



Environmental and Social Audit

Rehabilitation of Litani River Authority Hydropower
Plants, Lebanon

August 15, 2024

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ACRONYMS AND ABBREVIATIONS	
EIA	Environmental Impact Assessment
EHSG	World Bank Group Environmental, Health, and Safety Guideline
E&S	Environmental and social
ESF	World Bank Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESS	World Bank Environmental and Social Standard
ESIA	Environmental and Social Impact Assessment
GIIP	Good International Industry Practice
GM	Grievance mechanism
GW	Gigawatt
GWh (GWH)	Gigawatt hour
HPP	Hydropower plant
IBA	BirdLife International Important Bird Area
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
Km	Kilometer
masl	Meters above sea level
MOEW	Ministry of Energy and Water
MOE	Ministry of Environment
MW	Megawatt
MWh	Megawatt hour
SEP	Stakeholder Engagement Plan

Executive Summary

Background

The World Bank is considering a project to assist Lebanon's electricity sector to overcome many of the challenges it faces. Specifically, under the *Lebanon Renewable Energy and System Reinforcement Project* (World Bank, P180501), the World Bank would provide financing to help scale up renewable energy in the electricity supply mix, strengthen the electricity transmission network and its management, improve operating efficiency of Electricité du Liban (EDL), and rehabilitate critical assets at hydropower plants (HPPs).

One component of the project would be financing rehabilitation works¹ at the Markabi, Awali and Joun hydropower plants (HPPs) that form a cascade on the Litani River. The HPPs have a total installed capacity of about 192 MW and are owned and operated by the Litani River Authority (LRA), a governmental entity.

LRA retained the services of an international Consultant to carry out an audit of environmental and social performance and risks of the HPPs, with support of local consultants, in order to verify the rehabilitation project could meet the requirements of the World Bank's Environmental and Social Framework.

The primary objectives of the audit are the following:

- To identify and assess the potential environmental and social (E&S) risks of the rehabilitation of the Litani River HPPs and compliance of the HPPs with requirements of World Bank's Environmental and Social Framework (ESF) and the environmental and social legislation of Lebanon.
- To identify appropriate mitigation measures, to be set out in a separate Environmental and Social Management Plan (ESMP), that will allow the activities associated with the Project to meet the requirements of the ESF, Lebanese law, and good international industry practice.

The Project involves repairs and replacement of equipment and improvement of operating practices. All activities will take place on LRA premises, with few or none of them outside of buildings except at existing substations, and none are intended to be on unpaved ground. There will be no changes to operating practices or flow rates, but rather improvements in efficiency of electricity generation.

The Area of Influence in which potential impacts could occur, therefore, is entirely confined to the HPPs' property, where all Project activities will take place, plus the public roads that will be used to transport equipment and workers to and from the HPPs. There are no known Associated Facilities within the meaning of World Bank ESS1.

In general, potential adverse environmental and social impacts will not affect communities or external stakeholders, but will be confined to LRA workers and contractors. Positive effects, on the other hand, will affect the thousands of households who benefit from receiving electricity generated by LRA's HPPs. As noted, a separate Environmental and Social Management Plan has been prepared to define in more detail the actions that will be required, who will be responsible, implement the actions, and when they will be taken.

1. Introduction

1.1 Background

Under the *Lebanon Renewable Energy and System Reinforcement Project* (World Bank, P180501), the World Bank is considering providing financing to help scale up renewable energy in Lebanon’s electricity supply mix, strengthen the electricity transmission network and its management, improve operating efficiency of Electricité du Liban (EDL), and rehabilitate critical assets at hydropower plants.

One component of the project would be to finance certain rehabilitation of the Markabi, Awali and Joun hydropower plants (HPPs) that form a cascade the Litani River. The HPPs have a total installed capacity of about 192 MW and are owned and operated by the Litani River Authority (LRA), a governmental entity.

LRA retained the services of an international Consultant to carry out an audit of environmental and social performance and risks of the HPPs, with support of local consultants, to verify the rehabilitation works could meet the requirement of the World Bank’s Environmental and Social Framework.

1.2 Scope of Work

Environmental Solutions ER2M LLC was engaged to undertake the assignment and complete an environmental and social audit of ongoing HPP operations and of expected rehabilitation works. The audit was completed through desktop research, visiting and inspecting the three HPPs, interviewing LRA and local officials, and preparing this Audit Report, which describes the finding and conclusions of the audit and that identifies the key risks and impacts of the Project. The purpose is not to assess impacts caused by the original construction of the dams and associated reservoirs and diversions, but rather the incremental risks and impacts that could be caused by the rehabilitation activities. Following completion of the audit report, a second task was to prepare an Environmental and Social Management Plan (ESMP). The Plan, which is a separate document, defines the actions that LRA will need to take to address the risk and impacts identified in the Audit Report in order to avoid or reduce them to levels that comply with the ESSs and other applicable standards.

2. Environmental and Social Audit Team

The Consultant’s E&S team is summarized in Table 2-1.

Table 2-1: Consultant’s E&S Audit Team

<i>Team Member</i>	<i>Project Role</i>
Mr Jack Mozingo	Project Director & ESHS expert
Dr Ivan Maximov	Project Manager & ESHS specialist, Audit t team leader
Mr Ali Jan	Social and Resettlement Specialist
Dr Lara Awad	Local Biodiversity Specialist
Mrs. Sara Hteit	Local environmental specialist (Sustainable Environmental Solutions, Beirut)
Mrs. Amal Sultan	Local social and stakeholder engagement specialist (SES, Beirut)

3. Site Visit

A site visit was conducted from May 12 to May 25, 2024. The activities performed during the site visit included:

- Meetings and interviews with LRA managers and staff at LRA HQ in Beirut, including the head of Hydropower Department, the head of Governance Department, and various hydropower engineers.
- Collecting project information, including E&S data.
- Visits to Joun HPP, Awali HPP, and Markabi HPP) and nearby areas and site observation tours
- Meetings with the Mayors of Joun, Jezzine, and Qaraoun Municipalities
- Meeting with the Ministry of Energy and Water in Beirut
- Meeting with the World Bank in Beirut.

4. Litani River Authority

The Litani River Authority (LRA) is a state company established under State Law dated August 14, 1954 (as amended on December 30, 1955). LRA operates as a governmental and public institution with administrative and financial autonomy, reporting directly to the Ministry of Energy and Water (MOEW).

LRA has the following primary functions (mandates):

- To implement and manage irrigation, drinking water supply and hydropower projects in the Litani River Basin, which covers 2,170 square kilometers in Lebanon (Figure 4-1).
- To establish electrical networks a cascade of HPPs on the Litani River comprising Markabi, Awali, and Joun HPPs, including 66kV and 15kV power transmission lines and substations inter-connected with the HPPs.
- To establish electrical substations and high-voltage power transmission and distribution lines (T-lines) in all of Lebanon.
- To invest in prospective HPP generation and electricity transmission projects both the technical, administrative, and financial levels.

Other State decrees and decisions provide LRA with additional functions, including:

- To conduct surface and groundwater monitoring of all Lebanese rivers and study water quantity and quality in several mountain lakes.
- To manage and operate irrigation projects, including C900 in South Bekaa and Kasmieh (about 4,000 hectares of irrigated lands) in South Lebanon.

Figure 4-1: Litani River Basin



- To conduct feasibility studies on the construction of the other dams and hydropower projects (specifically Khardale dam and Choumarieh dam in the lower Litani River Basin.

LRA Headquarters (HQ) are located in Beirut. The total staff employed at LRA is 160 specialists, with 74 of them working at Joun, Awali and Markabi HPPs. The key departments within LRA that will be responsible for implementing the rehabilitation project include the following:

- Hydroelectric Production Department
- Markabi HPP and Qaraoun Lake Department
- Joun and Awali HPPs Department
- Tenders and Procurement Department
- Financial Department.

4.1 Environmental and Social Management Program

LRA does not currently have a formalized Environmental and Social Management System (ESMS) at either corporate or HPP levels. There is no Environmental Policy or Occupational Health and Safety Policy, and there are no specialized E&S managers/engineers or occupational health and safety (OHS) specialists/engineers.

Nor has LRA adopted a specific human resources (HR) policy, but it does have an internal manual, which specifies applicable requirements for HR management. A longstanding hiring freeze has resulted in LRA having to appoint contract employees rather than hiring new permanent workers. As a result, LRA employs both permanent employees, who are considered Government employees, and contract staff, who are not.

An HR manager is responsible for HR matters across the company, at both corporate and HPP site levels. There are no designated HR managers at site levels. Recruitment and employment is being done by a civil service board which checks the age (reportedly, none under 21), qualifications, and suitability of employees. LRA employees are bound by standard employment contract as per the requirements of the Lebanese Labor Code.

5. Project Description

As noted earlier, the Project will involve rehabilitation of electrical and mechanical equipment at three hydropower plants: Joun HPP, Awali HPP and Markabi HPP. Three HPPs operate in tandem as a cascade on the Litani River. Before the Project is described in section 5.4 below, the context of the cascade and the Project are described in sections 5.1 through 5.3.

5.1 Overview of the Litani River Cascade

The HPPs are located in the southern part of Lebanon approximately 60 to 100 kilometers driving distance from Beirut. Joun HPP is located in the Mount Lebanon Governorate, Chouf administrative district, Awali HPP is in the South Governorate, Jezzine district, and Markabi HPP is in Bekaa Governorate, West Bekaa district (Figure 5-1).

LRA constructed the cascade of HPPs between 1962 and 1968. The Cascade is situated within the two largest Lebanese river basins:

- Qaraoun Dam and Lake and Markabi HPP are in the Litani River Basin. Qaraoun Dam and Lake are the farthest upstream feature in the cascade.
- Awali HPP and Joun HPP are in the Bisri River Basin. Joun is the farthest downstream in the cascade.

The development involved the following:

- The construction of the Qaraoun dam (with the total storage capacity of 220,000,000 cubic meters)
- Construction of three underground water tunnels (total length of 30 kilometers) that convey water discharged from Qaraoun Dam to Markabi HPP, from Markabi HPP to Awali HPP, and from Awali HPPs to Joun HPP.
- Construction at each of the HPPs of a penstock and compensation/accumulation reservoir with auxiliary facilities
- Construction of Markabi, Awali, and Joun HPPs, with a combined installed power generation capacity of 192 MW, which is approximately 10 percent of total installed power generation in Lebanon.

At present, the Cascade produces an average of approximately 500,000,000 kilowatt hours (kWh) of electricity per year, with the capacity to generate over 1,000,000,000 kWh per year in extremely wet years. Figure 5-1 shows the locations and Figure 5-2 illustrates the longitudinal profile. Table 5-1 describes each of the facilities and relevant characteristics.

