REPUBLIC OF LEBANON

COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

EXPANSION AND UPGRADE OF AL-GHADIR WASTEWATER TREATMENT PLANT PROJECT – PHASE I: DESIGN, BUILD AND OPERATE, INCLUDING TWO NEW SEA OUTFALLS AND INSPECTION & ASSESSMENT OF EXISTING SEA OUTFALLS

Fund: Islamic Development Bank (IsDB)

Tender Documents

Part 5 – Other Information

Book 1/2

August 2026

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PART 5 – OTHER INFORMATION

BOOK 1/2

SECTION XII – ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDY FOR WWTP

SECTION XIII – DESIGN REPORT FOR WWTP

BOOK 2/2

SECTION XIV – REFERENCE DESIGN REPORT FOR JNAH SEA OUTFALL

SECTION XV – REFERENCE BOQ FOR JNAH SEA OUTFALL

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SECTION XII – ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDY FOR WWTP

Horizon 2020

INVESTMENT COMPONENT | MeHSIP-PPIF

MeHSIP-PPIF

PHASE II

Extension of Al-Ghadir Wastewater Treatment Plant - Lebanon

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LIST OF ACRONYMS

ALARP	As Low As Reasonably Practicable
AOX	Halogenated Organic Compounds
ASP	Activated Sludge Process
BAFF	Biological Aerated Flooded Filter
BIA	Beirut International Airport
BMLWWE	Beirut and Mount Lebanon Water and Wastewater Establishment
BOD	Biochemical Oxygen Demand
BPEO	Best Practicable Environmental Options
BTD	Bureau Technique pour le Développement
BTEX	Benzene and Toluene
CAS	Conventional Activated Sludge
CCTV	Closed-circuitTelevision
CDR	Council for Development and Reconstruction
CEMP	Construction Environmental Management Plan
CESMP	Construction Environmental and Social Management Plan
CHP	Cogeneration of Heat-Power
CHP	Combined Heat – Power
COD	Chemical Oxygen Demand
CoM	Council of Ministers
CZM	Coastal Zone Management
DBO	Design Build Operate
DGA	Directorate General of Antiquities
DGUP	Directorate General of Urban Planning
EBS	Environmental Baseline Survey
EC	European Commission
EDL	Electricité du Liban
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ELARD	Earth Link and Advanced Resources Development
ELV	Emission Limit Value
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
EU	European Union
FAO	Food and Agriculture Organization
FEMIP	Facility for Euro-Mediterranean Investment and Partnership
FS	Feasibility Study

GDP	Gross Domestic Product
GHG	Green House Gases
HAP	Hazardous Air Pollutants
HDPE	High-Density Polyethylene
IEE	Initial Environmental Examination
IFC	International Financing Corporation
IRI	Industrial Research Institute
IUCN	International Union for the Conservation of Nature
JV	Joint Venture
KfW	Kreditanstalt für Wiederaufbau
LCAA	Lebanese Civil Aviation Authority
LIBNOR	Lebanese Standards Institution
MBBR	Moving Bed Biological Reactor
MBR	Membrane Biological Reactor
MeHSIP-PPIF	Mediterranean Hot Spots Investment Programme - Project Preparation and Implementation Facility
MHER	Ministry of Hydraulics and Electric Resources
MoA	Ministry of Agriculture
MoC	Ministry Of Culture
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoIM	Ministry of Interior and Municipalities
MoPH	Ministry of Public Health
MoPWT	Ministry of Public Works and Transport
MoT	Ministry of Tourism
MSW	Municipal Solid Waste
MTBE	Methyl Tertiary Butyl Ether
NCMS	National Centre for Marine Sciences
NGOs	Non-Governmental Organzations
NSEQ	National Standards for Environmental Quality
OSHA	Occupational Safety and Health Administration
PAH	Poly Aromatic Hydrocarbons
PPE	Personal Protective Equipment
PS	Primary Sludge
PSTs	Primary Settling Tanks
SAS	Secondary Activated Sludge
SBR	Sequence Batch Reactors
SR	Scoping Report
SWEMP	Solid Waste Environmental Management Project

TMP	Traffic Management Plan
TOR	Terms of Reference
UASB	Upflow Anaerobic Sludge Blanket
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Frameworks Convention on Climate Change
USGS	United States Geological Survey
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

NON-TECHNICAL SUMMARY

INTRODUCTION

This report presents the results of the Environmental and Social Impact Assessment (ESIA) conducted for the design, construction and operation phases of the extension and upgrade of the Al-Ghadir Preliminary Wastewater Treatment Plant and related networks. The Council for Development and Reconstruction (CDR) is the Project Promoter, and the Ministry of Energy and Water (MoEW) and the Beirut and Mount Lebanon Water and Wastewater Establishment (BMLWWE) are the Project Beneficiaries. The Joint Venture (WS Atkins, LDK Consultants, and Pescares) is responsible for developing the Feasibility Study and counts as Project Developer, while the European Investment Bank (EIB) is funding the Study (Project Funder). ELARD is the certified practitioner conducting the ESIA Study.

The existing preliminary wastewater treatment facility is located in Al-Ghadir, about 7Km south of Beirut, at the direct proximity of the Beirut International Airport (Figure 1). The Project's Service Area (where the construction of networks would take place) covers parts of the Governorates of Beirut and Mount Lebanon. It encompasses the whole Southern part of Beirut city, a portion of the Northern Part of Beirut city and parts of the districts (cazas) of Baabda, Aaley, and the Chouf.



Figure 1 Aerial View of the Al-Ghadir Preliminary Treatment Facility

This ESIA is done in compliance with EIB guidelines on Environmental and Social Impact Assessment and with the Lebanese regulations as outlined in the Environmental Impact Assessment Decree (Decree No. 8633).

REGULATORY AND INSTITUTIONAL FRAMEWORK

The Project complies with Lebanese environmental laws and regulations and relevant international agreements of which Lebanon is signatory. Whenever there is lack of national legal documents and/or environmental standards, the present study will refer to international guidelines and standards such as those issued by the European Commission, the World Health Organization (WHO), the World Bank (WB/IFC), or the Occupational Safety and Health Administration (OSHA).

Legislative Framework Relevant to the Project

The ESIA is governed by Lebanon's main Environmental Framework Law (Law 444/2002 on Environmental Protection) and the Lebanese EIA decree which has been recently published in the official Gazette as Decree No. 8633 dated August 16, 2012.

Main identified national and international environmental standards and regulations relevant to the Project include, inter alia, the following:

- Ministerial Decision No. 52/1 (1996), MoE, specifying the National Standards for Environmental Quality and the Environmental Limit Values for Air and Water;
- Ministerial Decision No. 8/1 (2001), MoE, updating Decision No. 52/1; setting "Emission Standards for Air Pollutants And Wastewater Discharges from Classified Establishments and Wastewater Treatment Plants";
- Ministerial Decision 22/1 (1995), addressing the enforcement of Environmental Standards for Industries;
- Decree (3899) (1993), Regulating the Extraction of Sand and Other Materials from the Public Maritime Domain and Seabed;
- Legislative Decree 126 (1976), Ratification of the UNEP Barcelona Convention On Mediterranean Sea Protection;
- Decree 126 (1976), Convention for the Protection of the Mediterranean Sea against Pollution; and
- Decree 9791 (1968), Organization of Coastal Monitoring Activities.

Institutional Framework

Various governmental public institutions are involved in the different stages of the project development and operation. These include:

- Main governmental stakeholders: Ministry of Energy and Water (MoEW), Ministry of Environment (MoE), Ministry of Interior and Municipalities (MoIM), Ministry of Public Health (MoPH), Ministry of Public Works and Transport (MoPWT), Ministry of Agriculture (MoA), and Ministry of Tourism (MoT);
- The different Governorates (Mouhafaza) of Beirut and Mount Lebanon, and all municipalities in the Project Area;
- The CDR and public water and wastewater establishments, notably the BMLWWE; and
- Other stakeholders such as the General Directorate of Civil Aviation and the Lebanese Marine Research Centre.

PROJECT DESCRIPTION

The proposed Project consists of two main components:

- **Project Component 1:** The construction of networks in the Al-Ghadir WWTP Drainage Area.
- **Project Component 2:** The extension and upgrade of the existing Al-Ghadir Preliminary Treatment Facility.

Description of Project Component 1 -Construction of Networks

The length of primary sewers to be executed in the Project area is estimated at about 80 Km, and that of secondary and tertiary sewers at about 707 Km.

Description of Project Component 2 - WWTP Extension and Upgrade

The Conventional Activated Sludge with Anaerobic Sludge Treatment (CAS) is assessed to be the best treatment option for the upgraded Al-Ghadir WWTP. The CAS option is suggested to be constructed in three phases (subject to funds availability), based on the assumptions for the completion of all necessary networks serving the Ghadir drainage area, as follows:

- **Phase I.a (2015 to 2020)**: It will include ***extension*** of the preliminary treatment (to accommodate the increased flow beyond the plant's current capacity). **This process step will remove ~5% of the BOD.**
- **Phase I.b (2020 to 2030)**: It will include ***upgrade*** of the existing facilities to Primary Treatment (Settling), including Sludge Treatment and Energy Recovery facilities for the primary sludge. Effluent will be discharged through the existing Long Sea Outfall. There is no need for land reclamation (all facilities are on shore). By the operation of t**his process step 25-30% of the BOD will be removed from the inflow load.**
- **Phase II (2030 – 2050)**: ***Upgrade*** the plant to Secondary Treatment; ***extend*** sludge treatment to accommodate secondary sludge. Land reclamation required, extension of the plant off-shore. By the operation of t**his process step >95% of the BOD will be removed from the inflow load.**

Project Phasing and Cost Estimation

A summary of the project phasing and estimated costs is shown in Table 1.

Table 1 Project Phasing and Estimated Costs

PHASE	YEARS	DESCRIPTION OF TASKS	ESTIMATED COST
Phase I.A	2015-2020	Construct main wastewater conveyors to include pumping stations and complete Priority 1 networks to cover 77.5% of the Ghadir Drainage Basin between 2015 and 2020 (including the areas to be served by KfW funded networks)	60 Million
		Extend the capacity of existing preliminary works at the Al Ghadir wastewater treatment plant by 2015	16 Million
Phase I.B	2020	Upgrade the wastewater treatment plant to primary treatment by 2020 (consistent with sludge remedy)	66 Million

Phase II	2030-2050	Upgrade the WWTP to secondary level of treatment by 2030	160 Million
		Complete the remaining Networks to serve 22.5% of PE	83 Million
Total For Networks			143 Million
Total For Treatment Plant Extension and Upgrade			242 Million

** In today's price*

Source: Extension of the WWTP for Al-Ghadir- Lebanon. Summary note . 2012

ANALYSIS OF ALTERNATIVES

This section describes and compares different project alternatives with a view to determine the best way of achieving project objectives while minimizing environmental and social impacts, and/or indicates the best practicable option from an environmental and socio-economic point of view.

The following options were evaluated and compared:

- The "No Development" alternative; and
- The Process alternatives.

The analysis revealed that the "No Development" alternative is highly undesirable as it would result in the Al-Ghadir drainage area being retained in its current status. The no project alternative would imply:

- Continued or increased pollution and environmental stress in the Al-Ghadir river and drainage area due to uncontrolled wastewater discharges;
- Continued or increased pollutions of the Mediterranean Sea as ultimate recipient of the discharged wastewater flows;
- Continued or increased health risks posed to inhabitants of the Al Ghadir drainage basin.
- Continued negative impacts on marine and aquatic fauna and flora due to the deterioration of the quality of coastal waters and an increase in river contamination; and

Analyzed alternative treatment options included the following technologies:

- ASP: Activated Sludge Process without primary settling treatment and with aerobic digestion of the produced sludge;
- SBR: Sequence Batch Reactors with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- MBBR: Moving Bed Biological Reactor with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- MBR: Membrane Biological Reactor with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery; and
- UASB: Upflow Anaerobic Sludge Blanket Reactor combined with a smaller capacity CAS treatment option (secondary treatment, clarifiers…).

Following analysis (see Part II report of the FS) the CAS was identified as the most suitable option. It is one of the most established, cost effective and the least energy-intensive process treatments, of those considered, allowing for optimal phasing of the plant upgrade (depending on fund availability) and for simultaneous development of networks which in turn assures the Project's overall environmental integrity.

PUBLIC PARTICIPATION

Two public consultation meetings were held on July 31st, 2012 and October 24th, 2012. Scoping consultations were conducted in accordance with national guidance as per the EIA decree and as per the following guidance documents:

- The European Commission's Guidance on EIA Scoping, 2001;
- EIB's Statement of Environmental and Social Principles and Standards, 2009; and
- EIB's Environmental and Social Practices Handbook, 2010.

Prior to the meetings invitation letters were sent to public offices, municipalities, NGOs and other identified private stakeholders, and flyers were hung on public municipal boards located in the invited municipalities.

The main issues of concerns raised and discussed during public consultation meetings included industrial wastewater reaching the plant and the need for an industrial compliance plan, the fate of generated sludge, odor control measures, plant operation during electricity cut-offs, the impact of project/project location on potential airport extension plans, the need to coordinate with the different stakeholders (DGA, Directorate General of Land and Maritime Transport), and the Project duration and phasing.

DESCRIPTION OF THE ENVIRONMENT

Sensitive receptors in the proximity of the WWTP include the Beirut International Airport, beach resorts and army barracks on the coast, and residential and mixed industrial/agricultural areas nearby. These are depicted in an aerial view analysis using Google Earth in Figure 2.

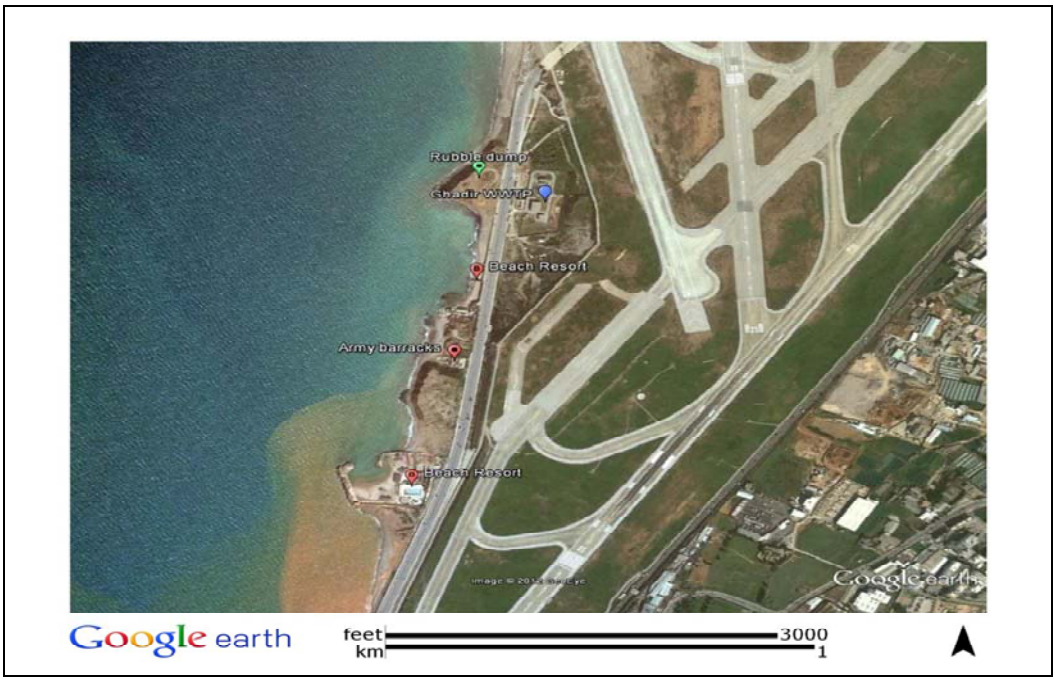


Figure 2 Aerial View of Sensitive Receptors around WWTP

Physical Environment

Climate and meteorology: The Climate conditions in the Study Area are those of a typical eastern Mediterranean climate characterized by warm to hot, dry summers and relatively mild, wet winters. Average monthly temperatures recorded between January 2006 and July 2012 at Beirut International Airport ranged between a minimum of 9.37°C in January 2008 and a maximum of 33.8°C in August 2010. An onshore south-westerly wind from the adjacent Mediterranean Sea affects the area most of the year .The maximum wind speed reported in the Beirut Airport weather station for the period between January 2006 and July 2012 ranged between 13.8m/sec in November 2010 and 32 m/sec in January 2012, while average speed ranged between 6.4m/sec in November 2010 and 14 m/sec in January 2012.

The yearly precipitation levels recorded at the Beirut Airport weather station between 2006 and 2011 varied between a minimum of 510 mm in 2008 and a maximum of 1112 mm in 2009. The highest monthly precipitation rates were recorded from October to March.

Ambient air quality: The high traffic density in Beirut and its suburbs is causing poor atmospheric quality conditions. Fuels and lubricants used in vehicles are a major source of Particulate Matter (PM), sulphur dioxide (SO_2), Nitogen Oxides (NOx), Carbon Monoxide (CO), and carbonyls emissions.

Acoustic environment: The area is expected to be subjected to relatively high noise levels, mainly associated with the contiguous Airport activity and the average traffic flows on the adjacent secondary road.

Soil and topography: The soil of the onshore area mainly consists of a thick layer of medium-dense to dense sand of 10 to 15 m thickness, overlying the sandstones formation. The water table is at 3.8 m depth. There are no major foundation problems for this part of the project area. For the offshore area, where the sea bottom was found at 2 m depth, the soil structure is the same as onshore,

consisting of a thick layer of medium-dense to dense sand resting on sandstone. At this location, the layers under the sea bottom form a stable base for filling with no risk of liquefaction, e.g. under seismic conditions. The seabed was generally higher on the southern side of the outfall pipe than to the north. The difference in level reached more than one meter at some locations.

Seawater quality: The lack of regular seawater quality measurements was noted given the absence of a fixed coastal/marine monitoring station in the Study Area as part of a national monitoring network. The CANA-CNRS study (conducted by the National Scientific Research Centre) showed that the pre-treated water discharged from Al-Ghadir station is always loaded with all sorts of contaminants and that an upwelling of contaminants from bottom till surface is taking place throughout the water column. High densities of fecal coliforms and fecal streptococcus colonies were measured in surface water (>200 ufc/100mL (FS), with the guide value being set at 100 ufc/100mL), accompanied by high levels of chlorophyll-a (1.24 µg/L) and pheophytin-a (0.35 µg/L). The maximum concentrations of nutrients measured were 0.64 µmol/L for phosphate *(~0.06mg/L compared to a Limit Value of 5mg/L when discharged in Sea Water as per Decision 8/1-2001),* 0.1 µmol/L for nitrite *(~0.0046 mg mg/L)* and 0.32 µmol/L for nitrate *(~0.02mg/L compared to an ELV of 90mg/L).* These concentrations were greater than those usually measured in oligotrophic regions, although they are well below respective ELVs. Seasonal thermocline, a natural barrier, did not prevent the ascending of contaminants up till surface when it existed.

These concentrations were greater than those usually measured in oligotrophic regions. Seasonal thermocline, a natural barrier, did not prevent the ascending of contaminants up till surface when it existed.

Biological Environment

Flora in the Buffer Zone around the WWTP

Four major natural subunits were observed in the Flora Study Area, consisting of a mixed habitat; a shoreline habitat; a road side habitat; and a marine habitat.

The mixed habitat is located mainly over the Rubble Dump facing the Preliminary WWTP and over the area surrounding the Plant. The vegetation cover is considered important. It is also a highly mixed area given the different sources of soil and waste making up the dump. Main species reported are species normally found around dumpsites.

The shoreline habitat facing the WWTP and following the coastline can be divided into two main parts:(i) the shoreline, considered as a typical sea shore habitat, covered with coastal plant species, and (ii) the second part of the shore line, mainly covered with algae and other marine plant species.

The road side ecosystem is composed of mixed vegetation and shrubs like *Salsola Kali, Inula sp* and *Ricinus communis* (widely spread), in addition to some cultivated trees such as Eucalyptus and palm trees.

The marine environment is home to phytoplankton which includes all microphytic algae, constituting the basis of the food chain through their primary productivity, and the micro and macrophytic benthic algae which are highly affected by the coastal pollution.

No endemic, rare, endangered or protected species were identified within the buffer zone of 0.5Km around the WWTP.
Plant communities in the Study Area are expected to have been subject to significant pressures, especially around the coastal strip, due to urbanization and land-based pollution. Similarly, and as a

result of the destruction of the vegetation cover by various factors including the extensive coastal urbanization, disturbances to fauna species are expected to be significant. It is thus assumed that they are already in a somewhat degraded state.

Flora in the Service Area (Networks)

The bio–ecological approach was used in the floristic diversity study. Two levels and series of vegetation can be revealed in Lebanon, which are the Mediterranean and pre-steppe Mediterranean, each divided into different sub-units. The Assessment Area is located within the Thermomediterranean and the Euromediterranean? zones. The floral diversity they may hold is based on the types of mother rocks present in each area (limestone, sandstone and marle and marly limestone).

A number of forests are located in the Assessment Area, mainly consisting of Coniferous forest Pinus pinea, Coniferous forest "other pines", mixed coniferous forest, broadleaved evergreen forest, broadleaved deciduous forest, mixed coniferous forest and broadleaved forests, and other wooded lands without trees. The Coniferous forest with "other pines" is considered as the dominant type of forests in the Assessment Area.

Fauna

There are 4.486 known fauna species in Lebanon. 13% of these species are found in the coastal region, while 47% are found in the overall Mount Lebanon region. Invertebrates, in particular insects, are expected to form the most abundant and widespread group of land fauna in the Study Area. A number of dragonflies and butterflies was observed during the field survey.

The marine ecosystem of Lebanon is part of the eastern Mediterranean marine division. Studies were mainly conducted in the 60's and 70's where a range of pelagic marine species in local waters were recorded and documented including 325 species of fish, 404 species of crustaceans, 354 species of molluscs, several species of sea urchins and some 21 species of sponges. Later, studies mainly focused on determining phytoplankton species with little interest on other species.

Socio-economic context

The projected population in the Project area in year 2015 is 1,049,686 inhabitants and the projected one in year 2040 is 1.571.258 inhabitants and in 2050, 1.664.830 inhabitants. School enrolment rates are generally high in Lebanon and in the Study Area, reaching 98 to 100% at the elementary level for both males and females. The highest economic activity rate for both Lebanon and the Study Area is found in Beirut, with 49.1% of the capital's residents economically active. Rates are very similar for the Governorate of Mount Lebanon (49.0%) when excluding the Southern Suburb of Beirut, where economic activity is slightly lower (44%).

Industrial zones in the Ghadir drainage area: Major industrial areas within the Ghadir drainage area are Beirut Southern Suburbs, Choueifat/Kfarchima and Haadath/Baabda. There is no accurate information as to whether these industries are connected to the existing municipal wastewater collection system or whether they discharge to the Ghadir River, other surface water or to soil. Information on whether the industrial plants are pre-treating or treating their wastewater prior to discharge to the respective receptors is not available; on site pre-treatment is however rare. No law-enforcement mechanism has been established to assure that all industries comply with their respective discharge requirements under MoE Decision 8/1 (2001). With the recent enactment of the environmental compliance decree (Decree 8471 of 2012), this situation is likely to improve in the

near-to-medium future, assuming that a suitable enforcement mechanism is developed and adequate resources are allocated by the Competent Authorities.

Fishing Activities near the Outfall Site: The outfall's site is subject to marine traffic and fishing activities that could damage diffusers through the deployment of anchors and fishing nets. A number of diffusers are reported to have been destroyed between 1983 and 1995 (Costain, 1995). Although these diffusers had been repaired in 1997, it is quite likely that some damage to diffusers has occurred over the last 15 years.

Archaeology and Cultural Heritage: Contacts with the Directorate General of Antiquities (DGA), which operates under the Ministry of Culture (MoC), were established with a view to retrieving information regarding cultural heritage in the Study Area. In a letter dated November 15, 2012, the DGA notified ELARD that the networks' area could potentially be home to a rich archaeological and cultural setting. As a result, it was recommended that exact network routes be sent to the DGA as soon as they are set and agreed upon in order to prepare a suitable "Archaeological Intervention Plan".

Municipal solid waste: Approximately 700 to 1000 tons of solid waste is expected to be produced within the Ghadir WWTP drainage area per day. Waste collection in the area is covered by a private company, under a contract from the CDR for the collection of household solid waste and street sweeping in Greater Beirut and some areas of Mount Lebanon.

Sludge management: There is no national sludge management strategy adopted. A national "waste to energy" strategy is under development by different parties (MoEW, MoE, CDR…) based on Council of Ministers decision No. 55 of 2010, and if found to be feasible, could regulate the disposal of sludge from WWTPs.

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Impact Assessment Methodology

Impacts were identified then evaluated and ranked according to their Likelihood of Occurrence (A. High, B. Medium and C. Low) cross-tabulated with their Consequence Rating Criteria reflecting the consequence and significance levels. The scale is illustrated in Table 3.

The assigned impact severity assessment was first considered assuming the absence of project control and mitigation measures. Following investigation and presentation of typical and commonly practiced project mitigations, the impact severities for the mitigated project activities were re-assessed.

Table 3 Environmental Impact Assessment Management Matrix *(Consequence and Significance versus Likelihood of Occurrence)*

		LIKELIHOOD RATING		
		A	B	C
CONSEQUENCE RATING	1	1A	1B	1C
	2	2A	2B	2C
	3	3A	3B	3C
	4	4A	4B	4C
	5	5A	5B	5C

LEGEND

Consequences		**Likelihood**	**Acceptability**
1 - Negligible	4 - Major	A – Low	Beneficial
2 - Minor	5 - Catastrophic	B – Medium	Negligible with minor mitigation
3 - Moderate	6 - Beneficial	C – High	Impacts need to be minimised
			Unacceptable

Impact Assessment Summary

A summary of impacts from WWTP's and Networks' Construction and Operation before and after mitigation is shown in the two tables below.

Summary of WWTP Construction and Operation Impacts Without Mitigation Measures

Impact/Pathway	Water Resources	Air Quality	Acoustic Environment	Landscape	Land Use	Soil & Sediment	Biodiversity	Socio-Economic	Occupational H&S
Construction Phase									
General Construction Activities		2C	3C	2C			3C		3B
Water Consumption	2A								
Oil Spills & Solid Waste Generation	3B					3B			
Excavation and Trenching						3B			
Dredging Works (Phase II)	3C					3C			
Job Creation								6C	
Traffic Generation								4A	
Operation Phase									
General Operation (Phase I)	6B		1A				6B		4B
General Operation (Phase II)	6C		1A	3C			6B		4B
Plant Failure Conditions	2B								
Water Consumption	3C								
Oil Spills	3A								
Wastewater Leakages	4A								
Odor Generation		2B							

Summary of WWTP Construction and Operation Impacts Without Mitigation Measures									
Impact/Pathway	Water Resources	Air Quality	Acoustic Environment	Landscape	Land Use	Soil & Sediment	Biodiversity	Socio-Economic	Occupational H&S
Solid Waste/Sludge Generation						1A			
Power Generation & Sludge Treatment		3B							
Public Health								6C	
Job Creation								6C	

Summary of WWTP Construction and Operation Impacts With Mitigation Measures									
Impact/Pathway	Water Resources	Air Quality	Acoustic Environment	Landscape	Land Use	Soil & Sediments	Biodiversity	Socio-Economic	Occupational H&S
Construction Phase									
General Construction Activities		1B	2C	1C			1A		2A
Water Consumption	1A								
Oil Spills & Solid Waste Generation	2A					2A			
Excavation and Trenching						2A			
Dredging Works (Phase II)	2B					2B			
Job Creation								6C	
Land Expropriation									
Traffic Generation								2A	
Operation Phase									
General Operation (Phase I)	6B		1A				6B		2B
General Operation (Phase II)			1A	2C			6B		2B
Plant Failure Conditions	2A								
Water Consumption	2B								
Oil Spills	2A								
Wastewater Leakages	2A								
Solid Waste/ Sludge Generation						1A			
Odor Generation		1B							
Power Generation & Sludge Treatment		2B							
Public Health								6C	
Job Creation								6C	

Summary of Networks' Construction and Operation Impacts Without Mitigation Measures in Place									
Impact/Pathway	Water Resources	Air Quality	Acoustic Environment	Landscape	Land Use	Soil & Sediment	Biodiversity	Socio-Economic	Occupational H&S
Construction Phase									
General Construction Activities		2C	3C	2C	3B		3B		3B
Water Consumption	2B								

Oil Spills & Solid Waste Generation	3B								
Excavation and Trenching						3B			
Job Creation								6C	
Land Expropriation								2C	
Traffic Generation								4A	
Operation Phase									
General Operation	6C		1A	1A		6B	6B		4B
Oil Spills	3B								
Wastewater Leakages	3A								
Public Health								6C	

Summary of Networks' Construction and Operation Impacts With Mitigation Measures

Impact/Pathway	Water Resources	Air Quality	Acoustic Environment	Landscape	Land Use	Soil & Sediment	Biodiversity	Socio-Economic	Occupational H&S
Construction Phase									
General Construction Activities		1B	2C	1C	2A		2A		2A
Water Consumption	1B								
Oil Spills & Solid Waste Generation	2A								
Excavation and Trenching						2A			
Job Creation								6C	
Land Expropriation								1C	
Traffic Generation								2A	
Operation Phase									
General Operation	6C		1A	1A		6B	6B		2B
Oil Spills	2A								
Wastewater Leakages	2A								
Public Health								6C	
Cultural Heritage								6C	

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Mitigation measures were identified and proposed for the Networks Construction (Table 4), the WWTP Construction (Table 5), the Networks Operation (Table 6), and the WWTP Operation (Table 7).

