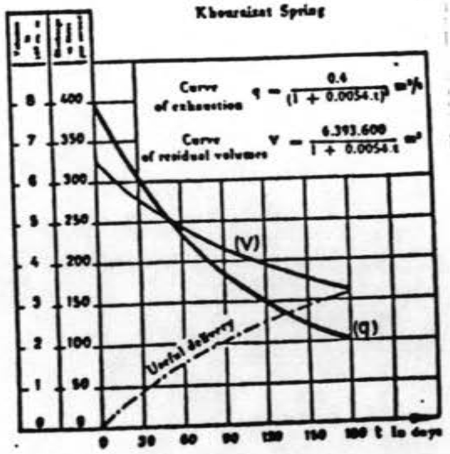
1. Fissured limestone massif (upper Jurassic).
2. Sandstones and clays with limestone and marl benches (lower Cretaceous).
3. Fissured limestone massif (Cenomanian).
4. Chalky withe marls (Senonian).
5. Marls, limestone and white subrecifal limestone (middle Eocene).

Barouk Spring

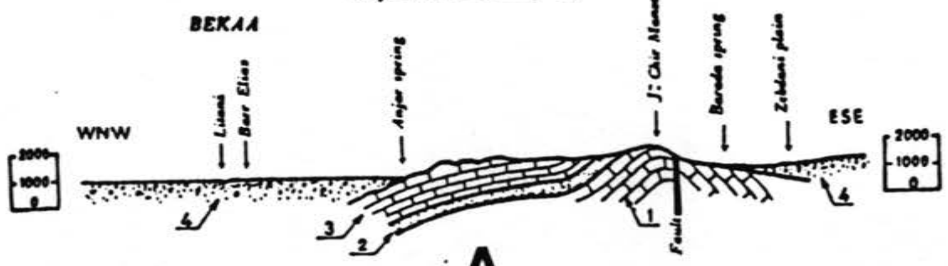


B

Khoursizat Spring



Anjar and Barada Springs

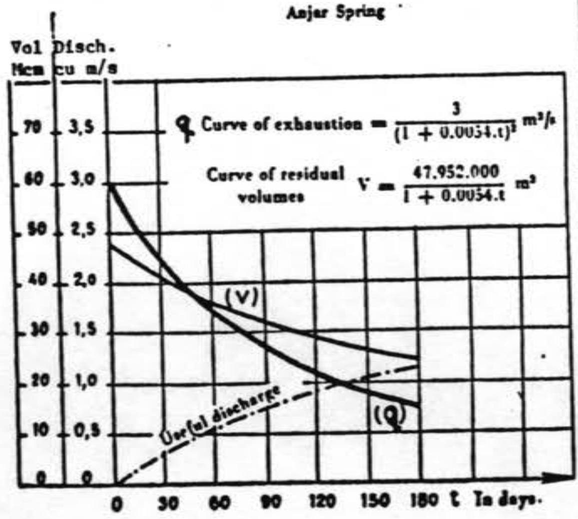


A

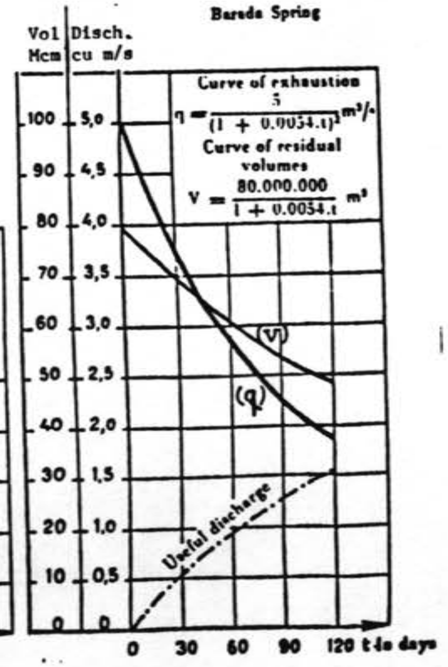
Section illustrating the formation of the springs

1. Fissured limestone massif (middle Jurassic).
2. Sandstones and clays with limestone and marl benches (lower Cretaceous).
3. Fissured limestone massif (Cenomanian).
4. Silts (Quaternary).

Anjar Spring



Barada Spring



Chapter 4

THE LITANI RIVER SYSTEM

The Litani River receives its water from three sources: springs, surface runoff during the winter months, and subsurface flow into the bed of the stream. The river rises a few kilometers west of Baalbek in the central Bekaa Valley (Map 3). Its profile has two distinctly different parts as shown in Graph RS-1. From its source to the Beirut-Damascus Road it has a slope of from 2.5 to 4.0 percent; from there to Mansura its fall is even less -- about 1.0 percent. Within this portion it receives all its permanent tributaries; the Nahr Bardaouni, Nahr Chtaura, and the Nahr Kob Elias from the Lebanon Mountains to the west; and the Nahr Ghzayel (which in turn derives from a series of important springs: Terbol, Faour, Ain el-Baida, Massaya, Hamsine, and Anjar) from the Anti-Lebanon Mountains to the east. Shortly after passing the site of the Qirawn Dam the slope becomes greater (4.8%) and soon the river enters a gorge with even steeper gradients from 27.7 percent to 39.7 percent. Finally in its west flowing portion from Khardale to Qasmieh its gradient again becomes less steep until it reaches the sea at Qasmieh. The general configuration of the Litani and its springs and tributaries is diagrammed in Diagram RS-1. Reference to this diagram as well as to Map 3 should facilitate understanding of the discussion which follows.

4.1. Precipitation, Evapotranspiration, and the Water Budget of the Litani Basin

The extreme seasonality of precipitation in the Bekaa Valley as well as throughout Lebanon means that the water supply of the Litani occurs in the months from October through May with the preponderance falling in December, January and February (Graph RS-2). Precipitation is reflected by stream flow which peaks in February and reaches its minimum in July, August and September (Graphs RS-3 and RS-4). While many of the tributaries of the Litani are reduced to trickles or dry up entirely in the summer (see Tables Appendix A), even in dry years the Litani preserves some flow throughout the twelve months (Graph RS-3). This is attributable to the storage capacity of the Cretaceous and Jurassic limestone massifs of the Lebanon and Anti-Lebanon mountains.

Abd-El-Al (Arid Zone Programme II, pp. 60-61)(0382) points out two opposing factors which nevertheless in unison account for the above conditions. Rainfall under Mediterranean conditions is so concentrated, even torrential, that stream flow begins with a pluviousity of about 100 mm rather than 250-500 mm usually considered for this area. That is, so much occurs in a short time that runoff is almost immediate. On the other hand, the highly karstic and fissured limestones of the mountains on either side of the Bekaa permit rapid and enormous infiltration of water within a brief period of time (Map 6). The water thus stored within the massifs prolongs stream flow, while surface waters temporarily swell the streams. In the Bekaa itself, where impervious alluvial materials prevent deep percolation, a near-surface water table forms which provides additional irrigation water pumped from relatively shallow wells.

While the above description explains the general regime of the Litani River, several anomalous conditions need further clarification. Table RS-1 and Map 7 show that while the upper reaches of the river -- as far downstream as Mansura -- encompass 61 per cent of the total surface area of the basin, and receive about 58 percent of the total precipitation, only about 37 percent of the total flow of the Litani is apparently derived from this area.[1] The Mansura to Qirawn area represents 10 percent additional surface upon which about 12 percent of the total precipitation falls. However, this same stretch of river accounts for an additional 22 percent of total stream flow. By the same token, the sub-section from Qirawn to Khardale accounts for 12 percent of the total area, 13.5 percent of its precipitation but slightly less than 31 percent of the Litani's total flow. In the final section from Khardale to the Qasmieh Delta, constituting 17 percent of the total basin area, 16 percent of total precipitation, but only about 10 percent of total stream flow occurs.

In other words, the upper and lower portions of the basin, comprising 78 percent of the area and nearly 75 percent of its precipitation, account for only 47 percent of its stream flow. The central portions, with 22 percent of the area and 25 percent of its precipitation, provide over half the water found in the stream. In order to explain this anomaly the role of evapotranspiration and the lithology and structural geology of the area must be considered.

Indices of evapotranspiration vary from north to south and from east to west within the Litani basin. Thornthwaite(3128) estimates that actual evapotranspiration (AE) at Rayak (Table RS-4) may reach 75 percent of total precipitation. This figure is matched by estimates of the United Nations team (GERSAR(1939), p. 7) of 79 percent in the East Bekaa. In the central portion of the valley at Joub Jannin about 41 percent of total precipitation is lost to AE, while in the south and at the coast this figure varies between 34 and 56 percent (Table RS-4). Examples of the complete water balance are shown in Table RS-3.

The data described above have been averaged and presented in terms of available surplus in Table RS-2. The term "available surplus" must be considered to include not only run-off on the surface but also infiltration into the aquifer with subsequent reappearance as springs and subsurface additions to river flow. Comparison of the parameters of the four sub-sections of the Litani employed in this analysis (Table RS-5) brings these many measures into focus.

The upper basin, as far downstream as Mansura, is the largest sub-section and receives an almost proportionate share of precipitation. Greater evapotranspiration reduces this share somewhat, but stream flow is significantly less. From Mansura to Qirawn 10 percent of the basin receives slightly more than its proportionate share of precipitation and has a proportionate share of available surplus water. Stream flow here, however, is twice as much as might be expected. It seems reasonable to suggest that the additional water found in the Litani at Qirawn has been added by means of subsurface flow from farther up the valley.

The river from Qirawn to Khardale flows through about 12 percent of the basin and receives 13.5 percent of the total precipitation. This is easily explained by a glance at the distribution of rainfall (Map 2). A greater supply of surplus water is an expression of lower actual and potential evapotranspiration in this portion of the basin. Nevertheless, additional streamflow entering the system in this stretch is significant and must be explained by its proximity to areas of high rainfall to the west as well as by recourse to large flows of karstic water and perhaps further flow through fissured limestones along the fault at the west side of the valley. The final section of the river from Khardale to Qasmieh Delta receives a proportionate share of precipitation (16.1%) which is enhanced by lower evapotranspiration and a somewhat greater share of available surplus (21%). On the other hand, the actual flow of the river at this point is considerably less than one might expect.

Special attention should be given to characteristics of the last two sections of the river described above. First, it should be kept in mind that all the above data represent natural flow and are corrected for removals. Second, precipitation figures taken from Map 2 (Vaumas(3291)) pre-date flow figures from more recent years. Thus, total basin-wide precipitation of 1822.4 Mcm compares with the 795.1 Mcm flow reported by Vaumas (43.6%) more exactly than with the 920 Mcm derived from recent flow figures (50.4%). Respective losses to evapotranspiration would be 56.4% and 48.7%.[2] Given these considerations, the following points may be made:

1. Although there is somewhat less water than might be expected upstream, and somewhat more downstream, the total amount of water in the system is commensurate with total precipitation balanced by total evapotranspiration. Differences from sub-section to sub-section within the basin may be accounted for by massive infiltration and subsequent equally large subsurface returns.

2. Despite withdrawals for the generation of electricity on the Awali River, nearly 200 Mcm flow are added to the system below the diversion (Table RS-6).[3] This, in combination with additional water allowed downstream from Qirawn could provide sufficient water to meet the agricultural and other needs of the latter area. Moreover, much of the flow as indicated by Table RS-5 reaches that part of the system by natural means beyond human control, i.e. karstic flow.

3. Considerably less water appears to enter the Qasmieh portion of the river than area and precipitation balanced by evapotranspiration demands would indicate (Table RS-5). This can be explained by either considerable subsurface flow within the bed of the Qasmieh-Litani and/or by additional karstic and fissure flow perhaps into the Hasbani. This, in turn, raises the need for further investigation. Research conducted in Israel indicates that significant amounts of water move down wadi beds beneath the surface even in the dry season.[4] It is possible that an important amount of water exists in the lower Litani as underflow and that this might be tapped for future use.

Having learned something of the regime of the Litani on its course to the sea, it is now possible to analyze flow data from springs and gauging stations along the way and to attempt some numerical estimate of the *natural flow* of the river.

4.2. The Natural Flow of the Litani: In View of Pumping, Diversions and Climatic Variation

Extensive precipitation and streamflow records exist which make it possible to analyze the flow of the Litani (Table RS-7 and Appendix A). The task is complicated, however, by the brief time period covered by all but a few stations, and also by various ongoing disturbances to the system. The most important of such disruptions are: (1) an apparent slow decline in precipitation over the last fifty years (although recent climatic events may in the long run offset such a trend); (2)

increased pumping of water from the stream and from aquifers for irrigation in the middle Bekaa; and (3) major diversions of water from the Litani to the Awali River beginning in the mid 1960s for hydroelectric power generation. Despite these perturbations it is believed that a reasonably reliable view of the natural flow of the river has been obtained.

Graph RS-5 displays the interaction of the various elements mentioned above. The correlation between precipitation at Ksara and streamflow at Khardale is apparent, as are the disruptions in the correlation in 1966 and from 1970 on, caused by removals to the Awali. The trend line indicates declining precipitation.

The first task of this analysis is to ascertain the flow regime of the river as it has varied historically under the impact of human activities. Table RS-8 and Graph RS-6 show three basic flow patterns. The first, during the period when little water was taken from the river (1940-54), indicates a steady increase in volume downstream. The second, representing a time when considerable water was taken from the river above Qirawn for irrigation purposes, but when no water was diverted outside the basin for hydroelectric purposes (1955-65), shows reduced accumulations upstream from Qirawn but a rapid recovery downstream from that point, although total volumes below Khardale could never reach those recorded earlier. The third and most recent flow pattern (1966-1973), displays the impact of removals for both irrigation and hydroelectric generation in the Awali watershed.

It is important to note that a further complication is inherent in this graph. That is, the intersect of each graph line on the ordinate is tied to the average precipitation during the time indicated. In other words, precipitation from 1940-1954 was less that that from 1966 to 1973;[5] all else being equal (i.e., natural flow rather than observed flow), adjusted volumes at Mansura should have been less for the earlier time than for the later one. What this means is that while the graph establishes the *pattern* of flow at various times, it does not determine the absolute *volume* of flow for a sufficient time span.

In order to reach some acceptable, long-term view of the Litani's natural flow it is necessary to establish a set of data offering consistent information for the springs, streams (wadis), and mainstream gauging stations given in Appendix A. This is no simple task, for many of the smaller stations were measured for only brief periods of time, and only in recent years. All data available for this analysis end with 1972-1973. Table RS-9 is the result of such an attempt. Some of the larger stations, for example the one at Mansura, have data sets going back many years. These are only partially indicated. Other stations have as few as seven years (Ghandouriye Wadi #32 and the Litani immediately downstream from #32 at #31). Other data sets (#1 through #6) are subsumed under downstream stations (#8 in the example given), and this must be carefully determined. Still others do not figure into the calculations (#7 Anjar Canal) or are withdrawals (#33 Qasmieh Canal) although the original materials do not indicate such variations. Finally, large amounts of water have been withdrawn to the Awali without mention. This has taken place between stations #19 (Qirawn) and #22 (the Litani at Qlaya). However, the station at #21 (Markabeh Tunnel), despite its name, represents a small sidestream addition and *not* the withdrawals near or at this point. In addition to all these variations, the numbers assigned the stations on the river and its tributaries are not necessarily in serial order from source to mouth. Thus, the sequence of numbered stations in Table RS-9 and the other tables that are based on it reflects geographical reality rather than strict numerical order.

For the time period from 1964-65 through 1972-73 only stations 18, 29, 31, and 32 lack one or two years. Therefore this time period was selected as being most complete.

The water budget of the Litani is shown by Table RS-6. Column one gives the location by station number. The phrase "s.s.addition" indicates estimated additions of water from subsurface sources at appropriate points along the river. Column two gives the average flow for the nine-year period discussed above. It should be noted that this table is divided into three parts, the first two of which form independent subsets divided below the Qirawn Dam. This division allows subtotals based on the sum of individual water sources shown in column three to be compared with mainstream gaugings listed in column four. The difference between the two values is assumed to be an increment of additional water from aquifers and/or soil throughflow. This is also shown (in parentheses) in column three. The first subset, from station #1 through station #21, totals 536.332 Mcm. A new accounting must begin after station #21, for large quantities of water have been removed from the river and directed to the Awali basin. Beginning with a measured value of 300.426 Mcm at station #22, the second subset totals 486.814 Mcm at the Qasmieh Delta. This includes estimated increments of subsurface waters and the removal of 77.433 Mcm into the Qasmieh Canal for irrigation. Obviously, the total for the second subset does not represent the natural flow. However, by using this second subset, the measured-value internal integrity of the data can be preserved and the increments mentioned above estimated.

One variant as yet unaccounted for is the amount of water removed above Qirawn for irrigation. While the impact of irrigation is discussed elsewhere in this report, mention should be made at this point of the value used for this computation. Two studies provide similar data referring to irrigation removals. A careful, crop-by-crop analysis of water demand and use was made utilizing aerial photos taken in 1969. This work was conducted by the Societe du Canal de Provence for the Office National du Litani(1942) (pp. 4 to 16 are of particular interest). An estimated 15,850 ha of irrigated land was found to use 118,600 Mcm of water annually. A second value is found in the Engineering Report(3092), p. 73, where 122 Mcm are said to be consumed but with no detailed explanation of how that sum was obtained. For the purposes of this analysis 120.000 Mcm has been accepted as the amount removed for irrigation. (This also is assumed to represent a total depletion after return flow of excess water has taken place.)

Given the above provisos, the third subset of Table RS-6 shows the estimated natural flow of the Litani below Qirawn. The total flow as far as station #21 is used as a base to which is added a compensatory 120.000 Mcm representing a replacement of irrigation waters for bookkeeping purposes. Thereafter, sidestream flow and subsurface additions are derived from the second subset of Table RS-6. No removals to the Qasmieh Canal are subtracted. The final result gives an estimated 920.153 Mcm per year natural flow at the Qasmieh Delta.

The relative shares of water provided by individual sources and/or removed for various purposes are indicated in Table RS-10. In this table stations #1 through #6 plus an additional increment of subsurface flow are subsumed under station #8. By the same token, irrigation withdrawals are replaced after station #19, and similar removals to the Qasmieh Canal are shown first as deficits and then as a replacement, again for bookkeeping purposes. One check on this table's accuracy is provided by comparing the share (42%) of subsurface waters estimated by the Societe du Canal de Provence study(1942), p. 3, with the total of such increments in Table RS-10 (354.14 Mcm, or 38.5%). Considering the complexities of the analyses involved, these two values seem reasonably close.

It should be kept in mind that the data upon which the above value (920 Mcm) is based represent a period of increased precipitation over a short run of years. Therefore, the results shown in Tables RS-6 and RS-10 do not necessarily represent an accurate long-term estimate of Litani flow. Rather, they indicate the relative proportion of various sources as mentioned above.

A second attempt to estimate the flow of the Litani was made. Two eleven-year periods were chosen for this purpose (Table RS-11). To reiterate, no data more recent than 1965 could be used because in 1966 the first major removals of water to the Awali Project occurred. This can be seen on Graph RS-5 where the flow of the stream takes dramatic plunges. While similar low water periods occurred previously, they were matched by severely lessened precipitation. Beginning in 1966 this was no longer the case. According to the history of water use in the Bekaa (Engineering Report(3092), p. 82) major removals by pumping began in 1954/55 and have continued since that time. Thus, the period from 1955 through 1965 represents a time of removals by pumping for irrigation but no diversions to the Awali. A similar eleven-year period was selected immediately preceding 1955 for comparative purposes with little or no pumping and no diversions.

Stream data for three stations -- Mansura, Qirawn, and Khardale -- are available for the above two periods. Their average flows have been computed for a number of time periods which are shown in Table RS-12 for comparative purposes.

By the same token, precipitation data for Ksara for the two periods chosen are available and their means computed. It is recognized that the correlation between streamflow and precipitation for the stations involved is not exact, but a value of r = .82 is considered sufficient for these conjectures (Graph RS-7).

Table RS-11 and Graph RS-8 compare flows at the above three stations for the two periods, and contrast the differences in flow with the differences in precipitation. Obviously, this technique provides only a crude measure or proportionality, but it does suggest some interesting relationships. The flow at Mansura in 1955-1965 was 42.2 percent less than it was during 1944-1954. However, there was only 12.8 percent less precipitation recorded at Ksara (which is located nearby) over the same period. This difference of 29.4 percent suggests that pumping, which began in 1954/55, made itself felt through reduced streamflow. This conclusion must be treated with caution, for no direct causality should be assumed. On the other hand, Graph RS-7 shows that all but one of the years when pumping took place fall below the regression line, and the one such year above the line was the driest of the twenty-two used. Thus, for the purpose of this analysis proportionate shares of the diminished flow have been assigned to pumping and decreased precipitation.

Similar data have been recorded for Qirawn and Khardale. While these stations are farther downstream and more removed from Ksara, comparison of flows at all three places (Graph RS-11) indicates a close parallel between the stations for the years before pumping and/or diversions took place.[6] A second data set is shown in Table RS-11 for comparison (1940-1954 and 1955-1969).

The mouth of the Litani at Qasmieh Delta has also been assigned flow figures on Graph RS-8. the largest value, 959 Mcm/yr, is found in the Engineering Report(3092) (see Table RS-13) where it is described as representing "an average year," for which 1974 is given with no explanation or comparative data. Since the data available for this analysis do not cover this year, little can be said of its accuracy.[7]

Another value, 795.1 Mcm/yr, has been computed from figures given by Vaumas(3291) for the years 1939-1947. This value is derived from a measured flow at Khardale of 23.2 cu m/s (p. 252) to which an additional 2 cu m/s have been added by him per the advice of Abd-El-Al.[8]

Measured flow at Qasmieh Delta of 610.8 Mcm/yr for the years 1965-66/1970-71 is taken from data found in the Engineering Report(3092) (Table 34, p. 71). This flow would be affected by pumping for irrigation and possible diversions to the Awali. In order to estimate natural flow at Qasmieh from this latter figure the following procedure was used:

$$\frac{P_{k39\text{-}47}}{F_{v39\text{-}47}} = \frac{P_{k66\text{-}71}}{F_{q66\text{-}71}}$$

$$\text{est. } F_{q66\text{-}71} = \frac{P_{k66\text{-}71} \times F_{v39\text{-}47}}{P_{k39\text{-}47}}$$

$$\text{est. } F_{q66\text{-}71} = \frac{\underline{(771)(795)}}{654} = 937 \text{ Mcm}$$

Where P_k = precipitation at Ksara.

F_v = flow for Qasmieh given by Vaumas(3291).

F_q = average annual flow for Qasmieh as computed.

Numbers refer to the years involved.

It is estimated on the basis of the above computation that approximately 937 Mcm/yr of natural flow should have reached the delta at Qasmieh during the period 1966-1971.[9] How does this compare with the measured flow of 611 Mcm for the same period?

It is assumed that pumping upstream from Khardale had already reached its limit due to the absolute limit on currently available irrigable fields. A value of 143 Mcm[10] has been deducted from the flow at Qasmieh as estimated. It is also true that the Vaumus(3291) datum would not include removals to the Qasmieh Canal. Therefore, an additional 77.4 Mcm removed by the canal should also be taken into account. The amount remaining after these deductions could be explained by the increased precipitation during the same period (771 mm for 1966-1971 as opposed to 654 mm for 1939-1947; i.e. 15.2%). On the other hand, the unexplained excess 106 Mcm could scarcely cover the removals to the Awali system, which range from 250 Mcm (Table RS-6) to as much as a possible 377 Mcm (Engineering Report(3092), Table 6, p. 9). These relationships are shown below.

Mcm/yr	
937.0	estimated flow 1966-1971
143.3	upstream removals for irrigation (estimated)
793.7	
77.4	Qasmieh Canal diversions 1966-1971
716.3	
610.8	measured flow 1966-1971
105.5	possible increase from additional precipitation (11.3%)

The above discussion is illustrated by Graph RS-8. It should be noted that the quantity falling between the "estimate 1966-1971" less "possible reduction from pumping" and the "measured 1966-1971" flow level for Khardale, Qirawn, and Mansura -- shown to the left on the graph -- can be explained by reductions resulting from less precipitation. This is not the case for measured flow at Qasmieh in 1966-1971. The caveat must also be repeated here that the apparent long-range diminishing trend in precipitation is contradicted by short, more recent sequences of abundant rainfall. There is a historical decline in precipitation of 1.43 mm/yr indicated over the last fifty years (1922-1971; Graph RS-5). Based on this trend, the computed annual natural flow of the Litani in 1980 would have been 587 Mcm instead of in the 900 Mcm range that has been shown.[11]

The natural flow estimates which are available are as follows:

Precip.	Flow (Mcm)	Time Period	Source
1174	1011	1969	ONL/FAO(3122), p. 50
NA	959	"1974"	Engineering Report(3092), p. 73
771	937	1966-1971	Estimated flow (see text, p. 28)
751	920	1965-1973	Computed value (Table RS-6)
654	795	1939-1947	Vaumas(3291), p. 252

Such a list provides scant material for analysis. What can be surmised is that a flow figure in the low 900 Mcms would be reasonable for precipitation values between 750 mm and 800 mm and that lower precipitation means lower values for discharge at the Qasmieh Delta. That this is possible is supported by the good correlation shown in Graph RS-7 between precipitation at Ksara and flow at Khardale. Thus, it becomes important to know something of the probability or recurrence interval for precipitation in the Bekaa.

Graph RS-9 and Table RS-14 show the recurrence interval of discharge volumes at Khardale for the period 1940 through 1965. It appears that such volumes fall into three categories, those of extreme low water, those of high to extreme high water, and a more frequently occurring middle or "normal" range. Examination of these figures shows that average flow conditions of slightly more than 600 Mcm will occur about every two years, and that extreme floods like that of 1969 (not shown) and 1953-54 will occur on the average about once every twenty-eight years. (The fact that the 1969 flood came only fifteen years after the 1954 flood has no bearing on the probabilities involved.) Considering the close relationship between precipitation at Ksara and flow at Khardale, and by inference, discharge at Qasmieh Delta, Table RS-15 and Graph RS-10 provide useful information regarding the probability of rainfall levels at Ksara; ergo, natural flow of the Litani. On Graph RS-10 both the 1969 and the 1954 flood years are indicated by the high precipitation values on the extreme right.

To reiterate the point made above, the small size of the Litani watershed combined with immediate runoff response and the rapid throughflow of water within the karstic aquifers creates rapid year to year fluctuations in the flow of the river. This is in addition to the high seasonal variance which occurs every year between summer and winter flows. Given a lead time of perhaps two months between the time of precipitation and the riverine response -- whether small or large -- plus a certain guaranteed flow from the larger springs as well as subsurface additions, short term predictability of river flow seems feasible. Long term prediction will depend upon the ability to predict precipitation over the watershed.

Given the above discussion it is now appropriate to discuss human use of the river in a historical context.

ENDNOTES

1. Table RS-1 displays two sets -- one found in Vaumas(3291), and the second computed for this report from a precipitation map provided by Vaumas -- for total water availability, and from stream gauging data found in Appendix A.

2. The implication here is that precipitation data derived from a map based on data matching the time period of the flow figures might show a greater total precipitation for the basin, which would explain the minor variations revealed here.

3. Available surplus indicated in Table RS-2 is even greater: 305.7 Mcm.

4. Y. Orev, "From Dry Wadi to Perennial Stream," *Israel -- Land and Nature*, V. 6, No. 2 (Winter 1908-81)(0750), pp. 54-58.

5. Available precipitation data end with 1970-71. An unavoidable error is introduced here by comparing 1966-1973 flow with 1966-1971 precipitation, but such a practice is unavoidable in this analysis.

6. Nine out of the ten rain gauging stations in the Bekaa show correlation coefficients greater than or equal to .90 with precipitation at Ksara(1939), Table I, p. 14.

7. The computed mean for the fifteen-year flow at Qirawn unaffected by pumping (Table RS-12), which presumably corresponds to the "Upstream of Qirawn" designation reproduced in Table RS-13, is 493.2 Mcm/yr. This compares with 527 Mcm/yr, which is a portion of the same 959 Mcm datum mentioned above.

8. See Vaumas(3291), footnote 17, p. 252.

9. Two years for which flow data exist were not used because no matching precipitation data are available (1971-72 and 1972-73).

10. That is, 19.6% of 730.9 Mcm. These figures are taken from the lower left of Table RS-11.

11. The author of this report views time series and trend analysis with considerable reservation. Results based on such techniques assume that the future will be similar to the past. At this writing, March 1987, reports from western Turkey and Israel (personal communications) indicate the greatest precipitation in fifty years, after three years of severe drought.

Table RS-1

PRECIPITATION AND STREAMFLOW -- THE LITANI BASIN

Litani Sub-section	Area (km^2)	% of Basin	Precip. (Mcm)	% of Total Precip.	Flow[1] (Mcm)	% of Total Flow
To Mansura						
Kolars	1311.50	60.50	1064.230	58.40	318.680	34.60
Vaumus	1323.00	61.00	NA	NA	312.600	39.20
Average	--	60.75	--	--	--	36.90
To Qirawn						
Kolars	227.50 1539.00	10.50 71.00	217.142 1281.372	11.90 70.30	216.741[2] 535.421	23.60 58.20
Vaumas	221.00 1544.00	10.20 71.20	NA	NA	167.700 480.300	21.10 60.40
Average	--	10.35 71.10	--	--	--	22.35 59.30
To Khardale						
Kolars	230.25 1769.25	10.60 81.60	246.778 1528.150	13.50 83.90	275.196 810.617	29.90 88.10
Vaumas	278.00 1822.00	12.80 84.00	NA	NA	251.700 732.000	31.70 92.10
Average	--	11.70 82.80	--	--	--	30.80 90.10
To Qasmieh Delta						
Kolars	398.75 2168.00	18.40 100.00	294.278 1822.428	16.10 100.00	131.938 942.555	11.90 100.00
Vaumas	346.00 2168.00	16.00 100.00	NA	NA	63.100 795.100	7.90 100.00
Average	--	17.20 100.00	--	--	--	9.90 100.00

Source: Vaumas(3291); Map 7. Computations by Kolars.

[1] Computed from stream gauging data (see Tables RS-6 and RS-10).
[2] includes 120 Mcm irrigation.

Table RS-2

ESTIMATED PRECIPITATION, ACTUAL EVAPOTRANSPIRATION (AS A PRECENT OF PRECIPITATION), AND AVAILABLE SURPLUS IN THE SUB-SECTIONS OF THE LITANI

Sub-section	Area (km^2)	Total P Mcm (% of total)	AE as a % of total P	AE x P	S = P - AE (% of total S)
(1) Basin to Mansura	1311.5	1064.23 (58.4%)	64.24	683.7	380.5 (49.6%)
(2) Mansura to Qirawn	227.5	217.142 (11.9%)	63.0	136.8	80.3 (10.5%)
(3) Qirawn to Khardale	230.25	246.778 (13.5%)	41.4	102.2	144.6 (18.9%)
(4) Khardale to Qasmieh Delta	398.75	294.278 (16.1%)	45.25	133.2	161.1 (21.0%)
TOTALS		1822.4		1055.9 (57.9%)	766.5 (42.1%)

P = Precipitation
AE = Actual Evapotranspiration
S = Surplus

Source: see Tables RS-1, RS-4, and RS-3.

Table RS-3

SELECTED WATER BALANCE STATIONS: THE LITANI BASIN

JEZZINE

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
PE	16	18	36	53	89	112	121	119	94	73	44	22	797
P	231	323	112	119	19	10	0	0	0	33	141	191	1179
ST	300	300	300	300	237	168	112	75	55	48	145	300	
AE	16	18	36	53	82	79	56	37	20	40	44	22	503
D	0	0	0	0	7	33	65	82	74	33	0	0	294
S	215	305	76	66	0	0	0	0	0	0	0	14	676

KSARA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
PE	10	14	29	53	91	116	138	137	110	72	36	16	822
P	183	129	62	34	16	1	0	1	1	18	74	115	634
ST	300	300	300	281	218	148	93	59	41	34	72	171	
AE	10	14	29	53	79	71	55	35	19	25	36	16	442
D	0	0	0	0	12	45	83	102	91	47	0	0	380
S	44	115	33	0	0	0	0	0	0	0	0	0	192

RAYAK

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
PE	10	14	27	48	83	108	132	129	101	70	37	17	776
P	159	126	63	31	16	1	0	0	1	19	69	93	578
ST	296	300	300	283	226	158	101	65	46	39	71	147	
AE	10	14	27	48	73	69	57	36	20	26	37	17	434
D	0	0	0	0	10	39	75	93	81	44	0	0	342
S	0	108	36	0	0	0	0	0	0	0	0	0	144

PE = Potential Evapotranspiration
P = Precipitation
ST = Storage
AE = Actual Evapotranspiration
D = Deficit
S = Surplus (In the case of the Litani this might be infiltration or runoff.)

Source: C. W. Thornthwaite Asscoiates, Publications in Climatology, Vol XVI, Number 1, "Average Water Balance Data of the Continents", p. 206.(3128)

Table RS-4

PRECIPITATION, ACTUAL EVAPOTRANSPIRATION AND AVAILABLE SURPLUS FOR SELECTED STATIONS IN THE LITANI BASIN
(See Map 3 for Locations)

Location	Lithology	Area of Sub-basin Aquifer km^2 (% of total)	Area of Sub-basin (km^2)	Average Annual Precip. (mm)	Precip. (Mcm)	Infiltration Mcm (%)	Runoff Mcm (%)	(AE) Actual Evapotranspiration Mcm (%)	
Sub-basin I* Anti-Lebanon	Cretaceuos Cenomanian- Turonien	355 (90%)	395	485	192	87 (45.5)	8 (4.0)	97 (50.5)	(1)**
Sub-basin II Barouk-Niha	Jurassic	100 (85%)	130	1310	170	67 (40.0)	10 (6.5)	93 (53.5)	(1)
Sub-basin IV South Bekaa	Eocene (Syncline) upper Cretaceous (Anticline)	122 (92%)	133	820	108	37 (35.0)	2 (2.0)	69 (63.0)	(2)
Sub-basin VII East Bekaa	Eocene (Limestone) Quarternary conglomerate	147 (100%)	147	525	77	14 (18.0)	2.6 (3.3)	60.4 (78.7)	(1)
(Jezzine***)	--	--	--	1179	--	(57.3%)		(42.7%)	(3)
Ksara***	--	--	--	634	--	30.3%		69.7%	(1)
Rayak***	--	--	--	578	--	24.9%		75.1%	(1)
Joub Jannin****	--	--	--	707	--	58.7%		41.3%	(3)
Anjar****	--	--	--	561	--	52.8%		47.2%	(1)
(Rashaya****)	--	--	--	756	--	(59.8%)		(40.2%)	(3)
Marjayoun****	--	--	--	1001	--	65.6%		34.4%	(4)
(Adloun****)	--	--	--	619	--	(43.9%)		(56.1%)	(4)

Sources: * GERSAR(1939) (see Map 4); *** Thorthwaite(3128), pp. 205-206; **** Baldy(2206), pp. 57-73.

** (1) = basin to Mansura; (2) = Mansura to Qirawn; (3) = Qirawn to Khardale; (4) = Khardale to Qasmieh Delta.
(   ) = outside Litani basin but used for approximation.

Table RS-5

HYDROLOGIC PARAMETERS OF THE SUB-SECTIONS OF THE LITANI RIVER

Sub-section	% of Basin	% of Precip.	% of Available Surplus	% of Streamflow
To Mansura	60.7	58.4	49.6	36.9
Mansura to Qirawn	10.3	11.9	10.5	22.4
Qirawn to Khardale	11.7	13.5	18.9	30.8
Khardale to Qasmieh Delta	17.2	16.1	21.0	9.9
TOTALS	99.9	99.9	100.0	100.0

Source: see Tables RS-1 and RS-2.

Table RS-6

SOURCES OF LITANI FLOW: 1964-65/1972-73

Station #*	Flow at Non-Litani Stations (Mcm/yr)	Subtotals + (Subsurface Additions)	Flow at Litani Stations (Mcm/yr)	
1	6.741			
2	3.147			
3	9.284			
4	8.733			
5	11.357			
6	62.213	(#7 Anjar Canal excluded)		
		101.475		
		(23.696)		
8			125.171	
9	63.576			
10	43.175			
11	6.945	(#12 & #13 subsumed under #11)		
14	23.046			
15	20.647			
		157.389		
		(36.120)		
16			318.680	
17	9.394			
		9.394		
		(87.347)		
19			415.421	
18	11.452			
20	83.643			
21	25.816			
		120.911		Estimated Natural Flow
	AT AWALI DIVERSION		536.332	536.332
	(Diverted to Awali)		235.906	+120.000 (irrigation replacement)
22			300.426	
23	6.000			
24	5.091			
29 (n=6)	31.596			
25	1.488			
26	1.091			
27	4.228	(#28 subsumed under #27)		
		49.494		+49.494
		(104.791)		+(104.791)
30			454.711	810.617
32 (n=7)	7.348			
		7.348		+7.348
		(37.142)		+(37.142)
31			499.201	855.107
33 (n=8)	-77.433			
		-77.433		
			421.768	
		(65.046)		+(65.046)
34 (n=8)			486.814	920.153

Source: Table RS-10.

* Station numbers in order of entry into Litani.