Figure 5-1. Litani Cascade Reservoir and HPPs From Upstream (East, right) to Downstream (West, left)

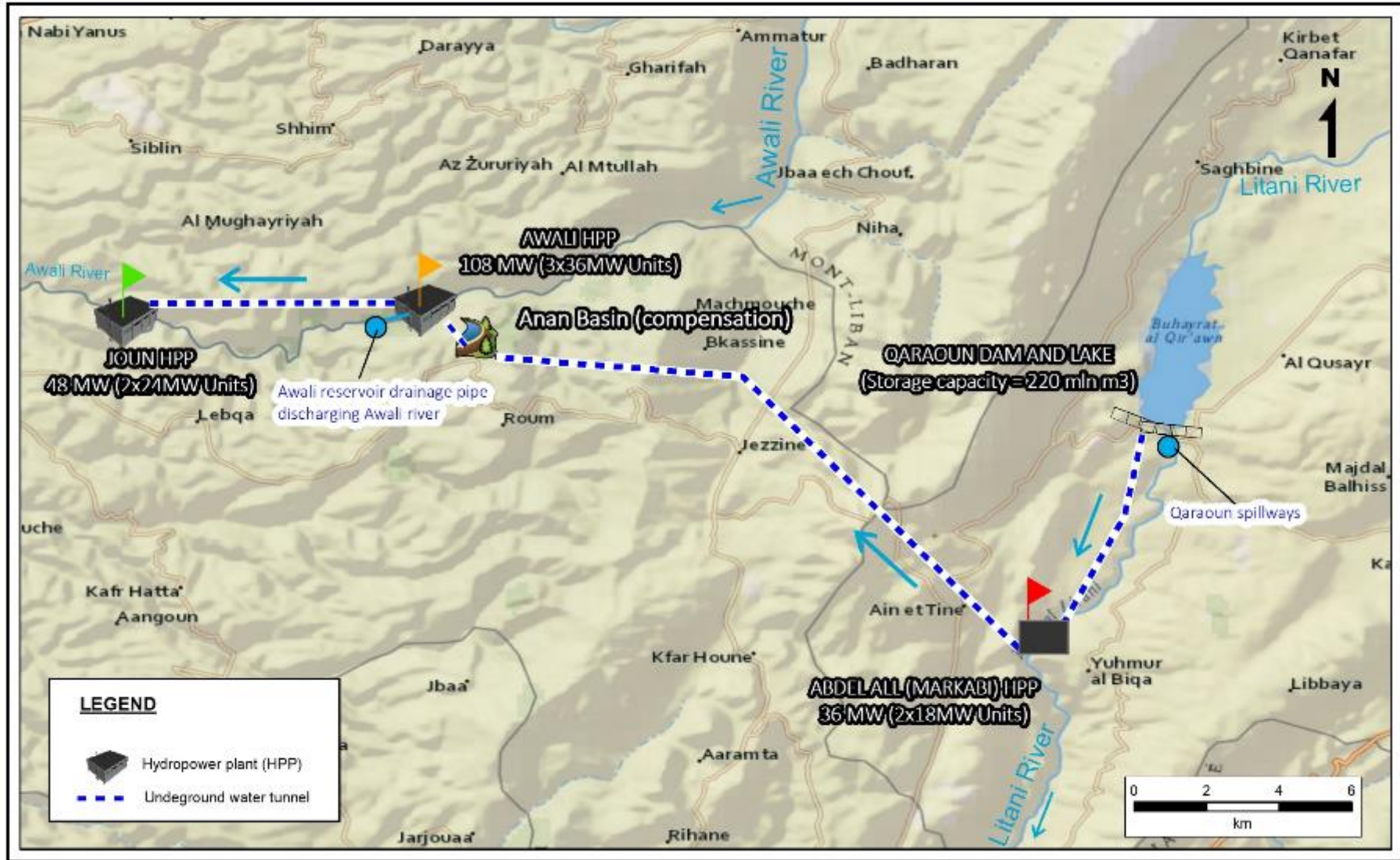


Figure 5-2. Longitudinal Profiles of the Key Features of the Litani Cascade

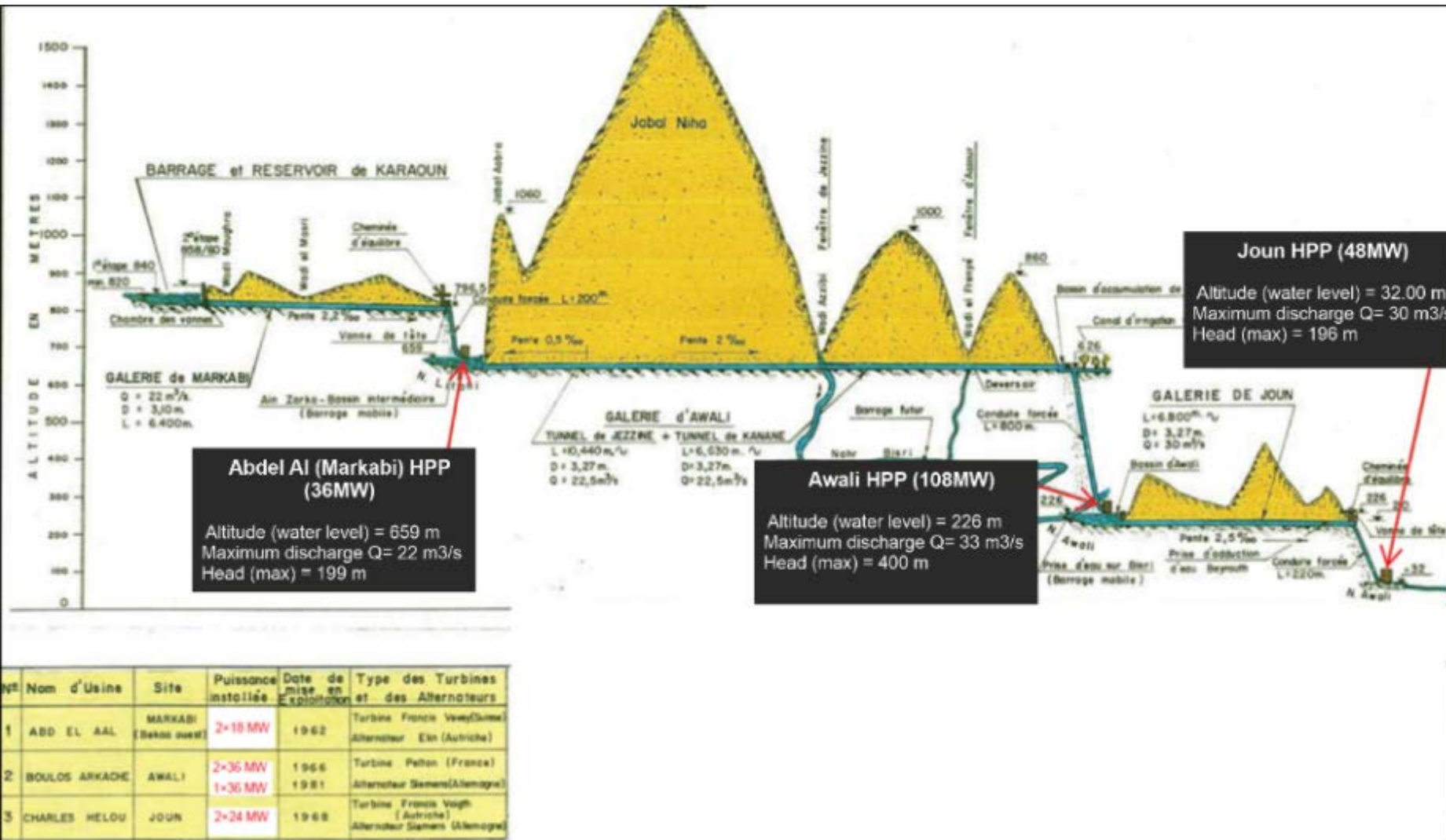










Table 5-1: Main Characteristics of the Litani HPP Cascade

No.	Facility/Structure	Year commissioned	Description and main characteristics	Photographs
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ADVANCED DRAFT Environmental and Social Audit of Litani River HPPs

No.	Facility/ Structure	Year commissioned	Description and main characteristics	Photographs
1.	Lake (Dam) Qaraoun (also known as Albert Naccash Dam)	1959	<ul style="list-style-type: none"> • 858 meters above sea level (masl) 	    
1.1.	Qaraoun Lake		<ul style="list-style-type: none"> • Largest artificial reservoir in Lebanon. • Total area = 11,800,000 m². • Storage (static) capacity = 220,000,000 m³. • Previously, water from the lake was used for irrigation purposes but is no longer due to poor water quality. 	
1.2.	Qaraoun Dam		<ul style="list-style-type: none"> • 60 meters high, 1,090 meters long, 162 meters wide • Rock-filled with cobble carapace, reinforced concrete tiles on front façade • Reinforced concrete decant facility (tulip) serves as inlet for flood discharge spillway tunnels. The tower is made of reinforced concrete. • Two discharge spillways with maximum design capacity of 60 cubic meters per second each. 	
2.	Markabi HPP	1962	<ul style="list-style-type: none"> • 660 masl, located underground (inside mountain). • 11 km from Lake Qaraoun, receives water through 6.4km Markabi Tunnel (3m diameter, 2.2% slope) • Underground penstock, powerhouse, and control room are located inside the mountain. • Design capacity = 36MW (2x18 MW vertical Francis 	



ADVANCED DRAFT Environmental and Social Audit of Litani River HPPs

No.	Facility/ Structure	Year commissioned	Description and main characteristics	Photographs
			<p>turbines).</p> <ul style="list-style-type: none"> • Maximum HPP discharge 22m³/s • 22 workers in two 12-hour shifts • 66kV substation located on the surface near the powerhouse entry tunnel. • Hydraulic head from Qaraoun Dam is about 200m. • Water discharged to Litani River Channel, then at Anai spring into 17km tunnel to Anane compensation pond and Awali HPP 	
3.	Awali HPP	1965 (2 units) 1981 (3 units)	<ul style="list-style-type: none"> • Altitude = 228.5 masl. • Largest HPP in Lebanon: design capacity 108MW (3x36 MW Pelton turbines (5 nozzles) with vertical shafts. • Maximum discharge 33m³/s. • Primary role is to regulate frequency of the country's power transmission networks, including coverage of consumption peaks. • 66kV substation. • 25 staff work two 12-hour Shifts daily • Hydraulic head 400 m. • Hydraulically connected to Anan compensation pond at 630 masl . See below. 	


ADVANCED DRAFT Environmental and Social Audit of Litani River HPPs

No.	Facility/ Structure	Year commissioned	Description and main characteristics	Photographs
3.1.	Markabi HPP-Anane compensation pond Underground Water Tunnel	1965	Water from Markabi HPP in the Litani River channel is joined by discharge from the Ain Zarga spring 300-400m downstream from Markabi HPP. A small artificial impoundment near the spring has the inlet for another underground water tunnel, the Markabi HPP – Anane compensation pond water tunnel. The tunnel is 17km long and is linked with the Anane compensation pond. The slope of the tunnel ranges from 0.5 to 2.0%.	
3.2.	Anane compensation pond	1965	<ul style="list-style-type: none"> • Altitude 630masl • Design storage capacity ranges between 150,000 to 170,000 m3. • Purpose is to regulate the supply of water to Awali HPP through a partly subsurface steel penstock • Maximum discharge capacity 33m3/s. The pond is located at an altitude of 630masl, while Awali HPP is at 228 masl, providing a hydraulic head of about 400m. • About 7,000,000m3 of water from the pond is used for irrigation annually 	

ADVANCED DRAFT Environmental and Social Audit of Litani River HPPs

No.	Facility/ Structure	Year commissioned	Description and main characteristics	Photographs
3.3.	Awali water storage reservoir	1965	<ul style="list-style-type: none"> • Located at the lower end of the Awali HPP. • Storage capacity 300,000 m3. • The reservoir accumulates water passed through the Awali HPP turbines, along with the incoming water from the Awali river and its tributaries. • Underground water drainage pipeline discharges from the reservoir to the Awali river main channel. 	
4.	Joun HPP	1969	<ul style="list-style-type: none"> • Altitude = 32 masl. • Design capacity 48MW (2x 24MW Francis turbines with horizontal shafts). • 20 workers in two 12-hour shifts • Water received from Awali water storage reservoir via Joun underground water tunnel and surface steel penstock. • Maximum discharge capacity 30 m3/s. • Hydraulic head 196 m. 	