Table 4 Construction Environmental and Social Management Plan (CESMP) – **Networks**

IMPACTED VEC	PROJECT ACTIVITY (IMPACT/ PATHWAY)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
Water resources	Water consumption	▪ Adopting Water Saving Techniques ▪ Raising Construction Workers' Awareness	Implementation: Contractor / Supervision: Supervision Consultant	Included in contractor cost
	Oil spills and solid waste generation	▪ Carrying out rehabilitation (reinstatement of soil, surface leveling, re-vegetation and mulching) of disturbed areas as soon as practicable and mmediately remediating any localized erosion ▪ Adopting and implementing IFC guidelines for the prevention and control of hydrocarbon / chemical releases ▪ Promoting "good housekeeping" practices ▪ Storing fuel, oil and chemicals in specifically designed areas on site, on an impermeable base within a suitability contained area ▪ Ensuring availability of oil spill response kits on the work area ▪ Installing drip trays underneath equipment to contain leakages ▪ Developing a spill contingency plan ▪ Installing drainage systems and erosion and sediment controls in case of a cross over a river or a stream, at the crossover between the network and the river, prior to commencement of construction and earth clearing ▪ Collecting and reusing or disposing of appropriately all used oils generated on the construction site.	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Air quality	General construction	▪ Using well designed, well maintained and well operated equipment/vehicles ▪ Employing environmentally friendly equipment (higher fuel efficiency, air pollution control devices ...). ▪ Installing diesel particulate filters on construction equipment ▪ Watering-down work area/s particularly near sensitive receptors ▪ Efficiently scheduling deliveries and enforcing appropriate speed limits (< 40 km/h) ▪ Travelling on existing and paved tracks wherever possible ▪ Maintaining stockpiles at minimum heights and in the optimum shape (i.e.	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost

IMPACTED VEC	PROJECT ACTIVITY (IMPACT/ PATHWAY)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
		Stabilization) to reduce wind erosion. ▪ Installing covers on back loads of dump trucks and large vehicles		
Acoustic environment	General construction	▪ Equipping all equipment with intake and exhaust mufflers ▪ All vehicles and machinery should be maintained in good repair ▪ Any machinery, which is intermittent in use, should be shut off in periods of non-use	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Landscape and land use	General construction	▪ Relocating any affected trees to a different land with the same specification ▪ Preserving removed roots and avoiding damaging them	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Soil and sediments	Excavation and trenching works, oil spills, and solid liquid waste generation	▪ Adopting minimum safe operating widths and using existing tracks whenever possible ▪ Adhering to proper waste management practices ▪ Keeping all equipment well maintained and adopting a Spill Prevention and Response Plan	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Biodiversity	General construction	▪ Preserving excavated top soil and re-vegetating disturbed areas ▪ Raising the awareness of workers on the respect and preservation of wildlife ▪ Spreading excavated topsoil containing pollen and roots of the original vegetation upon completion of construction works ▪ Conducting a biodiversity assessment over the network routes prior to the start of works on networks	Implementation: Contractor Supervision: Supervision Consultant CDR	Biodiversity assessment: 30,000 USD *(assuming 2 field visit rounds - wet and dry season)*
Socio-economic	Land expropriation and general construction activities	▪ Establishing a consultative process with potential affected families (if any) ▪ Ensuring fair and full compensation as per the Lebanese expropriation law ▪ Developing and "Archaeological Intervention Plan" in coordination with the DGA	CDR, DGA	To be determined
Occupational health and safety	General construction	▪ Provision and maintenance of appropriate Personal Protective Equipment (PPE) ▪ Warning staff about potential construction hazards ▪ Ensuring that qualified and accessible first-aid is provided at all times ▪ Posting signs throughout the construction area	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost

Table 5 Construction Environmental and Social Management Plan (CESMP) – **WWTP**

IMPACTED VEC	PROJECT ACTIVITY (IMPACT/ PATHWAY)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
Water resources	Water consumption	▪ Adopting Water Saving Techniques ▪ Raising Construction Workers' Awareness	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
	Oil spills and solid waste generation	▪ Carrying out rehabilitation (reinstatement of soil, surface leveling, re-vegetation and mulching) of disturbed areas as soon as practicable and immediately remediating any localized erosion ▪ Adopting and implementing IFC guidelines for the prevention and control of hydrocarbon / chemical releases *(International Finance Corporation's Environmental, Health, and Safety General Guidelines)* ▪ Promoting "good housekeeping" practices ▪ Storing fuel, oil and chemicals in specifically designed areas on site, on an impermeable base within a suitability contained area ▪ Ensuring availability of oil spill response kits on the work area ▪ Installing drip trays underneath equipment to contain leakages ▪ Developing a spill contingency plan ▪ Installing drainage systems and erosion and sediment controls in case of a cross over a river or a stream, at the crossover between the network and the river, prior to commencement of construction and earth clearing ▪ Collecting and reusing or disposing of appropriately all used oils generated on the construction site.	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
	Dredging activities	▪ Using Silt Curtains ▪ Reducing velocity of dredging ▪ Decreasing the time-frame over which the dredging operation is to take place ▪ Limiting dredging operations to calmer sea states ▪ Ensuring proper disposal of dredged material	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost

IMPACTED VEC	PROJECT ACTIVITY (IMPACT/ PATHWAY)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
Air quality	General construction activities	Same mitigation measures as the ones suggested for the construction of the Networks: ▪ Using well designed, well maintained and well operated equipment/vehicles ▪ Employing environmentally friendly equipment (higher fuel efficiency, air pollution control devices ...). ▪ Installing diesel particulate filters on construction equipment ▪ Watering-down work area/s particularly near sensitive receptors ▪ Efficiently scheduling deliveries and enforcing appropriate speed limits (< 40 km/h) ▪ Travelling on existing and paved tracks wherever possible ▪ Maintaining stockpiles at minimum heights and in the optimum shape (i.e. Stabilization) to reduce wind erosion. ▪ Installing covers on back loads of dump trucks and large vehicles	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Acoustic environment	General construction activities	Same mitigation measures as the ones suggested for the construction of the Networks: ▪ Equipping all equipment with intake and exhaust mufflers ▪ All vehicles and machinery should be maintained in good repair ▪ Any machinery, which is intermittent in use, should be shut off in periods of non-use	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Landscape and land use	General construction activities	▪ Hoarding or boundary fencing around construction site ▪ Coordinating with the Directorate General of Land and Maritime Transport	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Soil and sediments	Land excavation and trenching works, oil spills, and solid and liquid waste generation	▪ Adhering to proper waste management practices ▪ Keeping all equipment well maintained and adopting a #	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
	Land reclamation/ dredging activities	▪ Using silt curtains ▪ Reducing velocity of dredging ▪ Decreasing the time-frame over which the dredging operation is to take place ▪ Confining dredging operations to calmer sea states	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost

IMPACTED VEC	PROJECT ACTIVITY (IMPACT/ PATHWAY)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
Biodiversity	General construction	Same mitigation measures as the ones suggested for the construction of the Networks: ▪ Preserving excavated top soil and re-vegetating disturbed areas ▪ Raising the awareness of workers on the respect and preservation of wildlife ▪ Spreading excavated topsoil containing pollen and roots of the original vegetation upon completion of construction works ▪ Conducting a biodiversity assessment over the network routes prior to the start of works on networks	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost
Socio-economic context	Traffic generation and general construction activities	▪ Developing a traffic management plan ▪ Continuously liaising with local and the governmental authorities ▪ Allowing only certified and trained drivers to carry out transportation related activities ▪ Developing an "Archaeological Intervention Plan" in coordination with the DGA	Contactor Supervision consultant Municipalities Local committee	Included in contractor cost
Occupational health and safety	General construction	Same mitigation measures as the ones suggested for the construction of the Networks: ▪ Provision and maintenance of appropriate Personal Protective Equipment (PPE) ▪ Warning staff about potential construction hazards ▪ Ensuring that qualified and accessible first-aid is provided at all times ▪ Posting signs throughout the construction area	Implementation: Contractor Supervision: Supervision Consultant	Included in contractor cost

Table 6 Operation Environmental and Social Management Plan (OESMP) – **Networks**

Impacted VEC	PROJECT ACTIVITY (Impact/ Pathway)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
Water resources	Wastewater leakages	▪ Installing pressure monitors on force mains to allow the early detection of leaks ▪ Conducting regular inspection and maintenance of electrical and mechanical components at pumping stations – Regular testing (monthly) of back-up power (generator) at pumping stations ▪ Installing an emergency flow line or bypass chambers to divert sewage flow in case repairs to the sewer are needed and the construction of emergency storage pond near lifting stations for storage of wastewater in case of pump failure ▪ Carrying out flushing and a CCTV program to observe gravity sewer condition and monitor changes every 5 years ▪ Implementing a comprehensive alarm system at the pump station, monitoring numerous parameters covering station operation and the status of standby generator system ▪ Immediately reporting any leakages to municipal/governmental representative and stopping the source of leak (close valve, seal pipe, seal hole or as appropriate)	Networks operator(s)	Quotations for standby generator, flow meters, H2S and wastewater quality monitoring and alarm system to be requested Regular maintenance activities: USD1,000/year
Occupational health and safety	Operation	▪ Providing appropriate safety equipment, fire protection measures, and monitoring instruments on-site ▪ Providing sufficient lighting that should comply with zoning requirements.	Networks operator(s)	Included in contractor cost

Table 7 Operation Environmental and Social Management Plan (OESMP) – **WWTP**

Impacted VEC	PROJECT ACTIVITY (Impact/ Pathway)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
Water resources	Plant failure conditions	▪ Proper management coupled with continuous and effective monitoring and maintenance ▪ The preparation, implementation and monitoring of an industrial pollution abatement	Plant operator(s)	Industrial pollution abatement plan: Preliminary survey:

Impacted VEC	PROJECT ACTIVITY (Impact/ Pathway)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
		program in the Al-Ghadir drainage area ▪ Ensuring redundancy in the WWTP design ▪ Ensuring adequate training of plant operators		~300,000 USD Implementation: to be determined
	Water consumption	▪ Adopting water saving techniques ▪ Proper training and awareness raising among personnel (especially in maintenance and cleaning)	Plant operator(s)	Included in operator cost
	Oil spills	▪ Same mitigation measures suggested to mitigate the risk of oil spills and leakages during construction ▪ Using secondary containment basins for long term storage of lubricants and fuels used on site	Plant operator(s)	To be determined
	Wastewater leakages	▪ Immediate reporting of leakage to municipal/governmental representative ▪ Stopping the source of leak (close valve, seal pipe, seal hole or as appropriate) ▪ Immediate cleaning of the spill by removing affected topsoil layer by trained employee	Plant operator(s)	Included in operator cost
Air quality	Odor generation	▪ Conducting odor simulation studies for pumping stations and the WWTP during the detailed design phase to confirm that emissions thresholds are met and that concentrations of odorous compounds (mainly H_2S and NH_3) remain below threshold values at the nearest receptors ▪ Executing a regular program of maintenance to prevent the clogging of the fine-diffusers or diffuser plates to maintain adequate dissolved oxygen levels in the aeration tanks ▪ Executing regular cleaning of aeration tank walls and floors, washing weirs, and removing scum regularly ▪ Increasing the pumping rate of the thickened sludge, monitoring a low sludge blanket level, and increasing the influent flow rate to the sludge-holding tank without losing thickening to reduce odors from final settlement tanks and sludge holding tanks ▪ Providing flow regulating chambers, drainage valves, standby pumps, as well as electric standby generators to reduce the possibility of wastewater flooding	Plant operator(s)	Odor simulation study: 10,000 USD
	Air pollution from power generation and sludge	▪ Maximizing the energy recovery potential to reduce project contribution to air pollution and to climate change	Plant operator(s)	Included in operator cost

Impacted VEC	PROJECT ACTIVITY (Impact/ Pathway)	MITIGATION MEASURES	INSTITUTIONAL RESPONSIBILITIES	COST ESTIMATE
	treatment	▪ Choosing efficient and low-emission equipment ▪ Monitoring the heating value of the gas to maintain a stable flare		
Acoustic environment	General Operation	▪ Placing possibly noisy equipment in isolated units ▪ Equipping all equipment with intake and exhaust mufflers ▪ Fencing and screening the site with a green belt to muffle any residual noise generation.	Plant operator(s)	To be determined
Occupational health and safety	General Operation	▪ Restricting unattended public access by proper fencing and guarding ▪ Properly labeling and storing chemicals (NaOCl, $NaHSO_3$), oils, and fuel to be used on-sites ▪ Providing hand railing at all access corridors above and around all open treatment units, (except where sidewalls extend ≥1.1 meters above ground level); ▪ Providing appropriate safety equipment, fire protection measures, and monitoring instruments ▪ Providing sufficient lighting that should comply with zoning requirements. ▪ Preparing a fire protection and prevention program to be approved by the Government ▪ Ensuring that emergency action plan and fire hazard inspection procedures are available on-site at all times for all employees ▪ Training staff about the fundamentals of occupational health and safety procedures, and about handling hazardous material containers and related wastes.	Plant operator(s)	Included in operator cost

1 INTRODUCTION

1.1 GENERAL OVERVIEW

The Joint Venture (JV) formed by WS Atkins, LDK Consultants, and Pescares has been contracted by the European Investment Bank (EIB) to conduct a Feasibility Study (FS) for the extension and upgrade of the existing Al-Ghadir preliminary wastewater treatment facility (the "Project"). The Feasibility Study was later extended to include the construction of missing sewer networks in the related drainage area. The study is financed through the EIB under the Facility for Euro-Mediterranean Investment and Partnership (FEMIP) Support Fund, as part of the Horizon 2020 initiative for the depollution of the Mediterranean Sea, and is undertaken in cooperation with the Council for Development and Reconstruction (CDR) and the Ministry of Energy and Water (MoEW) in Lebanon.

The Project aims to improve wastewater services for the population of the Ghadir River Drainage Basin, which includes parts of Beirut City and its Southern Suburb and parts of the Baabda, Aley, and Chouf districts. The Feasibility Study aims to collect and analyze the necessary baseline data, examine different technical alternatives for Plant design, and estimate the costs related to the Project.

Earth Link and Advanced Resources Development s.a.r.l. (ELARD) is conducting an Environmental and Social Impact Assessment (ESIA) on behalf of the JV to support this Feasibility Study (FS). The ESIA aims to identify and assess all possible impacts resulting from the Project and to mitigate potential negative impacts while maximizing the benefits of positive impacts. It is to be executed in compliance with the Lebanese legislative framework on EIA and EIB guidelines on Environmental and Social Impact assessment.

1.2 PURPOSE AND SCOPE OF THE ESIA STUDY

The Environmental and Social Impact Assessment (ESIA) is a decision-making tool which systematically identifies the environmental impacts of development proposals. Its main objective is to evaluate, prevent, and mitigate any adverse impacts potentially generated by a proposed Project while also assessing possible alternatives. The ESIA Study also aims at developing an environmental action plan which will include guidelines and recommendations for proponents and contractors on actions that need to be taken in order to minimize environmental damage and enhance positive impacts, as well as a contingency plan in case damage/accidents occur, and an environmental monitoring of reconstruction activities.

The present ESIA includes an assessment of the potential impacts anticipated as part of the design, construction and operation phases of the extension and upgrade of the Al-Ghadir Preliminary Wastewater Treatment Plant. This is done through a systematic investigation of project components and identification of key sensitive receptors, based on a thorough baseline environmental and socio-economic assessment of the study area. It also proposes alternatives for preventing and mitigating those impacts as part of an Environmental and Social Management Plan.

This ESIA is done in compliance with the Lebanese EIA decree which has been recently published in the official Gazette as Decree No. 8633 dated August 16, 2012. The decree defines the procedures and steps to prepare and submit environmental impact assessment reports for review and approval by the Ministry of Environment (MoE). The overall EIA process is illustrated in Figure 1.1.

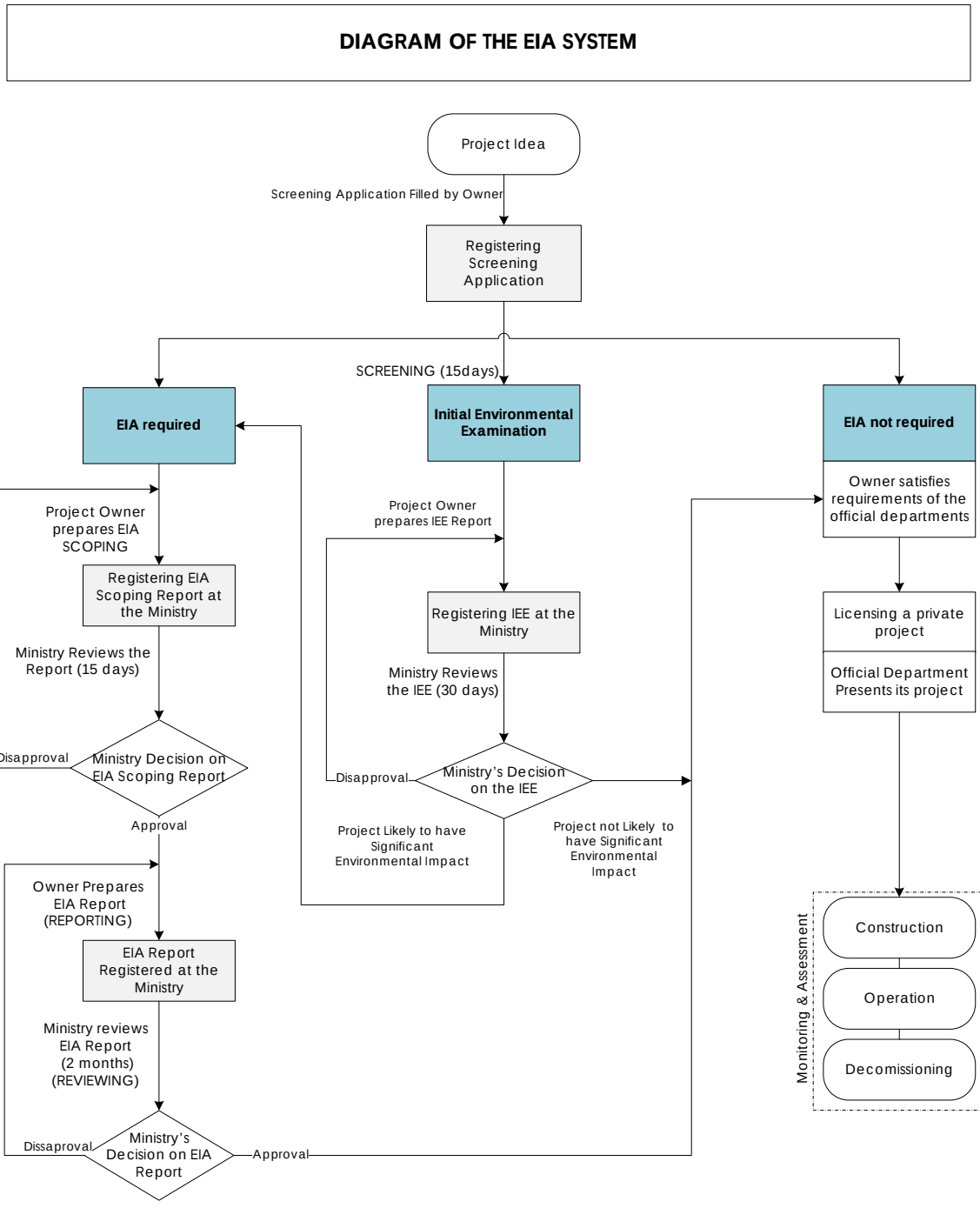


Figure 1.1 EIA Process as per Decree No. 8633 (EIA Decree)

With reference to the planned Project activities in Al-Ghadir and in compliance with the EIA Decree, the Project requires an EIA study (as an "Integrated Wastewater Project" which figures under Annex 1 of the EIA Decree) to ensure an environmentally sound management system (i.e. engineering design) for treated wastewater discharge into the sea.

1.3 PROJECT PROPONENTS

The project is financed by EIB. The CDR is the Project Promoter, and the Ministry of Energy and Water and the Beirut and Mount Lebanon Water and Wastewater Establishment (BMLWWE) under the auspices of Ministry of Energy and Water are the Project Beneficiaries.

The JV (WS Atkins, LDK Consultants, and Pescares) is responsible for developing the Feasibility Study and counts as Project Developer, while the EIB is funding the Study (Project Funder). ELARD is the certified practitioner conducting the ESIA Study.

1.4 ESIA PRACTITIONER

ELARD is a highly specialized consulting firm that employs professionals in the field of applied earth and environmental sciences, including solid waste management, water resources management and development, water and wastewater treatment, pollution containment and abatement, and environmental policy development and institutional strengthening. ELARD focuses on providing assistance to private developers, industries and public agencies in finding cost effective solutions for highly specialized and complex problems related to the management of earth resources, and the protection of the environment.

Founded in Beirut, Lebanon in 1996, the firm quickly expanded to become one of the leading environment and water resources management consulting firms in the region, offering its services in the Middle East, the Gulf, North Africa, South Western Asia and more recently in the Caspian Sea area. With established offices in Lebanon, Syria, and the Emirates, field offices are opened on an as-needed basis, as was the case in Pakistan for an extensive groundwater resource assessment project.

ELARD has accumulated hands-on experience in preparing Environmental and Social Impact Assessments (ESIAs) and Environmental Baseline Surveys (EBS) related to the development/construction sector, the industrial sector (cement manufacturing, wastewater treatment plants, etc.) and the oil and gas sector (onshore seismic, well exploration and drilling operations, oil refining, among others).

ELARD has gained vast experience in the establishment of objective-oriented, cost-effective and practical Environmental Management Plans/Procedures tailored to the local settings of each individual project context, project proponent's own health, safety and environmental policies and international guidelines and codes of practice.

ELARD is an accredited EIA practitioner in Lebanon and is eligible to submit EIA reports for approval by the Ministry of Environment (MoE) as per the local legislation.

A list of ESIA preparers is provided in Annex 7.

1.5 ESIA REPORT STRUCTURE

The ESIA Report was prepared following the requirements set by the national Environmental Impact Assessment (EIA) Decree (Decree. No. 8633). It is structured as follows:

- Introduction;
- Regulatory and Institutional Framework;
- Project Description;
- Analysis of Alternatives;
- Public Participation;
- Description of the Environment;
- Environmental and Social Impacts;
- Environmental and Social Management Plan;
- References; and
- Annexes.

2 REGULATORY AND INSTITUTIONAL FRAMEWORK

The aim of this section is to identify all relevant public and private institutional stakeholders and applicable Lebanese national environmental legislation, policies, and standards as well as international treaties, agreements, standards/ guidelines associated with the project.

2.1 LEGISLATIVE FRAMEWORK RELEVANT TO THE PROJECT

2.1.1 OVERVIEW OF LEGISLATION

An overview of the main environmental legislations relevant to the current project is presented in Table 2.1.

Table 2.1 Overview of the Lebanese legislative framework relevant to the project

Year	Law / decree	Relevant provisions
2012	Decree 8633	Defines scope and stages of the national EIA process.
2012	Decree 8471	Defines the applicability domain of environmental compliance in classified establishments.
In progress	Draft Decree	Integrated Coastal Zone Management.
2005	Law 690	Law on the Organization of the MoE.
2002	Decision 5/1	Review of the “Initial Environmental Examination" report.
2002	Decision 6/1	Review of Scoping report and EIA report.
2002	Law 444	Framework Law for Environmental Protection.
2002	Decree 8018	Establishes procedures and guidelines for the establishment and operation of industrial institutions/facilities and distance requirements from water resources according to industry classification.
2001	Decision 8/1	Sets “Emission Standards for Air Pollutants And Wastewater Discharges from Classified Establishments and Wastewater Treatment Plants".
2001	Law 377	Transformed the Ministry of Hydraulics and Electric Resources (MHER) into the Ministry of Energy and Water (MoEW) and named the regional water authorities as Water and Wastewater Establishments located in Beirut, Bekaa, North Lebanon and South Lebanon.
2000	Law 241	Reducing the number of Water Establishments to 4.
2000	Law 221	Organization of the Water Sector by the regrouping of 22 Offices and 216 Committees of Water in 5 regional Establishments.
1999	Decree 1039	Establishes drinking water standards.
1997	Law 623	Implementing penalties for vandalism of water, telephone and electricity infrastructure.
1996	Decision 52/1	Specifying the National Standards for Environmental Quality and the Environmental Limit Values for Air and Water.

Year	Law / decree	Relevant provisions
1996	Decision 40/1	Amendment of decision 22/1.
1995	Decision 22/1	Enforcement of Environmental Standards for Industries.
1994	Law 387	Allows the Government to support the Basel Convention concerning the control of the transboundary movement of hazardous waste and their disposal.
1993	Decree 3899	Regulates the Extraction of Sand and Other Materials from the Public Maritime Domain and Seabed.
1992	Decree 2522	Sets annual fees for the temporary use of the public maritime domain. Although the law does not forbid building on the coastal zone area, it sets the temporary character of any use of the public maritime domain.
1990	Law 14/90	Protection of the Sea and the Coast
1988	Law 64/88	Environmental protection against hazardous waste that could harm air, water, biodiversity, soil, and people.
1985	Legislative Decree 34	Cancels Decree 144/1983 relevant to settling violations of the public maritime domain and regional water depths.
1983	Legislative Decree 138	Specifies the width of the regional waters and regions where navigation is forbidden. Protection of the marine fauna and flora
1977	Legislative Decree 126	Ratification Of The UNEP Barcelona Convention On Mediterranean Sea Protection.
1976	Decree 126	Convention for the Protection of the Mediterranean Sea against Pollution.
1974	Decree 9132	Affiliates the seabed and depth of regional waters to the public maritime domain.
1974	Decision 7/1	Provides common instructions for coordinating the stoppage of contraventions on the public maritime domain.
1972	Decision 67	Methodology for bacteriological analysis of water.
1968	Decree 11541	Organization of the body responsible for monitoring the coast within the Internal Security Forces.
1968	Decree 9791	Organization Of Coastal Monitoring Activities.
1966	Decree 4810	Regulates the Occupation of the Public Maritime Domain. The decree sets the use of the public maritime domain as strictly given for public use. Any exception should be governed by specific rules determined in the decree.
1966	Decree 4809	Regulating The Lebanese Coastal Zone.
1964	Decree 17614	The Exploitation Of Public Maritime Lands.
1950	Law 63/50	Protection of the Marine Fauna and Flora.
1933	Decree 2761	Provides guidelines related to Wastewater Management and Disposal.
1932	Decree law 16 L	The decree law based on Decision 320/1926. It mandates the establishment of buffer zones for the protection of all surface and groundwater resources from any type of activity/potential source of pollution. Requirements for buffering are found in Decision 320/26.
1926	Decision 320/1	Decision relative to the conservation of public water and its use. It prohibits blocking the free flow of public water or the performance of some works such as drilling for underground or artesian water without obtaining the proper permit from the proper administration.
1925	Decision 144	Allows the granting of provisional permits for the exploitation of public governmental land through presidential decisions, or municipal properties by municipalities according to the texts regulating municipal works.

2.1.2 RELEVANT NATIONAL STANDARDS AND GUIDELINES

Effluents

Standards and quality requirements for bathing water in sea water, rivers and lakes in Lebanon were established by Decision 52/1 (in its Annex 4) dated 1996. Defined Guide values and maximum admissible limit values are shown in the table below.

Table 2.2 Guide values and maximum admissible limit values for bathing water

PARAMETER	GUIDE VALUE	MAXIMUM ADMISSIBLE LIMIT
Microbiological Parameters		
Total coliforms (/100 ml)	500	10000
Thermotolerant coliforms (/100 ml)	100	2000
Faecal streptococci (/100 ml)	100	-
Salmonellae (/L)	0	-
Enteroviruses (/10L)	0	-
Physicochemical Parameters		
pH	6-9	
Color	No abnormal change in color	No film visible on the surface of the water and no odor
Mineral oils (mg/L)	<0.3	

The new standards for discharge into receiving water bodies are presented in Decision no. 8/1, which updates similar standards set by Decision 52/1. Decision 8/1 also stipulates the maximum emission limits of air pollutants for all industrial plants as a basis to control pollution loads in the country.

The following table presents relevant standards for wastewater discharge into receiving water bodies (also referred to as ELVs).

Table 2.3 Maximum limits (ELVs) for wastewater discharge into receiving water bodies and public sewers

PARAMETER	MAXIMUM ALLOWABLE LIMITS FOR RECEIVING WATERBODIES		
	PUBLIC SEWERS	SURFACE WATER (INLAND)	SEA
Color	none	none	none
pH	6-9	6-9	6-9
Temperature	35ºC	30 ºC	35ºC
BOD (5 day, 20°C)	125 mg/l	25 mg/l	25 mg/l
COD (dichromate)	500 mg/l	125 mg/l	125 mg/l
Total Phosphorus	10 mg/l	10 mg/l	10 mg/l

PARAMETER	MAXIMUM ALLOWABLE LIMITS FOR RECEIVING WATERBODIES		
	PUBLIC SEWERS	SURFACE WATER (INLAND)	SEA
Total Nitrogen*	60 mg/l	30 mg/l	30 mg/l
Suspended solids	600 mg/l	60 mg/l	60 mg/l
AOX	5	5	5
Detergents	-	3 mg/l	3 mg/l
Coliform Bacteria 370 C in 100 ml**	-	2,000	2,000
Salmonellae	Absence	Absence	Absence
Hydrocarbons	20 mg/l	20 mg/l	20 mg/l
Phenol Index	5 mg/l	0.3 mg/l	0.3 mg/l
Oil and grease	50 mg/l	30 mg/l	30 mg/l
Total Organic Carbon (TOC)	750 mg/l	75 mg/l	75 mg/l
Ammonia (NH_4^+)	-	10 mg/l	10 mg/l
Silver (Ag)	0.1 mg/l	0.1mg/l	0.1 mg/l
Aluminium (Al)	10 mg/l	10 mg/l	10 mg/l
Arsenic (As)	0.1 mg/l	0.1 mg/l	0.1 mg/l
Barium (Ba)	2 mg/l	2 mg/l	2 mg/l
Cadmium (Cd)	0.2 mg/l	0.2 mg/l	0.2 mg/l
Cobalt (Co)	1 mg/l	0.5 mg/l	0.5 mg/l
Chromium total (Cr)	2 mg/l	2 mg/l	2 mg/l
Hexavalent Chromium (Cr^{VI+})	0.2 mg/l	0.2 mg/l	0.2 mg/l
Copper total (Cu)	1 mg/l	0.5 mg/l	1.5 mg/l
Iron total (Fe)	5 mg/l	5 mg/l	5 mg/l
Mercury total (Hg)	0.05 mg/l	0.05 mg/l	0.05 mg/l
Manganese (Mn)	1 mg/l	1 mg/l	1 mg/l
Nickel total (Ni)	2 mg/l	0.5 mg/l	0.5 mg/l
Lead total (Pb)	1 mg/l	0.5 mg/l	0.5 mg/l
Antimony (Sb)	0.3mg/l	0.3mg/l	0.3mg/l
Tin total (Sn)	2 mg/l	2 mg/l	2 mg/l
Zinc total (Zn)	10 mg/l	5 mg/l	5 mg/l
Active (Cl_2)	-	1 mg/l	1 mg/l
Cyanides (CN^-)	1 mg/l	0.1mg/l	0.1mg/l

PARAMETER	MAXIMUM ALLOWABLE LIMITS FOR RECEIVING WATERBODIES		
	PUBLIC SEWERS	SURFACE WATER (INLAND)	SEA
Fluorides (F)	15 mg/l	25 mg/l	25 mg/l
Nitrate (NO_3^-)	-	90 mg/l	90 mg/l
Phosphate (PO_4^{3-})	-	5 mg/l	5 mg/l
Sulphate (SO_4^{2-})	1,000 mg/l	1,000 mg/l	1,000 mg/l
Sulphide (S^{2-})	1 mg/l	1 mg/l	1 mg/l

*Sum of Kjeldahl-N(organic N + NH_3),NO_3-N, NO_2-N
**For discharges in close distance to bathing water, a stricter environmental limit value could be necessary

Table 2.4 Comparison of ELVs between MoE Decision 8/1-2001 and European Directive 91/271/EC for the discharge of municipal wastewater

PARAMETER	MOE DECISION 8/1 (2001)	DIRECTIVE 91/271/EC
pH	6 – 9	-
BOD_5 (mg/l)	25	25
COD (mg/l)	-	125
TSS (mg/l)	60	35*[1] (for PE >10.000) 60* (for 2.000 <PE<10.000)
Total N (mg/l)	30	Only for discharges to sensitive receptors: 10 (for PE >100.000) 15 (for 10.000 <PE<100.000)
NH_4^+ (mg/l)	10	-
NO_3^- (mg/l)	90	-
Total P (mg/l)	10	Only for discharges to sensitive receptors: 1 (for PE >100.000) 2 (for 10.000 <PE<100.000)
PO_4^{3-} (mg P/l)	5	-
Total Coliform 37°C (MPN/100 ml)	2000	-
Salmonellae:	absence	-

[1] Optional

The Decision 8/1 (2001) also refers to the required studies for the design of sea outfalls (bathymetric studies, soil stability, wind parameters, topographic surveys, biodiversity, socio economic analysis, chemical information about the sea water dilution/dispersion modelling, salinity and temperature).