Table RS-7

ANNUAL MEAN FLOW OF THE LITANI RIVER (Available Years) AND MEAN ANNUAL PRECIPITATION AT KSARA, BEKAA

Year	Damascus Road	Mansura	Qirawn	Qlaya	Khardale	Ghandouriye Wadi	Qasmieh Delta	Precipitation Ksara (mm)
1932		202.3						426
1933		111.3						330
1934		179.4						553
1935		311.4						775
1936		186.0						488
1937		254.1						498
1938		346.9						739
1939		336.2						597
1940		345.4	447.0		650.5			657
1941		378.9	517.0		724.5			734
1942		440.3	615.8		907.0			720
1943		442.7	582.7		951.7			757
1944		372.2	473.4		711.8			619
1945		446.6	553.3		850.4			715
1946		338.8	407.2		622.4			554
1947		279.2	361.6		586.5			535
1948		327.6	401.1		620.7			678
1949		492.1	601.5		927.1			790
1950		369.8	427.2	569.8	640.3			577
1951		175.6	223.6	306.8	362.4			443
1952		368.1	468.2	592.6	745.0			678
1953	92.5	410.0	618.5	763.7	854.0			800
1954	130.5	468.8	705.7	915.9	1119.0			770
MAJOR PUMPING BEGINS								
1955	26.2	191.9	264.5	359.5	404.5			461
1956	44.7	293.0	392.1	520.6	634.6			665
1957	32.0	243.0	293.9	428.0	531.1			645
1958	27.9	208.8	263.3	423.5	520.8			634
1959	20.4	141.8	193.3	330.1	392.9			466
1960	7.7	81.1	107.5	195.6	275.1			340
1961	7.5	90.7	127.3	217.2	337.4			436
1962	44.6	200.1	225.0	391.7	523.0			583
1963	62.4	297.9	326.9	455.0	599.9			716
1964	45.2	295.8	348.6	419.1	560.4			666
1965	54.1	294.2	330.4	422.1	621.1			631
FIRST MAJOR REMOVAL FOR AWALI								
1966	33.4	215.9	237.4	117.8**	208.7**		160.4	643
1967	98.1	471.7	579.9	436.2**	608.8**	634.0	678.8	864
1968	93.6	432.5	558.2	499.2**	663.2**	702.2	801.0	672
1969*	150.6	552.1	929.8	810.5**	1219.9**	1319.4	1501.6	1174
1970	48.8	281.2	307.5	89.0**	181.4**	185.9	177.4	590
1971	47.5	300.2	401.1	177.5**	296.7**	333.8	345.6	682
1972	33.5	221.7	264.8	87.7**	186.6**	202.5	170.5	NA
1973	12.6	98.6	129.7	64.0**	105.9**	116.5	59.3	NA

Source: Engineering Report(3092), Tables 2, 9, 16, 19, 22, 30, 31, and 34.

* Flood year.

** These data excluded.

Table RS-8

FLOW PATTERNS OF THE LITANI RIVER: 1940-54/1955-65/1966-73

(Flow in Mcm/yr; Precip. in mm/yr)

Year	Mansura	Qirawn	Qlaya	Khardale	Precip.
1966-73	321.7	426.1	285.2	433.9	NA
1966-71	375.6	502.3	355.0	529.8	770.8
1955-65	212.6	261.2	378.4	491.0	624.3
1940-54	377.1	493.6	NA	751.5	668.5

Source: Engineering Report(3092); Appendix A, this report.

Table RS-9

FLOW OF THE LITANI RIVER AT GAUGING STATIONS IN THE BEKAA VALLEY

	1972-73	71-72	70-71	69-70	68-69	67-68	66-67	65-66	64-65	63-64	62-63	61-62	n=9/$\bar{x}$ =	n=11/$\bar{x}$ =
1. Ras el-Ain Terbol	0.185	3.304	2.780	6.921	17.612	11.257	12.214	2.678	3.719	3.142	2.734*	--	6.741	6.050
2. Faour	0.363	1.460	1.617	3.366	7.777	4.513	4.509	2.373	2.347	3.888	3.388*	--	3.147	3.236
3. Nahr Saghir	0.440	4.403	4.523	9.270	24.685	14.577	14.472	4.745	6.442*	NA	NA	--	9.284	--
4. Ain el-Baida	1.411	6.281	6.972	9.744	19.165	13.226	8.772	6.862	6.163	4.028	2.310*	--	8.733	7.721
5. Hamsine	6.736	9.515	10.338	11.003	19.985	16.698	15.379	12.555	13.883	13.563	13.330*	--	11.357	11.737
6. Ghzayel Anjar	22.773	50.742	57.960	55.865	105.114	86.204	81.474	45.140	54.642	59.764	50.628	37.396*	62.213	60.937
7. Anjar Canal**	6.833	7.206	7.845	7.735	6.687	7.003	6.392	7.388	7.135	5.546	5.774*	--	7.136	6.868
8. Ghzayel Damascus Road	53.059	96.854	110.375	127.814	225.538	163.641	151.139	88.172	109.947	104.345	93.977	67.483	125.171	120.442
9. Litani Damascus Road	12.566	33.454	47.454	48.832	150.640	93.599	98.105	33.387	54.145	45.223	62.393	44.567	63.576	61.800
10. Bardaouni Damascus Road	14.735	24.612	35.886	31.532	88.021	52.173	67.425	31.284	42.910	41.566	47.872	38.902	43.175	43.456
12. Chtaura	9.380	11.911	14.143	11.992	19.595	16.728	16.627	12.307	14.404	13.463	13.114	14.708*	--	--
13. Chtaura wadi (subsumed under #11)	7.013	10.829	13.511	10.273	18.849	14.406	14.387	9.472	11.662	12.225*	--	--	--	--
11. Jalala	2.487	5.166	7.291	5.467	13.276	8.094	10.825	4.760	5.143	8.266*	--	--	6.945	--
14. Delem Wadi	12.174	15.889	23.871	19.274	36.340	27.739	30.848	16.463	24.819	18.994	16.816	16.405*	23.046	22.112
15. Amiq	3.283	8.834	21.184	16.018	38.865	28.259	31.061	14.213	24.108	19.822	20.842*	--	20.647	20.590
16. Litani Mansura	98.638	221.681	300.243	281.218	552.109	432.462	471.688	215.858	294.221	295.769	297.917	200.120	318.680	314.709
17. Khraizat	4.903	7.677	9.911	8.260	13.558	11.124	11.729	7.662	9.723	8.941	9.569	7.431*	9.394	9.369
19. Litani Qirawn	129.657	264.769	401.142	307.526	929.762	558.249	579.873	237.438	330.377	348.639	326.869	225.000	415.421	401.300

Table RS-9 continued

	1972-73	71-72	70-71	69-70	68-69	67-68	66-67	65-66	64-65	63-64	62-63	61-62	n=9/x =	n=11/x =
18. Nahr esh-Shita	8.368	5.744	9.747	9.508	22.513	14.137	13.760	7.840*	NA	--	--	--	11.452 (n=8)	--
20. Ain Zarqa	60.160	80.275	85.374	89.650	129.604	92.568	87.523	55.706	71.924	86.406	74.122*	--	83.643	83.028
21. Markabeh Tunnel	15.818	24.232	33.304	30.072	34.834	NA	NA	22.705	24.015	21.546*	--	--	25.816 (n=8)	--
22. Litani Qlaya	64.036	87.658	177.508	88.975^{t}	810.460	499.174	436.203	117.753^{t}	422.070	419.086	454.989	391.699	300.426	325.265
23. Safa Wadi	1.497	2.853	6.306	4.073	12.050	5.382	8.321	3.620	9.902*	--	--	--	6.000	--
24. Aajis Wadi	2.231	3.853	4.442	3.640	9.446	4.793	6.618	4.246	6.552*	--	--	--	5.091	--
29. Guelle	21.928	33.243	38.044	30.487	NA	NA	36.356	29.518*	NA	--	--	--	31.596 (n=6)	--
25. Naqouziya Wadi	0.432	0.620	1.465	1.157	3.176	2.310	2.001	0.570	1.662*	--	--	--	1.488	--
26. Aishiya Wadi	0.117	0.718	1.301	0.731	2.534	1.432	1.154	0.487	1.349*	--	--	--	1.091	--
27. Zaghria Wadi	0.605	2.447	4.175	2.777	11.282	4.074	5.143^{Sic}	2.406	^{Sic}5.143*	--	--	--	4.228	--
28. Maidane Spring (part of #27)	1.991	2.692	3.636	2.665	5.909	3.170	3.197	2.250	3.370	3.788	--	--	--	--
30. Litani Khardale	105.899	186.628	296.719	181.365^{t}	1219.948	663.240	608.818	208.666^{t}	621.113	560.389	599.894	522.965	454.711	477.516
32. Ghandouriye Wadi	0.055	6.175	5.614	5.129	21.780	7.313	5.369*	--	--	--	--	--	7.348 (n=7)	--
31. Litani	116.500	202.546	333.829	185.878	1319.431	702.238	633.986*	--	--	--	--	--	499.201 (n=7)	--
33. Qasmieh Canal**	82.580	75.833	79.251	77.815	76.071	81.098	75.075	71.743*	--	--	--	--	77.433 (n=8)	--
34. Litani Qasmieh Delta	59.298	170.489	345.576	177.350	1501.578	801.006	678.798	160.417*	--	--	--	--	509.216 (n=6)	486.814 (n=8)

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* Earliest available year. ** Removed to fields. ^{t} Figure low because of withdrawals.

Table RS-10

RELATIVE SHARES OF LITANI SOURCES
(at stations and subsurface additions)

Station #*	Flow	% of Total Natural Flow at Qasmieh Delta (Base 930 Mcm)	Station Name
1	6.741	0.7	Ras el-Ain; Terbol
2	3.147	0.3	Faour
3	9.284	1.0	Nahr Saghir
4	8.733	0.9	Ain el-Baida
5	11.357	1.2	Hamsine
6	62.213	6.8	Ghzayel Anjar (excludes Anjar Canal)
s.s.addition	23.696	2.6	
8	125.171	13.6	Ghzayel (Damascus Road)
9	63.576	6.9	Litani (Damascus Road)
10	43.175	4.7	Bardaouni (Damascus Road)
11	6.945	0.8	Jalala (includes #12 & #13)
14	23.046	2.5	Delem Wadi
15	20.647	2.2	Amiq
s.s.addition	36.120	3.9	
16	318.680	34.6	Litani Mansura**
17	9.394	1.0	Khraizat
s.s.addition	87.347	9.5	
19	415.421	45.1	Litani Qirawn**
irrigation***	120.000	13.0	(Removed above Qirawn)
18	11.452	1.2	Nahr esh-Shita
20	83.643	9.1	Ain Zarqa
21	25.816	2.8	Markabeh Tunnel
22	656.332	71.3	Litani Qlaya**
23	6.000	0.7	Safa Wadi
24	5.091	0.6	Aajis Wadi
29	31.596	3.4	Guelle
25	1.488	0.2	Naqouziya Wadi
26	1.091	0.1	Aishiya Wadi
27	4.228	0.5	Zaghria Wadi (includes #28)
s.s.addition	104.791	11.4	
30	810.617	88.1	Litani Khardale**
32	7.348	0.8	Ghandouriye Wadi
s.s.addition	37.142	4.0	
31	855.107	92.9	Litani Ghandouriye
	-77.433	-8.4	(Qasmieh Canal)
33	777.674	84.5	Litani Qasmieh Canal
s.s.addition	65.046	7.1	
34 (subtotal)	842.720	91.6	Litani Qasmieh Delta
	+77.433	+8.4	(Qasmieh Canal)
TOTAL	920.153	100.0	Flow at Qasmieh Delta

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* Station numbers in order of entry into Litani.

** Mainstream gauging stations.

*** Irrigation removals estimated and replaced at this point in order to balance the totals downstream. (Rounding error 0.1%)

Table RS-11

SUGGESTED RELATIONSHIP BETWEEN STREAM FLOW, PRECIPITATION, AND PUMPING ON THE LITANI RIVER

Dates	Description	Location Ave. Flow Mcm/yr	Commentary	Precip. at Ksara mm	Dates	Ave. Flow Mcm/yr	Precip. at Ksara mm	Commentary
		Mansura						
1944/54 n = 11	years immediately prior to intensive pumping: see entry below.	$\bar{x}$ = 368.1		$\bar{x}$ = 650.8	1940/54 n = 15	377.0	668.5	
1955/65 n = 11	years of intensive pumping before first major withdrawal for Awali Project	$\bar{x}$ = 212.6	42.2% less flow 12.8% less precip. 29.4% possible flow reduction by pumping*	$\bar{x}$ = 567.5	1955/69 n = 15	267.4	639.7	29.1% less flow 4.3% less precip. 24.8% possible flow reduction by pumping*
		Qirawn						
1944/54 n = 11	as above	$\bar{x}$ = 476.5		$\bar{x}$ = 650.8	1940/54 n = 15	493.6	668.5	
1955/65 n = 11	as above	$\bar{x}$ = 261.2	45.2% less flow 12.8% less precip. 32.4% possible flow reduction by pumping*	$\bar{x}$ = 567.5	1955/69 n = 15	345.2	639.7	30.1% less flow 4.3% less precip. 25.8% possible flow reduction by pumping*
		Khardale						
1944/54 n = 11	as above	$\bar{x}$ = 730.9		$\bar{x}$ = 650.8				
1955/65 n = 11	as above	$\bar{x}$ = 491.0	32.8% less flow 12.8% less precip. 19.6% possible flow reduction by pumping*	$\bar{x}$ = 567.5	-----Relationship obscured by Awali withdrawals-----			

Source: Engineering Report(3092), Tables 2, 9, 16, and 19. Computations by Kolars.

* No direct statistical or causal relationship is meant by the arithmetic exercise shown here. Rather, as shown on Graph RS-8, there is a strong correlation (r = .82) between precipitation (Ksara being chosen as indicative of general conditions in the Bekaa) and flow of the Litani. While the reduction in flow may be due to reasons other than either pumping from the river for agricultural use and/or less precipitation, a strong possibility exists that pumping in large part accounts for the suggested reduction. These conclusions should be viewed as speculative.

Table RS-12

MEAN FLOW -- THE LITANI RIVER -- VARIOUS TIME PERIODS AND CONDITIONS
(Mcm per Year)

				Time periods effected by pumping but not by Awali Project**				
Location	Dates	Mean Flow $\bar{x}$ (Longest Period Uneffected by Awali Project)* (Includes Pumping)	Mean Flow Uneffected by Pumping 1940-1954 n = 15	1940-65 $\bar{x}$ n = 26	1950-65 $\bar{x}$ n = 16	1953-73 $\bar{x}$ n = 21	1953-65 $\bar{x}$ n = 13	1955-65 $\bar{x}$ n = 11
Damascus Road	1953/73 n = 21	53.0	n.a.	n.a.	n.a.	53.0	45.8	31.5
Mansura	1932/73 n = 42	297.8	377.1	307.5	258.2	275.8	247.5	212.6
Qirawn	1940/73 n = 34	402.3	493.6	395.2	332.2	362.2	322.8	261.2
Qlaya	1950/65 n = 16	456.9	n.a.	n.a.	456.9	--	449.4	378.4
Khardale	1940/65 n = 26	641.3	751.5	641.3	570.1	--	567.2	491.0

Source: Engineering Report(3092), Tables 9, 16, 19, 22, 30. Computations by Kolars.

* First major removal of water for the Awali Project: 1966.

** Intensive pumping from the river began about 1955; therefore, the proportion of years effected by pumping removals increases from left to right in this section.

Table RS-13

WATER BALANCE OF THE LITANI

(Reproduced from the source given below)
(Mcm/yr)

	FOR AN AVERAGE YEAR		
	1974		
River	Annual Natural Flow	Amount Withdrawn	Amount Remaining
Upstream of Qirawn	527	122	405
Downstream of Qirawn	432	101	331
Total	959	223	736
	FOR SUMMER OF AN AVERAGE YEAR		
Upstream of Qirawn	159	122	37
Downstream of Qirawn	145	87	58
Total	304	209	95

Source: FAO(2899), Table 38, p. 90.

Table RS-14

PROBABILITY OF FLOW VOLUME AT KHARDALE
(1940-1965)

Year	Flow (Mcm)	m	T
1954	1119.0	1	27.00
1943	951.7	2	13.50
1949	927.1	3	9.00
1942	907.0	4	6.75
1953	854.0	5	5.40
1945	850.4	6	4.50
1941	724.5	7	3.86
1952	745.0	9	3.00
1944	711.8	8	3.38
1940	650.5	10	2.70
1950	640.3	11	2.45
1956	634.6	12	2.25
1946	622.4	13	2.08
1965	621.1	14	1.93
1948	620.7	15	1.80
1963	599.9	16	1.69
1947	586.5	17	1.59
1964	560.4	18	1.50
1957	531.1	19	1.42
1962	523.0	20	1.35
1958	520.8	21	1.29
1955	404.5	22	1.23
1959	392.9	23	1.17
1951	362.4	24	1.13
1961	337.4	25	1.08
1960	275.1	26	1.04

$n = 26$

$T = \frac{n + 1}{m}$ $\quad$ $T = \frac{27}{m}$

Source: Graph RS-9.

Table RS-15

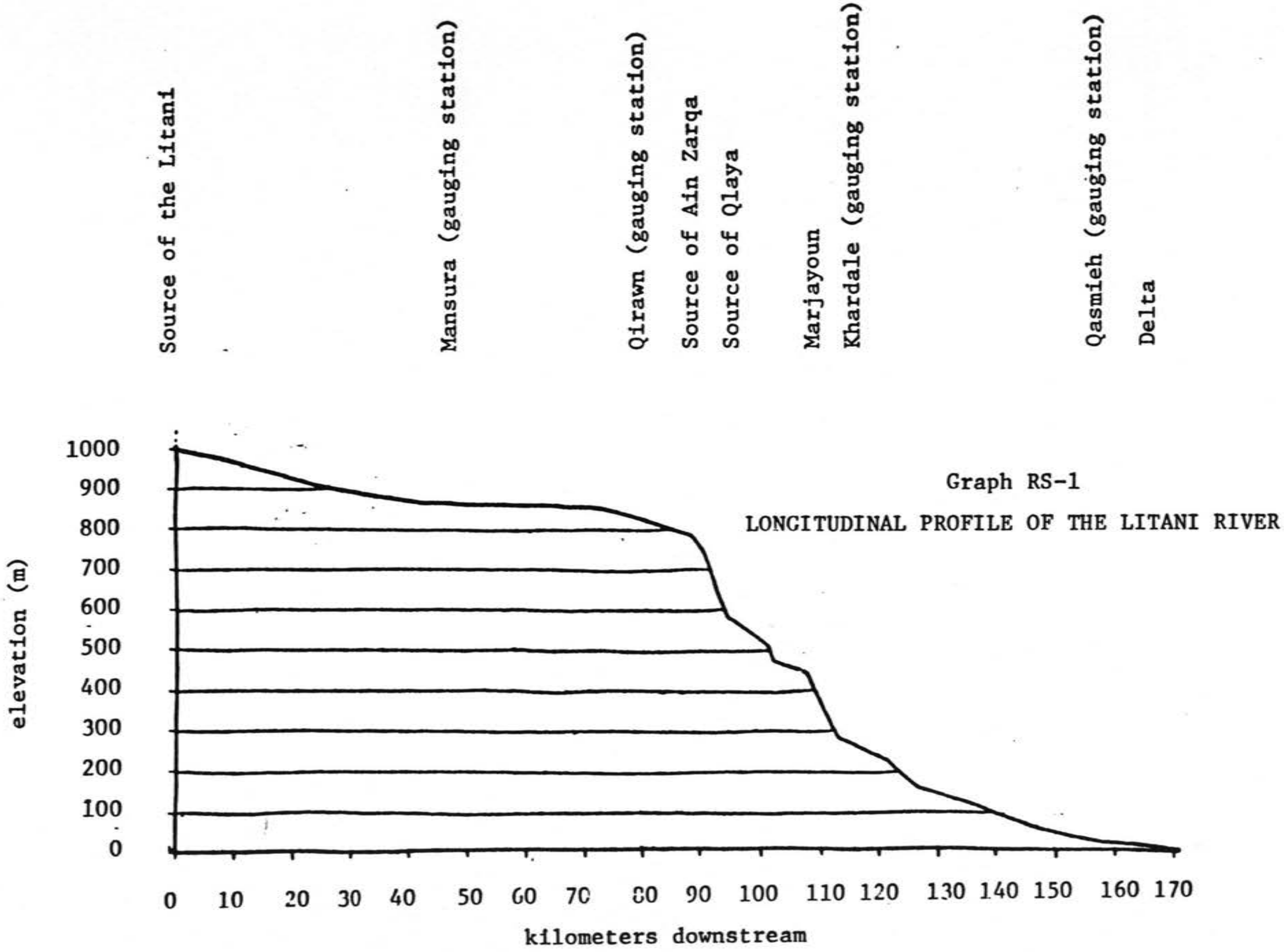
PROBABILITY OF PRECIPITATION AMOUNTS AT KSARA
(1921-22/1970-71)

Year	Prec.	m	F	Year	Prec.	m	F
1933	330	1	1.96	1927	650	26	50.98
1960	340	2	3.92	1940	657	27	52.94
1930	397	3	5.88	1922	662	28	54.90
1932	426	4	7.84	1956	665	29	56.86
1961	436	5	9.80	1964	666	30	58.82
1951	443	6	11.76	1968	672	31	60.78
1925	448	7	13.73	1952	678	32	62.75
1955	461	8	15.69	1948	678	33	64.71
1959	466	9	17.65	1923	681	34	66.67
1936	488	10	19.61	1971	682	35	68.63
1937	498	11	21.57	1945	715	36	70.59
1928	527	12	23.53	1963	716	37	72.55
1947	535	13	25.49	1931	717	38	74.51
1934	553	14	27.45	1942	720	39	76.47
1946	554	15	29.41	1941	734	40	78.43
1950	577	16	31.37	1938	739	41	80.39
1962	583	17	33.33	1943	757	42	82.35
1970	590	18	35.29	1954	770	43	84.31
1924	596	19	37.25	1935	775	44	86.27
1939	597	20	39.22	1949	790	45	88.24
1944	619	21	41.18	1953	800	46	90.20
1965	631	22	43.14	1967	864	47	92.16
1958	634	23	45.10	1926	866	48	94.12
1966	643	24	47.06	1929	960	49	96.08
1957	645	25	49.02	1969	1174	50	98.04

$n = 50$

$$F_i = \frac{m}{n + 1} \times 100\%$$

Source: Graph RS-10.



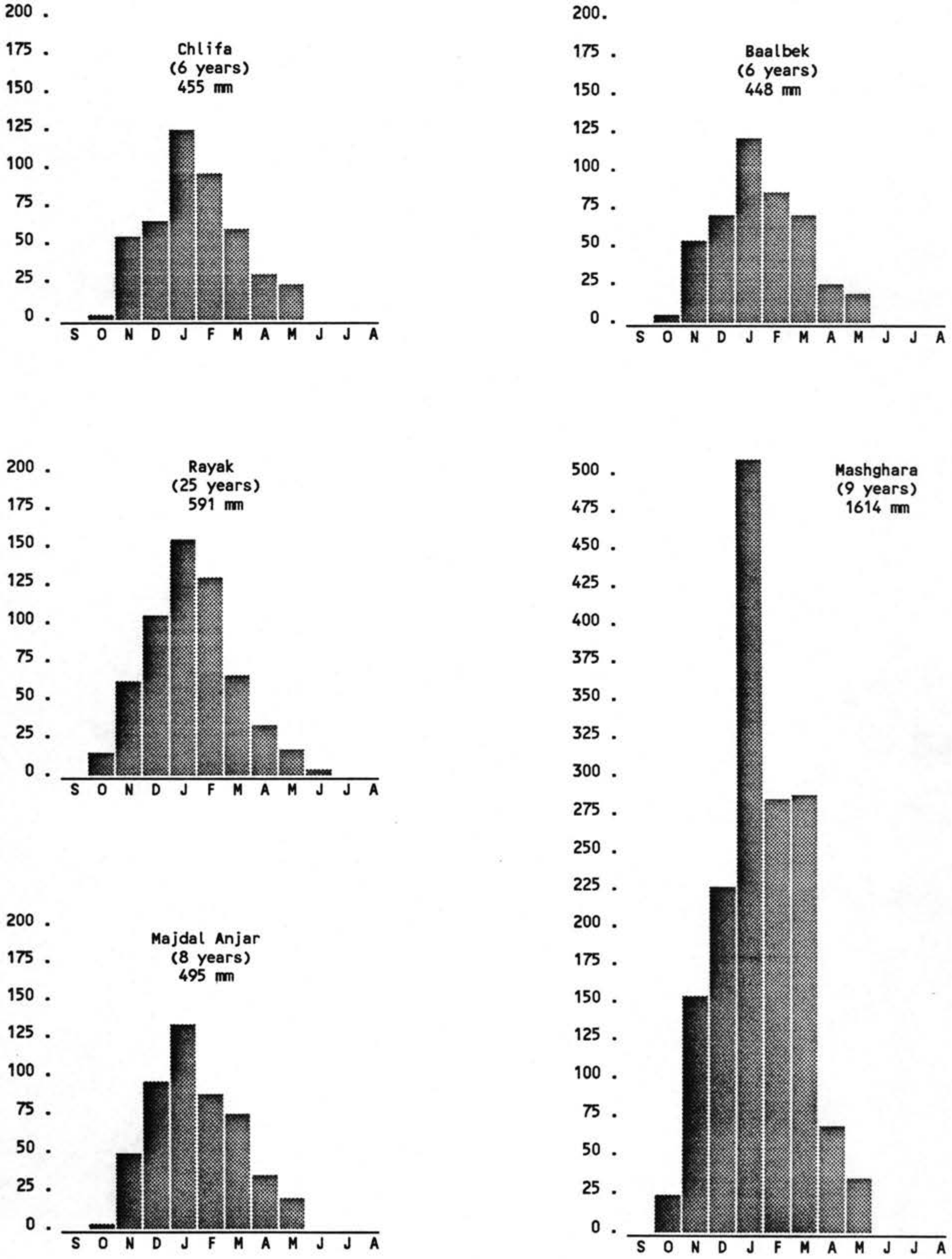
Graph RS-1

LONGITUDINAL PROFILE OF THE LITANI RIVER

Source: Vaumas(3291), p. 250.

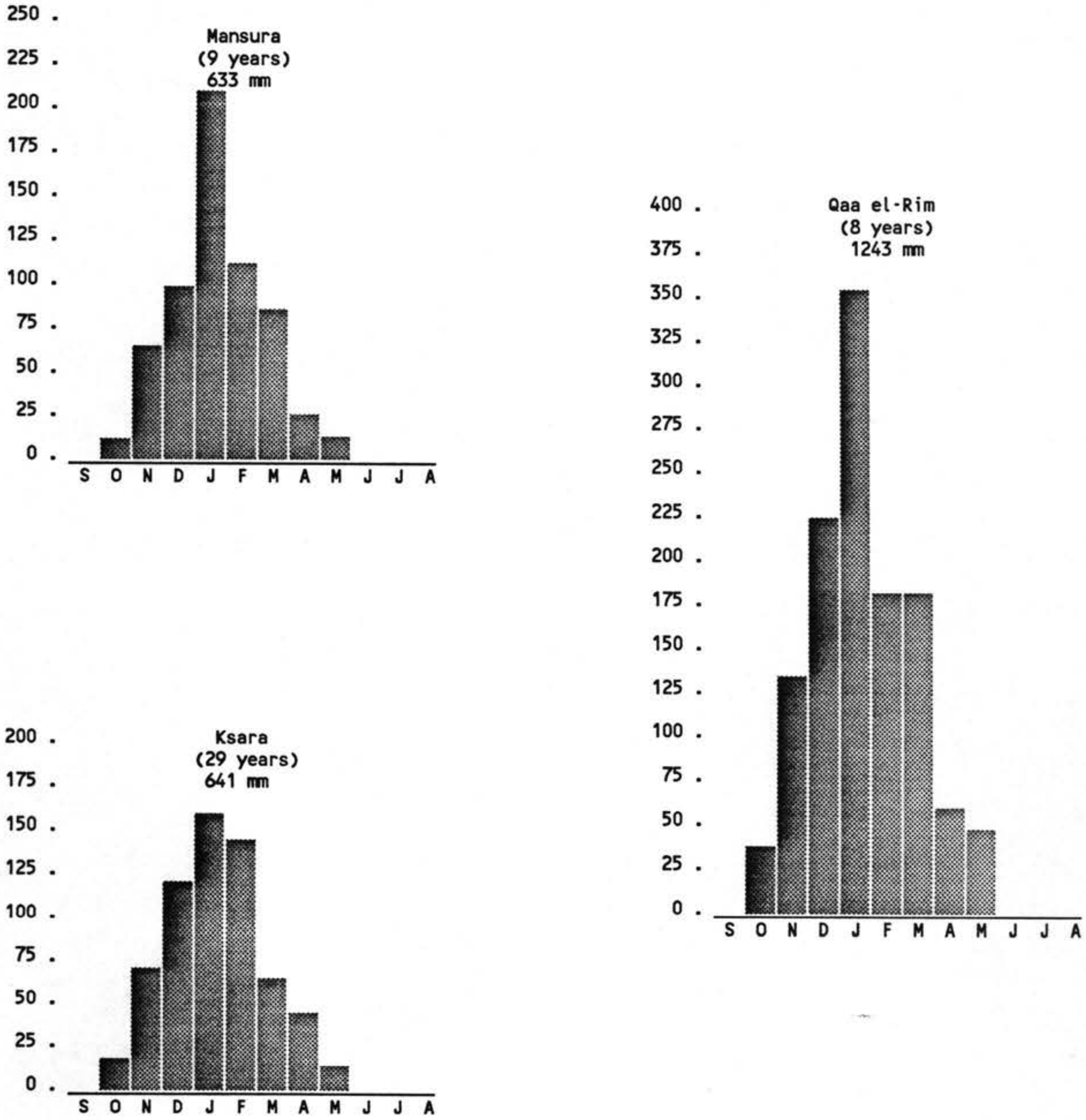
Graph RS-2

ANNUAL RAINFALL AT SELECTED STATIONS IN LEBANON
(Stations in the Bekaa)



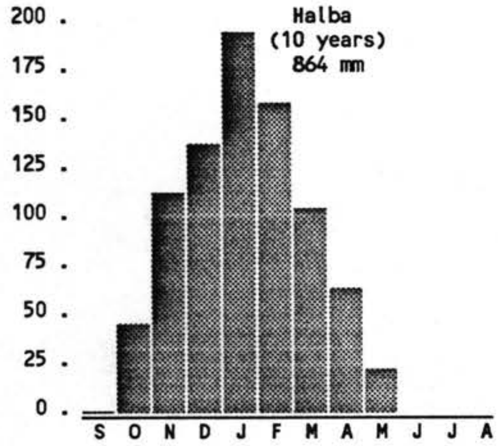
Graph RS-2 continued

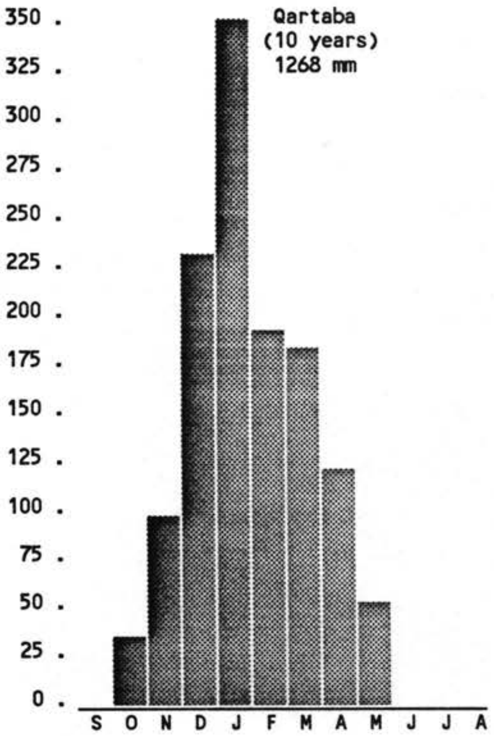
(Stations in the Bekaa)

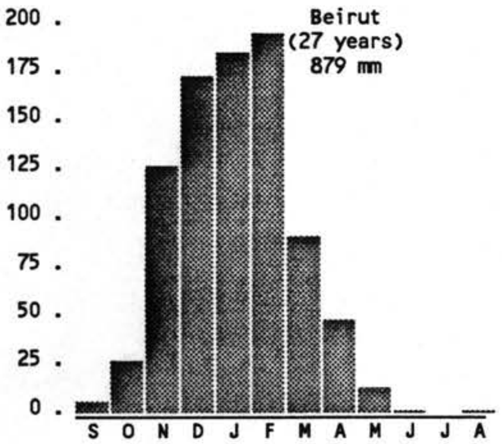


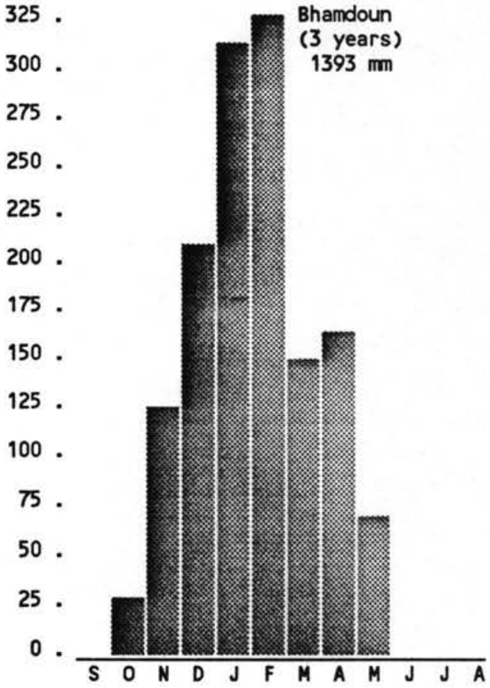
Graph RS-2 continued

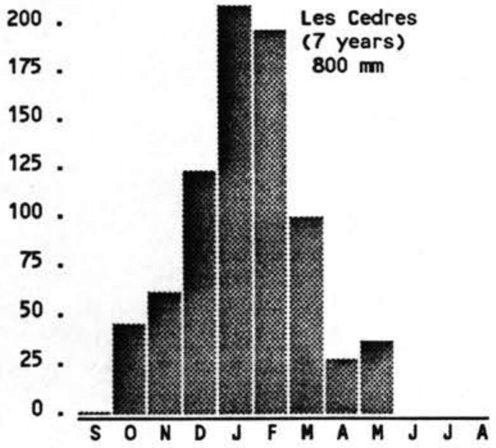
(Stations throughout Lebanon)





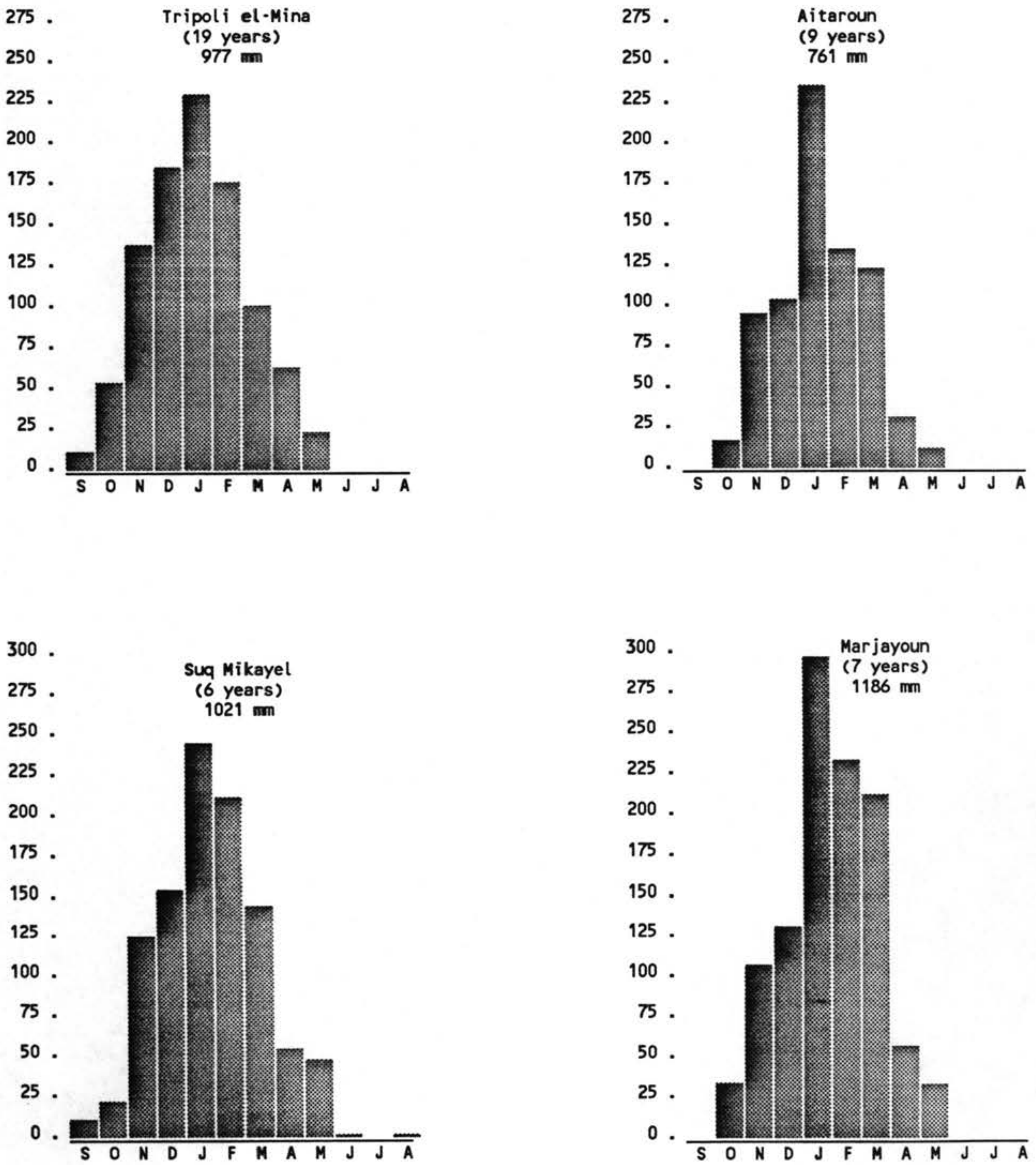






Graph RS-2 continued

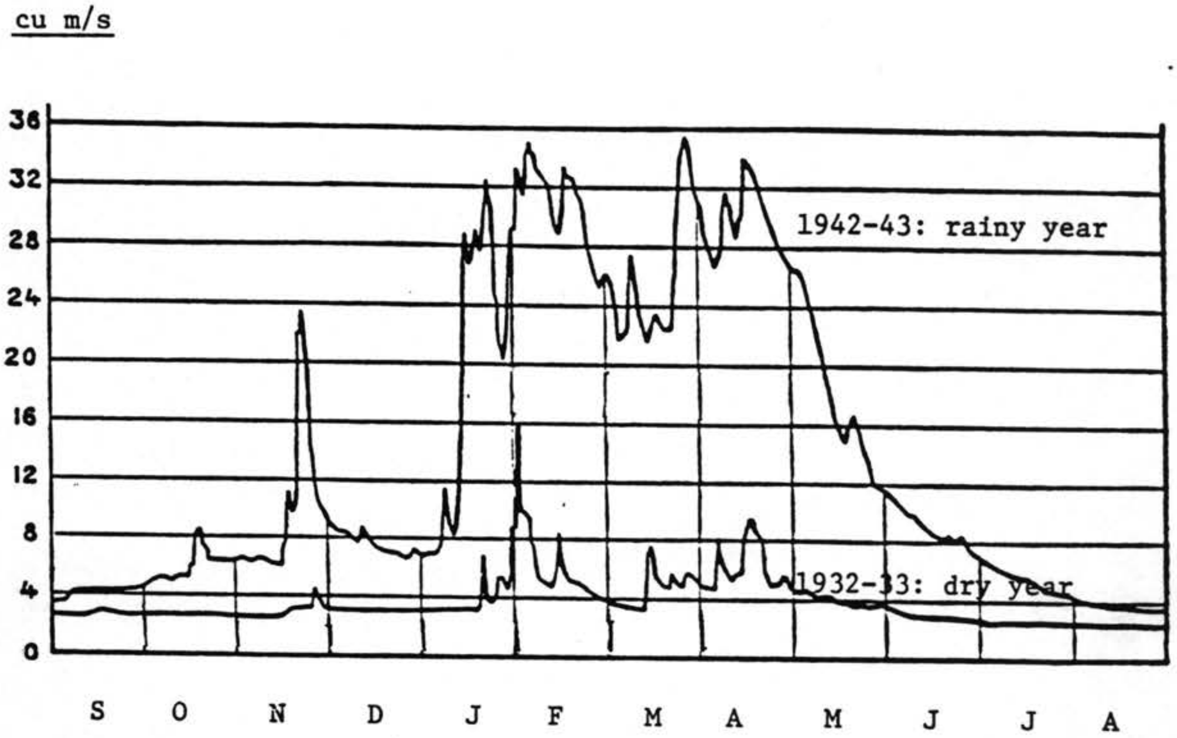
(Stations throughout Lebanon)



Source: Vaumas(3291).

