

## 2.3 Meteorology and Hydrology

### 2.3.1 Observation Stations

#### (1) Meteorological stations

Meteorological factors have been observed since the early 1920s. The only rainfall and temperature are available up to the early 1970s. The whole Lebanon can be divided into 8 climatic zones; North Lebanon, Central Lebanon, South Lebanon, North Mountain, Central Mountain, Inland Oronte, Inland Litani, Inland and Hasbani. There were in the past 150 historical stations in the whole Lebanon, of which 15, 35, 14, 8, 36, 11, 24 and 7 stations were distributed respectively in climatic zones mentioned above. However, all of these stations were destroyed during the civil war unfortunately.

In 1998, the new meteorological network system has been introduced by the Meteorology Department under the Ministry of Transport and Public Works supported by the Government of France, and up to now, 48 new meteorological stations have been reconstructed or rehabilitated. Of the total 48 new meteorological stations, 7, 6, 5, 4, 9, 4, 3, and 1 stations are distributed skilfully in the respective climatic zones with an average coverage of 270 km<sup>2</sup> per station. Five stations (Rayak, Abde, Sour, Kafar Chakhna and Lebaa) are being operated and managed by Lebanon Agriculture Research Institute (ARIL) under the Ministry of Agriculture.

These new meteorological stations are controlled by the telemeter system and main computer system is located in Beirut International Airport. At the big meteorological station such as Beirut International Airport, Beirut Golf, Zahle, Baidar, Rayak, Abde, Sour and Tripoli, complete set of climatic parameters including temperature, humidity, rainfall, wind (velocity and direction), air pressure, quantity of cloud, sunshine time, solar radiation and evaporation are available.

Considering that the long-term historical data of precipitation, especially, are available only up to 1974, installation of meteorological station is recommendable to be made at the same location as they were, so that the combination of old and new sets of observed data at the same location could be a base for analyzing complicated phenomenon of climate over the country.

“Meteorology Network System in Whole Lebanon” has been progressed since 1998 by the Meteorology Department located in Beirut International Airport Building. The systems are working for 24 hours and also staffs are available on a three-shift-a-day basis.

#### (2) Hydrolometric stations

River water levels and discharges have been measured in Lebanon since the early 1930s. Such flow records commonly cover the period from the date of opening of the station up to the early 1970s. River discharge data covering the period up to mid 1980s are available in a few stations. Most of stations, currently under operation, resumed their operation at around 1990. Water levels are always measured in terms of analogue chart record with occasional staff gauge measurement for

calibration of its rating curve at majority of the stations..

Discharge measurements are conducted by the Hydrology Department of the Litani River Authority (LRA) in Beirut in association with its regional offices in Tripoli, Chtaura and Saida, covering the entire Lebanon. Measured records are then transferred to its Beirut office for post processing.

In the past before civil war, LRA was managing 81 gauging stations in total, of which 70 hydrological stations were equipped with automatic recorder. . Out of the total 81 stations, recently since 1998 up to present, 41 stations have been rehabilitated and 6 stations have been newly constructed. Accordingly, automatic water level data are available currently at 38 stations. At the same time, LRA conducts direct measurement of stream flow that is less or equal 8-9 m<sup>3</sup>/s at all stations with the interval of 7days/15days for the purpose of calibration of rating curve to convert river water level into discharge.

As aforementioned, there operated 70 hydrological stations before the civil war in Lebanon. There are long period of almost 15 years from 1975 to 1990 where hydrological observation data are almost missing. Currently 41 stations of which were reconstructed and 6 were newly constructed for operation. Even for last 10 years from 1991 to 2000, available data are scattered depend on the stations. Since the accurate and as long data as possible are the foundation for evaluation of potential and available water resources based on which a proper plan of water resources development and management is formulated, accumulation of such data is important and urgent. And one third of the area of Lebanon is not yet covered by hydrological observation system. It is therefore recommendable to set up a program of construction of hydrological observation station and then to speed up the installation work of hydrometric stations.

At present, collected data from hydrological stations are transferred to Hydrological Department of LRA for further processing. HYDATA system, introduced by UK support, is used to convert water levels into discharge and to compute daily flow hydrograph, flow duration curve, flow statistics such as mean flow, peak flow, highest daily mean, lowest daily mean, and a mean flow and runoff. The HYDATA system is not provided in a form of source statements of program, not allowing modification. Accumulated data in the HYDATA system are therefore unusable for other data processing or analysis. This system is recommendable to be replaced by others.

**Figure 2.3.1 HYDROLOGICAL AND METEOROLOGICAL STATION LOCATION MAP**

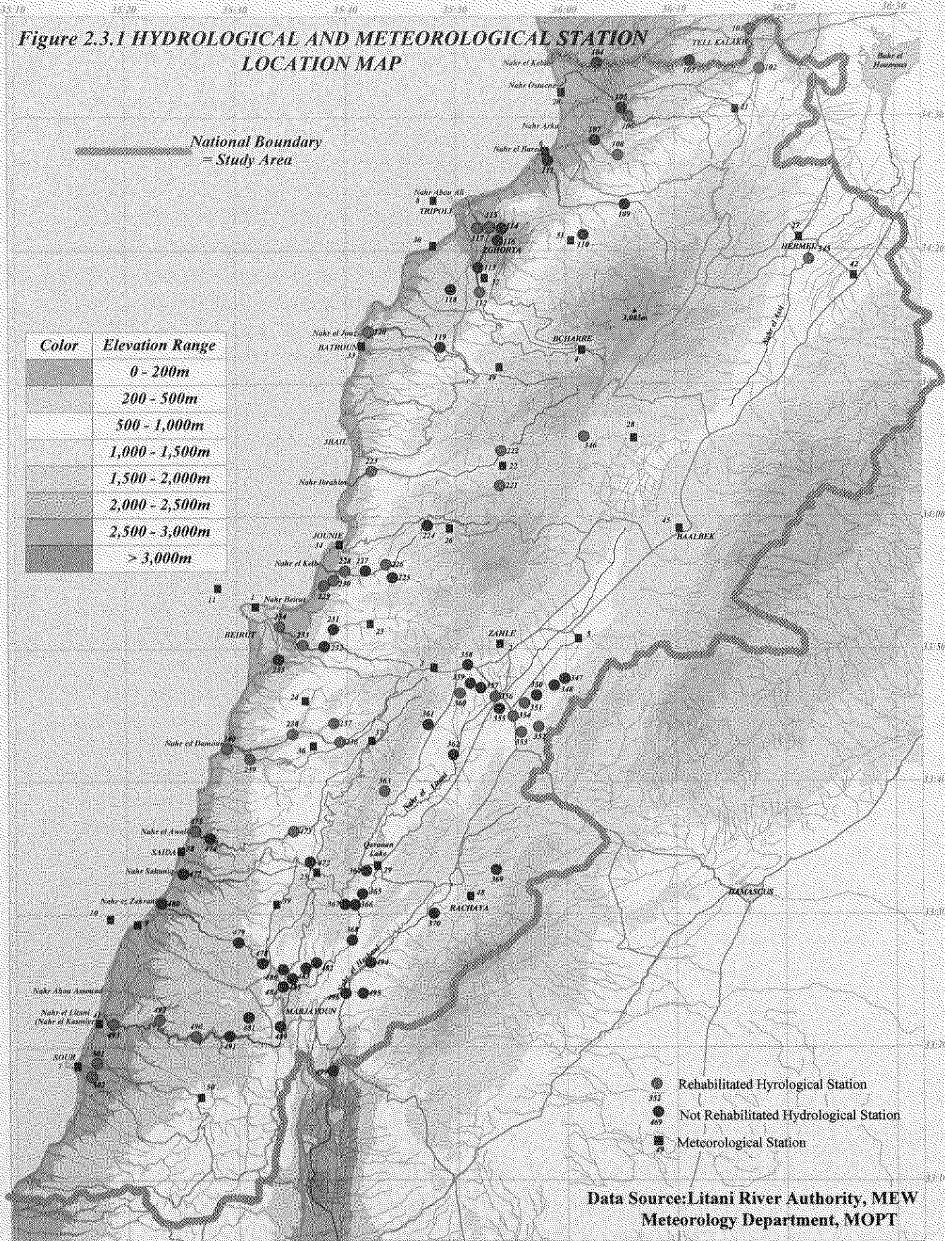


Table 2.3.1 List of New Meteorological Station for "Meteorology Network in Whole Lebanon"