Noise

The National Maximum allowable noise level and the permissible Noise Exposure standards according to Decision 52/1 are presented in Table 2.5 and Table 2.6, respectively. As per Decision 52/1, the Maximum instantaneous noise level (Lmax) should not exceed 134 dB(A).

Table 2.5 Permissible Ambient Noise Levels in Selected Regions

REGION TYPE	LIMIT FOR NOISE LEVEL DB(A)		
	DAY TIME (7:00.-18:00.)	EVENING TIME (18:00.- 22:00)	NIGHT TIME (22:00 – 7:00)
Residential areas with some construction sites or commercial activities or located near a road	50-60	45-55	40-50
Urban residential areas	45-55	40-50	35-45
Industrial areas	60-70	55-65	50-60
Rural residential areas, hospitals and gardens	35 – 45	30 – 40	25 – 35

Table 2.6 National Occupational Noise Exposure Standards in Work Areas

DURATION PER DAY (hours)	SOUND LEVEL db(a)
8	90
4	95
2	100
1	105
½	110
¼	115

Air Emissions

The maximum allowable limits of atmospheric ambient air pollutants (Decision 52/1) are presented in Table 2.7.

Table 2.7 Maximum Allowable Limits for Ambient Air Pollutants (Decision 52/1)

POLLUTANT	MAXIMUM ALLOWABLE CONCENTRATION (in µG/m^3)	AVERAGING PERIOD
Sulfur Dioxide (SO_2)	350	1 hour
	120	24 hours
	80	1 year
Nitrogen Dioxide (NO_2)	200	1 hour
	150	24 hours
	100	1 year
Ozone (O_3)	150	1 hour
	100	8 hours
Carbon Monoxide (CO)	30000	1 hour
	10000	8 hours
Total Suspended Particulate (TSP)	120	24 hours
Particulate Matter (PM-10)	80	24 hours
Lead	1.0	1 year
Benzene	5 ppb	1 year

The general emission limit values are specified in Decision 8/1. These emission limit values are valid for all industrial plants, including all kind of power plants, as long as no specific regulations for single branches are given.

Emission standards are given as mass flows and as concentrations. For mass flows lower than the ones given in column 3 of Table 2.8, no concentration emission limit value exists. If the mass flows given in column 3 are exceeded the concentration of emission limit values of column 2 will automatically have to be kept.

The assignment of different pollutants to the respective groups for particulate inorganic pollutants, gaseous inorganic pollutants and cancer causing pollutants are given in Table 2.8. The list and classification for gaseous organic compounds are given in Table 2.9.

Table 2.8 Maximum Emission Limits of Air Pollutants (Decision 8/1)

PARAMETER	EMISSION LIMIT VALUE	REMARK
Dust	200 mg/m^3 (for new facilities) 500 mg/m^3 (for existing facilities)	Non containing hazardous compounds
Particulate Inorganic Pollutants		
Group I	1 mg/m^3	Mass flow > 5g/h
Group II	10 mg/m^3	Mass flow > 25g/h
Group III	30 mg/m^3	Mass flow > 50g/h

PARAMETER	EMISSION LIMIT VALUE	REMARK
Gaseous Inorganic Pollutants		
Group I	1	Mass flow > 50g/h
Group II	5	Mass flow > 300g/h
Group III	30	Mass flow > 1,000g/h
Group IV	500	Mass flow > 10,000g/h
Gaseous Organic Pollutants		
Group I	20	Mass flow > 500g/h
Group II	100	Mass flow > 4,000g/h
Group III	200	Mass flow > 6,000g/h
Cancer Causing Pollutants		
Group I	0.2	Mass flow > 5g/h
Group II	2	Mass flow > 10g/h
Group III	10	Mass flow > 50g/h

Table 2.9 Types of Inorganic Pollutants and Groups (Decision 8/1)

PARTICULATE INORGANIC POLLUTANTS			
Group I	**Group II**	**Group III**	**Group VI**
Cd, Hg, Tl	As, Co, Ni, Se, Te	Sb, Pb, Cr, CN, F, Cu, Mn, Pt, Pd, Rh, V, Sn	-
GASEOUS INORGANIC POLLUTANTS			
Group I	**Group II**	**Group III**	**Group VI**
AsH3, ClCN, COCl2, HP	HBr, Cl2, HCN, HF, H2S	HCl not mentioned at Group I	SOX, NOX
CANCER CAUSING POLLUTANTS			
Group I	**Group II**	**Group III**	**Group VI**
Asbestos, Benzo(a)pyren, Beryllium and its breathable compounds calculated as Be, Dibenz(a,h) anthracen, 2-Napthylamin	Arsenic Oxides, several Chrome (VI) and Chrome (III). Combinations calculated as Cr, Cobalt, Nickel and its breathable compounds calculated as Co/ Ni, 3,3'-Dichlorbenzeden, Dimethylsulphate Ethylenimin	Acrylnitril, Benzene, 1,3-Butadien, 1-Chlor-2,3-epoxypropan (Epychlorhydrin), 1,2-Dibromethane, 1,2-Epoxypropane, Ethyleneoxide, Hydrazine, Vynilchloride	-

2.1.3 RELEVANT GAPS IN THE LEBANESE LEGISLATIVE FRAMEWORK

To date, and with relation to this particular project, Lebanon lacks legislation and/or standards related to:

- Soils and sediments standards;
- Guidelines for the disposal and reuse of sewage sludge;
- Guidelines for effluent/wastewater reuse; and
- A Framework Law pertaining to the protection, management, conservation and utilization of the Coastal Zone.

Two propositions for Lebanese Guidelines on Sewage Sludge Use in Agriculture and for Lebanese Wastewater Reuse Guidelines have been prepared by FAO in 2010. However, these have not been officially agreed to or enforced yet and are thus of no legal value to this date (September 2012).

Whenever there is lack of national legal documents and/or environmental standards, the present study will refer to international guidelines and standards such as those issued by the EU, the WHO, the World Bank (WB/IFC), Occupational Safety and Health Administration (OSHA), etc.

2.1.4 RELEVANT INTERNATIONAL CONVENTIONS, TREATIES AND PROTOCOLS

Table 2.10 summarizes all relevant international conventions and agreements that are signed or ratified by Lebanon. They include provisions relevant to the proposed project.

Table 2.10: Ratified or signed international agreements

Agreement	Objective	Relevance to Project
Stockholm Convention on Persistent Organic Pollutants (POPs) - 2001 Signed by Lebanon in 2001	To reduce intentional and unintentional production of POPs To develop country-specific implementation plans for this purpose	Regulates the emissions of POPs from waste burning *Poly-chlorinated biphenyls (PCBs) transformers, PCBs and poly-aromatic hydrocarbons (PAH) in soil and water*
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal-1989 Ratified by Lebanon in 1994	To control the transportation of dangerous non-radiant materials and their disposal across the border	Regulates the transfer of potentially hazardous wastes across national boundaries *Medical and industrial waste* *Hazardous demolition waste*
Kyoto Protocol -1997 Ratified by Lebanon in 2006	To reduce greenhouse gas emissions in an effort to prevent anthropogenic climate change	Regulates GHG emissions *Energy efficiency measures*
Convention to Combat Desertification - 1994	To combat desertification	Control land clearance and

Agreement	Objective	Relevance to Project
Ratified by Lebanon in 1994		project footprint size
The Framework Convention on Climate Change, or Global Warming Convention (UNFCCC) – 1994 Ratified by Lebanon in 1994	To achieve stabilization of greenhouse gas concentrations in the atmosphere in order to prevent dangerous anthropogenic interference with climate system	Reduce greenhouse gas emissions from operations *Energy efficiency measures* *Reconstruction*
Vienna Convention for the Protection of the Ozone Layer – 1985 Montreal protocol on ozone-depleting substances - 1987 Ratified by Lebanon in 1993	To protect human health and the environment from any activity that modifies the ozone layer Adopt measures to control human activities found to have adverse impact on the ozone layer	Regulates the use of ozone depleting substances (ODS) *Reconstruction activities*
International Labour Convention No. 139, 120 and 136 Lebanon has ratified 50 International Labor Conventions (48 actually in force)	To prevent vocational risks ensuing from cancer causing materials and tools Deals with sanitation in offices To protect workers against the risks of intoxication ensuing from benzene	Protects workers health and ensures proper sanitation and hygiene for base camps, work environment and offices *Reconstruction activities*
Barcelona Convention: Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources-1980 (Signature in 1980 and accession in 1994) Protocol Concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency-1976 (Ratified by Lebanon in 1977) Convention for the Protection of the Mediterranean Sea against Pollution-1976 (Ratified by Lebanon in 1977) Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter-1972 (Signed by Lebanon in 1973)	To ensure protection of the Mediterranean Sea and aquatic species from effluent discharges (solid/liquid waste)	To protect the coastal area from landfills and uncontrolled dumping practices in the Study Area resulting in leachate generation and run-off which pose a threat to the existing water resources. *Disposal of wastewater in the Mediterranean sea*

2.1.5 RELEVANT INTERNATIONAL GUIDELINES AND STANDARDS

In accordance with the **EIB "Statement of Environmental and Social Principles and Standards"** provisions, the report shall first refer to national legislation and international conventions ratified by Lebanon. Whenever confronted with a lack of relevant national legislation, EU standards will be referred to.

2.1.5.1 WASTEWATER REUSE

The **WHO "*Guidelines for the safe use of wastewater, excreta and greywater*"** were designed to protect the health of farmers (and their families), local communities and product consumers. They are meant to be adapted to take into consideration national socio-cultural, economic and environmental factors.

Table 2.11 presents recommended microbiological guidelines for reuse in agriculture. The guidelines have been revised in 2006. The revised "Guidelines for the safe use of wastewater, excreta and greywater" describe minimum requirements of good practice and provide information that is then used to derive health-based targets. However, neither the minimum good practices nor the health-based targets are mandatory limits.

Table 2.11 Recommended Microbiological Quality Guidelines for Wastewater Reuse in Agriculture (WHO, 1989)

CATEGORY	REUSE CONDITION	EXPOSED GROUP	INTESTINAL NEMATODESB (/L*C)	FEACAL COLIFORMS (/1000ML**C)	WASTEWATER TREATMENT EXPECTED TO ACHIEVE REQUIRED QUALITY
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks	Workers, consumers, public	≤1	≤1000	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment.
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees	Workers	≤1	None set	Retention in stabilization ponds for 8-10 days or equivalent helminth removal.
C	Localized irrigation of crops if category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pre-treatment as required by the irrigation technology, but not less than primary sedimentation.

a. In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account, and the guidelines modified accordingly.
b. *Ascaris* and *Trichuris* species and hookworms.
c. During the irrigation period.
d. A more stringent guideline (≤200 faecal coliforms/100ml) is appropriate for public lawns with which the public may come into direct contact.
e. In the case of fruit trees, irrigation should cease 2 weeks before the fruit is picked and none should be picked off the ground.
* Arithmetic mean
** Geometric mean

As already stated, FAO has recently (2010) released a proposition for Lebanese guidelines for wastewater reuse as well as for the use of sewage sludge in agriculture [53, 54]. However, these propositions still need to be reviewed and, most importantly, adopted by the Council of Ministers (CoM).

Based on the considerations that high risks are associated with intestinal nematodes and bacteria rather than with viruses and taking into account particular conditions in Lebanon, values are proposed as a discussion basis for the establishment of guidelines for the reuse of wastewater. Guideline values are proposed for each parameter and for three different usage categories. Adequate levels of waste water treatment in order to meet the criteria for each use are also presented. In another part of the document, good irrigation practices are described and another set of guidelines is proposed for irrigation water quality, irrigation methods, etc.

Similarly, the proposition for sewage sludge use guidelines presents treatment methods, proposes a classification of sludge according to its metal content and suggests usages and restriction levels on use for each defined class.

2.1.5.2 SLUDGE MANAGEMENT AND DISPOSAL; THE EU REQUIREMENTS

Across the EU, guidelines and requirements for the management and disposal of sewage sludge are comprised directly or indirectly in a set of legislation, mainly including the following seven Directives:

- Directive 2008/98/EC, Waste Framework Directive;
- Directive 1999/31/EC on the Landfill of Waste;
- Directive 86/278/EEC on Sewage Sludge application on land;
- Directive 91/676/EEC on the protection of waters against pollution caused by nitrates from agricultural sources;
- Directive 2000/76/EC on the Incineration of Waste;
- Directive 2009/28/EC on the promotion of the use of energy from Renewable Sources; and
- Directive 2008/1/EC on Integrated Pollution Prevention and Control (codified version, former Directive 96/61/EC).

Directive 2008/98/EC is the Waste Framework Directive that sets the basic concepts and definitions related to waste management and lays down waste management principles, such as the "polluter pays principle" or the "waste management hierarchy". The latter refers to the hierarchy of waste management which is, from first to last priority, the following:

- Prevention of waste production;
- Preparation for waste reuse;
- Recycling of waste;
- Other recovery, e.g. energy recovery; and
- Disposal.

This legislation has quite a significant effect on sewage sludge management, since it promotes in principal the reuse of the sludge on land application in comparison with energy recovery and disposal in landfills.

Directive 1999/31/EC on the Landfill of Waste implements EU policy for waste management (CEC 1999) which aims to encourage the recovery of value from waste products and **to reduce the disposal of biodegradable wastes to landfill**. The main obligation under this legislation is **to reduce the amount of biodegradable waste sent to landfills by 35% of 1995 levels by 2016**. This

implies that land filling is not considered a sustainable approach to sewage sludge management in the long-term.

Directive 86/278/EEC (Directive on Sewage Sludge) aims to regulate the use of sewage sludge in agriculture in such a way as to prevent harmful effects to soil, vegetation, animals and man, thereby encouraging the correct use of such sewage sludge. The Directive lays down limits for concentrations of heavy metals in soil and sludge and for the maximum annual quantities of heavy metals which may be introduced into the soil.

The mandates of this Directive are as follows:

The use of sludge must be carried out in such a way as to minimize the risk of negative effects to:

- Human, animal, and plant health;
- The quality of groundwater and/or surface water;
- The long-term quality of the soil; and
- The bio-diversity of micro-organisms living in the soil.

Thus, sludge disposal for land farming is subject to the following conditions:

- Sludge must be treated;
- Concentrations of heavy metals (cadmium, chromium, copper, mercury, nickel, lead and zinc) in soil to which sludge is applied should not exceed the limit values given in Table 2.12.
- Concentrations of heavy metals in sludge should not exceed the limit values given in Table 2.13.
- The maximum annual quantities of heavy metals which may be introduced into soil intended for agriculture should be considered and should not exceed the limit values given in Table 2.14.

Table 2.12 Limit values for concentration of heavy metals in soil

ELEMENTS	LIMIT VALUES (MG/KG DM)*		
	5<pH<6	6< pH <7	pH ≥7
Cadmium (Cd)	0.5	1	1.5
Chromium (Cr)	30	60	100
Copper (Cu)	20	50	100
Mercury (Hg)	0.1	0.5	1
Nickel (Ni)	15	50	70
Lead (Pb)	70	70	100
Zinc (Zn)	60	150	200

*dm: dry matter

Table 2.13 Limit values for concentration of heavy metals in sludge for land application

ELEMENTS	LIMIT VALUES (MG/KG DM)	LIMIT VALUES (MG/KG P)
Cadmium (Cd)	10	250
Chromium (Cr)	1000	25,000
Copper (Cu)	1000	25,000
Mercury (Hg)	10	250
Nickel (Ni)	300	7,500
Lead (Pb)	750	18,500
Zinc (Zn)	2,500	62,500

Table 2.14 Limit values for amounts of heavy metals which may be added annually to soil, based on a ten-year average

ELEMENTS	LIMIT VALUES (G/HA/YEAR)
Cadmium (Cd)	30
Chromium (Cr)	3,000
Copper (Cu)	3,000
Mercury (Hg)	30
Nickel (Ni)	900
Lead (Pb)	2,250
Zinc (Zn)	7,500

If the above listed conditions cannot be met, the sludge must be disposed either on sanitary landfills or re-diverted to other facilities, e.g. for incineration or energy recovery.

Directive 91/676/EEC (Nitrates Directive) has the objective of reducing water pollution caused or induced by nitrates from agricultural sources and preventing such pollution. To that aim the Directive requires Member States to designate vulnerable zones that contribute to the pollution of water by nitrates. Within these vulnerable zones, a code of good agricultural practice should be applied by farmers. Such a code could, for example, provide periods when the land application of

fertilizer is inappropriate or ban the land application of fertilizer on steeply sloping ground or to water-saturated, flooded, frozen or snow-covered ground. Since the Directive considers that nitrogen containing sewage sludge falls within the definition of fertilizers, such code of agricultural practice should also apply to the spreading of sewage sludge which negatively affects its unrestricted application on land.

Directive 2000/76/EC on the Incineration of Waste sets several standards and technical requirements (air emissions, water discharges contamination, plant designs) that have to be respected by the operators of the plants which incinerate dry sewage sludge. Sewage sludge falls within the category of waste and thus falls under the scope of Directive 2000/76/EC. Therefore, this directive allows for another significant alternative option for managing and treating sewage sludge by incineration in order to produce energy.

Directive 2009/28/EC is recently adopted legislation on the promotion of the use of energy from Renewable Sources. It sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport. Overall, in 2020 there shall be at least a 20% share of energy from renewable sources in the Community's gross final energy consumption. Such targets are likely to create incentives for the use of renewable energy sources, such as the biogas from sewage sludge or its thermal power. Therefore, anaerobic treatment of the sewage sludge and exploitation of the produced biogas and/or thermal treatment of the sewage sludge is promoted through this directive.

Finally, **Directive 2008/1/EC** on Integrated Pollution Prevention and Control, sets high standards for issuing permits for plants operating biological treatment of organic waste (if pre-treatment before disposal), such as composting plants and anaerobic digestion plants. The high standards pose more difficulties to application of sewage sludge to land, since the quality of the treated sludge needs to comply with stricter standards.

2.2 INSTITUTIONAL FRAMEWORK

2.2.1 PUBLIC STAKEHOLDERS

Various governmental public institutions are involved in the different stages of the extension and upgrade of Al-Ghadir WWTP project development and operation. These are briefly listed below, while a more detailed description of each institution follows in the subsequent sub-sections.

Main governmental stakeholders consist of the following ministries:

- Ministry of Energy and Water (MoEW);
- Ministry of Environment (MoE);
- Ministry of Interior and Municipalities (MoIM);
- Ministry of Public Health (MoPH);
- Ministry of Public Works and Transport (MoPWT);
- Ministry of Agriculture; and
- Ministry of Tourism (MoT).

At a regional level, the different Governorates (Mouhafaza) of Beirut and Mount Lebanon and municipalities have direct responsibilities/involvement with the project.

Other important local institutional stakeholders consist of the CDR and public water and wastewater establishments, notably the BMLWWE.

Finally, the General Directorate of Civil Aviation as well as the Lebanese Marine Research Centre constitute additional parties concerned with the security and environmental/research dimensions of the project.

2.2.1.1 COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION (CDR)

The CDR is a public authority established in 1977 to replace the Ministry of Planning after a two-year conflict. While its role evolved to include initiatives that address social and economic issues, the CDR grew to be the government unit responsible for wide-scale reconstruction and development projects in Lebanon, as well as the effective government counterpart of UNDP.

CDR has unprecedented powers to avoid any administrative routine that could slow down the reconstruction process, especially in the financial field. It is financially and administratively independent and directly affiliated to the CoM).

Projects and programmes are developed in close consultation with the CDR.

The CDR, in cooperation with other ministries, is responsible for (Decree 5/1977):

Planning, through the following tasks:

- Development of a general plan, consecutive plans and programs for construction and development activities, in addition to the suggestion of economic, financial and social policy in line with the general plan. All of these plans and policies are submitted to the CoM;
- Developing a budget for the implementation of the general plan;
- Suggesting project laws relating to construction and development and presenting them to the CoM; and
- Developing a general guidance framework for urban planning and presenting it to the CoM for approval.

Consultancy and Guidance, such as:

- Giving opinion to the CoM on economic and financial relationships with other countries, foreign associations and organizations;
- Getting in contact with foreign associations and organizations for the purpose of seeking economic, cultural, technical and social assistance;
- Preparing and publishing statistical studies relating to economic and social activities and projects;
- Conducting the necessary studies in the development and construction fields, or designating qualified parties to conduct them, and suggesting the enhancement of the Council's scientific capabilities;
- Requesting ministries, public institutions and municipalities to prepare projects in line with the Council's overall developmental and construction objectives;
- Providing information for ministries, public institutions, municipalities and the private sector; and
- Giving suggestions relating to the creation, development and guidance of financial establishments and companies working on development issues.

Executive tasks, illustrated by:

- Conducting feasibility studies for construction and development projects in the general plan, or preparing programs required for the development of plans;
- Executing the projects in the general plan and consecutive plans and programs, in addition to any other construction/development project requested by the CoM. The CDR selects the appropriate public institution, municipality or company for the execution of these projects and the appropriate means (bidding, subcontracting or partnership);
- The CDR is the exclusive party responsible for expropriation procedures and issuing administrative authorizations and licenses, except in the case where the CoM issues them.

Financial duties, such as financing any project or program referred to the CDR by the CoM through internal or external debts, etc.

Monitoring of:

- All projects in the plans and programs and those referred by the CoM and submitting relevant reports to the CoM; and
- The proper allocation of economic and financial subsidies to the proper targets.

The CDR is the Project Promoter, and will be responsible of project development and monitoring of works.

2.2.1.2 MINISTRY OF ENERGY AND WATER (MOEW)

The water sector in Lebanon is regulated by a set of laws, regulations and decrees, some of which are new and others old and still in effect. Of these, we shall mention:

1. **Law 221 of 29 May 2000** on the Organization of the Water Sector, of which:
   - **Article 1** states that the protection and development of water as a natural resource, within the framework of environmental and ecosystem protection, is a crucial public service.
   - Article 2 enumerates the competencies and missions of the Ministry of Energy and Water as follows:
     - Monitoring, studying and estimating the volume of water resources and estimating water needs and uses in all regions;
     - Monitoring the quality of surface and groundwater and establishing relevant standards;
     - Developing a general scheme for the allocation and distribution of drinking water and irrigation water throughout the country and designing and continuously updating a masterplan for water and sanitation to be submitted through the Minister to the CoM for approval;
     - Designing, studying and implementing large water projects such as dams, mountain lakes, tunnels, diversion of riverbeds, water networks, etc. and overseeing their operation;
     - Protecting water resources against losses and pollution by elaborating legal texts and taking necessary measures and action to prevent water pollution and restore its initial natural quality;
     - Giving licenses and permits for well exploration and drilling, public water usage and exploitation of public riverine properties, conducting all relevant paperwork and issuing permits according to relevant laws and regulations;
     - Developing standards to be adopted in the studies conducted by Water and Wastewater Establishments and the implementation of their works; in addition to guidelines and regulations for the exploitation of surface and groundwater and the management of wastewater and standards for the protection and monitoring of water quality;

- Giving a technical opinion on permits for quarries and mines with respect to their impacts on water resources;
- Public relations and informing citizens about water issues and conservation; and
- Enhancing the performances of public Water and Wastewater Establishments and evaluating their performance based on indicators mentioned in the action plan that have been approved according to legal procedures.

- **Article 4** states that the functions of public Water and Wastewater Establishments are to monitor the quality of distributed drinking water and irrigation water and the quality of wastewater at outfalls and treatment plants.

2. The Environment Protection Law No. 444 of 29 July 2002, issued by the Ministry of Environment.

2.2.1.3 PUBLIC WATER AND WASTEWATER ESTABLISHMENTS; THE BMLWWE

In 2001, Law No. 377 named the previously known Water Authorities as "Water and Wastewater Establishments." These four (4) Establishments are located in Beirut, Bekaa, North Lebanon and South Lebanon, and each operates on a defined geographical perimeter with financial and administrative autonomy. Duties performed by these establishments cover the following:

- Suggesting tariffs for drinking water, irrigation water and wastewater collection, taking into consideration the general socio-economic conditions of the country;
- Monitoring the quality of distributed drinking and irrigation water as well as wastewater quality at outfalls and wastewater treatment plant outlets; and
- Studies, implementation, exploitation, maintenance and renewal of water projects for the distribution of drinking and irrigation water, as well as the collection and treatment of wastewater in accordance with the General Water and Wastewater Master Plan, or based on the Ministry's initial approval on the use of public water resources, or on the location of WWTPs and new outfalls.

The four (4) water establishments already operate several major WWTP's (Saida, Tripoli, Beirut-Ghadir) via design build operate (DBO) contracts with the construction contractors or management contracts as in the case of Al Ghadir. Contracting-out of operations to private companies is likely to become the norm in the future.

The **Beirut and Mount Lebanon Water & Wastewater Establishment (BMLWWE)** is of particular relevance to this project, as the area to be served by the Al-Ghadir WWTP falls in the boundaries of "Beirut" and the previously named "Ein El Delbe" water service areas.

The BMLWWE actually provides water supply and wastewater management services to an estimated population of approximately 1.5 million people over an area of 2,000 km^2 (area served by the six (6) former water authorities known as Beirut, Jbeil, Barouk, Metn, Ein el Delbe and Kersouan[2]). The level of service provided varies considerably across the different service areas, both in terms of hours of pressurized service and average volume of water delivered to connected customers.

[2] In referring to the water supply service areas by the above names, it is important to remember that, for example, the City of Beirut administrative boundary is not the same as the water supply service area boundary called Beirut, which also includes parts of coastal Metn.

The Establishment is organized into four (4) Directorates under the Director General and various departments under each Directorate. At the start of the business planning process, the Establishment had a total work force of 702 people with an approved authorization, based on the regulations, to employ a staff of 1,120 people. However, the WE is still believed to suffer from lack of human resources.

In the Business Plan of 2006, the price of 1 m^3 equal current service was estimated at 1,469 LBP, while the average effective tariff to meet cash needs was estimated to be between 1,270 and 1,643 LBP/m^3 in the period 2007 – 2011.

The MoEW and the BMLWWE are the Project Beneficiaries; they will be responsible for plant operation and maintenance.

2.2.1.4 MINISTRY OF ENVIRONMENT (MOE)

Lebanon's Ministry of Environment (MoE) was established by *Law 216* of 2 April 1993, marking a significant step forward in the management of environmental issues in Lebanon. ***Article 2*** of Law No. 216 stipulates that the MoE should formulate a general environmental policy and propose measures for its implementation in coordination with the concerned government administrations. The article indicates that the MoE should protect the natural and man-made environment in the interests of public health and welfare and fight pollution from whatever source by taking preventative and remedial action. The MoE is particularly in charge of developing the following aspects of environmental management:

- A strategy for solid waste and wastewater treatment and disposal, through participation in appropriate committees, conducting studies for this purpose and commissioning appropriate infrastructure works;
- Permitting conditions for new industry, agriculture, quarrying and mining and the enforcement of appropriate remedial measures for establishments existing before promulgation of this law;
- Conditions and regulations for the use of public land, marine and riverine resources in such a way as to protect the environment; and
- Encouragement of private and collective initiatives that improve environmental conditions.

The Ministry of Environment is the competent authority responsible for reviewing the EIA report and for ensuring environmental acceptability of the Project.

2.2.1.5 MINISTRY OF INTERIOR AND MUNICIPALITIES (MOIM)

The Ministry of Interior was established in 1943 under the first Government after the Lebanese Independence. The institution later became known as The Ministry of Interior and Municipalities (MoIM) after several decrees, the last of which corresponds to Decree No. 4082 dated 14/10/2000 based on Law No. 247 Date 07/08/2000.

The MoIM is responsible for internal policy affairs and for safeguarding national security and domestic order. The Ministry thus oversees matters of Governorates, Districts, Municipalities and Federations of Municipalities in addition to political parties and organizations.

2.2.1.6 MUNICIPALITIES

A municipality is a local administration that has by-law prerogatives within its area of jurisdiction. It consists of a decision-making authority and an executive authority.

Municipalities are in charge of all projects benefiting the community within their area of jurisdiction. According to Decree 118/1977, they are responsible for:

- Determining municipal taxes or fees;
- Developing TORs for services, works and supplies, or for selling municipal properties;
- Accepting or rejecting funds and donations;
- General programs of works, cleanliness, health affairs, water and lighting projects, etc.;
- Planning, rectifying and enlarging roads, creating parks and public places;
- Formulating designs for the town and the master plan in cooperation with the Directorate General of Urban Planning (DGUP);
- Creating parks, courts, museums, hospitals, libraries, sewerage networks, and waste disposal options, etc.;
- Organizing transportation and specifying prices; and
- Approving permit applications for the exploitation of classified shops, restaurants, resorts, cafes, hotels and all kinds of tourist and leisure facilities.

The main municipalities involved in the Al-Ghadir WWTP extension project are those located in the direct vicinity of the project location as well as those to be served by the treatment, as shown in Table 2.15.

Table 2.15 List of municipalities in the Ghadir drainage area (in alphabetical order)

MUNICIPALITY
1. Aabey-Ain Drafil
2. Aaley
3. Ain Aanoub
4. Ain Ksor
5. Aramoun
6. Ayn el Remmane
7. Aynab
8. Aytate
9. Baabda
10. Baaouarta
11. Baysour
12. Bdedoun
13. Beirut
14. Blaybel
15. Bmakkine
16. Borj el Brajne
17. Boutchai-Merdashe
18. Bsaba
19. Bshamoun
20. Bsous
21. Chiyah
22. Daqqoun
23. Dayr Qoubil
24. Dfoun
25. Ed Damour
26. El Binnay
27. El Mechref
28. Esh Shwayfate
29. Fsaqine (Bsetin)
30. Ghaboun
31. Ghobeyre
32. Hadath
33. Haret el Sett
34. Haret Hreik
35. Houmale
36. Kahhale
37. Kayfoun
38. Kfarmatta
39. Majdaliya
40. Mrayje-Tahwitet el Ghadir-Laylaki
41. Naameh
42. Qmatiyye
43. Remhala
44. Shemlane
45. Souq el Gharb
46. Wadi Shahrour al Oulia
47. Wadi Shahrour al Soufla

2.2.1.7 MINISTRY OF PUBLIC HEALTH (MOPH)

The Ministry of Public Health (MoPH) is responsible for safeguarding and improving public health, through the prevention of disease, supervision of health care institutions, suggestions for enacting new legislation in the public health sector or modifying existing ones. The MoPH consists of Central and Regional Departments as well as a Department of Projects and Programs.

With regards to the Regional Departments (or Public Health Services), they are distributed in all Governorates, except in the Governorate of Beirut, and all districts. They are responsible for implementing health protocols in the Governorates and providing preventive and laboratory services. Sanitary Engineers in these services also give their opinion regarding the establishment of slaughterhouses and sewage networks in cities. As for the District Physicians, they monitor potable water quality, solid waste disposal and sanitary guidelines in residential, recreational and occupational settings.

2.2.1.8 MINISTRY OF PUBLIC WORKS AND TRANSPORT (MOPWT)

According to Decree 2872/1959 (Organization of the Ministry of Public Works and Transport) and its amendments, the Ministry of Public Works and Transport (MoPWT) is composed of:

- The Common Administrative Directorate;
- The Directorate General of Roads and Buildings;
- The Directorate General of Urban Planning;
- The Directorate General of Land and Maritime Transport; and
- The Directorate General of Civil Aviation.