Graph RS-3

THE REGIME OF THE LITANI AT MANSURA (after Abd El-Al)



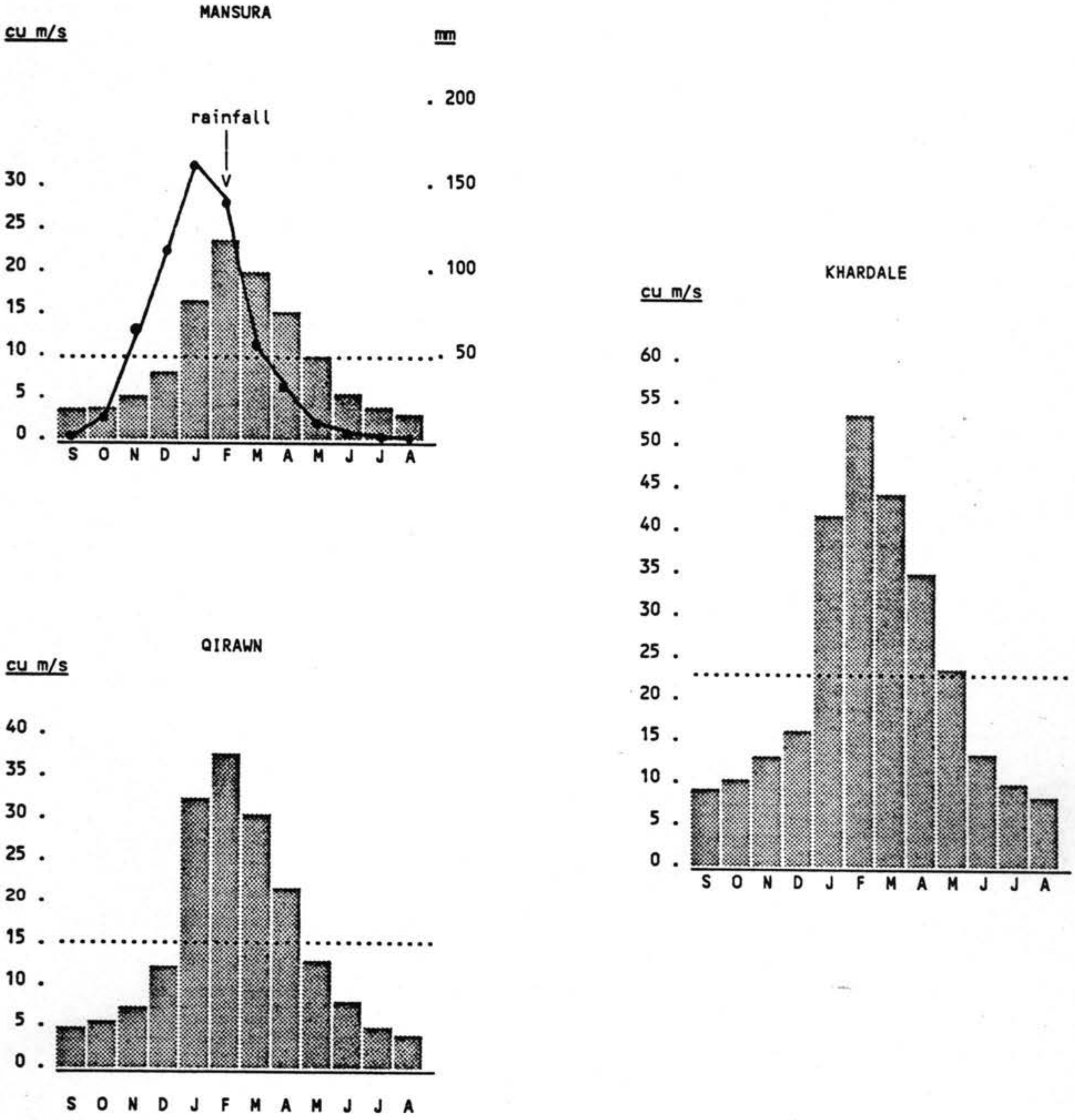
1932-33 = 111,700,512 cu m/yr

1942-43 = 449,249,242 cu m/yr

Source: Birot and Dresch(3281), p. 274.

Graph RS-4

FLOW OF THE LITANI AT THREE GAUGING STATIONS

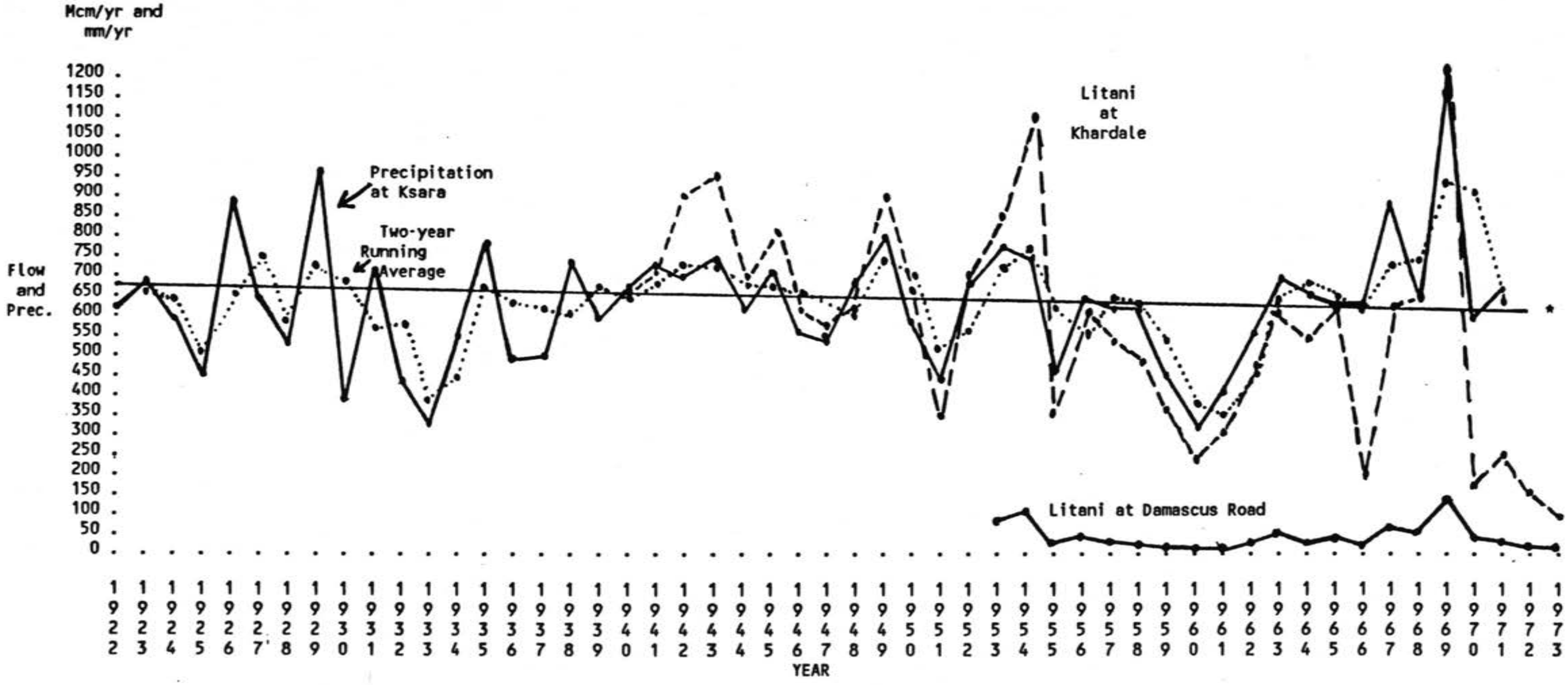


(......) = average flow.

Source: Vaumas.(3291)

Graph RS-5

LITANI FLOW AT KHARDALE (1940-1973) AS A FUNCTION OF PRECIPITATION AT KSARA (1922-1971)
(Also Litani Flow at Damascus Road, 1953-1973)



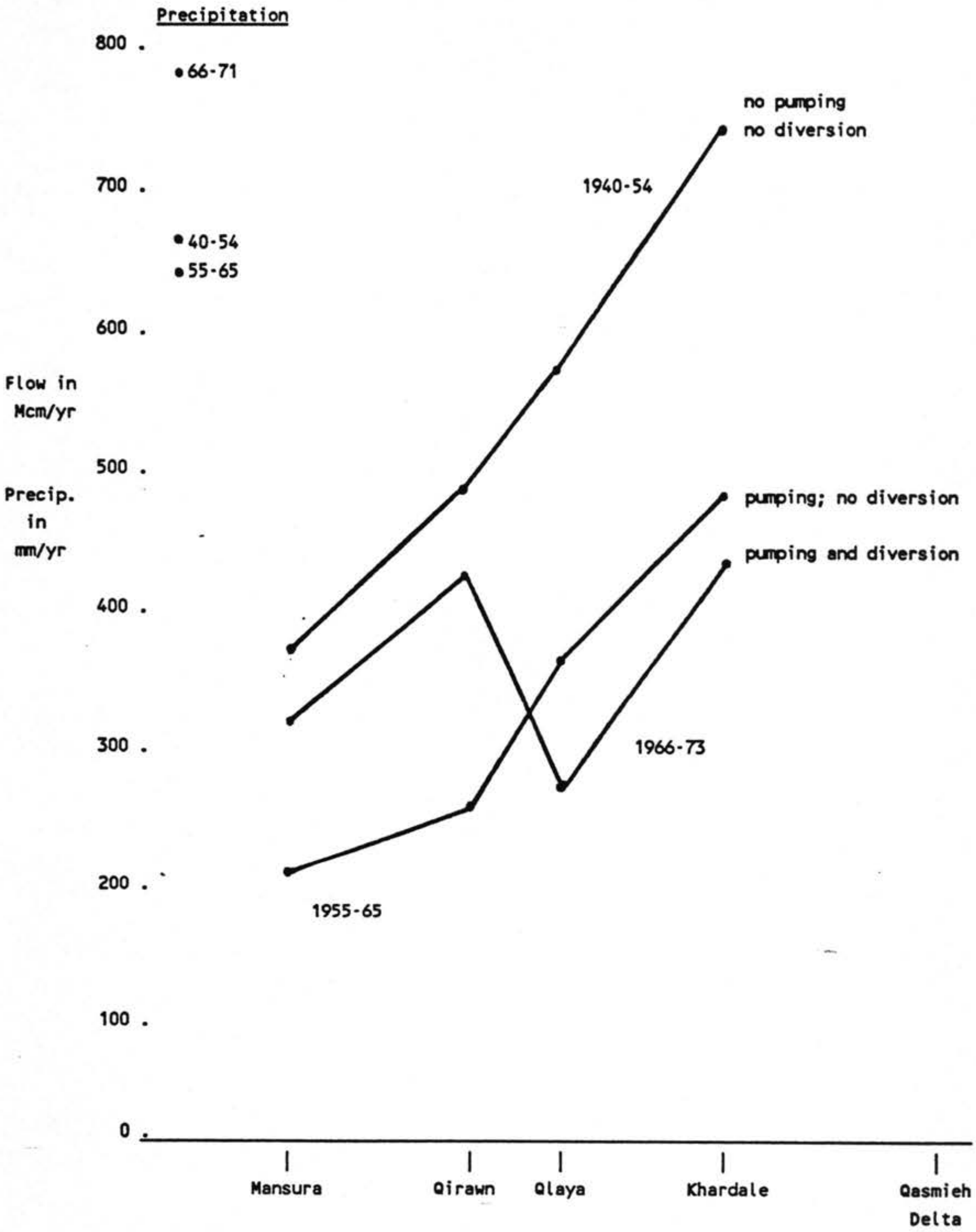
Calculated 50 year decline in precipitation: 1922 = 671.7
1971 = 600.2 = -10.6%
71.5

* Trend: Precipitation = -1.43(YR - 1946) + 636

Source: Engineering Report(3092), Tables 2, 9, and 30. Computations by Kolars.

GRAPH RS-6

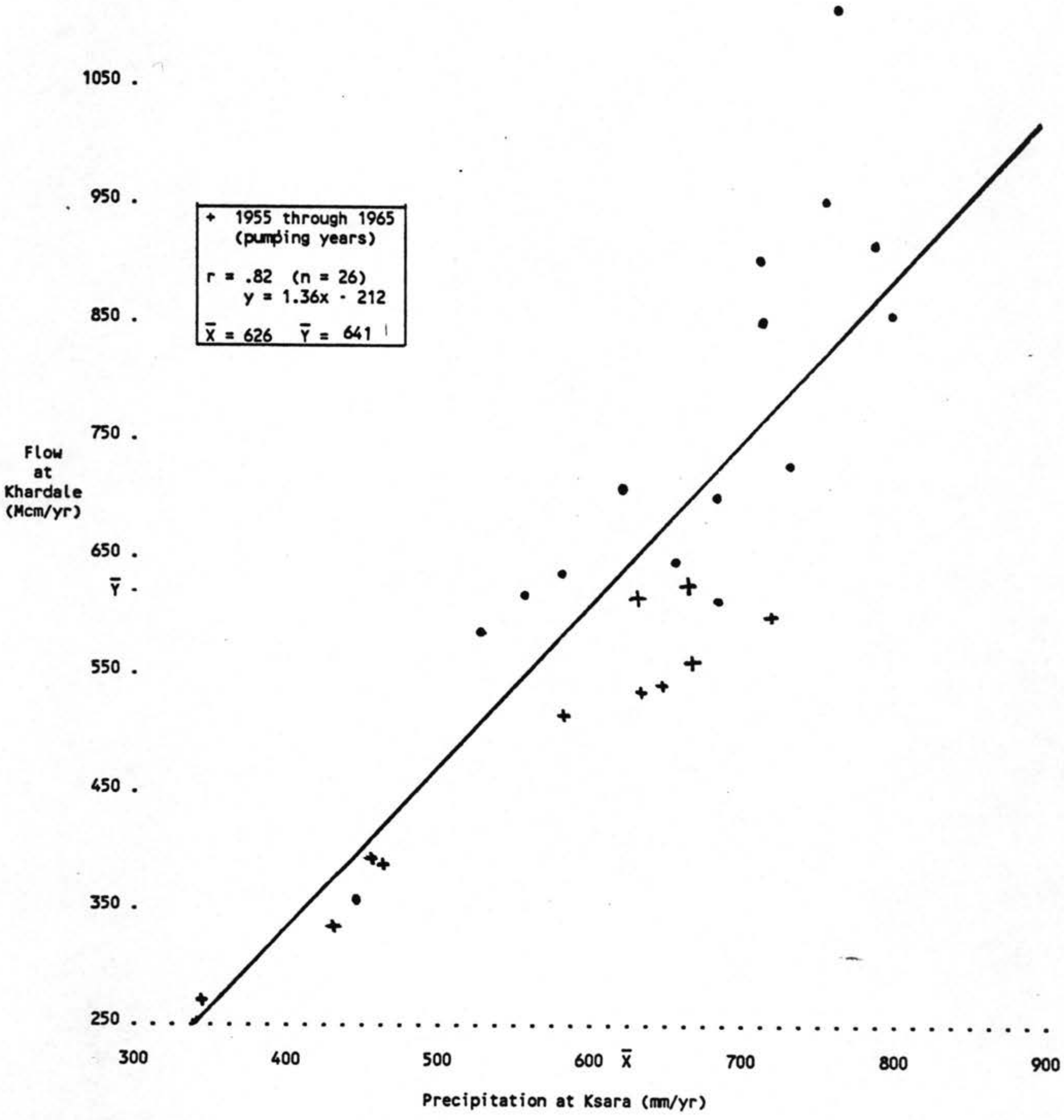
FLOW PATTERNS OF THE LITANI RIVER:
1940-1954/1955-1965/1966-1973



Source: Engineering Report(3092); Appendix A, this report.

Graph RS-7

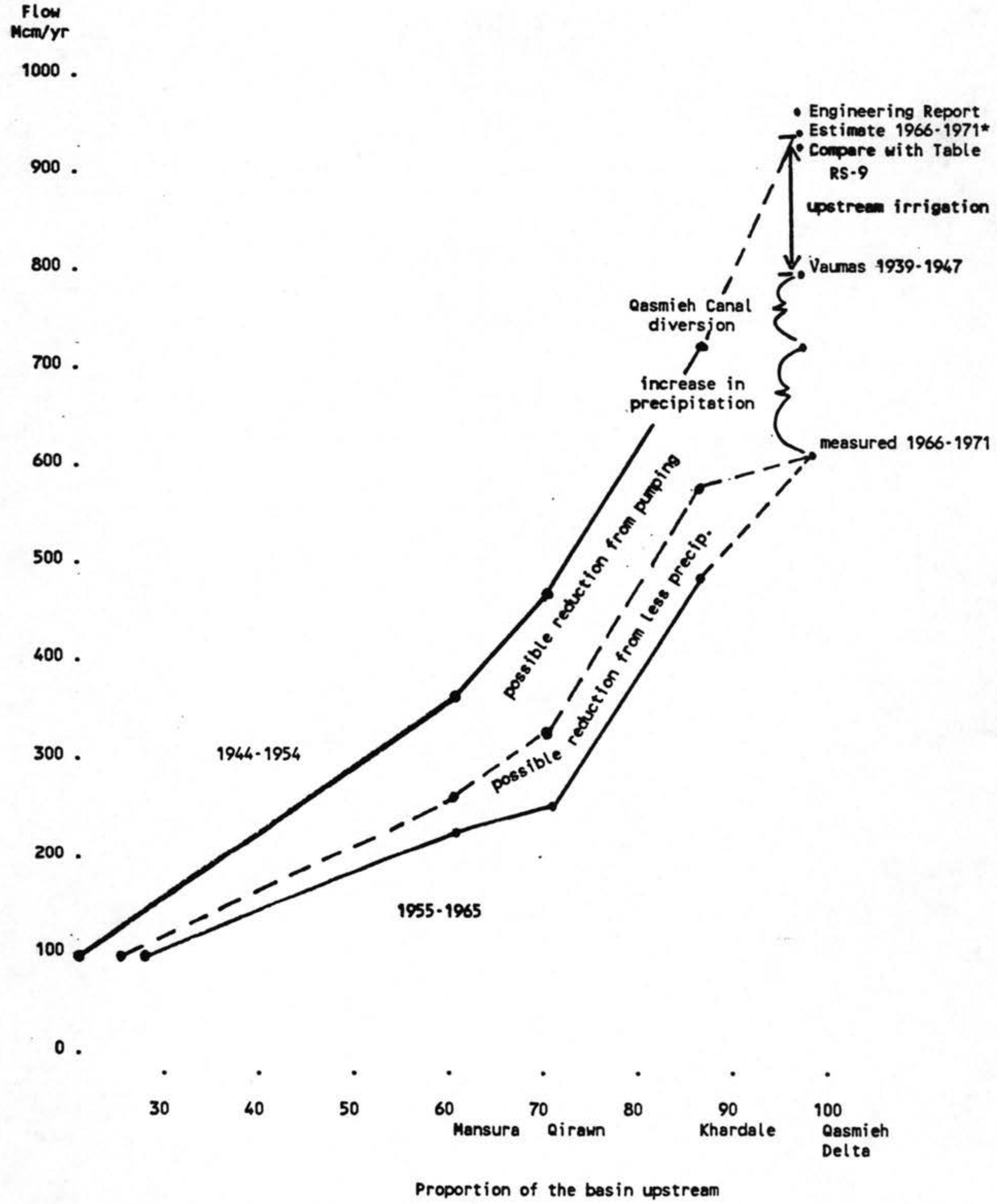
PRECIPITATION AT KSARA & FLOW OF LITANI AT KHARDALE
1940-1965



Source: Engineering Report[(3092)], Tables 2 and 30. Computations by Kolars.

Graph RS-8

THE NATURAL FLOW OF THE LITANI AND THE IMPACT OF PUMPING AND DIVERSIONS

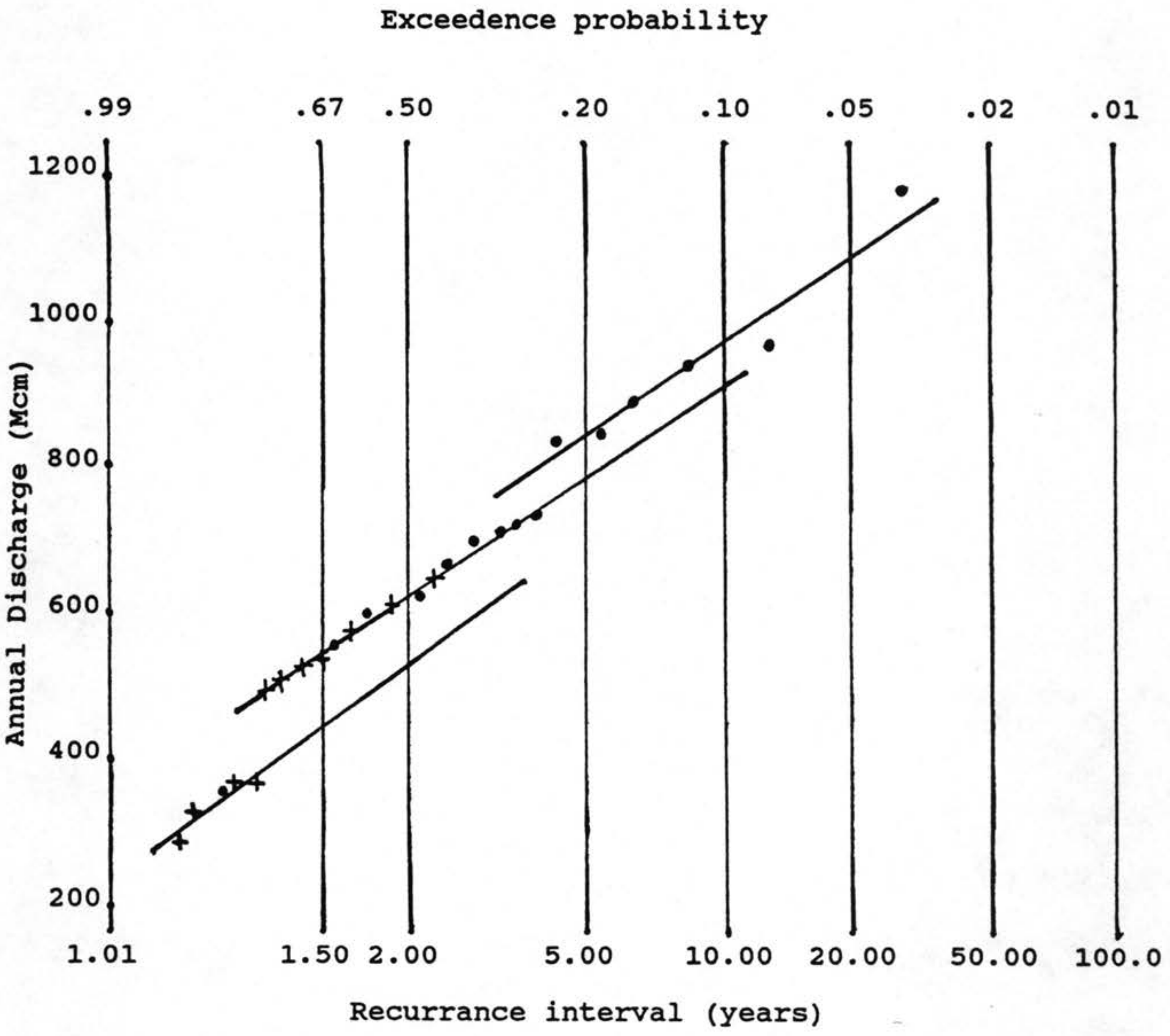


Sources: Engineering Report(3092), p. 73; Vaumas(3291); see Table RS-11.

* See text, p. 28.

Graph RS-9

DISCHARGE OF THE LITANI AT KHARDALE -- 1940-1965

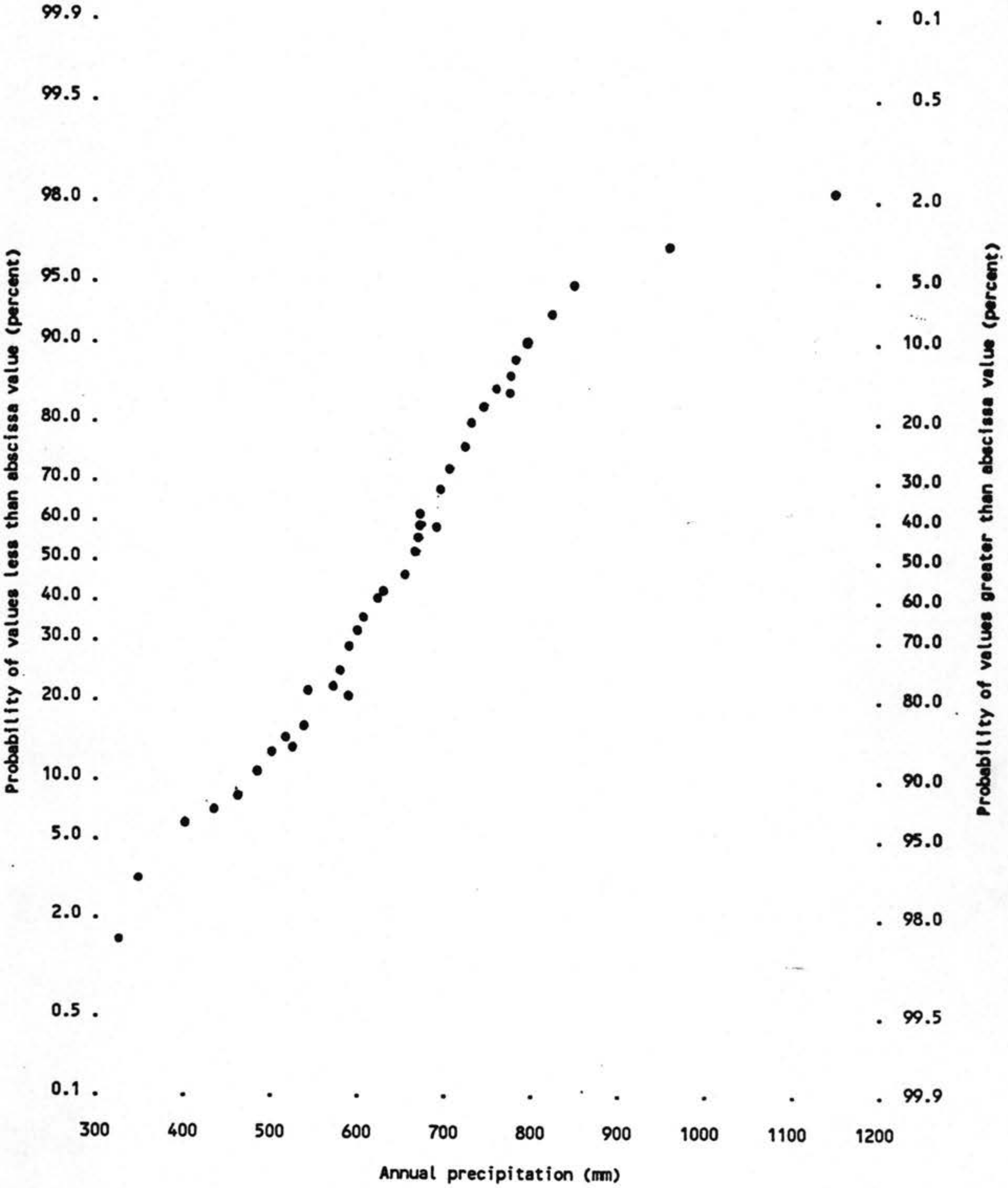


Source: Engineering Report⁽³⁰⁹²⁾, Table 30. Computations by Kolars. Trend lines estimated.

+ 1955-1965 (pumping years).

Graph RS-10

CUMULATIVE PERCENT FRENQUENCY OR PROBABILITY
OF ANNUAL PRECIPITATION AT KSARA, BEKAA, LEBANON
1921-22/1970-71*

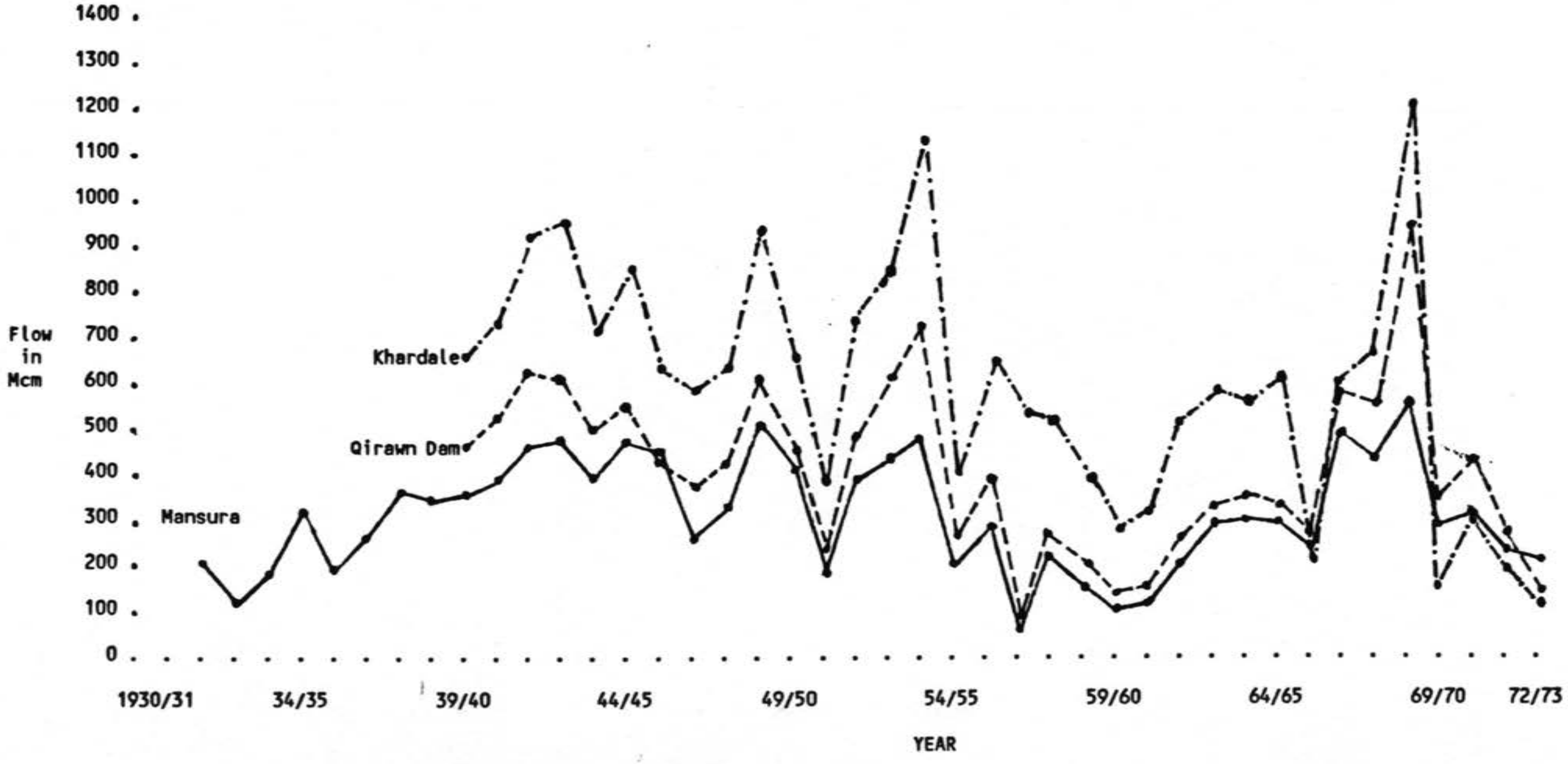


Sources: Engineering Report(3092), Table 2, p. 18; Dunne & Leopold(3059), pp. 44-46. Computations by Kolars.

* n = 50; 11 points omitted for graphic clarity.

Graph RS-11

ANNUAL FLOW OF THE LITANI AT SELECTED STATIONS (MANSURA, KHARDALE AND QIRAWN)
(1930/31-1972/73)



Source: Engineering Report.(3092)

KEY TO DIAGRAM RS-1

Number given station
in Engineering Report(3092)
(see Appendix A)

Official
Station Number

Station Name
(Spring or Stream)

20 (21) MARKABEH TUNNEL
15.8 - 34.8 (1962-1973)
27.5

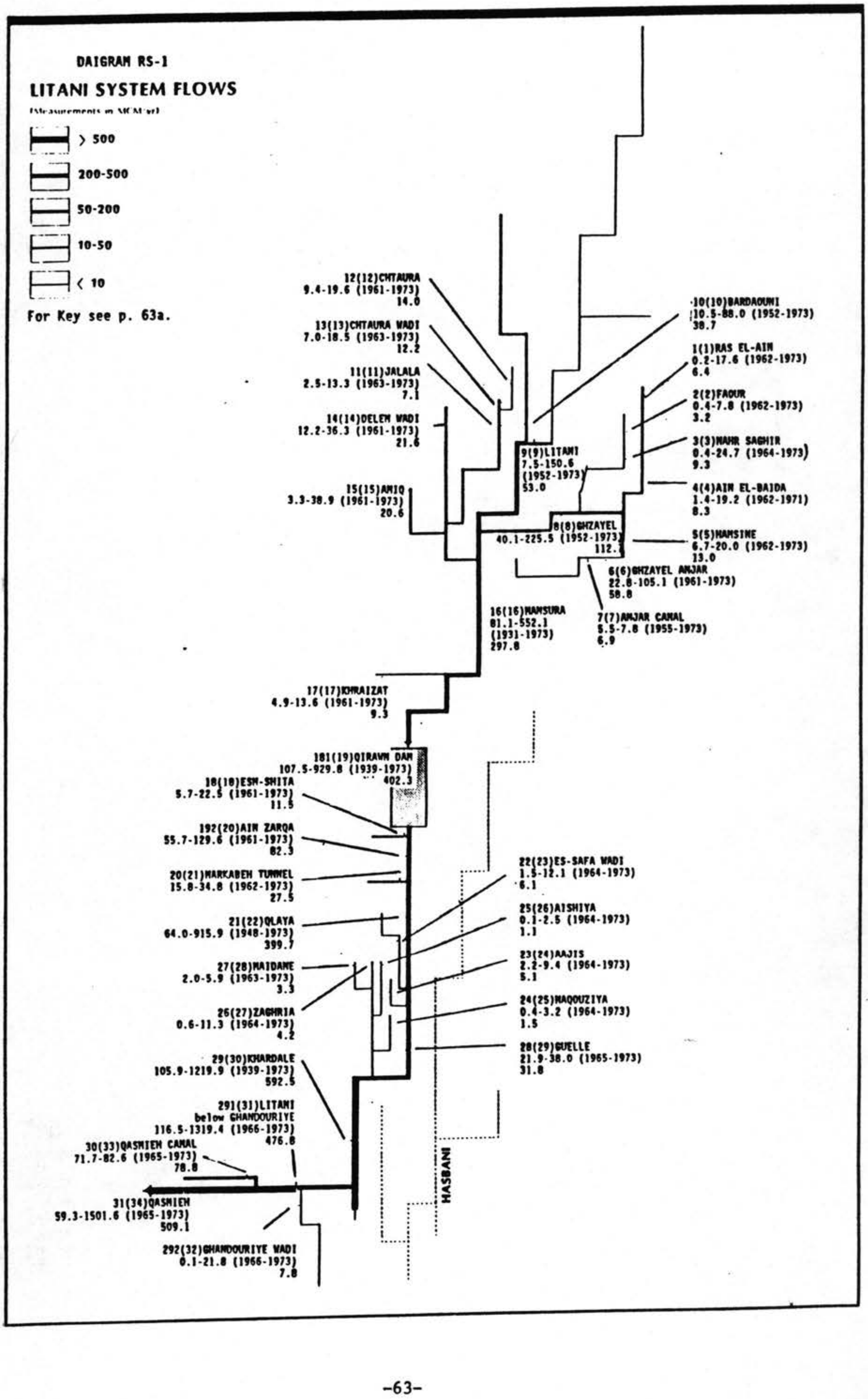
Years of Record

Smallest maximum
annual flow

Average annual flow

Largest maximum annual flow

See Appendix A for complete record.