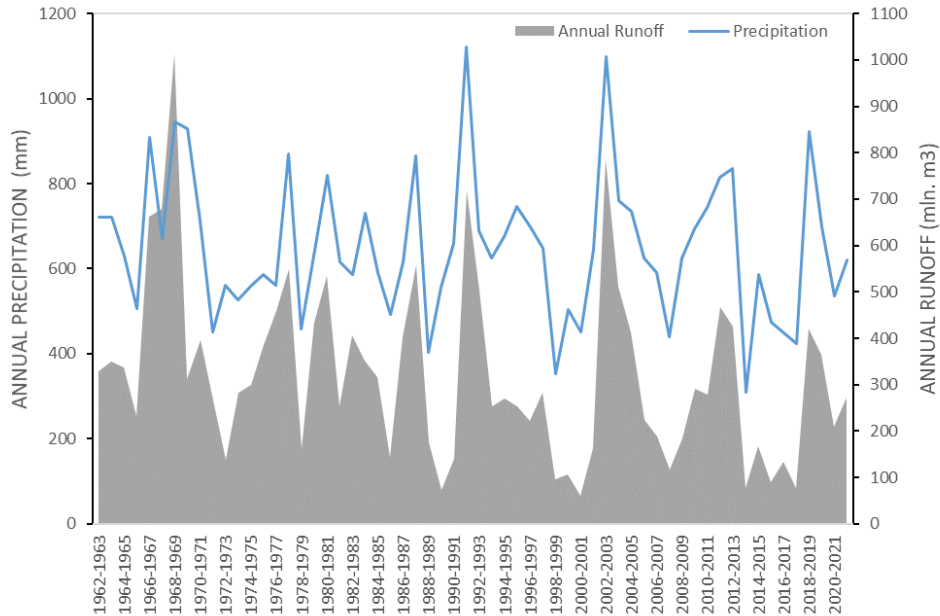
ADVANCED DRAFT Environmental and Social Audit of Litani River HPPs

<i>No.</i>	<i>Facility/ Structure</i>	<i>Year commissioned</i>	<i>Description and main characteristics</i>	<i>Photographs</i>
4.1.	Joun Underground Water Tunnel and Penstock	1969	<ul style="list-style-type: none">• Delivers water from Awali water storage reservoir 6.8km to Joun HPP.• Slope 2.5%• Water to HPP via 200m steel penstock, with head valve at 190masl.	

5.2 Hydrologic Regime

The water availability and thus the operational regime of the Cascade is dependent on the amount of precipitation received in the upper part of the Litani River Basin, specifically the amount of rainfall in the area upstream of the Qaraoun dam in the Litani River headwaters) (Figure 5-3).

Figure 5-3: Relationship Between Annual Precipitation in the Upper Litani River Basin and Annual Incoming Runoff into Qaraoun Lake, 1962-2021 (Source: LRA)



Monthly average discharges as measured at the entries to the powerhouse (i.e., at turbines) of each HPP in the Cascade is presented in Table 5-2 and shown on the annual hydrographs in Figure 5-4.

Figure 5-4. Annual Hydrographs of the HPPs (Source: LRA)

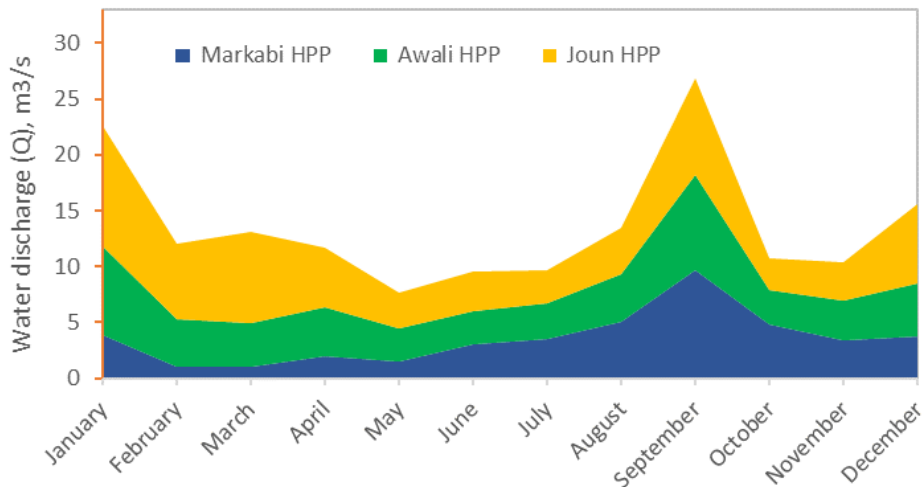


Table 5-2. Monthly Discharges at HPP Turbines, 2017 as example year (Source: LRA)

Month	Average monthly discharge (m ³ /s)		
	Abdel Al (Markabi) HPP	Awali HPP	Joun HPP
January	3.84	7.92	10.8
February	1.02	4.2	6.77
March	1.01	3.88	8.18
April	1.93	4.4	5.35
May	1.44	3.01	3.24
June	3.03	3	3.49
July	3.54	3.15	2.94
August	5.02	4.34	4.06
September	9.63	8.55	8.65
October	4.76	3.1	2.87
November	3.42	3.5	3.49
December	3.75	4.68	7.2
Year average	3.5	4.5	5.6

As shown on the figure and the table, the “water year” begins in late summer-early fall (August through September/October) when Qaraoun Lake starts filling with water from the Litani river headwaters. The water continues filling the reservoir for the following 7-8 months (September/October through April/May), known as “wet months”, when most of the annual precipitation (and flow) occurs in a given year. This period is also when LRA schedules and carries out all required maintenance works for HPPs. During the maintenance works, some units are temporarily shut down, which reduces consumption of water accumulated in Qaraoun Lake.

It is important to note that the hydrograph does not show river flows at the HPPs, but of water reaching the HPPs, which is through underground tunnels rather than the river channels. During dry months and seasons, the river channels downstream of the HPPs are dry since all water at those times is conveyed in tunnels, having been abstracted for electricity generation and/or irrigation.

5.3 Electricity Production and Distribution

Typically, the Cascade operates at full capacity during summer and fall, with the limiting factor being the water reserve (availability) in Qaraoun Lake (Figure 5-5), which must at a minimum remain at 50,000,000 m³ of its storage capacity. This limit must be met at all times by the end of each calendar year in order to ensure water availability in case the following year is dry or extremely dry. Monthly electricity production by the Cascade is presented in Figure 5-7.

Figure 5-5. Water Storage Dynamics in Qaraoun Lake (Source: LRA)

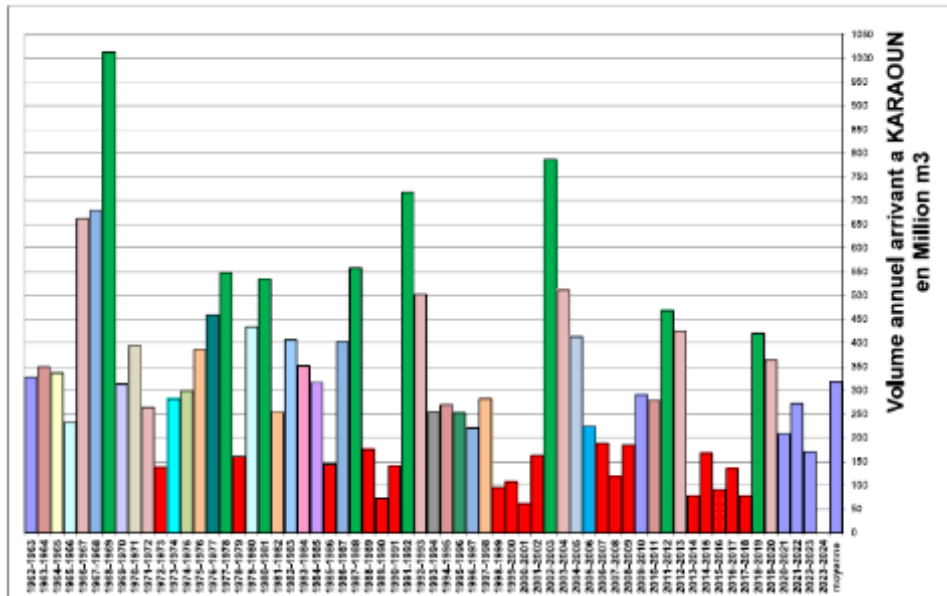


Figure 5-6 demonstrates the relationship of annual electricity production and the annual runoff to Qaraoun Lake.

As noted previously, one of LRA’s mandates is “establishing main electrical networks and 66kV substations connected to operational hydropower plants”. Those that connect to the Litani River Cascade HPPs include:

- Two 66 kV Saida-Joun HPP transmission lines linking a substation in the town of Saida with the Joun HPP substation.
- Two 66 kV Jamhour power transmission lines connecting Awali HPP with Jamhour substation near Beirut.
- Two 66 kV Beit Eddine power transmission lines connecting Awali HPP with the town of Beit Eddine.
- 66 kV Abdel Al (Markabi) HPP – substation Qaraoun-Jeb Jannine substation t- line

Figure 5-6. Annual Runoff and Electricity Production by the Litani River Cascade, 1965-2023 (Source: LRA)