In addition, a Higher Council for Land Transport was created in 1966 for organizing and developing land transport (also covering railways). Regional Directorates of Public Works were created in each of the Governorates with the Exception of Beirut. Of all directorates, the Directorate General of Land and Maritime Transport and the Directorate General of Urban Planning are mainly and directly involved in Coastal Zone Management (CZM).

2.2.1.9 MINISTRY OF INDUSTRY (MOI)

The Ministry of Industry (MoI) was established by Law 642/1997 which gave the Ministry overall jurisdiction over the permitting of industrial facilities. According to Article 4 of the Decree 9765/2003 of the MoI, the authorities in charge of the industrial pollution control are the MoI-Control Department, the municipalities and the competent authorities of MoE and MoPH.

The MoI consists of a Central Administration and four regional offices. The Central Administration, located in the Capital Beirut, consists of five departments that report directly to the General Director.

Regional offices are located in North Lebanon, South Lebanon, the Bekaa Valley and Nabatieh. Their role is to process the administrative work on behalf of the Ministry in the different regions, including receiving application forms from industrialists, delivering industrial permits and other services.

In addition, there are two legally and financially attached institutions to the MoI, which are:

- The Lebanese Standards Institution (LIBNOR); and
- The Industrial Research Institute (IRI).

The MoI is the authority with which further coordination is needed in order to ensure industrial compliance with local standards (mainly involving pre-treatment before discharges in common streams) so as to allow optimal plant operation.

2.2.1.10 MINISTRY OF AGRICULTURE (MOA)

The Central Administration is composed of several Directorates. The Directorate of Rural Development and Natural Resources, responsible for forests, green areas, parks, pastures, hunting and fishing issues, rural and irrigation projects and agricultural industries, is most relevant to the current project.

The MoA would need to be consulted should land application of sludge or wastewater reuse for agriculture be considered.

2.2.1.11 MINISTRY OF TOURISM (MOT)

The Ministry of Tourism (MoT) was created under Law 21, issued in 1966. However, it was not until 1992 that Decree 2829 gave full responsibility over tourism management to the MoT, transferring all tasks previously entrusted to the National Tourism Council (under Decree no.7142, 1967). The National Tourism Council was a private association in charge of conducting all tasks related to tourism promotion and investment.

The MoT is responsible for touristic sites or resorts which may potentially be affected by the Project.

2.2.1.12 MINISTRY OF CULTURE (MOC) AND THE DIRECTORATE GENERAL OF ANTIQUITIES (DGA)

The Ministry of Culture (MoC) is in charge of: antiquities; heritage; historical property; arts, literature and intellectual yield; cultural industries; and management of cultural property.

The MoC was formed in 1993 under Law 215. It was initially part of what was known as the Ministry of Culture and Higher Education until Law 247 (issued in 2000) decreed the separation between "Higher Education" and "Culture".

The MoC currently consists of two main units: the Directorate General of Cultural Affairs; and the Directorate General of Antiquities.

The DGA handles regulatory provisions related to archeological remains, antiques, and traditional and historical monuments. It shall be consulted and involved during construction works to ensure that no damage is done to archaeological remains or culturally sensitive areas.

2.2.1.13 THE LEBANESE CIVIL AVIATION AUTHORITY (LCAA)

The Lebanese Civil Aviation Authority (LCAA) is the body responsible for developing and administering policies, regulations and services for the promotion of safety and quality standards in civil aviation activities in Lebanon.

The LCAA needs to be continuously consulted during Project development and implementation so as to ensure that the highest security standards are met.

2.2.1.14 THE LEBANESE MARINE RESEARCH CENTRE

The National Centre for Marine Sciences (NCMS) was established in 1977 in response to the 1972 Stockholm Conference. Located in Batroun, north of Lebanon, the centre is a recognized institute

within the Mediterranean network of marine centres and is integrated in a number of regional and international activities.

The NCMS is mainly mandated to:

- Continually supervise the coastal and marine zone by creating a national network for scientific observation;
- Evaluate biodiversity by characterizing migrant communities and their habitats; and
- Produce, transform and transfer knowledge in the coastal and marine ecosystems.

A summary of the key stakeholders, their responsibilities and level of involvement in the Project is presented in Table 2.16.

2.2.2 PRIVATE, NON-GOVERNMENTAL, AND INTERNATIONAL STAKEHOLDERS

In addition to the above-mentioned public stakeholders, several local and international stakeholders play a role in the management of natural resources and livelihood strategies within the Project area. These include non-governmental organizations (NGOs), as well as community leaders. International stakeholders include the European Investment Bank (funding party).

Table 2.16 Environmental responsibilities matrix for key institutions in Lebanon

Institution	Water Resources			Urban planning/ zoning	Standards & Legi-slation	Enforce-ment	Marine Environment Protection	Protection of Natural Resources	Wastewater Discharge	Solid Waste Management	Issuing Permits
	Infrastructure	Quality & sanitation	Distribution &supply								
Council for Development and Reconstruction	✓			✓					✓	✓	
Ministry of Energy and Water	✓				✓				✓		
Public Water Establishments	✓		✓						✓		
Ministry of Environment	✓	✓	✓	✓	✓		✓	✓	✓	✓	
Ministry of Interior and Municipalities				✓		✓			✓	✓	✓
Municipalities	✓	✓	✓	✓		✓	✓	✓	✓	✓	
Ministry of Public Health		✓			✓		✓		✓	✓	✓

Institution	Water Resources			Urban planning/ zoning	Standards & Legi-slation	Enforce-ment	Marine Environment Protection	Protection of Natural Resources	Wastewater Discharge	Solid Waste Management	Issuing Permits
	Infrastructure	Quality & sanitation	Distribution &supply								
Ministry of Public Works and Transport				✓	✓	✓	✓	✓	✓	✓	✓
Ministry of Industry				✓	✓						✓
Ministry of Agriculture					✓	✓		✓			

3 PROJECT DESCRIPTION

3.1 PROJECT NEED AND OBJECTIVES

The overall Project objective is to upgrade the existing Al-Ghadir preliminary treatment plant and networks in order to improve wastewater and sanitary services in the Project area and reduce pollution levels. The Project also aims to eliminate all untreated sewage discharges to the sea and reduce uncontrolled discharges to the Ghadir River, thus reducing sea water and river contamination and minimizing health risks along with protecting the marine flora and fauna. The Project will also safeguard compliance with the environmental standards imposed by international conventions and national legislation, with reference to wastewater discharges.

Hence, the Project is expected to:

- Improve the quality of coastal waters;
- Improve the quality of life for an estimated number of 1 million inhabitants (25% of Lebanese population); and
- Reduce pollution and environmental stress on the Al-Ghadir drainage area and the Mediterranean Sea as ultimate recipient of the discharged wastewater flows, in line with Horizon 2020's mandate targeting the depollution of the Mediterranean Sea by the year 2020.

3.2 BACKGROUND INFORMATION

3.2.1 CURRENT SITUATION

3.2.1.1 WASTEWATER NETWORKS IN THE AL-GHADIR DRAINAGE AREA

At present, the project area can be subdivided into three (3) sectors with regard to the condition and existence of sewers:

- Sectors where no sewerage networks exist. These areas are served only with improper and unreliable onsite sanitation systems such as septic tanks or discharging directly into nearby water bodies;
- Sectors where old sewerage exists (particularly in the northern part of the project area). The collectors of these areas mainly discharge into Al Ghadir River and in the storm water culverts. Storm water and wastewater are conducted in one main, thus sewers are combined in these parts. The wastewater networks in these sections are being progressively renovated by the Municipality of Beirut.
- Sectors where a relatively new sewage system exists. The new system is not yet connected to the Al-Ghadir treatment plant and not yet operational. Most of the sewers in these sectors are separate ones where storm water and sanitary wastewater are conveyed separately into two different networks.

The Al-Ghadir River serves in its lower section as a combined sewerage and stormwater conveyor, connected to the Al Ghadir WWTP. Additionally, industries located along the river commonly discharge untreated wastewater directly into the river.

The overall length of the existing wastewater primary major conveyors is about 125 Km (including the coastal collectors). Other wastewater conveyors that are linked to the major ones have a total length of 77 Km approximately. The total length is about 202 Km (77 Km + 125 Km).

The map in Annex 1 shows the existing wastewater conveyors and the designed ones which funds for construction is secured, and the designed ones which funds for construction are not secured.

As presented in the **Feasibility Study Part I : Project background and baseline data**, the wastewater collection networks within the Ghadir WWTP drainage basin have not yet been fully constructed; with the exception of those of Beirut and Southern Beirut areas. The wastewater collection networks of Beirut city and the Southern suburb of Beirut discharge in the following locations:

- El Qassis stormwater culvert;
- Haret Hreik sands stormwater-wastewater culvert; and/or
- Al-Ghadir River.

None of the networks of Beirut and Southern Beirut areas is yet connected to the newly constructed wastewater collectors. It is assumed that they will be connected by 2015, ultimately discharging into the Al-Ghadir plant.

Storm Water Drainage

Storm water is only drained by appropriate networks in Beirut and Southern Beirut areas; at the North of Al-Ghadir River and the Beirut International airport. Stormwater networks are not covering all the sewered areas. Sewers tend to collect both stormwater runoff and wastewater, and as a result of the war, lack of maintenance, and illegally executed works connecting surface water from roads and roof drains of buildings to the sewerage system. The mixing of wastewater and stormwater leads to an increase in flow in the sewers mainly during winter and spring periods.

3.2.1.2 THE AL-GHADIR PRELIMINARY TREATMENT PLANT

The existing preliminary wastewater treatment facility is located in Al-Ghadir, about 7Km south of Beirut, at the direct proximity of the Beirut International Airport (Figure 3.1). Based on recent flow measurements the plant receives on average an equivalent flow of 30% of its capacity, of mixed wastewater and stormwater flow from sewer collectors and stormwater drainage channels. Once the main collectors that have recently been completed are connected to the plant, the flow is anticipated to increase significantly.



Figure 3.1 Aerial View of the Al-Ghadir Preliminary Treatment Facility and Project Location

3.2.1.2.1 Operation Process at the existing Al-Ghadir Preliminary Treatment Facility

The Al-Ghadir Preliminary Treatment Facility was commissioned under a loan through Kreditanstalt für Wiederaufbau (KfW) in 1998, at a cost of around 7.5 M Euros. Operator of the plant is the BMLWW while a private company is subcontracted to Maintain & Operate the Plant.

The plant consists of preliminary treatment works including (Figure 3.2):

- Inlet works of the incoming wastewater from the sewage networks and the tanker tracks;
- Lifting station;
- Screening;
- Grit and scum removal;
- Pumping station for feeding the sea outfall (3 pumps: 2 on duty, 1 standby);
- Main sea outfall for the discharge of the treated wastewater to the sea;
- Emergency sea outfall for the discharge of untreated wastewater; and
- Bypass/overflow facilities.


Lifting Station Unit Screw Pumps


Screening unit


Screening unit


De-gritting Unit (a) Grit classifier


De-gritting Unit's aeration blowers


Outfall Pumping Station

Figure 3.2 Al-Ghadir Preliminary Treatment Plant – Selected Pictures

Once collected and pre-treated, the wastewater is discharged into the Mediterranean Sea via one main sea outfall. An emergency sea outfall also exists for stormwater overflows.

The existing plant operates manually and has been overall assessed to be **in good condition**. It is assumed that there will be a need to replace the outflow pumping station to accommodate the increasing wastewater flow. The current maximal wastewater flow to the plant has recently been measured at 0.8 m^3/s, and the current pumping station has a capacity of 2.6 m^3/s.

3.2.1.2.2 Quality of Wastewater currently treated at the Ghadir Preliminary Treatment Plant

Ghadir WWTP is equipped with a laboratory where waste water samples are tested and results are recorded on a regular basis. Calibration of the equipment is carried out regularly, according to the technical specifications.

Results from the laboratory analysis of the wastewater entering the Ghadir pre-treatment plant for the year 2009 (period for which records were available from the laboratory) is presented in Table 3.1, in comparison with the ELVs from the Decision 8/1 (2001).

Table 3.1 Laboratory results at the Ghadir pre-treatment Plant for 2009

Parameter	ELV for sea discharge	ELV for surface water discharge	ELV for sewer discharge	Sampling Point	Laboratory Results (Year 2009)		
					min	max	avr
Temperature	35° C	30° C	35° C	After screens	15,3	30,3	23,2
				After aerated de-gritters	16	30,7	23,94
pH	6-9	6-9	6-9	After screens	7,38	8,61	8,0
				After aerated de-gritters	7,25	8,39	7,77
DO mgO_2/L	-	-	-	After screens	1,46	4,32	2,43
				After aerated de-gritters	1,96	4,43	2,83
Total Suspended Solids mg/L	60	60	600	After screens	481	1050	734
				After aerated de-gritters	402	894	585
Volatile Suspended Solids mg/L	not available	not available	not available	After screens	177	630	380
				After aerated de-gritters	154	570	307
COD mgO_2/L	125	125	500	After screens	376	986	677,3
				After aerated de-gritters	327	824	556,8
BOD_5 mgO_2/L	25	25	125	After aerated de-gritters	168,6	284	241,2
Ammonia (NH_4^+) mg/L	10	10	-	After aerated de-gritters	41,5	129	81,2
Phosphate (PO_4^{3-}) mgP/L	5	5	-	After aerated de-gritters	4,2	14,5	9,2
Alkalinity mg/L	-	-	-	After aerated de-gritters	412	924	644
Total Nitrogen mgN/L (Sum of Kjeldahl-N)	30	30	60	After aerated de-gritters	-	-	-
Total Phosphorous mgP/L	10	10	10	After aerated de-gritters	-	-	-
Iron total (Fe) mg/L	5	5	5	After aerated de-gritters	0,46	5,72	2,12
Copper total (Cu) mg/L	1,5	0,5	1	After aerated de-gritters	0,06	0,92	0,43
Chromium total (Cr) mg/L	2	2	2	After aerated de-gritters	0	0,24	0,06
Cadmium (Cd) mg/L	0,2	0,2	0,2	After aerated de-gritters	0,19	3,65	1,1
Zinc total (Zn) mg/L	5	5	10	After aerated de-gritters	0	0,76	0,22
Nickel total (Ni) mg/L	0,5	0,5	2	After aerated de-gritters	0,53	5,42	1,76
Lead total (Pb) mg/L	0,5	0,5	1	After aerated de-gritters	0	0,7	0,31
Mercury total (Hg) mg/L	0,05	0,05	0,05	After aerated de-gritters	0	0,18	0,031
Sulphate (SO_4^{2-}) mg/L	1000	1000	1000	After aerated de-gritters	212	312	263
Nitrate (NO_3) mg/L	90	90	-	After aerated de-gritters	12	19	14
Detergents (Surfactants) mg/L	3	3	Not available	After aerated de-gritters	5,4	29,6	23,2
Phenol index mg/L	0,3	0,3	5	After aerated de-gritters	0,59	1,12	0,78
Cyanides (CN^-) mg/L	0,1	0,1	1	After aerated de-gritters	0,25	2,7	1,68
Aluminum (Al) mg/L	10	10	10	After aerated de-gritters	0,01	0,26	0,08
Molybdenum (Mo) mg/L	-	-	-	After aerated de-gritters	0	0,7	0,3
Manganese (Mn) mg/L	1	1	1	After aerated de-gritters	0	0,63	0,31
Tannines (mg/L)	-	-	-	After aerated de-gritters	17,7	22,8	20,1
Potassium (K) mg/L	-	-	-	After aerated de-gritters	11,5	109,3	69,6
Boron (Bo) mg/L	-	-	-	After aerated de-gritters	0	2,92	1,56
Silica (Si) mg/L	-	-	-	After aerated de-gritters	13	27	21
AOX (Adsorbable Organic Halides, mg/L)	5	5	5	After aerated de-gritters	-	-	-
Hydrocarbons mg/L	20	20	20	After aerated de-gritters	-	-	-
Oil and Grease mg/L	30	30	50	After aerated de-gritters	-	-	-
Total Organic Carbon (TOC) mg/L	75	75	750	After aerated de-gritters	-	-	-
Silver (Ag) mg/L	0,1	0,1	0,1	After aerated de-gritters	-	-	-
Arsenic (As) mg/L	0,1	0,1	0,1	After aerated de-gritters	-	-	-
Barium (Ba) mg/L	2	2	2	After aerated de-gritters	-	-	-
Cobalt (Co) mg/L	0,5	0,5	1	After aerated de-gritters	-	-	-
Hexavalent Chromium (Cr^{VI}) mg/L	0,2	0,2	0,2	After aerated de-gritters	-	-	-
Antimony (Sb) mg/L	0,3	0,3	0,3	After aerated de-gritters	-	-	-
Tin total (Sn) mg/L	2	2	2	After aerated de-gritters	-	-	-
Active $C1_2$ mg/L	1	1	Not available	After aerated de-gritters	-	-	-
Fluoride (F^-) mg/L	25	25	15	After aerated de-gritters	-	-	-
Sulphide (S^{2-}) mg/L	1	1	1	After aerated de-gritters	-	-	-
Coliform Bacteria 37°C in 100 ml*	2000	2000	Not available	After aerated de-gritters	-	-	-
Salmonellae	absence	absence	absence	After aerated de-gritters	-	-	-

Based on the laboratory results, wastewater from the currently connected Ghadir drainage area is considered to have medium strength, since the annual average value of BOD5 for 2009 measured after the aerated grit chambers is 241 mg/l (maximum 284 mg/l) and assuming that approximately only 5 % of the influent BOD5 is reduced in the de-gritters. On the other hand, ammonia concentration is high, even for high strength wastewater (MoE Decision 8/1-2001, SPD9 Wastewater Treatment).

Additionally, increased concentrations (above the respective ELVs for discharging to sewers) are observed for certain pollutants which include Fe, Cd, Ni, Hg and CN- (highlighted red cells in Table 3.1 above). Increased concentrations of these pollutants in the wastewater may be explained by discharge of industrial wastewater into the municipal sewage network and the Ghadir River from the industrial areas and/or by the discharge of the leachate from the Naameh landfill (taking place daily and every hour via tanker trucks). The concentrations of TSS and VSS are also high, which is probably due to the sand and mud conveyed by the "open" Ghadir River to the plant.

Temperature measurements of wastewater range from 15.3 to 30.3°C, with an average of ~23°C.

3.2.1.2.3 The Existing Sea Outfall System (Main and Overflow Outfalls)

The **main sea outfall** extends over about 2.6 km into the sea and has a diameter of 1,200 mm. Its outlet point lies at a depth of approximately 60 meters. Both outfalls were installed in 1983-1985 by Land & Marine of Bromborough Merseyside, UK. However, the system was not commissioned until 1997 after the preliminary wastewater treatment plant became operational. A condition assessment survey conducted prior to commissioning the pipes (in 1995) by Costain Oil & Process Overseas Ltd showed that the outfall pipe has deviated to the north in the order of 0.3° (Costain, 1995). The deviation affects the last 0.8 km and the pipe is deviated by 15 to 20 m from its theoretical end point location. This deviation could have occurred during construction or due to post-construction currents or loss of seabed stability. The external outfall survey conducted in 1995 also noted physical damage to the outfall at three (3) locations (Costain, 1995). The damages at two of the locations were found to be localized in nature and were not expected to adversely affect the condition of the outfall and thus no remedial work was undertaken. At the third location, the string joint (connection of two pipe sections that is filled with concrete on-site after welding) indicated only 20 to 30 mm of concrete cover to the pipe. It was recommended to install a concrete mattress over this area. The theoretical maximum capacity of the main sea outfall is about 3.4 m^3/s. Some reduction of the theoretical capacity is expected as a result of sedimentation. As such, the long sea outfall could be used until sometime between 2025 and 2030. Beyond this period, either the secondary treatment should be implemented for the effluent to be discharged via the short outfall or a second long sea outfall should be provided.

The **emergency sea outfall** (overflow pipe) is 0.5 km long and has a diameter of 1,500 mm. A maximum flow of 5.3 m^3/s can be delivered at maximum head of 3.0 m. As per the 1995 survey report, the emergency overflow pipe was found to run within 2 to 3 m of its as-built centreline. No physical damage to the overflow pipe was reported.

The condition of the sea water outfalls will be assessed through appropriate surveys that will apply as part of the Ghadir project Upgrade priority actions.

3.2.2 PROJECT STATUS

The Project is currently at its Feasibility stage. While conclusions and decisions have been reached with regard to general Project aspects (baseline data, area coverage, project components, etc.), specific details such as project phasing and prioritization are still under consideration and finalisation through Governmental Organisations, subject to fund availability. Nevertheless, both the FS and the current ESIA deal with all project components which, when completed, will ensure the realization of an integrated project for the Ghadir WWTP Drainage area.

3.3 PROJECT LOCATION

The Project Site is located at the current Al-Ghadir preliminary wastewater treatment facility, about 7 Km south of Beirut, at the direct proximity of the Beirut International Airport. The approximate stereographic coordinates at the centre of the WWTP are X:-339421.906 and Y: -36805.945. The Project's Service Area (where the construction of networks would take place) covers parts of the Governorates of Beirut and Mount Lebanon. It encompasses the whole Southern part of Beirut city, a portion of the Northern Part of Beirut city and parts of the districts (cazas) of Baabda, Aaley, and the Chouf (Figure 3.3).

The preliminary WWTP was considered suitably distant from residential areas at the time of construction. However, the proximity to the Airport has entailed certain limitations on extension due to limited land availability and to airport security issues (aspects taken into consideration in the design). The land surrounding the plant (on shore) has been expropriated by the Airport Authorities for security reasons and for possible future extension of airport facilities. It was confirmed that this area is not planned for the development of any specific facilities under the official Master Plan for the airport extension.

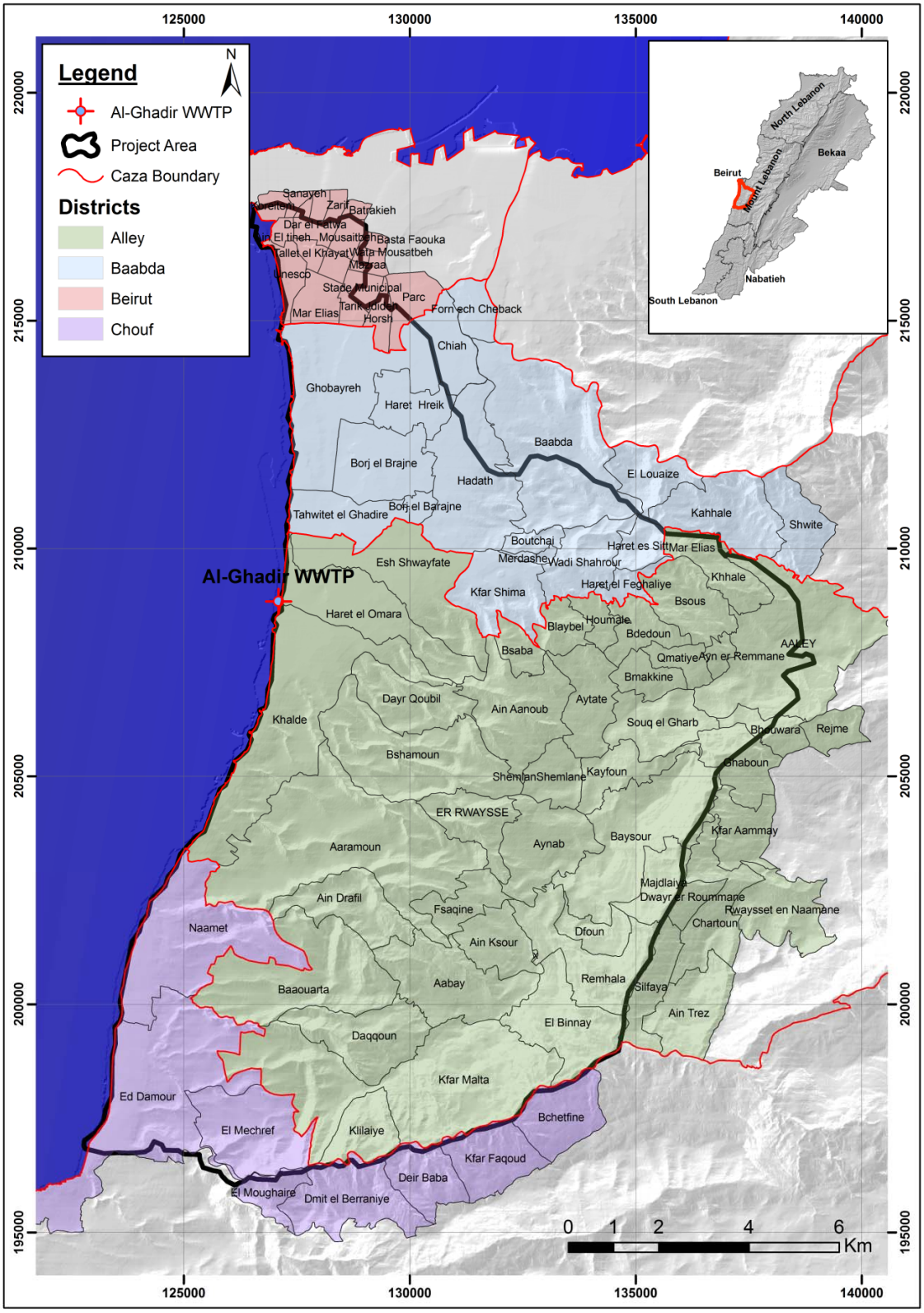


Figure 3.3 Project Location and Study Area

3.4 PROJECT COMPONENTS

The proposed Project consists of two main components:

- **Project Component 1:** The construction of networks in the Al-Ghadir WWTP Drainage Area.
- **Project Component 2:** The extension and upgrade of the existing Al-Ghadir Preliminary Treatment Facility.

The two components are further described in section 3 of this report.

3.5 DESCRIPTION OF PROJECT COMPONENT 1 - CONSTRUCTION OF NETWORKS

Project Component 1 will consist of three (3) main activities:

1. Immediate connection of the already sewered areas to the main collectors to be undertaken as a priority task in parallel with activity 2 hereunder. Planned implementation during 2014; commissioning and operation in 2015 to coincide with the expansion of the WWTP.
2. The existing facility at Al Ghadir provides preliminary treatment and will soon need to be extended to accommodate the increased incoming flow. Therefore an integral part of the first component of the project is to expand the capacity of the wastewater treatment plant to be able to receive the increased incoming flows; planned implementation during 2014; commissioning and operation in 2015.
3. Implementation of the Priority networks identified as Zones G4, G5, G6 and G7 on the map (see Annex 1), equivalent to 77.5% of the un-served population; commence implementation: 2015, gradual network extension works over the following five years – expected completion 2020.

With reference to the "Feasibility Study Part II b: Cost estimate for completing construction of all networks in Ghadir WWTP Drainage Area" (2012), the length of primary sewers to be executed in the Project area was estimated at about 80 Km, and that of secondary and tertiary sewers at about 707 Km.

The Al-Ghadir drainage area was subdivided into 44 zones according to the administration limits of each Municipality (Table 3.2).

Zone I, also called Northern Beirut Area, included Raouche, Mssaitbe, Ramlet el Baida, Tallet el Khayat and Cornich el Mazraaa[3]. This area is 100% sewered and residences are connected to the sewers.

The total length of the existing sewers in Southern Beirut area is: about 204 Km and the total length of the new sewers to be executed is 21 Km. The Southern Beirut area wastewater collection situation is described below.

[3]Areas which belong to Beirut Municipality but which wastewaters are conveyed to Ghadir WWTP

- Ghobayreh Municipality (Zone 2) is covered with 66,337 m of sewers. Served residences are all connected to them. 10,907 m of sewers are to be newly constructed or renovated.
- HaretHreik Municipality (Zone 3) is covered with 27,720 m of sewers. Served residences are all connected to them. 250 m of sewers are to be newly constructed or renovated.
- Borj el Barajneh Municipality (Zone 4) is covered with 85,984 m of sewers. Served residences are all connected to them. 5,567 m of sewers are to be newly constructed or renovated.
- El Mreijeh Municipality (Zone 5) is covered with 23,597 m of sewers. Served residences are all connected to them. 5,079 m of sewers are to be constructed and/or renovated.

The total length of existing sewers (conveyors and collection sewers) in the remaining municipalities (Zone 6 to Zone 44) is about 203,638 m about 204 km.

Table 3.2 Data on existing sewers in the settlements falling within Ghadir WWTP and lengths of additional sewers to be executed

ZONES, VILLAGES, SETTLEMENTS		POPULATION	LENGTH OF SECONDARY EXISTING SEWERS (m)	LENGTH OF SECONDARY SEWERS TO BE EXECUTED (m)
ZONE	NAME			
1	Raouche, Mazraat, Ramlet el Beida	202960	About 100,000 m	None
2	Ghobaireh	166310	66337	10907
3	HaretHreik	63710	27720	250
4	Borj el Barajneh	90970	85984	5567
5	El Mreije	57500	23597	5079
6	Hadath	107190	20000	23810
7	Baabda	25361	43670	9713
8	Boutchay	3597	0	13793
9	OuadiChahrour	7459	8100	14000
10	Kfarchima	20120	8660	50000
11	EshShuayfat	300000	85150	81000
12	DayrQoubil	9000	7750	21450
13	AinAanoub	4475	7690	6887
14	Aitate	3431	3000	14000
15	Blaybel*	1044	0	1500
16	Bdedoun	3431	0	8804
17	Bsous*	4028	0	15000
18	AinRemmaneh	1000	900	3620
19	Qmatiye	4625	0	14000
20	AinSaydeh	1000	1950	1400

21	Souq el Gharb	2089	0	9880
22	Keyfoun	4923	0	13581
23	Aynab	1939	0	23355
24	Bayssour	7907	9700	50000
25	QabrShmoun	3448	0	18150
26	Bshamoun	5371	6350	43000
27	Sarahmoul*	320	0	500
28	Aramoun	35000	6070	66000
29	Naameh*	36899	0	35000
30	Damour	29150	34460	0
31	Baaouerta*	11439	0	30000
32	Daqqoun*	1181	0	2000
33	Kfarmatta*	3506	0	16500
34	Aabay	3690	0	17000
35	El Binnay*	2767	0	12000
36	AinDrafil*	471	0	600
37	AinKsour*	1044	0	2100
38	Fsakine*	1121	0	2500
39	Rwaysse*	230	0	400
40	Aaley	12000	6275	55000
41	Houmal	2536	6000	6000
42	Bsaba*	1492	0	3300
43	Chemlane	1525	0	2380
44	Bmakine	700	3820	2350
	Total	**1,228,086**	**463,183**	**707,376**

* Villages without any sewers

Source: Extension of Al-Ghadir WWTP Feasibility Study Part II b: Cost estimate for completing construction of all networks in Ghadir WWTP Drainage Area" .2012

3.6 DESCRIPTION OF PROJECT COMPONENT 2 - WWTP EXTENSION AND UPGRADE

The Conventional Activated Sludge with Anaerobic Sludge Treatment (CAS) is assessed to be the best treatment option for the upgraded Al-Ghadir WWTP. The CAS option is suggested to be constructed in three phases (subject to funds availability), based on the assumptions for the completion of all necessary networks serving the Ghadir drainage area, as follows:

- **Phase I.a (2015 to 2020)**: It will include ***extension*** of the preliminary treatment (to accommodate the increased flow beyond the plant's current capacity). **This process step will remove ~5% of the BOD.**
- **Phase I.b (2020 to 2030)**: It will include ***upgrade*** of the existing facilities to Primary Treatment (Settling), including Sludge Treatment and Energy Recovery facilities for the primary sludge. Effluent will be discharged through the existing Long Sea Outfall. There is no need for land reclamation (all facilities are on shore). By the operation of t**his process step 25-30% of the BOD will be removed from the inflow load.**
- **Phase II (2030 – 2050)**: ***Upgrade*** the plant to Secondary Treatment; ***extend*** sludge treatment to accommodate secondary sludge. Land reclamation required, extension of the plant off-shore. By the operation of t**his process step >95% of the BOD will be removed from the inflow load.**

3.6.1 DESCRIPTION OF THE TREATMENT FACILITY

The treatment facility will include the following units (layout provided under Annex 2 and flow chart provided in Figure 3.4):

- Preliminary Treatment Unit which includes:
  - Initial Lifting Pumping Station;
  - Screening; and
  - Aerated De-gritting Chambers.
- Primary Treatment Unit (lamella settling tanks);
- Secondary Treatment Unit, including:
  - Anoxic tanks;
  - Aeration tanks;
  - Secondary Settling Tanks; and
  - Chlorination/de-chlorination tanks.
- Sludge Treatment Facilities, including:
  - Gravity Thickeners, for primary sludge (PS);
  - Sludge Screening, for primary sludge;
  - Mechanical Thickening, for secondary activated sludge (SAS);
  - Buffering-Mixing tanks, for PS and SAS;
  - Anaerobic Digestion Treatment, for mixed sludge;
  - Mechanical Dewatering of digested sludge; and
  - Storage of dewatered sludge.
- Biogas Utilisation Unit, including:
  - Biogas Collection and Storage;
  - Combined Heat – Power (CHP) Engines, for power production; and
  - Emergency Flaring Station.