St. No.	Name of Station	Tel No.	Starting of Observation	Latitude	Longitude	Elevation	Note
00000001	Beirut-Golf		1999	33 51	7 35 29	31	E12
00000002	IL200018	Houch El Omara-Zahle	1998	33 50	35 54	920	E12
00000003	MC100025	Dahr El Baider	1998	33 49	35 46	1524	E12
00000004	MN100007	Al Arz-Les Cedres	1998	34 15	36 3	1916	E12
00000005	IL200016	Rayak-Amara	1998	33 51	36 0	905	E12
00000006	LN000037	El Abde	1998	34 31	36 0	40	E12
00000007	LS000046	Sour	1999	33 16	35 12	5	E12
00000008	LN100047	Tripoli-Bouy	1999	34 27	35 49	0	Marine
00000009	LC000048	Zahrani	1999	33 30	414 35 20	450	E12
00000010	LC010049	Zahrani-Buoy	1999	33 30	495 35 19	913	0
00000011	LC010050	Beirut-Buoy	1999	33 50	866 35 28	516	0
00000020	LN300033	El Qlaiaat-Akkar	1999	34 35	36 0	5	E6
00000021	LN200035	El Goubayat	1999	34 34	36 17	540	E6
00000022	MC200012	Gartaba	1999	34 6	35 51	1150	E6
00000023	MC000041	El Goussabiah	1999	33 52	35 39	585	E6
00000024	LC000038	Bayssour	1999	33 45	827 35 33	414	E6
00000025	MC200035	Jezzin	1999	33 33	35 35	955	E6
00000026	LS000048	Fagra	1999	33 59	248 35 48	696	E6
00000027	IO200001	El Hermel	1999	34 24	36 24	700	E6
00000028	IO000040	Deir-EI-Ahmar	1999	34 7	36 8	1080	E6
00000029	IL200030	El Qaraoun-Barrage	1999	33 33	35 41	855	E6
00000030	LN000039	Balamand	1999	34 22	35 46	442	E4
00000031	MN200002	Syr-Ed-Denniyeh	1999	34 23	36 2	915	E4
00000032	LN000117	Kafar Chakhtna	1999	34 15	35 40	300	E4
00000033	LC300002	Beitroun	1999	33 59	35 37	20	E4
00000034	LC200005	Kaslik Jounieh	1999	33 43	35 42	850	E4
00000036	MC000042	Deir-EI-Kamar	1999	33 34	35 23	1250	E4
00000037	MC300029	Barouk Faidis	1999	33 34	35 23	5	E4
00000038	LC200025	Saïde	1999	33 33	35 27	360	E4
00000039	LC000040	Lebaa	1999	33 24	35 29	440	E4
00000040	LC000041	Habbouche-Nabatiye	1999	33 21	35 15	30	E4
00000041	LS000042	El Quasmiye	1999	34 21	36 28	650	E4
00000042	IO200002	El Qaa	1999	34 11	36 25	1400	E4
00000043	IO200005	Arsal	1999	34 8	36 2	1370	E4
00000044	IO200006	Yammoune	1999	34 0	36 12	1150	E4
00000045	IL000041	Douris	1999	33 63	35 53	1320	E4
00000046	IL300013	Qaa-EI-Rim	1999	33 38	35 44	950	E4
00000047	IL200027	Kherb Qansafar	1999	33 30	35 51	1235	E4
00000048	IH200036	Kafar Gouq/Rachaya	1999	33 30	35 51	1235	E4
00000049	IL300023	Tannourine	1999	33 30	35 51	1235	E4
00000050	IL000042	Kafar Dounine	1999	33 30	35 51	1235	E4
00000051	LS000043	Ras An Naqoura	1999	33 7	35 24	765	E4
00000052	LS000044	Ain Ebel	1999	33 21	35 35	760	E4
00000053	IH100039	Megjayoun	1999	33 24	35 41	750	E4
00000054	IH300038	Hasbaya	1999	33 24	35 41	750	E4
00000055	IH300037	EI Meshref	1999	33 43	35 27	250	E4

Not Yet Rehabilitated  
 Data Source : Meteorological Service in AIB  
 AIB 33-49-07 N. 35-29-35 E EL=12.5m  
 Tollpoh 34-27 N. 35-48 E EL=5.0m

Table 2.3-2 List of Historical Meteorological Stations (150 stations)

No	Zone	Name of Station	Elevation	St. Year	No	Zone	Name of Station	Elevation	St. Year	No	Zone	Name of Station	Elevation	St. Year
1	(1)North Leba	Kaouachra	400	1963	51	(3)South Leba	Irsirnye	160	1965	101		Beit-Din-Loqch	835	1968
2	(15)	Glaizat-Aakker	5	1937	52	(14)	Aedoun	15	1951	102		Machmouch	940	1954
3		Qasbrin	25	1967	53		Douair	380	1962	103		Jezzin	945	1928
4		Qoubayyat	540	1965	54		Jarmaq	400	1965	104		Qaitoute	900	1966
5		Berno	510	1967	55		Nabatiye	410	1965	105		Jbaa-Halawi	800	1955
6		Halba	160	1940	56		Qasniye	30	1944	106		Dahr-Daraje	1150	1965
7		Ashde	40	1955	57		Sour(Tyr)	5	1965	107		Jariouaa	850	1965
8		Tripoli Mina	2	1931	58		Jousya	300	1965	108		Rhan	850	1966
9		Barad-Moussa	250	1967	59		Gana	300	1965	109	(8)Inland-Oro	Hermel	750	1932
10		Bahraoun	630	1967	60		Tbrine	680	1965	110	(11)	al-Oaa	650	1966
11		Zagarta-KT-Dlaq.	110	1967	61		Taibe	610	1950	111		Fakehe et Ras-Baalbek	1060	1933
12		Bechmezzin	275	1967	62		Aitaroun	680	1939	112		Nabha	1100	1967
13		Cheikka	15	1952	63		Ain-Ebel	765	1960	113		Aarsal	1400	1964
14		Abou-Aali	250	1939	64		Aalma-Chaab	385	1960	114		Yammoune	1370	1939
15		Amoun	300	1946	65	(4)North Mox	Michnich	1080	1965	115		Flawi	1170	1964
16	(2)Central Leba	Kaftoun	215	1952	66	(8)	Sl-Darriye	915	1939	116		Chiffa	1000	1944
17	(35)	Batroun	20	1940	67		Bouhairat-Toula	1135	1967	117		Younin	1200	1967
18		Kfar-Halda	580	1941	68		Kfar-Sghab	1310	1965	118		Haouch-Dahab	1009	1961
19		Aamchit	135	1967	69		Beharre-ville	1480	1968	119		Baalbek	1150	1939
20		Fatre	410	1944	70		Beharre-usine	1400	1949	120	(7)Inland-Liban	Kfar-Dan	1080	1967
21		Ghazir	415	1949	71		Les Cedres	1925	1938	121	(24)	Haouch-Snaid	995	1957
22		Ghoshra	650	1949	72		Hseroun	1375	1963	122		Beit-Chama	1000	1947
23		Zoug-Mikayel	70	1944	73	(5)Central M	Maifouq	875	1967	123		Qaa-Rim	1320	1940
24		Gornet-Chafwan	603	1949	74	(36)	Laglouq	1700	1965	124		Sarain	1000	1946
25		Aarbaniye	510	1960	75		Tourazaya	880	1940	125		Haouch-Ghanam	952	1951
26		A.U.B	34	1877	76		Qartaba	1140	1949	126		Tejj-Aamaza	905	1954
27		Jdaide	45	1951	77		Grebata	970	1944	127		Rayak	920	1932
28		U.S.J	90	1923	78		Faraya-village	1320	1963	128		Zahle	990	1951
29		Nazarath	55	1866	79		Faraya-Mzar	1840	1966	129		Ksara	920	1909
30		Inst.Geog.	51	1939	80		Raifoun	1050	1949	130		Chitaura	920	1953
31		Medecine	60	1940	81		Glaizat-Kesrouan	1050	1944	131		Terbol	890	1967
32		Bir-Hassan	15	1964	82		Baskinta	1220	1967	132		Taanayel	880	1958
33		Aerogare	12	1954	83		Bikfaya	900	1949	133		Aajar	980	1939
34		Jamhour	410	1956	84		Jouar-Haouz	1290	1967	134		Aammig	870	1962
35		Chouaifat	100	1957	85		Arsoun	750	1946	135		Mansoura	860	1939
36		Dekouane	20	1968	86		Ra-Maten	920	1942	136		Soultan-Yaacoub	1400	1967
37		Souq-Gharb	700	1949	87		Jabal-Kneisee	2090	1962	137		Kherbet-Qanatar	940	1956
38		Ashy	730	1966	88		Falougha	1250	1967	138		Joubb-Jannin	920	1947
39		Jar-Qadi	280	1949	89		el-Graye	1010	1901	139		Qaroun-village	950	1953
40		Dmit	350	1947	90		Dahr-Baidar	1510	1953	140		Qar-Bar-E	855	1966
41		Gharife	680	1965	91		Bhamdoun-Ettaloun	1090	1947	141		Qar-Bar-W	1070	1939
42		Katmaya	380	1965	92		Ain-Zhalta	1080	1940	142		Machhara	670	1966
43		Saida	5	1962	93		Majdel-Maouch	810	1947	143		Markabe	1500	1965
44		Sfarai	570	1962	94		Fraides	1250	1967	144	(8)Inland-Hasb	Yanta	1280	1966
45		Maghdouche	230	1965	95		Kfar-Nabrakh	1020	1945	145	(7)	Deir-Aachayer	1210	1962
46		Aangour	380	1965	96		Beit-ed-Din	880	1941	146		Kfar-Geuq	1235	1931
47		Maamariyet-Kharab	282	1966	97		Jabal-Barouk	1940	1964	147		Rachaya	940	1940
48		Deir-Zahrani	450	1965	98		Jdaidet-Chouf	770	1964	148		Kfair-Zeit	750	1944
49		Aarab-Salim	580	1965	99		Moukhtara	810	1955	149		Haabaya	760	1943
50					100		Jbaa-Chouf	1130	1965	150		Marjayoun		