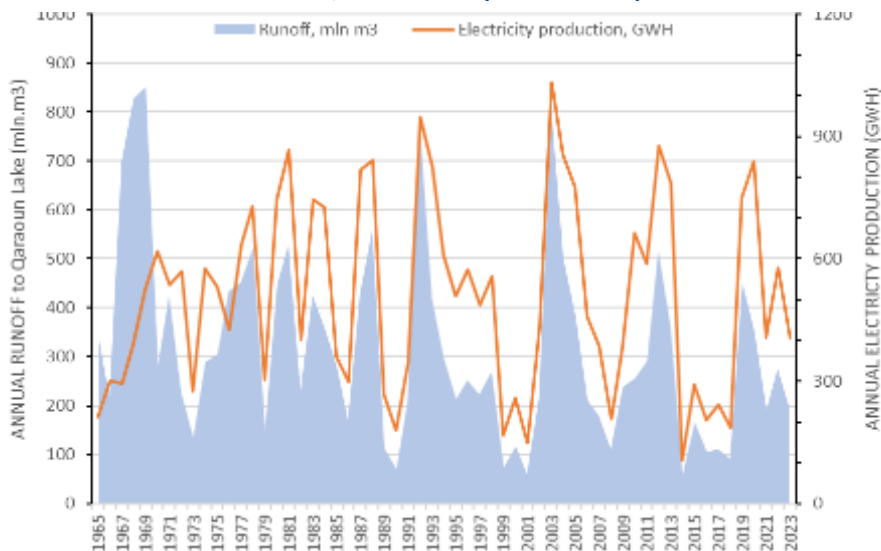
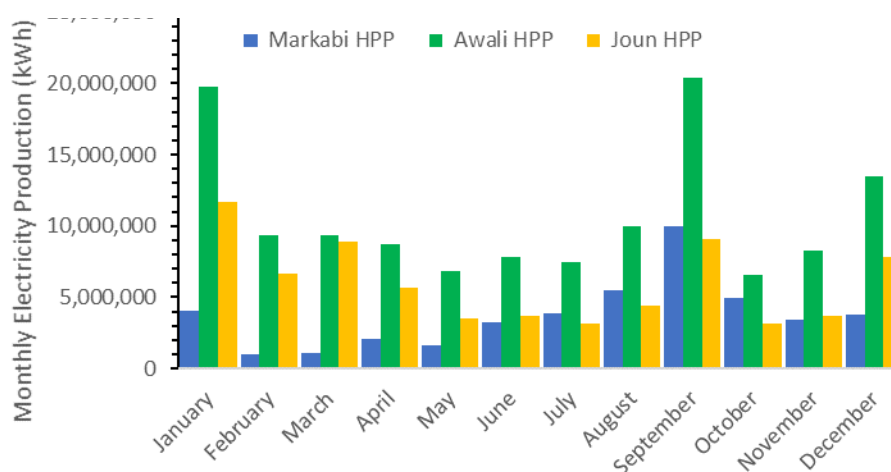


Figure 5-7. Monthly Electricity Production by the Litani River HPPs, 2017
(Source: LRA)



- 66 kV Abdel Al (Markabi) –Merjayoun substation– Soutaniye power transmission line
- 66 kV power lines (Awali-Joun and Awali-Markabi) linking all three HPPs in the Cascade
- Six major 15 kV overhead power transmission lines directly connected to more than one hundred small villages/towns.

The Litani HPPs and the LRA-operated power network are connected to the National Grid through 66 kV substations:

- Substation at Saida (south Lebanon)
- Substation at Joun HPP
- Substation at Jamhour near Beirut(Beirut)
- Substation at Awali HPP
- Substation at Abdel Al (Markabi) HPP
- Substation Merjayoune (south Lebanon)
- Substation Soutaniye (south Lebanon)
- Substation Jeb Jannine (Bekaa)
- Substation Beit Eddine (Mount Lebanon).

5.4 Proposed Rehabilitation of the Litani HPPs Cascade (the Project)

5.4.1 Background and Need

A total of 109 villages and towns, with about half a million residents, are provided electricity generated by LRA HPPs, as shown in Table 5-3. . In addition, the LRA facilities supply electricity to support operations of drinking water pumping stations, wastewater treatment plants and other services situated in the southern Lebanon region. LRA’s HPPs also provide power to important/strategic facilities, including the Beirut airport and water pumping stations that provide potable water to Beirut and its suburbs.

Table 5-3. Towns and Villages Connected to LRA HPPs

<i>Caza/District</i>	<i>Number of villages and towns connected to LRA HPPs</i>	
	<i>directly via 15kV network</i>	<i>Indirectly via 66kV network</i>
Hasbaia	3	Hasbaia town and surrounding villages
Rachia	3	
Saida	6	Saida town and surround villages
Chouf	15	
Aley		Beit Eddine town and surrounding villages
Jezzine	57	
Nabatieh	4	
South Bekaa	21	
North Bekaa		Jib Jannine town and surround villages
Beirut and suburbs, through Jamhour substation		Jamhour town and surrounding villages
Total	109	

LRA has performed regular maintenance of the HPPs, as shown in Table 5-4, which shows the rehabilitation works/upgrades since 1995.

Table 5-4: Previous Rehabilitation Works Completed at the Litani HPPs

<i>HPP</i>	<i>Year works undertaken</i>	<i>Description of rehabilitation works</i>
Markabi HPP	1995	Replacement of two turbine Governors
	2000	Installation of a new SCADA system
	2014	Replacement of Stators and rehabilitation of Rotors (Unit-1)
	2017	Replacement of alternator excitation systems with voltage regulators (Unit-1)
	2018	<ul style="list-style-type: none"> • Replacement of Stators and rehabilitation of Rotors (Unit-2) • Replacement of alternator excitation systems with voltage regulators (Unit-2) • Replacement of power transformers (24 MVA), (Unit-1 and Unit-2)
	2022	Replacement of protection systems for alternators (Unit-1 and Unit-2)
Paul Arcashe Hydropower Plant (Awali HPP)	1995	<ul style="list-style-type: none"> • Replacement of three turbines Governors with actuators (Unit-1, Unit-2 and Unit-3) • Replacement of the three voltage regulators at each Unit
	2016	Replacement of power transformer (45 MVA) (Unit-3)
Charles Helou Hydropower Plant (Joun HPP)	1995	Replacement of the two turbines Governors with actuators (without new spare parts due to absence on the market)
	2010	Replacement of power transformer (30 MVA) at Unit-2
	2012	Replacement of the two turbines (Runner, Wicket gates, Right and Left covers) at Unit-1

<i>HPP</i>	<i>Year works undertaken</i>	<i>Description of rehabilitation works</i>
	2014	Replacement of alternator excitation systems, synchronization systems and protection systems for alternators
	2016	<ul style="list-style-type: none"> • Replacement of the two turbines (Runner, Wicket gates, Right and Left covers) at Unit-2 • Installation of a new SCADA system and replacement of protection systems for three 66kV transmission lines

In recent years, however, with the emerging economic and financial crisis in the country and rapid devaluation of the Lebanese currency, LRA has not been able to upgrade critical components of the HPPs. This in turn jeopardizes the sustainability of continued operations.

5.4.2 Proposed Rehabilitation Project

The World Bank supported a technical assessment of the HPPs that was undertaken by the Swiss engineering and consulting firm Gruner Stucky SA². This resulted in a series of recommendations for rehabilitation works in a due diligence report, “Rehabilitation needs for Litani River hydropower projects”. Table 5-5 summarizes the proposed rehabilitation works (the Project) planned for each HPP in the Cascade.

Table 5-5: Litani HPP Cascade Rehabilitation Project

<i>Hydro Power Plant (HPP)</i>	<i>Year est.</i>	<i>Installed capacity (MW) and number of units</i>	<i>Proposed rehabilitation works</i>
Markabi HPP	1962	36 (2 x 18)	<ul style="list-style-type: none"> • Speed governor replacement (2) • Control, and SCADA systems (in the same location as now) • Low voltage distribution cabinet replacement (1) • Protection for overhead lines (3) • Motorized 71kV triphasic disconnectors (17)
Awali HPP	1965	108 (3x36)	<ul style="list-style-type: none"> • \ • Safety valve (1)– Electrical cabinet renewal • Turbine inlet valve (3) – Inspection, overhaul of actuator (servo-cylinder), supply and replacement of service and maintenance seals. • Injectors including deflector actuator (3) – Complete overhaul • Speed governor including spare parts (3) • Excitation and voltage regulator, including generator assessment (3) • Control, and SCADA systems • Low voltage distribution cabinet replacement (1) • Protection for generator(3) • Protection for transformer (3) • Protection for overhead line (6)
Joun HPP	1968	48 (2x24)	<ul style="list-style-type: none"> • Safety valve DN 3000 (1) – Replacement of main seal (assumed possible)

² Gruner Stucky SA. 2024 (May 14). “Rehabilitation needs for Litani River hydropower projects”, due diligence report prepared for Litani River Authority.

<i>Hydro Power Plant (HPP)</i>	<i>Year est.</i>	<i>Installed capacity (MW) and number of units</i>	<i>Proposed rehabilitation works</i>
			<ul style="list-style-type: none"> • Turbine inlet valve including HPU (1) – New supply • Turbine inlet valve (1) – Rehabilitation in Contractor's workshop • Speed governor, including spare parts (2) • Generator assessment (2), including dielectric tests (before and after), dry ice cleaning and varnishing • Anticorrosion protection of the spiral case and draft tube elbow including dismantling and reinstallation of the turbine (2) • Voltage transformer VT in the switchyard (3)
Steel Underground Water Tunnels	1962-1968	-	<ul style="list-style-type: none"> • Inspection of steel lined waterways of Joun, Awali and Markabi

As can be seen, all works are to take place in the HPPs or in substations or transmission lines where there are ongoing activities.

6. Legal and Institutional Framework

This chapter describes the national and international legal framework that apply or may apply to the rehabilitation of the HPPs.

It is noted that LRA and the EPC contractor(s) will be required to comply with the provisions and requirements of Lebanese laws and regulations as well as to meet World Bank ESF and ESSs and good international industry practice.

6.1 National Institutional Framework

Various institutional stakeholders will be involved in the proposed Project, including those in Table 6-1. At the national level, the primary institutions are the Ministry of Energy and Water (MoEW), the Ministry of Environment (MoE), Ministry of Interior and Municipalities (MoIM), and Labor. At the regional level, the main institutions would include the West and South Governorates, the Coalition of Jezzine municipalities and the Coalition of Bouhayra Municipalities, the Joun and Mashghara Municipalities, and the Regional Water Establishment (Bekaa Water Establishment and South Lebanon Water Establishment). Although these institutions have some responsibilities that may be related to LRA operations, none will be actively involved in the rehabilitation Project except possibly the Ministry of Labor.