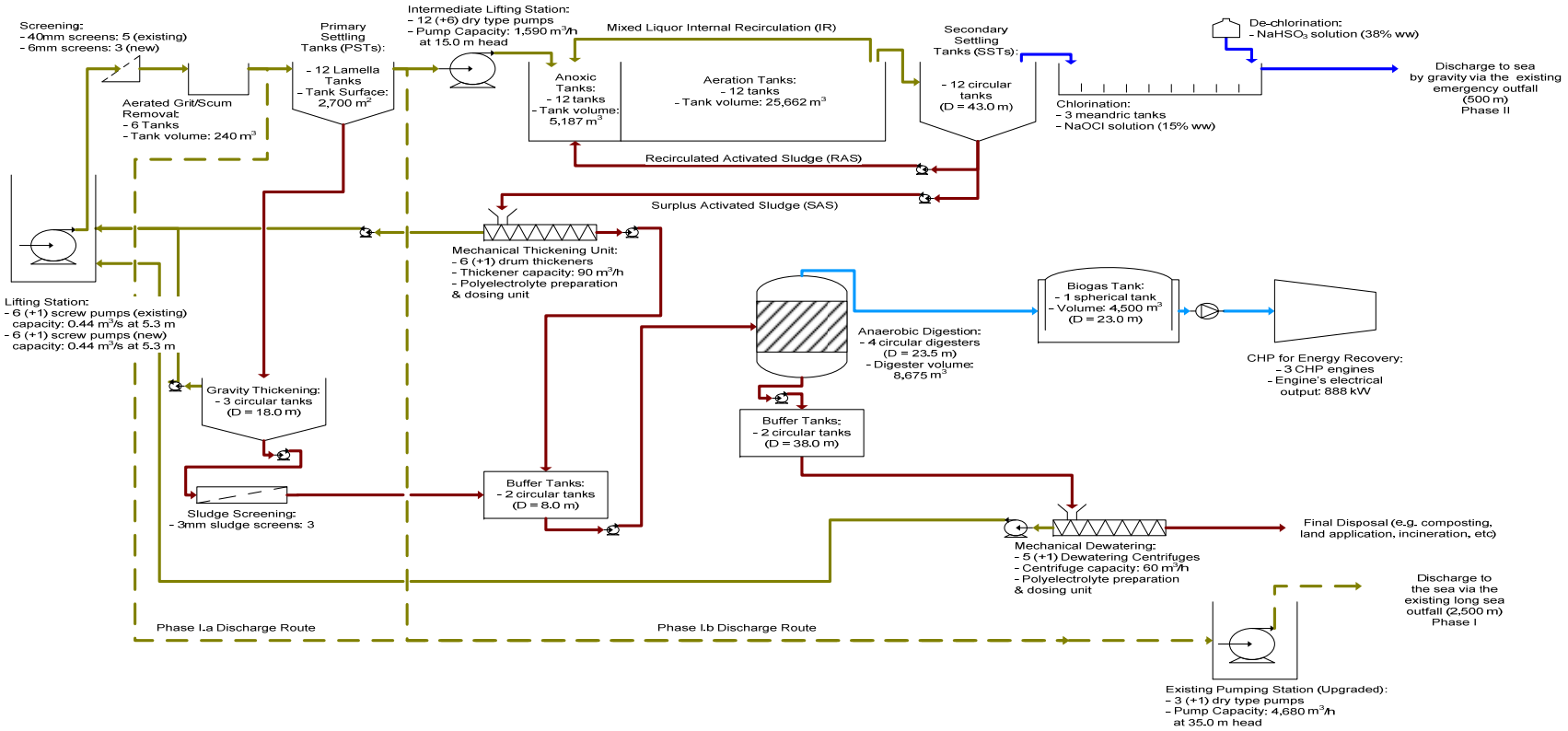


Figure 3.4 Flow chart of the CAS treatment option (Source: Extension of Al-Ghadir WWTP - Feasibility Study Part II a: Development of Alternative Processes for the WWTP. 2012

3.6.2 CIVIL WORKS

The Civil Works needed for the WWTP upgrade are summarised in Table 3.3.

Table 3.3 Civil Works needed for Project Component 2

UNIT	SURFACE REQUIREMENTS (m^2)	VOLUME REQUIREMENTS (m^3)	NO OF UNITS
PHASE I			
Lifting Station	-	-	1
Screening	-	-	3
De-gritting chamber	-	950	2
Primary Settling Tanks	3,166	-	12
Gravity PS Thickeners	699	-	3
Buffer Tanks I (Prior to Digestion)	-	564	2
Anaerobic Digesters	-	33,824	4
Buffer Tanks II (Prior to Dewatering)	-	11,275	2
PHASE II			
Anoxic Tanks	-	54,441	12
Aeration Tanks	-	281,794	12
Secondary Settling Tanks	15,830	-	12
Buffer Tanks III (Prior to Sludge Mechanical Thickening)	-	2,055	1
Chlorination Tanks	-	6,332	3

Source: Extension of Al-Ghadir WWTP Feasibility Study Part II a: Development of Alternative Processes for the WWTP. 2012

3.6.3 MECHANICAL WORKS

The Mechanical Works needed for the WWTP upgrade (Project Component 2) are summarised in Table 3.4.

Table 3.4 Mechanical Works for Project Component 2 (Phase I & II)

EQUIPMENT	NO OF DUTY ITEMS	STANDBY ITEMS	TECHNICAL SPECIFICATIONS FOR EACH ITEM	
			CAPACITY (m^3/h)	HEAD (m)
PHASE I				
Preliminary Treatment				
Lifting Screw Pumps	6	1	1,584	5.3
Intake Screens	3	1	Bar Spacing: 6mm, Indicative dimensions WxH: 2400 mm x 5000 mm	

EQUIPMENT	NO OF DUTY ITEMS	STANDBY ITEMS	TECHNICAL SPECIFICATIONS FOR EACH ITEM	
			CAPACITY (m^3/h)	HEAD (m)
Grit Chambers' Blowers	2	1	960	4.0
Bridge with scum skimmers and Scrappers	1		Bridge equipped with 2 Scum skimmers and 2 Scrappers. Bridge Width: 16.0 m. Scum skimmers width: 3.0 m each. Scrappers width: 0.5 m each	
Grit Pumps	6	2	2.0	6.0
Grit classifiers	2			
Launder Wash Pumps	2	1		
Screenings compactor	3	1		
Primary Treatment				
Lamellas in PSTs	12		Dimensions per tank of lamellas media LxWxH: 30.0 m x 9.0 m x 2.0 m	
Surface and Bottom Scrapers	24		Dimensions of scrapers L x W: 9.0 m x 0.30 m 12 scrapers per system (interval of 5.0 m between scrapers)	
Primary Sludge Pumps	12	4	30	6.0
Penstocks	24		Allow 1 per feed and 1 per exit to isolate each line	
Sludge Thickening				
Bridge of gravity thickeners	3		Radius of 9.0 + 0.6 m equipped with sludge scrappers and scum hopper	
Thickened PS Pumps	3	3	30	6.0
Supernatant Leachate Pumps	3	3	30	5.0
Sludge Screens	3		30	
Anaerobic Digestion				
Thickened Mixed Sludge Pumps	4	4	24	22.0
Low-speed Mixers	4	1	Minimum Power Input: 30 kW	
Biogas Blowers	6	3	250	5.0
Biogas Storage Tank	1		Spherical Tank with Diameter 23.0 m and Height 20.0 m Capacity 4500 m3	
Sludge Recirculation Pumps	4	4	48	20.0
Blowers and Pumps Building	1		Dimensions of the Building LxWxH: 15.0 m x 10.0 m x 6.0 m	
Biogas Utilisation				
CHP Engines	2	0	Jenbacher, frame 4, model 412	
CHP Engines Building	1		Dimensions of the Building LxWxH: 30.0 m x 23.0 m x 8.0 m	
Bridge Crane	1		Dimensions of the Building LxWxH: 30.0 m x 23.0 m x 8.0 m Capacity of the Bridge Crane: 45 tones	
Spiral Heat Exchangers	4	2		
Dual-fuel Boiler	4			
Biogas Burner and Flare Stack	1		990	

EQUIPMENT	NO OF DUTY ITEMS	STANDBY ITEMS	TECHNICAL SPECIFICATIONS FOR EACH ITEM	
			CAPACITY (m^3/h)	HEAD (m)
Buffer Tank prior to Dewatering				
Digested Sludge Blowers	2	1	5,638	6.0
Sludge Dewatering				
Digested Sludge Feed Pumps	3	1	50	5.0
Dewatering Centrifuges	3	1	60	
Polyelectrolyte Dosing Pumps	3	1	0.02	5.0
Dewatered Cake Sludge Pumps	3	1	8.0	12.0
Dewatering liquor return Pumps	2	2	57	6.0
Sludge Mechanical Dewatering Building	1		Dimensions of the Building LxWxH: 28.0 m x 12.0 m x 8.0 m	
Bridge Crane	1		Dimensions of the Building LxWxH: 28.0 m x 12.0 m x 8.0 m Capacity of the Bridge Crane: 12 tones	
Dewatered Sludge Silos	4		Dimensions of each Tank D x H: 12.0 m x 8.0 m	
Polyelectrolyte Preparation and Dosing System for Mechanical Dewatering				
Polyelectrolyte Solution Preparation and Storage Tank	1	1	Volume of Tank: 2.20 m3	
Polyelectrolyte Solution Tank Mixer	1	1		
Chemicals Storage Building	1		Dimensions of the Building LxWxH: 18.0 m x 12.0 m x 5.0 m	
Discharge Pumping Station				
Discharge Pumps (via the long sea outfall)	3	1	4,680	35
Miscellaneous				
Primary effluent Washwater Booster Set	2	1		
Odour control Unit	1			
PHASE II				
Preliminary Treatment				
Lifting Screw Pumps	6	1	1,584	5.3
Intake Screens	4	1	Bar Spacing: 40 mm, Indicative dimensions WxH: 1600 mm x 5000 mm	
Interim Lifting Pumps	12	6	1,584	10.0
Interim Lifting Pumps Building	1		Dimensions of the Building LxWxH: 33.0 m x 10.0 m x 4.0 m	
Anoxic Tanks				
Mixers	24	4	Minimum Power Input: 18.5 kW	
Aeration Tanks				
Aeration Blowers	16	2	14,732	6.8
Fine-bubble Diffusers	235,896		1	

EQUIPMENT	NO OF DUTY ITEMS	STANDBY ITEMS	TECHNICAL SPECIFICATIONS FOR EACH ITEM	
			CAPACITY (m^3/h)	HEAD (m)
Internal Recirculation Pumps (Mixed Liquid)	24	12	910	0.8
Blowers Building	1		Dimensions of the Building LxWxH: 50.0 m x 12.0 m x 6.0 m	
Penstocks	48		Allow 1 per feed and 3 to Isolate Recirculation per lane	
Secondary Settling Tanks				
Bridge of SSTs	12		Radius of 21.5 m equipped with sludge scrappers and scum hopper	
SAS Pumps	6	6	90	10.0
RAS Pumps	12	6	610	6.0
Penstocks	12		Allow 1 per feed	
SAS Mechanical Thickening				
SAS Feeding Pumps	6	2	86	5.0
Drum Thickeners	6	1	90	
Polyelectrolyte Dosing Pumps	6	1	0.01	5.0
Thickened SAS Pumps	6	1	12	30.0
Leachate Pumps	2	1	149	5.0
Polyelectrolyte Preparation and Dosing System for Mechanical Thickening				
Polyelectrolyte Solution Preparation and Storage Tank	1	1	Volume of Tank: 1.30 m3	
Polyelectrolyte Solution Tank Mixer	1	1		
Polyelectrolyte System Building	1		Dimensions of the Building LxWxH: 20.0 m x 9.0 m x 6.0 m	
Sludge Dewatering				
Digested Sludge Centrifuge Feed Pumps	2		50	5.0
Dewatering Centrifuges	2		60	
Polyelectrolyte Dosing Pumps	2		0.02	5.0
Dewatered Cake Sludge Pumps	2	1	8,0	12.0
Biogas Utilisation for Phase II				
Biogas Blowers	2	1	250	5.0
CHP Engines	1		Jenbacher, frame 4, model 412	
CHP Engines Building	1		Dimensions of the Building LxWxH: 30.0 m x 23.0 m x 8.0 m	
Bridge Crane	1		Dimensions of the Building LxWxH: 30.0 m x 23.0 m x 8.0 m Capacity of the Bridge Crane: 45 tones	
Biogas Burner and Flare Stack	1		990	
Chlorination System				
NaOCl Solution Tank	1		Volume of Tank: 70 m3	

EQUIPMENT	NO OF DUTY ITEMS	STANDBY ITEMS	TECHNICAL SPECIFICATIONS FOR EACH ITEM	
			CAPACITY (m^3/h)	HEAD (m)
Dosing Pumps	3	3	0.15	5.0
De-chlorination System				
$NaHSO_3$ Solution Tank	1		Volume of Tank: 42 m3	
Dosing Pumps	3	3	0.090	5.0
Chemicals Storage Building	1		Dimensions of the Building LxWxH: 20.0 m x 8.0 m x 6.0 m	

3.6.4 LAND RECLAMATION WORKS

Land reclamation works required for WWTP upgrade are summarized in Table 3.5. A section drawing illustrating reclamation works figures under Annex 3.

Table 3.5 Land Reclamation needed for Phase II of Project Component 2

ITEM	DESCRIPTION	UNIT	QUANTITY
A	Mobilization and Demobilization	LS	1
B	***Dredging Works***		
B.1	Dredging under toe for Accropodes	m^3	25,640
C	***Rock Works***		
C.1	Reclamation to level +5.00	m^3	613,240
C.2	Rocks (1 -3 T)	m^3	17,530
C.3	Rocks (3-6 T)	m^3	9,240
C.4	Rocks (4-8 T)	m^3	9,800
D	***Concrete Works***		
D.1	Accropodes 9 m^3	m^3	43,670
D.2	Reinforced Concrete Structure	m^3	5,310

Source: Extension of Al-Ghadir WWTP Feasibility Study Part II a: Development of Alternative Processes for the WWTP. 2012

3.6.5 INPUTS AND OUTPUTS

This section summarizes input and output flows into and from the upgraded WWTP during its operation.

3.6.5.1 WASTEWATER FLOWS

The estimated flows that would reach the WWTP until 2050 are shown in Table 3.6.

Table 3.6 Estimated Wastewater Flows

	UNIT/YEAR	2015	2020	2025	2030	2035	2040	2045	2050
DRY SEASON – FLOWS (IN M^3/S)									
Domestic commerce and industry	m^3/s	1.47	1.81	2.04	2.31	2.47	2.58	2.74	2.96
Inflow and infiltration	m^3/s	0.20	0.25	0.28	0.32	0.34	0.36	0.38	0.41
Average flow (total)	m^3/s	**1.67**	**2.06**	**2.32**	**2.64**	**2.81**	**2.93**	**3.12**	**3.38**
Peak flow	m^3/s	**2.57**	**3.06**	**3.39**	**3.78**	**3.99**	**4.14**	**4.36**	**4.66**
WET SEASON - FLOWS (IN M^3/S)									
Domestic commerce and industry	m^3/s	1.47	1.81	2.04	2.31	2.47	2.58	2.74	2.96
Inflow and infiltration	m^3/s	1.02	1.13	1.13	1.12	1.03	0.89	0.95	1.03
Average flow (total)	**m^3/s**	**2.49**	**2.94**	**3.17**	**3.44**	**3.50**	**3.47**	**3.69**	**3.99**
Peak flow	**m^3/s**	**3.39**	**3.94**	**4.24**	**4.58**	**4.68**	**4.67**	**4.93**	**5.28**

Source: Extension of Al-Ghadir WWTP Feasibility Study Part I : Project background and baseline data. 2012

3.6.5.2 ELECTRIC POWER CONSUMPTION

The daily consumption of electric power at full load operation in Phase I (year 2030) of the preliminary treatment facilities is calculated at 85,767 kWh and for the entire facilities (preliminary & primary wastewater treatment and sludge treatment with energy recovery) is calculated at 82,983 kWh, while the respective value for Phase II is 117,152 kWh (year 2050). This power demand is calculated after excluding the power generated onsite by the CHP engines (Phase I.b and II) and refers to the full inflow of wastewater which is 286,912 m^3/day for Phase I (I.a & I.b) and 345,044 m^3/day for Phase II.

3.6.5.3 CHEMICALS' CONSUMPTION

The chemicals used for the treatment process include polyelectrolyte for the mechanical thickening and dewatering of the produced sludge and NaOCl & NaHSO3 solutions (15% and 38% respectively) for the disinfection (chlorination/de-chlorination) of the treated effluent prior to its discharge to the sea.

The daily consumption of these chemicals at full load operation of the WWTP during Phases I.b & II (no chemicals are consumed during Phase I.a) are presented per phase of operation in Table 3.7.

Table 3.7 Chemicals' daily consumption at the upgraded WWTP

CHEMICALS' DAILY CONSUMPTION	PHASE I (I.b)	PHASE II
Polyelectrolyte (kg/day)	247	757
NaOCl solution 15% (l/day)	-	10,152
$NaHSO_3$ solution 38% (l/day)	-	6,000

Source: Extension of Al-Ghadir WWTP Feasibility Study Part IIa : Development of Alternative Processes for the WWTP. 2012

3.6.5.4 SLUDGE GENERATION AND MANAGEMENT

The daily sludge production at full load operation (year 2030) of the WWTP during Phase I.b (no sludge is produced during Phase I.a) is calculated at 162 m^3/day, while the respective value for Phase II is about 324 m^3/day (year 2050).

The sludge is to be thickened, stabilized and dewatered on-site, within closed units to avoid odour generation, before being disposed of into landfills or in energy recovery facilities, depending on national waste management strategies to be adopted. Energy recovery units are also planned for the utilisation of biogas produced during the anaerobic sludge digestion process, for use in the WWTP itself (see section 3.6.5.2).

3.6.6 OPERATING PERSONNEL

The estimated number of personnel required for the operation of the plant per Phase is presented in Table 3.8. Three (3) main shifts and one spare (for the day-offs of regular personnel) are considered to run the plant.

Table 3.8 Personnel requirements for upgraded WWTP operation

PERSONNEL	UNIT	PHASE I.A & I.B	PHASE II
Management	Persons/year	1	1
Administration	Persons/year	2	2
Shift supervisors	Persons/year	4	4
Operators	Persons/year	12	16
Mechanic/Electrician	Persons/year	4	4
Laboratory staff	Persons/year	3	3
Cleaning staff	Persons/year	2	2

Source: Extension of Al-Ghadir WWTP Feasibility Study Part IIa : Development of Alternative Processes for the WWTP. 2012

3.7 PROJECT PHASING

The proposed phasing for the implementation of the Project is described in Table 3.9.

Table 3.9 Phasing of Networks and Estimated Cost

Phases	Years	Description of Tasks	Estimated Cost in USD*
Phase I.A	2015-2020	Construct main wastewater conveyors to include pumping stations and complete Priority 1 networks to cover 77.5% of the Ghadir Drainage Basin between 2015 and 2020 (including the areas to be served by KfW funded networks)	60 Million
		Extend the capacity of existing preliminary works at the Al Ghadir wastewater treatment plant by 2015	16 Million
Phase I.B	2020	Upgrade the wastewater treatment plant to primary treatment by 2020 (consistent with sludge remedy)	66 Million
Phase II	2030-2050	Upgrade the WWTP to secondary level of treatment by 2030	160 Million
		Complete the remaining Networks to serve 22.5% of PE	83 Million
Total For Networks			**143 Million**
Total For Treatment Plant Extension and Upgrade			**242 Million**

** In today's price*

Source: Extension of the WWTP for Al-Ghadir- Lebanon. Summary Note. 2012

4 ANALYSIS OF ALTERNATIVES

In this section the retained Project Options, including the "No project" situation, are systematically compared in terms of their potential environmental impacts, the feasibility of mitigating these impacts, their suitability under local conditions, and their institutional, training, and monitoring requirements.

4.1 NO-PROJECT ALTERNATIVE

The "No Project" alternative implies the interruption of the project implementation, and would result in the Al-Ghadir WWTP and drainage area being retained in their current status.

The wastewater collection networks within the Ghadir drainage basin have not been fully constructed yet. At present, the project area still encompasses sectors with no sewerage networks, and sectors with old network connections. As a result, uncontrolled discharges in the open environment are frequent; and the Al-Ghadir River serves in its lower section as a combined sewerage and storm water conveyor connected to the Al Ghadir WWTP. If the network is not extended and upgraded, diffused pollution problems related to uncontrolled discharges are thus likely to persist.

On another front, the existing Al Ghadir wastewater treatment facility is likely to reach saturation if not extended, given additional wastewater flows reflective of expected population growth. Additionally, the plant currently treats incoming wastewater up to a preliminary level only. As a result, the effluent is loaded with contaminants (nitrates, nitrites, phosphates, fecal coliforms and streptococcus colonies), which have proved to be subject to an upwelling from bottom till surface even when discharged through the 60 m deep outflow. As such, there is a need to upgrade the treatment so as to reduce the pollution load reaching the Mediterranean sea.

In conclusion, the No-Project alternative would imply:

- Continued or increased health risks posed to inhabitants of the Al Ghadir drainage basin.
- Continued or increased pollution and environmental stress in the Al-Ghadir river and drainage area due to uncontrolled wastewater discharges;
- Continued or increased pollutions of the Mediterranean Sea as ultimate recipient of the discharged wastewater flows;
- Continued negative impacts on marine and aquatic fauna and flora due to the deterioration of the quality of coastal waters and an increase in river contamination; and

4.2 PROCESS ALTERNATIVES

The treatment option selected for this Project is the Conventional activated sludge (CAS) with lamella primary settling tanks, anaerobic digestion of sludge and energy recovery.

Alternative treatment options considered are as follows:

- ASP: Activated Sludge Process without primary settling treatment and with aerobic digestion of the produced sludge;
- SBR: Sequence Batch Reactors with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- MBBR: Moving Bed Biological Reactor with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery;
- MBR: Membrane Biological Reactor with primary settling tanks (lamella) and with anaerobic digestion of the produced sludge for energy recovery; and
- UASB: Upflow Anaerobic Sludge Blanket Reactor combined with a smaller capacity CAS treatment option (secondary treatment, clarifiers…).

These are further described and compared in this section; from an environmental, economic, legal, and technical perspective.

4.2.1.1 ACTIVATED SLUDGE PROCESS WITHOUT PRIMARY SETTLING TREATMENT (ASP) AND WITH AEROBIC DIGESTION OF THE PRODUCED SLUDGE

The ASP treatment is an alternative CAS process, without primary treatment; another variation to the CAS is that the sludge (biomass) produced from the biological processes (carbonation, nitrification, de-nitrification) is digested aerobically (rather than anaerobically, due to the low potential for biogas production). The treatment scheme of this option includes a Preliminary Treatment Unit, a Secondary Treatment Unit, and Sludge Treatment Facilities.

Main advantages related to this treatment technology include:

- Aerobic digestion has **the lowest risk of odour nuisance** when compared to anaerobic digestion. The latter also may raise safety concerns in the vicinity of the airport, due to its need for biogas storage and/or flaring;
- It's a simple open source technology;
- Small volumes of sludge are generated and need final disposal; and
- Likely low capital costs; low mechanical and electrical content for achieving all ELVs.

The key issues of concern related to this alternative are:

- Its large land footprint;
- The high electrical operating cost for the secondary treatment plant, as there is increased aeration demand for the biological process;
- The fact that there is no biogas production and therefore no electricity recovery; and
- The fact that wetter volumes of sludge need disposal (possible necessity for additional fuel if incineration off-site is used).

4.2.1.2 SEQUENCE BATCH REACTORS (SBR) WITH PRIMARY SETTLING TANKS (LAMELLA) AND WITH ANAEROBIC DIGESTION OF THE PRODUCED SLUDGE FOR ENERGY RECOVERY

The Sequence Batch Reactor process is also an activated sludge process, but where the biological treatment (carbonation, nitrification and denitrification) and the liquid/biomass separation (sludge settling) are combined in a single tank, taking place in sequential phases. The treatment scheme of this option includes the following steps:

- Preliminary Treatment Unit

- Primary Treatment Unit (lamella settling tanks)
- Secondary Treatment Unit
- Sludge Treatment Facilities
- Biogas Utilisation Unit

The advantages of this treatment option include:

- Well proven process, with a lot of plants operating all over the world;
- Proven process at similar scale at large cities (e.g. Cardiff 300,000 PE, Dublin 1.2 M PE (peak wet flow 11.1 m^3/s), currently to be installed in Liverpool (approx. 1 M PE) to replace existing BAFF (Biological Aerated Flooded Filter);
- Likely low investment cost (for all ELVs met);
- Small footprint due to the combination of the biological and clarification functions in one tank; and
- Energy recovery (biogas utilisation from anaerobic sludge digestion).

The key issues of concern related to SBR alternative treatment option are stated below

- More complex control (as a semi-batch process); and
- Operational concern regarding the wastewater biological solids separation (sludge bulking).

4.2.1.3 MOVING BED BIOLOGICAL REACTOR (MBBR) WITH PRIMARY SETTLING TANKS (LAMELLA) AND WITH ANAEROBIC DIGESTION OF THE PRODUCED SLUDGE FOR ENERGY RECOVERY

The MBBR system is a combination of activated sludge systems (e.g. CAS, ASP etc) and attached growth systems (e.g. Trickling Filters, BAFF etc) developed to combine the advantage of both these process categories. MBBR system is very similar to CAS system with the main differences being: a) the addition of plastic carriers (moving bed) in the anoxic and aeration tanks (for the growth of biomass film), b) there is no need for sludge recycling from the clarifiers to the carrier tanks. The treatment scheme of this option includes the following steps:

- Preliminary Treatment Unit
- Primary Treatment Unit (lamella settling tanks)
- Fine Screening up to 2.0-3.0 mm
- Secondary Treatment Unit
- Sludge Treatment Facilities
- Biogas Utilisation Unit

The advantages of this treatment option include

- Significantly small footprint of the anoxic/aeration tanks;
- Excellent tolerance to toxic shocks from industrial wastewater pollutants; this could be an advantage considering the current status regarding the uncontrolled industrial discharges to the Ghadir river;
- Commonly applied for upgrading (with minimum retrofitting works) existing CAS systems that have reached their capacity (in terms of hydraulic and/or organic load);

- There are some large scale reference plants for the treatment of municipal wastewater;
- Eliminates sludge bulking (main operational problem of CAS and SBR plants); and
- Energy recovery (biogas utilisation from the anaerobic sludge digestion).

The key issues of concern related to MBBR alternative treatment option are stated below

- Cost of the media used; it may not compensate for the construction savings (from the smaller anoxic/aeration tanks);
- Potential for fouling of the media and of the media separation screens; to address this requires second stage of screening after PSTs (Primary Settling Tanks) to screen to 2-3 mm (not a major cost burden);
- Needs good grease and fat removal upstream (existing works in Ghadir preliminary treatment works are adequate for this);
- Can be difficult to maintain diffusers in the aeration tanks

4.2.1.4 MEMBRANE BIOLOGICAL REACTOR (MBR) WITH PRIMARY SETTLING TANKS (LAMELLA) AND WITH ANAEROBIC DIGESTION OF THE PRODUCED SLUDGE FOR ENERGY RECOVERY

The MBR system is a CAS system where the final clarifiers for the separation of solids from the treated effluent are replaced with Ultrafiltration (UF) membranes (separately or within the biological reactor. This allows for the operation of the biological treatment with higher biomass concentrations in the main process reactors (anoxic/aeration) which in turn results in significantly smaller plant footprint, due to the smaller tank volumes and the absence of final clarifiers. The treatment scheme of this option includes the following steps:

- Preliminary Treatment Unit which include:
- Primary Treatment Unit (lamella settling tanks)
- Fine Screening up to 0.8-1.0 mm
- Secondary Treatment Unit
- Sludge Treatment Facilities
- Biogas Utilisation Unit

The advantages of this treatment option include:

- Very small footprint; the option with the highest potential to fit on-shore (no need for land reclamation off shore);
- Production of very high quality effluent meaning; there is no need for advanced treatment (tertiary) in case of reuse;
- No sludge bulking concerns during the operation of the plant (as there are no secondary clarifiers);
- No need for further disinfection (which is required for all other processes) prior to the sea discharge; and
- Energy recovery as in CAS system (due to the sludge anaerobic digestion).

The key issues of concern related to MBR alternative treatment option are stated below

- Locked into a single supplier for the certain membrane replacement; risk of cost escalation and/or difficult or even impossible to replace in case the manufacturer suspends their operation;

- High Membrane replacement cost;
- Potential for fouling of the membranes;
- High energy cost for aeration;
- Need for high level of operator skill and monitoring;
- Need for ultra-fine pre-screening required (up to 0.8 mm screening);
- Uncertainty on membrane life; the membranes have to be replaced, typically after 5-10 years of operation.