Table 2.3-3 List of Rehabilitated Hydrometric Station (53 stations)

No	Region	St. No	River	Station	Form	Frequent	Time	Equipment	Completion Date
						of Measurement	Type	Type	
1	North	101	Nahr el Kebir	Arida	Concrete	15 days	Monthly	SIAP	1998
2	(13)	102	Nahr el Chadra	Chadra Bridge	Steel	15 days	Monthly	OTT	1998
3		104	Nahr el Kebir	Sea Mouth		15 days	Monthly	OTT	2002
4		105	Nahr Oustene	Beit El Haji		Weekly	Monthly	OTT	2002
5		106	Nahr Oustene	Halba Bridge	Concrete	Weekly	Monthly	OTT	1998
6		108	Nahr Arqua	Hakour	Concrete	Weekly	Monthly	SIAP	2001
7		111	Bared	Sea Mouth		Weekly	Monthly	SEBA	2003
8		112	Nahr Abouli	Kousba	Concrete	Weekly	Half Month	OTT	1998
9		115	Nahr Rachaine	Zgharta	Steel	Weekly	Monthly	SIAP	1998
10		117	Nahr Abouali	Abou Samra	Concrete	Weekly	Monthly	OTT	1998
11		118	Es Asfour	Bziza Bridge					△
12		119	Nahr El Jouz	Beit Chlala					△
13		120	Nahr El Jouz	Sea Mouth	Steel	Weekly	Monthly	SIAP	1998
14	Mount	221	Afqa Spring	Near the Spring	Steel	15 days	Monthly	OTT	1998
15	Lebanon	222	Nahr Roueiss	Majdel Bridge	Steel	15 days	Monthly	OTT	1998
16	(15)	223	Nahr Ibrahim	Sea Mouth	Concrete	Weekly	Monthly	SIAP	1998
17		224	Moughara	Hrajel		Weekly	Monthly	OTT	2002
18		226	Nahr el Kelb	Daraya	Concrete	15 days	Monthly	OTT	2001
19		228	Nahr el Kelb	Sea Mouth	Steel	Weekly	Monthly	SIAP	1998
20		229	Canal Dbaiye	Before the Tunnel	Steel	Weekly	Monthly	SEBA	1998
21		230	Canal Dbaiye	After the Tunnel	Concrete	Weekly	Monthly	OTT	1998
22		233	Nahr Beirut	Dachounieh	Concrete	Weekly	Monthly	SIAP	1998
23		234	Nahr Beirut	El Bacha Bridge	Steel	Weekly	Monthly	SEBA	1998
24		236	Nahr Safa	Wadi sitt	Steel	15 days	Monthly	SEBA	1998
25		237	Nahr Abouzibli	Rach Maya	Steel	15 days	Monthly	SIAP	1998
26		238	Nahr el Damour	Jisr el Kadi	Concrete	15 days	Monthly	SIAP	2001
27		239	Nahr el Hamam	Before the Connection of the Two river	Steel	Weekly	Monthly	SIAP	1998
28		240	Nahr el Damour	Sea Mouth	Concrete	Weekly	Monthly	SEBA	1998
29	Bekaa	345	Nahr el Assi	Hermel Bridge	Steel	15 days	Monthly	OTT	2001
30	(12)	346	Yammone Spring	Entrance of the Tunnel	Steel	15 days	Monthly	SEBA	1998
31		351	Nahr Chamsine	Anjar	Steel	15 days	Monthly	SEBA	1998
32		352	Nahr el Ghazail	Anjar	Steel	15 days	Monthly	SIAP	1998
33		353	Anjar (Spring)	Anjar	Steel	15 days	Monthly	SEBA	1998
34			El Zaghir	Kfarzabad					△
35		354	Nahr Ghazeil	Road of Damascus	Concrete	Weekly	Monthly	OTT	1998
36		356	Nahr Berdaoumi	Road of Damascus	Concrete	Weekly	Monthly	OTT	1998
37		360	Wadi Delm	Qabb Elias	Steel	15 days	Monthly	SEBA	1998
38			Yahfoufa	Ain El Sikeh					△
39		363	Nahr Litani	Jibjanwine Bridge	Concrete	Weekly	Monthly	OTT	1998
40		368	Nahr Litani	Qillya		15 days	Monthly	OTT	2002
41	South	473	Nahr Awali	Bisli	Steel	15 days	Monthly	OTT	1998
42	(13)	475	Nahr Awali	Sea Mouth	Concrete	Weekly	Monthly	SEBA	1998
43		476	Saitaniq	El Lemon Valley		15 days	Monthly		△
44		478	Zahrani	El Akhdar Valley		15 days	Monthly	OTT	2002
45		479	Zahrani	Deir el Zahrani		15 days	Monthly	OTT	2003
46		489	Nahr Litani	Khaldaly		15 days	Monthly	SEBA	2002
47		490	Nahr Litani	Ghandourieh	Steel	15 days	Monthly	OTT	1998
48		492	Quasmieh Canal	After Canal Inlet	Steel	Weekly	Monthly	SEBA	1998
49		493	Quasmieh River	Sea Mouth	Steel	Weekly	Monthly	OTT	1998
50		496	Hasbani	Fardiss Bridge		15 days	Monthly	SEBA	2002
51		499	Hasbani	Wazzani Spring					△
52		501	Ras el Ain Reservoir	North the Canal	Steel	Weekly	Monthly	SEBA	1998
53		502	Ras el Ain Reservoir	Near the Sea	Steel	Weekly	Monthly	SEBA	1998