DAIGRAM RS-1

LITANI SYSTEM FLOWS

(Measurements in MCM/yr)

Chapter 5

A CHRONOLOGY OF DEVELOPMENT

The Litani basin opens to the sea along the Qasmieh portion of its course. By the time it reaches Khardale the valley is narrow and the gorges near that point make travel north to the Bekaa Valley difficult. The Bekaa has, instead, found access to the outside world along the Beirut-Damascus highway which cuts across it about mid-way between the Litani-Orontes watershed divide and the gorges mentioned above. Despite the presence of this well travelled road, the Bekaa itself received little attention until the second half of this century. This is in sharp contrast to an earlier period when it served as a granary for Roman troops in the east.

The story of water use in recent times in the basin of the Litani begins in the early thirties when a local leader, Sheik Yakoub, and his followers began to use waters of the Anjar Canal on the eastern flank of the valley in the upper Litani basin. This was a local enterprise and consumed only about 45 Mcm of water per year from that source.

Armenian refugees still on the move after their displacement during World War I arrived in the vicinity of Anjar in 1939. The country was still under French mandate at the time and it was with French assistance that some 800 ha were irrigated for use by the refugees. It was also under foreign occupation that other developmental schemes began. The Qasmieh irrigation plan was begun in 1942. Following independence in 1943, the first phase of the Qasmieh irrigation canal was opened in 1948. Then, in 1951 the United States sent a team of experts to analyze the basin's water and energy potentials.[1] This resulted in a comprehensive report and recommendation(2740) which outlined what were to become the general developmental goals for the Litani, though many were not attained, and some of those that were have suffered grievously from subsequent civil war and invasion. A description of their recommendations would be overlong and in large part extraneous to what actually followed. Some indication of the scope of the U.S. team's proposals can be revealed through an inspection of the *General Location Map* which prefaced their report (Map 8). The centerpiece of their ideas, the Qirawn-Awali generating system, was to be realized in slightly altered form. On the other hand, their suggestion for a dam at the site of Khardale was never implemented.

Meanwhile, development of the Litani's resources went ahead both in the public and private sectors. Work began on the second phase of the Qasmieh Canal in 1954, while at the same time pumping by private parties started along the Litani in the South Bekaa (i.e. that part of the valley which contains the Litani and is south of the Beirut-Damascus Road). This amounted to about 10 Mcm per year.

The Office of the Qasmieh Project was created in 1956. The development of irrigated land followed quickly and by 1959 there were 3059 ha under irrigation in the Qasmieh Canal and Ras el-Ain (spring) area. Meanwhile, to the north pumping groundwater by local farmers had begun in earnest in the Bekaa with 50 Mcm/yr being used in 1958-59. This was followed by groundwater pumping in the Qasmieh delta (enough to irrigate 500 ha) in the period from 1961 to 1975.

The construction of the major dam at Qirawn was started in 1958 under government auspices and completed in 1961. In 1962 the reservoir was filled (220 Mcm) and in February of the same year the Markabeh hydroelectric plant downstream from the dam began operation. (Details of the entire Qirawn-Awali system are given in Table RU-4.) By 1965 (July) the sister plant to that at Markabeh was completed and operation begun on the Awali River. Then in October 1969 a third plant at Joun joined the first two in producing power for Beirut and the surrounding area.

The management of the Qasmieh and Ras el-Ain irrigation areas was consolidated under an office of the same name and was continued until 1974 when it was formally placed under the Litani River Authority by the Lebanese Council of Ministers.

Development of the water resources of the Litani was, however, not completely controlled by the government. Groundwater pumping by individuals increased rapidly in the South Bekaa: in 1970 64 Mcm were pumped, in 1973 that total was 79 Mcm. An effort was made to unify and consolidate such activities by a Decree(1422) passed by the central government on May 16, 1970. This *General Outline of Hydrological Development* spelled out the need for planning and control not only of the Litani's waters but of all the water resources in Lebanon. A thorough and very large study of the subject was initiated by the National Office of the Litani (ONL) and the Food and Agriculture Organization of the United Nations (FAO). This ONL/FAO report(3122) in numerous volumes was published in 1972 and had as its goals:

1. A systematic estimate of the water resources within the region, their actual utilization and their future possibilities;

2. An estimate of the needs of the population of the south and of Beirut for drinking water;

3. The allocation of priorities for drinking water and irrigation water both for the present and for the future;

4. The equitable sub-division of available waters between the diverse sub-regions of the south in order to assist with agricultural development.

Meanwhile, other tangible developments were taking place. By 1972, 3822 ha were being irrigated in the Qasmieh Canal/Ras el-Ain area. The so-called "900 meter" canal was constructed and put in use at Qirawn. (Details of this and other projects referred to in this section will be found in the following pages.) Private well drilling for groundwater and pumping from the Litani itself in the decade following 1975 began to stabilize, largely because no new lands were available for further expansion. By 1985 about 107 Mcm of water were being taken from the Litani and another 30 Mcm from its tributaries (Engineering Report(3092), p. 82).[2]

At this point in time the record begins to disintegrate. In June 1982 Israeli units began the invasion of Lebanon where they remained until June 1985. During that time considerable damage was done to the various water works throughout the south. Even before the formal invasion, factional fighting had brought about the partial destruction of the siphon near Tyre, the destruction of the Zahreni siphon near Sidon, and the blowing up of the Qasmieh pumping station. At about the same time the Joun generating plant was rendered useless as the result of the destruction of the Awali generating station. It seems that for the Joun to be brought back into production a by-pass canal must be rigged to bring water past the Awali area. In 1982 irrigation in the Sidon-Jezzine area was brought to a complete halt, while on the Litani extensive damage was done to the Qirawn pumping station. The net result of the latter event was to further encourage individuals in the farming area upstream to drill more wells and pump more water from the mainstream. It would seem that once in place such entrepreneurial efforts will be difficult to dislodge and that long range planning has received a serious blow. Finally, it is reported that in February 1984 Israeli forces seized major supplies of materials from the warehouse at Qirawn (pumping equipment, pipe, etc.) in addition to the dam's records of its management, river flow, etc. Very little coherent or complete information regarding these latter events is available and speculations and accusations from all sides are rife.

What then can be made of this muddled record vis-a-vis the devlopment of the Litani and the neighboring areas associated with that stream? The section that follows will try to summarize the situation past, present and future in connection with parallel demands for drinking water, water needed for hydroelectric generation, and for irrigation.

ENDNOTES

1. This is not to imply that a number of other studies had not been undertaken. A review of those efforts, as summarized by the American writers, is included in Appendix D of this report.

2. The same report on page 77 gives somewhat different totals -- "Irrigation upstream of Qirawn by surface water: 17,600 ha" which when measured proportionately against data for an earlier time (1972 = 6300 ha = 43 Mcm used) would equal 120.1 Mcm, a difference of 10 Mcm. See irrigation section that follows.

Chapter 6

MULTIPLE RIVER USE -- PAST, PRESENT AND FUTURE

The multiple demands placed on the Litani were reviewed in Chapter 2 of this report. It is necessary, however, to consider the question of irrigation in greater detail before summarizing overall river use.

6.1. The Status of Irrigation -- Circa 1972

The ONL/FAO report of 1972(3122) establishes a reasonably early (i.e. pre-civil war) base line for the irrigation of land in the area of concern. This area includes not only the southern Bekaa Valley (i.e. the portion watered by and furnishing water to the Litani River) but also the coastal zone from Beirut south to the border with Israel and including the zone between the Qasmieh portion of the river and that same border. (See Table RU-7.) This coastal zone includes four streams in addition to the Litani. These latter streams rise on the western slope of the Lebanon Mountains and flow directly to the Mediterranean Sea, unlike the Litani which rises in the interior and reaches the sea by cutting through the coastal highlands. The characteristics of the five rivers are summarized in Table RU-1.

Irrigated lands upstream from the Qirawn Reservoir totaled 15,800 ha in 1972 (ONL/FAO(3122), pp. 37-38). Of this amount 6300 ha received surface water (43 Mcm) and 9500 were supplied by pumping from underground sources (79 Mcm). The area in question is defined as being south of the 900 m contour and the Beirut-Damascus Road, extending to the Qirawn Dam, and bounded on the east and west by the break in slope of the parallel massifs. A detailed ONL/FAO examination of this section(2982) (dated 1973) gives its total surface area as 25,000 ha of which 23,000 ha are effectively cultivated though not necessarily irrigated. The same report cites an annual water need based on evapotranspiration (method unspecified) of 6300 cu m/ha making a total of 144.9 Mcm per growing season (April through October) for 23,000 ha or 99.5 Mcm for 15,800 ha, compared with the 122 Mcm cited above. This is not necessarily contradictory, for over-irrigation is a common practice on almost all unprofessionally managed farms everywhere.

The ONL/FAO summary(3122) cites water use downstream from Qirawn for 3270 ha on the lower Qasmieh (59 Mcm) and 1140 ha between Qirawn and the Qasmieh intake (12 Mcm). The total for the Litani basin was 20,200 ha using 193 Mcm water annually.

Lands of the South Lebanon Project incorporated in the ONL/FAO investigation(3122) included 4020 ha irrigated in the Qasmieh/Ras el-Ain area, 3270 of which have been discussed above and an additional 750 ha supplied by the Ras el-Ain Canal. Scattered surface areas using surface water along the coast to the north accounted for 5250 ha (75 Mcm). Underground waters from sea-level to 200 meters provided an additional 6700 ha with 70 Mcm from approximately 800 wells. The above information is summarized in Table RU-2.

6.2. The Qirawn Reservoir Project -- Circa 1972

The fields of the south Bekaa have been grouped into three sub-units: those of the right bank (9200 ha), those of the left bank (8200 ha), and those of the northern zone (5600 ha). Those on the right bank receive sufficient water from the Barouk-Niha aquifer (the Amiq, Akhdar, and Kob Elias springs) and the Tel Znoub area. The fields on the left bank are less favored with local sources of water and have received supplemental water from the Qirawn Reservoir (elevation 852 m) by means of a pumping station at the foot of the dam (elevation 804.6 m) which raises water to an elevation of 909.8 m into what is known as the "900 meter canal". This canal follows the 900 m contour north along the east edge of the Bekaa and has a gradient of about .2m/km to ensure gravity flow. It is intended to supply 8200 ha of land with from 4 to 5.5 cu m/s during the growing season from April to October (major withdrawals from May to September). To accomplish this 30 Mcm per year have been allocated from the reservoir fund. The fields of the Northern Zone are largely dependent on local sources and some surplus from the Anjar-Hamsine area. The water supply derived from various sources in the project area are shown in Table RU-3.

In summation, the 8200 ha on the left bank require roughly 6300 cu m/ha/yr (51.66 Mcm) and have 55 Mcm available (see Table RU-3). The right bank with 9200 ha (of which some 7900 ha were apparently irrigated in 1972) needs from 46 Mcm to 58 Mcm per year of which 50 Mcm is available in addition to supplies from the Anjar-Hamsine sources.(2982)

6.3. The Qirawn-Awali Generating System

As has been stated earlier, a major goal of development planning for the Litani basin was the construction of a complex hydroelectric generating system using both the Litani and Awali River basins. The scheme which was eventually realized begins with the Qirawn Dam and Reservoir. Water from the reservoir is diverted through a tunnel to the Abd El-Al Power Station (generally known as the Markabeh Plant). Having passed through these turbines water then continues through a tunnel under the Barouk-Niha crest to the headwaters of the Awali River. On the way, it is supplemented by the flow of the Ain Zarqa spring and additional waters of the Litani. Having also received some inflow from the Jezzine area the water is led to a holding basin before being directed by pipe (pressurized) to a second generating station, the Paul Arcache (known as the Awali Plant).

The water is again passed on to a second holding basin further down the Awali where it is supplemented by some flow from the Bizri River before entering the third power station (the Charles Helou Station, or Joun Plant). Thereafter the water is released into the Mediterranean. During the period 1965-1971 an average of 401 Mcm/yr were diverted through these three plants generating an average of 412,500,000 kWh[(1936)] (p. 6). (Technical details of this system are found in Table RU-4.) Under undisturbed operating conditions as much as 461 Mcm/yr would be diverted from the Litani basin into that of Awali for these plants (Table RU-6). It should be noted that some of this water would be diverted from the first holding basin above Awali for an irrigation pilot project at Sidon (6 Mcm) with 350 ha currently farmed and 3000 ha planned (personal communication, April 1986).

6.4. Conditions Circa 1985

As stated earlier, ten years of civil war and invasion have disrupted any centrally organized efforts at developing the Litani and its resources. The destruction of the Qasmieh pumping station, the damaging of the siphons at Tyre and Zahreni, and the apparent destruction of the Awali generating facility have slowed or stopped governmental management of water resources. (Appendix E contains one personal estimate by a Lebanese engineer of the impact of these events.) On the other hand, private pumping of water in the Bekaa has steadily increased. Table RU-5 gives some indication of this. (Also, see section 2.4. of this report.) The same source as that for Table RU-5 estimates that underground water will contribute to another 2700 ha by the year 2000 in the Bekaa and an additional 1300 ha in South Lebanon. Presumably this supposes an end to hostilities.

What appears is that at present hydroelectric power has been disrupted on the Awali but that enough thermal power is produced to sell some surplus to Syria (see Table DL-3). Drinking water is in short supply throughout the country because of various disruptions. Industrial usages are diminished. Irrigation in the Bekaa has continued to expand through private means to fill deficits left when government-operated systems were disrupted. This, on the other hand, means it may be almost impossible to return to a centrally managed system in times of peace, for once divided up a resource is hard to reconsolidate. A further discrepancy appears in the data for 1985 which show a total of 32,960 ha being irrigated upstream of Qirawn. Other data indicate a maximum of 23,000 ha available, both being used in 1972 and projected for use in the future (Table RU-5). Either the 1985 estimate is overly optimistic or, given complete lack of central control, marginal lands are being farmed and/or aquifers depleted. Irrigation in the Jezzine area appears to be ended and that along the coast greatly reduced. Much of these latter areas could be restored given calmer times. There remains speculation about the future which will be taken up in the next section.

6.5. The Future of the Litani and Neighboring Streams

The most comprehensive picture of the Litani and its uses can be gained from examining a composite picture of what its use might be in the year 2000 if peace were to come to Lebanon and the original ONL/FAO plans(3122) under the aegis of Decree 15.522 were to be realized. Table RU-6 presents such a picture carefully exerpted from the various reports mentioned in this study. While exact references are limited to four sources, another ten to fifteen reports had to be assimilated in order to achieve some coherence vis-a-vis the complexity of the materials.

The area considered in this synthesis is essentially all of Lebanon south of Beirut and the Beirut-Damascus Road road as well as the 900 meter contour in the Bekaa Valley with the exception of the Hasbani watershed. Nonetheless, a comprehensive analysis of the complete hydro-energy sector of the Lebanese economy remains outside the scope of this study. What is covered here, instead, is a summary of *water use* as the National Office of the Litani conceived it for the future.

6.5.1. Domestic Water Use

The city of Beirut will have doubled in size by the year 2000 -- according to this view which does not take current events into consideration. Total water use for domestic purposes will amount to 195 Mcm of which 60 Mcm will come from the study area. Of this 60 Mcm, 55 Mcm will be taken from the Jezzine-Bizri watersheds with the help of the Beit ed-Dine barrage project. The Litani will provide 5 Mcm during the summer months by way of the Awali diversion project.

North coast villages near Beirut will receive 24 Mcm water from the Damour and Barouk systems and will be essentially independent of the Litani watershed.

Villages of the south, both along the coast, south of the Litani (i.e. the Qasmieh) to the Israeli border, and in the Bekaa, will use 81 Mcm of which 21 Mcm will come from Litani sources. As reported elsewhere in this study, this will represent an ensuring of flow throughout the year and also an improvement in the per capita available domestic water.

6.5.2. Irrigation

The south Bekaa -- i.e. that area between the Beirut-Damascus Road and the Qirawn Dam will continue to pump 122 Mcm from both the river and the aquifers. Pumping from the latter will have the effect of pumping from the river because of the rapid flow-through time resulting from the karstic nature of the strata. (It should be mentioned here that the estimate given in Table RU-5 of 32,960 ha irrigated from all sources in the Bekaa as of 1985 is considered suspect -- although included in this report since little else could be found regarding contemporary conditions.) Because the careful projections made by the ONL/FAO(3122) limit themselves to about 23, 000 ha and 122 Mcm water and since inspection of maps and reports indicate no other possible land to irrigate, the 122 Mcm cited here is considered realistic for both the present and the year 2000.

One concession has been made to this. That is, 30 Mcm have been shown being taken to the "900 meter canal" as a separate withdrawal. This might increase to 35 Mcm in dry years, but in truth, the runaway private pumping that has taken place during the last decade precludes much organized use of the South Bekaa area in the future.

The Sidon Project based on waters led from the Awali holding basin is apparently defunct as of 1987 but was planned for the future as well as being in place in the past. This and parts of the upper and lower Nabatiya areas (covered below under "New Southern Projects") are now on prolonged hold.

The Qasmieh Project presents a somewhat different picture. Several accounts mention the profligate use of water within this area. Approximately 78 Mcm were used annually in 1972 -- although much of this has either come to a halt because of the destruction of canals and siphons or has been replaced by local pumping. Planners estimated that with proper management 47 Mcm should suffice for this area. Though the inefficient use of water is not mentioned as a cause, this may be the reason for this project's being subsumed under the Litani River Office in 1974.

The New Southern Projects will extend along the coast from the mouth of the Awali in the north, southward past the mouth of the Zahrani and Litani Rivers to the frontier with Israel. Between the Awali and Zahrani at an elevation between 300 and 600 meters 2,300 ha of land will use 16.1 Mcm water. From the Zahrani to the Litani at the same elevation another 3300 ha will consume 23.1 Mcm and along the coast south of the Litani and in the interior (former Haddad Land) an additional 9400 ha would need 38.5 Mcm for irrigation. Almost all of this water would be led from the Qirawn Reservoir and the incoming flow from upstream with considerable amounts *en passant* since the capacity of the reservoir is 220 Mcm) by a series of canals and pipes on both sides of the river to the south.[1]

Within this complex of uses there remains the largest of all; that is, the Awali-Litani diversion for generating hydroelectric power. At peak operation under ideal conditions -- assuming the Khardale Dam in place -- the complex of three power stations would require 563 Mcm of water in order to generate an estimated 563 GWh (the coincidence of values is not a typographic error -- see ONL(1936), p. 4). Of this amount, 346 Mcm would come from the Qirawn Reservoir and above, 115 Mcm from the Ain Zarqa and the river below the Qirawn Dam before the diversion, and 102 Mcm from the Awali and its tributaries.

The numerous withdrawals from the Litani would result in an estimated subtotal of 402 Mcm being provided from above the Qirawn Dam, and another 235 Mcm downstream from that point. This total should fall within the average annual flow of the river although in dry years particularly the upstream quantity might be severely reduced. Certainly the presence of the Qirawn Dam helps to buffer seasonal differences in flow from winter to summer. However, the capacity of the reservoir is such that no significant amount can be held over from one year to the next. On the other hand, the karst reservoirs provided by nature also serve through pumping by human means to match dry years with more abundant ones. In the event of a series of dry years, however, water would have to be diverted from the Awali generating plants (with thermal substitutions) in order to ensure downstream irrigation viability..

ENDNOTES

1. An alternate plan would include the storage of water behind a smaller dam to be built at Khardale. The water thus impounded would be used to augment supplies to these southern areas. Such holding back of winter rains for summer needs would also have taken advantage of by increased pumping from the stretch of the river below the Khardale Dam as it released its waters. Reports indicate that considerable pumping of water from the Qasmieh portion of the river took place prior to and even during the Israeli occupation of this area. At least one pumping station established for this purpose has been destroyed while another is still in use. (Interview by author with UN Observer.)

Table RU-1

WATER AVAILABILITY SOUTH LEBANON PROJECT AREA (1967/68-1972/73)

Estimated Natural Flow
(Observed Flow in Parentheses)

Watersheds (N to S)	Average Year			Dry Year		
	Annual	Nov/Apr	May/Oct	Annual	Nov/Apr	May/Oct
Damour	255 (218.4)	213.8 (205.4)	41.2 (13.0)	115.5 (82.8)	86.4 (77.9)	29.1 (4.9)
Awali	238 (217)	187 (182)	51 (35)	110 (89)	86 (80)	24 (9)
Saitaniq	16.9 (14.1)	14.5 (13.9)	2.4 (1.1)	2.7 (1.1)	1.6 (1.1)	1.1 (0)
Zahrani	38.1 (29.7)	32.9 (29.0)	5.2 (0.7)	13.2 (4.8)	8.7 (4.8)	4.5 (0)
Litani above Qirawn*	536 (414)	368 (368)	168 (46)	277 (130)	113 (113)	114 (17)
Litani below Qirawn*	481 (388)	335 (311)	146 (77)	201 (110)	109 (82)	92 (28)
Total Litani*	1017 (802)	703 (679)	314 (123)	478 (240)	222 (195)	206 (45)

Source: ONL/FAO(3122), Chapter 4.

* These figures are particularly large due to the influence of 1968-69 precipitation. See page 50 of ONL/FAO(3122); also see Tables DL-4 and DL-5.

Table RU-2

IRRIGATED LANDS -- CA 1972

	ha	cu m/ha	Water Used (Mcm)
Litani Basin			
Upstream from Qirawn			
Surface	6300		43
Underground	9500		79
	15,800 ha		122 Mcm
Downstream from Qirawn			
Lower Qasmieh & Litani	3270		59
Areas scattered between Qirawn and the Qasmieh intake	1140		12
	4410 ha		71 Mcm
Total Litani Basin	20,200 ha		193 Mcm
South Lebanon*			
Qasmieh Canal/Ras el-Ain surface waters			
Qasmieh Canal	3140**		
Ras el-Ain Canal	750		
Lower Litani valley	130**		
	4020 ha	18,600 cu m/ha	74 Mcm
Scattered irrigated areas using surface waters			
Damour	1940		29
Other	3310		46
	5250 ha	14,200 cu m/ha	75 Mcm
Underground water sources (sea-level to 200 m)***			
Litani to southern border	3400		
Other	3300		
	6700 ha	10,400 cu m/ha	70 Mcm
Total South Lebanon	15,970 ha		219 Mcm

Source: ONL/FAO(3122), pp. 37-38.

* See Table RU-7 for a description of this region.
** Also counted under "Litani Basin".
*** Approximately 800 wells.

Table RU-3

WATER SUPPLY FOR THE SOUTH BEKAA

Source	Location	Amount (Mcm)	
Qirawn Reservoir	to left bank	30	"900 meter canal"
Anjar-Hamsine	to both banks	35	
Terbol	to left bank	15	
Amiq	to right bank	20	Barouk-Niha
Tel Znoub	to right bank	30	
Khamed Lauze	to left bank	10	pumped aquifer
Total		140	

Table RU-4

THE QIRAWN/AWALI GENERATING SYSTEM

The Qirawn Dam (Albert Naccache Dam) and Reservoir

		Source
Length	1090 m	# 2706, p. 36
Height	62 m	"
Width at base	162 m	"
Width at crest	6 m	"
Basin capacity	220 Mcm	"
Average annual evaporation	-670 mm	# 2740, p. III-8
Estimated evaporation loss from reservoir		" , p. III-9
- elevation = 840 m: area	5.66 km^2	
estimated loss	3.8 Mcm	
- elevation = 856 m: area	11.04 km^2	
estimated loss	7.4 Mcm	
Estimated sedimentation filling rate	23,000 cu m/yr	# 2740, p. III-21

Markabeh Generating Plant (Abd El-Al Station)

		Source
Tunnel (Qirawn Dam to plant)		# 2706, p. 36
Length	6400 m	"
Diameter	3 m	"
Distance of drop	199 m	"
Generation	34 Kw (34,000 kW)	"
Coefficient of transformation	0.42 kWh/cu m	# 1936, p. 1

Awali Generating Plant (Paul Arcache Station)

		Source
Tunnel (Markabeh Plant to holding basin near Jezzine)*		
Length	17,070 m	# 2706, p. 36
Diameter	3.27 m	"
Holding basin capacity	0.15 Mcm	"
Pipe to Awali generators (pressurized)		"
Length	776 m	
Diameters	3.20 m -- 2.80 m -- 2.60 m	
Distance of drop	403 m	"
Generation	72 Kw	"
Coefficient of transformation	0.92 kWh/cu m	# 1936, p. 1

Table RU-4 continued

Joun Generating Plant (Charles Helou Station)

		Source
Holding basin capacity	0.25 Mcm	# 2706, p. 36
Tunnel to Joun plant		
Length	6894 m	"
Diameter	3.4 m	"
Distance of drop	180 m	"
Generation	49.3 Kw	"
Coefficient of transformation	0.41 kWh/cu m	# 1936, p. 1

Electric Production Qirawn/Awali System (kWh)

(Source: # 1936)

Year	Markabeh	Awali	Joun	Total
1965	98,627,000	121,295,500	--	219,922,500
1966	78,950,000	221,738,000	--	300,688,000
1967	96,053,000	197,126,000	--	293,170,000
1968	141,335,000	229,963,000	19,216,000	390,514,000
1969	117,384,000	298,381,000	113,917,000	529,682,000
1970	112,010,000	340,888,000	164,336,000	617,234,000
1971	93,247,000	307,601,000	135,301,000	536,139,000

Sources: *Syrie at Monde Arabe*(2706), p. 36; US Department of the Interior(2740); Nader for ONL(1936).

* Water issuing from the Markabeh Plant is augmented by the flow of the Ain Zarqa spring.

Table RU-5

IRRIGATION FROM THE LITANI -- 1985

	Using Surface Water		Using Underground Water		Total
	ha	Mcm	ha	Mcm	ha
Irrigation upstream of Qirawn	17,600	120	15,360	127.7	32,960
Irrigation downstream of Qirawn*					
Qasmieh sector	3200		--		3200
Model sector	300		--		300
Other scattered sectors	1140		160	11.2	1300
Total	22,240	199.1	15,520	138.9	37,760 (338 Mcm)

Source: Engineering Report(3092), p. 77.

* These figures seem inconsistent with reports of destruction in this area.

Table RU-6

ESTIMATED FUTURE WATER USE (CA 2000) IN THE LITANI BASIN AND THE SOUTHERN COASTS AND INTERIOR

(All values in Mcm)

Type and Location	Normal Year	Dry Year	Surface Water	Comments	Reference
DOMESTIC					
Beirut	5*	--	Awali-Litani diversion	Out of a total of	# 3122 (unless other-
	55	--	Jezzine-Bizri	195 for the city	wise noted)
Villages -- North coast	24	--	Damour-Barouk		
Villages -- South coast and interior	15*	--	Qirawn Reservoir		
	7*	--	Khardale Reservoir	Proposed	
	24	--	Beit ed-Dine	Proposed	
	35	--	Local		
IRRIGATION					
South Bekaa	122	142	Local pumped groundwater and surface water		# 3122 & # 1942
Sidon Project	30*	35	Qirawn Reservoir	"900 meter canal"	
	6*	7	Litani diversion	From Awali holding basin	
Qasmieh/Ras el-Ain	78	--	In 1972: 3140 ha Qasmieh Canal 750 ha Ras el-Ain Canal 130 ha lower Litani	Used ca 1972; considered excessive	
	47*			After proposed reorganization	
New Southern Projects elev. ha			From Qirawn Res. --	7000 cu m/ha average water consumption	# 3123, p. 1
Awali to Zahrani 300/600 2300	16.1		Zahrani 38.1		
Zahrani to Litani 300/600 3300	23.1		Awali 238.0		
Litani to border 300/600 3900	27.3*		Lower Litani --		
600/800 5500	38.5*				
Sub-total 15,000	105.0				
LITANI-AWALI HYDROELCTRIC DIVERSION	115*		Ain Zarqa and below Qirawn Dam		
	346*		Qirawn Reservoir and upstream		
	102		Awali basin		
Sub-total	563				# 1936, p. 1

Sources: ONL/FAO(3122); ONL(1942); Moudallal for ONL(3123); Nader for ONL(1936).

* Litani water; total for Litani waters = 636.8 Mcm.

Table RU-7

THE SOUTH LEBANON PROJECT AREA

(Decree #14.522) Located on the Western slope of the Lebanon [Mountains] below the 800 m contour and south of the Beirut River south to the border with Israel.

Northern Development Region (Beirut to the Awali River)	465 km^2
Southern Development Region	
Sidon Zone	36 km^2
Jezzine Caza north of Marjayoun	114 km^2
Specific southern development area*	1486 km^2
Coastal Zone = 205 km^2	
Interior = 1281 km^2	
Total	2101 km^2

Watersheds of the South Lebanon Project

Damour	277 km^2
Awali (Barouk, Bizri, Jezzine [cavern], Awali)	302 km^2
Saitaniq	109 km^2
Zahrani	106 km^2
Litani (below Qirawn)	616 km^2
minor sheds	1015 km^2
Total	2425 km^2

Source: ONL/FAO(3122), pp. 2 & 26.

CHAPTER 7

Conclusion

The small size of the Litani watershed and the immediate response from year to year of river volume to available precipitation necessitate careful management strategies. Additional dams and reservoirs (such as the one planned at Khardale) would provide some means to control and smooth the variance of flow from season to season and year to year. The range of volumes involved and the scarcity of good dam and reservoir sites limit this solution. What is necessary is to carefully integrate and coordinate thermal and hydroelectric generating means -- as worked out by the ONL/FAO in 1972(3122) -- in order to assure a fixed minimum flow of irrigation and drinking water to users in central and southern Lebanon as well as in the growing cities of the coast.

The work accomplished in 1972 makes an excellent base line against which reconstruction can be attempted. In addition, further study and data gathering should make clear a more exact relationship between climatic indicators and river discharge on a real time basis. Once such measures are established, and assuming the necessary negotiations between different regional and economic interests have been worked out, the Litani should prove to be a manageable system and the keystone of peaking power and domestic as well as irrigation water supplies in Lebanon.

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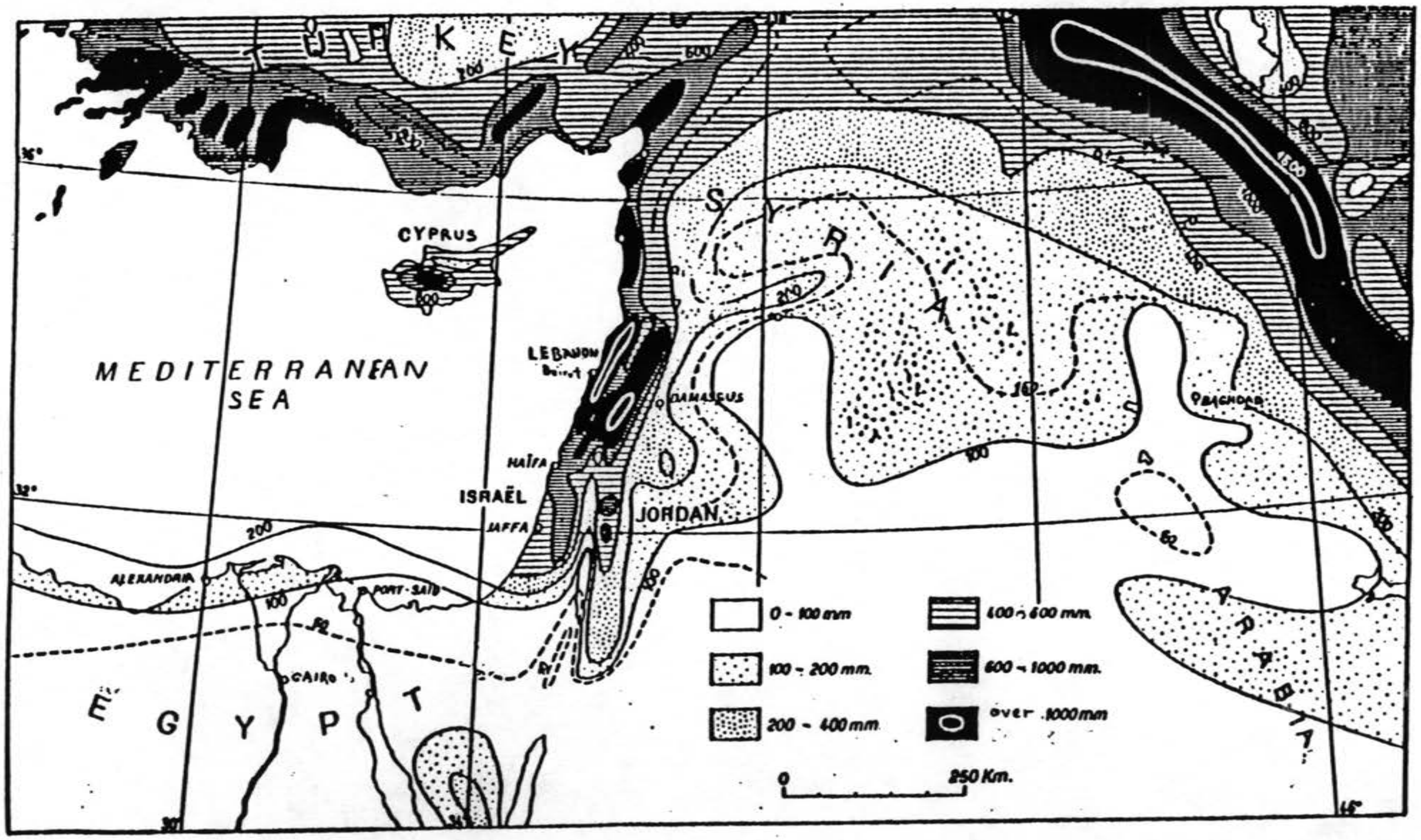
MAP 1

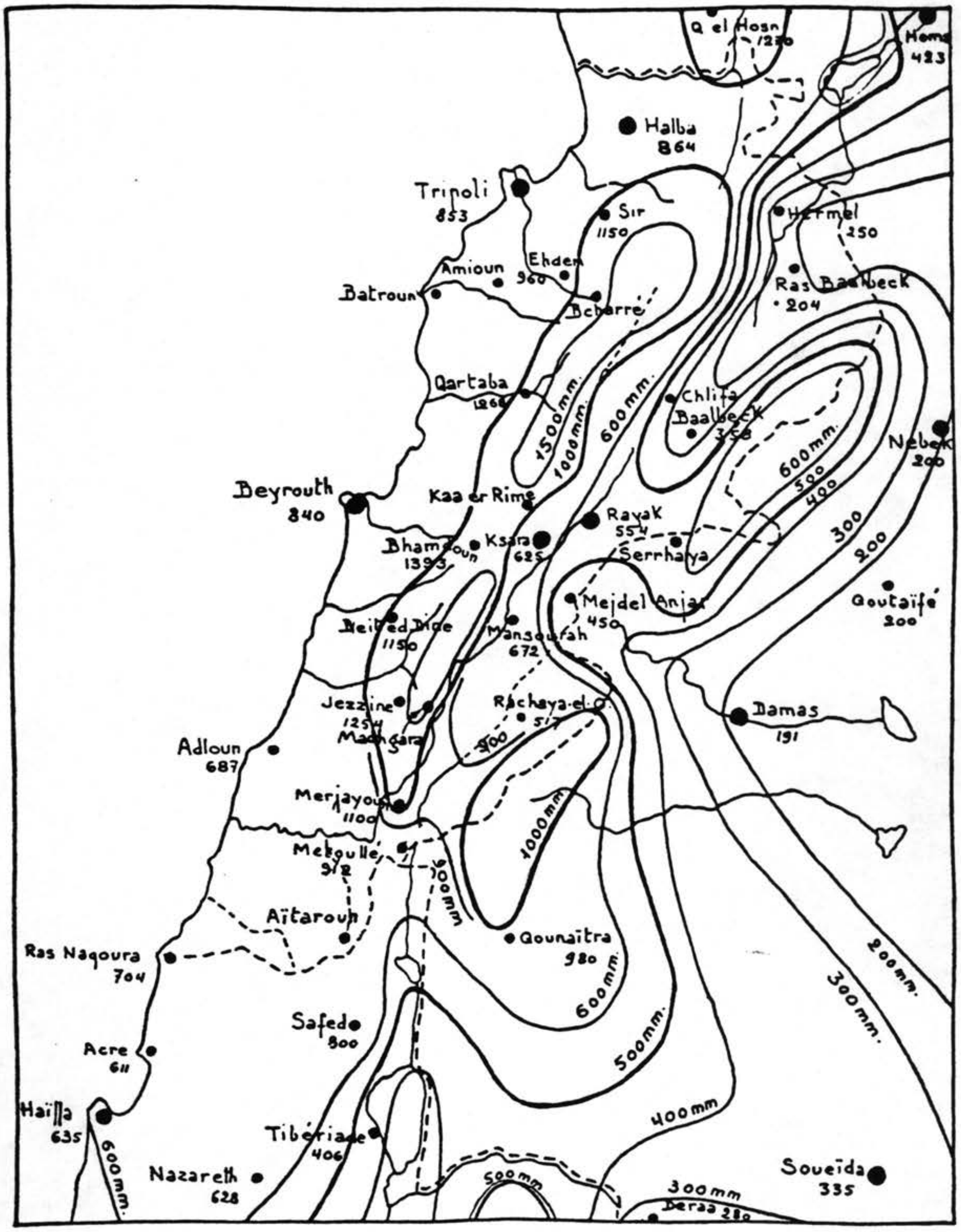
PRECIPITATION IN THE NEAR EAST



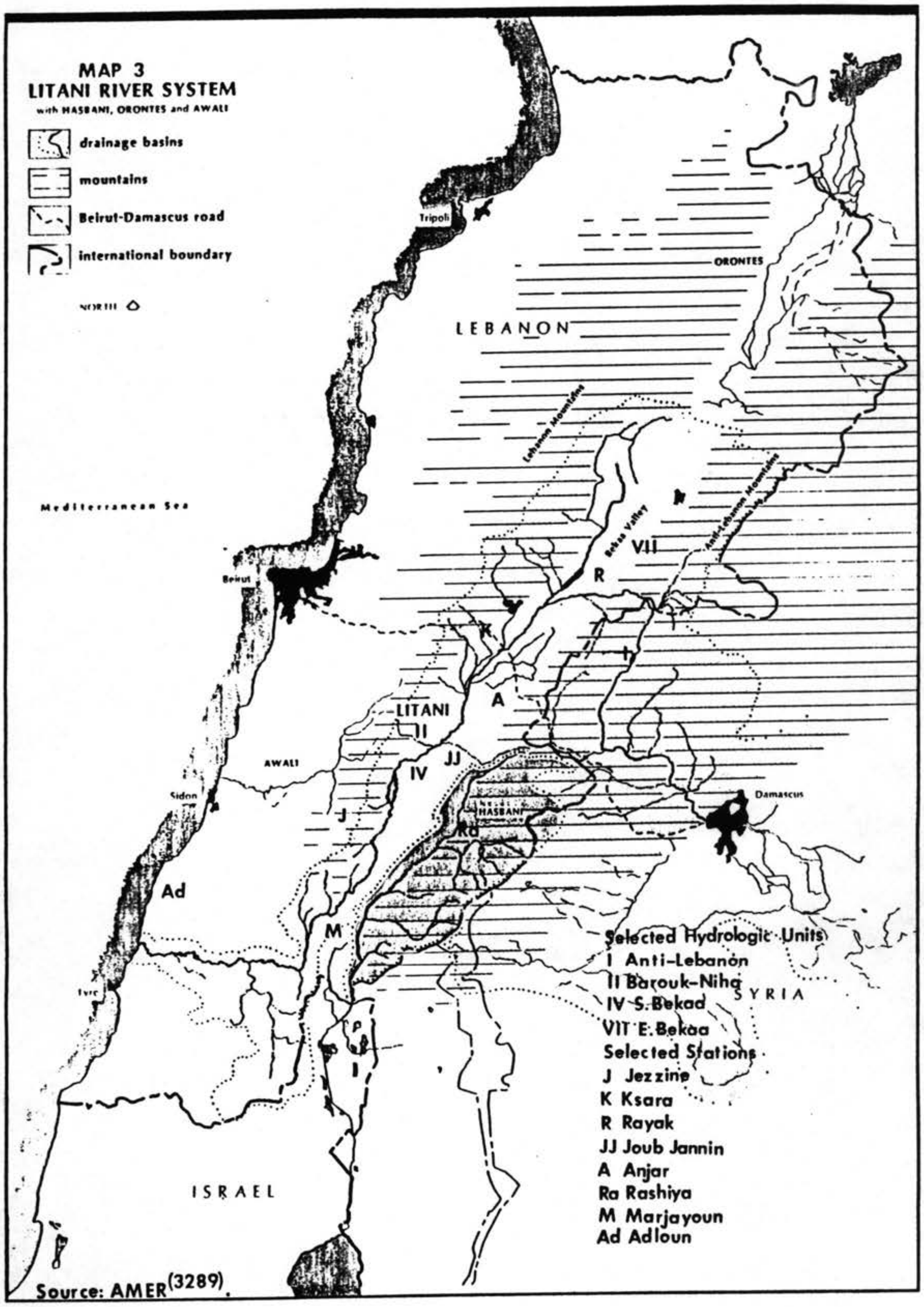
Source: Birot and Dresch(3280).