4.2.1.5 UPFLOW ANAEROBIC SLUDGE BLANKET (UASB) REACTOR COMBINED WITH A SMALLER CAPACITY CAS TREATMENT OPTION (SECONDARY TREATMENT, CLARIFIERS…)

The anaerobic treatment of wastewater is a well-established wastewater treatment process mainly designed as a primary biological process in high organic load wastewaters from industrial activities (e.g. pig farms, food industry etc). Over the last decades, it has also been used for the treatment of municipal wastewater, in warm countries (e.g. Brazil, India etc). It allows the degradation of organic pollution without the need for aeration, while it produces biogas which can be used for electric energy production. The treatment scheme of this option includes the following steps:

- Preliminary Treatment Unit
- "Primary" Biological treatment using Upflow Anaerobic Sludge Blanket (UASB) Reactors
- Secondary Biological Treatment Unit
- Sludge Treatment Facilities
- Biogas Utilisation Unit

The advantages of this treatment option include

- Presents the potential for lowest energy requirement, if the production and utilisation of the biogas can be achieved;
- UASB as Phase I treatment can remove 60% - 70 % of the BOD depending on wastewater temperature – it allows for good phasing of the project.

The key issues of concern related to UASB alternative treatment option are stated below

- Lack of references at lower wastewater temperature range (the winter wastewater temperature in Ghadir is 15 $^{\circ}$C). Only one major plant in region in Ajman (UAE) with capacity of 81,000 m^3/d has recently been built, so there is no long term performance established yet;
- BOD removal efficiency may drop to only 40-45 % in winter;
- Plant stability, BOD removal, sludge production and gas production need to be proven for Lebanese winter wastewater temperatures. Therefore, a full scale pilot UASB cell is suggested for the first year to prove the design parameters;
- Requires a secondary aerobic treatment (including clarification) after the UASB to achieve ELVs for, BOD, ammonia, suspended solids, phosphate;
- Significant odour concerns (especially due to proximity to the airport);
- Difficulty of proven gas recovery system for energy recovery at this scale. None of the existing major UASB facilities recover electrical energy from biogas; and
- Where sulphates, from infiltration of seawater, are present in sewage, there is the production of hydrogen sulphide in the anaerobic reactor. This can be troublesome in

terms of odour, and can increase the oxygen requirement of the effluent from the UASB reactor as any sulphide is oxidised to sulphate.

4.2.1.6 SYNOPSIS OF ALTERNATIVE TREATMENT OPTIONS

A synopsis of the advantages, key issues of concern, assumed phasing, and investment cost per process alternative examined is presented in Table 4.1.

Table 4.1 Synopsis of alternative treatment options

Option	Advantages	Key Issues of Concern	Phase I	Phase II
CAS	▪ Well proven process; ▪ Simple open source technology; ▪ Applicable (suggested) for other WWTPs in Lebanon; ▪ Energy recovery	▪ Requires large land footprint ▪ Operational concern regarding the separation of biomass from the treated effluent	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**
ASP	▪ Less odour nuisance; ▪ Simple open source technology; ▪ Small volumes of sludge ▪ Likely low capital costs; low mechanical and electrical content for achieving all ELVs.	▪ Large land footprint; ▪ High electrical operating cost ▪ No biogas is production and no electricity recovery; ▪ Wetter volumes of sludge need disposal	a) Extension of Preliminary Treatment **BOD removal: 5%-10%**	a) Upgrade to Secondary Treatment b) **Aerobic** Sludge Treatment for Secondary Sludge **BOD removal: 96%**
SBR	▪ Well proven process; ▪ Likely low investment cost ▪ Small footprint; ▪ Energy recovery.	▪ More complex control ▪ Operational concern regarding sludge bulking.	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**
MBBR	▪ Significantly small footprint; ▪ Excellent tolerance to toxic shocks from industrial wastewater pollutants; ▪ Commonly applied for upgrading existing CAS systems ▪ Eliminates sludge bulking; ▪ Energy recovery	▪ Cost of the media used ▪ Potential for fouling of the media and of the media separation screens; ▪ Needs good grease and fat removal upstream ▪ Can be difficult to maintain diffusers in the aeration tanks	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**

Option	Advantages	Key Issues of Concern	Phase I	Phase II
MBR	▪ Very small footprint; ▪ Production of very high quality effluent →no need for tertiary treatment; ▪ No sludge bulking concerns; ▪ No need for further disinfection; ▪ Energy recovery	▪ Locked into a single supplier; ▪ High Membrane replacement cost; ▪ Potential for fouling of the membranes; ▪ High energy cost for aeration; ▪ Need for high level of operator skill and monitoring; ▪ Need for ultra-fine pre-screening ▪ Uncertainty on membrane life	a) Extension of Preliminary Treatment b) Upgrade to Primary Treatment (Settling Tanks) c) Anaerobic Sludge Treatment for Primary Sludge **BOD removal: 25%-30%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**
UASB	▪ Potential for lowest energy requirement; ▪ Phase I treatment can remove 60% - 70 % of the BOD	▪ Lack of references at lower wastewater temperature range ▪ BOD removal efficiency may drop to only 40-45 % in winter; ▪ Needs to be proven for Lebanese winter wastewater temperatures ▪ Requires a secondary aerobic treatment ▪ Significant odour concerns ▪ Difficulty of proven energy recovery at this scale ▪ Potential odours and increase in the oxygen requirement of the effluent sulphate.	a) Extension of Preliminary Treatment and Pilot UASB reactor (Phase I-a: 2015) b) Upgrade to UASB treatment (Phase I-b: 2016) c) Anaerobic Sludge Treatment for UASB Sludge (Phase I-b: 2016) **BOD removal: 60%-70%**	a) Upgrade to Secondary Treatment b) Extension of Anaerobic Sludge Treatment for Secondary Sludge **BOD removal: 96%**

Source: Extension of Al-Ghadir WWTP Feasibility Study Part IIa : Development of Alternative Processes for the WWTP. 2012

As a result, the CAS is identified as the most suitable option. It is one of the most established, cost effective and least energy-intensive process treatments. This option also allows for optimal phasing depending on fund availability, allowing for simultaneous development in networks and by that ensuring the Project's overall environmental integrity.

5 PUBLIC PARTICIPATION

5.1 PUBLIC ENGAGEMENT METHODOLOGY

Scoping consultations were conducted in accordance with national guidance as per the EIA decree and as per the following guidance documents:

- The European Commission's Guidance on EIA Scoping, 2001;
- EIB's Statement of Environmental and Social Principles and Standards, 2009; and
- EIB's Environmental and Social Practices Handbook, 2010.

Stakeholder engagement and consultation activities undertaken to date include a public consultation meeting held on July 31st, 2012. Prior to the meeting:

- Invitation letters (Annex 4) were sent to public offices, municipalities, NGOs and other private stakeholders as identified in the List of Invitees (Annex 5); and flyers (Annex 4) were hung on public municipal boards located in the invited municipalities.

5.2 FIRST PUBLIC PARTICIPATION MEETING

This section describes and summarises the issues raised during the First Public Consultation Meeting held on July 31st 2012 at the Lebanese University, Faculty of Fine Arts, Hadath. Photos from the meeting are shown in Figure 5.1.



Figure 5.1 Photos from the First Public Consultation Meeting

The number of attendees reached around twenty people. Attendees represented the following main affiliations:

- Ministries of Industry, Tourism, and Interior and Municipalities;
- Airport- Directorate General for Civil Aviation;
- Directorate General of Land and Maritime Transport;
- National Centre for Marine Sciences (NCMS);
- Directorate General of Antiquities (DGA);
- Municipalities of Batchay Elmerdacheh, Chiyah, Haret el Set, and Haret Hrek;
- The MEHSP-PPIF; and
- Bureau Technique Pour Le Developpement (BTD).

The meeting lasted for about two hours (10:00am-12:00pm); the Project and the ESIA process were presented followed by a discussion session in which questions, comments and enquiries were received. The presentation – in Arabic and English – is appended (Annex 6).

Forms were distributed to collect written feedback from the attendees. On the overall, the feedback from the participants was positive, and comments mentioned were similar to those collected through the discussion and noted in Table 5.1.

Table 5.1 Concerns Raised During First Public Consultation Meeting

NO.	QUESTION/ISSUE RAISED	PARTY	RESPONSE BY PANELISTS/DISCUSSION
1	Concerns about fate of sludge to be produced at the Wastewater Treatment Plant (WWTP)	Haret Hreik Municipality	- Sludge will be treated onsite to first reduce its water content and make it easier and more cost effective to transport, and then to stabilize it to reduce its health impacts and make it safe to handle - Sludge will be suitable to be used for energy recovery (depending on waste to energy regulation) or to be safely disposed of in sanitary landfills.
2	Inquiry about difference between primary and secondary networks	Haret Hreik Municipality	The difference between primary and secondary networks was explained to attendees
3	Industrial pollution and lack of data on industrial facilities and industrial effluents: - Industries in the area heavily discharge in the river (example of filler from upstream industries in Kfarchima and Choueifat, slaughterhouse waste, etc.) - Data insufficiency: comprehensive survey of industrial facilities needed, but ministry lacks adequate resources and needs enhancement - Need to coordinate with and involve MoI in project	Ministry of Industry	Industrial wastewater should be treated (pre-treatment) prior to disposal into sewers, as it may affect the biological treatment and the quality of the sludge produced. The on-site pre-treatment should be tailored to the size and type of industry. All industries, including small scale ones need to treat their wastewater on site prior to discharge to public sewers. Environmental compliance decree has been recently approved and needs to be enforced; industries would then need to comply with set limit values, depending on proper enforcement.
4	Odor control methods: are they effective? are any installed at the existing plant?	Directorate General of Land and Maritime Transport	Wastewater is currently aerated to reduce odors at the existing plant, but odors still occur and mainly result from: - Solid waste (from wastewater screening)being stored on-site for long periods - Uncontrolled discharges of wastewater along the coastline Odors can be controlled through adequate design and proper management, mainly: - Installation of odor control systems - Proper management of wastewater flows through networks and inside the plant - Proper management and storage of sludge and solid waste in closed systems

NO.	QUESTION/ISSUE RAISED	PARTY	RESPONSE BY PANELISTS/DISCUSSION
5	Concerns about sustained plant operation during electricity cut-offs	Directorate General of Land and Maritime Transport	Standby generators are part of the design and can cover plant operation for up to 6 hours. Additional potential for power from energy recovery units.
6	Coordination with the Directorate General of Antiquities (DGA): - Many potential sensitive areas exist in the Al-Ghadir Drainage area. - Project maps need to be sent to the DGA through the CDR for approval of networks routing. A representative from DGA should also supervise the construction of networks.	Directorate General of Antiquities	The consultants will coordinate with CDR to issue a letter to DGA along with the networks plans Efforts shall be made to coordinate with DGA throughout the project progress
7	Impact of project/project location on potential airport extension plans	Civil Aviation Authority	Continuing coordination with civil aviation authority on this matter. There is a plan for extension but no specific uses for the areas considered by the Al Ghadir project. Reclamation area to be coordinated with Airport Authority in due time.
8	Insect control to be taken into consideration similarly to bird control	Haret Hreik Municipality	Insects (and birds) can be reduced through adequate management of solid waste and odors during operation
9	Justification of the drainage area	Haret Hreik Municipality	Drainage area already established in First master plan and previous Feasibility study (2000). Boundaries also agreed upon with the CDR and the Ministry of Energy and Water
10	Land tenure/requirements	Ministry of Interior and Municipalities	Land surrounding the WWTP has been expropriated by the airport. Current plant is being operated by the Beirut Mount Lebanon Water Establishment.
11	Sea Outfall: The National Center for Marine Sciences (NCMS) representative noted the following - Emergency outfall (200m, 4 m depth) is a major source of coastline contamination - Studies conducted by the NCMS proved an upwelling of contaminants at the level of the long sea outfall - Recommendation to discharge beyond 2.5Km length/60 m depth because of the upwelling of contaminants and hydrodynamics of the area. - It is important to take into account the impact of wind driven	National Center for Marine Sciences(NCMS)	Results of studies conducted by the NCMS to be made available to project team Project team to confirm results of outfall discharge modelling

NO.	QUESTION/ISSUE RAISED	PARTY	RESPONSE BY PANELISTS/DISCUSSION
	currents (South West direction) - pH values at the outfall should be around 8- 8.3, high concentrations of fecal streptococci were observed approximately 1 km to the North, phosphates…)		
12	What is seawater pH indicative of?	--	Seawater pH levels guidelines values should be between 6 and 9 to maintain aquatic life
13	Project duration and phasing, and type of wastewater received	Chiyah Municipality	- The project is designed to meet the increased demands for wastewater treatment for the next 35 to 40 years - The WWTP is planned to receive municipal wastewater - There is no firm timescale for implementation yet. The project's execution and phasing depend on the availability of funds
14	Separating storm water from Wastewater is a priority	Chiyah Municipality	This is one of the objectives of the project
15	The decision to give permits to touristic facilities is highly influenced by the Mohafaza (Governorate). Hence the need to coordinate with the Governorates to ensure effective wastewater management in classified touristic facilities.	Ministry of Tourism	--
16	Why hasn't tertiary wastewater treatment been considered?	NCMS	Lebanese requirements can be met through secondary treatment, which is also in line with European Legislation. Secondary treatment is the common practice for wastewater treatment in Europe, except in specific cases where tertiary is required mainly for wastewater reuse purposes or discharges to sensitive receptors.
17	Need to coordinate with the Directorate General of Land and Maritime Transport especially during the phase of the project which requires land reclamation	Directorate General of Land and Maritime Transport	--
18	Need to communicate with municipalities especially during the networks construction	Ministry of Industry	--
Additional comments collected in writing			
19	Fill material for reclamation work: Receive filling material from the public for the land reclamation works of phase II. It is suggested also to charge the public for using	Haret Hreik Municipality	--

NO.	QUESTION/ISSUE RAISED	PARTY	RESPONSE BY PANELISTS/DISCUSSION
	their fill material.		
20	Need to coordinate with municipalities throughout the project phases to safeguard public health and safety	Chiyah Municipality-Social affairs committee	--

5.3 SECOND PUBLIC PARTICIPATION MEETING

A second Public Consultation Meeting was held on October 24th, 2012 at the Lebanese University, Faculty of Fine Arts, Hadath. Photos from the meeting are shown in Figure 5.1.



Figure 5.2 Photos from the Second Public Consultation Meeting

The number of attendees reached around twenty people, representing the following main affiliations:

- Ministries of the Environment, Tourism, and Public Health;
- The Council for Development and Reconstruction;
- The Beirut and Mount Lebanon Water & Wastewater Establishment;
- Airport- Directorate General for Civil Aviation;
- Directorate General of Land and Maritime Transport;
- National Centre for Marine Sciences (NCMS);
- Directorate General of Antiquities (DGA);
- The Municipalities of Ghobeiri, Borj el Brajneh, Boutchay, Bchamoun, Abbey – Ein Draffil, Mrayjeh, Ghadir, Laylaki, Aley, Kfarshima, and the Union of Municipalities of the Southern Beirut Suburbs;
- The Lebanese University – Faculty of Engineering,
- The MEHSP-PPIF; and
- The Bureau Technique Pour Le Developpement (BTD).

The Project was first briefly presented, and then the results of the ESIA were discussed. A Q&A session followed in which questions, comments and enquiries were received. A summary of the discussion is provided in Table 5.2. The presentation – in Arabic and English – is appended (Annex 6).

Forms were distributed to collect written feedback from the attendees. On the overall, the feedback from the participants was positive. Additional comments collected in writing are reported in Table 5.2.

Table 5.2 Discussion raised during Second Public Consultation Meeting

NO.	QUESTION/ISSUE RAISED	PARTY	RESPONSE BY PANELISTS/DISCUSSION
Main issues raised during preliminary round of introductions			
1	Interest in project due to several problems and complaints at the municipal level from lack of proper network connections and treatment	Municipality of Bchamoun	--
2	Public complaints concerning uncontrolled discharges → importance of the project	Ministry of Health	--
3	Lack of wastewater networks in the villages and use of septic tanks is leading to odor generation, diseases, insects, and an overall negative impact on health and the environment	Municipality of Abey – Ein Drafil	--
4	Need to extend the WWTP capacity to be able to treat increasing volumes of wastewater from the municipalities of the southern suburbs of Beirut and remaining areas	Union of Municipalities of Dahyeh (Southern Suburb of Beirut)	--
5	Need to conduct detailed surveys over all industries located within the Ghadir River Basin Need to understand exact sources of pollution/risk to plant	Ministry of Industry (MoI)	Beirut and Mount Lebanon Water & Wastewater Establishment (BMLWWE): Main issues are with the quarries and slaughterhouses
6	Clear interest in the project; looking forward to project implementation	BMLWWE	--
Main issues raised during post-presentation discussions			
7	Need to ensure the implementation of the networks component to avoid operational problems as experienced in previous similar projects Need to take odors resulting from the pumping and lifting stations into consideration	Ministry of Environment (MoE)	BTD: Networks are a priority. A study was done to assess feasibility and costs. It is projected that 80% of the population will be served by 2029. CDR: Ongoing coordination with municipalities regarding networks Financial sustainability: operational costs are to be covered by operators for the first few years, until there is a stable income through tariffs to entirely

NO.	QUESTION/ISSUE RAISED	PARTY	RESPONSE BY PANELISTS/DISCUSSION
	Need to ensure funds to guarantee the plant's operational sustainability Need to separate the industrial wastewater from the municipal wastewater – especially slaughterhouses which contribute the most to high pollution levels in the Ghadir River Need to separate Wastewater discharge from storm water culvert It is suggested to consider a landscaping plan including implementation of a green belt (trees planting) around the WWTP to reduce the impact on landscape/visual impact and to reduce impacts from odors. Treated wastewater from the plant could be used for irrigation.		cover budget BMLWWE: the water establishment currently covers all operational costs. Additionally, there is already a wastewater tariff added to the water bill for those connected to wastewater networks; this tariff already covers operation costs. CDR: One of the main elements tackled in this FS is the separation of Wastewater from storm water drainage which is affecting the plant capacity during winter season. ELARD: Consideration of Odors simulation at pumping/lifting stations is recommended to be conducted during detailed design as part of the environmental management plan
8	Ministry of Industry already involved in different projects on industrial discharges, but urgent need for more cooperation and commitment from other essential stakeholders (municipalities, other ministries, etc.) Lack of interest/commitment from industries themselves	Ministry of Industry (MoI)	ELARD: Implementation of an Industrial Pollution Abatement Program in the Ghadir basin is an essential pre-requisite for the success of the project
9	Suggestion: the creation of an independent civil committee to monitor the implementation and the operation of the project	Municipality of Aley	CDR: It is usually the duty of governmental authorities to monitor projects implementation; monitoring mechanisms already exist… but an independent committee could be an idea to be considered
Additional comments collected in writing			
10	Plant location is ideal (distant from residential areas) Need to monitor contractor's implementation of measures suggested in EMP	BMLWWE	--

NO.	QUESTION/ISSUE RAISED	PARTY	RESPONSE BY PANELISTS/DISCUSSION
11	Need to detail measures which could be taken by municipalities to coordinate/monitor successful implementation of the project	Municipality of Boutchay El-merdacheh	--
12	Need to raise awareness and involve civil society to ensure optimal project implementation	MoI	--
13	Adopt “dry well” techniques instead of “wet well” for pumping stations	Anonymous	--

6 DESCRIPTION OF THE ENVIRONMENT

This chapter sets the baseline environmental and social conditions within the Project Area. Environmental aspects considered mainly cover the physical and biological environments, as well as the socio-economic and cultural contexts.

Existing documents were collected, reviewed and analysed in order to define the characteristics of the existing environment and the projected future environment assuming the non-implementation of the project. Additional data was collected through:

- a site reconnaissance visit on February 18, 2011;
- preliminary consultation meetings with the project developers and current plant operators; and
- a field visit on September 2, 2012.

6.1 STUDY AREA AND SENSITIVE RECEPTORS

The Study Area has been defined under section 3.3 and in the map shown in Figure 3.3.

Sensitive receptors in the proximity of the WWTP include the Beirut International Airport, beach resorts and army barracks on the coast, and residential and mixed industrial/agricultural areas nearby. These are depicted through an aerial view analysis using Google Earth in Figure 6.1 and Figure 6.2.



Figure 6.1 Aerial View of Sensitive Receptors around WWTP

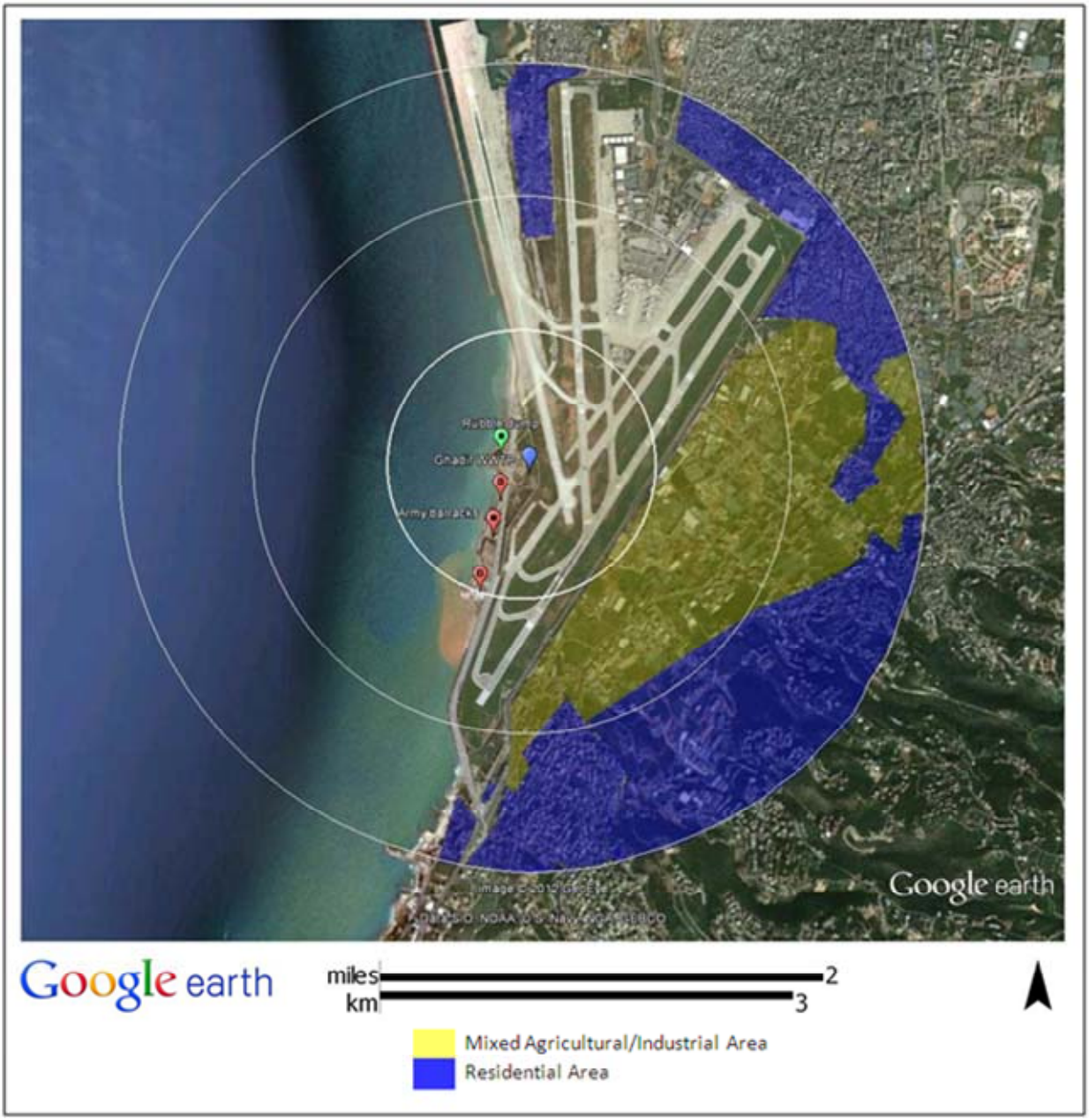


Figure 6.2 Aerial view of Sensitive Receptors within a Radius of 1, 2, and 3 Km from the WWTP

6.2 PHYSICAL ENVIRONMENT

6.2.1 CLIMATE AND METEOROLOGY

The Climate conditions in the Study Area are those of a typical eastern Mediterranean climate. Rainfall is restricted to the period between October and March, and temperatures are high in summer. An onshore south-westerly wind from the adjacent Mediterranean Sea affects the area most of the year.

Data presented below were collected at the Beirut Airport Weather Station (33°49'0.00"N, 35°28'60.00"E, 12.3 m), located at the direct vicinity of the Al-Ghadir WWTP and in the heart of the Project Area.

6.2.1.1 TEMPERATURE

The Study Area is characterized by warm to hot, dry summers and relatively mild, wet winters. Average Minimal and Maximal temperatures recorded between January 2006 and July 2012 is represented in Figure 6.3 below. Average monthly temperatures ranged between a minimum of 9.37°C in January 2008 and a maximum of 33.8°C in August 2010.

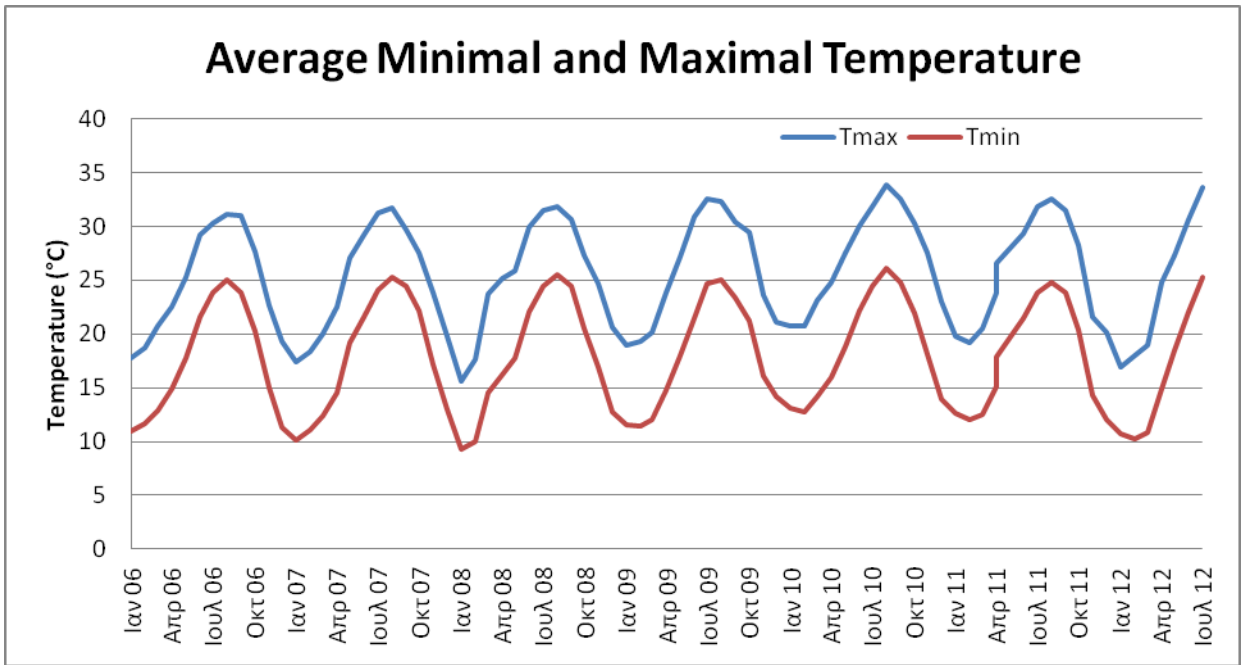


Figure 6.3 Average Max & Min Temperatures at Beirut Airport Weather Station (Jan.06-Jul.12)

6.2.1.2 WIND

The maximum wind speed reported in the Beirut Airport weather station for the period between January 2006 and July 2012 ranged between 13.8m/sec in November 2010 and 32 m/sec in January 2012, while average speed ranged between 6.4m/sec in November 2010 and 14 m/sec in January 2012,

as illustrated in Figure 6.4 below. Wind direction results revealed a prevailing yearly average wind blowing southwest (Figure 6.5).

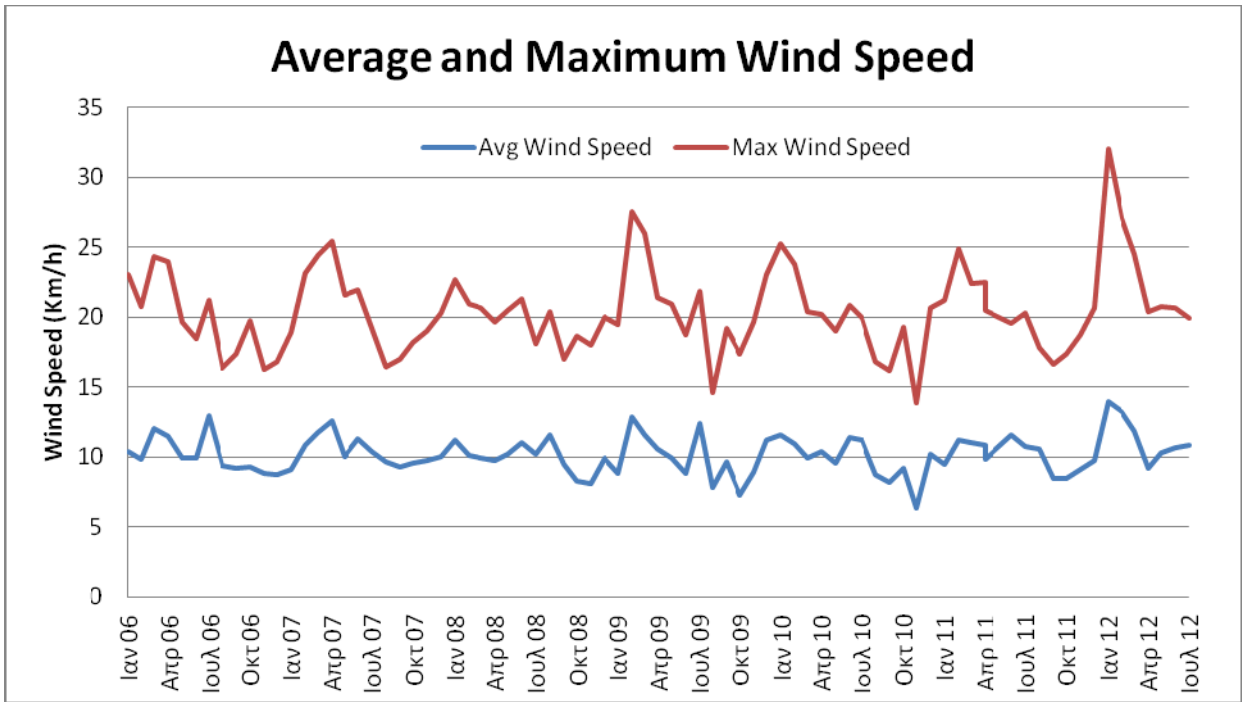


Figure 6.4 Maximum & Average Wind Speed Data recorded at Beirut Airport Weather Weather Station (Jan.06-Jul.12)

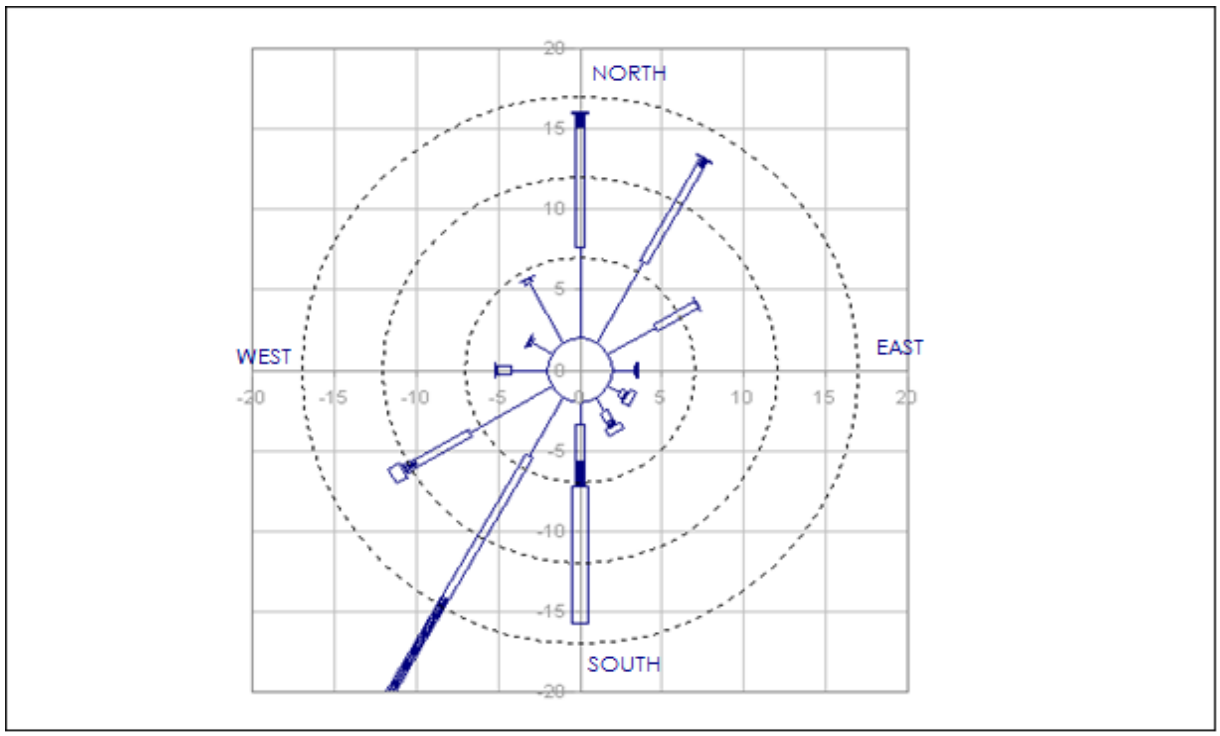


Figure 6.5 Wind Direction near Al Ghadir WWTP (Source: MOEW/UNDP/CEDRO. 2011. The National Wind Atlas of Lebanon).