\*) Note: 47 Stations are completed (As of June 2003)

△: 6 planning station will be installed until end of August in 2003

Data Source: Litani River Authority

OTTO Germany  
SIAP Germany  
SEBA Italy

Table 2.3-4(1) List of Hydrological Station under Litani River Authority

No	Rehabilitated	Station No.	Basin	River	Station	CA(km <sup>2</sup> )	EL(m)	Latitude	Longitude
1	⊙	101	Kebir	El Kabir	Arida	437.0	250	34 40 30	36 15 0
2	⊙	102	Kebir	Chadra Valley	Chadra Bridge	37.5	353	34 37 48	36 19 36
3		103	Kebir	El Kabir	Noura El Tahta	552.0			
4	⊙	104	Kebir	El Kabir	Sea Mouth				
5	⊙	105	Ostouene	Ostouene	Beit El Haj	102.0	91	34 33 48	36 6 12
6	⊙	106	Ostouene	Ostouene	Haba Bridge	103.0	81		
7		107	Arka	El Housaiche	Ilat	75.0	285	34 30 54	36 6 18
8	⊙	108	Arka	Arka	Hakour	102.0	75	34 32 0	36 3 30
9		109	Bared	Mechmech	Qabaait	161.0	390	34 27 12	36 7 12
10		110	Bared	Bared	Tirane	40.0	510	34 24 18	36 1 48
11	⊙	111	Bared	Bared	Sea Mouth	264.0	0.5	34 29 54	35 58 24
12	⊙	112	Abou Ali	Abou Ali	Kousba	142.0	240	34 20 10	35 51 50
13		113	Abou Ali	Abou Ali	Daraya	144.0	195	34 21 36	35 51 18
14		114	Abou Ali	Racheine Spring	After Spring				
15	⊙	115	Abou Ali	Racheine	Zghorta Bridge	202.0	61	34 24 40	35 53 50
16		116	Abou Ali	Joueit	Zghorta	98.0	59	34 23 48	35 53 36
17	⊙	117	Abou Ali	Abou Ali	Abou Samra	466.0	29	34 24 48	35 51 36
18	△	118	Asfour	El Asfour	Bziza Bridge	44.0	315		
19	△	119	Jouz	El Jouz	Beito Chiale	74.0	598	34 14 48	35 48 30
20	⊙	120	Jouz	El Jouz	Sea Mouth	189.0	1	34 16 30	35 40 50
21	⊙	221	Ibrahim	Afga Spring	After Spring	90.0	1200	34 3 48	35 53 48
22	⊙	222	Ibrahim	El Roueiss	Majdel Bridge	100.6	1100	34 6 42	35 54 12
23	⊙	223	Ibrahim	Ibrahim	Sea Mouth	326.6	6	34 4 48	35 41 18
24	⊙	224	Keib	El Mougharah	Hrajel	75.0	1200	34 0 24	35 47 0
25		225	Keib	El Hardoun	Daraya	66.5	600	33 56 24	35 43 30
26	⊙	226	Keib	El Kelb	Daraya	143.0	650	33 57 18	35 42 42
27		227	Keib	Jeita	Central Canal-Hrache				
28	⊙	228	Keib	El Kelb	Sea Mouth	257.5	20	33 56 42	35 38 48
29	⊙	229	Keib	Canal Dbaïye	Before Tunnel			33 55 48	35 36 48
30	⊙	230	Keib	Canal Dbaïye	After Tunnel			33 55 42	35 37 48
31		231	Beirut	El Joamani	Ras el Metn Bridge	127.0	270	33 51 48	35 37 36
32		232	Beirut	Beirut	After Connection Joamani-Metn	195.0	200	33 50 24	35 36 48
33	⊙	233	Beirut	Beirut	Dachounieh	209.0	112	33 50 18	35 34 36
34	⊙	234	Beirut	Beirut	El Basha Bridge	217.0	21		
35		235	Ghadir	El Ghadir	Kfarsheima Bridge	30.0	10		
36	⊙	236	Damour	Es Safa	Es Sitt Valley	40.0	518	33 42 48	35 39 12
37	⊙	237	Damour	Bou Zebli	Rachmayya plant	52.0	447	33 44 6	35 38 18
38	⊙	238	Damour	Damour	El Kadi Bridge	185.0	250	33 42 48	35 34 0
39	⊙	239	Damour	El Hammam	At Connection	77.0	45	33 40 54	35 29 24
40	⊙	240	Damour	Damour	Sea Mouth	293.0	0	33 42 22	35 27 34

Table 2.3-4(2) List of Hydrological Station under Litani River Authority

No	Rehabilitated	Station No.	Basin	River	Station	CA(km <sup>2</sup> )	EL(m)	Latitude	Longitude
41	⊙	345	Assi	Oronte	Hermel Bridge	1,221.0	585.0	34 20 24	36 22 48
42	⊙	346	Yammouneh Spring (Lake)		Tunnel Entrance	46.0			
43	⊙	351	Litani	S Chomsin	After Spring		870.5	33 44 48	35 57 36
44	⊙	352	Litani	Ghazvel	Anjar		871.8	33 44 0	35 57 12
45	⊙	353	Litani	Canal Anjar	Anjar		879.3	33 43 48	35 56 18
46	⊙	354	Litani	Ghazvel	Damascus Road	126.0	867.0	33 45 12	35 55 0
47	⊙	355	Litani	Litani	Damascus Road	878.0	866.0	33 46 0	35 53 48
48	⊙	356	Litani	Berdourmi	Damascus Road	77.0	866.0	33 46 42	35 53 42
49		357	Litani	Jalala	Damascus Road	22.0	890.0	33 47 18	35 52 6
50		359	Litani	Chtaure Valley	Damascus Road	2.0	910.0	33 48 12	35 51 18
51	⊙	360	Litani	Ed Delem Valley	Qabb Elias	19.0	914.0	33 47 24	35 49 48
52		362	Litani		Mansourah	1,345.0	859.3	33 40 48	35 39 42
53	⊙	363	Litani	Joub Janine	Job Jannine Bridge	1,443.0			
54		364	Litani	Ech Chita	Qaraoun Dam	14.6	872.7	33 32 12	35 41 24
55		365	Litani	Litani	Qaraoun Dam	1,545.0	810.4		
56	⊙	368	Litani	Litani	Oillya	1,680.0	521.0	33 26 24	35 39 48
57		369	Hasbani	Kfarkouk Valley	Kfarkouk	64.0	1,165.0	33 31 36	35 53 24
58		370	Hasbani	Ed-Delb Valley	Beit Lahia	114.0	850.0	33 28 42	35 48 0
59	⊙	473	Awali	Awali	Bisri	222.0	385.8	33 25 24	35 33 42
60	⊙	475	Awali	Awali	Sea Mouth	302.0	3.5	33 24 42	35 24 30
61		477	Saitaniq	Saitaniq	Sea Mouth	108.0	2.0	33 31 30	35 23 6
62	⊙	478	Zahrani	Zahrani	El Akhdar Valley	47.0	445.0	33 24 30	35 30 48
63	⊙	479	Zahrani	Zahrani	Deir el Zahrani	66.0	301.6	33 25 54	35 28 48
64		480	Zahrani	Zahrani	Sea Mouth	96.0	3.0	33 28 54	35 21 12
65		481	Abou El Assoud	Kfar Dajjal Valley	Mayfadoun Dam	18.0	345.7		
66		482	Litani	Es-Safa Valley	Near Khallet Khasen	10.8	728.0	33 25 12	35 35 48
67		483	Litani	Ajiz Valley	Near Khallet Khasen	5.8	580.0	33 24 24	35 34 48
68		484	Litani	Naqousiye Valley	Near Jarmaq	2.4	449.0	33 22 36	35 33 12
69		485	Litani	Aichiye Valley	Near Jarmaq	4.5	339.0		
70		486	Litani	Zaghriye Valley	Near Jarmaq	13.6	413.0	33 23 30	35 31 48
71	⊙	489	Litani	Litani	Khardaly	1,808.0	239.2	33 19 18	35 32 54
72	⊙	490	Litani	Litani	Ghandourieh	2,066.0	110.0		
73		491	Litani	El Ghandouniye	Before Litani	185.0	125.0		
74	⊙	492	Litani	Canal Qasmiye	After Canal Inlet	75.0	26.3	33 19 42	35 20 54
75	⊙	493	Litani	Qasmiye	Sea Mouth	2,153.0	0.0		
76		494	Hasbani	Hasbani	Before Hasbaya Spring	340.0	548.0	33 24 48	35 41 48
77		495	Hasbani	Fardis Valley	Before Hasbani		497.0	33 21 54	35 40 54
78	⊙	496	Hasbani	Hasbani	Fardis Bridge	448.0	494.6	33 22 0	35 39 12
79	△	499	Hasbani	Hasbani	Wazzani Spring	526.0	271.2	33 16 6	35 37 48
80	⊙	501	Ras el Ain	Ras el Ain	North Canal		0	33 13 40	35 30 35
81	⊙	502	Ras el Ain	Ras el Ain Spring	Sea Mouth		0	33 13 43	35 13 6