Table 6-1: Project Institutional Stakeholders and Responsibilities

<i>Institution</i>	<i>Mission/Responsibility</i>
Ministry of Environment (MoE)	<ul style="list-style-type: none"> • Responsible for monitoring and control of environmental protection, prevention of pollution, protection of wildlife, and preservation of environmental balance. • Set environmental standards, specifications and guidelines for sectors that might have an impact on the environment and for the management of natural resources and amenities. • Responsible for policy planning and setting laws and regulations required to protect public health and the environment and then to strictly enforce them. • Advocate and develop measures for the reduction of intentional and unintentional discharge to the environment. • Define the environmental policy and ensure that it is appropriate to the nature, scale and environmental impacts of the activities. • Coordinate and encourage environmental awareness programs. • Responsible for approving EIA studies (should they are required).
Ministry of Energy and Water (MoEW)	<ul style="list-style-type: none"> • Establishes plans for the provision of energy for the industrial sector • Designs, builds, puts into operation and maintains power generation and supply facilities • Monitors the quality of fuel used in Lebanon • Monitors surface and underground water quality. It also estimates water needs and uses in all the regions, and identifies the conditions and systems needed for surface and underground water exploitation. It then develops the schemes for distribution of water (drinking and irrigation).
Ministry of Labor	<ul style="list-style-type: none"> • Responsible for labor and employment issues. Labour inspections are the responsibility of the Department of Labour Inspection, Prevention and Safety (DLIPS) under the Labour Relations Authority of the Ministry of Labour
Ministry of Interior and Municipalities (MoIM)	<ul style="list-style-type: none"> • Contribute to strengthening decentralization and activation of local government. • Provide technical assistance and support to municipal federations. • Cooperate and coordinate with other administrations on issues related to municipal and rural affairs. • Implementation of waste management activities. • Responsible for solid waste collection and disposal of domestic wastes. • Supervise municipal federations units and ensure conformity with administrative and financial regulations. • Approve sewerage networks projects. • Organize and manage civil defense activities. • Maintain and rehabilitate infrastructure (water, wastewater, and storm water drainage systems). • Provide technical assistance and support to municipal federations.
Regional Water Establishments	<ul style="list-style-type: none"> • Distribute potable water equally to all citizens. • Distribute irrigation water. • Monitor the quality of water that reaches homes. • Study water networks. • Implement, invest in, maintain, and renew water networks to distribute drinkable and irrigation water. • Study and implement reservoirs to collect and distribute water. • Operate wastewater refining plants. • Collect, treat, and dispose of wastewater in accordance with the general plan for water and sanitation approved by the Ministry of Energy and Water, in coordination with official references. • Monitor the quality of potable and irrigation water. • Monitor the quality of wastewater in the areas of water purification plants.
Local municipalities, Coalition of municipalities and	<ul style="list-style-type: none"> • Involved in the permitting procedure for new establishments • Involved in ensuring the well-being of the populations in its territory • Involved in environmental protection

<i>Institution</i>	<i>Mission/Responsibility</i>
Governorates	

6.2 National Legal and Regulatory Framework

6.2.1 EIA Requirements

The Environmental Impact Assessment (EIA) Decree 8633 was endorsed and issued by the Lebanese Government dated August 7, 2012, followed by Decision 261/1 dated June 25, 2015. The EIA Decree sets the necessary principles and measures to assess the environmental impact of projects, covers the objectives of the regulation, definitions, as well as various stages of the national EIA process including screening, scoping, implementation, and review of the EIA report, in addition to the period of validity, and the appeal process.

In accordance with the EIA Decree 8633, there are three categories of environmental appraisals that may apply to any proposed industrial development, depending on the type and scale of the project and potential adverse E&S impacts:

- Full-scale EIA for a greenfield industrial development with moderate to major impacts expected, including EIA scoping, detailed impact evaluation and development of mitigation measures.
- Environmental Examination (IEE) for other types of projects (brownfield, expansion, extension projects) and for some projects to confirm whether full-scale EIA is needed.
- No EIA option if the screening and/or IEE confirms minor or negligible E&S risks or impacts as a result of project implementation.

The HPPs were constructed and began operation many years before the Decree was issued, and no EIA was required at the time. Although the Ministry is not known to have made a formal determination, it is expected that the rehabilitation project would not trigger an EIA or an IEE, as there would be essentially no environmental impacts and limited or no social impacts.

6.2.2 Key National Laws and Regulations

Table 6-2 lists the key national legislative acts, decrees, and decisions that may be applicable to the Project.

Table 6-2. Applicable Laws and Decrees

<i>Law/Decree or Decision</i>	<i>Date of Issue</i>	<i>Subject</i>	<i>Applicability</i>
Labor			
Labor Law	1946	The Lebanese Labor Code	Applicable
Law 207	2000	Prohibits discrimination between men and women	Applicable
Law 205	2020	Criminalizes sexual harassment in the workplace	Applicable

<i>Law/Decree or Decision</i>	<i>Date of Issue</i>	<i>Subject</i>	<i>Applicability</i>
			Applicable
Decree 8987	2012	Prohibition of employment of minors under the age of 18 in work that may harm their health, safety or morals	
Decree 3791	2016	Minimum Wage	Applicable
Environment			
Law 64	1988	Protection of the environment from toxic and dangerous substances	Applicable
Law 444	July 2002	Code of the environment indicating the necessity to conduct EIA and IEE for development projects.	Applicable (subject to confirmation by MOE)
Law 77	2018	Water Law	Applicable
Law 80	2018	Integrated Solid Waste Management	Applicable
Decree 2761	1933	The prohibition of wastewater discharge into water streams	Applicable
Decree 10276	1962	Protection of Surface and Groundwater Resources	Applicable
Decree 8735	1974	Conservation of Public Hygiene (solid waste)	Applicable
Decree 8633	March 2012	The EIA decree: sets the requirements and procedures for the preparation of an EIA report.	Applicable (subject to confirmation by MOE)
Decree 5606	2019	Management of hazardous waste	Applicable
Decree 7935	1931	Prohibition on open dumping	Applicable
Decree 5605	2019	Management of domestic solid waste	Applicable
Decisions 998/1 and 999/1	2019	Procedures for hazardous waste generators, transportation, and temporary storage facilities	Applicable
MoE Decision 52/1	1996	Standards and specific levels for limiting air, water, soil and noise pollution	Applicable
MoE Decision 8/1	2001	Revised standards for air emissions, liquid effluents and wastewater treatment plants	Applicable
MoE Decision 16/1	2022	Emission limit values for air emissions (updating air quality standards specified in Decision 8/1 2001)	Applicable
Circular 11/1	2013	Regulates the operation of	Applicable

<i>Law/Decree or Decision</i>	<i>Date of Issue</i>	<i>Subject</i>	<i>Applicability</i>
		generators, sets air pollution control requirements and emissions limits	
Health and Safety			
Decree 11802	January 2004	Occupational health and safety	Applicable
General			
Law of 14/8/1954	1997	Establishment of Litani River Authority	Applicable
Note: for most laws and decrees, only the year of initial passage or issuance is provided, with subsequent amendments not shown. All subsequent decrees issued under the laws, similar, are not shown.			

6.2.3 Applicable Environmental Standards

EIA

As noted above, it is not expected that screening under Decree 8633 will result in the need for an IEE or EIA, as the impacts of the rehabilitation will be minimal, as described in subsequent sections. However, this decision will be made by the Ministry of the Environment.

Air Quality

It is not expected that either HPP operations or the rehabilitation works will result in emissions of pollutants to ambient air other than minor emissions from vehicles. The ambient air standards Law 78, MOE Decision No. 16/1 will necessarily apply, but will not require action by LRA or Contractor(s).

Wastewater

Effluent discharges into receiving natural water bodies are specified in Law 77, Decision No 8/1 of January 2001. No such discharges are expected from the Project as the HPPs rely on septic systems for their wastewater. Construction will not result in significant increases or changes in wastewater.

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LRA manages small quantities of hazardous materials, specifically turbine oil, transformer oil, and diesel fuel, as shown in In addition, workers had not received training in their proper use or in responding to spills or other emergencies.

LRA reported there was no asbestos at the HPPs, and none was observed during the audit. [Électricité du Liban \(EDL\)](#) is responsible for dealing with polychlorinated biphenyls (PCBs) nationwide. Their survey determined that some transformers at Awali HPP contained PCBs, and these were removed for disposition at an appropriate facility.

Table 6-3. However, the HPPs do not comply with Lebanese law for waste management. They do not have a plan for management of materials and wastes. There are records of materials that are present but no corresponding records for the small amounts of used oil and other wastes that are generated. Nor are there dedicated spaces for materials and wastes, which were observed to be stored in areas not designed to contain such materials (that is, no secondary containment) and with evidence that minor spills had occurred in the past. In addition, workers had not received training in their proper use or in responding to spills or other emergencies.

LRA reported there was no asbestos at the HPPs, and none was observed during the audit. [Électricité du Liban](#) (EDL) is responsible for dealing with polychlorinated biphenyls (PCBs) nationwide. Their survey determined that some transformers at Awali HPP contained PCBs, and these were removed for disposition at an appropriate facility.

Table 6-3. Hazardous Materials Managed by HPPs

<i>HPP</i>	<i>Amount managed (liters)</i>		
	<i>Turbo oil T68</i>	<i>Transformer oil Shell Diala B</i>	<i>Diesel Oil</i>
Markabi	4000	1000	2000
Awali	6800	1200	4000
JOUN	4000	600	2000

Noise

Noise exposure limits are specified in Ministerial Decision No. 52/1 of July 1996 and provided in Table 6-4. Noise from the HPPs does not reach any distance off-site at present, and it is considered unlikely that noise from the rehabilitation works will be audible for more than a very short distance off-site even under unfavorable conditions. However, LRA workers are exposed to (relatively low levels of) noise in their workplaces and Contractor workers will be exposed to noise during the rehabilitation works. National limits for occupational exposure to noise are shown in Table 6-5.

Table 6-4. Limits for Noise Established by Decision 52/1 of July 1996

Region Type	Limit for Noise Level dB(A) (Lebanese standards)			WBG Guidelines 8-hour LAeq (dBA)	
	Day time (7 a.m. - 6 p.m.)	Evening time (6 p.m. - 10 p.m.)	Night Time (10p.m. - 7a.m.)	Daytime	Nighttime
Residential areas having some construction sites or commercial activities or that are located near a road	50-60	45-55	40-50	55	45
Urban residential areas	45-55	40-50	35-45	55	45
Industrial areas	60-70	55-65	50-60	70	70
Rural residential areas	35 – 45	30 – 40	25 – 35		

Table 6-5: National Standards for Occupational Noise Levels

Duration (Hours)	Maximum allowed sound level, dBA
8	90
4	95
2	100
1	105
½	110
¼	115

6.3 World Bank Environmental and Social Standards

6.3.1 Environmental and Social Framework

All projects financed by the World Bank are required to meet the Bank’s environmental and social standards, which are set forth in the 2018 Environmental and Social Framework (ESF). The ESF includes the Environmental and Social Policy for Investment Project Financing, which describes the requirements the Bank itself must follow, and 10 Environmental and Social Standards (ESSs), which establish requirements for Borrowers to identify, assess, and control the environmental and social risks and impacts of Bank-supported projects. ESSs that would apply to rehabilitation and operation of the HPPs are identified in Table 6-6.