6.2.1.3 PRECIPITATION

The yearly precipitation levels recorded at the Beirut Airport weather station between 2006 and 2011 varied between a minimum of 510 mm in 2008 and a maximum of 1112 mm in 2009. The highest monthly precipitation rates were recorded from October to March. Monthly precipitation rates and total number of rainy days over the period running of January 2006 through July 2012 are illustrated in Figure 6.6 below. A rainfall map of the Study Area is provided under Figure 6.7.

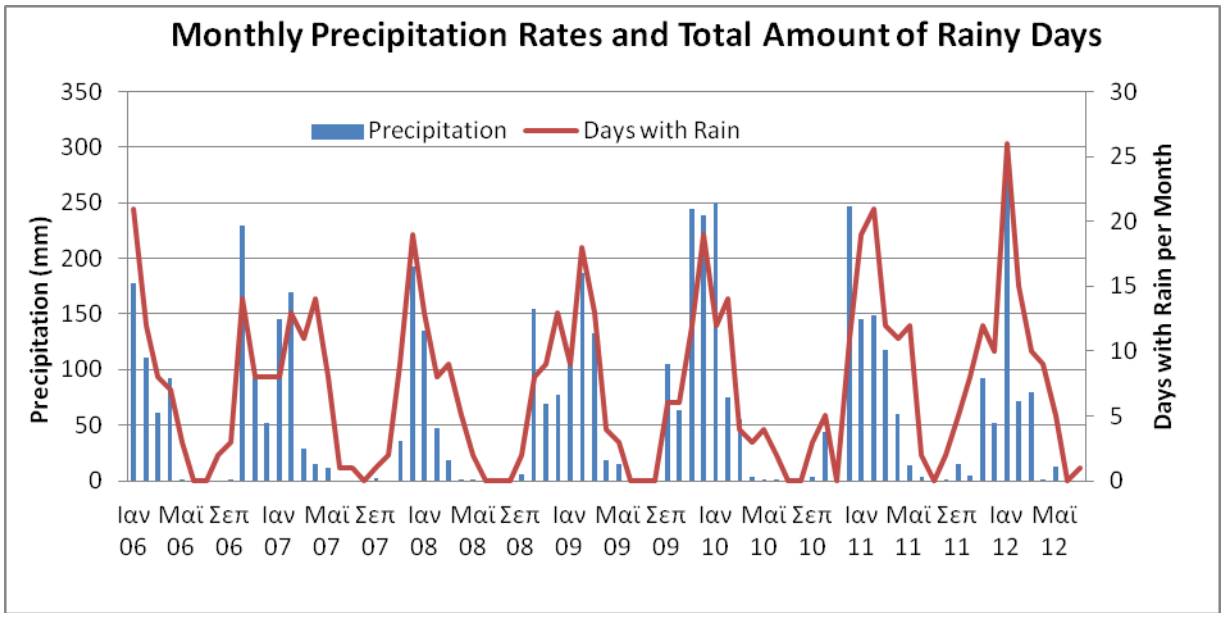


Figure 6.6 Monthly Precipitation Rates and Total Amount of Rainy Days Recorded at Beirut Airport Weather Station (Jan.2006 – July 2012)

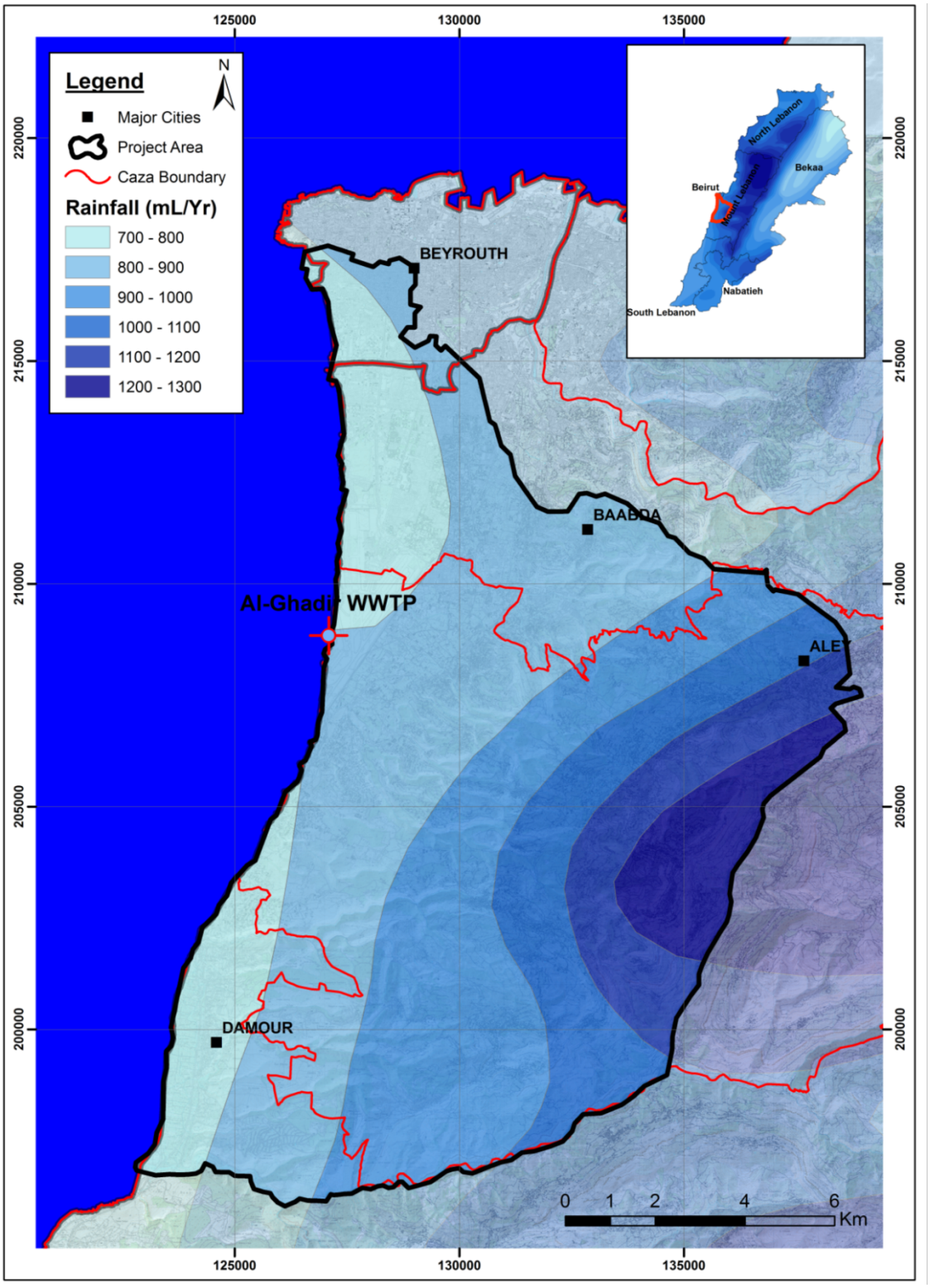


Figure 6.7 Rainfall Map of the Study Area

6.2.2 AMBIENT AIR QUALITY

Air pollution is defined as the modification of the natural characteristics of the atmosphere by any chemical, physical or biological contaminant such as Particulate Matter (PM), Carbon Monoxide (CO), Ozone, Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2) (WHO, 2011).

Sources of pressures on ambient air quality in Lebanon can be natural phenomena or anthropogenic activities such as transportation (vehicles), energy production (power plants, private generators and gas stations), industrial manufacturing processes, construction, quarries, fireworks, burning tires, open dumping and wars (MoE/UNDP/ECODIT, 2011). The cost of environmental degradation from air pollution related problems in Lebanon was estimated at $170 million/year (1.02% of the GDP) (World Bank, 2004).

Private cars are excessively used by the Lebanese population for daily commuting; the transport sector is thus one of the leading sources of air pollution in the country and more specifically in Beirut. The high traffic density in Beirut and its suburbs is causing poor atmospheric quality conditions in this area. Fuels and lubricants used in vehicles are a major source of Particulate Matter (PM), sulphur dioxide (SO_2), Nitogen Oxides (NOx), Carbon Monoxide (CO), and carbonyls emissions (Afif et al., 2009; Kouyoumjian & Saliba, 2006; Moussa et al., 2006; Saliba et al., 2006, 2007). Those air pollutants are identified for the risk they represent through long-term or short-term exposure, for their toxicity, or even for their environmental interference.

A list of main findings from different Air Quality studies conducted for the urban area of Beirut is provided in Table 6.1 and further discussed below.

NO_2 levels in Beirut are mainly attributed to traffic (Afif et al. 2008). The yearly average of 2005 was recorded to be 67µg/m3. It reached its peak in December with 178µg/m3 and drops to 17µg/m3 in May (Afif et al. 2008). NO_2 concentrations are generally within acceptable range of allowable limits for ambient air pollutants (Decision 52/1). This is also applicable to the concentrations given in the month of May. However, exposures are significant in the month of December since the average concentration of the month exceeds the permissible exposure over a 24 hour period of time.

SO_2 levels are mainly attributed to traffic and central heating burners (Saliba et al. 2006 & Afif et al. 2008). The monthly average of SO_2 concentration in samples collected in Beirut varied between 13µg/m3 in summer 2004 and 25µg/m3 in winter 2004-2005 (Saliba et al. 2006). Another study conducted between December 2004 and July 2006 showed a yearly average of 8.11 µg/m3 (Afif et al. 2008). SO_2 levels measured in both studies were below the maximum allowable limits for ambient air pollutants (Decision 52/1).

Particulate matter emissions are mainly attributed to natural and anthropogenic activities (Shaka & Saliba 2004). Observed levels of PM10 varied between 20.8 and 238 µg/m3 (monthly average) (Shaka & Saliba 2004). Exceedance in PM10 was noted in March, April and May 2003 (Table 6.1). PM2.5 annual levels were below IFC guideline values.

Table 6.1 Review of Literature on Ambient Air Quality in Beirut

Region	Parameter	Description	Period	Mean concentration (µg/m3)*	Averaging Period	Maximum Allowable Limits for Ambient Air Pollutants (µg/m3) (Decision 52/1)**	Reference
Beirut							
Beirut	NO2	Traffic	May-05	17	Monthly Average	150 (24 Hours) 100 (1-year)	Afif et al. 2009
	NO2)	Traffic	2005	67	Annual Average	100	Afif et al. 2009
	NO2	Traffic	Dec-05	178	Monthly Average	150 (24 Hours) 100 (1-year)	Afif et al. 2009
	SO2	Traffic	Summer 2004 Winter 2004-2005	13 25	Monthly Average	120 (24 Hours) 80(1-year)	Saliba et al. 2006
	SO2	Traffic- central heating burners	Year 2005	8.11	Annual Average	80	Afif et al. 2008
American University of Beirut	PM2.5	Natural and anthropogenic Sources of PM	February 2003 March 2003 April 2003 May 2003	33.8 25.2 63.7 36.9	Monthly Average	**24-hour averaging period:** 75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline **1-year averaging period:** 35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3)	Shaka & Saliba 2004
Bourj Hammoud	PM2.5	Urban Area	Febuary 2004 to January 2006	0.039	Annual Average		Saliba et al. 2007

Region	Parameter	Description	Period	Mean concentration (µg/m3)*	Averaging Period	Maximum Allowable Limits for Ambient Air Pollutants (µg/m3) (Decision 52/1)**	Reference
						10 (guideline)**	
	PM10-2.5	Urban Area	Febuary 2004 to January 2005	0.065	Annual Average	-	Saliba et al. 2007
American University of Beirut	PM10-2.5	Natural and anthropogenic Sources of PM	February 2003 March 2003 April 2003 May 2003	51.8 20.8 174 68.8	Monthly Average	-	Shaka & Saliba 2004
American University of Beirut	PM10	Natural and anthropogenic Sources of PM	February 2003 March 2003 April 2003 May 2003	85.6 46.0 238 106	Monthly Average	80 (24 Hours)-	Shaka & Saliba 2004
Beirut	PM10	Traffic	Summer 2004 Winter 2004-2005	44 60	Monthly Average		Saliba et al. 2006

*Concentrations were converted to µg/m3 unless indicated otherwise in the Table
** Pollutants not regulated under the Lebanese guidelines were assessed according to the WHO guidelines as suggested in the IFC guidance, Environmental Air Emissions and Ambient Air Quality, 2007.

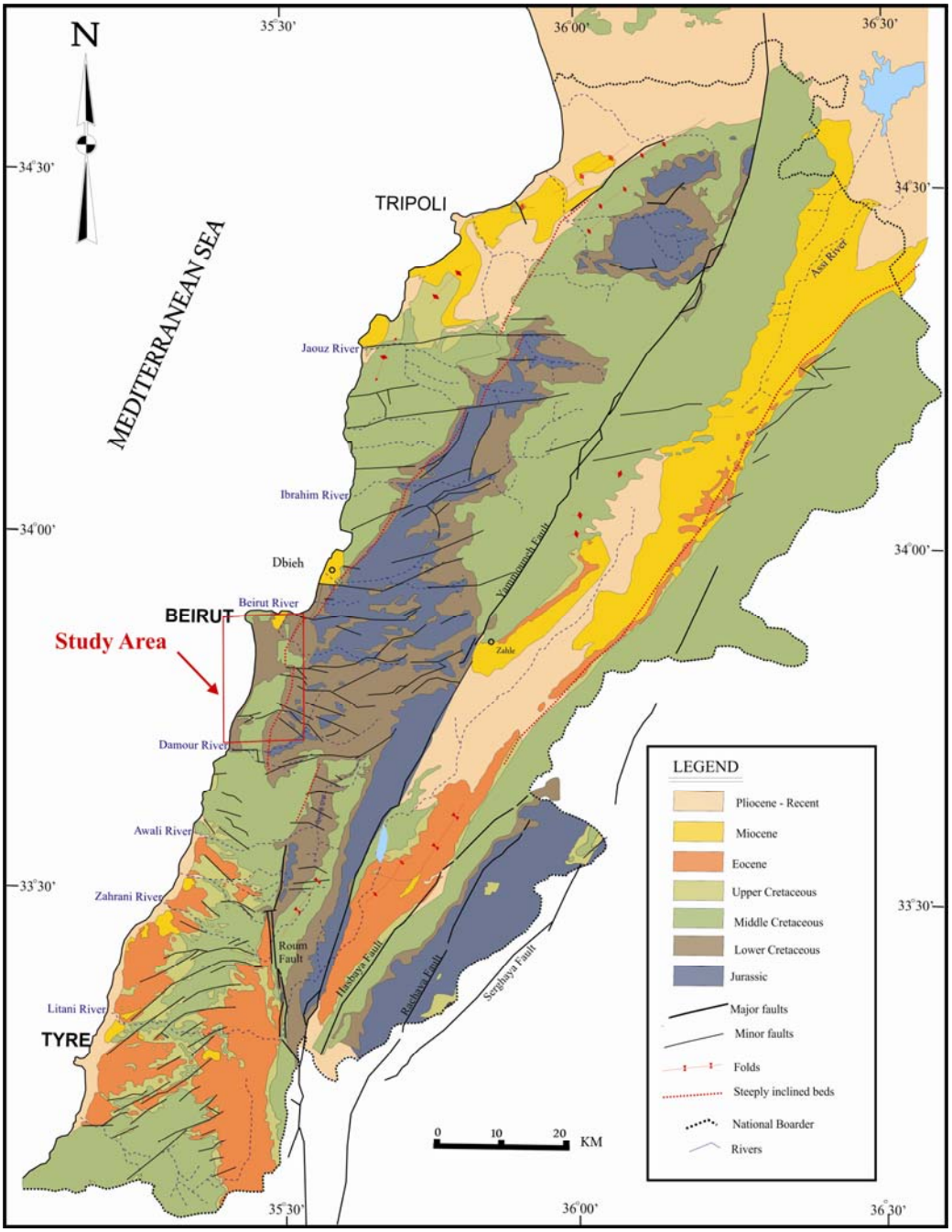
6.2.3 ACOUSTIC ENVIRONMENT

The area is expected to be subjected to relatively high noise levels, mainly associated with the contiguous Airport activity and the average traffic flows on the adjacent secondary road.

6.2.4 GEOLOGICAL SETTING

The drainage basin of the Ghadir WWTP extends over an area of around 173 km^2 along the coastline of Lebanon. It is located between the coast to the west and Aley to the east and is bounded by the Damour River to the south and Beirut River to the north Al Ghadir River emerges near Aley, flows across the drainage area and discharges into the sea, about 1 km to the north of the Ghadir WWTP Location.

Sub-sections 6.2.4.1, 6.2.4.2, and 6.2.4.3 discuss the geological features of the Study Area in terms of stratigraphy, hydrogeology and groundwater, and tectonics and seismicity. These features are also depicted in Figure 6.8 and Figure 6.9



(Not to Scale, Adapted from Dubertret 1/200,000 Map)

Figure 6.8 General Geological and Tectonic Map of Lebanon Showing the Study Area

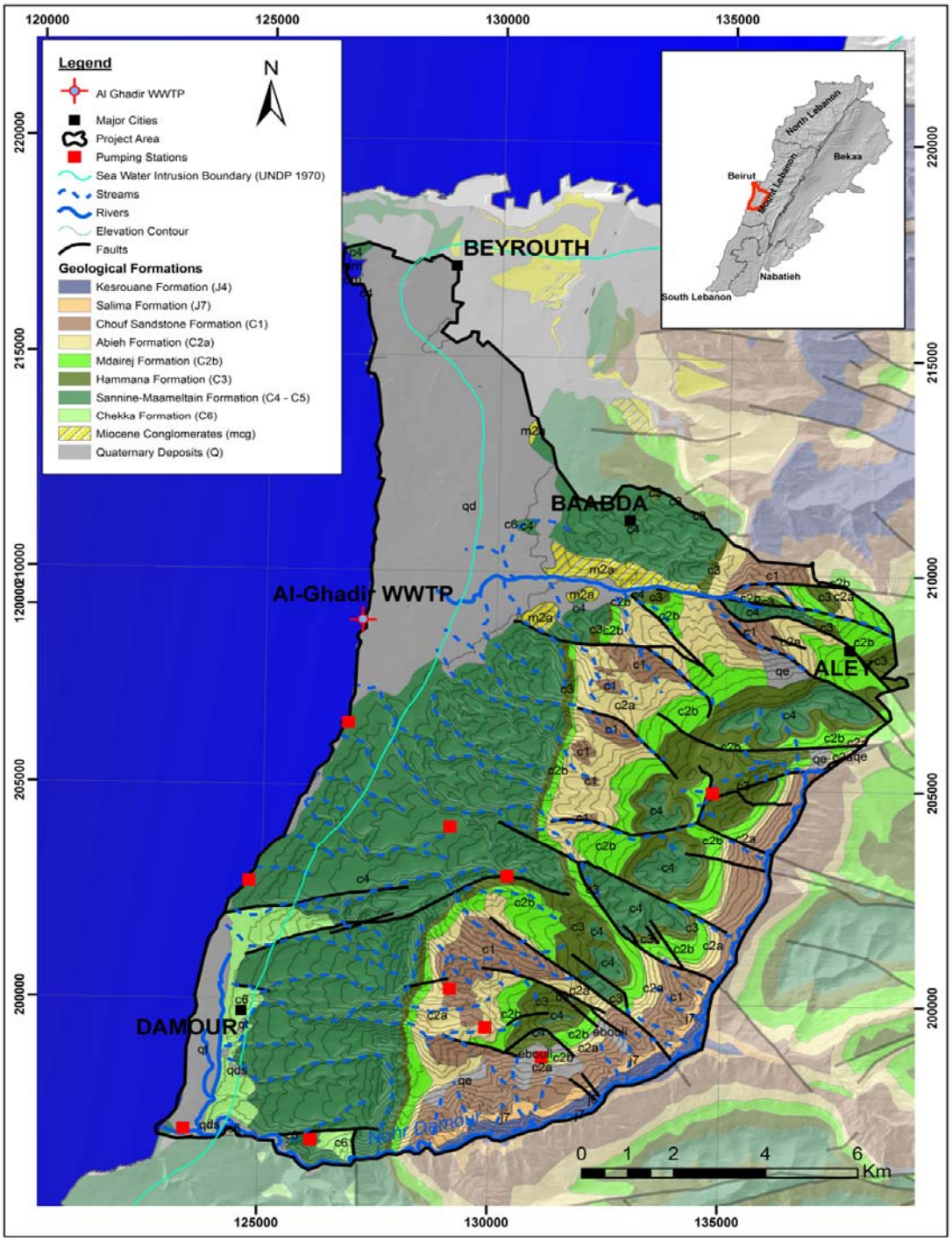


Figure 6.9 Geological Map of the Study Area (Adapted from Duberteret 1/50,000)

6.2.4.1 STRATIGRAPHY

The geological formations outcropping within the study area range from the middle Jurassic to the Quaternary periods. These are, from older to younger, the Keserouane Formation (J4), the Salima Formation (J7), the Chouf Sandstone Formation (C1), the Abieh Formation (C2a), the Mdairej Formation (C2b), the Hammana Formation (C3), the Sannine-Maameltain Formation (C4-C5), the Chekka Formation (C6) and rocks from the Miocene epoch (mcg) and Quaternary period (Q) (refer to figure 2).

The lithological characteristics of the above-mentioned formations are described in the following paragraphs:

The Quaternary Deposits in the Study Area are composed of aeolian, beach, and alluvial deposits. They consist of a number of different lithologies ranging from marly conglomerates, Terra Rosa, dune sands, sandstones, river deposits, and alluvium. They lie unconformably over the Miocene limestones and Sannine-Maameltain Formations and cover the northern part of the study area extending mostly over the southern suburbs of Beirut.

The Chekka Formation outcrops in the south western part of the Study Area. It lies below the Quaternary/ Miocene semi aquifer and consists of over 300m of marl rocks.

The Sannine-Maameltain Formation consists of an alternating sequence of finely bedded limestone, dolomitic limestone and marly limestone and has a thickness of approximately 600-900m. The Sannine-Maameltain formation is outcropping mostly to the south of Wadi Ghadir and to a smaller extent on the north eastern side of the stud area.

The Hammana Formation consists of thin bedded carbonates, marls and terrigenous sands. The Hammana Formation is around 100m thick and outcrops in the faulted zone on the east south east part of the study area.

The Mdairej Formation is a very distinctive cliff forming formation of around 50 to 90 m of limestones. This formation outcrops in the faulted zone on the east south east part of the study area.

The Abieh Formation is a variable unit of fossiliferous limestones, marls and sandstones. The thickness of the Abieh Formation varies between 65 and 170 m.. This formation outcrops in the faulted zone on the east south east part of the study area.

The Chouf Sandstone Formation consists of sandstone interbedded with layers of clay, lignite, tuff, shale and volcanic rocks. The thickness of this formation reaches approximately 200 to 220m. This formation outcrops in the faulted zone on the east south east part of the study area

The Salima Formation consists of oolitic ferruginous limestone with interbeds of marls and clays exposed below the Chouf Sandstone Formation. Its thickness ranges between 0 to 40m and might be completely eroded in some locations. This formation outcrops only in the southern part of the study area to the north of the Damour River.

The Kesrouane Formation consists mainly of massive dolomite, dolomitic limestone, and limestone. It has only few 10's of meters of exposure in the southern part of the study area, on the sides of the Damour River. This formation can reach a thickness of 1000 m.

6.2.4.2 HYDROGEOLOGY AND GROUNDWATER QUALITY

Each of the formations exhibit different hydrogeological characteristics. The major aquifer in the study area is the Sannine-Maameltain aquifer. It is highly karstic in nature with groundwater flowing mainly through conduits and fractures. The water table in this aquifer within the Study Area is approximately at sea level so any well penetrating the aquifer will have to reach this level to produce water.

The fact that this aquifer has been highly exploited by wells in the study area, its proximity to the sea, and the high level of fracturing and jointing of its forming rocks, increased its susceptibility to sea water intrusion.

Although the Keserouane Formation is one of the major aquifers of Lebanon, it is not considered as an important one in the study area due to its very limited exposure in the southern boundary.

The Salima, Abieh, Hammana and Chekka Formations act as semi-impermeable horizons and hence are considered aquicludes.

The Mdairej Formation is also a karstic formation but it is considered as a semi aquifer due to its limited exposure and extent.

The Abieh Formation forms an aquiclude between the Mdairej karstic semi-aquifer and the Chouf sandstone semi-aquifer.

The Chouf Sandstone and The Quaternary deposits and the Miocene conglomerates are considered semi-aquifers since they can store and transmit groundwater but not to the same extent as aquifers because of their porous nature and limited exposure and extent.

The Chouf Sandstone Formation acts as a porous medium semi-aquifer. This semi-aquifer is characterized by a steady flow of water throughout the year as the groundwater slowly percolates and moves in between sand grains. However, due to its nature it does not produce large quantities of water. In some locations the Quaternary Formation overlies the Sannine-Maameltein Formation effectively forming one aquifer because they show a hydraulic continuity between them (Peltekian, 1980).

These marl layers of the Chekk Formation effectively act as the lower boundary to any water flow and separates the Quaternary semi-aquifer from the Sannine-Maameltain aquifer.)

The hydrogeological significance of the above aquifers is summarized in Table 6.2.

Table 6.2. Hydrostratigraphy of the Study Area

PERIOD	AGE	FORMATION	LITHOLOGY	THICKNESS IN AREA (M)	HYDRO-GEOLOGICAL CLASSIFICATION
Quaternary/ Tertiary	Quaternary/ Miocene	Quaternary/ Miocene Deposits (Q/ mcg)	Alluvial Deposits and conglomerates (gravel, Sand, Silt and Clay)	Few tens of meters	Semi-aquifer
Cretaceous	Coniacian – Lower Paleocene	Chekka Formation (C6)	White chalky and marly with chert and phosphate beds and nodules	300	Aquiclude
	Cenomanian-Turonian	Sannine-Maameltein Formation (C4-C5)	Alternating sequence of finely bedded limestone, marly limestone and dolomitic limestone	600-900	Aquifer
	Albian	Hammana Formation (C3)	Green calcareous marl and detrital limestone and sand	~100	Aquiclude
	Aptian	Mdairej Formation (C2b)	Cliff forming pale grey limestone	50-90	Semi-Aquifer
	Aptian-Barremian	Abeih Formation (C2a)	Brown grey sand, green gray marl and clay, yellowish brown sandy limestone	65-170	Aquiclude
	Hauterivian-Valanginian	Chouf Sandstone Formation (C1) with (ßC1)	Highly ferruginous red to white sandstone, with localized volcanic (ßC1), marls and lignites	200-220	Semi-Aquifer
Jurassic	Tithonian	Salima Formation (J7)	Yellowish oolitic limestone and marls	0-40	Aquiclude
	Aalenian – Callovian	Kersouane Formation (J4)	Limestone-Dolomitic Limestone	~1000	Aquifer

Water resources mismanagement, extensive aquifer over-abstraction, continuous urban growth, and repeated natural droughts have resulted in seawater intrusion in coastal areas of Lebanon.

A study conducted between 1999 and 2002 in the region of Choueifat-Rmeyle indicated that the regions of Choueifat, Jiye and Rmeyle (all part of the Study Area) were subject to seawater intrusion. Salinity ranged between 0.7dS/m and 5.5dS/m, rendering the water and soil inadequate for the cultivation and irrigation of many crops (Bakalowicz, 2009). In fact, as per the FAO "Guidelines for Interpretation of Water Quality for Irrigation", the degree of restriction on the use of water for irrigation should be "slight to moderate" for salinity rates between 0.7 and 3dS/m and "severe" for salinity rates over 3dS/m.

The Greater Beirut Area's subsurface water salinity levels were reported to be over 5,000 mg/l in some of the surveyed public and private wells being utilized for various domestic, industrial and limited agricultural purposes (Saadeh, 2008). Such high levels of salinity theoretically indicate a mixing of no less than 10%, placing seawater intrusion beyond the 2% irreversible contamination limit which would render subsurface water unsuitable for public supply.

Additional data on groundwater quality will be collected through existing data. New findings (if available) shall be included in the ESIA Report.

6.2.4.3 TECTONICS AND SEISMICITY

Lebanon is located on the eastern coast of the Mediterranean Sea, along the Dead Sea Transform fault system. The Dead Sea Transform fault system in Lebanon has several surface expressions, represented in major faults (Yammouneh, Roum, Hasbaiya, Rachaiya and Serghaya faults), in uplifts as high mountainous terrain (Mount Lebanon and Anti Lebanon), and from the seismic activity record. Recent work has categorized the Lebanese section of the Dead Sea Transform fault as being a strong seismic activity zone (Khair et al., 2000).

The Study Area lies to the west of the Yammouneh Fault and north of Roum Fault. The western part of the study area forms a part of the coastal flexure which is a possible extension of the Roum fault (Nemer, 1999); this area is characterized by steep dipping beds. The formations in the study area especially in its south eastern part have been displaced by numerous E-W faults presented on the geological maps of Dubertret 1:50,000 (Figure 2).