MAP 2

PRECIPITATION IN LEBANON



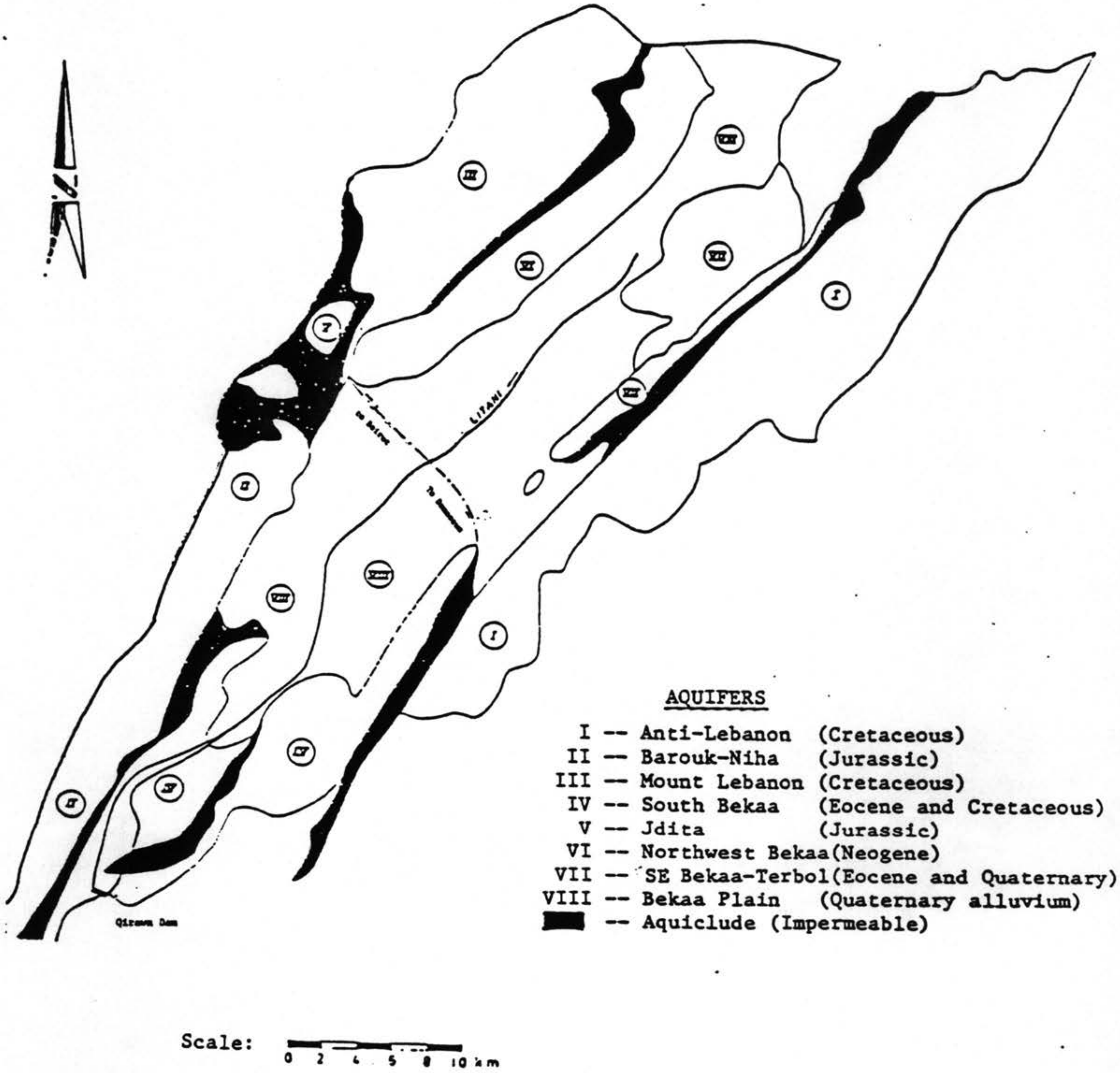
Source: Vaumas(3291), p. 221.



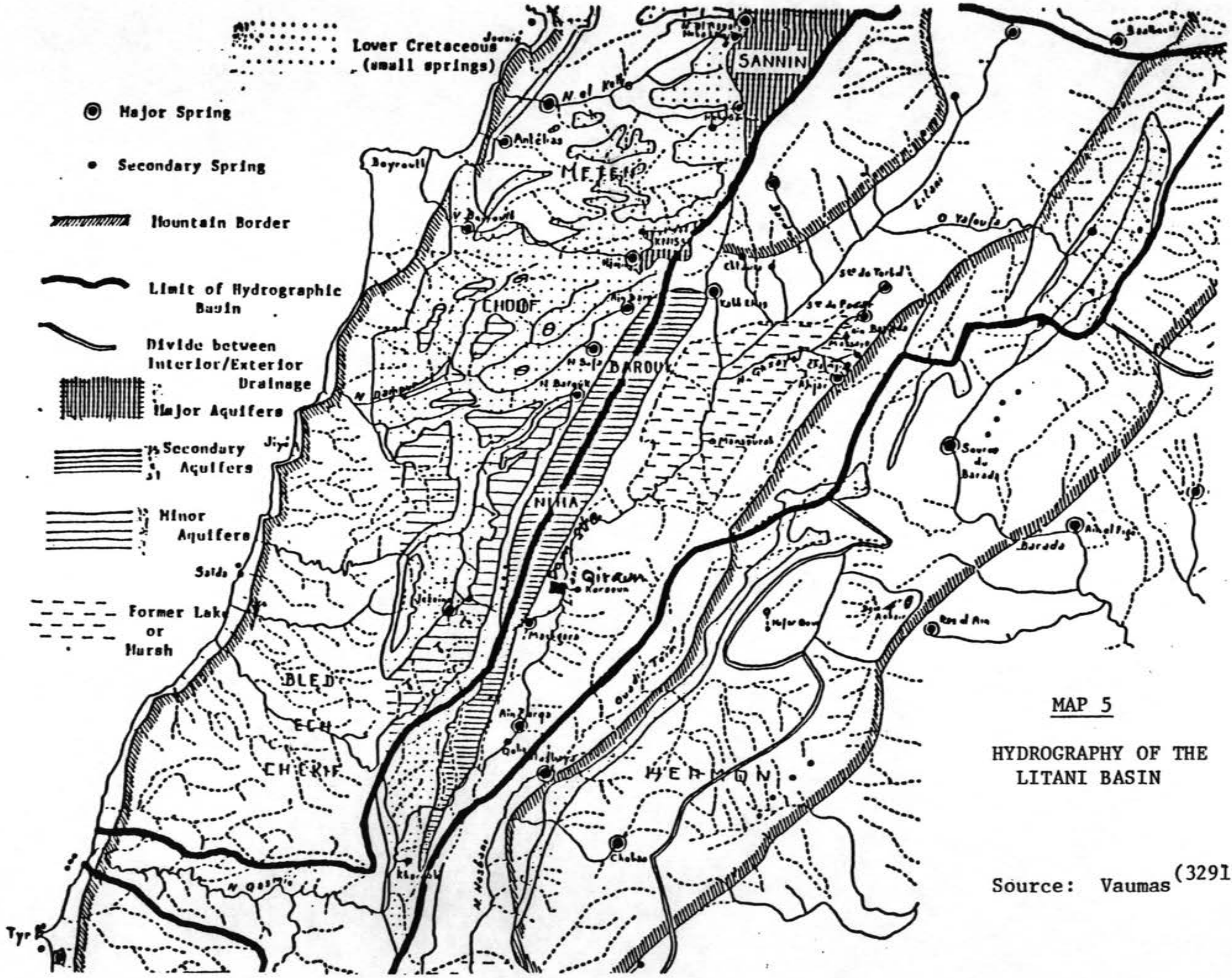
MAP 3
LITANI RIVER SYSTEM
with HASBANI, ORONTES and AWALI

Source: AMER(3289).

Map 4: HYDROLOGIC SUBUNITS OF THE LITANI BASIN ABOVE QIRAWN



Source: Mission GERSAR$^{(1939)}$ pp. 4/8 and end map.

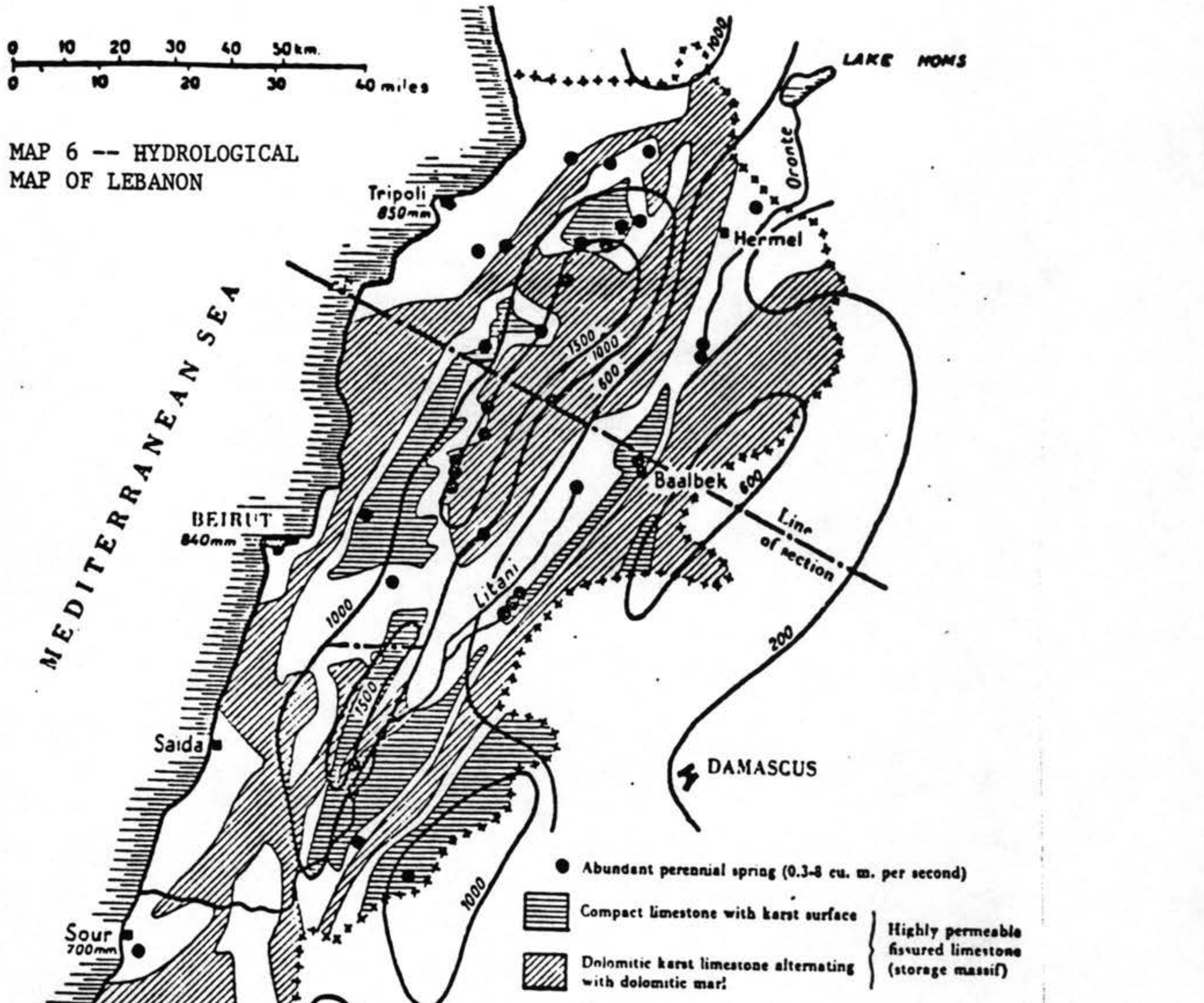


MAP 5

HYDROGRAPHY OF THE LITANI BASIN

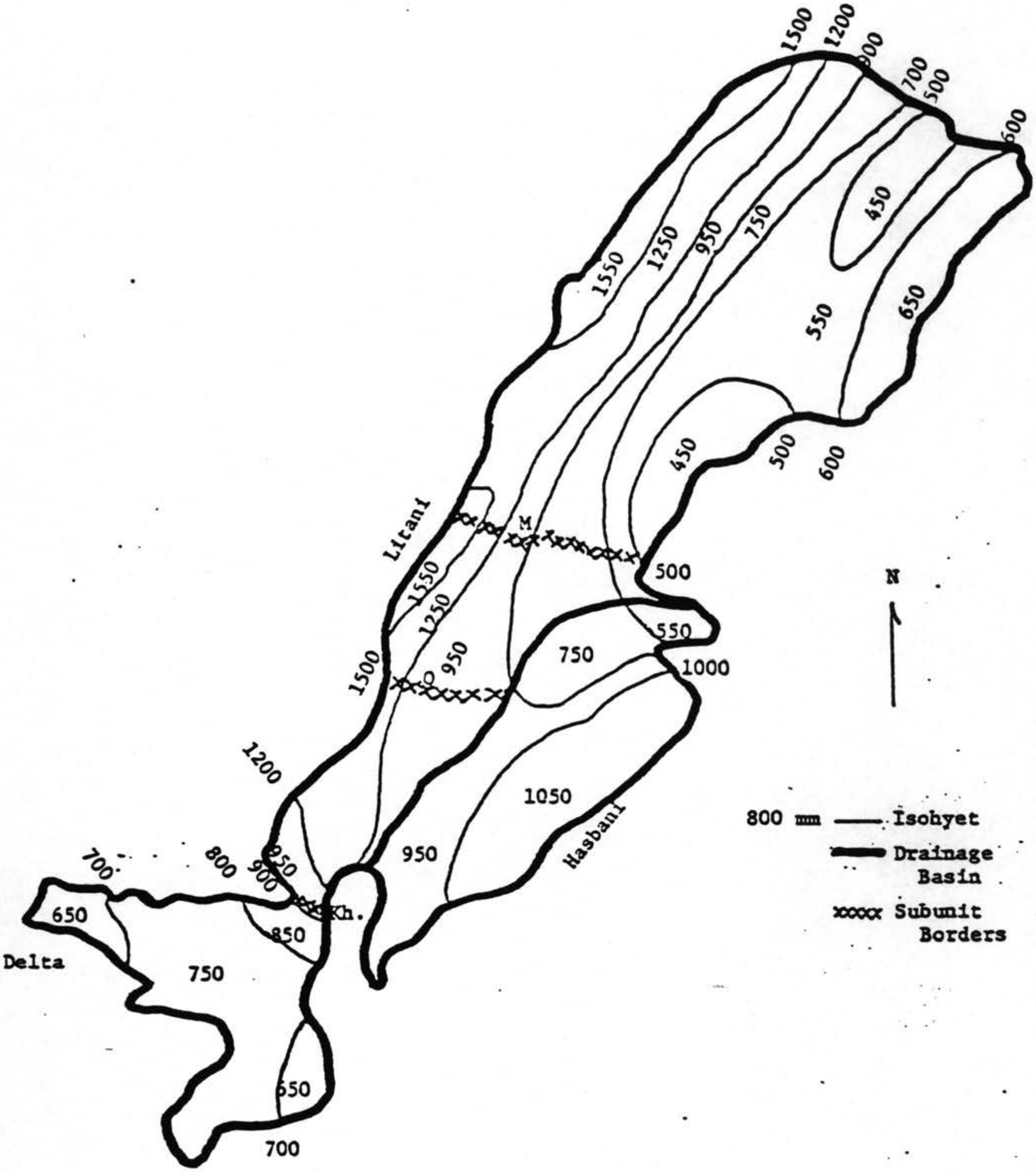
Source: Vaumas (3291).

MAP 6 -- HYDROLOGICAL MAP OF LEBANON



Source: Abd-El-Al(0382), p. 63.

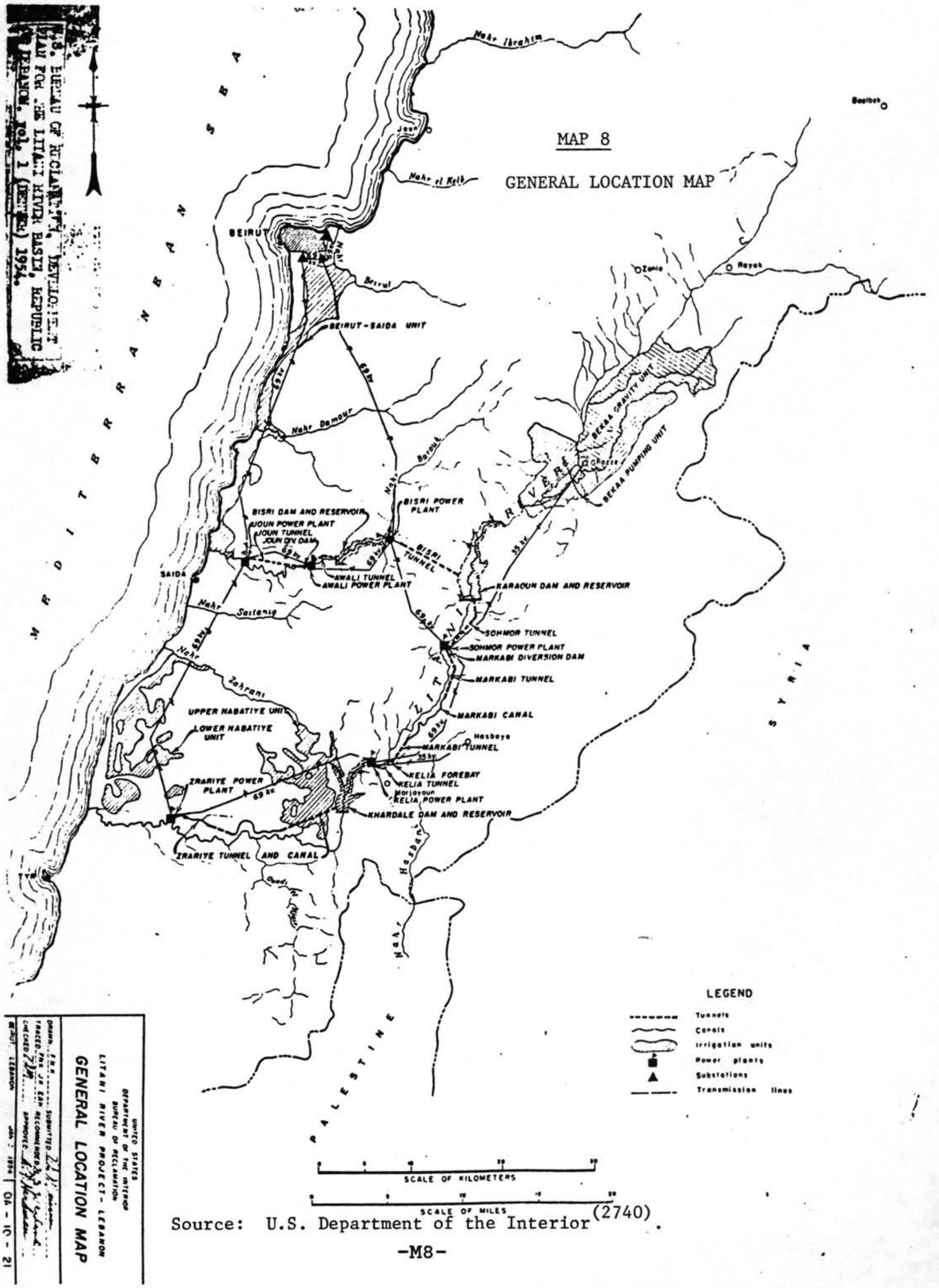
Map 7: PRECIPITATION IN THE LITANI AND HASBANI DRAINAGE BASINS



Source: Map 2, Map 4.

MAP 8

GENERAL LOCATION MAP



Source: U.S. Department of the Interior (2740).

APPENDIX A

PRECIPITATION AND FLOW DATA

Source: Engineering Report(3092).

TABLE 1: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE RAS EL-AIN
Sampling Station Near Terbol

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1962-1963	0.000	0.000	0.000	0.000	0.000	0.314	0.723	0.764	0.920	0.013	0.000	0.000	2.734
1963-1964	0.000	0.000	0.013	0.080	0.187	0.400	1.106	1.115	0.241	0.000	0.000	0.000	3.142
1964-1965	0.000	0.000	0.005	0.071	0.190	0.653	1.130	1.135	0.530	0.005	0.000	0.000	3.719
1965-1966	0.000	0.000	0.143	0.233	0.388	0.520	0.710	0.679	0.005	0.000	0.000	0.000	2.678
1966-1967	0.000	0.000	0.000	0.000	0.268	0.871	2.427	3.045	2.478	1.464	1.058	0.603	12.214
1967-1968	0.336	0.683	0.855	0.830	1.286	2.080	2.116	1.348	1.018	0.492	0.200	0.013	11.257
1968-1969	0.039	0.107	0.402	1.044	2.089	3.005	3.027	2.851	1.902	1.231	1.085	0.830	17.612
1969-1970	0.415	0.782	0.874	0.857	0.795	0.791	1.184	1.102	0.121	0.000	0.000	0.000	6.921
1970-1971	0.000	0.000	0.000	0.000	0.067	0.327	0.544	1.039	0.798	0.005	0.000	0.000	2.780
1971-1972	0.000	0.000	0.000	0.388	0.496	0.745	0.723	0.791	0.161	0.000	0.000	0.000	3.304
1972-1973	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.060	0.000	0.000	0.000	0.000	0.185
1967/68 - 1972/73	0.1	0.3	0.4	0.5	0.8	1.2	1.3	1.2	0.7	0.3	0.2	0.1	7.1
1963/64 - 1972/73	0.079	0.157	0.229	0.350	0.577	0.939	1.309	1.317	0.725	0.320	0.234	0.145	6.381

TABLE 2: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE FAOUR
Sampling Station Near Kfar-Zabad

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1962-1963	0.000	0.000	0.000	0.000	0.000	0.423	1.272	0.946	0.643	0.104	0.000	0.000	3.388
1963-1964	0.000	0.013	0.207	0.334	0.429	0.472	0.645	0.898	0.755	0.130	0.005	0.000	3.888
1964-1965	0.013	0.000	0.020	0.107	0.308	0.448	0.562	0.557	0.241	0.078	0.000	0.013	2.347
1965-1966	0.000	0.134	0.306	0.228	0.294	0.462	0.493	0.389	0.067	0.000	0.000	0.000	2.373
1966-1967	0.130	0.000	0.000	0.040	0.222	0.363	0.919	0.765	1.125	0.528	0.249	0.168	4.509
1967-1968	0.104	0.343	0.384	0.295	0.723	1.161	0.835	0.272	0.174	0.124	0.085	0.013	4.513
1968-1969	0.220	0.254	0.319	0.530	0.522	1.137	1.339	1.244	0.616	0.544	0.562	0.490	7.777
1969-1970	0.000	0.327	0.207	0.482	0.375	0.435	0.579	0.700	0.230	0.031	0.000	0.000	3.366
1970-1971	0.000	0.000	0.000	0.129	0.206	0.290	0.407	0.285	0.222	0.078	0.000	0.000	1.617
1971-1972	0.000	0.003	0.104	0.179	0.220	0.242	0.346	0.259	0.107	0.000	0.000	0.000	1.460
1972-1973	0.000	0.000	0.000	0.013	0.040	0.060	0.167	0.075	0.008	0.000	0.000	0.000	0.363
1967/68 - 1972/73	0.1	0.2	0.2	0.3	0.3	0.6	0.6	0.5	0.2	0.1	0.1	0.1	3.3
1963/64 - 1972/73	0.047	0.107	0.155	0.234	0.334	0.507	0.629	0.544	0.355	0.151	0.090	0.068	3.221

TABLE 3: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT NAHR SAGHIR

Sampling Station Downstream from Faour

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	0.000	0.000	0.111	0.324	0.616	1.304	1.762	1.633	0.624	0.047	0.000	0.021	6.442
1965-1966	0.039	0.150	0.389	0.624	0.603	0.798	1.187	0.902	0.053	0.000	0.000	0.000	4.745
1966-1967	0.000	0.000	0.000	0.088	0.485	1.447	2.804	3.173	2.844	1.791	1.053	0.787	14.472
1967-1968	0.461	0.978	1.166	1.203	2.250	2.714	2.309	1.646	1.176	0.500	0.161	0.013	14.577
1968-1969	0.054	0.343	0.604	1.701	4.304	4.393	3.980	3.548	2.386	1.278	1.189	0.905	24.685
1969-1970	0.472	0.814	1.055	1.082	1.211	1.173	1.637	1.426	0.364	0.036	0.000	0.000	9.270
1970-1971	0.000	0.000	0.021	0.099	0.222	0.523	1.061	1.490	1.029	0.078	0.000	0.000	4.523
1971-1972	0.000	0.019	0.119	0.525	0.611	0.839	1.066	0.972	0.252	0.000	0.000	0.000	4.403
1972-1973	0.000	0.000	0.000	0.000	0.008	0.070	0.271	0.091	0.000	0.000	0.000	0.000	0.440
1967/68 - 1972/73	0.2	0.4	0.5	0.8	1.4	1.6	1.7	1.5	0.9	0.3	0.2	0.2	9.7
1964/65 - 1972/73	0.114	0.256	0.385	0.627	1.146	1.473	1.786	1.653	0.970	0.414	0.267	0.192	9.283

TABLE 4: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE AIN EL-BAIDA

Sampling Station Near Kfar-Zabad

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1962-1963	0.000	0.000	0.000	0.000	0.000	0.230	0.562	0.617	0.482	0.143	0.129	0.147	2.310
1963-1964	0.186	0.134	0.168	0.147	0.246	0.319	0.509	0.803	0.790	0.316	0.241	0.169	4.028
1964-1965	0.168	0.375	0.376	0.434	0.375	1.113	0.763	0.881	0.710	0.492	0.321	0.155	6.163
1965-1966	0.078	0.723	0.739	0.857	1.339	0.825	0.683	0.829	0.643	0.065	0.054	0.027	6.862
1966-1967	0.026	0.000	0.026	0.054	0.187	0.363	1.594	1.400	1.500	1.426	1.178	1.018	8.772
1967-1968	0.518	1.232	0.829	0.723	1.446	2.177	1.808	0.881	0.750	0.933	1.152	0.777	13.226
1968-1969	1.321	1.647	1.140	1.500	2.000	3.500	2.500	1.192	1.178	1.192	0.991	1.004	19.165
1969-1970	0.700	0.549	0.669	1.125	0.603	0.835	1.312	1.281	0.924	0.648	0.576	0.522	9.744
1970-1971	0.446	0.549	0.778	0.777	0.608	0.435	0.656	1.166	0.937	0.467	0.086	0.067	6.972
1971-1972	0.143	0.817	0.713	0.621	0.716	0.823	0.496	0.842	0.584	0.285	0.174	0.067	6.281
1972-1973	0.000	0.003	0.117	0.225	0.308	0.170	0.435	0.145	0.008	0.000	0.000	0.000	1.411
1967/68 - 1972/73	0.5	0.8	0.7	0.8	0.9	1.3	1.2	0.9	0.7	0.6	0.5	0.4	9.3
1963/64 - 1972/73	0.359	0.603	0.556	0.646	0.783	1.056	1.076	0.942	0.802	0.582	0.477	0.381	8.263

TABLE 5: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE HAMSINE

Sampling Station Downstream from Source

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1962-1963	1.389	0.900	0.717	0.785	0.879	1.335	1.420	1.340	1.312	1.068	1.154	1.031	13.330
1963-1964	0.928	0.879	0.837	0.862	0.921	1.508	1.567	1.306	1.377	1.267	1.085	1.026	13.563
1964-1965	0.951	1.010	0.982	0.916	1.085	1.369	1.428	1.529	1.334	1.104	1.130	1.045	13.883
1965-1966	1.019	0.994	0.889	0.920	1.050	1.110	1.353	1.151	1.085	1.104	0.988	0.892	12.555
1966-1967	0.804	0.828	0.684	0.809	1.082	1.430	2.033	2.019	1.720	1.348	1.350	1.272	15.379
1967-1968	1.234	1.219	1.146	1.184	1.733	1.989	1.902	1.418	1.315	1.260	1.200	1.098	16.698
1968-1969	1.055	1.192	1.164	1.738	2.716	2.666	2.194	1.926	1.677	1.402	1.245	1.010	19.985
1969-1970	0.920	0.948	0.894	0.916	0.940	0.856	1.114	1.001	0.865	0.907	0.895	0.747	11.003
1970-1971	0.664	0.675	0.661	0.624	0.613	0.740	1.034	1.558	1.178	0.899	0.854	0.838	10.338
1971-1972	0.801	0.817	0.692	0.782	0.895	0.962	0.900	0.827	0.804	0.677	0.702	0.656	9.515
1972-1973	0.552	0.595	0.533	0.565	0.450	0.423	0.712	0.759	0.654	0.596	0.479	0.418	6.736
1967/68 - 1972/73	0.9	0.9	0.8	1.0	1.2	1.3	1.3	1.2	1.1	1.0	0.9	0.8	12.4
1962/63 - 1972/73	0.938	0.914	0.836	0.918	1.124	1.308	1.423	1.348	1.211	1.057	1.007	0.912	12.966

TABLE 6: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT GHZAYEL

Sampling Station Anjar

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961-1962	1.283	1.390	1.205	3.383	2.954	9.641	7.877	3.206	2.732	1.545	1.197	0.983	37.396
1962-1963	1.019	1.339	1.449	2.095	4.497	11.513	9.859	7.740	6.859	2.281	1.977	1.495	50.628
1963-1964	1.040	2.212	2.164	2.267	5.434	14.802	12.575	7.666	5.177	2.514	2.113	1.800	59.764
1964-1965	2.048	2.330	2.921	2.981	5.858	11.989	8.236	7.890	4.783	2.198	1.842	1.566	54.642
1965-1966	2.074	2.558	2.481	2.525	5.924	5.821	7.541	5.892	2.515	2.037	4.462	1.310	45.140
1966-1967	1.265	1.829	1.628	3.254	5.953	12.531	18.462	15.586	8.844	4.697	4.042	3.383	81.474
1967-1968	3.292	3.985	3.618	5.515	13.242	16.998	14.412	7.657	6.683	4.463	3.503	2.836	86.204
1968-1969	2.880	3.056	3.590	11.311	13.293	19.627	16.298	12.569	8.491	5.658	4.449	3.892	105.114
1969-1970	4.132	4.476	4.723	3.715	5.475	5.857	10.422	7.172	3.873	2.385	2.055	1.580	55.865
1970-1971	1.817	2.349	2.245	2.279	2.301	5.559	10.245	14.280	7.941	3.872	2.986	2.086	57.960
1971-1972	2.164	2.678	2.727	4.845	6.101	9.554	6.900	6.109	4.441	1.918	1.698	1.607	50.742
1972-1973	1.550	1.867	1.978	2.041	1.690	1.701	4.505	2.921	1.495	1.156	1.004	0.865	22.773
1967/68 - 1972/73	2.6	3.1	3.1	4.9	7.0	9.9	10.5	8.4	5.5	3.2	2.6	2.1	62.9
1961/62 - 1972/73	2.047	2.506	2.561	3.851	6.060	10.466	10.611	8.224	5.319	2.894	2.611	1.950	59.100

TABLE 7: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT ANJAR CANAL

Sampling Station Beginning of Canal

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1955-1956	0.588	0.305	0.091	0.000	0.000	0.000	0.000	-	0.747	1.078	1.173	1.181	-
1956-1957	0.752	0.581	0.143	0.070	0.013	0.000	0.027	0.137	0.619	1.024	1.213	0.991	5.570
1957-1958	0.653	0.372	0.093	0.019	0.000	0.036	0.067	-	-	-	-	-	-
1958-1959	-	-	0.153	0.035	0.040	0.056	0.104	0.210	1.138	1.255	-	1.262	-
1959-1960	0.731	0.479	0.145	0.027	0.005	0.018	0.062	-	-	-	1.216	-	-
1960-1961	-	0.078	0.000	0.000	0.000	0.034	0.080	-	-	-	-	-	-
1961-1962	-	-	-	-	-	-	-	0.295	0.651	1.229	-	1.187	-
1962-1963	0.601	0.324	0.215	0.094	0.011	0.007	0.013	0.047	0.359	1.213	1.379	1.511	5.774
1963-1964	0.658	0.321	0.109	0.027	0.032	0.025	0.032	0.114	0.276	1.309	1.256	1.387	5.546
1964-1965	0.682	0.346	0.210	0.150	0.096	0.090	0.123	0.184	0.509	1.700	1.481	1.564	7.135
1965-1966	0.829	0.273	0.161	0.129	0.013	0.039	0.166	0.384	1.323	1.242	1.578	1.251	7.388
1966-1967	1.055	0.335	0.308	0.027	0.000	0.092	0.257	0.060	0.185	1.166	1.337	1.570	6.392
1967-1968	0.956	0.204	0.078	0.054	0.027	0.025	0.027	0.334	1.093	1.325	1.369	1.511	7.003
1968-1969	0.780	0.367	0.098	0.040	0.027	0.039	0.051	0.031	0.530	1.392	1.575	1.757	6.687
1969-1970	0.972	0.348	0.047	0.104	0.107	0.099	0.104	0.233	0.892	1.532	1.607	1.690	7.735
1970-1971	0.990	0.469	0.270	0.096	0.088	0.065	0.104	0.171	0.889	1.382	1.658	1.663	7.845
1971-1972	1.001	0.496	0.176	0.054	0.035	0.028	0.040	0.140	0.825	1.625	1.543	1.243	7.206
1972-1973	0.959	0.461	0.298	0.177	0.145	0.090	0.142	0.232	0.956	0.925	1.393	1.055	6.833
1967/68 - 1972/73	0.9	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.9	1.4	1.5	1.5	7.4
1962/63 - 1972/73	0.862	0.359	0.179	0.087	0.053	0.054	0.096	0.175	0.712	1.346	1.471	1.473	6.867