⊙ 47 Rehabilitated Station with automatic hydrograph recorder (~ June 2003)

△ 6 Planned rehabilitation (June ~ August 2003)

### 2.3.2 Meteorology

The climate of Lebanon is the typical Mediterranean, with heavy rain in the winter season from January to May and dry and arid conditions in the remaining 7 months of the year. However, influenced by the Mediterranean Sea, the topographical features, as well as by the Syrian Desert in the North, a variety of micro-climate occurs within the country with contrasting temperatures and rainfall distribution.

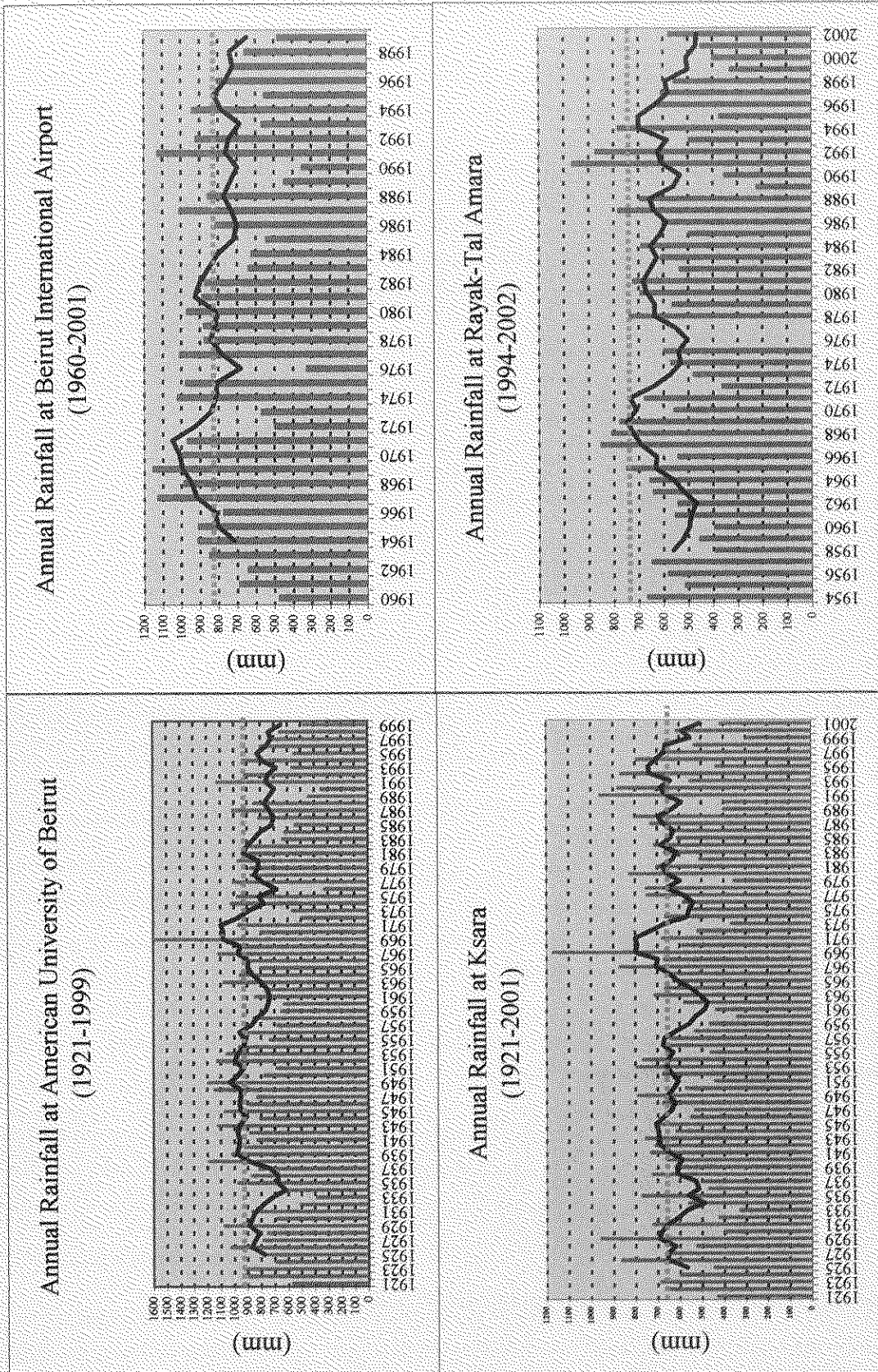
Temperatures in Lebanon vary considerably corresponding to the time of the year and elevation. During the summer season, the coastal plain receives a hot and humid semi-tropical climate with an average temperatures of around 28°C. Maximum summer temperatures, in the range of 44 to 46°C, are commonly recorded along the coastal zone (Akkar plain, Beirut and Sour) and in inland near Baalbeck in the Bekaa Valley. Winter temperatures vary from about 14°C along the coastal zone to the minimum of -23.5°C near Yammounh on the eastern slope of the Lebanon Mountains at an elevation of 1,500m. At elevations above 1,800m, average temperatures remain below freezing for the duration about 100days in each year.

Average annual rainfall is varying from 600 to 1,000 mm in the coastal area, from 900 to 1,700 mm in the Lebanon mountain range and from 200 to 900 mm in the Bekaa Valley. In the Anti-Lebanon mountain range, rainfall is 500 to 900 mm. At Beirut, rainfall occurs during the period seventy to ninety days a year, between the months October and April. About 90 % of annual river runoff concentrates in the five month period from December to April and only 10 % in the remaining 7 months from May to November, according to the record collected at Sinn el Fil of Beirut River. Statistical analysis of annual precipitation based on the 80 year's observation shows a decreasing tendency starting from the year 1970. The average annual precipitation of the recent 5 years gives some 200 mm smaller value than the long-term average.

Winds are variable with no specific predominant direction for the whole country. This is apparently due to the effects of the mountains; at high altitudes winds from east to west are much dominant than at lower altitude.

Land and sea breezes are found along the coastal zone especially in the summer. Relative humidity is constant throughout a year with relatively higher value along the coastal areas (for example in Beirut it varies between 65 and 75 %), while it is lower and varied inland with an example, between 35 and 75 % in the Bekaa valley.