In terms of seismicity and according to the United States Geological Survey (USGS) earthquake hazard program, the most recent earthquake that occurred near the study area was in Cyprus region on Saturday July 28, 2012 at 11:07 pm UTC. This earthquake had a magnitude of 4.5 on the Richter scale and occurred at a depth of 35.50 km below the surface. Its center was 152.38 km away from Nahr al Ghadir (Figure 3).

A historical seismicity map and a seismic hazard map of the regions are presented in Figure 4 and Figure 5 respectively.

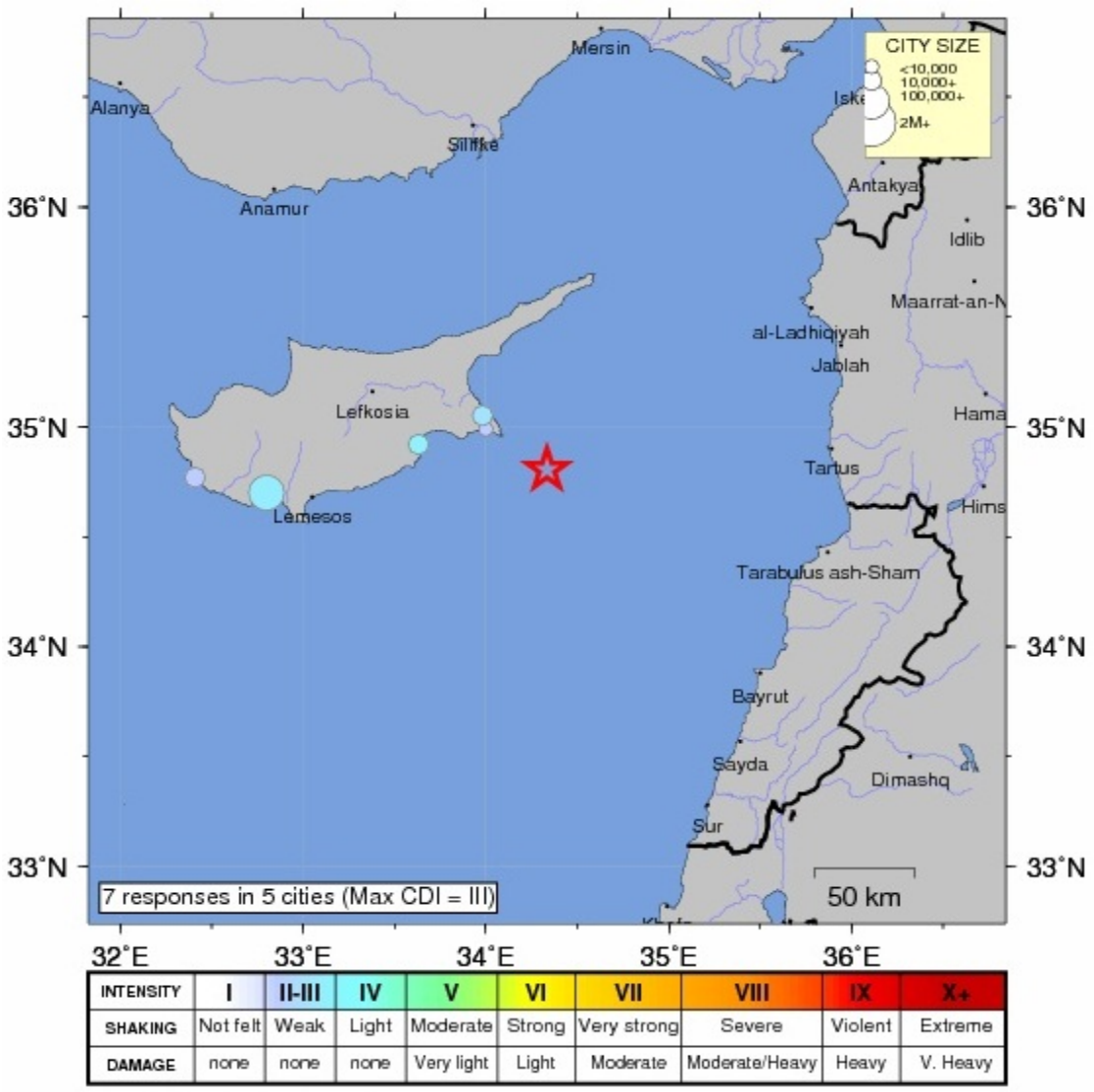


Figure 6.10 Location of the Most Recent Earthquake Nearby the Region

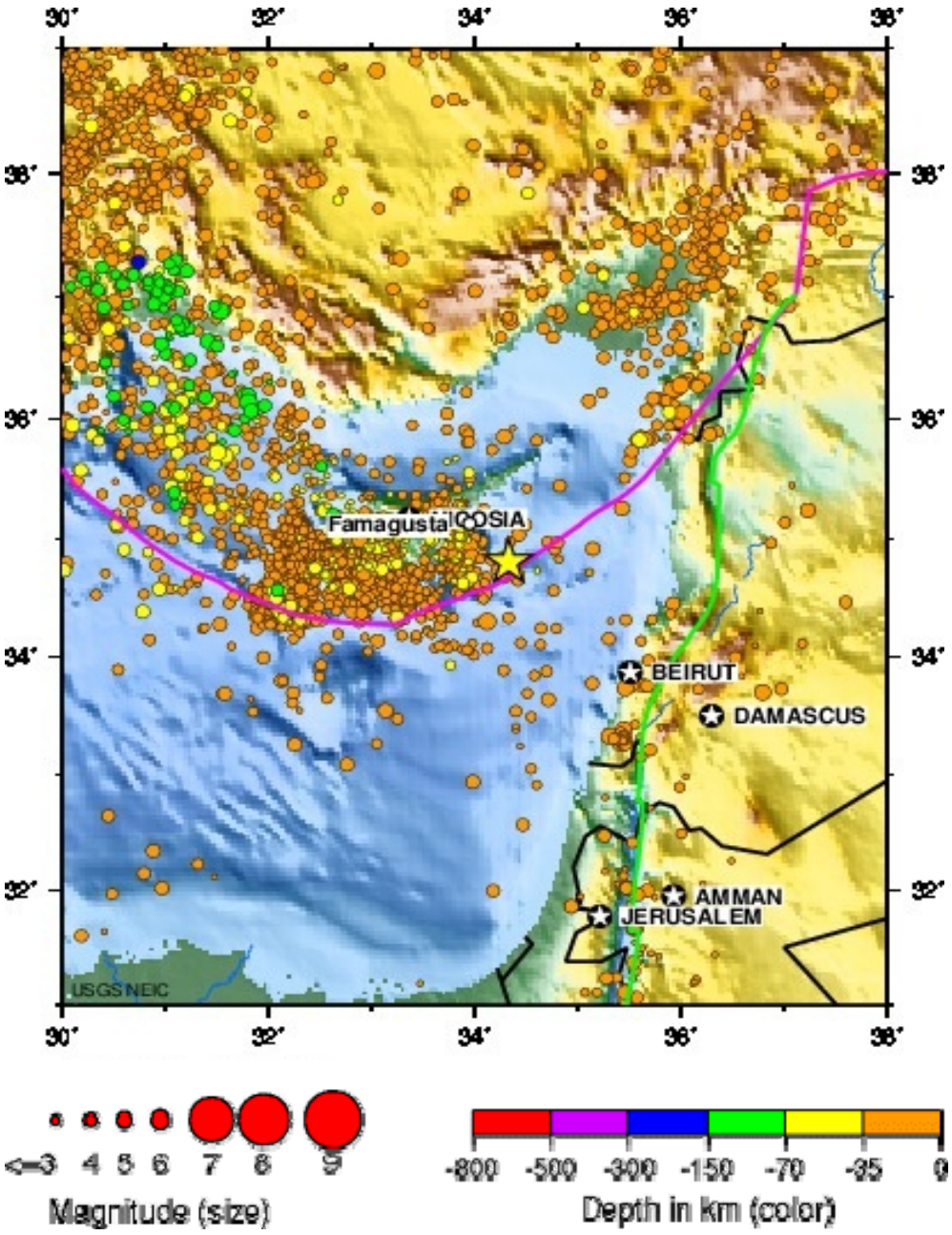


Figure 6.11 Historical Seismicity of the Region (1990 to Present)

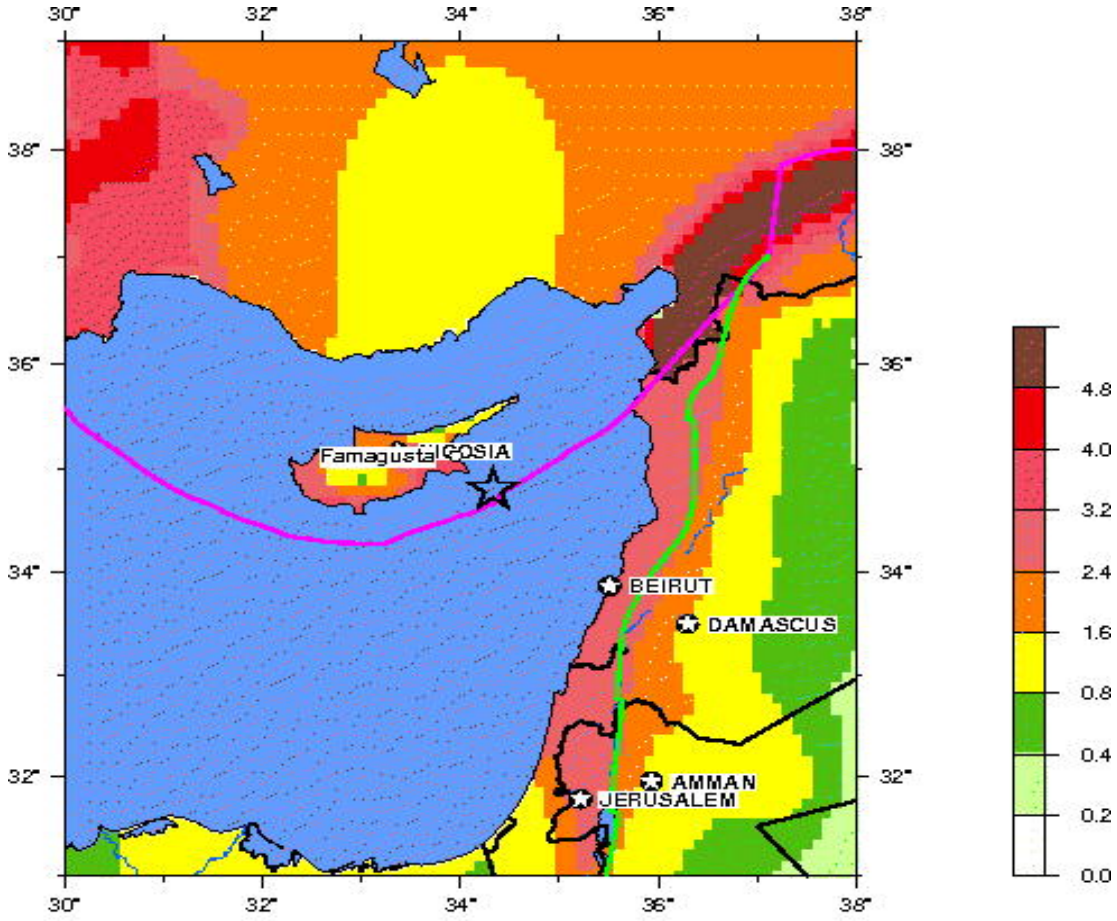


Figure 6.12 Seismic Hazard Map

6.2.5 SOIL AND TOPOGRAPHY

The evaluation presented in this sub-section is based on a previous soil investigation executed as part of the previous FS2000 (by G.S.C in 1998) and on observations of the Geotechnical expert following an on-site visit, as presented in the **Feasibility Study Part I: Project background and baseline data**.

6.2.5.1 ONSHORE AREA

The onshore area can be divided into two zones based on the geotechnical investigations. The "**level zero**" is the ground level of the existing plant which is about 4 to 4.5 m a.s.l. (above sea level).

The onshore area can be classified into two categories as follows:

- With the exception of a not well limited zone located to the north of the existing plant, the soil mainly consists of a thick layer of medium-dense to dense sand of 10 to 15 m thickness, overlying the sandstones formation. The water table is at 3.8 m depth. There are no major foundation problems for this part of the project area.
- The not well delineated area to the north of the existing plant is probably an old quarry of sand which has been backfilled with garbage and sand without any treatment. In this area, soil extends from the ground surface level to nearly sea level and is made of an organic loose fill, composed of a mixture of garbage (plastics, clothes, rubbers, metallic pieces…) and sand (total height approximately 8 to 12m). Under the fill, the natural, medium dense to dense sandy soil is encountered. If the garbage fill is removed and replaced by a controlled/well compacted sandy fill, there will be no major problem for foundations in it.

6.2.5.2 OFFSHORE AREA

The level zero is the reference sea level. The sea bottom in the offshore part of the project is between 0 and 3.5 m depth approximately.

Only one borehole has been drilled around 100 m east off the coastal road. The sea bottom was found at 2 m depth. The soil structure is the same as onshore, consisting of a thick layer of medium-dense to dense sand resting on sandstone. Assuming that this borehole is representative of the offshore site, the layers under the sea bottom form a stable base for filling with no risk of liquefaction, e.g. under seismic conditions.

6.2.5.3 SEABED LEVELS

According to the hydrographic survey undertaken in 1995, the seabed levels showed little overall change between 1983 and 1995 at depth but significant changes were observed towards the shore. The outfall pipe was originally buried for the first 1,000 m from the land side in 1983 but was found to be partially exposed beyond 500 m from the coastline in the 1995 survey.

The seabed was generally higher on the southern side of the outfall pipe than to the north. The difference in level reached more than one meter at some locations.

6.2.6 SEA WATER QUALITY

The lack of regular seawater quality measurements was noted given the absence of a fixed coastal/marine monitoring station in the Study Area as part of a national monitoring network.

Data on seawater quality was mainly obtained from yearly sampling reports prepared by the current Plant Operators and from a study conducted by the CNRS in the context of the Lebanese-Italian project "CANA-CNRS[4]".

Yearly sampling reports have been prepared by the current Plant Operators for the analysis of seawater quality surrounding the Ghadir WWTP between 2002 and 2007. At each monitoring campaign, an average of nineteen (19) seawater samples had been collected and analyzed for pH, coliform count (colonies/100ml), temperature (ºC), salinity (ppth), oxygen content (ppm), and current (direction [degree]/Intensity [cm/s]). The different sampling locations are presented in Table 6.3, Figure 6.13, and Figure 6.14.

Table 6.3 Sampling Locations - Marine Test

Point	X	Y	Depth (m)	Approximate Distance to Shore (m)
A	-341997	-36519	Surface	2.430
B	-341997	-36519	20	2.430
C	-341997	-36519	50	2.430
A1	-341776	-36316	Surface	2.230
A2	-341776	-36316	30	2.230
A3	-341795	-36740	Surface	2.220
A4	-341795	-36740	30	2.220
B1	-341288	-36149	Surface	1.745
B2	-341288	-36149	10	1.745
B3	-341322	-36948	Surface	1.730
B4	-341322	-36948	10	1.730
C1	-340799	-36570	Surface	1.215
C2	-340799	-36570	10	1.215
E1	-340967	-35726	Surface	1.453

[4] "Establishing Monitoring and Sustainable Development of the Lebanese Sea; CANA-CNRS Project" - http://www.cnrs.edu.lb/index.php?option=com_content&view=article&id=77:international-projetcs&catid=1:programs#cana

E2	-341038	-37396	Surface	4.320
F1	-340432	-35630	Surface	885
F2	-340513	-37537	Surface	750
G1	-340086	-36300	Surface	560
G2	-340112	-36899	Surface	545

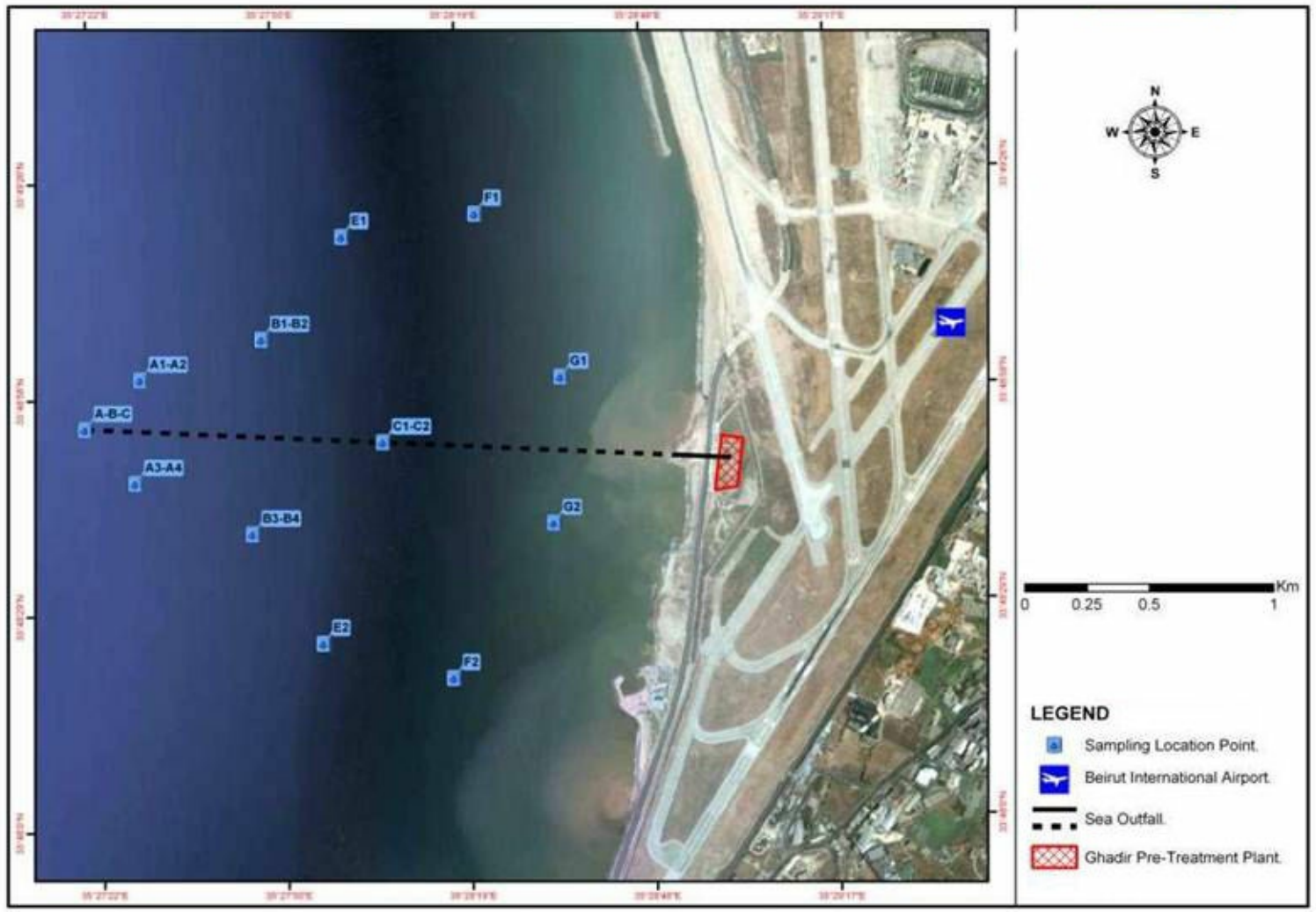
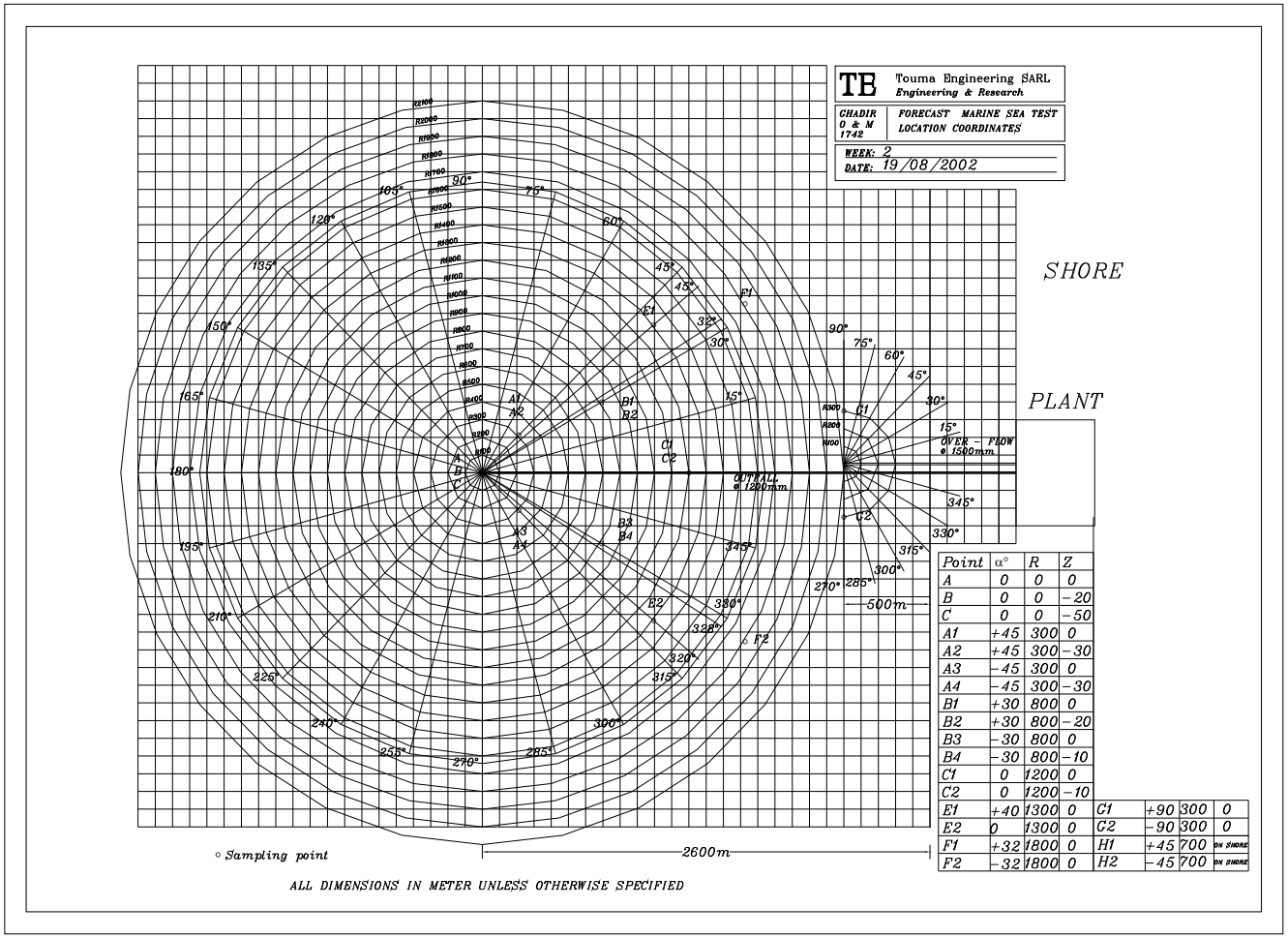


Figure 6.13 Distribution of sampling points (2002 – 2007)
(Source: Feasibility Study Part I : Project background and baseline data. 2012)



Point	α°	R	Z
A	0	0	0
B	0	0	−20
C	0	0	−50
A1	+45	300	0
A2	+45	300	−30
A3	−45	300	0
A4	−45	300	−30
B1	+30	800	0
B2	+30	800	−20
B3	−30	800	0
B4	−30	800	−10
C1	0	1200	0
C2	0	1200	−10
E1	+40	1300	0
E2	0	1300	0
F1	+32	1800	0
F2	−32	1800	0

C1	+90	300	0
C2	−90	300	0
H1	+45	700	ON SHORE
H2	−45	700	ON SHORE

Figure 6.14 Schematic illustration of the 2002 - 2007 sampling campaign – distribution of sampling *locations*

(Source: Feasibility Study Part I : Project background and baseline data. 2012)

Sampling results are provided in Table 6.4. Average pH, oxygen content and temperature values were recorded at 9.28, 5.93 ppm and 23.1ºC respectively for the whole sampling period. However, sampling results show mainly concentrations in coliforms ranging from 30/100 ml to 3.800/100 ml (Nazih S. Braidy Est., Rafik el Khoury) with the highest coliform counts recorded at "Location C" throughout the monitoring periods. This could be explained by the depth of sampling (i.e. at 50 m below sea level) which is at close proximity to the point of discharge designed at 60 m below sea level.

Elevated coliform concentrations are also observed at points located to the south of the outfall (e.g. G2 and E2), despite the direction of the currents reported to be mainly from south to north. These could be attributed to direct discharges through the emergency sea outfall, localized turbulence, or possibly to other discharges located south of the pipe.

Overall, the measured values (averages) are close to the guide value of 500 colonies/100 ml for most sampling locations; however the maximum acceptable value (10,000 colonies/100mL according to Annex 4 of Decision 52/1 – Quality Requirements for Bathing Waters) is never exceeded.

The sampling locations closest to the coast are G1 (560 m) and G2 (545 m). For G1, lower coliform measurements are given (average 170 col/100ml, max 590 col/100ml), compared to G2 (average 454 col/100ml, max 3500 col/100ml).

Table 6.4 Seawater Sampling Results: Average and Peak Values on Samples taken between May 2003 and October 2007

	Oxygen Content (ppm)		Salinity (ppth)		Temperature (ºC)		Coliform Count (colonies/100mL)		pH	
Point							***10,000 (Maximum Acceptable Value) / 500 (Guide Value)***[5]		***6 to 9 (Guide Value)***	
	Average	**Peak**	**Average**	**Peak**	**Average**	**Peak**	**Average**	**Peak**	**Average**	**Peak**
A	6,22	7,7	36,85	38,11	23,19	28,55	797	3000	9,27	9,57
B	5,98	7,16	37,24	38,22	23,02	28,49	520	1650	9,32	9,71
C	6,14	7,34	37,19	38,07	21,64	26,84	1373	3800	9,23	9,7
A1	5,94	7,73	37,31	38,04	23,16	28,60	486	1750	9,3	9,6
A2	5,8	6,3	37,35	38,36	22,97	28,49	348	980	9,31	9,59
A3	6	6,67	37,33	37,96	23,23	28,59	485	1600	9,28	9,65
A4	6,09	7,45	37,26	38,32	23,04	28,49	278	770	9,25	9,63
B1	5,93	7,02	37,28	38,47	23,28	28,62	307	1240	9,29	9,61
B2	5,84	7,58	37,37	38,51	23,11	28,5	437	2120	9,32	9,6

[5] Guideline Values (as per Decision 52/1 – Quality Requirements for Bathing Water)

	Oxygen Content (ppm)		Salinity (ppth)		Temperature (°C)		Coliform Count (colonies/100mL)		pH	
Point							***10,000 (Maximum Acceptable Value) / 500 (Guide Value)[5]***		***6 to 9 (Guide Value)***	
B3	5,98	7,03	37,15	38,26	23,39	28,8	295	780	9,32	9,59
B4	5,9	7,56	37,25	38,36	23,29	28,52	217	530	9,29	9,6
C1	5,86	6,85	37,32	38,53	23,45	28,67	330	1300	9,28	9,61
C2	5,73	6,06	36,74	37,21	21,51	27,27	491	930	9,15	9,22
E1	5,73	6,55	37,29	38,29	23,48	28,73	92	260	9,29	9,59
E2	5,93	6,41	37,19	38,05	23,56	28,7	436	1850	9,28	9,58
F1	5,99	7,55	37,24	38,26	23,37	29	125	460	9,29	9,62
F2	5,92	6,67	37,21	38,2	23,49	28,9	446	1800	9,31	9,58
G1	5,78	6,68	37,3	38,42	23,63	28,8	170	590	9,28	9,6
G2	5,88	7,7	37,22	38,15	23,68	28,8	454	3500	9,25	9,57

Source: Seawater Quality Reports-Ghadir Plant 2003-2007

Additional data on seawater quality was obtained from a study conducted by the CNRS in the context of the Lebanese-Italian project "CANA" to identify the impact of the discharged wastewater on the oligotrophic marine environment of Lebanon (Fakhri et al., 2010). Three vertical profiles up to 60 m were executed above the outlet of the main pipe of discharge installed at 60 m deep and at a distance of 2.6 Km offshore, in October 2008, April 2009 and August 2009. The purpose was to measure physicochemical and biological parameters of the water column.

The study showed that the discharged wastewater from Al-Ghadir station is always loaded with several contaminants and that an upwelling of contaminants from bottom till surface is taking place throughout the water column. High densities of fecal coliforms and fecal streptococcus colonies were measured in surface water (>200 ufc/100mL (FS), with the guide value being set at 100 ufc/100mL), accompanied by high levels of chlorophyll-a (1.24 µg/L) and pheophytin-a (0.35 µg/L). The maximum concentrations of nutrients measured were 0.64 µmol/L for phosphate *(~0.06mg/L compared to an Limit Value of 5mg/L when discharged in Sea Water as per Decision 8/1-2001)*, 0.1 µmol/L for nitrite *(~0.0046 mg/L)* and 0.32 µmol/L for nitrate *(~0.02mg/L compared to an ELV of 90mg/L).* These concentrations were greater than those usually measured in oligotrophic regions, although they are well below respective ELVs. Seasonal thermocline, a natural barrier, did not prevent the ascending of contaminants up till surface when it existed.

Findings of this study highlight the need to upgrade the wastewater treatment plant to reduce the levels of contaminants in the effluent discharged from the main sea outfall at a depth of 60 m.

6.3 BIOLOGICAL ENVIRONMENT

6.3.1 FLORA

This section covers a detailed study of Flora in the Al-Ghadir WWTP's (Project component 2) Location followed by a general description of Flora in the whole Study Area (encompassing the networks construction area which covers the whole Southern part of Beirut city, a portion of the Northern Part of Beirut city and parts of the districts (cazas) of Baabda, Aaley, and the Chouf.

6.3.1.1 METHODOLOGY

6.3.1.1.1 Preliminary Data Gathering

Available references relating to the natural environment in the Study Area were first consulted with a view to defining the main aims and major issues for the field survey.

6.3.1.1.2 Rapid Ecological Survey

An ecological survey was conducted on September 5, 2012, over accessible areas within a buffer zone of 0.5Km around the Ghadir WWTP (Project Site). The buffer zone was selected to cover the highest level of natural features around the Project Site so as to embrace the ecological functionalities within and around it. The zone, which mainly consists of mixed degraded habitats, covers an area of 78.5 ha and is considered to be the area of potential impacts from the Project.

6.3.1.1.3 Confirmed Species versus Potential Species

The report distinguishes between confirmed species and potential species. Confirmed species are species observed during field surveys, whereas potential species are species that could have been observed based on bibliographical data and actual habitats.

The present report focuses on confirmed species reported in field surveys around the WWTP location, and introduces potential species in the latter part covering the whole Study Area.

6.3.1.2 RESULTS OF THE FIELD SURVEY

6.3.1.2.1 Natural habitats

Four major natural subunits were observed in the Flora Study Area, consisting in:

- A mixed habitat;
- A shoreline habitat;
- A road side habitat; and
- A marine habitat.

These are represented in Figure 6.15, and further described in the following sub-sections.