TABLE 8: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT GHZAYEL

Sampling Station Damascus Road

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1952-1953	8.289	8.771	8.727	10.186	14.145	25.630	41.094	30.645	16.668	12.794	11.386	11.543	199.878
1953-1954	10.137	9.645	11.070	13.384	31.860	35.407	28.276	25.762	14.902	10.433	9.350	10.049	210.275
1954-1955	9.593	9.083	8.374	8.330	7.582	8.719	11.359	8.354	7.127	4.502	4.470	5.030	92.523
1955-1956	5.246	5.448	5.565	6.717	9.763	17.193	16.464	12.302	8.748	8.389	5.713	6.085	107.633
1956-1957	5.850	5.946	6.262	7.173	7.583	17.839	17.134	12.719	8.825	6.117	6.093	6.401	107.942
1957-1958	5.822	5.694	5.936	7.007	13.654	13.973	11.204	9.152	8.241	5.124	4.018	4.018	93.843
1958-1959	4.264	4.960	4.435	4.832	5.185	6.232	19.097	10.646	6.174	3.903	4.283	4.087	78.098
1959-1960	5.329	4.853	4.305	3.999	4.880	4.242	4.184	4.196	2.255	2.154	2.274	1.880	44.551
1960-1961	1.926	2.411	2.494	2.850	3.704	4.536	5.394	5.767	3.790	2.250	2.274	2.678	40.074
1961-1962	2.683	2.906	2.690	4.985	7.159	12.065	12.755	7.144	4.502	3.877	3.827	2.890	67.483
1962-1963	4.044	4.676	3.883	5.011	7.524	16.676	15.741	13.351	10.475	5.352	3.707	3.557	93.997
1963-1964	4.399	4.998	5.238	5.791	7.071	20.578	20.329	13.577	8.871	4.622	4.650	4.221	104.345
1964-1965	4.722	5.255	6.104	7.358	10.987	19.628	15.615	15.630	9.289	5.347	5.250	4.762	109.947
1965-1966	6.280	6.942	6.871	7.607	8.847	10.136	13.049	11.547	5.183	3.839	4.218	3.653	88.172
1966-1967	4.051	4.604	3.810	6.996	9.557	19.550	30.153	25.446	17.961	11.381	9.407	8.223	151.139
1967-1968	8.121	10.213	10.135	11.991	23.538	25.672	23.725	14.546	13.612	8.131	7.194	6.763	163.641
1968-1969	7.312	8.608	8.753	23.393	39.801	34.118	31.428	24.074	17.324	11.314	10.285	9.128	225.538
1969-1970	9.510	11.413	11.612	10.250	13.657	12.299	19.732	13.748	8.536	5.886	5.710	5.461	127.814
1970-1971	4.795	5.426	5.456	5.943	5.697	10.470	17.969	21.021	14.750	7.610	5.903	5.335	110.375
1971-1972	5.549	6.578	6.770	10.140	11.105	12.863	12.157	11.921	7.743	3.981	3.696	3.351	95.854
1972-1973	3.885	4.942	5.101	4.936	5.381	4.938	8.632	6.291	3.236	2.436	1.824	1.457	53.059
1967/68 - 1972/73	6.5	7.9	8.0	11.1	16.5	16.7	18.9	15.3	10.9	6.6	5.8	5.2	129.4
1952/53 - 1972/73	5.800	6.351	6.362	8.042	11.842	15.846	17.880	14.183	9.439	6.164	5.502	5.265	112.676

TABLE 9: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT LITANI

Sampling Station Damascus Road

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1952-1953	0.303	1.748	1.983	3.332	7.984	18.599	29.237	22.089	3.777	1.664	1.120	0.662	92.498
1953-1954	1.050	1.516	4.103	6.385	28.506	39.342	23.468	20.738	3.723	0.892	0.501	0.284	130.508
1954-1955	0.712	1.347	2.309	3.402	4.110	4.250	6.316	3.222	0.442	0.028	0.000	0.034	26.172
1955-1956	0.065	0.109	1.075	4.231	6.779	14.445	12.370	4.243	1.100	0.215	0.035	0.005	44.672
1956-1957	0.060	0.196	0.412	3.102	4.068	9.788	8.341	3.232	1.926	0.718	0.003	0.144	31.990
1957-1958	0.024	0.387	0.918	3.822	8.517	8.189	4.494	1.350	0.225	0.000	0.000	0.000	27.927
1958-1959	0.000	0.174	0.443	1.460	2.676	4.449	7.869	2.716	0.512	0.145	0.000	0.000	20.444
1959-1960	0.091	0.265	0.464	0.975	1.564	1.240	1.312	1.192	0.511	0.103	0.000	0.000	7.717
1960-1961	0.003	0.062	0.116	0.292	1.406	2.342	1.237	1.410	0.533	0.095	0.000	0.000	7.496
1961-1962	0.000	0.070	0.130	3.806	7.033	15.350	13.140	3.243	1.275	0.472	0.048	0.000	44.567
1962-1963	0.000	0.348	0.443	3.608	7.583	16.821	16.239	10.259	5.737	0.876	0.447	0.032	62.393
1963-1964	0.070	0.672	1.172	2.006	2.936	13.149	14.932	7.232	2.303	0.622	0.129	0.000	45.223
1964-1965	0.008	0.324	2.423	2.598	6.670	16.700	10.941	10.850	2.560	0.927	0.144	0.000	54.145
1965-1966	0.122	1.138	1.376	4.636	6.072	5.538	8.568	4.686	1.165	0.086	0.000	0.000	33.387
1966-1967	0.000	0.303	0.454	2.614	7.063	15.884	27.020	23.128	15.961	3.123	1.682	0.873	98.105
1967-1968	0.918	2.609	3.818	6.913	22.946	22.488	19.220	7.841	4.947	1.752	0.147	0.000	93.599
1968-1969	0.485	1.575	2.755	18.098	31.586	28.513	29.610	22.677	9.377	3.650	2.041	0.273	150.640
1969-1970	0.990	3.401	3.878	3.894	7.936	7.618	12.905	5.783	2.116	0.311	0.000	0.000	48.832
1970-1971	0.000	0.303	1.034	2.263	2.502	5.816	10.941	18.735	4.567	1.164	0.129	0.000	47.454
1971-1972	0.010	0.300	1.366	3.977	5.373	7.685	6.854	5.386	2.267	0.236	0.000	0.000	33.454
1972-1973	0.000	0.000	0.316	0.683	1.061	1.759	4.652	3.186	0.777	0.132	0.000	0.000	12.566
1967/68 - 1972/73	0.4	1.4	2.2	6.0	11.9	12.3	14.0	10.6	4.0	1.2	0.4	0.0	64.4
1952/53 - 1972/73	0.233	0.802	1.476	3.909	8.303	12.379	12.841	8.724	3.133	0.820	0.306	0.110	53.036

TABLE 10: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT BARDAOUNI

Sampling Station Damascus Road

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1952-1953	0.000	0.051	0.308	1.290	4.630	10.559	15.510	14.349	8.903	3.895	1.162	0.273	60.930
1953-1954	0.142	0.182	1.242	2.094	12.176	12.750	10.260	11.076	7.355	3.883	1.093	0.201	62.454
1954-1955	0.023	0.171	0.550	1.136	1.307	2.172	4.400	4.898	2.751	0.510	0.010	0.002	17.930
1955-1956	0.062	0.204	1.607	4.614	4.687	8.835	8.872	5.721	4.567	2.252	0.758	0.051	42.230
1956-1957	0.036	0.075	0.353	2.523	3.702	6.960	7.291	6.343	5.469	1.402	0.088	0.008	34.250
1957-1958	0.021	0.142	0.324	2.598	6.942	5.741	7.513	7.167	2.360	0.207	0.000	0.000	33.015
1958-1959	0.000	0.104	0.236	0.595	1.484	2.185	6.557	5.365	2.927	0.371	0.000	0.000	19.824
1959-1960	0.049	0.185	0.280	0.340	1.120	0.937	2.233	3.765	1.323	0.230	0.000	0.000	10.462
1960-1961	0.000	0.000	0.080	0.214	1.778	2.557	2.715	6.298	3.206	0.254	0.000	0.000	17.102
1961-1962	0.000	0.024	0.334	4.031	5.721	9.362	10.063	5.531	3.099	0.708	0.029	0.000	38.902
1962-1963	0.000	0.112	0.143	2.751	4.926	9.379	9.605	9.666	7.422	3.167	0.664	0.037	47.872
1963-1964	0.111	0.297	0.524	2.078	2.561	7.943	11.260	7.561	5.844	3.082	0.300	0.005	41.566
1964-1965	0.007	0.072	1.830	1.813	4.478	9.442	7.583	8.743	5.925	2.805	0.212	0.000	42.910
1965-1966	0.016	0.549	0.454	3.814	5.469	4.693	7.068	6.236	2.700	0.285	0.000	0.000	31.284
1966-1967	0.000	0.078	0.073	3.005	4.626	8.322	12.238	13.237	11.710	8.123	2.716	0.297	67.425
1967-1968	0.052	0.699	1.117	5.153	11.102	8.659	8.886	7.195	6.841	2.292	0.177	0.000	52.173
1968-1969	0.000	0.005	0.578	11.324	17.811	11.977	15.835	11.633	11.110	6.379	1.286	0.083	88.021
1969-1970	0.000	0.587	1.221	1.575	4.502	4.505	9.096	6.568	3.086	0.384	0.008	0.000	31.532
1970-1971	0.000	0.059	0.189	1.628	2.049	4.950	8.231	12.332	3.659	2.252	0.516	0.021	35.886
1971-1972	0.000	0.005	0.425	3.217	3.439	3.653	3.948	6.804	2.828	0.293	0.000	0.000	24.612
1972-1973	0.000	0.000	0.031	0.238	0.745	2.206	4.960	3.753	2.753	0.049	0.000	0.000	14.735
1967/68 - 1972/73	0.0	0.2	0.6	3.9	6.6	6.0	8.5	8.0	5.0	1.9	0.3	0.0	41.0
1952/53 - 1972/73	0.025	0.171	0.567	2.668	5.012	6.561	8.292	7.821	5.040	2.039	0.429	0.047	38.672

TABLE 11: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT JALALA

Sampling Station Damascus Road

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1963-1964	0.000	0.000	0.220	0.329	0.573	2.405	3.983	0.697	0.104	0.000	0.000	0.000	8.266
1964-1965	0.000	0.000	0.650	0.152	0.800	1.407	1.331	0.660	0.083	0.000	0.000	0.000	5.143
1965-1966	0.000	0.021	0.119	1.047	1.031	1.043	1.055	0.410	0.029	0.005	0.000	0.000	4.760
1966-1967	0.000	0.005	0.023	0.916	0.828	2.056	2.317	3.450	1.160	0.070	0.000	0.000	10.825
1967-1968	0.000	0.019	0.155	1.746	1.867	1.496	1.843	0.912	0.056	0.000	0.000	0.000	8.094
1968-1969	0.000	0.000	0.083	2.472	2.877	2.535	3.712	1.415	0.182	0.000	0.000	0.000	13.276
1969-1970	0.000	0.016	0.200	0.512	0.712	1.350	1.974	0.601	0.102	0.000	0.000	0.000	5.467
1970-1971	0.000	0.000	0.000	0.450	0.469	1.297	1.998	2.849	0.228	0.000	0.000	0.000	7.291
1971-1972	0.000	0.000	0.026	0.972	0.870	0.834	1.505	0.511	0.445	0.003	0.000	0.000	5.166
1972-1973	0.000	0.000	0.010	0.000	0.010	0.651	1.106	0.630	0.080	0.000	0.000	0.000	2.487
1967/68 - 1972/73	0.0	0.0	0.1	1.0	1.1	1.4	2.0	1.2	0.2	0.0	0.0	0.0	7.0
1963/64 - 1972/73	0.000	0.006	0.149	0.860	1.004	1.507	2.082	1.214	0.247	0.008	0.000	0.000	7.077

TABLE 12: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE CHTAURA

Sampling Station Downstream of Source

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961-1962	1.024	0.723	0.389	0.616	2.411	2.685	1.821	1.387	1.326	0.933	0.777	0.616	14.708
1962-1963	0.428	0.442	0.363	0.670	0.857	1.597	2.611	1.737	1.527	1.128	0.991	0.763	13.114
1963-1964	0.609	0.562	0.480	0.670	1.112	1.839	2.491	1.892	1.312	1.037	0.830	0.629	13.463
1964-1965	0.480	0.522	0.661	0.830	0.790	2.468	2.277	1.918	1.553	1.218	0.964	0.723	14.404
1965-1966	0.580	0.501	0.439	0.921	1.728	1.438	1.541	1.610	1.254	0.964	0.719	0.612	12.307
1966-1967	0.470	0.397	0.384	0.491	1.127	1.911	3.117	2.758	2.233	1.541	1.213	0.985	16.627
1967-1968	0.726	0.603	0.493	0.804	2.678	2.649	2.652	2.009	1.438	1.089	0.937	0.704	16.782
1968-1969	0.531	0.501	0.454	1.982	2.772	2.903	2.544	2.234	2.076	1.490	1.205	0.903	19.595
1969-1970	0.609	0.616	0.531	0.576	1.125	1.430	1.995	1.788	1.232	0.881	0.633	0.576	11.992
1970-1971	0.454	0.469	0.368	0.616	0.696	1.258	2.317	2.216	2.210	1.464	1.205	0.870	14.143
1971-1972	0.752	0.624	0.505	0.844	1.433	1.476	1.634	1.244	1.085	0.881	0.790	0.643	11.911
1972-1973	0.530	0.455	0.450	0.560	0.415	0.615	1.420	1.270	1.950	0.725	0.535	0.455	9.380
1967/68 - 1972/73	0.6	0.5	0.5	0.9	1.5	1.7	2.1	1.8	1.7	1.1	0.9	0.7	14.0
1961/62 - 1972/73	0.599	0.535	0.460	0.800	1.429	1.856	2.202	1.839	1.600	1.113	0.900	.0707	14.040

TABLE 13: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT CHTAURA WADI
Sampling Station Damascus Road

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1963-1964	0.334	0.238	0.257	0.635	0.900	2.115	2.518	1.965	1.300	0.814	0.672	0.477	12.225
1964-1965	0.435	0.359	0.391	0.629	1.018	2.080	1.870	1.730	1.180	0.810	0.660	0.500	11.662
1965-1966	0.389	0.359	0.270	0.742	1.414	1.241	1.414	1.317	0.905	0.588	0.407	0.426	9.472
1966-1967	0.334	0.308	0.275	0.637	1.208	2.032	2.807	2.338	1.770	1.148	0.852	0.678	14.387
1967-1968	0.526	0.445	0.381	0.911	2.694	2.325	2.258	1.654	1.165	0.788	0.662	0.597	14.406
1968-1969	0.378	0.354	0.371	1.993	3.276	2.934	2.721	2.343	1.658	1.063	0.787	0.611	18.489
1969-1970	0.495	0.415	0.410	0.426	0.986	1.280	1.904	1.563	1.010	0.710	0.544	0.530	10.273
1970-1971	0.446	0.391	0.342	0.541	0.632	1.231	2.266	2.613	2.076	1.325	0.978	0.670	13.511
1971-1972	0.583	0.458	0.441	0.913	1.398	1.551	1.497	1.260	0.964	0.757	0.576	0.431	10.829
1972-1973	0.381	0.348	0.340	0.364	0.303	0.564	1.353	1.172	0.849	0.586	0.407	0.346	7.013
1967/68 - 1972/73	0.5	0.4	0.4	0.9	1.5	1.6	2.0	1.8	1.3	0.9	0.7	0.5	12.5
1963/64 1972/73	0.430	0.368	0.348	0.780	1.383	1.735	2.061	1.796	1.288	0.859	0.655	0.527	12.230

TABLE 14: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT DELEM WADI
Sampling Station Kob Elias

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961-1962	0.894	0.951	0.933	1.272	2.277	3.048	2.879	0.907	0.911	0.752	0.844	0.737	16.405
1962-1963	0.570	0.562	0.583	1.500	1.312	1.984	2.839	2.372	2.210	1.063	0.951	0.870	16.816
1963-1964	0.684	0.686	0.816	1.460	2.394	3.550	4.465	1.776	1.095	0.791	0.715	0.562	18.994
1964-1965	0.562	0.608	2.058	1.039	3.618	4.156	3.495	5.592	1.543	0.788	0.672	0.688	24.819
1965-1966	0.570	0.726	0.923	2.571	2.563	2.441	2.759	1.301	0.640	0.718	0.632	0.619	16.463
1966-1967	0.718	0.844	0.796	2.936	2.911	5.421	6.417	4.982	2.518	1.296	1.112	0.897	30.848
1967-1968	0.933	1.034	1.262	3.706	4.722	4.570	5.134	2.408	1.403	0.990	0.865	0.712	27.739
1968-1969	0.816	0.726	0.871	6.075	7.291	5.315	6.059	3.507	2.271	1.288	1.117	1.004	36.340
1969-1970	0.446	1.015	1.140	1.591	2.877	2.748	4.184	1.812	1.125	0.758	0.774	0.804	19.274
1970-1971	0.627	0.704	1.039	2.194	1.819	4.057	3.940	5.757	1.642	0.804	0.643	0.645	23.871
1971-1972	0.645	0.763	0.723	2.421	2.328	2.137	2.095	1.708	1.122	0.643	0.656	0.648	15.889
1972-1973	0.531	0.544	0.848	0.763	1.251	1.638	2.394	1.814	0.715	0.653	0.562	0.461	12.174
1967/68 - 1972/73	0.7	0.8	1.0	2.8	3.4	3.4	4.0	2.8	1.4	0.9	0.8	0.7	22.7
1961/62 - 1972/73	0.666	0.763	0.999	2.294	2.947	3.422	3.888	2.828	1.433	0.879	0.795	0.721	21.635

TABLE 15: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE AMIQ

Sampling Station Downstream from Source

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961-1962	-	-	-	-	-	-	-	-	1.446	0.583	0.241	0.241	-
1962-1963	0.156	0.258	0.363	0.536	0.777	3.871	4.928	4.212	2.745	1.750	0.911	0.335	20.842
1963-1964	0.194	0.469	0.661	0.750	0.911	3.387	4.982	4.471	1.942	1.037	0.777	0.241	19.822
1964-1965	0.130	0.335	0.842	1.232	2.170	5.927	4.285	4.277	2.678	1.361	0.670	0.201	24.108
1965-1966	0.001	0.392	0.642	1.230	2.120	2.310	2.988	2.405	1.446	0.478	0.201	0.000	14.213
1966-1967	0.000	0.000	0.204	1.258	2.399	3.772	6.831	6.027	4.809	3.072	1.768	0.921	31.061
1967-1968	0.531	0.804	1.037	1.406	4.821	5.201	4.982	3.953	2.812	1.426	0.951	0.335	28.259
1968-1969	0.233	0.509	0.583	2.009	5.892	6.774	6.294	6.674	5.022	2.398	1.473	1.004	38.865
1969-1970	0.518	0.603	0.726	0.670	1.272	2.117	3.455	3.227	2.143	0.778	0.455	0.054	16.018
1970-1971	0.000	0.005	0.324	1.004	0.670	1.960	3.817	5.036	4.821	2.074	1.138	0.335	21.184
1971-1972	0.039	0.107	0.454	0.536	1.446	1.742	2.344	1.244	0.857	0.065	0.000	0.000	8.834
1972-1973	0.000	0.000	0.000	0.000	0.200	0.289	1.228	1.115	0.425	0.026	0.000	0.000	3.283
1967/68 - 1972/73	0.2	0.3	0.5	0.9	2.4	3.0	3.7	3.5	2.7	1.1	0.7	0.3	19.3
1962/63 - 1972/73	0.164	0.317	0.531	0.966	2.062	3.395	4.194	3.876	2.700	1.315	0.759	0.288	20.567

TABLE 16: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT LITANI

Sampling Station Mansura

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1931-1932	8.294	8.571	8.872	19.359	22.697	42.500	29.050	20.998	15.698	10.560	8.338	7.398	202.335
1932-1933	7.273	7.765	8.012	8.258	9.998	14.481	12.200	14.313	9.819	7.144	6.246	5.834	111.343
1933-1934	5.731	5.986	5.788	9.857	16.411	41.861	37.899	20.881	12.524	8.416	7.242	6.838	179.434
1934-1935	6.682	6.755	6.747	15.985	47.322	74.032	47.949	45.521	24.298	14.642	11.833	9.623	311.389
1935-1936	8.839	9.830	14.909	17.578	12.610	41.994	29.685	16.915	11.164	8.385	7.226	6.830	185.965
1936-1937	6.506	6.988	15.923	25.667	48.766	47.300	32.813	26.716	17.211	9.492	8.606	8.067	254.055
1937-1938	7.633	9.163	10.964	13.148	38.989	58.426	66.146	54.663	39.581	20.593	15.556	12.026	346.888
1938-1939	11.910	13.360	21.231	20.329	43.098	45.599	65.814	51.739	25.964	15.495	11.306	10.349	336.194
1939-1940	11.050	11.627	15.264	23.642	43.452	70.405	60.050	45.158	25.030	18.364	11.509	9.819	345.370
1940-1941	10.466	12.519	13.401	54.248	75.416	64.629	60.526	35.233	21.084	12.934	9.621	8.863	378.940
1941-1942	9.632	12.077	11.809	33.933	87.705	70.958	82.138	59.678	32.015	18.486	11.777	10.044	440.252
1942-1943	10.663	15.707	25.583	19.815	56.495	73.832	70.362	76.285	47.282	22.343	13.930	10.430	442.727
1943-1944	10.412	12.945	12.377	13.245	54.050	66.531	64.271	58.553	35.516	17.068	14.102	13.140	372.210
1944-1945	11.625	15.077	27.250	31.927	77.907	75.810	72.052	48.408	36.651	20.176	15.128	14.613	446.624
1945-1946	14.261	15.658	16.446	21.135	22.070	50.085	74.894	43.175	43.106	15.264	11.451	11.255	338.800
1946-1947	11.687	13.258	12.701	13.783	53.038	73.846	38.373	22.758	17.525	9.181	7.307	5.713	279.170
1947-1948	6.469	7.885	9.979	10.947	23.447	64.214	73.008	54.678	42.675	16.905	9.998	7.435	327.640
1948-1949	8.872	11.113	15.902	31.059	43.149	78.776	91.130	88.978	62.109	26.075	18.004	16.956	492.123
1949-1950	16.205	16.504	16.503	27.823	73.286	58.015	59.115	47.527	28.190	11.078	7.837	7.751	369.834
1950-1951	8.535	11.450	12.011	13.767	31.418	28.960	20.975	19.997	12.621	5.824	4.901	5.121	175.580
1951-1952	6.166	7.741	8.276	35.840	40.899	82.472	85.586	43.898	26.583	13.683	9.125	7.869	368.138
1952-1953	8.323	10.288	12.348	19.314	47.043	69.407	90.573	72.685	36.557	20.324	12.990	10.116	409.968
1953-1954	11.882	14.838	24.704	32.050	84.423	81.174	76.575	70.580	35.872	17.626	10.363	8.697	468.784
1954-1955	10.674	14.102	17.460	21.663	20.367	22.423	40.645	27.063	11.785	2.009	1.856	1.878	191.925
1955-1956	3.087	5.986	16.234	33.035	37.096	66.837	60.727	36.296	23.867	6.345	2.427	1.069	293.006
1956-1957	2.626	5.485	10.003	23.136	30.397	51.640	51.690	36.248	22.940	5.080	2.052	1.706	243.003
1957-1958	2.709	6.798	10.438	24.689	52.491	38.840	33.234	23.966	10.550	3.087	0.683	1.340	208.825
1958-1959	1.382	4.430	5.949	8.764	14.498	23.178	45.651	23.947	9.527	1.729	1.269	1.511	141.835
1959-1960	1.200	3.849	6.638	7.561	12.396	10.496	17.227	18.849	2.879	0.000	0.000	0.000	81.095
1960-1961	0.083	1.711	4.204	4.962	12.139	18.633	17.560	21.573	9.099	0.692	0.000	0.018	90.674

TABLE 16 CONTINUED

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961-1962	0.285	1.733	2.356	18.138	30.665	65.014	48.648	19.634	9.803	2.229	0.868	0.747	200.120
1962-1963	2.354	4.880	4.349	18.077	34.811	76.369	70.152	49.502	27.703	6.594	2.411	0.715	297.917
1963-1964	2.273	5.836	8.852	15.848	24.079	78.801	80.124	46.446	24.722	6.988	1.307	0.493	295.769
1964-1965	2.680	5.611	18.061	18.476	43.037	81.488	45.058	49.536	22.857	5.389	1.190	0.838	294.221
1965-1966	3.896	11.689	11.394	31.661	40.487	35.998	44.070	30.295	7.797	0.982	0.324	0.265	215.858
1966-1967	1.830	5.876	5.907	31.302	44.421	76.205	105.427	92.210	65.862	24.165	12.661	5.822	471.688
1967-1968	6.521	15.061	17.753	42.161	93.926	91.977	78.790	39.813	30.186	11.244	2.820	2.210	432.462
1968-1969	4.230	11.557	15.381	73.819	99.339	92.914	97.716	81.327	49.333	20.985	10.553	4.855	552.109
1969-1970	7.693	17.053	20.174	22.338	44.352	43.021	70.466	36.493	14.804	3.450	0.919	0.455	281.218
1970-1971	2.475	6.401	9.119	19.587	19.212	42.752	68.755	79.507	39.220	9.712	2.732	0.771	300.243
1971-1972	3.095	8.134	12.247	34.683	36.659	44.317	33.684	31.825	16.159	0.822	0.019	0.037	221.681
1972-1973	0.630	4.425	5.700	6.482	9.787	15.996	30.654	19.984	4.980	0.000	0.000	0.000	98.638
1967/68 - 1972/73	4.1	10.4	13.4	33.2	50.5	55.2	63.3	48.2	25.7	7.7	2.8	1.4	316.0
1931/32 - 1972/73	6.639	9.470	12.600	23.073	41.758	56.005	56.701	42.949	25.313	10.751	6.869	5.703	297.831
1931/32 - 1953/54	9.527	11.178	14.217	22.292	45.813	59.797	58.312	45.189	28.655	14.785	10.626	9.339	329.730

TABLE 17: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE KHRAIZAT

Sampling Station Downstream from Source

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961-1962	0.311	0.281	0.324	0.643	0.710	0.895	1.259	1.076	0.763	0.486	0.375	0.308	7.431
1962-1963	0.272	0.308	0.272	0.348	0.442	0.932	1.580	1.516	1.420	1.140	0.763	0.576	9.569
1963-1964	0.415	0.375	0.298	0.335	0.402	1.165	1.420	1.439	1.205	0.829	0.562	0.496	8.941
1964-1965	0.363	0.335	0.433	0.469	0.769	1.198	1.406	1.231	1.303	0.938	0.769	0.509	9.723
1965-1966	0.389	0.321	0.363	0.552	0.670	0.877	1.037	1.083	0.830	0.664	0.501	0.375	7.662
1966-1967	0.324	0.268	0.233	0.402	0.836	1.178	1.923	1.944	1.607	1.192	1.018	0.804	11.729
1967-1968	0.518	0.485	0.363	0.367	1.339	1.644	1.556	1.361	1.272	0.907	0.723	0.589	11.124
1968-1969	0.441	0.367	0.290	0.804	1.580	1.669	1.741	1.970	1.594	1.198	1.100	0.804	13.558
1969-1970	0.555	0.509	0.428	0.367	0.442	0.738	1.104	1.270	1.037	0.752	0.643	0.415	8.260
1970-1971	0.332	0.343	0.332	0.351	0.375	0.702	1.307	1.426	1.741	1.330	0.970	0.702	9.911
1971-1972	0.454	0.412	0.324	0.557	0.702	0.832	0.991	0.876	0.870	0.679	0.562	0.418	7.677
1972-1973	0.337	0.348	0.337	0.308	0.300	0.280	0.555	0.640	0.660	0.435	0.365	0.338	4.903
1967/68 - 1972/73	0.4	0.4	0.3	0.5	0.8	1.0	1.2	1.3	1.2	0.9	0.7	0.5	9.2
1961/62 - 1972/73	0.393	0.363	0.333	0.458	0.714	0.984	1.323	1.319	1.192	0.879	0.696	0.644	9.298

TABLE 18: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT NAHR ESH-SHITA

Sampling Station Qirawn Dam

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	-	-	-	-	-	-	1.484	1.788	0.667	0.000	0.000	0.000	-
1965-1966	0.000	0.426	0.446	1.406	1.521	1.565	1.535	0.941	0.000	0.000	0.000	0.000	7.840
1966-1967	0.000	0.086	0.065	2.300	1.947	2.110	3.509	2.214	1.529	0.000	0.000	0.000	13.760
1967-1968	0.000	0.000	0.638	2.989	4.060	3.971	1.353	0.531	0.595	0.000	0.000	0.000	14.137
1968-1969	0.000	0.000	0.518	5.847	7.047	0.948	4.733	2.600	0.820	0.000	0.000	0.000	22.513
1969-1970	0.000	0.327	0.181	0.742	1.473	2.056	2.419	1.654	0.656	0.000	0.000	0.000	9.508
1970-1971	0.000	0.335	0.524	0.536	0.737	0.919	1.607	3.683	1.393	0.013	0.000	0.000	9.747
1971-1972	0.000	0.281	0.564	0.643	1.098	0.629	1.098	0.923	0.508	0.000	0.000	0.000	5.744
1972-1973	0.000	0.028	0.388	0.482	0.844	4.981	0.750	0.467	0.428	0.000	0.000	0.000	8.368
1973-1974	0.002	0.201	0.363	0.500	-	-	-	-	-	-	-	-	-
1967/68 - 1972/73	0.0	0.2	0.5	1.9	2.5	2.3	2.0	1.6	0.7	0.0	0.0	0.0	11.7
1965/66 - 1972/73	0.000	0.185	0.416	1.868	2.341	2.147	2.126	1.627	0.741	0.002	0.000	0.000	11.453

TABLE 19: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT LITANI

Sampling Station Qirawn Dam

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1938-1939	-	-	-	-	-	-	85.626	65.912	33.635	20.202	14.335	12.436	-
1939-1940	12.390	14.670	18.948	28.587	71.195	92.715	68.915	53.359	37.787	23.579	14.027	10.824	446.996
1940-1941	11.265	14.351	14.510	65.066	132.442	87.244	79.176	46.560	27.020	15.840	12.026	11.477	516.977
1941-1942	12.162	16.070	16.039	40.779	147.355	91.668	120.874	72.208	41.065	27.294	17.195	13.132	615.841
1942-1943	13.349	18.393	30.039	26.256	69.435	101.352	99.583	101.114	57.132	30.715	20.208	15.095	582.671
1943-1944	14.103	18.926	18.681	20.369	72.400	87.195	77.722	71.814	42.710	20.969	15.487	12.990	473.366
1944-1945	12.563	16.692	31.726	36.737	115.613	93.947	86.609	58.919	43.481	25.508	17.029	14.442	553.266
1945-1946	14.868	16.670	18.725	25.241	28.528	68.064	86.344	50.852	51.982	22.226	14.295	9.380	407.175
1946-1947	11.379	15.280	14.691	16.887	66.315	102.146	49.359	30.604	24.205	13.315	9.707	7.725	361.613
1947-1948	8.478	10.328	12.118	13.802	28.544	83.572	86.333	66.327	48.131	21.607	12.773	9.037	401.050
1948-1949	10.617	13.649	16.949	32.998	50.129	118.294	114.389	103.317	68.382	32.128	22.632	18.018	601.502
1949-1950	18.001	18.693	18.271	29.449	91.502	67.375	61.967	51.669	33.105	14.956	11.541	10.261	427.190
1950-1951	10.257	13.949	14.992	17.195	37.069	37.669	28.115	29.303	16.443	8.261	5.692	4.612	223.557
1951-1952	6.356	10.081	11.327	43.969	42.986	118.785	109.276	51.112	32.184	18.749	12.765	10.641	468.231
1952-1953	10.975	13.089	16.068	22.817	62.570	100.365	174.217	107.392	46.682	28.147	20.093	16.062	618.477
1953-1954	17.131	19.994	28.165	34.050	131.121	163.330	112.204	96.290	45.825	25.407	17.699	14.496	705.712
1954-1955	17.278	19.815	21.713	28.035	27.421	28.619	53.871	34.632	19.290	5.811	4.205	3.814	264.504
1955-1956	5.555	8.399	20.586	39.844	50.852	96.598	80.446	44.388	27.496	10.638	4.492	2.756	392.050
1956-1957	4.186	7.810	11.358	24.928	32.494	70.933	61.842	40.471	26.208	7.286	3.710	2.649	293.875
1957-1958	3.872	7.457	10.127	29.291	69.909	54.546	40.746	25.461	11.565	5.161	2.826	2.373	263.334

TABLE 19 CONTINUED

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1958-1959	2.683	5.769	7.478	10.505	18.366	33.351	65.990	28.209	12.698	3.966	2.236	2.052	193.303
1959-1960	2.496	5.188	8.214	9.940	15.631	13.433	21.296	20.386	5.582	2.164	1.891	1.241	107.462
1960-1961	1.304	2.628	5.605	6.498	16.970	28.164	23.224	26.262	10.746	2.666	1.811	1.379	127.257
1961-1962	1.000	3.000	6.100	22.600	37.800	48.000	61.600	24.500	12.900	3.600	2.000	1.900	225.000
1962-1963	3.800	7.000	6.600	22.500	38.435	71.100	72.595	44.098	31.918	15.049	8.196	5.598	326.869
1963-1964	6.822	9.707	12.701	20.624	28.820	87.420	94.735	47.434	26.784	8.683	2.927	1.982	348.639
1964-1965	4.588	10.714	22.186	22.874	45.131	95.994	48.134	51.840	22.364	5.184	0.487	0.881	330.377
1965-1966	4.199	12.428	12.571	37.498	41.649	41.224	47.408	27.423	7.017	0.239	2.850	2.932	237.438
1966-1967	3.845	7.875	7.607	36.426	52.497	99.455	147.086	106.350	74.800	30.900	9.818	3.214	579.873
1967-1968	6.455	14.650	19.040	47.000	151.380	125.280	87.200	46.800	30.832	8.767	2.727	3.468	558.249
1968-1969	5.363	11.200	16.848	163.320	246.647	163.700	127.022	98.350	58.420	22.000	11.000	5.892	929.762
1969-1970	9.331	19.552	20.736	24.105	50.354	44.271	78.745	39.398	15.392	2.592	1.875	1.175	307.526
1970-1971	3.369	7.232	11.664	23.570	21.159	49.554	77.406	136.857	54.372	11.405	2.411	2.143	401.142
1971-1972	5.035	10.603	13.900	43.650	42.240	51.430	37.104	34.100	21.975	1.398	1.834	1.500	264.769
1972-1973	3.790	8.175	10.447	11.114	13.600	19.455	37.352	20.724	5.000	0.000	0.000	0.000	129.657
1973-1974	2.152	3.375	8.502	15.803	-	-	-	-	-	-	-	-	-
1967/68 - 1972/73	5.6	11.9	15.4	52.1	87.6	75.6	74.1	62.7	31.0	7.7	3.3	2.4	429.4
1939/40 - 1953/54	12.260	15.389	18.750	30.280	76.480	94.248	90.339	66.189	41.076	21.913	14.878	11.879	493.681
1939/40 - 1972/73	8.202	12.060	15.492	31.721	63.487	77.537	77.026	55.545	32.103	14.006	8.543	6.622	402.344

TABLE 20: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE AIN-ZARQA

Sampling Station Downstream from Source

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961-1962	2.618	-	-	-	-	-	-	-	5.625	4.018	3.080	3.616	-
1962-1963	3.421	2.949	2.825	4.018	4.955	8.709	14.999	10.109	6.428	5.638	5.464	4.607	74.122
1963-1964	4.212	3.616	3.344	3.375	4.312	8.951	15.534	15.811	10.714	6.091	5.598	4.848	86.406
1964-1965	2.799	3.817	3.499	4.821	7.767	9.919	8.491	8.813	7.165	5.378	5.491	3.964	71.924
1965-1966	2.981	2.893	3.188	3.348	5.759	7.306	7.553	6.221	4.982	3.681	4.232	3.562	55.706
1966-1967	4.795	3.080	2.592	3.150	5.357	9.314	14.062	15.163	10.579	7.646	6.294	5.491	87.523
1967-1968	5.184	4.687	4.400	5.022	12.388	14.515	14.062	10.498	6.294	4.536	5.223	5.759	92.568
1968-1969	6.765	5.424	6.480	8.000	15.450	14.500	18.500	17.150	14.600	7.776	7.861	7.098	129.604
1969-1970	4.795	6.910	5.651	5.330	5.892	7.258	10.044	15.552	9.508	6.558	6.750	5.402	89.650
1970-1971	6.610	4.553	3.655	3.696	5.356	7.250	11.785	11.665	10.310	8.424	5.350	6.720	85.374
1971-1972	3.110	6.535	6.247	7.513	5.678	8.467	9.642	8.709	7.419	6.402	5.732	4.821	80.275
1972-1973	3.758	3.810	4.790	5.150	4.550	4.350	7.500	5.440	5.620	5.500	5.080	4.612	60.160
1973-1974	-	3.803	4.018	5.089	-	-	-	-	-	-	-	-	-
1967/68 - 1972/73	5.0	5.3	5.2	5.8	8.2	9.4	11.9	11.5	9.0	6.5	6.0	5.7	89.5
1962/63 - 1972/73	4.403	4.734	4.243	4.857	7.042	9.140	12.016	11.376	7.926	5.636	5.758	5.171	82.302

TABLE 21: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT MARKABEH TUNNEL

Sampling Station Jezzine-Markabeh Window

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1962-1963	1.555	1.567	1.459	1.687	2.009	1.972	2.196	1.853	1.870	1.776	1.754	1.848	21.546
1963-1964	1.853	1.955	1.776	1.888	1.955	2.032	2.491	2.268	2.062	1.905	1.888	1.942	24.015
1964-1965	1.762	1.821	1.776	1.942	2.089	1.947	1.942	1.801	2.022	2.255	1.982	1.366	22.705
1965-1966	-	-	-	-	-	-	-	-	-	-	-	-	-
1966-1967	-	-	-	-	-	-	-	-	-	-	-	-	-
1967-1968	-	-	-	-	-	-	-	-	-	-	-	-	-
1968-1969	2.073	2.400	2.592	2.764	5.050	3.600	3.135	2.592	2.680	2.592	2.678	2.678	34.834
1969-1970	2.592	2.678	2.592	2.678	2.678	1.814	2.900	2.720	2.678	2.592	2.008	2.142	30.072
1970-1971	2.075	2.678	2.592	3.450	2.945	2.900	3.482	3.370	2.940	2.592	2.140	2.140	33.304
1971-1972	2.300	1.070	1.070	2.140	2.410	2.505	2.678	2.333	2.300	1.944	1.875	1.607	24.232
1972-1973	1.348	1.098	1.037	1.205	1.339	1.210	1.902	1.607	1.607	1.296	1.098	1.071	15.818
1968/69 - 1972/73	2.1	1.9	2.0	2.4	2.9	2.4	2.8	2.5	2.4	2.2	2.0	1.9	27.5