Figure 2.3.2 Annual Rainfall at Beirut (AUB and AIB), Ksara and Rayak-Tal Anala



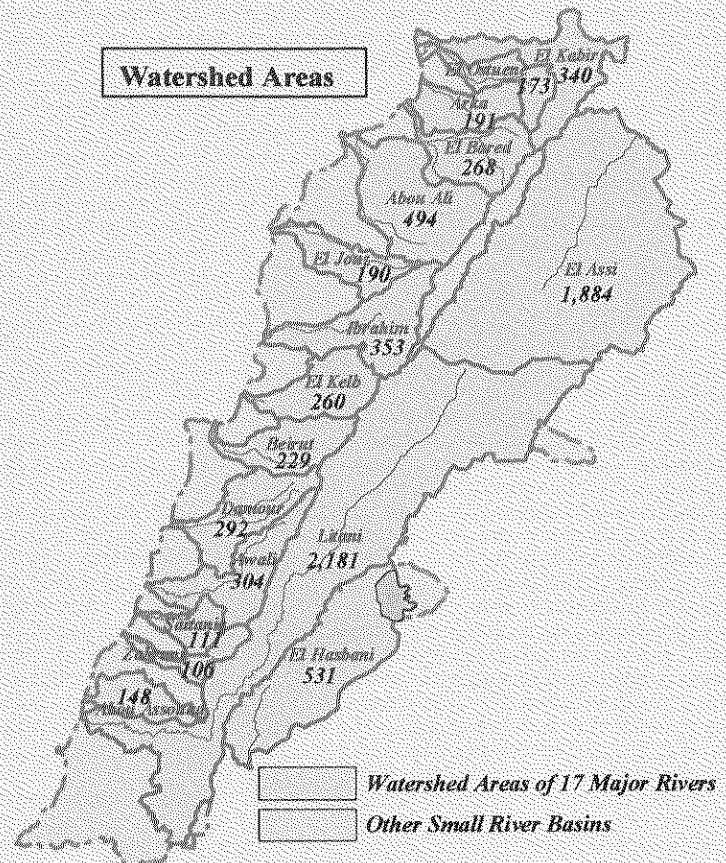
Note: Data of different locations have been grouped in one series as follows except Rayak-Tal Amara  
 AUB(1921-1977 : hill side of campus, 1978-up to now : near sea side of campus)  
 BIA(1940-1953 : Bir Hassan, 1954-1963 : apron of airport, 1994-1981 : landing field of airport, 1982 : another landing field, 1983-up to now : landing field of airport (same place of the period 1994-1981)  
 Ksara(1921-1966 : Ksara, 1967-up to now : Houch El Oumara)

### 2.3.3 Hydrology

#### (1) Major Rivers

There are 17 perennial rivers and numbers of smaller and seasonal rivers in Lebanon. River basins can be divided into five categories as follows:

- El Assi (Orontes) river basin in the north. El Assi river flows into Syria in the north-eastern corner of the country;
- Litani river basin in the east and south. Litani river reaches the sea in the south-western part of the country;
- Hasbani river basin in the south-east. Hasbani river, which flows into Israel in the south-eastern part of the country, is a tributary of the Jordan river;
- All the remaining major coastal river basins. All rivers flow westward emptying into the Mediterranean Sea. At the northern border of the country, El Kebir river basin is shared with Syria, the river itself forming a part of the border between the two countries before flowing into the sea;
- All the remaining small river basins isolated and scattered between major coastal river basins with no remarkable surface stream flow



Catchment areas of major 17 rivers were measured by the Study on GIS system and compared with those given in the UNDP study in 1970. There are no significant differences between two studies, except those for El Kabir, Arka, Ibrahim and El Hasbani rivers. Total catchment area of 17 major rivers is evaluated by the JICA Study at 8,087.6 km<sup>2</sup>.

Catchment areas of major 17 rivers are summarized in Table 2.3-5.

Table 2.3-5 Watershed Area of Major 17 Rivers in Lebanon

No	Region	Name of River	Watershed Area(km <sup>2</sup> )(*1)			Note
			UNDP (1970)	LRA	JICA(2003)(*2)	
1	The North	El Kebir	437	300.0	341.5	Shared with Syria
2	(6)	El Ostouene	160	161.0	173.7	
3		Arka	153	121.0	136.3	
4		El Bared	277	281.0	270.4	
5		Abou Ali	484	481.0	498.7	
6		El Jouz	198	189.0	193.0	
7	Mount Lebanon	Ibrahim	330	335.6	352.5	
8	(4)	El Kelb	260	257.5	264.3	
9		Beirut	231	221.5	230.0	
10		Damour	288	293.0	293.0	
11	The South	Awali	302	302.0	305.1	
12	(5)	Saitaniq	111	108.0	111.2	
13		El Zahrani	88	109.0	106.6	
14		Abou Assouad	132	143.3	155.2	
15		Litani	2,168	2,163.0	2,194.5	
16	The Bekaa	El Assi	1,870	1,734.0	1,893.1	Flowing into Syria
17	(2)	El Hasbani(*3)	526	526.0	568.5	Flowing into Israel
Total	(17)		8,015	7,725.9	8,087.6	

Note: (\*1) Watershed Area of International river shows the area of Lebanon territory only

(\*2) By GIS System under JICA Study

(\*3) Excluded Marjayoun Basin

## (2) River Runoff

The Lebanon has the national land of 10,452 km<sup>2</sup> with considerable spatial diversity in terms of topography, rainfall and patterns of landuse. Generally, rainfall is sufficient to meet demands but its regional and seasonal variations result in significant stress on available amount of water for both water supply networks and irrigation schemes. Relatively smaller numbers of Lebanese rivers only are perennial and the remarkable seasonality in rainfall – most rainfalls concentrate between October and March – results in a considerable range of seasonal flow. Commonly 70% of the annual runoff can occur in less than 3 months during which the risk of flooding can also be high. Many streams keep runoff of short period and flows in seasonal rivers can be very intermittent. River channels are usually steep and, flow conditions are deeply dependent on availability of spring sources along the river courses.

Based on the river discharge data collected from LRA, average runoff in terms of a specific runoff yield in mm are calculated for 17 major rivers in Lebanon. Then based on these specific runoff yields, potential river runoffs at their estuaries are evaluated, in proportion to their catchment areas

as shown in Table 3.2-2.

**Table 2.3-6 Annual Runoff of Major 17 Rivers in before and after the war for 10 years**

No	Region	Name of River	Watershed	Before (1965-1974)		After (1991-2000)		Repsetative Station(*6)
			Area (km2)	(mm)(*1)	(MCM)	(mm)(*1)	(MCM)	
1	The North	El Kebir	341.5	245	84	356	122	No.101,102,103
2	(6)	El Ostouene	173.7	389	68	385	67	No.106
3		Arka	136.3	435	59	382	52	No.108
4		El Bared	270.4	620	168	315	85	No.111
5		Abou Ali	498.7	440	219	387	193	No.117
6		El Jouz	193.0	292	56	208	40	No.120
7	Mt Lebanon	Ibrahim	352.5	1,119	394	936	330	No.223
8	(4)	El Kelb	264.3	1,137	301	627	166	No.228
9		Beirut	230.0	650	150	318	73	No.234
10		Damour	293.0	706	207	342	100	No.238,239,240
11	The South	Awali(*2)	305.1	628	192	628	192	No.473
12	(5)	Saitaniq	111.2	121	13	96	11	No.477
13		El Zahrani	106.6	265	28	143	15	No.480
14		A. Assouad(*3)	155.2	24	4	24	4	No.481
15		Litani(*4)	2,194.5	342	751	342	751	No.362,368
16	The Bekaa	El Assi	1,893.1	340	644	354	670	No.345
17	(2)	El Hasbani(*5)	568.5	272	155	272	155	No.499
<b>Total</b>	<b>(17)</b>		<b>8,087.6</b>		<b>3,491</b>		<b>3,024</b>	

Note: (\*1) Yield(mm) denote a specific runoff yield, equivalent to runoff in volume divided watershed area

(\*2) Data No.473 in 1965-1974 (Not included water from Litani)

(\*3) Data No.481 in 1965-1970

(\*4) AVERAGE of Data No.362(up-stream) and No.368(down-stream) in 1940-1949 (Before Construction of Qaraoun Dam)

(\*5) Data NO.499 in 65-66 (Wazzani)

(\*6)Data source: Monthly runoff data from RLA



Figure 2.3-3 Major Rivers and Its Watershed in Lebanon



Table 2.3-7(1) Annual Runoff at Hydrological Station in Past Each 10 Year Average (Unit:MCM)