Table 6-6. Applicability of World Bank ESSs to LRA HPPs

<i>ESS No.</i>	<i>Title</i>	<i>Scope</i>	<i>Applicability to HPP(s)</i>
1	Assessment and Management of Environmental and Social Risks and Impacts	Identification, control, and monitoring of risks, impacts, and mitigation	Applicable: Operations and construction works will present certain risks that must be managed, since they will be supported by the World Bank.
2	Labor and Working Conditions	Labor relations, rules of employment, occupational health and safety, worker grievance mechanism	Applicable: <ul style="list-style-type: none"> LRA currently employs workers: Contractors will also employ workers.
3	Resource Efficiency and Pollution Prevention and Management	Conservation of resources and control/prevention of wastes and pollution.	Applicable: <ul style="list-style-type: none"> HPPs currently store, use, and dispose of (minor) amounts of waste Contractors will do the same, with larger amounts of scrap and debris.
4	Community Health and Safety	Avoidance and control of risks and impacts on communities	Applicable. Some mitigation required to minimize impacts
5	ESS5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement	Rules for mitigating physical and/or economic displacement of affected people	Not applicable. No land will be affected.
6:	Biodiversity Conservation and Sustainable Management of Living Natural Resources	protection and conservation of biodiversity and habitats	<ul style="list-style-type: none"> Not applicable. the Project will not affect biodiversity. <ul style="list-style-type: none"> No effect on habitats, flora, or fauna No change to river flows or aquatic habitats
7	Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities	Rules for managing relations with and impact on indigenous peoples	Not applicable: No indigenous peoples could be affected.
8	Cultural Heritage	Protection of tangible and intangible cultural heritage.	Not applicable: No tangible or intangible heritage will be affected.
9	Financial Intermediaries	Application of standards to institutions receiving financial support from the Bank.	Not applicable: LRA is not an FI
10	Stakeholder Engagement and Information Disclosure	Identification and engagement of affected and interested parties, information disclosure, grievance redress mechanism for external	Applicable: There are both interested and affected stakeholders to be informed and

<i>ESS No.</i>	<i>Title</i>	<i>Scope</i>	<i>Applicability to HPP(s)</i>
		stakeholders.	consulted

The Bank classifies all projects into one of four risk classifications:

- **High Risk** (Medium-or long-term effects that impact local or regional areas (outside of site boundaries) that cannot be remediated using good practices)
- **Substantial Risk** (Short-or medium-term effects that impact local or regional areas (outside of site boundaries) but can be remediated using good international practices).
- **Moderate Risk** (Local and short-term effects that are contained on site and can be remediated and managed using Developer/Operator’s standard management plans and codes of practice).
- **Low Risk** (Minimal or non-detectable effects that are contained on site and can be managed using Developer/Operator’s standard management plans and codes of practice).

In determining the appropriate risk classification, the Bank takes into account relevant issues, such as the type, location, sensitivity, and scale of the project; the nature and magnitude of the potential environmental and social risks and impacts; and the capacity and commitment of the Borrower (including any other entity responsible for the implementation of the project) to manage the environmental and social risks and impacts in a manner consistent with the ESSs.

6.3.2 World Bank Group Environmental, Health, and Safety Guidelines

The World Bank Group has promulgated a number of Environmental, Health, and Safety (EHS) Guidelines that are recognized as good international industry practice. Applicable EHSs would include:

- General EHS Guidelines (April 30, 2007) includes guidelines for environmental controls during facility operation (air and water emissions, hazardous materials management, noise, contaminated land, etc.) and occupational and community health and safety during operation. This guideline also covers the same topics for construction.

The World Bank has also promulgated a variety of guidance manuals and good practice notes that would be applicable to the Project, among them:

- Non-Discrimination and Disability (World Bank, 2019)
- Addressing Gender-Based Violence in Investment Project Financing involving Major Civil Works (2018)
- Gender (2019) explains how the World Bank ESF supports the closure of gaps between men and women, girls, and boys, and enhancement of women’s leadership and voice.

In addition, the International Finance Corporation, which is part of the World Bank Group, has promulgated the Good Practice Note on Environmental, Health and Safety Approaches for Hydropower Projects (2018), which is considered to be good international industry practice.

7. Environmental and Social Audit

7.1 Environmental Setting and Baseline Conditions

This chapter presents an overview of the E&S setting for the Project areas. A wide variety of information sources were consulted to define the E&S baseline, including publicly-available websites, documents and publications of official statistics as well as direct observation. A GIS database was developed based on publicly available GIS data sources (e.g. Diva ArcGIS and GoogleEarth) and digital information received from LRA.

7.1.1 Litani River and Qaraoun Lake

The Litani River rises south of Baalbek in North Bekaa and flows for 161 km before discharging to the Mediterranean Sea nine kilometers north of Tyre in South Lebanon. Its basin covers 2,170 km² and receives an annual average precipitation of 770 mm. Recognizing the river's potential for irrigation and energy production, the Litani Project has been ongoing by the Lebanese government since the mid-1950s. The elevation of the Litani River watershed ranges between 0 to 2,360 masl.

Initially, the Qaraoun reservoir was designed to provide water for irrigation, domestic use, and hydropower production (Photograph 1). Water for hydropower flows into a tunnel to Markabi HPP. Currently, it releases water to meet variable demands, primarily during peak consumption hours. Lebanon's sole electricity distributor, EDL, relies mostly on thermal energy but uses the Qaraoun hydropower system as a supplementary source, making water release independent of storage levels or prior inflows.



Photograph 1. Qaraoun Lake

7.1.2 Locations of Joun, Awali, and Markabi HPPs

The nearest villages to Joun HPP, the farthest downstream of the Cascade are Bqosta, , Almane, and Joun. The HPP is located 4.2 kilometers from the Saida main road and 4 kilometers from the residential areas of Joun.

Al Awali HPP is situated in the Qtaleh valley, bordering the Jezzine/South Governorate and the Shouf cadastral area/Mount Lebanon Governorate. Surrounding villages include Qtaleh, Bisri, Baanoub, Mazraat Al Mathaneh, and Anan. The plant site is situated approximately 1.2 kilometers from the nearest residential area (Almuhataaqara). Specifically, it is five kilometers from the residential areas

of Bisri, seven kilometers from the residential areas of Qtaleh, and nine kilometers from Anan. The site is directly adjacent to the Al Awali artificial lake and is approximately 9.9 kilometers from the Roum-Anan Road.

Markabi HPP is situated in Mashghara in the Western Bekaa District, south of the Bekaa Governorate. It lies just to the northwest of Sohmor, southwest of Lake Qaraoun, south of Aitanit, and north of Ain Et Tine. The HPP site is situated approximately four kilometers from the residential areas of Yohmor and six kilometers from the residential areas of Sohmor.

7.1.3 Air Quality

There are no significant sources of point or nonpoint sources of air pollutant emissions since the Joun, Awali and Markabi HPP areas are entirely rural with predominantly agricultural activities and very limited industrial, commercial, and significant construction activities. There may be short periods of very localized particulate matter emissions due to the movement of agricultural vehicles in fields and unpaved tracks.

7.1.4 Topography and Landscape

The topography of the Project area (Jezzine and West Bekaa region in general) is characterized by mild to steep rolling hilly or dissected terrain with mild or gently rolling slopes, occasionally



Photograph 2. Landscape Around Joun HPP

transitioning to rugged terrain, particularly evident in some parts of the Awali River watershed. Joun HPP is found between two major mountain ridges and is primarily defined by a fluvial landscape shaped by the meandering river (Photograph 2). This river manifests typical erosional and depositional activities that contribute to the formation of the surrounding topography.

The landscape surrounding the Awali HPP is similar to that of Joun HPP and the area is also predominantly rural. Positioned at the valley's base, the Awali HPP overlooks the Al Awali reservoir (Photograph 3). The Markabi HPP is situated within the Jabal Mashghara-Niha region and has similar topographic features as the Joun and Awali HPP sites. After Markabi HPP was established, LRA undertook reforestation efforts, planting cedar, pine, and cypress trees on the slope facing the HPP on Jabal Yohmor. The surrounding landscape is characterized by presence of a variety of tree species, including cedar, cypress, pine, mastic, and chinaberry trees (Photograph 4).

7.1.5 Geology and Hydrogeology

The underlying geology at all three HPP sites is predominantly characterized by limestone and dolomite rock formations. The Joun and Awali sites are underlain by alternating layers of pale grey limestones and marly limestones (with fine and thick fractures, geodes, and chert. The area is characterized by presence of Cretaceous karst formations, which are well-developed and exhibit relatively high infiltration rates, resulting in significant groundwater flow. (MoEW & UNDP, n.d.).

The Markabi HPP is situated on formations dating back to the Upper Cretaceous and mid-Cenozoic periods. The formations are characterized by high porosity, ranging from 20 to 40 percent due to



Photograph 3. Landscape Around Awali HPP



Photograph 4. Landscape Around Markabi HPP

their chalk and marly limestone composition chalk and marly limestone composition. Hydrogeology

at all three HPP sites is predominantly defined by a karst-type hydrogeology, which is characterized by high porosity and permeability of nummulitic limestone. This makes it an excellent aquifer, capable of storing and transmitting significant quantities of groundwater.

7.1.6 Hydrology and Surface Water Quality

The primary watercourses in the region are the Awali River, which is known as the Bisri River in its upper section, and the Litani River. The Awali River stretches approximately 48 kilometers in length, originating from the Barouk mountain, which has an elevation of 1,492 meters above sea level, and Niha mountain, 1,100 meters. The river traverses the western face of Mount Lebanon before emptying into the Mediterranean Sea. The Awali River watershed has an area of 294 square kilometers and the annual average discharge is 10,200 liters per second.

The Litani River is formed by the convergence of numerous seasonal and permanent watercourses originating at an average altitude of around 600 meters and is downstream of towns such as Anane, Azour, Roum, and Qaitoule. The total area of the Litani watershed is 2,170 square kilometers. The river is impounded by Qaraoun Dam, which forms Qaraoun Lake, which in turn is situated five to six kilometers north-northeast of the Markabi HPP. Another notable water body, the Ain Zarka Spring, is located 200+ meters downstream of the HPP and contributes its flow to the river.

It is important to note that the Litani River and the Awali River are both profoundly influenced by the existing HPPs. In dry months and seasons, the river channels may be dry for extended distances and for extended periods due to water having been abstracted into tunnels for hydropower or for irrigation.

A study conducted by Beirut and Mount Lebanon Water Establishment (BMLWE) examined water quality data from Joun, Bisri/Awali River, Anane, and Qaraoun (Karoun) Reservoirs. Samples were collected between December 2011 and November 2012, encompassing 24 rounds of physical, chemical, and microbiological analysis, along with three rounds of metal and organic compound testing. The findings are summarized as follows:

- The Qaraoun Reservoir exhibited the highest levels of COD and TOC, followed by Anane, Joun Reservoir, and Bisri, which had the lowest levels. This trend was consistent in the organic analysis.
- Elevated nitrite levels were found in Joun, Anane, and Qaraoun Reservoirs, posing a contamination concern.
- Metal analysis primarily detected barium and beryllium at very low levels.
- Organic analysis identified the presence of polynuclear aromatic hydrocarbons (PAH), phthalates (plasticizers), pesticides, chloro-benzenes, trihalomethanes, and xylenes. Qaraoun Reservoir typically showed the highest concentrations and the greatest variety of detected compounds, indicating contamination from agricultural and industrial activities.

Qaraoun Lake is considered to be highly polluted from agricultural runoff and other discharges to the point that hydrogen sulfide from decomposing organic matter is a problem at Markabi HPP.

The HPPs have had a profound effect on the flows in the respective rivers, since water is diverted into tunnels and the downstream river reaches are significantly reduced at all times the HPPs are in operation, and left completely dry during seasonal or other dry periods. The current operational pattern will not change after the rehabilitation works are complete. In order to avoid changes in the current situation during the rehabilitation works, LRA will schedule the works for the same periods of time (dry season) when routine maintenance is now performed.

Although not required since the project will not affect stream flows, it is recommended that LRA evaluate the feasibility of having each dam and HPP provide some minimum flow to the downstream river reaches at all times as a means to stabilize and improve the riparian and aquatic habitats.