TABLE 22: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT LITANI

Sampling Station Qlaya

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1948-1949	-	-	-	-	-	-	-	-	98.562	51.244	36.518	27.724	-
1949-1950	25.205	26.409	24.292	36.474	109.174	86.266	84.431	71.270	48.310	23.463	18.181	16.341	569.816
1950-1951	16.817	19.834	19.932	22.828	49.074	49.071	39.691	33.439	24.312	12.455	10.202	9.168	306.823
1951-1952	9.984	13.105	14.456	54.797	59.179	135.282	127.503	69.056	46.028	27.154	19.330	16.721	592.595
1952-1953	17.320	18.446	20.018	26.910	73.112	130.174	187.247	125.170	68.420	43.385	29.928	23.538	763.668
1953-1954	22.937	25.198	33.621	42.723	161.853	215.142	141.162	114.017	67.873	39.886	28.688	22.825	915.925
1954-1955	22.557	26.406	27.812	33.793	36.054	37.311	69.041	46.710	27.079	12.877	10.574	9.286	359.500
1955-1956	10.800	13.456	24.818	47.381	61.309	107.668	104.918	62.384	41.936	20.124	14.825	10.933	520.552
1956-1957	10.495	12.575	17.978	34.640	42.212	84.875	80.550	59.295	40.045	20.005	13.266	12.015	427.951
1957-1958	12.053	14.512	17.499	43.832	87.728	77.567	62.892	42.392	24.092	15.998	13.116	11.785	423.466
1958-1959	11.387	14.584	15.954	18.668	28.024	47.073	84.627	48.001	24.957	14.653	12.005	10.210	330.143
1959-1960	9.772	12.634	14.088	13.044	23.693	21.040	30.577	30.526	14.048	9.606	9.058	7.550	195.636
1960-1961	6.475	7.406	10.930	10.901	22.560	39.535	37.393	38.079	18.762	10.469	8.391	6.286	217.187
1961-1962	6.555	8.791	12.234	42.233	47.732	78.259	75.429	48.463	35.149	16.825	9.160	10.869	391.699
1962-1963	8.268	12.680	7.781	28.150	44.357	77.487	79.956	59.199	57.023	36.280	25.772	18.036	454.989
1963-1964	16.544	17.254	19.330	27.582	33.491	59.693	95.739	48.063	40.883	20.039	19.228	21.240	419.086
1964-1965	25.850	36.595	27.000	42.793	32.570	46.860	62.840	44.761	33.175	22.353	35.092	12.181	422.070
1965-1966	13.128	5.836	9.235	27.092	1.958	4.144	5.439	14.419	7.858	8.901	9.428	10.315	117.753
1966-1967	9.756	7.708	7.841	6.792	4.556	14.043	159.076	98.882	76.150	38.139	4.885	8.375	436.203
1967-1968	11.013	11.271	9.552	4.915	139.121	121.020	82.591	49.461	35.933	14.699	9.811	9.787	499.174
1968-1969	11.677	12.639	67.205	121.776	88.711	125.177	123.309	104.792	85.334	32.498	27.258	10.084	810.460
1969-1970	8.582	7.725	2.525	3.469	4.018	6.175	7.620	16.135	8.895	5.886	8.054	9.891	88.975
1970-1971	9.725	9.273	6.765	6.608	4.079	4.841	8.667	68.543	44.247	4.266	4.419	6.075	177.508
1971-1972	9.253	8.480	6.353	2.708	3.977	7.121	5.461	3.896	14.214	7.690	8.782	9.723	87.658
1972-1973	10.310	10.207	7.932	2.885	1.639	1.427	1.907	2.123	4.942	7.087	7.143	6.434	64.036
1967/68 - 1972/73	10.1	9.9	16.7	23.7	40.3	44.3	38.3	40.8	32.3	12.0	10.9	8.7	288.0
1949/50 - 1972/73	13.186	14.709	17.715	29.291	48.341	65.719	73.253	54.128	37.067	19.364	14.858	12.070	399.701

TABLE 23: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT ES-SAFA WADI
Sampling Station Khallet Khazem

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	0.000	0.000	2.328	1.409	2.751	2.146	0.297	0.829	0.142	0.000	0.000	0.000	9.902
1965-1966	0.000	0.000	0.016	0.723	0.983	0.997	0.795	0.106	0.000	0.000	0.000	0.000	3.620
1966-1967	0.000	0.000	0.000	1.082	1.912	2.351	2.362	0.513	0.099	0.002	0.000	0.000	8.321
1967-1968	0.000	0.000	0.119	0.790	3.029	1.012	0.383	0.036	0.013	0.000	0.000	0.000	5.382
1968-1969	0.000	0.000	0.298	3.402	5.566	1.229	1.441	0.114	0.000	0.000	0.000	0.000	12.050
1969-1970	0.000	0.048	0.130	0.362	0.728	0.719	1.888	0.166	0.032	0.000	0.000	0.000	4.073
1970-1971	0.000	0.000	0.000	0.670	0.643	0.439	1.087	3.269	0.185	0.013	0.000	0.000	6.306
1971-1972	0.000	0.000	0.013	0.814	0.522	0.742	0.388	0.334	0.040	0.000	0.000	0.000	2.853
1972-1973	0.000	0.000	0.000	0.004	0.404	0.322	0.718	0.049	0.000	0.000	0.000	0.000	1.497
1967/68 - 1972/73	0.0	0.0	0.1	1.0	1.8	0.7	1.0	0.7	0.0	0.0	0.0	0.0	5.4
1964/65 - 1972/73	0.000	0.048	0.336	1.028	1.837	1.106	1.040	0.602	0.057	0.002	0.000	0.000	6.056

TABLE 24: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT AAJIS WADI
Sampling Station Near Khallet Khazem

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	0.000	0.000	1.530	0.541	1.532	1.504	0.485	0.798	0.147	0.010	0.005	0.000	6.552
1965-1966	0.000	0.019	0.075	1.023	1.104	0.965	0.766	0.228	0.059	0.007	0.000	0.000	4.246
1966-1967	0.000	0.000	0.000	0.809	1.267	1.689	1.998	0.635	0.169	0.041	0.010	0.000	6.618
1967-1968	0.000	0.016	0.052	0.739	2.196	1.007	0.536	0.181	0.056	0.010	0.000	0.000	4.793
1968-1969	0.000	0.000	0.130	2.941	3.744	0.830	1.283	0.355	0.145	0.018	0.000	0.000	9.446
1969-1970	0.000	0.000	0.249	0.147	0.629	0.472	1.781	0.259	0.080	0.023	0.000	0.000	3.640
1970-1971	0.018	0.048	0.089	0.611	0.185	0.876	0.986	1.446	0.088	0.047	0.032	0.016	4.442
1971-1972	0.016	0.016	0.039	0.868	0.868	1.275	0.319	0.264	0.083	0.041	0.032	0.032	3.853
1972-1973	0.031	0.035	0.031	0.040	0.295	0.571	0.723	0.262	0.131	0.083	0.029	0.000	2.231
1967/68 - 1972/73	0.0	0.0	0.1	0.9	1.3	0.9	0.9	0.5	0.1	0.0	0.0	0.0	4.7
1964/65 - 1972/73	0.007	0.015	0.244	0.858	1.313	1.021	0.986	0.492	0.106	0.031	0.012	0.005	5.090

TABLE 25: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT NAQOUZIYA WADI
Sampling Station Near Jarmaq

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	0.000	0.000	0.264	0.037	0.246	0.426	0.147	0.534	0.008	0.000	0.000	0.000	1.662
1965-1966	0.000	0.000	0.010	0.051	0.155	0.232	0.115	0.007	0.000	0.000	0.000	0.000	0.570
1966-1967	0.000	0.003	0.000	0.131	0.378	0.523	0.862	0.104	0.000	0.000	0.000	0.000	2.001
1967-1968	0.000	0.000	0.003	0.107	1.516	0.649	0.027	0.008	0.000	0.000	0.000	0.000	2.310
1968-1969	0.000	0.000	0.005	0.986	1.529	0.312	0.300	0.044	0.000	0.000	0.000	0.000	3.176
1969-1970	0.000	0.000	0.003	0.054	0.276	0.174	0.627	0.023	0.000	0.000	0.000	0.000	1.157
1970-1971	0.000	0.000	0.000	0.019	0.027	0.510	0.404	0.492	0.013	0.000	0.000	0.000	1.465
1971-1972	0.000	0.000	0.000	0.094	0.158	0.281	0.056	0.031	0.000	0.000	0.000	0.000	0.620
1972-1973	0.000	0.000	0.000	0.000	0.048	0.097	0.287	0.000	0.000	0.000	0.000	0.000	0.432
1967/68 - 1972/73	0.0	0.0	0.0	0.2	0.6	0.3	0.3	0.1	0.0	0.0	0.0	0.0	1.5
1964/65 - 1972/73	0.000	0.000	0.032	0.164	0.481	0.356	0.314	0.138	0.002	0.000	0.000	0.000	1.487

TABLE 26: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT EL-AISHIYA WADI
Sampling Station Jarmaq

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	0.000	0.000	0.290	0.024	0.230	0.368	0.142	0.295	0.000	0.000	0.000	0.000	1.349
1965-1966	0.000	0.003	0.003	0.064	0.169	0.114	0.134	0.000	0.000	0.000	0.000	0.000	0.487
1966-1967	0.000	0.000	0.000	0.153	0.246	0.276	0.399	0.080	0.000	0.000	0.000	0.000	1.154
1967-1968	0.000	0.000	0.000	0.067	0.793	0.559	0.013	0.000	0.000	0.000	0.000	0.000	1.432
1968-1969	0.000	0.000	0.003	0.712	1.342	0.261	0.206	0.010	0.000	0.000	0.000	0.000	2.534
1969-1970	0.000	0.000	0.010	0.046	0.220	0.109	0.343	0.003	0.000	0.000	0.000	0.000	0.731
1970-1971	0.000	0.000	0.000	0.019	0.051	0.157	0.099	0.975	0.000	0.000	0.000	0.000	1.301
1971-1972	0.000	0.000	0.000	0.303	0.126	0.220	0.043	0.026	0.000	0.000	0.000	0.000	0.718
1972-1973	0.000	0.000	0.000	0.000	0.051	0.010	0.056	0.000	0.000	0.000	0.000	0.000	0.117
1967/68 - 1972/73	0.0	0.0	0.0	0.2	0.4	0.2	0.1	0.2	0.0	0.0	0.0	0.0	1.1
1964/65 - 1972/73	0.000	0.000	0.034	0.154	0.359	0.230	0.159	0.154	0.000	0.000	0.000	0.000	1.090

TABLE 27: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT ZAGHRIA WADI

Sampling Station Jarmaq

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	0.000	0.000	0.726	0.337	0.870	1.502	0.485	0.705	0.308	0.122	0.056	0.032	5.143
1965-1966	0.000	0.000	0.000	0.179	0.461	0.823	0.541	0.264	0.118	0.020	0.000	0.000	2.406
1966-1967	0.000	0.000	0.000	0.179	0.616	1.290	1.674	0.889	0.305	0.096	0.048	0.046	5.143
1967-1968	0.021	0.005	0.000	0.185	1.915	0.980	0.522	0.241	0.126	0.052	0.019	0.008	4.074
1968-1969	0.000	0.000	0.000	2.397	4.976	2.076	0.943	0.446	0.193	0.090	0.099	0.062	11.282
1969-1970	0.047	0.048	0.023	0.020	0.287	0.225	1.461	0.420	0.153	0.080	0.013	0.000	2.777
1970-1971	0.000	0.000	0.000	0.150	0.126	0.610	0.616	2.017	0.426	0.117	0.067	0.046	4.175
1971-1972	0.031	0.032	0.031	0.279	0.319	0.581	0.348	0.347	0.257	0.109	0.078	0.035	2.447
1972-1973	0.000	0.000	0.000	0.000	0.037	0.080	0.439	0.049	0.000	0.000	0.000	0.000	0.605
1967/68 - 1972/73	0.0	0.0	0.0	0.5	1.3	0.8	0.7	0.6	0.2	0.1	0.0	0.0	4.2
1964/65 - 1972/73	0.011	0.009	0.087	0.414	1.067	0.907	0.781	0.598	0.210	0.076	0.042	0.025	4.227

TABLE 28: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE MAIDANE

Sampling Station Near the Source

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1962-1963	-	-	-	-	-	-	-	0.285	0.214	0.168	0.169	0.086	-
1963-1964	0.130	0.147	0.156	0.161	0.321	1.173	0.884	0.311	0.147	0.130	0.107	0.121	3.788
1964-1965	0.130	0.131	0.143	0.348	0.375	0.895	0.267	0.415	0.187	0.176	0.169	0.134	3.370
1965-1966	0.135	0.120	0.119	0.241	0.388	0.351	0.201	0.194	0.142	0.137	0.120	0.102	2.250
1966-1967	0.085	0.112	0.104	0.187	0.362	0.569	0.736	0.414	0.193	0.181	0.147	0.107	3.197
1967-1968	0.104	0.134	0.122	0.228	0.884	0.544	0.321	0.194	0.174	0.163	0.147	0.155	3.170
1968-1969	0.150	0.160	0.150	0.696	2.116	0.847	0.643	0.428	0.241	0.168	0.155	0.155	5.909
1969-1970	0.148	0.134	0.140	0.174	0.268	0.206	0.868	0.181	0.155	0.137	0.142	0.112	2.665
1970-1971	0.106	0.139	0.143	0.220	0.228	0.605	0.562	0.804	0.254	0.197	0.204	0.174	3.636
1971-1972	0.168	0.171	0.181	0.295	0.335	0.319	0.228	0.259	0.220	0.176	0.174	0.166	2.692
1972-1973	0.132	0.147	0.143	0.147	0.187	0.174	0.295	0.185	0.147	0.150	0.145	0.139	1.991
1967/68 - 1972/73	0.1	0.1	0.2	0.3	0.7	0.4	0.5	0.3	0.2	0.2	0.2	0.2	3.3
1963/64 - 1972/73	0.129	0.140	0.140	0.270	0.546	0.568	0.501	0.339	0.186	0.162	0.151	0.136	3.268

TABLE 29: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT SOURCE GUELLE

Sampling Station Near the Source

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1965-1966	1.361	1.071	0.842	1.540	3.019	4.161	4.687	4.277	3.611	2.177	1.540	1.232	29.518
1966-1967	1.102	1.071	0.778	1.330	1.942	4.499	5.973	5.314	4.955	4.303	3.013	2.076	36.356
1967-1968	1.426	1.205	0.881	1.674	-	-	-	-	-	3.577	2.464	1.808	-
1968-1969	1.452	1.232	-	-	-	-	-	-	-	3.888	3.214	2.384	-
1969-1970	1.555	1.553	1.192	0.870	1.942	2.722	4.339	5.054	4.352	2.877	2.210	1.821	30.487
1970-1971	1.231	1.406	0.897	1.205	1.138	3.498	6.503	6.428	6.602	4.342	2.812	1.982	38.044
1971-1972	1.607	1.286	1.037	1.607	3.884	4.476	4.285	4.406	4.152	2.981	2.116	1.406	33.243
1972-1973	1.192	1.138	0.972	0.870	1.004	1.452	4.220	2.840	2.480	2.070	1.945	1.745	21.928
1967/68 - 1972/73	1.4	1.6	1.0	1.2	2.0	3.0	4.8	4.7	4.4	3.3	2.5	1.9	31.8

TABLE 30: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT LITANI
Sampling Station Khardale

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1938-1939	-	-	-	-	-	89.922	128.461	103.040	57.554	37.447	27.654	23.878	-
1939-1940	21.838	22.973	27.065	40.029	96.012	137.009	111.604	84.704	46.468	27.175	19.509	16.116	650.502
1940-1941	15.378	17.064	18.279	85.184	166.063	127.143	114.255	69.095	42.284	26.931	21.963	20.891	724.530
1941-1942	21.851	27.389	27.146	61.236	207.386	130.593	170.507	104.178	61.651	42.644	28.943	23.444	906.968
1942-1943	38.647	57.216	73.820	39.260	126.699	142.946	134.673	137.510	89.595	50.425	35.087	25.806	951.684
1943-1944	23.315	26.133	24.958	27.229	104.837	124.240	112.129	105.479	71.069	40.619	27.874	23.878	711.760
1944-1945	22.963	25.281	47.802	52.333	168.769	144.227	135.377	90.717	68.755	41.441	28.458	24.272	850.395
1945-1946	23.559	24.588	25.373	36.448	39.769	95.737	128.415	79.611	80.207	37.078	27.754	23.840	622.379
1946-1947	21.825	24.644	22.333	24.119	103.547	151.870	81.849	52.107	39.718	25.150	20.913	18.438	586.513
1947-1948	17.890	18.918	21.164	22.657	42.927	122.689	127.805	91.837	70.281	37.219	26.256	21.068	620.711
1948-1949	19.450	21.561	24.839	48.715	88.222	174.724	162.365	151.557	108.063	57.032	39.755	30.852	927.135
1949-1950	27.727	28.458	25.580	42.246	115.867	98.456	97.858	81.829	55.917	26.493	21.253	18.575	640.259
1950-1951	18.590	21.588	22.156	24.505	55.866	56.239	47.330	38.094	29.031	16.918	16.336	15.706	362.359
1951-1952	15.485	17.552	17.128	55.376	66.772	154.599	147.901	83.519	57.800	83.585	24.467	20.851	745.035
1952-1953	19.712	21.371	22.843	29.580	86.590	140.488	205.771	140.873	78.442	50.733	33.166	24.440	854.009
1953-1954	25.215	27.595	38.540	49.569	185.782	255.163	189.564	157.804	85.117	47.672	31.723	25.231	1118.975
1954-1955	23.779	26.658	28.198	33.576	35.684	43.139	79.883	57.651	29.286	20.492	13.898	12.294	404.538
1955-1956	11.939	12.953	26.423	58.097	76.117	142.351	128.450	74.862	47.686	23.182	17.640	14.945	634.645
1956-1957	15.170	17.782	21.311	38.371	54.018	114.730	103.630	72.174	43.312	20.360	16.137	14.067	531.062
1957-1958	13.841	16.981	18.844	53.343	121.752	104.746	73.964	47.467	26.433	17.040	13.641	12.755	520.807

TABLE 30 CONTINUED

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1958-1959	13.123	15.205	16.293	19.935	32.468	56.672	106.962	58.336	29.085	16.796	14.453	13.620	392.948
1959-1960	13.476	15.205	16.599	17.525	35.433	29.508	45.669	44.240	20.369	13.563	12.813	10.671	275.071
1960-1961	9.406	11.552	15.570	16.509	34.251	65.451	54.096	59.352	30.475	17.441	13.184	10.081	337.368
1961-1962	7.763	9.577	16.140	63.794	62.088	106.034	103.978	63.672	44.065	21.384	11.413	13.057	522.965
1962-1963	10.025	13.622	10.648	32.696	53.150	105.767	113.369	81.697	74.484	43.216	38.644	22.576	599.894
1963-1964	20.482	22.970	23.525	31.723	42.434	95.090	137.348	63.613	49.044	25.474	23.506	25.180	560.389
1964-1965	28.950	39.975	38.146	56.854	63.181	80.279	89.946	75.194	49.248	33.665	50.330	15.345	621.113
1965-1966	14.030	8.177	11.260	40.064	16.681	23.732	22.464	21.848	16.017	10.759	11.972	11.662	208.666
1966-1967	11.926	10.213	10.788	13.563	17.675	35.003	187.070	154.032	98.096	49.256	9.848	11.348	608.818
1967-1968	13.266	12.540	11.389	10.446	187.887	164.573	112.643	63.094	41.253	20.129	13.397	12.623	663.240
1968-1969	13.393	13.818	88.776	183.355	206.218	210.513	176.059	136.469	107.685	37.434	31.629	14.599	1219.948
1969-1970	11.620	11.244	5.552	6.198	17.780	15.357	34.203	29.637	16.480	10.656	10.917	11.721	181.365
1970-1971	10.905	11.670	8.458	10.266	8.126	23.193	26.473	99.997	63.122	13.642	9.752	11.115	296.719
1971-1972	11.882	11.016	9.321	12.653	16.823	23.377	18.650	15.850	24.331	14.487	14.021	14.217	186.628
1972-1973	11.628	11.667	9.749	5.137	5.231	5.199	12.505	7.320	8.445	10.106	10.344	8.568	105.899
1967/68 - 1972/73	12.1	12.0	22.2	38.0	73.7	73.7	63.4	58.7	43.6	17.7	15.0	12.1	442.2
1939/40 - 1953/54	22.230	25.489	29.268	42.566	110.354	137.075	131.160	97.928	65.627	40.741	26.897	22.227	751.562
1939/40 - 1972/73	17.649	19.858	24.295	39.488	80.650	102.966	105.728	79.277	53.039	30.300	21.794	17.466	592.510

TABLE 31: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT LITANI

Sampling Station Ghandouriye Wadi

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1966-1967	11.148	9.508	8.932	13.274	19.218	39.929	197.130	167.210	97.754	49.603	9.964	10.316	633.986
1967-1968	12.592	12.476	11.483	9.875	200.269	176.790	120.300	70.777	41.159	19.393	13.890	13.234	702.238
1968-1969	14.476	13.786	88.550	201.453	225.621	237.115	198.244	145.875	110.018	37.346	31.659	15.288	1319.431
1969-1970	10.964	10.531	5.661	5.351	15.510	16.143	40.117	32.918	18.039	9.691	10.114	10.839	185.878
1970-1971	11.656	11.544	8.377	10.676	9.417	26.797	31.576	121.033	64.424	15.479	11.311	11.539	333.829
1971-1972	14.673	14.075	11.291	13.510	17.841	25.089	21.114	17.885	22.531	14.933	15.280	14.324	202.546
1972-1973	11.900	12.000	10.000	5.700	7.300	7.800	14.100	8.400	9.200	10.500	10.700	8.900	116.500
1967/68 - 1972/73	12.7	12.4	22.6	41.1	79.3	81.6	71.0	66.1	44.2	17.9	15.5	12.4	476.8

TABLE 32: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT GHANDOURIYE WADI

Sampling Station Upstream Litani

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1966-1967	0.000	0.000	0.000	0.000	0.001	0.387	1.328	1.591	0.975	0.495	0.356	0.236	5.369
1967-1968	0.075	0.099	0.246	0.153	1.069	1.939	1.446	0.835	0.579	0.433	0.241	0.198	7.313
1968-1969	0.114	0.070	0.122	0.426	2.518	4.691	3.800	3.092	2.577	1.949	1.414	1.007	21.780
1969-1970	0.495	0.568	0.334	0.123	0.442	0.385	0.544	0.645	0.509	0.358	0.445	0.281	5.129
1970-1971	0.124	0.037	0.000	0.000	0.008	0.128	0.378	1.633	1.720	0.739	0.536	0.311	5.614
1971-1972	0.145	0.343	0.422	0.429	0.662	1.070	0.991	0.570	0.654	0.477	0.265	0.147	6.175
1972-1973	0.008	0.005	0.008	0.003	0.021	0.002	0.005	0.003	0.000	0.000	0.000	0.000	0.055
1967/68 - 1972/73	0.2	0.2	0.2	0.2	0.8	1.4	1.2	1.1	1.0	0.7	0.5	0.3	7.8

TABLE 33: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT QASMIEH CANAL

Sampling Station Connecting Point of the Canal

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1965-1966	10.723	6.653	6.706	5.815	0.924	0.510	0.000	1.867	9.437	9.189	9.878	10.041	71.743
1966-1967	9.355	8.158	6.807	4.942	3.377	1.522	0.696	3.525	9.449	10.552	8.306	8.386	75.075
1967-1968	10.210	9.353	8.551	1.987	0.000	0.000	1.037	6.610	11.139	10.918	10.660	10.633	81.098
1968-1969	9.754	9.701	4.979	4.516	5.611	0.118	0.000	1.322	10.403	10.109	10.427	9.131	76.071
1969-1970	9.111	7.786	3.048	5.378	4.039	3.247	3.857	3.491	9.283	9.090	9.519	9.966	77.815
1970-1971	9.541	9.230	6.063	3.568	3.675	5.138	5.793	0.472	5.901	10.272	9.728	9.870	79.251
1971-1972	10.158	10.609	7.620	3.477	1.248	2.333	1.192	1.431	8.199	10.034	10.075	9.457	75.833
1972-1973	9.865	10.325	7.136	7.782	2.764	3.065	4.468	2.696	7.382	9.168	9.029	8.900	82.580
1967/68 - 1972/73	9.8	9.5	6.2	4.5	2.9	2.3	2.7	2.7	8.7	9.9	9.9	9.7	78.8*

* including 2.4 Mcm pumped into the Litani near its delta

TABLE 34: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT LITANI - QASMIEH

Sampling Station Near the Delta

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1965-1966	5.270	4.200	3.326	37.854	14.016	24.971	25.793	23.439	9.618	3.616	4.358	3.956	160.417
1966-1967	3.333	3.552	3.955	13.049	21.068	46.262	223.606	207.891	104.056	41.695	5.306	5.025	678.798
1967-1968	5.184	5.919	7.195	11.206	230.771	236.306	157.423	77.102	41.096	15.790	7.202	5.812	801.006
1968-1969	5.363	6.998	91.765	226.416	263.196	300.665	222.647	177.993	119.446	44.655	31.458	10.976	1501.578
1969-1970	8.040	9.575	7.797	8.536	18.473	17.142	43.837	33.045	13.502	5.819	5.729	5.855	177.350
1970-1971	5.938	6.953	6.864	12.286	8.699	29.783	36.892	131.062	82.034	10.767	7.374	6.924	345.576
1971-1972	7.260	6.626	7.162	13.692	19.378	29.641	24.122	20.262	22.531	7.061	6.634	6.120	170.489
1972-1973	4.606	5.432	4.619	3.991	5.700	4.858	12.122	7.009	3.549	3.186	2.828	1.398	59.298
1967/68 - 1972/73	6.1	6.9	20.9	46.0	91.0	103.1	82.8	74.4	47.0	14.5	10.2	6.2	509.1

TABLE 35: AVERAGE MONTHLY AND YEARLY VOLUME OF WATER FLOW IN Mcm AT KFAR DAJJAL WADI
Sampling Station Maifadoun Dam

Time Period	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964-1965	0.000	0.000	0.000	0.000	0.005	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.036
1965-1966	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.010
1966-1967	0.000	0.000	0.000	0.064	0.171	0.102	0.128	0.000	0.000	0.000	0.000	0.000	0.465
1967-1968	0.000	0.000	0.000	0.000	0.252	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.287
1968-1969	0.000	0.000	0.000	0.252	0.686	0.370	0.051	0.000	0.000	0.000	0.000	0.000	1.359
1969-1970	0.000	0.000	0.000	0.000	0.054	0.000	0.155	0.000	0.000	0.000	0.000	0.000	0.209
1970-1971	0.000	0.000	0.000	0.000	0.000	0.119	0.003	0.163	0.000	0.000	0.000	0.000	0.285
1971-1972	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1972-1973	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967/68 - 1972/73	0.000	0.000	0.000	0.042	0.165	0.087	0.035	0.027	0.000	0.000	0.000	0.000	0.356

Table 1

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Ksara Station, Central Bekaa (altitude - 920 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1921/22	0	9	36	209	195	159	33	15	8	0	0	0	662
1922/23	0	1	112	116	149	116	81	83	23	1	0	0	681
1923/24	4	9	17	124	164	205	55	11	5	3	0	0	596
1924/25	0	35	126	93	82	49	5	45	1	12	0	0	448
1925/26	1	31	23	118	311	181	101	79	18	0	3	0	866
1926/27	0	1	5	167	122	193	47	109	7	0	0	0	650
1927/28	0	21	14	59	99	308	20	3	3	0	0	0	527
1928/29	0	11	88	146	174	421	59	41	16	4	0	0	960
1929/30	0	1	47	90	72	147	10	19	2	0	0	9	397
1930/31	3	1	55	175	156	212	73	33	2	6	0	0	717
1931/32	2	1	26	157	73	94	34	39	1	0	0	0	426
1932/33	0	4	73	2	74	64	67	46	1	0	0	0	330
1933/34	6	15	18	133	117	210	28	13	13	0	0	0	553
1934/35	0	32	3	222	231	161	26	100	0	0	0	0	775
1935/36	4	34	112	59	37	155	53	9	23	0	0	2	488
1936/37	0	7	184	102	89	33	11	62	10	1	0	0	498
1937/38	0	73	64	38	227	189	60	28	58	0	0	0	739
1938/39	3	1	121	97	105	111	95	59	1	5	0	0	597
1939/40	0	18	99	90	238	99	86	27	0	0	0	0	657
1940/41	0	19	118	252	194	42	95	13	0	0	0	0	734
1941/42	1	20	23	214	240	72	133	8	10	1	0	0	720
1942/43	0	67	106	33	270	80	117	78	6	0	0	0	757
1943/44	0	6	4	68	283	124	78	29	26	0	0	0	619
1944/45	0	8	183	156	164	126	33	15	31	0	0	0	715
1945/46	0	0	72	78	29	180	97	7	92	0	0	0	554
1946/47	0	28	13	61	299	73	29	9	24	0	0	0	535
1947/48	0	1	50	53	134	242	131	47	19	0	0	0	678
1948/49	0	7	86	129	163	189	121	87	7	0	0	0	790
1949/50	5	0	2	184	181	66	77	36	26	0	0	0	577
1950/51	1	58	42	71	86	77	28	76	4	0	0	0	443
1951/52	0	43	58	209	79	167	99	23	0	0	0	0	678
1952/53	0	28	42	124	199	184	202	19	1	0	0	0	800
1953/54	0	2	142	128	179	206	49	59	4	0	0	0	770
1954/55	3	4	69	85	26	80	140	40	14	0	0	0	461

(continued)

Table continued

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1955/56	0	17	132	132	125	132	89	4	32	0	0	0	665
1956/57	0	0	52	160	187	87	96	16	40	7	0	0	645
1957/58	0	11	52	183	209	16	36	14	13	0	0	0	634
1958/59	1	19	11	71	167	100	62	24	13	1	0	0	466
1959/60	10	8	40	42	92	31	85	30	2	0	0	0	340
1960/61	0	12	76	45	126	97	68	8	4	0	0	0	436
1961/62	14	7	61	183	117	141	34	23	4	0	0	0	583
1962/63	0	36	0	223	161	117	93	82	4	1	0	0	716
1963/64	7	58	38	102	88	217	82	50	24	0	0	0	666
1964/65	0	0	165	41	157	135	51	74	7	2	0	0	631
1965/66	0	86	30	227	99	88	109	0	4	0	0	0	643
1966/67	0	54	10	234	161	136	205	24	40	0	0	0	864
1967/68	0	91	71	138	261	55	33	6	16	0	0	0	672
1968/69	0	24	132	373	403	62	126	41	14	0	0	0	1174
1969/70	0	58	62	81	153	75	115	45	3	0	0	0	590
1970/71	0	17	39	115	72	175	69	195	0	0	0	0	682

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 2

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Baalbek Station, Bekaa (altitude - 1150 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1938/39	0	2	113	53	56	86	158	57	0	0	0	0	525
1939/40	0	1	79	30	149	26	34	14	0	0	0	0	333
1940/41	0	28	66	146	109	34	54	9	0	0	0	0	446
1941/42	-	-	-	-	-	-	-	-	-	-	-	-	-
1942/43	-	-	-	-	-	-	-	-	-	-	-	-	-
1943/44	0	0	2	28	228	121	121	25	33	0	0	0	558
1944/45	0	0	133	141	108	84	15	23	23	0	0	0	527
1945/46	0	0	21	29	35	136	73	23	35	0	0	0	352
1946/47	0	11	4	43	143	67	18	7	9	0	0	0	303
1947/48	0	2	26	27	106	232	89	51	9	0	0	0	541
1948/49	0	3	64	57	104	133	97	65	0	0	0	0	523
1949/50	0	0	1	113	129	32	52	33	34	0	0	0	394
1950/51	0	19	43	89	54	73	18	63	0	0	0	0	360
1951/52	0	15	33	174	30	134	61	25	0	0	0	0	473
1952/53	0	10	27	58	88	135	153	30	0	0	0	0	502
1953/54	0	0	98	74	187	141	32	61	6	0	0	0	609
1954/55	9	6	47	48	11	51	85	31	17	0	0	0	305
1955/56	0	2	78	51	117	95	44	5	20	0	0	0	412
1956/57	0	0	17	83	87	38	41	23	34	5	0	0	327
1957/58	0	9	26	95	113	20	18	5	5	0	0	0	291
1958/59	0	3	9	44	91	82	32	10	8	0	0	0	279
1959/60	8	5	22	10	34	8	74	8	12	0	0	0	181
1960/61	0	2	35	32	70	41	29	8	2	0	0	0	218
1961/62	1	12	22	128	64	136	6	36	12	0	0	0	416
1962/63	0	55	1	105	126	49	60	59	11	0	0	0	465
1963/64	2	35	29	54	34	150	26	15	17	0	0	0	362
1964/65	0	0	150	10	84	94	55	45	2	0	0	0	441
1965/66	0	41	16	94	35	57	77	1	3	0	0	0	324
1966/67	4	15	10	152	100	61	164	12	43	0	0	0	560
1967/68	1	66	53	75	162	33	28	6	34	0	0	0	457
1968/69	0	8	61	179	212	26	67	21	23	0	0	0	462
1969/70	0	52	37	39	74	24	59	31	4	0	0	0	320
1970/71	0	4	27	63	40	92	54	99	5	0	0	0	384

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 3

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Tel Amara Station, Central Bekaa (altitude - 905 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1953/54	0	1	163	133	204	205	42	65	5	0	0	0	817
1954/55	0	0	66	82	18	81	125	27	12	0	0	0	411
1955/56	0	11	105	126	155	131	86	6	35	0	0	0	653
1956/57	0	0	27	141	181	80	72	16	54	2	0	0	572
1957/58	0	17	56	174	191	23	43	14	7	0	0	0	524
1958/59	0	17	4	95	175	88	62	17	27	0	0	0	486
1959/60	4	8	31	45	98	38	81	39	2	0	0	0	346
1960/61	0	10	71	57	125	86	72	17	2	0	0	0	440
1961/62	7	16	50	182	112	136	35	27	3	0	0	0	567
1962/63	0	24	0	200	152	142	103	80	4	4	0	0	708
1963/64	0	54	38	72	91	207	81	35	23	0	0	0	602
1964/65	0	0	182	38	138	152	64	71	6	2	0	0	652
1965/66	0	54	29	237	99	75	111	0	4	0	0	0	609
1966/67	0	33	10	213	162	126	208	32	40	0	0	0	824
1967/68	0	92	74	123	220	61	27	2	46	0	0	0	645
1968/69	0	21	120	315	345	59	133	39	14	0	0	0	1046
1969/70	0	49	63	75	164	74	117	45	4	0	0	0	591
1970/71	0	9	36	109	60	165	46	200	0	0	0	0	625

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 4

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Qirawn Dam (altitutde - 950 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1961/62	5	10	173	355	142	281	37	32	13	0	0	0	1048
1962/63	0	25	0	349	308	256	243	79	49	0	0	0	1309
1963/64	3	53	53	171	177	363	227	39	48	0	0	0	1134
1964/65	0	0	346	72	227	279	84	100	1	2	0	0	1110
1965/66	0	79	72	261	177	124	174	6	1	0	0	0	894
1966/67	5	32	5	296	246	219	330	53	29	0	0	0	1215
1967/68	0	62	107	247	414	92	57	10	35	0	0	0	1024
1968/69	0	38	144	540	608	95	255	34	4	0	0	0	1718
1969/70	0	93	87	185	171	101	205	66	0	0	0	0	908
1970/71	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 5

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Taanayel Station, Bekaa (altitude - 880 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964/65	0	0	161	37	164	195	54	54	5	1	0	0	670
1965/66	0	88	37	206	103	109	109	1	4	0	0	0	659
1966/67	0	52	12	235	204	182	234	27	44	0	0	0	990
1967/68	0	75	73	182	351	58	34	4	45	0	0	0	820
1968/69	0	17	129	402	412	68	143	65	20	0	0	0	1255
1969/70	-	-	-	-	-	-	-	-	-	-	-	-	-
1970/71	-	-	-	-	-	0	100	229	1	0	0	0	-

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 6

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Terbol Station (altitutde - 890 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1966/67	0	39	11	186	152	121	198	26	74	0	0	0	807
1967/68	0	144	58	130	168	52	41	9	40	0	0	0	641
1968/69	0	19	117	277	329	48	132	34	8	0	0	0	964
1969/70	-	-	-	66	167	71	111	50	4	0	0	0	-
1970/71	0	11	-	-	88	250	75	158	-	0	0	0	-

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 7

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Qirawn Village Station (altitude - 950 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1952/53	0	4	30	105	230	165	201	22	2	0	0	0	759
1953/54	0	0	141	128	220	195	37	65	0	0	0	0	786
1954/55	0	0	34	92	22	72	121	37	10	0	0	0	388
1955/56	0	4	94	80	98	105	50	10	22	0	0	0	463
1956/57	0	0	53	132	143	80	79	21	32	5	0	0	545
1957/58	0	14	31	158	158	14	32	6	10	0	0	0	423
1958/59	0	30	20	80	142	87	48	3	8	0	0	0	418
1959/60	2	0	26	10	83	12	79	31	0	0	0	0	243
1960/61	0	4	122	28	87	143	28	2	3	0	0	0	417
1961/62	2	10	80	192	81	120	9	8	3	0	0	0	503
1962/63	0	26	0	262	215	79	76	49	4	0	0	0	711
1963/64	-	-	-	-	-	-	-	-	-	-	-	-	-
1964/65	-	-	-	-	-	-	-	-	-	-	-	-	-
1965/66	0	-	-	241	175	137	145	3	0	0	0	0	-
1966/67	0	45	32	300	237	197	231	28	39	0	0	0	1109
1967/68	0	70	77	191	402	59	39	9	12	0	0	0	859
1968/69	0	23	110	515	558	73	184	25	1	0	0	0	489
1969/70	0	78	61	141	171	88	161	46	4	0	0	0	750
1970/71	0	59	33	126	72	227	135	285	0	0	0	0	937

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 8

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Jarmaq Station (altitude - 400 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1964/65	0	0	282	103	239	169	56	115	2	0	0	0	966
1965/66	0	70	51	168	244	155	146	14	0	0	0	0	848
1966/67	20	50	24	304	239	207	312	42	7	0	0	0	1205
1967/68	0	28	84	215	403	82	17	88	40	0	0	0	957
1968/69	0	-	136	-	563	41	-	-	-	0	0	0	-
1969/70	0	57	81	121	196	88	293	32	6	0	0	0	874
1970/71	0	11	81	150	94	291	86	299	0	0	0	0	1021

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

Table 9

MONTHLY AND YEARLY AVERAGE RAINFALL (mm)

Qasmieh Station, Coastal Area (altitude - 30 m)

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1944/45	0	30	142	96	128	170	49	19	16	0	0	0	650
1945/46	0	8	115	160	84	156	49	0	60	0	0	0	592
1946/47	0	3	0	133	279	30	22	19	40	0	0	0	526
1947/48	3	41	68	68	154	228	118	45	30	0	0	0	755
1948/49	0	10	79	370	89	212	102	126	0	0	0	0	988
1949/50	12	0	10	275	97	-	-	-	-	0	0	0	-
1950/51	7	29	122	59	118	64	13	75	0	0	0	0	487
1951/52	0	71	93	209	74	151	10	20	0	0	0	0	708
1952/53	0	42	108	130	328	144	163	39	0	0	0	0	953
1953/54	0	0	121	17	194	178	58	105	0	0	0	0	673
1954/55	0	5	84	210	58	78	84	41	25	0	0	0	572
1955/56	1	40	162	284	165	-	-	-	-	0	0	0	-
1956/57	0	0	12	125	-	-	-	-	-	-	-	-	-
1957/58	-	25	65	240	310	10	35	20	-	0	0	0	705
1958/59	38	12	6	93	195	113	54	34	25	3	0	0	573
1959/60	20	32	70	54	156	13	136	20	4	0	0	0	524
1960/61	0	0	120	24	97	209	68	34	6	0	0	0	557
1961/62	2	7	57	236	168	129	7	19	0	1	0	0	626
1962/63	0	40	0	353	189	133	59	38	13	0	0	0	825
1963/64	0	100	58	114	59	225	162	7	25	0	0	0	750
1964/65	0	0	255	94	138	72	67	60	0	0	0	0	686
1965/66	0	52	19	134	193	102	53	0	0	0	0	0	553
1966/67	4	57	32	219	176	133	125	17	6	0	0	0	769
1967/68	0	11	79	210	243	44	31	22	0	0	0	0	640
1968/69	0	82	227	304	567	25	91	20	6	0	0	0	1321
1969/70	0	61	89	79	109	88	100	41	0	0	0	0	567
1970/71	0	20	92	90	92	233	63	189	0	0	0	0	784

Source: Hydrology of Lebanon: Preliminary Technical Report, AMER, 1986.