Station	Basin	River	Station	km2	31-39	40-49	50-59	60-69	70-79	80-89	90-2001	Average	Runoff (mm)	River
101	Kebr	El Kabir	Arida	437			116.381	202.601	137.702	75.3026	171.6786	140.733	322	
102	Kebr	Chadra Valley	Chadra Bridge	38			0.9018	6.16795	6.52498	13.70462	8.887	237		
103	Kebr	El Kabir	Noura El Tahra	552			136.378	119.616			127.997	232		
104	Kebr	El Kabir	Sea Mouth				233.074	254.688			228.439	238.734		264
105	Ostouene	Ostouene	Beit El Haj	102			59.5929	40.281				49.937	490	
106	Ostouene	Ostouene	Halba Bridge	103			29.5401	41.7042	29.4084	10.1617	40.53304	30.270	294	392
107	Arka	El Houaiche	Ilat	75			23.0629	8.1203				15.592	208	
108	Arka	Arka	Hakour	102			27.1001	40.9134	33.9686	7.81447	36.80812	29.321	287	248
109	Bared	Mechmech	Qabanit	161			101.741					101.741	632	
110	Bared	Bared	Tirane	40			102.664	72.6818				87.673	2,192	
111	Bared	Bared	Sea Mouth	264			257.559	105.89			75.79924	146.416	555	1,126
112	Abou Ali	Abou Ali	Kousba	142		199.097	92.8428	99.3643	62.5084	35.1048	86.12275	95.840	675	
113	Abou Ali	Abou Ali	Daraya	144			119.183	63.9477			87.80753	90.313	627	
114	Abou Ali	Racheine Spring	After Spring				28.3032	1.12464				14.714		
115	Abou Ali	Racheine	Zghorta Bridge	202			106.273	59.6494	95.4786	75.97552	84.344	84.344	418	
116	Abou Ali	Joueit	Zghorta	98			30.5163	12.3943			7.289914	16.734	171	
117	Abou Ali	Abou Ali	Abou Samra	466			255.003	135.957	100.576	181.4203	168.239	361		398
118	Asfour	El Asfour	Bziza Bridge	44				6.10358				6.104	139	
119	Jouz	El Jouz	Beito Chiala	74			75.6383	42.6834				59.161	799	
120	Jouz	El Jouz	Sea Mouth	189			73.8679	38.0169	39.8453	36.71348	47.111	47.111	249	524
221	Ibrahım	Afga Spring	After Spring	90			138.18	178.062			79.3176	131.853	1,465	
222	Ibrahım	El Rouaiss	Majdel Bridge	101			136.825	70.8704			81.55895	96.418	958	
223	Ibrahım	Ibrahım	Sea Mouth	327			431.48	299.33			305.81	345.541	1,058	1,160
224	Kelb	El Mougharah	Hrajel	75			2.78657	1.67778				2.232	30	
225	Kelb	El Hardoun	Daraya	67			40.3444	25.8855			16.52893	27.586	415	
226	Kelb	El Kelb	Daraya	143			111.453	74.0828	59.7799	64.95062	77.567	77.567	542	
227	Kelb	Jeita	Central Canal-Hrache				157.197	97.3246	67.6694	64.90844	96.775	96.775		
228	Kelb	El Kelb	Sea Mouth	258		177.579	240.775	327.746	184.469	118.834	161.5761	201.830	784	
229	Kelb	Canal Dbaiye	Before Tunnel				63.2757	66.7788			74.47151	68.175		
230	Kelb	Canal Dbaiye	After Tunnel				8.99186	8.63715			6.160631	7.930		443
231	Beirut	El Joamani	Ras el Metn Bridge	127			60.5524	27.7914				44.172	348	
232	Beirut	Beirut	After Connection Joamani	195			129.583	53.2553				91.419	469	
233	Beirut	Beirut	Dachouieh	209			51.0532	174.987	86.2329		52.45613	91.182	436	
234	Beirut	Beirut	El Basha Bridge	217			207.081	74.9571	35.9762	69.5381	96.892	96.892	447	425
235	Ghadir	El Ghadir	Kfarshema Bridge	30			20.7424	7.12387			5.126501	10.998	367	
236	Damour	Es Safa	Es Sitt Valley	40			30.6966	23.0414			13.99859	22.579	564	
237	Damour	Bou Zebli	Rachmaya plant	52			95.2597	63.3934	20.5326	42.53927	55.431	55.431	1,066	
238	Damour	Damour	El Kadi Bridge	185		223.115	131.123	183.835	121.325	16.7182	88.99998	127.519	689	
239	Damour	El Hammam	At Connection	77			47.3285	30.4105			32.59002	36.776	478	
240	Damour	Damour	Sea Mouth	293							100.1092	100.109		699



### 2.3.4 Surface Water Quality

#### (1) River and Lake

The water quality of surface water is influenced by the human activities such as industries, agriculture and domestic life. Industrial activities release various chemical effluents into water areas. The use of pesticides and fertilizers in agriculture causes the deterioration of the composition of the water of rivers and lakes. The domestic wastewater increases the concentration of biological and chemical parameters of water quality.

In Lebanon, the wastewater from the factories discharges directly into the water areas without any treatment. The sewage network has not been developed in nationwide. The existing wastewater treatment plant does not have any sufficient function (The Ghadir Treatment Plant located in the south part of Beirut is in operation with only primary treatment).

In 1999 AUB (American University of Beirut) Water Resource Center conducted the water quality survey for 9 rivers in Lebanon to assess the impact of waste disposal on water quality. The results from 65 sampling sites showed generally high concentration of BOD<sub>5</sub> (154 mg/l as highest), fecal and total coliform. This indicates that untreated domestic sewage is directly discharged into surface water areas. Table 2.3-8 shows the mean recorded values for BOD<sub>5</sub> and Nitrate (NO<sub>3</sub><sup>-</sup>). The high figures of Nitrate (NO<sub>3</sub><sup>-</sup>) of El Kebir and Abou Ali are suspected to be caused by the agricultural lands (greenhouses) located along the rivers.

**Table 2.3-8 Water Quality of Nine Rivers in Lebanon measured in November 1999**

Name of River	BOD <sub>5</sub> (mg/l)	NO <sub>3</sub> <sup>-</sup> (mg/l)
Litani	79	1.7
Ibrahim	2.2	1.1
El Kebir	4.1	3.3
El Kalb	26.3	1.1
El Jaouz	6.6	1.9
Al Damour	1.4	3.0
Al Bared	4.7	1.4
Al Awali	3.7	1.4
Abou Ali	69.7	7.3

Source: 2001 Lebanon State of the Environment Report, MOE

There are several reports which discussed the water quality of the surface water in Lebanon. One of them is “Environmental Master Plan for Litani River and Lake Qaraoun Cathment Area” conducted by the Swedish Consultant MVM in May 2000, and another “Evaluation of Water Quality of the Qaroun Reservoir Lebanon: Suitability for Multipurpose Usage” prepared by Dr. Mey Jurdi et al. in 2001.

MVM conducted the water quality survey for the Litani River and the Qaroun Lake between November 1998 and May 2000. The results for the survey are shown as follows.

- The organic matters were assessed by the values of COD. The Litani River was highly affected by organic matter originating from the sewage. This was confirmed both in the upstream and downstream of the river. The effluent from the city of Zahle was evident, where the COD value of the river water was caused by the sewage sludge. Also, the factory such as sugar-refinery and untreated sewage water could be suspected to cause these high values of COD.
- As for chemical substances, two substances were notable. For example, Gammahexachloro Cyclohexan showed higher concentrations from Barr Elias and downstream. An industrial impact from the Barr Elias or Zahle area could be suspected. Hexachlorobensene showed a leap in concentration in the Jobb Janin area. This might be an impact from an agricultural pesticide or an industrial outlet.
- The metal concentrations showed a pattern of lower concentrations in the upstream part of the Litani, with an increase in concentration from the densely populated area of Zahle-Barr Elias. After that the concentrations were diluted downstream towards the Lake Qaraoun. Copper was an exception with continuously somewhat higher concentrations in the downstream area of Jobb Janin. Mercury was also an exception with the highest concentrations in the upstream area and the downstream area, with lower concentrations in between the areas.