7.1.7 Soils and Land Use

At Joun HPP and surroundings, the soils are mostly presented by Arenic Leptosols, Calcic Leptosols, Eutric Leptosols, and Calcic Regosols. Similarly, the soils surrounding Awali HPP predominantly consists of eroded Luvisols, Leptosols, and terric Anthrasols, with Gleic Andosols and Cambisols present in the western areas. This distribution underscores the direct influence of climate on soil formation and development (*Darwish et al., 2005*). The soils at Markabi HPP and surroundings are predominantly presented by Eutric Cambisols. As noted earlier, the land use at all three Project sites is predominantly agricultural with ownership distributed among both public and private sectors. Since most or all activities will be inside the HPPs, the rehabilitation activities should have no effect on soils; no additional land will be needed so there will also be no change in land use.

7.1.8 Noise

During the course of the audit, rapid noise surveys were conducted at Joun HPP, yielding an average noise level of 64 dB(A) over a 15-minute duration during daylight hours. Noise emissions from the HPP are considered negligible, audible only to on-site workers. During rehabilitation works, noise levels will be higher, but will be confined to the HPP premises. The HPP is 870 meters from the Bqosta village and 300 meters higher, and 1,200 meters from Joun, and 350 meters higher, and this effectively prevents noise from reaching these locations.

Noise from Awali HPP also would not reach neighboring villages, which include Bisri (2.5 kilometers away and 150 meters higher), Anan (580 meters away and 140 meters higher), and Mazraat Almatha and Qataleh (870 and 250 meters away, respectively). Here, noise measurements were made near the entrance of the premises during daylight hours, which showed an average noise level of 60 dB(A).

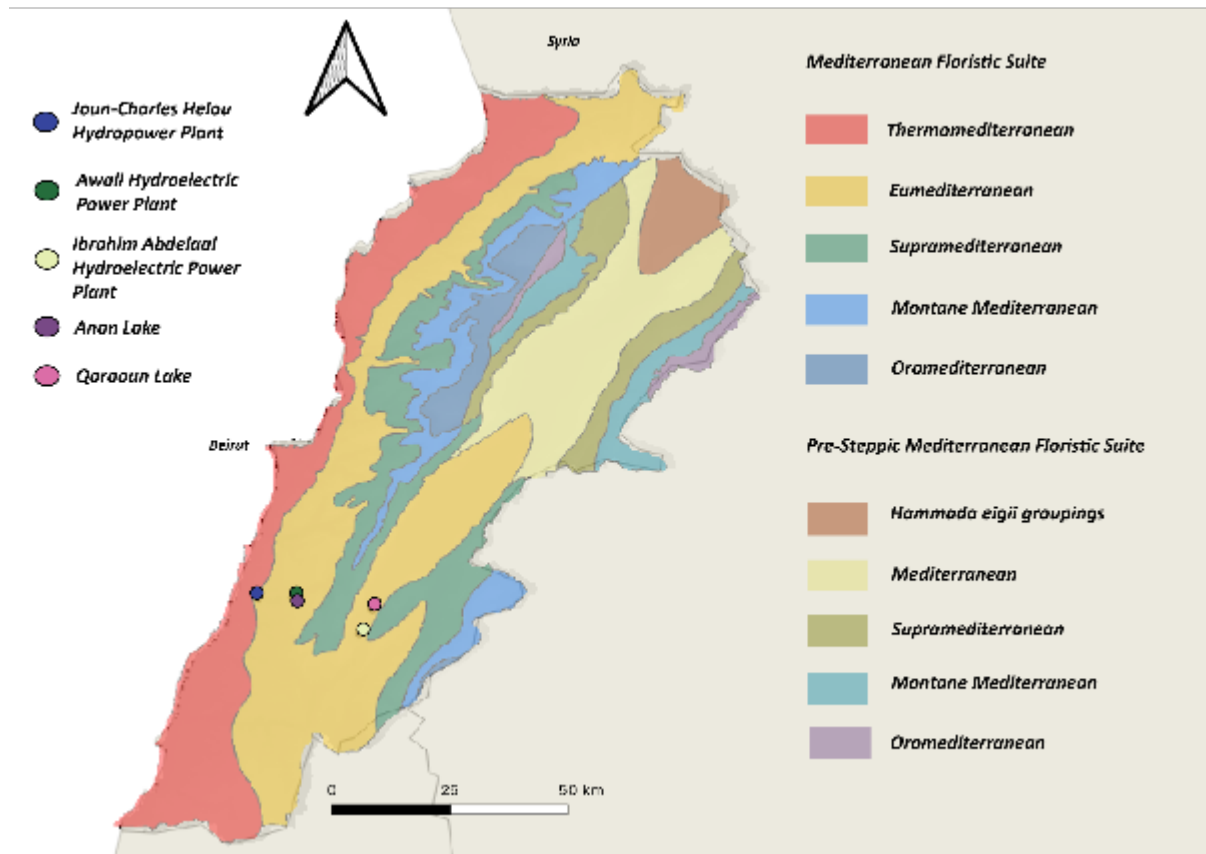
Noise measurements recorded at the parking lot at Markabi HPP, showed levels less than 55 dBA.

The only potential impacts from Project noise would be on HPP and Contractor employees conducting rehabilitation works. These would be confined to HPP premises. Compliance with Lebanese and World Bank noise standards will require the use of mitigation measures, achieved through the development and implementation of an Occupational Health and Safety Management Plan.

7.1.9 Biodiversity

The Joun HPP is found within the Thermomediterranean vegetation zone, while the other two

Figure 7-1. Location of Cascade HPPs within the Ecosystems of Lebanon
(adapted from Abi-Saleh & Safi, 1988; Safi, 2012)



Project HPPs are situated within the Eumediterranean vegetation zone. (Figure 7-1).

The Cascade is found within the humid to subhumid bioclimatic zone, using the Emberger’s bioclimatic zones classification of the Mediterranean. It was observed that riparian habitats and areas surrounding the HPPs have recovered from past disturbance and are currently relatively undisturbed. No terrestrial or aquatic habitats or organisms will be affected by the Project, which will take place in and on existing facilities.

Two endemic plant species were observed in a small orchard that is managed by Awali HPP on the Awali HPP property: Tripoli mullein (*Verbascum tripolitanum*), which is endemic to the Eastern Mediterranean, and Sidon bellflower (*Campanula sidoniensis*), which is endemic to Lebanon and listed as Vulnerable by the Lebanese Red Book but not assessed by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. This is a tended orchard so is not Natural Habitat as defined by World Bank Environmental and Social Standard 6 (“Biodiversity Conservation and Sustainable Management of Living Natural Resources”).

Although not required, since there will be no change in current conditions (thus, no impact from operations or from construction), it is recommended that LRA consult with Lebanese authorities responsible for conserving biodiversity in order to develop an approach to protection of the endemic species that occur on LRA property at all the HPPs. This could involve surveys of flora and fauna and

development of plans to protect or enhance biodiversity that is found there. This would not necessarily involve any expenditure of funds, as either the authorities or interested experts may be able to provide expertise and time. Based on findings, LRA could then proceed to protect or even enhance these endemic species as determined most appropriate.

7.1.10 Social and Economic

Key considerations addressed in the audit included the following.

- **Employment.** LRA has a total staff of 155 permanent employees, of which 35 are female (23.2 percent). Of these, 25 women are among the 104 skilled employees (university degrees). Three of 12 section chiefs (25 percent) are women, as are eight of 35 engineers (22.9 percent). Due to a longstanding hiring freeze, LRA also employs another 120 daily workers for irrigation projects, for monitoring 65 river gauging stations, and for the HPPs. These are employed through a contractor selected and appointed through an annual public tender process. Table 7-1 shows the number of employees and contract workers at Cascade facilities.

Table 7-1. Number of Workers Employed by LRA in the Litani River Cascade

Location	Number of Employees			Women
	Civil Servants	Contract Workers	Total	
Qaraoun Dam	4	5		1
Markabi HPP	18	8		1
Awali HPP	16	10		2
Joun HPP	16	8		1
Totals	54	31		

- **Local/Regional Economy:** The Project will produce a net positive impact on local economies and the regional economy by ensuring a steady electricity supply to local residents and businesses. There may be some minor employment but this would be temporary and very small-scale, not significant on the local or regional scale.
- **Communities:** no communities are situated in close proximity to the HPPs, and most are uphill. Non are adversely affected by the operating HPPs and none will be affected by the rehabilitation works. As noted above, many towns and villages in the region and throughout the country currently benefit from the electricity provided by the HPPs, and that benefit will be increased once the rehabilitation works are completed. Additional information on the Municipalities in which the HPPs are located is presented in the next section.
- **Vulnerable Groups:** local authorities and others reported there are no ethnic minorities or Syrian refugee camps near any of the sites. There may be elderly or disabled people, people, women-headed households, or other vulnerable groups in surrounding communities. Their prevalence was not determined or evaluated since impacts are expected to be positive, with no adverse impacts on communities or households.
- **Cultural Heritage:** The Project activities will take place in the HPPs where existing activities currently take place. The HPPs do not currently affect tangible or intangible cultural heritage, and the rehabilitation works will not result in new effects.

- **Labor.** As noted, LRA currently employs 155 permanent staff and 120 contract workers—the longstanding hiring freeze has made it impossible to hire new government employees directly, so LRA relies on contracted workers. There will be no change in LRA employment as a result of the rehabilitation.

The works activities will be undertaken by one or more Contractors appointed by LRA. It is not yet decided if the work will be done sequentially or at all HPPs simultaneously. Regardless, only a small number of workers will be needed to complete the work at any of the HPPs, no more than 15-20—therefore, there could be as few as 15-20 in total if the work will take place sequentially or possibly as many as 45-60 if simultaneously.

As noted earlier, LRA is not responsible for recruiting and hiring new workers. Rather, this is handled by a central civil service board, which reportedly checks ages to verify applicants are 18 or over as well as their qualifications and suitability. LRA and employees are bound by standard employment contract as per the requirements of the Lebanese Labor Code/Bylaws.

- **Grievance Management.** There is no formal mechanism by which workers can present grievances to management and be assured they will be addressed. Rather, the process is informal and not documented.
- **Occupational Health and Safety.** Ongoing and future operations at the HPPs present few acute risks, but workers are continually exposed to the risks of working near equipment, with electricity, some degree of working near water, and other hazards common to working around machinery. At present, there is no organized program to manage occupational health and safety and no systematic recordkeeping. It was reported that workers are not provided, and it was observed that they do not routinely use, personal protective equipment such as safety boots, hard hats, or high-visibility vests. LRA reported there have not been serious injuries in at least the past few years but there is no documentation to that effect. Even so, the HPPs are not in compliance with the occupational health and safety requirements of the Labor Code.

The rehabilitation works will present somewhat more risks to workers, including from falls while working at height, working with tools and equipment, working with electricity, and other tasks that have to be performed. Although some activities may require unskilled labor, most are likely to require semi-skilled and skilled workers and professionals.