APPENDIX B

EXCERPTS FROM THE U.S. DEPARTMENT OF THE INTERIOR REPORT OF 1954

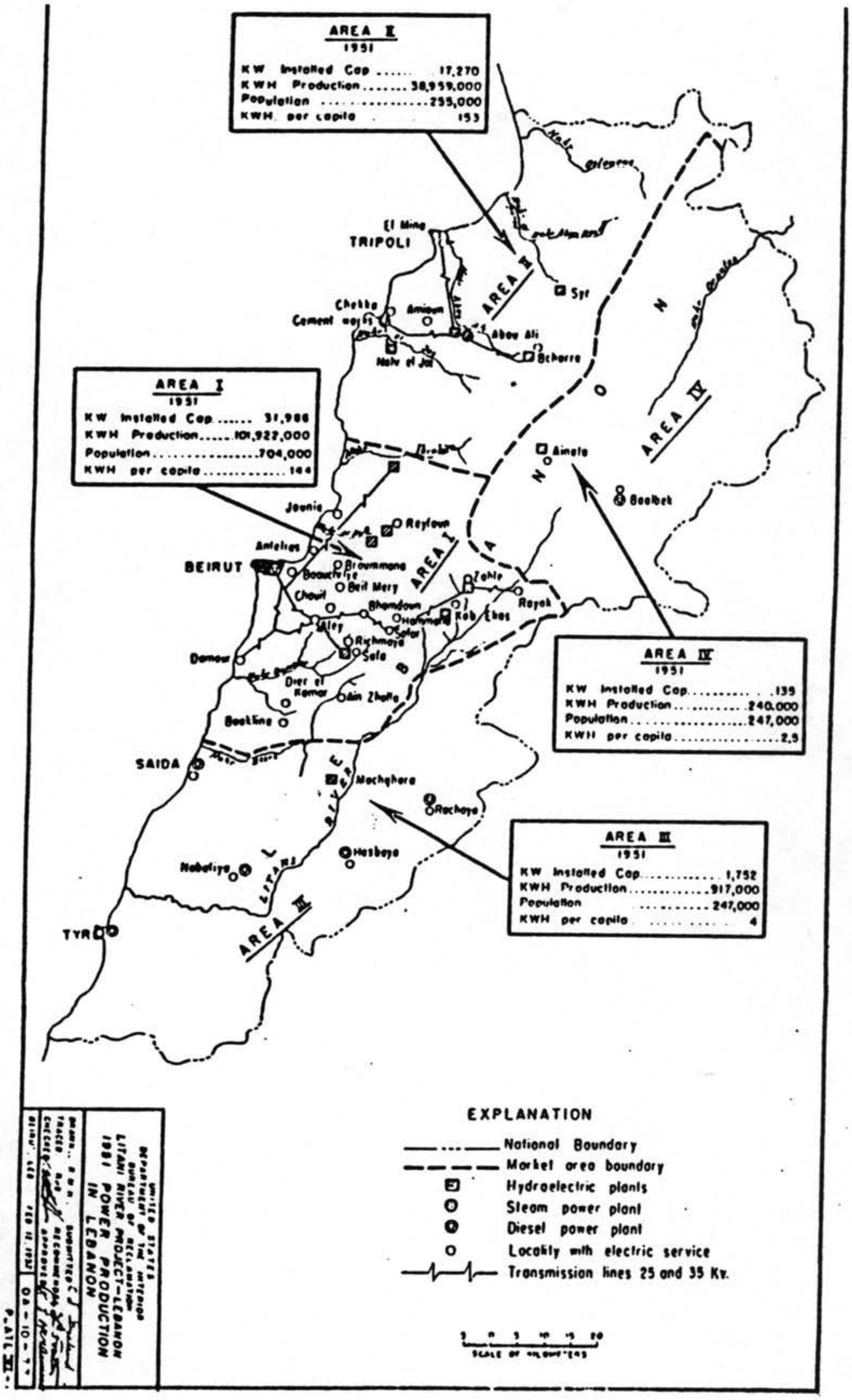
Source: U.S. Department of the Interior(2740).

TABLE J

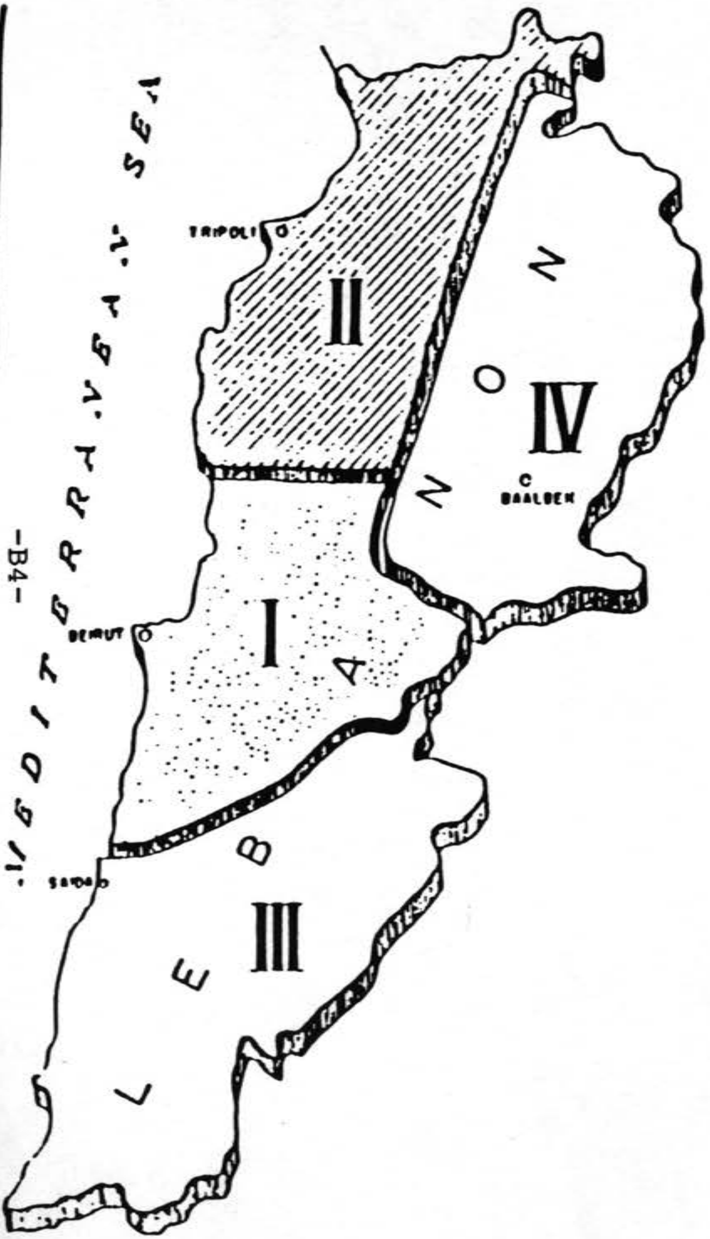
1951 INSTALLED CAPACITY AND ENERGY PRODUCTION OF POWER PLANTS IN LEBANON

Name of Plant	Load Area	Principal Load	Year Installed	Installed -KW-	Type of Power Plant	1951 Energy Production-KWH-
Safa	I	Beirut	1932	6,400	Hydro	28,568,510
Nahr Ibrahim	I	Beirut	1950	3,200	Hydro	17,164,100
Beirut Diesel	I	Beirut	1924 to 1950	12,400	Diesel	45,950,310
Nahr el Kelb	I	Jounie	1925	300	Hydro	379,500
Kab Elias	I	Kab Elias	1930	136	Hydro	210,000
Zahle	I	Zahle	1925	550	Hydro	1,899,680
Total Area I				22,986		94,172,100
Total Hydro, Area I				10,586		48,221,790
Total Thermal, Area I				12,400		45,950,310
Bcharre	II	Tripoli	1925	1,630	Hydro	2,887,000
Abou Ali	II	Tripoli	1930	5,440	Hydro	15,649,850
Abou Ali	II	Tripoli	1932(1)	1,630	Steam	2,522,420
Nahr el Joz	II	Chekka Cement	1950	4,280	Hydro	11,113,800
Syr	II	Village of Syr	1939	30	Hydro	90,000
Total Area II				14,770		36,709,170
Total Hydro, Area II				11,380		29,740,650
Total Thermal, Area II				3,390		6,968,520
Tyr	III	Tyr	1948	140	Diesel	61,100
Nabatiye.	III	Nabatiye	1933	64	Diesel	51,000
Hasbaya	III	Village of Hasbaya	1937	16	Diesel	4,400
Machgara	III	Village of Machgara		22	Hydro	19,300
Saida	III	City of Saida	1930 to 1951	1,500	Diesel	774,921
Rachaya	III	Village of Rachaya	1939	10	Diesel	6,000
Total Area III				1,752		916,721
Total Hydro, Area III				22		19,300
Total Thermal, Area III				1,730		897,421
Baalbek	IV	City of Baalbek	1947	120	Diesel	200,000
Ainata	IV	Village of Ainata	1948	15	Hydro	40,000
Total Area IV				135		240,000
Grand Total				39,643		132,037,991
Total Hydro in Lebanon				22,003		78,021,740
Total Thermal in Lebanon				17,640		54,016,251

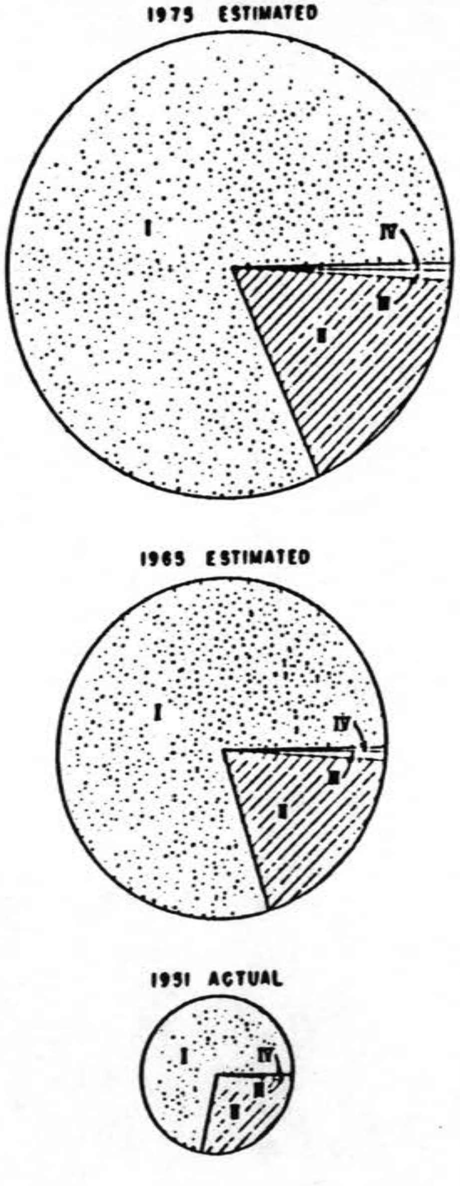
(1) Abou Ali steam plant-Turbo-Generator unit moved to Lebanon in 1932. It had been in operation in Franch since 1908.


AREA II
1951
KW Installed Cap 17,270
KWH Production 38,959,000
Population 255,000
KWH per capita 153
AREA I
1951
KW Installed Cap 31,986
KWH Production 101,922,000
Population 704,000
KWH per capita 144
AREA IV
1951
KW Installed Cap 135
KWH Production 240,000
Population 247,000
KWH per capita 2.9
AREA III
1951
KW Installed Cap 1,752
KWH Production 917,000
Population 247,000
KWH per capita 4
El Mina
TRIPOLI
Chekka
Cement works
Amioun
Abou Ali
Syr
Becharre
Nahr el Jaz
Ainata
Baalbek
Jounie
Reyfoun
Antelias
BEIRUT
Broummana
Beit Mery
Chouit
Bhamdoun
Aley
Hammana
Sofar
Zahle
Rayak
Ksara
Richmaya
Sofa
Damour
Deir el Kamar
Ain Zhalta
Baakline
SAIDA
Machghara
Rachaya
Hasbaya
Nabatiya
TYR
LITANI RIVER
N
O
N
A
B
L
AREA I
AREA II
AREA III
AREA IV
EXPLANATION
National Boundary
Market area boundary
Hydroelectric plants
Steam power plant
Diesel power plant
Locality with electric service
Transmission lines 25 and 35 Kv.
SCALE OF KILOMETERS
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
LITANI RIVER PROJECT—LEBANON
1951 POWER PRODUCTION
IN LEBANON
DRAWN R.B.R. SUBMITTED
TRACED R.B.R. RECOMMENDED
CHECKED APPROVED
DENVER, COLO. FEB 11, 1952
OA-10-??
P.A.IL XI

MAP B



ELECTRICAL ENERGY
REQUIREMENTS BY AREAS



INDEX MAP

AREA \ YEAR	1951 kwh.	1965 kwh.	1975 kwh
I	101,922,000	471,100,000	861,600,000
II	38,959,000	114,150,000	170,020,000
III	917,000	5,565,000	7,800,000
IV	240,000	655,000	6,175,000
TOTAL	142,038,000	591,470,000	1,055,600,000

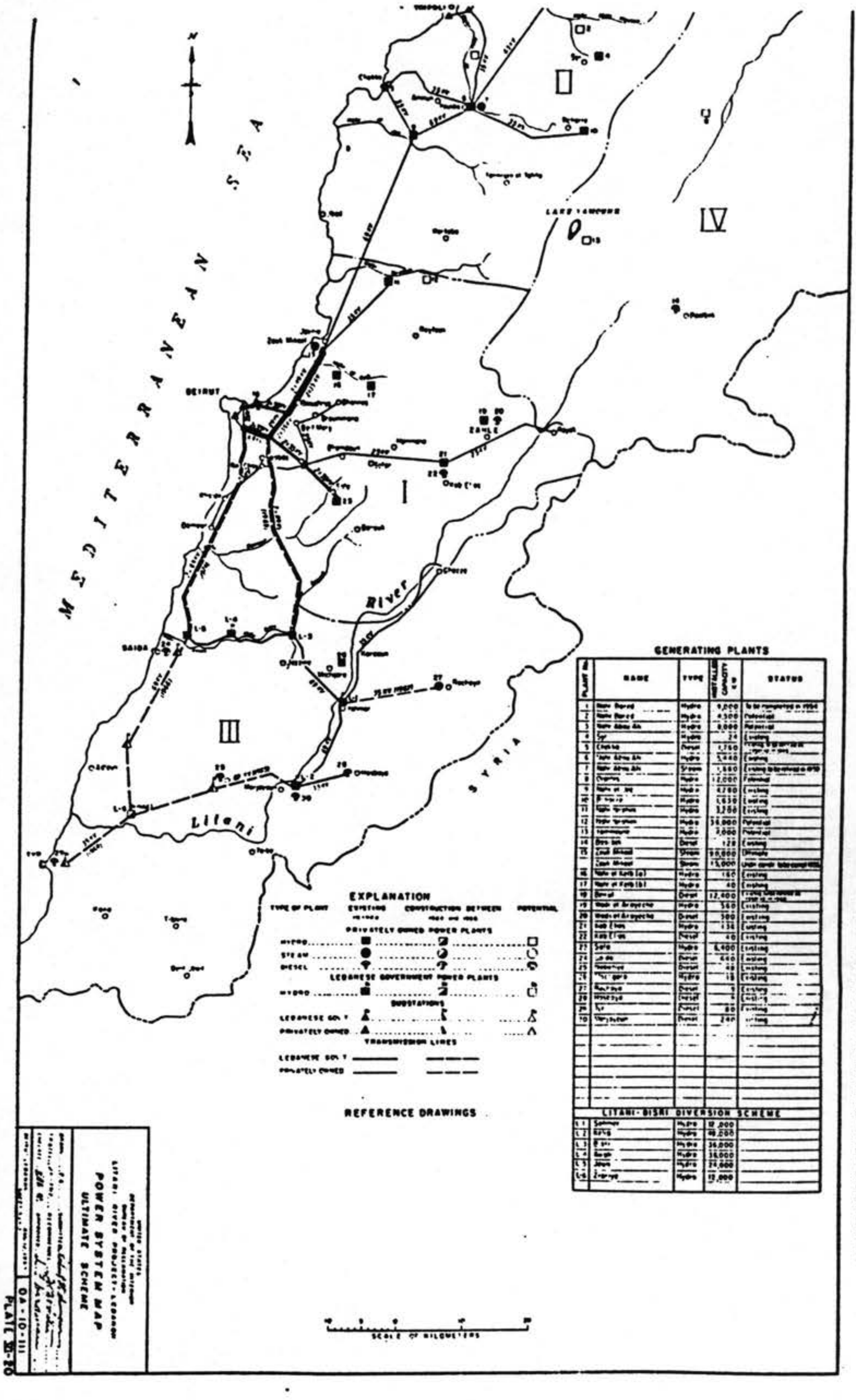
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
LITANI RIVER PROJECT – LEBANON

FUTURE ELECTRICAL ENERGY REQUIREMENTS IN LEBANON

DRAWN J.T. SUBMITTED C. J. Gyland
TRACED R.B. RECOMMENDED S. J. Foster
CHECKED APPROVED R. Y. Herdman
BEIRUT, LEBANON · MAY 19, 1953
0A-10-85

PLATE II

MAP C



GENERATING PLANTS

PLANT No.	NAME	TYPE	INSTALLED CAPACITY KW	STATUS
1	Nahr Bared	Hydro	9,000	To be completed in 1956
2	Nahr Bared	Hydro	4,500	Potential
3	Nahr Abou Ali	Hydro	8,000	Potential
4	Syr	Hydro	24	Existing
5	Chekka	Diesel	1,760	[illegible]
6	Nahr Abou Ali	Hydro	5,440	Existing
7	Nahr Abou Ali	Steam	1,660	Existing [illegible]
8	[illegible]	Hydro	12,000	Potential
9	[illegible]	Hydro	4700	Existing
10	[illegible]	Hydro	1,630	Existing
11	Nahr Ibrahim	Hydro	3,200	Existing
12	Nahr Ibrahim	Hydro	36,000	Potential
13	[illegible]	Hydro	7,000	Potential
14	[illegible]	Diesel	128	Existing
15	Zouk Mikael	Steam	90,000	Ultimate
	Zouk Mikael	Steam	15,000	[illegible]
16	Nahr el Kelb (a)	Hydro	160	Existing
17	Nahr el Kelb (b)	Hydro	40	Existing
18	Beirut	Diesel	12,400	[illegible]
19	Wadi el Arayeche	Hydro	560	Existing
20	Wadi el Arayeche	Diesel	500	Existing
21	Kab Elias	Hydro	134	Existing
22	Kab Elias	Diesel	40	Existing
23	Safa	Hydro	6,400	Existing
24	[illegible]	Diesel	440	Existing
25	Nabatiye	Diesel	48	Existing
26	[illegible]	Hydro	18	Existing
27	Rachaya	Diesel	9	Existing
28	Hasbaya	Diesel	9	Existing
29	Tyr	Diesel	80	Existing
30	Marjayoun	Diesel	240	Existing

LITANI-BISRI DIVERSION SCHEME

PLANT No.	NAME	TYPE	INSTALLED CAPACITY KW	STATUS
L-1	[illegible]	Hydro	12,000	
L-2	[illegible]	Hydro	48,000	
L-3	[illegible]	Hydro	36,000	
L-4	[illegible]	Hydro	36,000	
L-5	[illegible]	Hydro	24,000	
L-6	[illegible]	Hydro	12,000	

APPENDIX C

HYDROGEOLOGICAL LEGEND

Eras	Periods	Lower periods		Epochs	AGE
					MARİNE (d)
CENOZOIC	Quarter-nary n k (399)	Holocene (399)			
		Pleistocene Pt (399)		Upper	3
				Middle	2
				Lower	1
					Plie-Pleistocene
	Tertiary T	Neogene (n) (374)	Plicone Pl (374)	Upper	2
				Lower	1
			Miocene m (373)	Upper	5
				Middle	4 Tortonian
					3 Helvetian
				Lower	2 Burdigalian
					1 Aquitanian
		Paleogene Pij	Oligocene Ol (412)	Upper	3 Chattian
				Middle	2 Stampian
				Lower	1 Tongrian
			Eocene e (372)	Upper	3 Bartonian
				Middle	2 Lutelian
				Lower	1 İpretian
			Paleocene op (372)	Upper	2 Lundenian
				Lower	1 Montian

Eras	Periods	Lower periods	Epochs	AGE
				MARINE (d)
MESOZOIC	Cretaceous Kr (392)		Upper (392)	12 Danian
				11 Mestrihtien
				10 Kampanien
				9 Santonien
				8 Koniasien
				7 Turonien
				6 Senomanien
			Lower (416)	5 Albien
				4 Apsien
				3 Barremien
				2 Hotrivien
				1 Valanjinien
	Jurassic J (393)		Upper (393)	15 Portlandien
				14 Kimmericien
				13 Sequanian
				12 Rauracian
				11 Argovian
				10 Oxfordian
				9 Callovian
			Middle (393)	8 Pathonian
				7 Bajocian
			Lower (376)	6 Alenian
				5 Tortonian
				4 Charmouthian
				3 Sinemurian
				2 Hettangian
				1 Rhaetian
	Triassic (377)		Upper	5 Norian
				4 Carnian
			Middle	3 Ladinian
				2 Anisian
			Lower	1 Skythian

Eras	**Periods**	**Lower periods**	**Epochs**	**AGE**
				MARİNE (d)
PALEOZOIC	**Permian** **p** **(398)**		**Upper**	5 Tatorian
				4 Kazanian
			Middle	3 Kungurian
			Lower	2 Artinskian
				1 Sakmarian
	Carboniferous **k** **(378)**		**Upper**	4 Uralian
			Middle	3 Moscovian
				2 Baskirian
			Lower	1 Dinantian
	Devonian d (397)		Upper	6 Famennian
				5 Frasnian
			Middle	4 Givetian
				3 Eifelian
			Lower	2 Coblanzian
				1 Gedinnian
	Silurian S (428)		Upper	4 Downtonian
				3 Ludlovian
			Lower	2 Wenlockian
				1 Landoverian
	Odrovician or (428)		Upper	5 Ashaillian
				4 Caradocian
			Middle	3 Landenian
			Lower	2 Lanvirian
				1 Arenigian
	Cambrian (430)		Upper	4 Tremadocian
				3 Potsdamian
			Middle	2 Acadian
			Lower	1 Georgian
Proterozoic	**Pre - cambrian** **Prk**			
	Algonkian **Ag**			
	Archean **(ar)(424)**			

APPENDIX D

SUMMARY OF REPORTS ON THE LITANI BASIN PREVIOUS TO THAT OF THE U.S. DEPARTMENT OF THE INTERIOR IN 1954

Source: U.S. Department of the Interior(2740).

APPENDIX D: PREVIOUS STUDIES AND REPORTS (on the Litani Basin)

Source: #2740: U.S. Dept. of the Interior,
Bureau of Reclamation, for the
Foreign Operations Administration,
Development Plan for the Litani River Basin
Republic of Lebanon (June, 1984),
Vol. I, pp. I-3/I-5.

Previous Studies and Reports

Studies by Lebanese Government. The Lebanese Government, through the Ministry of Public Works, has given consideration to the development of the Litani River for a number of years. Studies prior to 1948 were the basis for the report of that year, "The Litani - Hydrology Study" by Ibrahim Abd-el Al, who is now Director General of Concessions and Representative of the Ministry of Public Works to U.S.A. Operations Mission to Lebanon. The general plan conceived by the Ministry of Public Works included a storage reservoir on the Litani River at the Karaoun site and the multi-purpose development of the Litani River for irrigation and the production of hydroelectric energy. The plan provided for a storage reservoir at Khardale to be used for the development of power and for the diversion of water for irrigation of the Lower Nabatiye Plateau

Included in this plan was the Bekaa Sud Irrigation Project, located above Karaoun Reservoir, to be supplied by direct diversion from the Litani River and east-side tributaries and springs. Also included in this plan was the completion of the Kasmie Coastal Irrigation Project to be supplied by direct diversion from the Litani River. This project has been under construction for a number of years, first by the French, then by the British, and and subsequently to 1954 by Lebanese. Excavation of the main canal was essentially completed and a portion of the canal was lined. The remainder of the main canal and appurtenant works are now being completed under an agreement between the U.S. Foreign Operations Administration and the Government of Lebanon. The irrigation and drainage plans of the Lebanese Government in general agreed with those of the French Mandate period.

The Taibe Project, an extensive plan to pump water from the Litani River near Deir Mimass for domestic purposes, has been under construction for some time. The plan calls for a slow filter and other treatment and distribution to some 127 villages in the Litani River Basin and adjacent areas south of the Litani River bend.

An alternative plan for making use of the Litani River water proposed the trans-mountain diversion from the Karaoun Reservoir through the Lebanon Mountain Range and the multiple purpose use of the water in the Bisri Basin for irrigation development and the production of hydro-electric energy. Water diverted from the Litani would be stored with Bisri River flood waters behind the Bisri Dam.

The above studies, with the exception of the Kasmie and Taibe Projects, did not include basic designs or foundation and geological explorations.

The Maasry Plan. The Maasry Plan is described in a report by Mr. George Maasry, a Beirut businessman. His plan for development on the Litani River is for production of hydro power from purely run-of-river plants. If the Maasry plan is constructed prior to the Lebanese Government plan, the Maasry plants might be considered to establish water rights in conflict with those proposed by the government. The Maasry plan comprises three units: a development to divert water from the Litani River immediately below Ain-el-Zarka, a second development to divert from the river near Kelia, and a third development to divert from the Litani River below Khardale bridge.

Plan for Irrigation made during the French Mandate. In the early part of the decade 1930 - 1940, during the French Mandate, detailed plans for irrigating a portion of the Bekaa plain were prepared. The study entitled, "Drainage and Irrigation of the Plain of the South Bekaa", covered 11,000 hectares largely on the east side of the Litani.

The plan called for irrigating these lands from surface sources only These sources were springs such as those found near Terbol, Chamsine, and Anjar, as well as a diversion from the Litani River south of Rayak. Several alternative schemes were studied, but all had the same major features and included the same lands. According to the data available, 5000 hectares could be irrigated only during the high water months in the spring, and 6000 hectares throughout the irrigation season

This study also considered drainage of some swampy areas but did not include all of the drainage works now believed to be needed in connection with irrigation. The general plan for improving the flow of the Litani by cutting off meanders has been largely completed through the years but has been generally unsuccessful in accomplishing its purpose.

The Report of the United Nations Economic Survey Mission for the Middle East. This report, in two volumes, dated 28 December 1949, was made by a mission of the United Nations directed to study ways and means of alleviating problems brought about through hostilities between the Arab Nations and Israel. The United Nations Conciliation Commission for Palestine established the Economic Survey Mission". . . . to examine the economic situation in the countries affected by the recent hostilities, and to make recommendations to the Commission for an integrated programme. . ."

The mission, of which Gordon R. Clapp was Chairman, obtained the services of a staff of experts who made a rapid study in the field of the problem of the refugees, the economy of the areas where the refugees were found, and measures which might remedy the "economic dislocations created by the hostilities."

The mission recommended, among other things, four pilot demonstration projects to enable the countries of Jordon, Arab Palestine, Syria, and Lebanon to exemplify methods of turning ideas into actions suited to the economic problems of each One project was recommended for each country; that for Lebanon was the Litani River Investigation Project, with emphasis on the need for an over-all study to include all uses of the waters of the basin.

The Economic Development of Lebanon: A Report by Sir Alexander Gibb and Partners - 1948. The firm of Sir Alexander Gibb and Partners, consulting engineers, entered into an agreement with the Government of Lebanon on 27 December 1946 to "investigate and report on the economic development of Lebanon." The report covers land and water utilization with respect to irrigation and drainage, communications, and industry and commerce.

This report contains a full study of the economics of Lebanon and is replete with recommendations and suggestions to the Lebanese Government regarding the subjects covered. One of the construction projects recommended was the South Bekaa Irrigation Project. Another recommendation in the "Long Term Plan" was the development of hydro-electric power with storage on the Litani.

Report of the United States--Lebanon Agricultural Mission. Under the joint sponsorship of the Department of State and the Department of Agriculture, the United States--Lebanon Agricultural Mission was organized and sent to Lebanon, arriving there in March 1946. This mission was formed in answer to a number of requests from Lebanon for assistance in matters relating to agricultural problems and developments.

The members of the mission followed an intensive one-month itinerary which included field trips and conferences. The Mission also visited neighboring countries to obtain the perspective needed for an appraisal of the agricultural problems of Lebanon.

As a result of this short, if intensive, study, the mission prepared a report which includes recommendations and suggestions to the Lebanese Government in regard to solving the nation's agricultural problems. The full utilization of the waters of the Litani was recommended for "(1) expansion of irrigation, (2) development of electrical power for small industries as well as for home use, and (3) distribution of potable water to villages and towns to satisfy the needs of people and livestock."

A Coordinated Plan for Lebanese Waters. A report dated 1950 by Maurice Gemayel and generally referred to as the "Gemayel--Naccache" Plan calls for the unified development of Lebanon's water resources for power and irrigation. This plan stems from studies made over a period of years by Albert Naccache, a Lebanese engineer. Mr. Gemayel, a Lebanese lawyer, published the plan in a book under the above title. Consideration was given to the plan, as it affects the Litani Project in the current studies.

Reconnaissance Report - Litani River Project, Lebanon: A Report by the U.S. Bureau of Reclamation - June 1951. This report, prepared in June 1951 by the United States Bureau of Reclamation, at the request of the Government of Lebanon, presented the results of the first stage of the current investigations, consisting of a reconnaissance survey of the Litani River Basin to determine the feasibility of a basin-wide development of the Litani River and justification for detailed studies.

This report proposed a plan for development and recommended a program for further investigations to be directed toward integrated development, with specific emphais on certain features which could be scheduled for early construction. The current program is based upon this proposal.

Development of Electricity for Lebanon: A Report by Monsieur Henri Olivier, Chief Engineer for Electricity for France - Undated but Released in Spring of 1953. This report, consisting of four folios of narrative, maps, and charts, is the result of a country-wide water resource reconnaissance for determining the hydroelectric power and irrigation potential of the country.

The plan proposed for the development of the Litani River Basin provides for a major dam and reservoir at the Karaoun site, a tunnel 7500 meters long and power plant below the Karaoun Reservoir to have an installed capacity of 40,000 kilowatts, a river-run diversion in the vicinity of the village of Yohmor through a tunnel 7500 meters long to a power plant on the Litani River in the vicinity of Kelia to have an installed capacity of 40,000 kilowatts, and a small regulating reservoir immediately below the latter plant diverting into a tunnel 17,000 meters long across the Litani bend to a plant in the vicinity of Zaoutar ech Charqiye to have an installed capacity of 90,000 kilowatts. Included in this plan is a relatively high dam on the Litani at Tarfalsiye and a power plant just above the diversion for the Kasmie Irrigation Project. The plan includes provision for irrigation by pumping from Karaoun Reservoir to lands in the Bekaa-Sud area, by gravity to lands in the Nabatiye area, and by gravity to lands along the Mediterranean coasts south of the Litani River north of the city of Tyr.

Consideration was given to an alternate plan providing for the storage of Litani waters in the Karaoun Reservoir and their diversion by means of a tunnel through the Lebanon Mountains to the Bisri Basin. Power would be developed by a plant below the outlet of this tunnel and two additional plants along the Bisri River. Storage and regulation of the Bisri and Litani waters would be accomplished by a reservoir on the Bisri River. Monsieur Olivier considered this scheme undesirable and discarded it in favor of the classical Litani scheme for development of the Litani Basin because of the difficulties expected to be encountered in the construction of the diverion tunnel through the mountains and because of the unsuitable foundation conditions for a major dam on the deep silt bed of the Bisri Valley.

Consideration was given to the Olivier proposals in the current studies.

APPENDIX E

REPORT OF LEBANESE ENGINEER ON CONDITIONS AFTER THE ISRAELI INVASION

15. Physical damage due to the Israeli invasion and occupation of the region

There have been three invasions of the southern part of Lebanon since 1978, the most recent being in June 1982. The physical damage to the pumping equipment and the distribution network was substantial. There was total destruction of a part (300 m) of the Zahrani siphon that carries water from Qasmieh toward Ghazieh sector (200 ha) near Sidon (July 1981). The result was that the irrigation process totally stopped for two months. Since then, this sector has received underground water from certain artesian wells, from which the Office of the Litani has signed contracts to buy water. The direct and indirect losses due to such a situation can be estimated at tens of millions of Lebanese pounds.

There was almost total destruction of the pumping station of Qasmieh in July 1981, including the blowing up of the temporary dam, the destruction of three electrical transformers (250 KVA each), the partial destruction (65 m) of the siphon of Tyre carrying water by gravity from the dispatcher to the collecting canal (southern branch), and the destruction of three pumps at the station. The results were a general cutoff of electrical power for 45 days. The direct and indirect cost of such a loss reaches tens of millions of Lebanese pounds. The main collecting network was heavily damaged at several points, particularly at Adloun near the siphon of Abou el-Asouad at Ras el-Ain (Qana circle) and within 1 km of the South branch of Ras el-Ain.

The invasion of the region in 1982 caused human and material damage that is difficult to estimate. The installations of the Qasmieh perimeter were the most affected. Damages to collective installations included: destruction of the new pumping station of Qasmieh (dam, transformers, and pumps); the bursting of one of the three water reservoirs of the Ras el-Ain source as well as a part of the collecting canal (dead head); bursting of a part of the main pipe that provides water to the distribution network of the model perimeter of Sidon-Jezzine; general cutoff of electrical power from 7 June to 25 July 1982, stopping all irrigation in the area; occupation of the buildings of the Litani authority in Sidon, Tyre, Qirawn, and Lebaa, during which important documents were stolen; and destruction of the station for pumping drinking water to Jebel Amel, which provides drinking water to all the area south of the Litani.

With respect to private installations, damages included: total destruction of some 30 pumping stations along the Qasmieh canal - Ras el-Ain; destruction of dozens of hectares of citrus and bananas located along the national road between Sidon and the south border in an effort to minimize the daily military operations carried out by the National Lebanese Resistance against the Israeli forces who were using this road; reduction of the total agricultural production of 1982 to one-half of its normal volume; and the loss of one-third of the total agricultural production during the three years of occupation. This last effect was essentially due to disturbances in the distribution market for goods, since the south was cut off from the northern part of the country, and also due to the military operations.

Finally, a number of government buildings were occupied. It is recorded that many geological and hydrological maps were lost or stolen, as well as important reports and basic documents on the hydrology of southern Lebanon. However, the most important loss was related to the plunder of Qirawn warehouse in February 1984. The Israelis, occupying the South Bekaa, took all the pumping installations that had been stored at Qirawn since 1964. This equipment was provided by the League of Arab States to help pump water from the Hasbani to Lebanese territory in accordance with the decision of the Arab League concerning the diversion of the tributaries of the Jordan River.

The Israeli invasion and the civil war provoked a change in the structure of the private property system in the Qasmieh perimeter. Indeed, almost 50% of the land in that region formerly belonged to nonresident Christians in that sector. They have since sold their land to Muslim residents or immigrants. Another change of significance was the total halt of irrigation in the model sector of Sidon-Jezzine. Following the unrest that took place east of Sidon in May 1985, a large number of the Christian population left the area.