According to “Evaluation of Water Quality of the Qaroun Reservoir Lebanon: Suitability for Multipurpose Usage”, the suitability of the water quality of the Qaroun Reservoir was examined for drinking water and general domestic use, irrigation and livestock, fisheries, recreational activities, and industrial use in its 3 zones (Zone I (upstream side of the lake:6 points), Zone II (mid of the lake: 6 points), Zone III (downstream of the lake: 6 points)).

Table 2.3-9 shows the summary of the suitability of Qaraun Lake for each water use.

**Table 2.3-9 Summary of Suitability of Qaroun Lake for Water Use**

Water Use	Major Parameters	Applied Standards / Guidelines	Suitability
Drinking Water & General Domestic Use	Fecal Coliform (FC) / E. Coli.	US EPA Drinking Water Regulations (US EPA, 1999), WHO Guidelines (1996), EEC Standard (1980)	Water use for drinking water is subject to filtration or disinfection. Most water should be extracted from the mid of the lake.
Irrigation & Livestock	SAR*1, Electric Conductivity (EC)	Ayers, R.S. and Wescot, D.W. "Water Quality for Irrigation", FAO Irrigation and Drainage Paper No,29	Suitable for irrigation use and drinking for livestock
Fisheries	DO (Dissolved Oxygen), Temperature, pH, Ammonia	US EPA 1986; Harvey 1989	Acceptable to maintain fish population. However, further fishery studies should be conducted.
Industrial Use	Faecal Coliform	WHO guideline, AWWA Guideline	The results of faecal coliform comply with the guidelines. However, the continuous monitoring is necessary.

Remarks: \*1: SAR (Sodium Adsorption Ratio)= $\frac{Na}{\sqrt{Ca+Na}}$ 2

Source: "Evaluation of Water Quality of the Qaroun Reservoir Lebanon: Suitable for Multipurpose Usage" prepared by Dr. May Jourdi et al., Journal of Environmental Monitoring and Assessment

## (2) Coastal Water

Various contaminated waters discharge into the coastal area as their final outfalls. The domestic and industrial wastewater in the coastal area, agricultural runoff, leachate from the open dumpsite of the solid waste and the illegal dump of the ballast water cause the water contamination of the coastal water.

The water samples of 30 separate locations were surveyed by the AUB Water Resources Center in 2000 along the coast from Tyre to Akkar. According to the survey, high concentrations of heavy metals such as nickel, copper, chromium, lead and arsenic were identified from the seven samples near the industrial areas.

Table 2.3-10 shows the results of the survey compared to the background figures taken at the spot of 2 km off the coastal of Chekka. The concentration of chromium shows the highest value in Dora industrial complex. The tanneries of the area are suspected to cause such concentration. The locations of power plants also shows the comparatively higher temperature compared to the figures of the background. The thermal discharge from these power plants are suspected to cause the higher temperature.

**Table 2.3-10 Water Quality of Coastal Water near Industrial Areas**

Location	Concentration (µg/l)				Temperature °C
	Arsenic	Lead	Zinc	Chromium	
Background	5.1	2	3.8	2	28.8
Al Ghazieh	14	2	32	35	29.7
Jiyeh Power Plant	7.7	17	19	24	31.3
Dora Industrial Complex	51	2	24	100	29.1
Zouk Power Plant	47	2	17	81	30.3
Selaata Chemical Plant	10	2	9.6	36	28.7
Chekka Cement Plant	13	2	26	23	29.5
Akkar Future Popes Industries	13	3	23	33	29

Source: 2001 Lebanon State of the Environment Report, MOE

ECODIT-IAURIF conducted the water quality survey in the major coastal areas of Tripoli, Jounieh and Beirut. Table 2.3-11 shows the results of the survey of the 10 stations based on fecal coliform per 100 ml applied in the WHO/UNEP/MAP (1994) interim criteria for recreational waters (which shall not exceed 100 for FC50 and 1000 for FC100). Table 2.3-11 shows that the high concentration of fecal coliforms near the large cities such as Jounieh and Beirut are caused by the discharge of the domestic and industrial wastewater into the coastal areas.

**Table 2.3-11 Bacteriological Water Quality of Coastal Water**

Stations	1	2	3	4	5	6	7	8	9	10
FC50	8	763	492	213	18	58	43	1000	22	1000
FC90	44	1000	1000	1000	109	122	92	1000	210	1000

**Remarks:**

FC50: 100 fecal coliforms per 100 ml in 50 percent of the samples

FC100: 1000 fecal coliforms per 100 ml in 90 percent of the samples

Station: 1 (Batroun), 2 (Nahr Ibrahim), 3 (Tabarja), 4 (Maameltein), 5 (Green Beach), 6 (Lagoon), 7 (Kaslik), 8 (Antelias), 9 (AUB), 10 (Ramlet el Baida)

Source: Regional Environmental Assessment Report on the Coastal Zone of Lebanon - Final Report, ECODIT-IAURIF, September 1997

**Literature Cited**

Ministry of Environment (MOE). (2001). Lebanon State of Environment Report.

MVM Consultant. (2000). Environmental Master Plan for Litani River and Lake Qaraoun Catchment Area.

Dr. Mey Jurdi et al. (2001). Evaluation of Water Quality of the Qaroun Reservoir Lebanon: Suitability for Multipurpose Usage.

ECODIT-IAURIF. (1997). Regional Environmental Assessment Report on the Coastal Zone of Lebanon – Final Report.

## 2.4 Hydrogeology

### 2.4.1 Hydro-geological Setting of Lebanon

#### (1) Hydrogeology general

The unique hydrogeological settings of Lebanon are relatively high precipitation, calcareous and karstic foundation underlying, and steep mountain slopes covering almost whole country. By these settings, the nation is likened to a “water pot” having many holes around the side and bottom. That means, there is a big storage capacity in the pot (groundwater storage) but heavily leaking, so that remaining water in the pot (available water) is always scarce. The leakage from the side holes means springs and they can be exploitable at the downstream, but the leakage through the bottom holes, which means groundwater flow out to the sea or submarine springs, are quite difficult to exploit.

The pot with big capacity is the calcareous and karstic rocks underlying and/or cropping out everywhere in the country. The rocks have quite high infiltration ratio when they outcrop and have also very high effective porosity to store groundwater. Further, they have many sinkholes and karst caves which suck huge volume of surface water into the ground, store and run down (a kind of) groundwater through underground channels. They flow-out to the ground surface again as springs or pour into the sea uselessly. Thus, the foundation of the country has huge groundwater storage capacity with almost enough precipitation but the volume of available water resources is in chronic shortage.

#### (2) Stratigraphic classification and aquifers

Around three-fourth of the country is underlain by the thick sedimentary sequence from Jurassic to Recent. The stratigraphic classification from a hydrogeological point of view is shown as Figure 2.4-1. Total thickness of them exceeds some 7,000 m in total, from the practical basement of Jurassic Limestone to Alluvium (Hydrogeological Map of Lebanon, 1/200,000, 1967). As shown in the figure, the major part of the sequence is highly permeable rocks such as limestone, dolomite, and sandstone. These highly permeable rock layers consist of aquifers, and the minority of impervious or hardly permeable rocks in between them form aquicludes working as confining layers. The thick sequence of the foundation is, thus, classified into four (4) major aquifers and three (3) aquicludes separating the aquifers.

The most excellent aquifer in Lebanon is said as the combination of Cretaceous bedding limestone and Eocene calcareous rocks of both massive and coral limestones. The aquifer used to yield more than 1000 lit/sec of groundwater. The second excellent aquifer is the base aquifer consisted of Jurassic limestone which used to yield in between 100 and 1000 lit/sec (Hydrogeological Map, mentioned above), followed by the Tertiary sedimentary rocks and the Quaternary deposits. The uppermost aquifer, the Quaternary Aquifer, is phreatic and the lower three aquifers are mostly in confined condition. However, these aquifers also have phreatic groundwater when they crop out directly to the ground surface.