7.2 Stakeholder Engagement During Audit

During the course of the audit, stakeholders in the local Municipalities of Joun, Jezzine, Qaraoun, Bouhayra were consulted and interviewed. The interviews were carried out by phone and physical meetings. Stakeholder perceptions and comments related to the proposed Project are summarized in Table 7-2

Table 7-2. Consultations During Audit

<i>Date</i>	<i>Stakeholder</i>	<i>Short description of stakeholder</i>	<i>Comments/feedback received</i>
May 14, 2024	Joun Municipality	Mayor of Joun: Mr. Hussam Chamselddine; Environmental Officer in the municipality: Mr.	The town's population is estimated to be around 8,000 inhabitants, with 3,500 being permanent residents and 4,500 visiting during weekends and the

<i>Date</i>	<i>Stakeholder</i>	<i>Short description of stakeholder</i>	<i>Comments/feedback received</i>
		Ibrahim Eid	<p>summer.</p> <p>During summer months, the number of people in Joun can reach up to 12,000 due to the presence of water and the provision of 20 hours/day of electricity from the HPP. The village has two public schools and two private schools. Although there are no universities in the area, the literacy rate is very high, with almost no illiterate residents in Joun. Regarding healthcare facilities, there is one dispensary in the village. Residents primarily seek medical services at hospitals in Mazboud, Sibline, and Saida, which are approximately 7, 8, and 13 km away, respectively.</p> <p>The main types of employment in Joun include positions such as doctors, engineers, university and school teachers, judges, and members of the internal security forces and army, in addition to various public and private sector jobs.</p> <p>The economy is predominantly agriculture (olive oil production, honey); The primary drinking water supply are mountain springs, which are known to be abundant in the area.</p> <p>With respect to Joun HPP – the Mayor fully supports the project and rehabilitation of the plant. At present, the residents of Joun and nearby smaller villages receive electricity directly from LRA at about 18 hours/day. He hopes that with rehabilitation of HPP, the communities will be receiving electricity 24 hours per day.</p>
	Jezinne Municipality	Mayor: Mr. Khalil Harfouch –Head of Union of Municipalities of Jezzine	<p>The Mayor was very satisfied with the service offered by LRA. He said that unlike other governmental authorities, they are very responsive and professional. The residents of Jezzine and surrounding villages are supplied with electricity at 18-20 hrs/day from LRA . Ninety percent of the villages are supplied with electricity from the LRA HPP. Only seven villages are not connected due to technical issues.</p> <p>Many studies have been conducted for the Caza of Jezzine, including the strategic plan for Jezzine. Normally, Jezzine relies on tourism in the summer, but this season, tourism has been significantly impacted due to the war activities in the south.</p>

<i>Date</i>	<i>Stakeholder</i>	<i>Short description of stakeholder</i>	<i>Comments/feedback received</i>
May 15, 2024:	Qaraoun and Bouhayra Municipalities	Mayor: Eng. Yahya Daher; Treasurer: Mr. Omar Jbara	<p>Qaraoun residential area occupies 25.2 km², with approximately 7 km² occupied by the lake. Around 6.8 km² of the land is owned by the government.</p> <p>Population Size in Qaroun:</p> <ul style="list-style-type: none"> • 5,000 permanent Lebanese residents • 4,600 Syrian refugees • 7,000 Lebanese living abroad <p>Total number of households: 1,155</p> <p>Infrastructure and Services:</p> <ul style="list-style-type: none"> • Primary source of potable water: Ain Zarqa spring and three artesian wells (two owned by the Bekaa Water Establishment and one owned by the municipality). • Electricity supply: LRA typically supplies the town with electricity 24 hours per day. 100% of all electricity is sourced from LRA HPPs/network. In cases of shortage, the supply is reduced to 22 hours. No private diesel generators are available in Qaroun. LRA services 112 municipalities in the region via the Aabd Al Aal HPP. • In the last few years, the municipality has planted around 138 hectares of land. Last year alone, the municipality planted 15 hectares of oak, almond, and pine trees. • Solid waste in Qaroun is collected by the municipality. Sorted waste is collected three times per week, while rejects are collected daily. In 2016, the municipality initiated waste sorting efforts, with two projects underway: one with DAWERR, funded by USAID, focusing on organic waste treatment, and another with ESFD for briquetting. • The wastewater network covers 70% of the town, connected to the wastewater treatment plant in Aitit. The remaining 30% rely on open-ended septic tanks. <p>Socio-economics:</p> <ul style="list-style-type: none"> • The main sources of income in Qaroun are derived from expatriates, the agricultural sector, and trade. • The town has two public schools, two private schools, and a center named NABAD catering to Syrian refugees. • Qaroun hosts seven stone industries, five brick industries, and one steel industry. • The closest hospitals to the town are Joub Jannine Hospital and Sohmor

<i>Date</i>	<i>Stakeholder</i>	<i>Short description of stakeholder</i>	<i>Comments/feedback received</i>
			<p>Hospital.</p> <p>Water level monitoring: Around the lake, there are 120 piezometers. Every two days, the team at LRA takes measurements from these meters to check the water level at the dam. In case of a change in level, it indicates potential infiltration from the dam.</p> <p>Dam inspection and water quality testing: The Qaroun municipality is now responsible for inspecting the equipment at the dam. Every six months, they sample the quality of t water (as required).</p> <p>The Municipalities are in full support of the Litani HPP rehabilitation project and they understand the importance of LRA electricity generation and production to local economies and people.</p>

7.3 Environmental and Social Audit Findings

This section defines the Area of Influence and identifies the E&S risks and impacts that may result from the Project. The need for mitigation measures to avoid or minimize risks and impacts is identified and outlined, with detailed mitigation measures to be defined in an Environmental and Social Management Plan (ESMP) that will be presented in Appendix A of the next version of this report.

This section defines the Area of Influence and describe the key findings of the audit with a focus on the key areas where LRA will need to implement corrective measures in order to meet the requirements of the World Bank’s ESF and Lebanese law. The specific corrective measures are defined in a separate Environmental and Social Management Plan (ESMP).

The Area of Influence in which potential impacts could occur is entirely confined to the HPP properties, where all Project activities will take place, plus the public roads that will be used to transport equipment and workers. There are no known Associated Facilities within the meaning of World Bank ESS1.

Table 7-3 presents the key findings of the audit and the potential impacts they may cause, and that will require the implementation of certain measures to avoid or reduce the impacts in order to meet applicable standards. As noted above, a separate Environmental and Social Plan describes these measures as well as the party responsible for ensuring their implementation and the timeframe in which they must be implemented.

Table 7-3. Key Audit Findings

<i>Environmental Aspect</i>	<i>Relevant Audit Findings for Current Operations and Rehabilitation Works</i>
Physical Environment	
Air Quality	<ul style="list-style-type: none"> • Very minor dust or pollutant emissions (limited vehicles, mostly paved surfaces) at present and during rehabilitation Technical due diligence reported hydrogen sulfide in some indoor spaces (none was detected during the E&S audit)
Hydrology	<ul style="list-style-type: none"> • Under the current operating regime, downstream river reaches are significantly reduced at most times and entirely dry during dry periods • Rehabilitation will not cause change in future flow rates or patterns, and rehabilitation works are scheduled to avoid changes in existing patterns and amounts of river flows •
Water quality	<ul style="list-style-type: none"> • Gray water and sanitary water currently report to septic systems and this will continue during and after rehabilitation works. • Evidence of past (small) leaks and spills of hazardous substances present (see below) • Very limited usage of hazmats by HPPs (some use of diesel fuel, lubricating oil, and transformer oil, etc.), all in buildings, over paved surfaces, and at substations • Rehabilitation works will introduce additional quantities of similar hazmats
Noise	<ul style="list-style-type: none"> • Noise does not reach off-site receptors at present and rehabilitation noise will be minor outside of HPPs • Current workers are exposed to low levels of machinery noise in some areas of HPPs • Construction workers will be exposed to some higher levels during rehabilitation works
Waste and Materials Management	<ul style="list-style-type: none"> • HPP store and use small amounts of hazmats (lubricating oils, paints, etc.) and generate small amounts of waste at present, with some increase expected during rehabilitation • HPPs generate small amounts of nonhazardous solid waste, with some increase during construction, including significant metal scrap • Small amounts of gray and sanitary water managed in septic systems • Poor management of hazmats and wastes at present—no program, no secure storage or training, evidence of minor leaks
Biodiversity	
Biodiversity (habitats, ecosystems, flora, and fauna)	<ul style="list-style-type: none"> • Endemic plant species observed in Awali orchard • No rehabilitation activities in the orchard or in other areas not currently used for operations or otherwise disturbed •
Community Health and Safety	

<i>Environmental Aspect</i>	<i>Relevant Audit Findings for Current Operations and Rehabilitation Works</i>
Community health, safety, and welfare	<ul style="list-style-type: none"> • Civil Service board checks ages and prohibits employment under 18 years (none actually under 21) • No formal mechanism for external grievances • Positive impact from stabilization and enhancement of electricity supply Rehabilitation works that would affect power supply to be scheduled at normal maintenance times in order to avoid disruptions in supply
Stakeholder engagement	<ul style="list-style-type: none"> • No formal engagement program • LRA has regular interactions with local authorities • No formal GM • Local leaders support the HPPs and the rehabilitation works
Emergency preparedness and response	<ul style="list-style-type: none"> • HPPs have emergency plans • Workers have not been trained
Workers and Security	
Labor management	<ul style="list-style-type: none"> • Temporary minor employment by Contractors during rehabilitation (15-20 maximum at each HPP or in total. (At present, unclear if works at the HPPs will be done sequentially or simultaneously) • All workers have written employment contracts • LRA employment not planned to change. • Civil Service recruits and hires permanent and contract employees. A hiring freeze causes all new employees to be contract workers. • Nearly 77 percent of the 155 permanent LRA employees are men. At HPPs, men account for almost 94 percent of permanent and contract employees, . • Civil service Bylaws apply to all workers,, although there are some adjustments for contract workers to account for different employment conditions (benefits, etc.) • No formal grievance mechanism and no code of conduct except in Bylaws • Pay scale was reported to be uncompetitive
Occupational health and safety	<ul style="list-style-type: none"> • At present: <ul style="list-style-type: none"> – No OHS program – No OHS specialists or safety officers – No OHS training – No formal reporting, record-keeping, or investigations of near misses and/or incidents – Very limited use of PPE, which is not provided • Some unsafe working conditions and equipment at present, with risk of falls, equipment impact, electricity, exposure to hazmats, and exposure to H²S in poorly ventilated spaces • No worker injuries or deaths reported for several years • Contractors will be exposed to similar types of risks but with more activity, hence higher risks
Site Security	<ul style="list-style-type: none"> • HPPs are fenced, with unarmed security personnel who monitor CCTVs • No incidents reported • Unknown at present if Contractor will provide security—considered likely

8. Conclusion

The environmental and social audit revealed there were some shortcomings in current environmental and social management, including insufficient attention to the management of occupational health and safety (ESS2) and of materials and wastes handling (ESS3). In addition, there were reports that economic conditions had caused payments of workers' salaries to be late in some cases. At the same time, however, it is important to note that it was reported there have been no work-related injuries or fatalities for many years, although there is no log to demonstrate this or to record minor issues. Similarly, there was no evidence of major spills or contamination but no record of even the minor spills that had occurred.

In general, there is no reason the project could not meet the requirements of the World Bank's Environmental and Social Framework with the development and implementation of management programs to address risks and impacts (e.g., near misses or first aid incidents). An Environmental and Social Management Plan has been prepared to identify the actions that LRA will need to take to comply with Lebanese law and meet the requirements of the World Bank's ESF. This Plan is presented as a separate document.

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